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ENVIRONMENTAL TEST METHODS

M1 TANK PROGRAM

(FOR THE M1 WEAPON SYSTEM ONLY)

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M1 TANK PROGRAM

ENVIRONMENTAL TEST METHODS
FOR
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TABLE OF CONTENTS

(This is a hyper-linked document. Actual on file document will vary in format only)

Para. No.	Title	Page
1.	SCOPE	1
1.1	Purpose	1
1.2	General requirements	1
2.	APPLICABLE DOCUMENTS	5
2.1	Government documents	5
2.2	Other publications	6
3.	TEST METHODS	7
3.1	Temperature	7
3.2	Vibration	9
3.3	Shock	10
3.4	Humidity	15
3.5	Salt fog	19
3.6	Fungus	25
3.7	Dust and sand	34
3.8	Rain and wind	38
3.9	Solar radiation	39
3.10	Cleaning spray	45
3.11	Submergence	48
3.12	Chemicals	49
3.13	Bench handling shock	49
3.14	Temperature shock	50
3.15	Explosive atmosphere	51

LIST OF FIGURES

Figure No.	Title	Page
1	Peak vibration envelopes	11
2	Vibration logarithmic sweep range	12
3	Half sine shock pulse configuration	13
4	Shock measuring system frequency response	16
5	Humidity cycle	18
6	Variations of specific gravity of salt (NaCL) solution with temperature	22
7	Salt solution filter	24
8	Location of salt solution filter in reservoir	24
9	Solar radiation test cycles	47
10	Explosive atmosphere air weight - temperature characteristics, chamber volume dependent	53
11	Explosive atmosphere fuel weight - temperature characteristics	56
12	Explosive atmosphere fuel weight - temperature characteristic correction factors	57

LIST OF TABLES

Table No.	Title	Page
I	Test fungi	30
II	Dust and sand particle size blend	36
III	Dust/quartz sand composition	36
IV	Spectral energy distribution and permitted tolerances	42

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1. SCOPE

1.1 Purpose. This document establishes uniform environmental test methods for determining the resistance of land mobility vehicle equipment to the effects of natural and induced environments peculiar to military operations. It includes environmental test methods that will provide, as much as possible, consistently reproducible test results. The test methods described herein are intended to be implemented by reference in contractual documents and apply to all land mobility vehicle equipment. When it is known that the equipment will encounter conditions more severe or less severe than the environmental levels stated herein, the test may be modified by the applicable document (specification, drawing, Quality Assurance Requirement (QAR), etc).

1.2 General requirements.

1.2.1 Test conditions. Unless otherwise specified herein or in the equipment specification, measurements and tests shall be made at standard ambient conditions. Standard ambient conditions are:

Temperature	73 ± 18 degrees Fahrenheit (°F)
Relative humidity	50 ± 30 percent
Atmospheric pressure	28.5 (+2.0, -3.0) inches of Mercury (in. Hg)

1.2.1.1 Tolerances. Unless otherwise specified, tolerance of test conditions shall be as follows:

a. Air temperature at the control sensor shall be ±2.5°F. The equipment sensor response time (T) shall be 20 seconds or less. Temperature gradient across the cross-sectional area occupied by the test item shall not exceed 0.5°F per foot in any direction, but never more than 4°F total (equipment nonoperating).

NOTE: (T) is the time required for the sensing system to respond to 62.3 percent of a step change in temperature in the measured environment.

b. Pressure: When measured by devices such as manometers, ±5 percent or 0.059 inch of mercury, whichever provides the greatest accuracy. When measured by devices such as ion gages, ±10 percent to 10^{-1} Torr.

c. Relative humidity at the control sensor: ±5 percent.

d. Vibration amplitude: ±10 percent.

e. Vibration frequency: ±2 percent, or ±1/2 Hertz (Hz) below 25 Hz.

f. Acceleration: ±10 percent.

1.2.1.2 Test apparatus accuracy. The accuracy of instruments and test equipment used to control or monitor the test parameters shall be verified and shall satisfy the requirements of MIL-STD-45662 to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall: conform to laboratory standards whose calibration is traceable to the prime standards at the National Institute of Standards and Technology; and, unless otherwise specified in the equipment specification, have an accuracy of at least one-third the tolerance for the variable to be measured (in the event of conflict between this accuracy and a requirement for accuracy in any one of the test methods of this document, the latter shall govern).

1.2.2 Test temperature stabilization.

1.2.2.1 Operating. Unless otherwise specified herein or in the equipment specification, temperature stabilization will have been attained when the temperature of the part of the test item considered to have the longest thermal lag is changing no more than 3.6°F per hour.

1.2.2.2 Nonoperating. Unless otherwise specified, temperature stabilization will have been attained when the temperature of the part of the test item considered to have the longest thermal lag reaches a temperature within 3.6°F of the prescribed temperature, except that any critical component (e.g., battery electrolyte for engine starting test) will be within 1.8°F. When changing temperatures, the temperature of the chamber air may be adjusted up to 9°F beyond the desired end point for a period of time of up to 1 hour to reduce stabilization time, provided that the stabilization requirements of this paragraph are ultimately attained relative to the specified end point temperature, and provided the extended chamber temperatures will not cause damage to the test item.

1.2.3 Performance of test.

1.2.3.1 Pretest performance record. Prior to proceeding with any of the environmental tests, the test item shall be operated under standard ambient conditions (see 1.2.1) to obtain data for determining satisfactory operation of the item as specified in the equipment specification. A record of specific pretest data shall be made to verify that the test item performed within the equipment specification requirements.

NOTE: It shall be permissible during consecutive environmental tests to use post environmental performance test data (see 1.2.3.4) as pretest performance test data as long as the item under test has not been mishandled and was stored under standard ambient conditions as defined in 1.2.1.

1.2.3.2 Installation of test items in test facility. Unless otherwise specified, 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 adequately 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 may then be operated to determine that no malfunction or damage was caused due to faulty installation or handling when operation is required during exposure to the specified test.

1.2.3.3 Performance check during test. When operation of the test item is required during the test exposure, suitable tests shall be performed to determine whether the test exposure is producing changes in performance when compared with pretest data.

1.2.3.4 Post-test data.

1.2.3.4.1 Preproduction (qualification) and initial production (first article) testing. At the completion of each environmental test, the test item shall be inspected for damage and tested in accordance with the equipment specification. The test results (data) shall be compared with the pretest data obtained in accordance with 1.2.3.1.

1.2.3.4.2 Quality conformance (control) testing. At the completion of all environmental testing, the test item shall be inspected for damage and performance tested. Performance testing between environments shall be at the option of the contractor.

1.2.3.5 Failure criteria.

a. The item shall have failed the test when any of the following occur:

    (1) Monitored functional parameters deviate beyond acceptable limits established in 1.2.3.1.

    (2) Catastrophic or structural failure.

(3) Mechanical binding or loose parts, including screws, clamps, bolts, and nuts, that clearly result in component failure or a hazard to personnel safety.

(4) Malfunction.

(5) Degradation of performance beyond pretest record or equipment specification requirements established in 1.2.3.1 (record to be made after test).

NOTE: Certain types of equipment (e.g., propellants and electrically driven devices) are often expected to demonstrate lesser performance at an environmental extreme, particularly low temperature. A failure would occur only if degradation is more than expected.

(6) Any additional deviations from acceptable criteria established before the test and recorded according to 1.2.3.1.

(7) Deterioration, corrosion, or change in tolerance limits of any internal or external parts which could in any manner prevent the test item from meeting operational service or maintenance requirements.

b. Any additional or different failure criteria shall be as specified in the equipment specification.

1.2.3.6 Under/over test. If an under test or an over test condition occurs, testing shall immediately cease and direction as to how to proceed shall be obtained from the procuring activity.

1.2.4 Test facilities and apparatus. Test facilities, chambers, and apparatus used in conducting the tests contained in this standard shall be capable of meeting the conditions required.

1.2.4.1 Test chamber. The following shall apply to test chambers, as applicable.

1.2.4.1.1 Volume. The volume of the test chamber shall be such that the bulk of the item under test will not interfere with the generation and maintenance of the test conditions. When testing multiple sample items simultaneously, the test chamber shall be of sufficient size so that each test unit is provided uniform environmental conditions and is not subjected to nontest environments.

1.2.4.1.2 Heat source. The heat source of the test facility shall be so located that radiant heat from the source will not fall directly on the test item, except where application of radiant heat is one of the test conditions.

1.2.4.1.3 Temperature sensors location. Unless otherwise specified, thermocouples or equivalent temperature sensors utilized to determine or control the specified chamber temperature shall be located centrally within the chamber, in the supply airstream, or in the return airstream whichever provides the specified test conditions at the bulk under test and shall be baffled or otherwise protected against radiation effects.

1.2.4.1.4 Internal air circulation. The conditioned air flow shall be suitably baffled to provide uniform air flow around the test item. If multiple test items are tested, they shall be so spaced as to provide free circulation between the test items and the chamber walls.

1.2.5 Test data. Test data shall include complete identification of all test equipment and accessories. The data shall include the actual test sequence used and ambient test conditions recorded periodically during the test period. Where measureable, quantitative data is involved, the actual measured value shall be annotated; checking a box to denote a measurement was within a range, for example, shall not be acceptable. The test record shall contain a signature and data block for certification of the test data by the test engineer.

2. APPLICABLE DOCUMENTS.

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following documents of the issue listed in the current Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, if applicable, form a part of this standard to the extent specified herein.

FEDERAL

P-C 437	Cleaning, Compound, High Pressure (Steam) Cleaner

MILITARY

MIL-C-9435	Chamber, Explosion-Proof Testing
MIL-T-43566	Tape, Textile, Cotton or Polyester, General Purpose, Natural or in Colors

STANDARDS

MIL-STD-45662	Calibration System Requirements

OTHER

AR 70-38	Research, Development, Test, and Evaluation of Material for Extreme Climatic Conditions

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers with respect to specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise stated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Geophysical Union

"The Relationship of Raindrop Size to Intensity" - Laws and Parsons, Translations of the American Geophysical Union, Part II, para 452-459, 1943.

(Copies of the above publication may be obtained from the American Geophysical Union, 2100 Pennsylvania Ave., N.W., Suite 435, Washington, D.C. 20037).

American Society for Testing Materials (ASTM)

ASTM D910-88

(Copies of the above publication may be obtained from ASTM, 1916 Race Street, Philadelphia, PA 19103).

Society of Automotive Engineers (SAE).

SAE J726	Air Cleaner Test Code

(Copies of the above publication may be obtained from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

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3. TEST METHODS.

3.1 Temperature.

3.1.1 High. The high temperature test is conducted to determine the resistance of equipment to elevated temperatures that may be encountered during service life either in storage (without protective packaging) or under service conditions.

3.1.1.1 General effects. High temperature conditions may cause the permanent set of packings and gaskets, change the physical and functional characteristics of electrical/electronic parts, and shorten equipment operating life. In items of complex construction, binding of parts may also result due to differential expansion of dissimilar materials. Protective coatings may discolor, materials may crack, closure and sealing strips may partially melt and adhere to contacting parts. These are a few of the problems associated with high temperature.

3.1.1.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: required pretest data; failure criteria; highest operating temperature expected for equipment operation; required measurements; and internal chamber temperature dwell time if other than 48 hours.

3.1.1.3 Procedures. Using a temperature chamber, proceed as follows:

NOTE: The rate of temperature change (steps b, d, and f) may be the maximum attainable by the chamber, but shall not exceed 18°F per minute.

a. Prepare the test item in accordance with the general requirements of 1.2.

b. Raise the internal chamber temperature to 160°F, or as specified in the equipment specification.

c. Maintain the internal chamber temperature for a period of 48 hours, or as specified in the equipment specification, while ensuring the relative humidity is not in excess of 15 percent. If operation of the equipment "during exposure" is not required, immediately proceed to step f.

d. Adjust the internal chamber temperature to the highest operating temperature for which the test item is designed to operate and maintain until temperature stabilization of the test item is reached.

e. Operate the test item until the item is stabilized, or as specified in the equipment specification, and obtain results in accordance with 1.2.3.3.

f. Return the test item, nonoperating, to standard ambient condition and stabilize.

g. Operate and inspect test item and obtain results in accordance with 1.2.3.4.

3.1.2 Low. The low temperature test is conducted to determine the effects of low temperature on equipment during storage (without protective packaging) and service use.

3.1.2.1 General effects. Differential contraction of metal parts, loss of resiliency of packing and gaskets, congealing of lubricants, and changes in the physical and functional characteristics of electrical/electronic parts are a few of the problems associated with low temperature.

3.1.2.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: required pre-test data; failure criteria; lowest temperature expected for equipment operation; required measurement; and internal dwell time.

3.1.2.3 Procedure. Using a temperature chamber, proceed as follows:

NOTE: The rate of temperature change (steps b, d, and f) may be the maximum attainable by the chamber, but shall not exceed 18°F per minute.

a. Prepare the test item in accordance with the general requirements of 1.2.

b. Lower the internal chamber temperature to the storage temperature of -60°F, or as otherwise specified in the equipment specification.

c. Maintain the temperature for a period of 24 hours after stabilization, or for the period specified in the equipment specification. If operation of the equipment "during exposure" is not required, immediately proceed to step f.

d. Adjust the internal chamber temperature to the lowest temperature under which the test item is designed to operate as specified in the equipment specification and maintain until temperature stabilization of the test item is reached.

e. Operate the test item until the item is stabilized or for the time specified in the equipment specification and obtain results in accordance with 1.2.3.3.

f. Return the test item, nonoperating, to standard ambient conditions and stabilize.

g. Operate and inspect test item and obtain results in accordance with 1.2.3.4.

3.2 Vibration. The vibration test is performed to determine if equipment is constructed to withstand expected dynamic vibrational stresses and to ensure that performance degradations or malfunctions will not be produced by the service vibration environment. Tests specified herein are established for equipment which is used in a tank environment.

3.2.1 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: pretest data required; failure criteria; weight of test item; vibration frequency, amplitude and duration; and temperature extremes, if applicable.

3.2.2 Procedures. The entire sequence of tests may be accomplished for any one axis before changing to the next axis. The transverse motion at the input monitoring point(s) shall be minimized, and should be limited to 100 percent of the input motion except that reaction machines shall be balanced to reduce transverse motion ±10 percent.

3.2.2.1 Test item operation. Unless otherwise specified in the equipment specification, the test item shall be operated during application of vibration so that functional effects caused by these tests may be evaluated. The procedure provides for a functional and an endurance vibration test. The test item shall meet the requirements using the method of test specified in Section 4 of the equipment specification and, as applicable, the General Requirements of 1.2 herein.

3.2.2.2 Mounting techniques. The test item shall be attached by its normal mounting means, either directly to the vibration exciter or transition table, or by means of a rigid fixture capable of transmitting the vibration conditions specified herein. Precautions shall be taken in the establishment of mechanical interfaces to minimize the introduction of extraneous responses in the test setup. The test load shall be distributed as uniformly as possible on the vibration exciter table in order to minimize effects of unbalanced loads. The input control sensing device(s) shall be rigidly attached to the vibration table, or fixture if used, as near as possible to the attachment point(s) of the test item. Locations to be selected should include main structure, printed circuit boards, large components and modules, where practicable. The sensor sizes and weights shall be limited so that their effect on the dynamic responses being measured is minimal. For sinusoidal vibration, when necessary for obtaining uniform results, a tracking filter should be used in the vibration exciter control feedback loop prior to the servo input.

3.2.2.3 Combined temperature-vibration test. Tests shall be performed under room ambient conditions unless a high or low temperature vibration test is specified, in which case the temperature extremes shall be as specified in the equipment specification.

3.2.2.4 Sinusoidal vibration tests. The vibration shall be applied along each of three mutually perpendicular axes of the test item. The vibratory acceleration levels or double amplitudes of the specified test curve shall be maintained at the test item mounting points. When necessary for obtaining uniform results, a tracking filter should be used in the exciter control feedback loop prior to the servo input. When the input vibration is measured at more than one control point, the control signal shall be the average of all the accelerometers unless otherwise specified. For massive test items, fixtures and large force exciters, it is recommended that the input control level be an average of at least three or more inputs.

3.2.2.5 Cycling. The test item shall be vibrated along each axis in accordance with the test level and frequency range of the equipment specification and Figure 1. Unless otherwise specified in the equipment specification, the frequency of applied vibration shall be swept over a 5 to 500 to 5 Hertz (Hz) range logarithmically in accordance with Figure 2 for a period of 180 minutes in each of the three mutually perpendicular axes. The specified sweep time is that of an ascending plus a descending sweep and is twice the ascending sweep time shown on Figure 1 for the specified range. When required by the equipment specification, the test item shall be operating during the test and performance shall be verified in accordance with 1.2.3.3, as required. At the conclusion of the test, the test item shall be returned to standard ambient conditions (see 1.2.1), then examined and tested in accordance with 1.2.3.4.

3.3 Shock. The shock test is performed to determine if equipment is constructed to withstand expected dynamic shock stresses and that performance degradations or malfunctions will not be produced by the service shock environment expected in handling, transportation, and service use.

3.3.1 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: pretest data required; shock pulse type, amplitude and duration; temperature extremes, if applicable; and operational requirements during exposure (i.e., intermittent operation, relay chatter, etc.).

3.3.2 Apparatus.

3.3.2.1 Shock machine. The shock machine utilized shall be capable of producing the specified input shock pulse shown on Figure 3. The shock machine may be of the free fall, resilient rebound, nonresilient, hydraulic, compressed gas, computer-controlled electrodynamic exciter or other activating types.

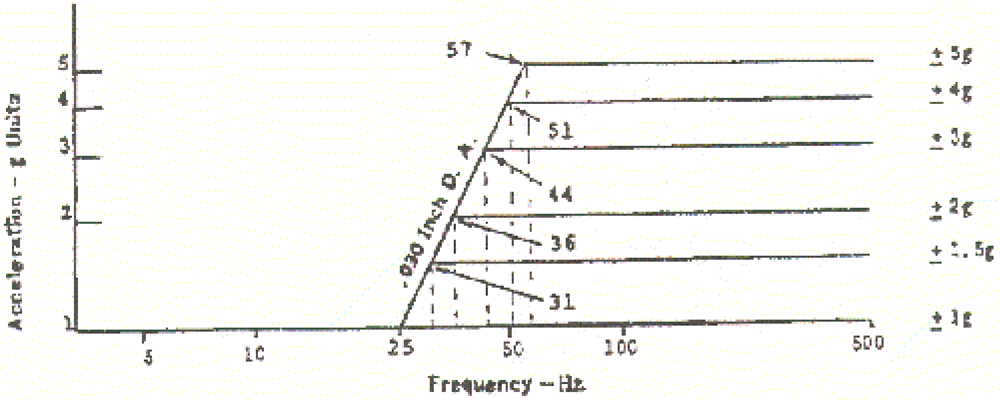


FIGURE 1. Peak vibration envelopes.

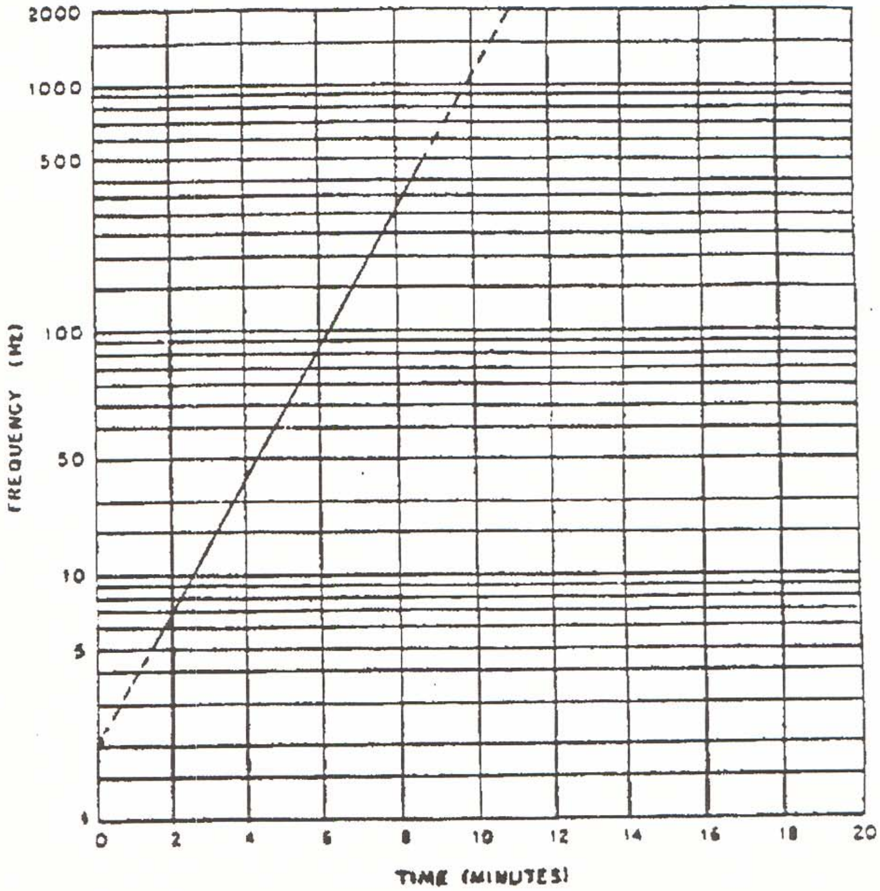
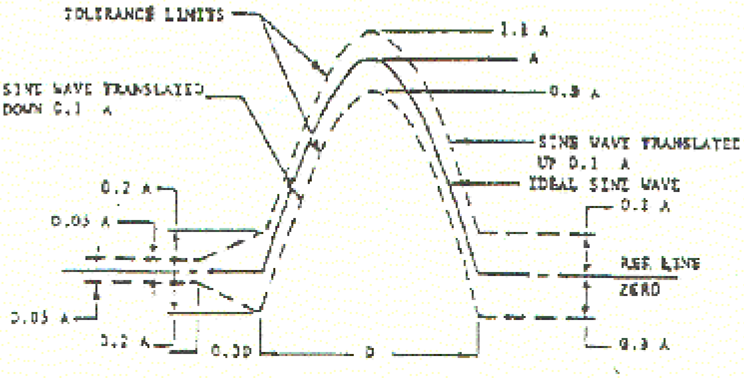


FIGURE 2. Vibration logarithmic sweep range.



NOTE: THE OSCILLOGRAM SHALL INCLUDE A TIME ABOUT 3D LONG WITH A PULSE LOCATED APPROXIMATELY IN THE CENTER. THE ACCELERATION AMPLITUDE OF THE IDEAL HALF SINE PULSE IS A AND ITS DURATION IS D. THE MEASURED ACCELERATION PULSE SHALL BE CONTAINED BETWEEN THE BROKEN LINE BOUNDARIES AND THE MEASURED VELOCITY CHANGE (WHICH MAY BE OBTAINED BY INTEGRATION OF THE ACCELERATION PULSE) SHALL BE WITHIN THE LIMITS $V_i \pm 0.1\ V_i$ WHERE V_i IS THE VELOCITY-CHANGE ASSOCIATED WITH THE IDEAL PULSE WHICH EQUALS $2\ AD/\pi$. THE INTEGRATION TO DETERMINE VELOCITY CHANGE SHALL EXTEND FROM 0.4D BEFORE THE PULSE TO 0.1D AFTER THE PULSE.

FIGURE 3. Half sine shock pulse configuration.

3.3.2.1.1 Shock machine calibration. The actual test item, a rejected item, or a rigid dummy mass shall be used to calibrate the shock machine for conformance with the specified wave shape. When a rigid dummy mass is used, it shall have the same center of gravity and the same mass as that intended for the test item and shall be installed in a manner similar to that of the test item. (When a rigid dummy mass or rejected item is used for calibration, the waveform during the actual test may be somewhat different from that observed during calibration.) The shock machine shall then be calibrated for conformance with the specified waveform. Two consecutive shock applications to the calibration load shall produce waveforms which are all within the tolerance envelope given. The calibrating load shall then be removed and the shock test performed on the actual test item. Provided all conditions remain the same, other than the substitution of the test item for the calibrating load, the waveform shall be considered to meet the specified test requirement. The actual test waveform shall be recorded for later use should a failure analysis be required.

3.3.2.2 Instrumentation. The instrumentation used to measure the input shock pulse, in order to meet the tolerance requirements of the test procedure, shall have the following characteristics:

3.3.2.2.1 Frequency response. The frequency response of the complete measuring system, from the accelerometer through the readout instrument, shall be as shown on Figure 4. Particular care shall be exercised in the selection of each individual instrument of the shock measuring instrumentation system in order to assure compatibility with the prescribed frequency response tolerance.

3.3.2.2.2 Accelerometer, piezoelectric. When a piezoelectric accelerometer is employed as the shock sensor, the fundamental resonant frequency of the accelerometer shall be greater than 14,000 Hz (resonant frequencies of 30,000 Hz or higher are recommended). For suitable low frequency response, the accelerometer and load (cathode follower, amplifier, or other load) shall have the following characteristics:

$$RC > 0.2$$

Where R = load resistance (ohms)
C = accelerometer capacitance plus shunt capacitance of cable and load (farads)

3.3.2.2.3 Accelerometer, strain gage. A strain gage accelerometer may be used provided the undamped natural frequency is equal to or greater than 1,500 Hz with damping approximately 0.64 to 0.70 of critical.

3.3.2.2.4 Accelerometer calibration. The accelerometer shall be dynamically calibrated to the specified accuracy.

3.3.2.3.5 Accelerometer mounting. The monitoring accelerometer shall be rigidly attached to the test item support fixture at or near the attachment point(s) of the test item.

3.3.3 Procedures.

3.3.3.1 Shock pulse. The shock pulses shall be as shown on Figure 3. All points of the acceleration waveform obtained shall lie within the area enclosed by the tolerance limit lines.

3.3.3.2 Mounting of test item. The test item shall be rigidly attached to the shock machine table following the general requirements of 1.2.3.2, as applicable. Wherever possible, the test load shall be distributed uniformly on the test platform in order to minimize the effects of unbalanced loads.

3.3.3.3 Procedure. This procedure shall be used for shock testing of equipment assemblies (mechanical, electrical, hydraulic, electronic, etc.) of medium size, including items which mount on vibration isolators and equipment racks. Three shocks in each direction shall be applied along three mutually perpendicular axes of the test item (total of 18 shocks). If the test item is normally mounted on vibration isolators, the isolators shall be functional during the test. The shock pulse shape shall be in accordance with Figure 3 and of duration and amplitude as specified in the equipment specification. When required by the equipment specification, the test item shall be operating during the test and performance verified in accordance with 1.2.3.3, as required. At the conclusion of the test, the test item shall be operated and inspected and results obtained shall be verified in accordance with 1.2.3.4.

3.4 Humidity. The humidity test is conducted to determine the resistance of equipment to the effects of exposure to warm, highly humid atmosphere such as is encountered in tropical areas. This is an exaggerated environmental test, accomplished by the continuous exposure of the equipment to high relative humidity at cycling elevated temperatures. These conditions impose a vapor pressure on the equipment under test which constitutes the major force behind the moisture migration and penetration.

3.4.1 Apparatus. A humidity chamber is required. The chamber and accessories shall be constructed and arranged in such a manner as to avoid condensate dripping on the test item. The chamber shall be trap-vented to the atmosphere to prevent the buildup of total pressure. Relative humidity shall be determined from the dry bulb-wet bulb thermometer comparison method or an equivalent method approved by the procuring activity. When readout charts are used, they shall be capable of being read with a resolution within 1°F. When the wet bulb control method is used, the wet bulb and tank shall be cleaned and a new wick installed at least every 30 days. The air velocity flowing across the wet bulb shall be not less than 900 feet per minute. Provisions shall be made for controlling the flow of air throughout the internal chamber test space where the velocity of air shall not exceed 150 feet per minute. Steam or distilled, demineralized, or deionized water having a pH

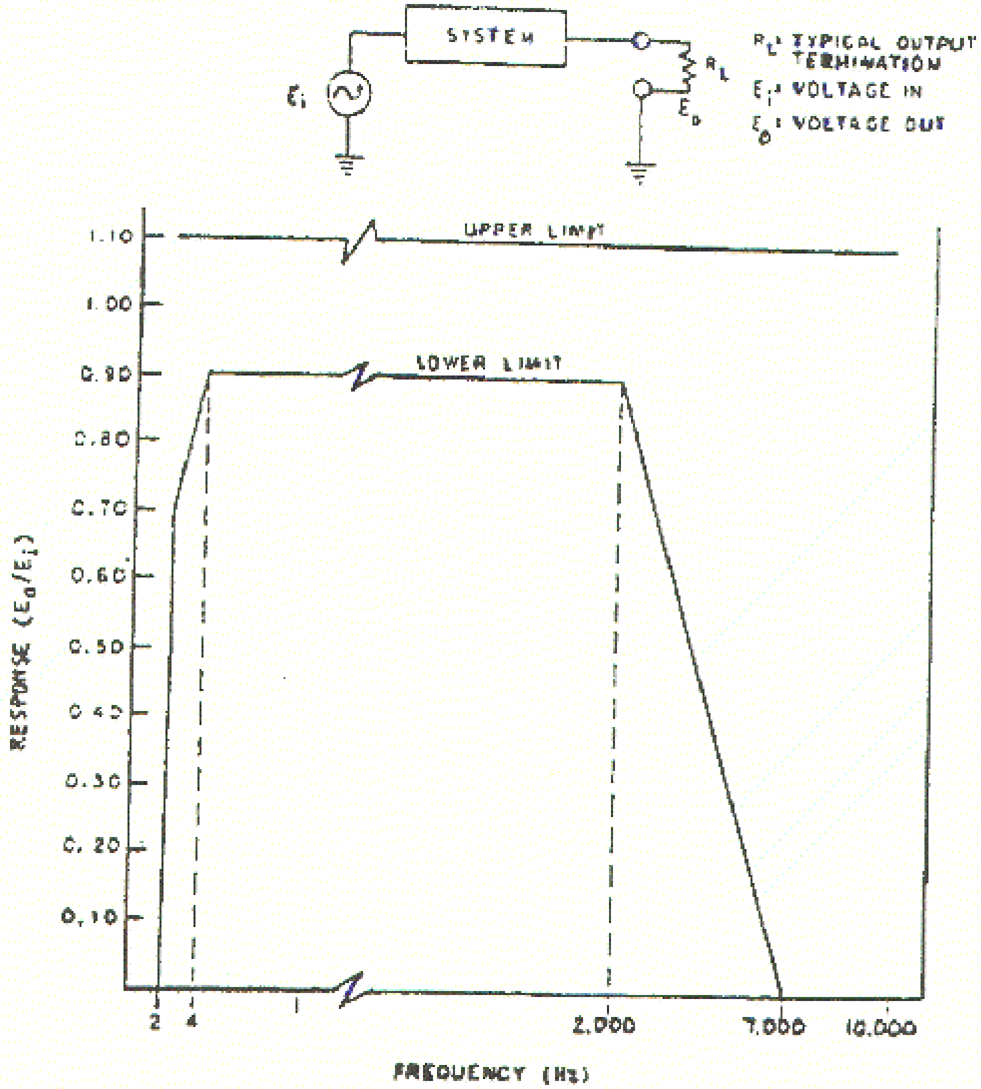


FIGURE 4. Shock measuring system frequency response.

value between 6.0 and 7.2 at 73°F shall be used to obtain the specified humidity. No rust or corrosive contaminants shall be imposed on the test item by the test facility.

3.4.2 Procedure.

a. Prepare the test item, as required, in accordance with the general requirements of 1.2 except make initial measurements as specified in step d following.

b. Dry the test item at 129°F for 24 hours.

c. Condition the test item at 73 ± 18°F and 50 ± 10 percent relative humidity for 24 hours.

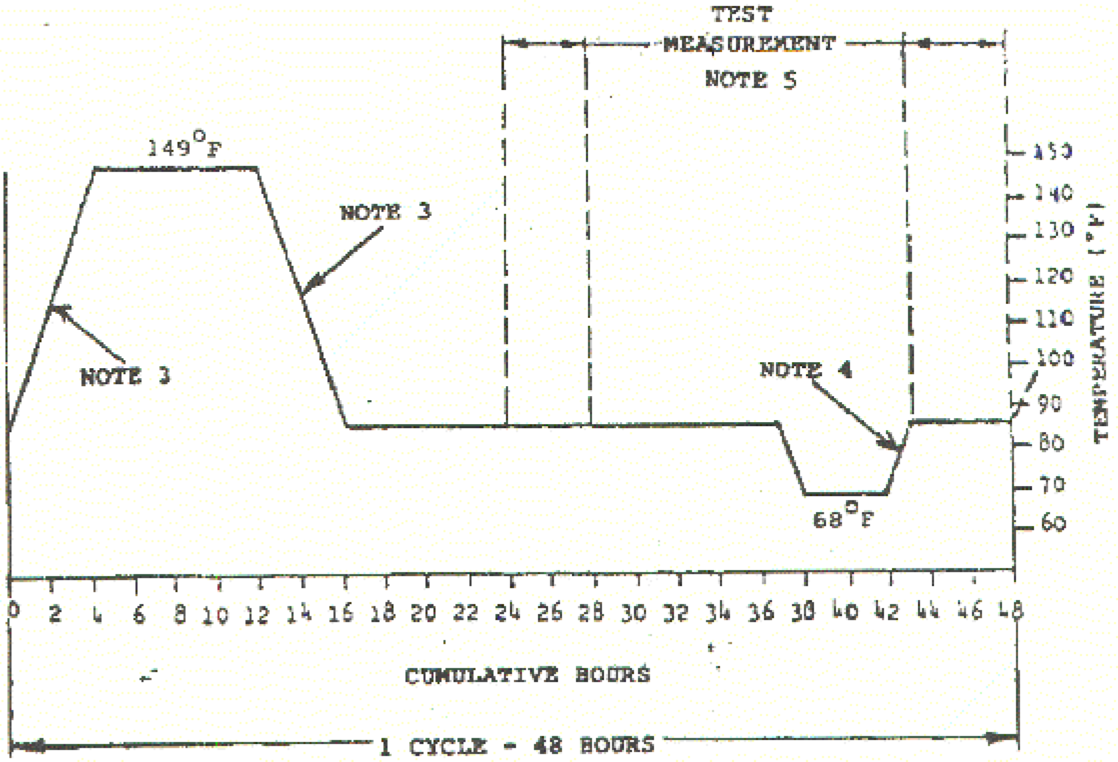
d. If no pre-test data exists, take initial measurements in accordance with 1.2.3.1.

e. Raise the internal chamber temperature to 86°F and the relative humidity to 95 ± 5 percent.

f. Subject the test item to five continuous 48-hour cycles in accordance with Figure 5. During the 24th to 28th or 44th to 48th hours of the fifth cycle, operate the equipment as specified in the equipment specification and verify performance in accordance with 1.2.3.3, as required.

g. After completion of step f, condition the test item for 24 hours at 73°F and 50 ± 10 percent relative humidity. During conditioning, remove accumulated moisture by turning the assembly upside down and shaking, if practicable. In the case of surfaces such as glass through which one must view, wiping and patting dry is also acceptable. Disassembly of the unit is not permissible. Any evidence of internal moisture, visible for example in the case of optical devices, is unacceptable.

h. Following conditioning, operate and inspect the item in accordance with the equipment specification and verify the results in accordance with 1.2.3.4. Evidence of any internal moisture is cause for rejection.



NOTES:

1. TOLERANCE DURING TEMPERATURE CHANGE SHALL BE NOT GREATER THAN 3°C (5°F).
2. RELATIVE HUMIDITY SHALL BE MAINTAINED AT 95 ± 5 PERCENT AT ALL TIMES, EXCEPT THAT DURING THE DESCENDING TEMPERATURE PERIOD, THE RELATIVE HUMIDITY MAY BE PERMITTED TO DROP AS LOW AS 85 PERCENT.
3. RATE OF TEMPERATURE CHANGE BETWEEN 86 and 149°F SHALL BE NOT LESS THAN 14.4°F PER HOUR.
4. THE TEMPERATURE INCREASE IN THIS PORTION OF THE CURVE SHALL BE NOT LESS THAN 18°F.
5. TEST MEASUREMENTS SHALL BE TAKEN ONLY AT THE PERIOD SPECIFIED.

FIGURE 5. Humidity cycle.

3.5 Salt fog. The salt fog test is conducted to determine the resistance of equipment to the effects of a salt atmosphere. The specified concentration of moisture and salt is greater than is found in service. The test is applicable to any equipment exposed to salt fog conditions in service. The test is valuable for determining the durability of coatings and finishes exposed to a corrosive salt atmosphere. For other applications, however, this test should be applied only after full recognition of its deficiencies and limitations.

3.5.1 General effects.

3.5.1.1 Deficiencies. Testing deficiencies include:

a. The successful withstanding of this test does not guarantee that the test item will prove satisfactory under all corrosive conditions.

b. The salt fog used in this test does not truly duplicate the effects of a marine atmosphere.

c. It has not been demonstrated that a direct relationship exists between salt fog corrosion and corrosion due to other media.

d. This test is generally unreliable for comparing the corrosion resistance of different materials or coating conditions, or for predicting their comparative service life.

3.5.1.2 Limitations. The salt fog test is acceptable for evaluating the uniformity (i.e., thickness and degree of porosity) of protective coatings, metallic and nonmetallic, of different lots of the same product, once some standard level of performance has been established. When used to check the porosity of metallic coatings, the test is more dependable when applied to coatings which are cathodic rather than anodic toward the basic metal. This test can also be used to detect the presence of free iron contaminating the surface of another metal by inspection of the corrosion products.

3.5.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: pretest data required; failure criteria; applicable salt solution, if other than 5 percent; salt fog exposure period if other than 48 hours; drying period if other than 48 hours; inspection and operation after 24 hours of exposure where buildup of salt deposits are detrimental to the proper operation of the equipment; and specify whether operation of an electrical system is required.

3.5.3 Apparatus. The apparatus used in the salt fog test shall include the following:

a. Exposure chamber with racks for supporting test items.

b. Salt solution reservoir with means for maintaining an adequate level of solution.

c. Means for atomizing salt solution, including suitable nozzles and compressed air supply.

d. Chamber heating means and control.

e. Means for humidifying the air at a temperature above the chamber temperature.

3.5.3.1 Chamber. The chamber and all accessories shall be made of material that will not affect the corrosiveness of the fog (e.g., glass, hard rubber, plastic, or kiln dried wood other than plywood). In addition, all parts which come in contact with test items shall be of materials that will not cause electrolytic corrosion. The chamber and accessories shall be constructed and arranged so that there is no direct impingement of the fog or dripping of the condensate on the test items, that the fog circulates freely about all test items to the same degree, and that no liquid which has come in contact with the test items returns to the salt-solution reservoir. The chamber shall be properly vented to prevent pressure buildup and allow uniform distribution of salt fog. The discharge end of the vent shall be protected from strong drafts which can create strong air currents in the test chamber.

3.5.3.2 Atomizers. The atomizers used shall be of such design and construction as to produce a finely divided, wet, dense fog. Atomizing nozzles shall be made of material that is nonreactive to the salt solution.

3.5.3.3 Air supply. The compressed air entering the atomizer shall be essentially free from all impurities, such as oil and dirt. Means shall be provided to humidify and warm the compressed air as required to meet the operating conditions. The air pressure shall be suitable to produce a finely divided dense fog with the atomizer or atomizers used. To insure against clogging the atomizers by salt deposition, the air should have a relative humidity of at least 85 percent at the point of release from the nozzle. A satisfactory method is to pass the air in very fine bubbles through a tower containing heated water which should be automatically maintained at a constant level. The temperature of the water should be at least 95°F. The permissible water temperature increases with increasing volume of air and with decreasing insulation of the chamber and the chamber's surroundings. However, the temperature should not exceed a value above which an excess of moisture is introduced into the chamber (for example 109° at an air pressure of 12 psi) or a value which makes it impossible to meet the requirements for operating temperature.

3.5.3.4 Preparation of salt solution. The salt used shall be sodium chloride containing, on the dry basis, not more than 0.1 percent sodium iodide and not more than 0.5 percent of total impurities. A 5 ± 1 percent solution shall be prepared by dissolving five parts by weight of salt in 95 parts by weight of distilled or demineralized water. The solution shall be adjusted to and maintained at a specific gravity between the limits shown on Figure 6 by utilizing the measured temperature and density of the salt solution. Sodium tetraborate (common borax) may be added to the salt solution in a ratio not to exceed 0.7 gms (1/4 level teaspoon) sodium tetraborate to 20 gallons of salt solution as a pH stabilization agent.

a. Adjustment of pH of the salt solution shall be so maintained that the solution atomized at 95°F and collected by the method specified in 3.5.4.3 will be in the pH range of 6.5 to 7.2.

b. Only diluted, chemically pure, hydrochloric acid or chemically pure, sodium hydroxide shall be used to adjust the pH. The addition of sodium tetraborate as recommended herein will aid in maintaining a stable pH value.

c. The pH measurement shall be made electrometrically using a glass electrode with a saturated potassium chloride bridge, or by a colorimetric method, such as bromothymol blue, provided the results are equivalent to those obtained with the electrometric method.

d. The pH shall be measured when preparing each new batch of solution and as specified in 3.5.4.4.

3.5.3.5 Filter. A filter fabricated of noncorrosive materials similar to that shown in Figure 7 shall be provided in the supply line and immersed in the salt solution reservoir in a manner such as that illustrated in Figure 8.

3.5.4 Procedure.

3.5.4.1 Temperature. The test shall be conducted with a temperature in the exposure zone maintained at 95°F. Satisfactory methods for controlling the temperature accurately are by housing the apparatus in a properly controlled constant temperature room, by thoroughly insulating the apparatus and preheating the air to the proper temperature prior to atomization, or by jacketing the apparatus and controlling the temperature of the water or of the air used in the jacket. The use of immersion heaters within the chamber for the purpose of maintaining the temperature within the exposure zone is prohibited.

3.5.4.2 Atomization. Suitable atomization has been obtained in chambers having a volume of less than 12 cubic feet under the following conditions:

a. Nozzle pressure shall be as low as practicable to produce fog at the required rate.

b. Orifices between 0.02 and 0.03 inch in diameter.

c. Atomization of approximately 3 quarts of salt solution per 10 cubic feet of chamber volume per 24 hours.

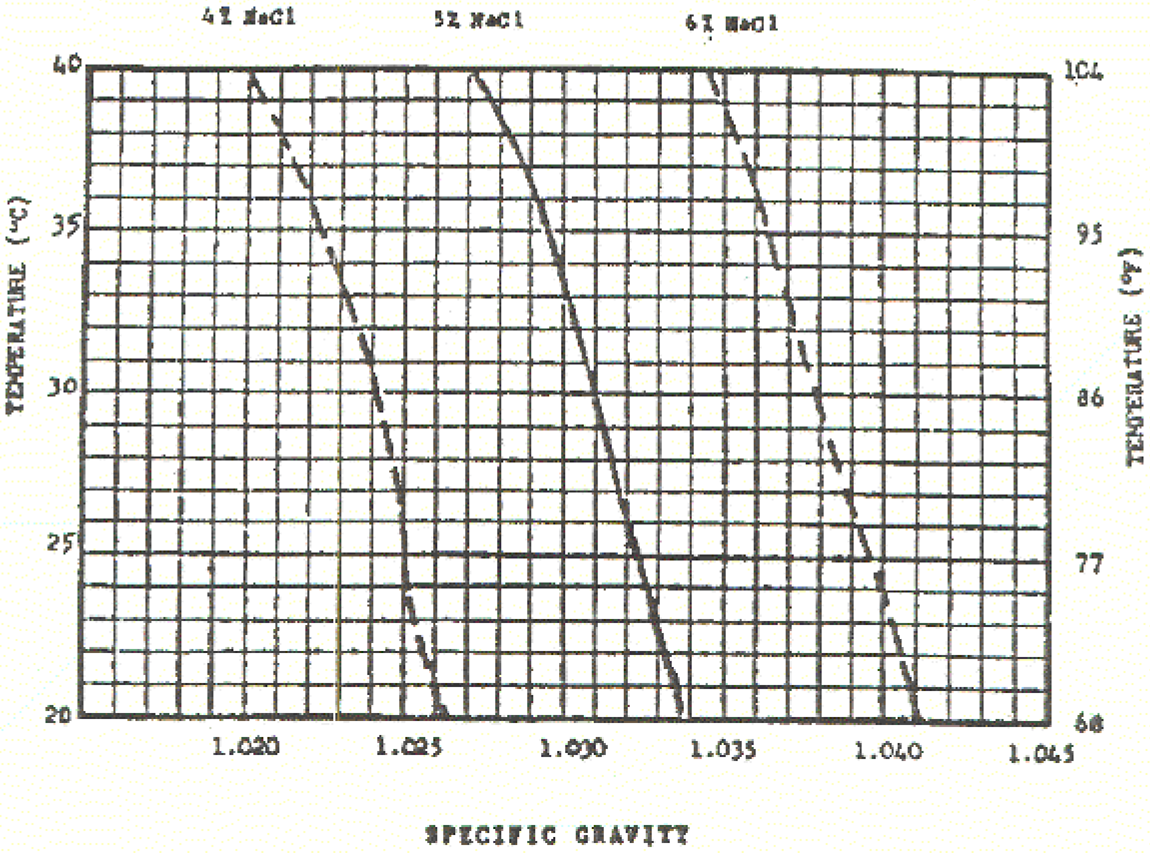


FIGURE 6. Variations of specific gravity of salt (NaCl) solution with temperature.

When using large size chambers having a volume considerably in excess of 12 cubic feet, the conditions specified may require modification to meet the requirements for operating conditions.

3.5.4.3 Placement of salt fog collection receptacles. The salt fog conditions maintained in all parts of the exposure zone shall be such that a clean fog collecting receptacle placed at any point in the exposure zone will collect from 0.5 to 3.0 milliliters of solution per hour for each 80 square centimeters of horizontal collecting area (10 centimeter diameter) based on an average test of at least 16 hours. A minimum of two receptacles shall be used, one placed nearest to any nozzle and one farthest from all nozzles. Receptacles shall be placed so that they are not shielded by test items and so no drops of solution from test items or other sources will be collected.

3.5.4.4 Measurement of salt solution. The solution, collected in a manner specified in 3.7.4.3, shall have the sodium chloride content and pH specified in 3.5.3.4 when measured at a temperature of 95°F. The salt solution from all collection receptacles used can be combined to provide that quantity required for the measurements specified.

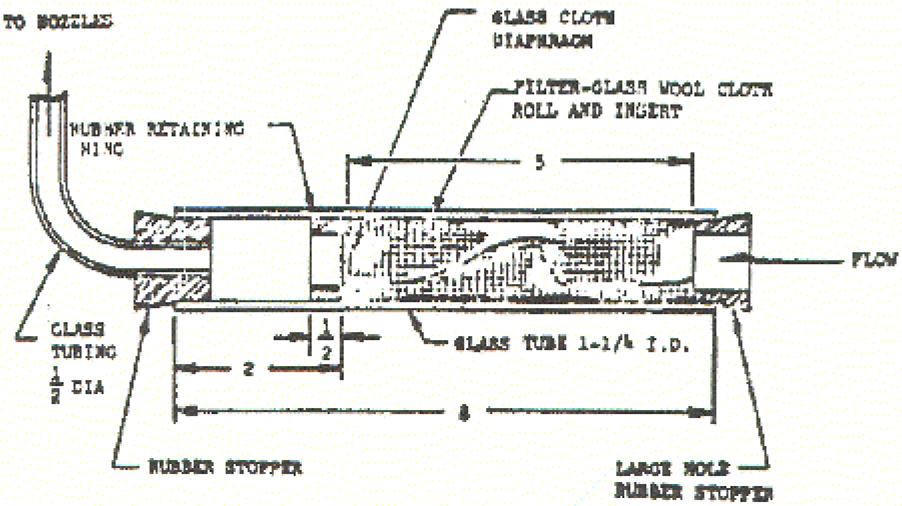
3.5.4.4.1 Measurement of sodium chloride content. The solution, maintained at the specified temperature, can be measured in a graduate of approximately 2.5 centimeters inside diameter. A small laboratory type hydrometer will be required for measurement within this volume.

3.5.4.4.2 Time of measurements. The measurement of both sodium chloride content and pH shall be made at the following specified times:

a. For salt fog chambers in continuous use, the measurements shall be made following each test.

b. For salt fog chambers that are used infrequently, a 24-hour test run shall be accomplished followed by the measurements. The test item shall not be exposed to this test run.

3.5.4.5 Preparation of test item. The test item shall be given a minimum of handling, particularly on the significant surfaces, and shall be prepared for test immediately before exposure. Unless otherwise specified, uncoated metallic or metallic coated devices shall be thoroughly cleaned of oil, dirt, and grease as necessary until the surface is free from water break. The cleaning methods shall not include the use of corrosive solvents nor solvents which deposit either corrosive or protective films, nor the use of abrasives other than a paste of pure magnesium oxide. Test items having an organic coating shall not be solvent cleaned. Those portions of test items which come in contact with the support - and unless otherwise specified in the case of coated devices or samples, cut edges and surfaces not required to be coated - shall be protected with a suitable coating of wax or similar substance impervious to moisture.



DIMENSIONS IN INCHES.

FIGURE 7. Salt solution filter.

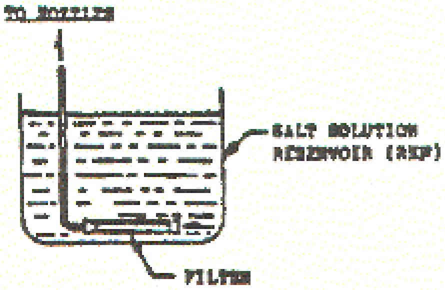


FIGURE 8. Location of salt solution filter in reservoir.

3.5.4.6 Performance of test. The test item shall be placed in the test chamber in accordance with the general requirements of 1.2.3.2, and exposed to the salt fog for a period of 48 hours, or as specified in the equipment specification. At the end of the exposure period, unless otherwise specified, the test item shall be operated and the results compared with the data obtained in accordance with the general requirements of 1.2.3.1. The test item shall be inspected for corrosion in accordance with the general requirements of 1.2.3.4. If necessary to aid in examination, a gentle wash in running water not warmer than 100°F may be used. The test item shall then be stored in an ambient atmosphere for 48 hours or as specified in the equipment specification for drying. At the end of the drying period, when specified, the test item shall be again operated and the results compared with the data obtained in accordance with the general requirements of 1.2.3.1. The test item shall then be inspected in accordance with general requirements of 1.2.3.4.

3.6 Fungus. The fungus test is used to determine whether the test item will support fungal growth and/or whether a fungal environment will adversely affect test item operation.

3.6.1 General effects. Fungal growth impairs the functioning or use of equipment by changing the physical properties of the equipment.

3.6.1.1 Damage mechanisms. Damage mechanisms are as follows:

3.6.1.1.1 Direct attack on materials. Non-resistant materials are susceptible to direct attack as the fungi break the material down and use it as food. This results in deterioration affecting the physical properties of the material. Examples of non-resistant materials are:

3.6.1.1.1.1 Natural materials. Products of natural origin are most susceptible to this attack. Examples of such products are: cellulosic materials (e.g., wood, paper, natural fiber textiles, and cordage); animal and vegetable based adhesives; grease, oils, and many hydrocarbons; and leather.

3.6.1.1.1.2 Synthetic materials. Synthetic products are also susceptible to this attack. Examples of such products are: polyvinylchloride (PVC) formulations (e.g., those plasticized with fatty acid esters); certain polyurethanes (e.g., polyesters and some polyethers); plastics, which contain organic fillers of laminating materials; and paints and varnishes which contain susceptible constituents.

3.6.1.1.2 Indirect attack on materials. Damage to fungus resistant materials results from indirect attack when: fungal growth on surface deposits of dust, grease, perspiration, and other contaminants find their way onto equipment during manufacture or accumulate during service causing damage to the underlying material even though that material may be resistant to direct attack; metabolic waste products (i.e., organic acids), excreted by fungi, cause corrosion of metals, etching of glass or staining or degrading of plastics and other materials; and products of fungal growth on adjacent materials, which are susceptible to direct attack, come in contact with the resistant materials.

3.6.1.2 Physical interference. Physical interference can occur as follows:

3.6.1.2.1 Electrical or electronic systems. Damage to electrical or electronic systems may result from either direct or indirect attack. Fungal growth can form undesirable electrical conducting paths across insulating materials or may adversely affect the electrical characteristics of critically adjusted electronic circuits.

3.6.1.2.2 Optical systems. Damage to optical systems results primarily from indirect attack. The fungal growth can adversely affect light transmission through the optical system; block delicate moving parts; and change non-wetting surfaces to wetting surfaces with resulting loss in performance.

3.6.1.3 Health and aesthetic factors. Fungus growth on equipment can cause physiological problems, (e.g., allergies) or be so aesthetically unpleasant that the users will be reluctant to use the equipment.

3.6.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: pretest data required; failure criteria; test period if other than 28 days; and whether the equipment should be operated during test.

3.6.3 Special considerations.

3.6.3.1 Failure analysis. Any fungi on the test item must be analyzed to determine if the growth is on the test item material(s) or on contaminants. Any fungal growth on the test item material(s) (whether from the inoculum or other sources) must be evaluated by qualified personnel for: the extent of growth on the component(s); the immediate effect that the growth has on the physical characteristics of the test item; the long range effect that the growth could have on the test item; and the specific material(s) (nutrient) supporting the growth. Fungal growth must not be disturbed during the operational checkout. Human factors effects must be evaluated.

3.6.3.2 Test interruption. This policy is designed to provide a standard methodology for selecting a course of action in the event of an unscheduled interruption in a test. Any deviation from this policy shall be explained in the test report. Every case of an interrupted test shall be examined individually using the logical decision process provided in this document. The fungus test, unlike other environmental tests, involves living organisms. If the test is interrupted, the fact that live organisms are involved must be considered.

3.6.3.2.1 Early interruption. If the interruption occurs early in the test, the test should be restarted from the beginning with a new test item, or a cleaned item.

3.6.3.2.2 Later interruption. If the interruption occurs late in the test cycle, examine the item for evidence of fungal growth. If the test item is biosusceptible, there is no need for a retest. If there is no evidence of fungal growth or if the interruption occurred early, proceed as follows:

3.6.3.2.2.1 Lowered temperature. A lowering of the test chamber temperature generally will retard fungus growth. If there is no evidence of mycological deterioration and the relative humidity has been maintained, re-establish test conditions and continue the test from the point that the temperature fell below the prescribed tolerances.

3.6.3.2.2.2 Elevated temperature. Elevated temperatures may have a drastic effect on fungus growth. Any rise in temperature above 88°F for a period of 4 hours or more shall result in complete re-initiation of the test. If the over temperature condition is less than 4 hours and there is no evidence of mycological deterioration, re-establish test conditions and continue the test as if no interruption had occurred.

3.6.3.2.2.3 Lowered humidity. Any drop in humidity levels below 90 percent for a period of 4 hours or more shall result in complete re-initiation of the test. If the occurrence results in a more moderate drop in relative humidity that does not result in fungal deterioration, re-establish test conditions and continue the test as if no interruption had occurred.

3.6.3.2.3 Reinitiating test. Although it is preferable to use a new test item when reinitiating a test, the same test item may be used if it is cleaned. New cotton control strips shall be placed in the test chamber and both the test item and controls will be reinoculated with the test fungi.

3.6.4 Apparatus. The required apparatus consists of chambers or cabinets together with auxiliary instrumentation capable of maintaining and monitoring the specific conditions of temperature and humidity and complies with 1.2.4.1.

3.6.5 Preparation for test.

3.6.5.1 Chamber and accessories. The chamber and accessories shall be constructed and arranged in such a manner as to avoid condensate dripping on the test item. The chamber shall be vented to the atmosphere to prevent the buildup of total pressure.

3.6.5.2 Relative humidity (RH). Relative humidity shall be determined from the dry bulb - wet bulb temperature comparison method or an equivalent method approved by the procuring activity. When the wet bulb control method is used, the wet bulb assembly shall be cleaned and a new wick installed for each test. The air velocity across the wet bulb shall not be less than 900 feet per minute. The wet and dry bulb sensors shall not be installed in the discharge side of any local fan or blower used to create the requirements of 3.6.5.3.

3.6.5.3 Air flow. Provisions shall be made for controlling the flow of air throughout the internal test chamber space so that the air velocity shall be between 197-394 ft/min. Free circulation of air around the test item shall be maintained, and the contact area of fixtures supporting the test item shall be kept to a minimum (see 1.2.4).

3.6.5.4 Data to be recorded. Continuous recordings of test section temperature and relative humidity conditions shall be taken. Readout charts shall be capable of being read with a resolution within 1°F. The desired humidity shall be generated by using steam or distilled, demineralized or deonized water having a pH value between 6.0 and 7.2 at 73°F.

a. Live steam shall not be injected directly into the test section working space where it may have an adverse affect on the test item and microbial activity.

b. Rust or corrosive contaminants shall not be imposed on the test item by the test facility.

3.6.5.5 General conditions. Unless otherwise specified: all reagents shall conform to the specification of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available; and references to water shall be understood to mean distilled water or water of equal purity. If the test is interrupted, follow the procedure of 3.6.3.2.

3.6.6 Procedures. The following test phases are provided for application in combinations, as required.

3.6.6.1 Phase I, pre-test checkout. All items require a pre-test checkout to provide baseline data. Conduct the checkout as follows:

a. Prepare the test item in accordance with 1.2.3.2 and required test item configuration.

b. Conduct a complete visual examination of the test item with special attention to discolored areas, imperfections, or the existence of any other conditions that could be conducive to fungus growth.

c. Document the results of step b.

d. Conduct an operational checkout in accordance with the approved test plan if operation is specified by the requirements document during or following the fungus test.

e. Record results for compliance with 1.2.3.1.

f. Proceed to phase II.

3.6.6.2 Phase II, chamber test.

3.6.6.2.1 Preparation.

3.6.6.2.1.1 Preparation of mineral-salts solution.

a. Using clean apparatus, prepare the mineral salts solution to contain the following:

Potassium dihydrogen orthophosphate (KH_2PO_4)	0.7 g
Potassium monohydrogen orthophosphate (K_2HPO_4)	0.7 g
Magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$)	0.7 g
Ammonium nitrate (NH_4NO_3)	1.0 g
Sodium chloride (NaC1)	0.005 g
Ferrous sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$)	0.002 g
Zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$)	0.002 g
Manganous sulfate monohydrate ($MnSO_4 \cdot H_2O$)	0.001 g
Distilled water	1000 ml

b. Measure the pH of the mineral salts solution. If not between 6.0 and 6.5, discard and prepare a proper solution.

3.6.6.2.1.2 Preparation of mixed spore suspension. NOTE: PRECAUTIONS: Although the fungi specified for this test are not normally considered to present a serious hazard to humans, certain people may develop allergies or other reactions. It is therefore recommended that standard operation procedures (SOPs) for safety be employed. It is also recommended that the tests be conducted by personnel trained in microbiological techniques.

a. Using aseptic techniques, prepare the spore suspension containing the test fungi specified in Table I.

TABLE I. Test fungi.

Fungi 1/	Fungus source identification no.	
	USDA 2/	ATCC 3/
Aspergillus niger	QM 386	ATCC 9642
Aspergillus flavus	QM 380	ATCC 9643
Aspergillus versicolor	QM 432	ATCC 11730
Penicillium funiculosum	QM 474	ATCC 11797
Chaetomium globosum	QM 459	ATCC 6205

Notes:

1. The fungi may be distributed in a lyophilized state, or on agar slants.

2. U.S. Department of Agriculture (SEA/FR), Northern Regional Research Center, ARS Culture Collection, 1815 N. University Street, Peoria, Illinois 60604

3. American Type Culture Collection, 12301 Parklawn Drive,
Rockville, Maryland 20852

b. Maintain pure cultures of these fungi separately on an appropriate medium such as potato dextrose agar except that chaetomium globosum shall be cultured on strips of filter paper overlayed on the surface of mineral salts agar.

c. Prepare mineral salts agar by dissolving 15.0g agar in a liter of the mineral salts solution described in 3.6.6.2.1.1. Note: Do not keep the stock cultures for more than 4 months at 43 ± 7°F; after that time, prepare subcultures and use them for the new stocks.

d. Verify the purity of fungus cultures prior to the test.

e. Incubate subcultures used for preparing new stock cultures or the spore suspension at 86.0 ± 2.5°F for 14 to 21 days.

f. Prepare a spore suspension of each of the five fungi by pouring into one subculture of each fungus 10 ml of an aqueous solution containing 0.05g per liter of a nontoxic wetting agent such as sodium dioctyl sulfosuccinate or sodium lauryl sulfate.

g. Use a rounded glass rod to gently scrape the surface growth from the culture of the test organism.

h. Pour the spore charge into a 125 ml capped Erlenmeyer flask containing 45 ml of water and 50 to 75 solid glass beads, 5 mm in diameter.

i. Shake the flask vigorously to liberate the spores from the fruiting bodies and to break the spore clumps.

j. Filter the dispersed fungal spore suspension into a flask through a 6 mm layer of glass wool contained in a glass funnel. Note: This process should remove large mycelial fragments and clumps of agar.

k. Centrifuge the filtered spore suspension and discard the supernatant liquid.

l. Resuspend the residue in 50 ml of water and centrifuge. Wash the spores obtained from each of the fungi in this manner three times.

m. Dilute the final washed residue with mineral-salts solution in such a manner that the resultant spore suspension shall contain 1,000,000 ± 200,000 spores per ml as determined with a counting chamber.

n. Repeat this operation for each organism used in the test.

o. Perform a viability check for each organism in accordance with 3.6.6.2.1.3.

p. Blend equal volumes of the resultant spore suspension to obtain the final mixed spore suspension. Note: The spore suspension may be prepared fresh. If not freshly prepared, it should be held at 43 ± 7°F for not more than 7 days.

3.6.6.2.1.3 Control items. Two types of control tests are required. Using the procedure of 3.6.6.2.1.3.1, verify the viability of the spore suspension and its preparation. Using the procedure of 3.6.6.2.1.3.2, verify the suitability of the chamber environment.

3.6.6.2.1.3.1 Viability of spore suspension. Prior to preparing the composite spore suspension, inoculate sterile potato dextrose agar plates with 0.2 to 0.3 milliliters of the spore suspension of each of the individual fungal species using separate potato dextrose agar plates for each species.

a. Distribute the inoculum over the entire surface of the plate.

b. Incubate the inoculated potato dextrose agar plate at 75 to 88°F for 7 to 10 days.

c. After the incubation period, check the fungal growth. Note: The absence of copious growth of any of the test organisms over the entire surface in each container will invalidate the results of any tests using these spores.

3.6.6.2.1.3.2 Test chamber environment. Inoculate a known susceptible substrate along with the test item to ensure that proper conditions are present in the incubation chamber to promote fungal growth. Note: The controlled substrate shall consist of cotton fabric strips conforming to MIL-T-43566A Tape, Type 1a, Class 2, bleached, white flat construction.

a. Prepare the following solution:

  (1) 10.0 grams glycerol

  (2) 0.1 potassium dihydrogen orthophosphate (KH_2PO_4)

  (3) 0.1g ammonium nitrate (NH_4NO_3)

  (4) 0.025g magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2$)

  (5) 0.05g yeast extract

  (6) Distilled water to a total volume of 100 ml

  (7) Hydrochloric acid (HC1) and sodium hydroxide (NaOH) base, as required, to adjust the final solution pH to 5.3.

b. Dip the cotton strips into the above solution. After dipping, remove the excess liquid from the strips and hang them to dry before placing them in the chamber and inoculating them.

c. Within the chamber, place the strips vertically in proximity to and bracketing the test item so that the test strips and test items experience the same test environment. The length of the strips shall be at least the height of the test item.

3.6.6.3 Phase III, test performance.

3.6.6.3.1 Preparation for incubation. Assure that the condition of the test items subjected to testing is similar to that as delivered by the manufacturer or customer for use, or as otherwise specified. Any cleaning of the test item shall be accomplished at least 72 hours prior to the beginning of the fungus test.

a. Install the test item in the chamber or cabinet on suitable fixtures or suspended from hangers.

b. Hold the test item in the operating chamber for at least 4 hours immediately prior to inoculation.

c. Inoculate the test item and cotton fabric chamber control items (3.6.6.2.1.3.2) with the mixed fungal spore suspension (3.6.6.2.1.2) by spraying it on the control and on and into the test item(s) (if not hermetically sealed) 1/ in the form of a fine mist from an atomizer or nebulizer. Note: In spraying the test and control items with composite spore suspension, care should be taken to cover all external and internal surfaces which are exposed during use or maintenance. If the surfaces are nonwetting, spray until initiation of droplet coalescence.

d. Replace covers of the test items loosely.

e. Start incubation immediately following the inoculation.

1/ Personnel with appropriate knowledge of the test item should be available to aid in exposing its interior surfaces for inoculation.

3.6.6.3.2 Incubation of the test item. Incubate the test item(s) under a daily cycle of temperature and humidity conditions consisting of 20 hours at a relative humidity of 95 ± 5 percent at an air temperature of 86 ± 2°F followed by a 4-hour period in which conditions of 95 percent relative humidity at 77 ±2°F are maintained for at least 2 hours. Up to a total of 2 hours of the 4-hour period will be used for the transition(s) of temperature and relative humidity. Temperature and humidity conditions during the transition periods shall be controlled as follows: temperature 75° to 88°F and relative humidity above 90 percent.

a. Repeat the 24-hour daily cycle for the test duration.

b. After 7 days, inspect the growth on the control cotton strips to assure that the environmental conditions in the chamber are suitable for growth. For this assurance, 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 fungi when inspected visually. If not, repeat the entire test with the required adjustments of the chamber to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test; note their condition at this time and record it with the test item data as described in 3.6.6.1, step c.

c. If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period of days from the time of inoculation. If there is a decrease in fungal growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

3.6.6.3.3 Inspection. 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 not completed in 8 hours, return the test item to the test chamber or similar humid environment for a minimum of 12 hours. Except for hermetically sealed equipment, open the equipment enclosure and examine both the interior and exterior of the test item. Record results of the inspection to include applicable information. Note: Data shall be used for comparison with that obtained in 3.6.6.1 c.

3.6.6.4 Phase III, operation/usage. If operation is required (e.g. electrical equipment), conduct the operation in the period as specified in 3.6.6.3.3. Data shall be recorded for comparison with the baseline data obtained in 3.6.6.1 c. Personnel with appropriate knowledge should be available to aid in exposing interior surfaces of the item for inspection and making operational and use decisions.

3.7 Dust and sand. The dust and fine sand test is used to ascertain the ability of equipment to resist the effects of a dry dust and sand laden atmosphere. This test simulates the effect of sharp edged dust and fine sand particles, up to 150 microns in size or as otherwise specified in the equipment specification, that may penetrate into cracks, crevices, bearings, and joints. This test is applicable to all mechanical, electrical, electronic, electrochemical, and electromechanical devices for which exposure to the effects of a dry dust or fine sand laden atmosphere is anticipated.

3.7.1 General effects. General effects resulting from the penetration of dust and fine sand, hereafter also referred to as contaminants,, can cause a variety of damage such as fouling moving parts, making relays inoperative, forming electrically conductive bridges with resulting shorts and acting as a nucleus for the collection of water vapor, and hence a source of possible corrosion and malfunction of equipment.

3.7.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: pretest data required; failure criteria; change in orientation during test, if required; whether the equipment is supposed to operate during test and for how long; and whether the equipment shall be subjected to sand, dust, or sand and dust environments.

3.7.3 Apparatus.

3.7.3.1 Test facility. The test facility shall consist of a chamber (see 1.2.4.1) with accessories to control dust concentration, velocity, temperature, and humidity of dust laden air. In order to provide adequate circulation of the dust and sand laden air, no more than 50 percent of the cross-sectional area (normal to air flow) and 30 percent of the volume of the chamber shall be occupied by the test item(s). The chamber shall be provided with a suitable means of maintaining and verifying the dust and sand concentration in circulation. A minimum acceptable means for doing this is by use of a properly calibrated smoke meter and standard light source. The dust and sand laden air shall be introduced into the test space in such a manner as to allow it to become approximately laminar in flow before it strikes the test item.

3.7.3.2 Dust and sand characteristics. Unless otherwise specified in the equipment specification, contaminants used in this test shall be dry dust and a fine sand, both 97-99 percent by weight silicon dioxide ($Si0_2$), of angular structure, and shall have the size distribution determined by weight, as specified in Table II. The typical composition of the dust and quartz sand used shall be as specified in Table III.

3.7.4 Procedures. Prepare the test item in accordance with the general requirements of 1.2.3 positioning the test item as near the center of the chamber as practical. If more than one item is being tested, there shall be a minimum clearance of 4 inches between surfaces of test items or any other material or object capable of furnishing protection. Also, no surface of the test item shall be closer than 4 inches from any wall of the test chamber. Orient the item so as to expose the most critical or vulnerable parts to the dust stream. Proceed as follows unless otherwise specified in the equipment specification and depending on whether the dust and sand tests are to be performed separately or together as deemed acceptable by the procuring activity.

3.7.4.1 Dust.

a. Set the chamber controls to maintain an internal chamber temperature of 73°F and a relative humidity of less that 22 percent. Adjust the air velocity to 1,750 ±250 feet per minute (fpm). Adjust the dust feeder to control the dust concentration at 0.3 ±0.2 grams per cubic foot. With the test item nonoperating, maintain these conditions for 6 hours.

b. Stop the dust feed and reduce the air velocity to 300 ±200 fpm. Raise the internal chamber air temperature to 145°F. Hold these conditions 16 hours.

c. While holding chamber temperature at 145°F, adjust the air velocity to 1,750 ±250 fpm. Adjust the dust feeder to control the dust concentration at 0.3 ±0.2 grams per cubic foot. Unless otherwise specified, with the test item nonoperating, maintain these conditions for 6 hours.

d. Turn off all chamber controls and allow the test item to return to standard ambient conditions. Remove accumulated dust from the test item by brushing, wiping, or shaking while exercising care to avoid introduction of additional dust into the test item. Dust shall not be removed by either air blast or vacuum cleaning.

e. Operate and inspect the test item in accordance with 1.2.3.4.

f. Inspect the test item and obtain results as specified in the general requirements of 1.2.3.4. In the performance of this inspection, test items containing bearings, grease seals, lubricants, et cetera, shall be carefully examined for the presence of dust deposits.

TABLE II. Dust and sand particle size blend.

Particle size range (Microns)	Blend by weight (percent)	
	Sand blend	Dust blend
1000.0 - 400.0	14.3	0.0
400.0 - 200.0	18.7	0.0
200.0 - 80.0	31.1	6.3
80.0 - 40.0	10.6	21.5
40.0 - 20.0	6.6	18.9
20.0 - 10.0	7.2	20.5
10.0 - 5.0	6.4	18.2
5.0 - 2.5	2.5	7.3
2.5 - 1.0	1.2	3.3
1.0 - 0.1	1.4	4.0
0.1 - 0.0	-	-

Note: Mixture conforms to SAE J726.

TABLE III. Dust/quartz sand composition.

Material	Composition by weight (percent)
Silicon dioxide	99.500
Rare earth oxides (R_2O_3)	0.200<
Chromium	0.002<
Phosphorus	0.010<
Carbonate	0.010<
Trapped water	0.500<

Note: Mixture conforms to SAE J726.

3.7.4.2 Sand.

a. Set the chamber controls to maintain an internal chamber temperature of 73°F and a relative humidity of less that 22 percent. Adjust the air velocity to 1,750 ±250 fpm. Adjust the sand feeder to control the sand concentration at 0.3 ±0.2 grams per cubic foot. With the test item nonoperating, maintain these conditions for 0.5 hour.

b. Stop the sand feed and reduce the air velocity to 300 ±200 fpm. Raise the internal chamber air temperature to 145°F. Hold these conditions 16 hours.

c. While holding chamber temperature at 145°F adjust the air velocity to 1,750 ±250 fpm. Adjust the sand feeder to control the sand concentration at 0.3 ±0.2 grams per cubic foot. Unless otherwise specified, with the test item nonoperating, maintain these conditions for 0.5 hour.

d. Turn off all chamber controls and allow the test item to return to standard ambient conditions. Remove accumulated sand from the test item by brushing, wiping, or shaking while exercising care to avoid introduction of additional sand into the test item. Sand shall not be removed by either air blast or vacuum cleaning.

e. Operate and inspect the test item in accordance with 1.2.3.4.

f. Inspect the test item and obtain results as specified in the general requirements of 1.2.3.4. In the performance of this inspection, test items containing bearings, grease seals, lubricants, et cetera, shall be carefully examined for the presence of sand deposits.

3.7.4.3. Dust and sand combined.

a. Set the chamber controls to maintain an internal chamber temperature of 73°F and a relative humidity of less that 22 percent. Adjust the air velocity to 1,750 ±250 fpm. Adjust the dust feeder to control the dust concentration at 0.3 ±0.2 grams per cubic foot. With the test item nonoperating, maintain these conditions for 5.5 hours.

b. While maintaining the conditions of step a, adjust the sand feeder to control the sand concentration at 0.3 ±0.2 grams per cubic foot and continue testing for an additional 0.5 hour.

c. Stop the dust and sand feed and reduce the air velocity to 300 ±200 fpm. Raise the internal chamber air temperature to 145°F. Hold these conditions 16 hours.

d. While holding chamber temperature at 145°F, adjust the air velocity to 1,750 ±250 fpm. Adjust the dust feeder to control the dust concentration at

0.3 ±0.2 grams per cubic foot. Unless otherwise specified, with the test item nonoperating, maintain these conditions for 5.5 hours.

e. While maintaining the conditions of step d, adjust the sand feeder to control the sand concentration at 0.3 ±0.2 grams per cubic foot and continue testing for an additional 0.5 hour.

f. Turn off all chamber controls and allow the test item to return to standard ambient conditions. Remove accumulated dust and sand from the test item by brushing, wiping, or shaking while exercising care to avoid introduction of additional dust into the test item. Dust shall not be removed by either air blast or vacuum cleaning.

g. Operate and inspect the test item in accordance with 1.2.3.4.

h. Inspect the test item and obtain results as specified in the general requirements of 1.2.3.4. In the performance of this inspection, test items containing bearings, grease seals, lubricants, et cetera, shall be carefully examined for the presence of dust and sand deposits.

3.8 Rain and wind. The rain and wind test is conducted to determine the effectiveness of protective covers or cases to shield equipment from rain. This test is applicable to equipment which may be exposed to rain under service conditions.

3.8.1 Equipment specification data required. Before proceding, verify that the equipment specification specifies the following as a minimum: pretest data required; failure criteria; and whether the equipment is to operate for a specified period of time during the rain fall.

3.8.2 Apparatus. A chamber having the general characteristics of 1.2.4.1, but with rain and wind source, is required. The rain chamber shall have the capability of producing falling rain and wind blowing horizontally at up to 40 miles per hour (35 knots). The chamber temperature shall be uncontrolled, except as regulated by water introduced as rain, throughout the test period.

a. The rain shall be produced by a water distribution device of such design that the water is emitted in the form of droplets having a diameter range between 0.5 and 4.5 millimeters. (NOTE: A recommended method of measuring raindrop size is the flour pellet method as referenced in "The Relation of Raindrop Size to Intensity" by Laws and Parsons, Transactions of the American Geophysical Union, Part II, pps 452 to 459, -1943.) The temperature of the water shall be between 52° and 95°F. The water distribution shall be such that, with the wind source turned off, the rain is dispersed completely over the test item; an additional test area shall be provided to accomplish the wind blown rain effects on the equipment.

b. The wind source shall be positioned with respect to the test item such that it will cause the rain to beat directly (with variations up to 45 degrees from the horizontal) and uniformly against one side of the test item. The wind velocity shall be measured at the position of the test item, prior to placement of the item in the chamber. No rust or corrosive contaminants shall be imposed on the test item by the test facility.

3.8.3 Procedure. The procedure is intended for evaluating equipment used outdoors under blowing rain conditions. All test conditions shall apply except as otherwise stated in the equipment specification. The test item shall be placed in the chamber in its normal operating position in accordance with 1.2.3.2. The test item shall be exposed to a simulated rain at a rate of 2 ± 0.5 inches per hour for 10 minutes. The rate of rainfall shall then be raised to 5 ± 1 inches per hour and held at this rate for 5 minutes. The rate shall then be reduced to 2 ± 0.5 inches per hour for the next 15 minutes. Starting 5 minutes after the initiation of the rain, the wind source shall be turned on and adjusted to produce a horizontal wind velocity of 40 miles per hour (3,500 feet per minute). The wind source shall be maintained at this velocity for 15 minutes after which the wind source shall be turned off.

NOTE: If specified in the equipment specification, the test item shall be operated during the last 10 minutes of the 30-minute rain. Each of the sides of the test item that could be exposed to blown rain shall be subjected to the rain for a period of not less than 30 minutes, for a total test duration of not less than 2 hours. At the conclusion of the test period, the test item shall be removed from the test chamber, operated, inspected, and the results obtained shall be recorded in accordance with 1.2.3.4. The protective cover or case shall, where possible, then be removed and the test item inspected for compliance with 1.2.3.4.

3.9 Solar radiation. This test is conducted to determine the effects of solar radiation on equipment that may be exposed to sunshine during operation or unsheltered storage on the earth's surface or in the lower atmosphere.

3.9.1 General effects.

3.9.1.1 Heating. The heating effects of solar radiation differ from those of high air temperature alone in that the amount of heat absorbed or reflected depends on the roughness and color of the surface on which the radiation is incident. In addition to the differential expansion between dissimilar materials, changes in the intensity of solar radiation may cause components to expand or contract at different rates, which can lead to severe stresses and loss of structural integrity. In addition to those specified in 3.1.1.1, some other examples of heating effects include:

a. Jamming or loosening of moving parts.

b. Weakening of solder joints and glued parts.

c. Change in strength and elasticity.

d. Loss of calibration or malfunction of linkage devices.

e. Loss of seal integrity.

f. Changes in electrical or electronic components.

g. Premature actuation of electrical contacts.

h. Fading of colors of color-coded components.

i. Changes in characteristics of elastomers and polymers.

j. Blistering and peeling of paints and other finishes.

k. Softening of potting compounds.

3.9.1.2 Actinic. In addition to the heating effects of 3.9.1.1, which are caused by the infrared portion of the solar spectrum, certain degradation from solar energy may be attributable to other portions of the spectrum, particularly the ultraviolet. Since the rate at which these reactions will occur generally increases as the temperature rises, the full spectrum must be used to adequately simulate the actinic effects of solar radiation. Some examples of deterioration caused by actinic effects are:

a. Fading of fabric color.

b. Checking and fading of paints.

c. Deterioration of natural and synthetic elastomers and polymers through photochemical reactions initiated by shorter wavelengths radiation.

3.9.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: test item configuration and orientation; pretest data required; failure criteria; number of test cycles and temperature and solar radiation intensity if other than that given in the following procedure; and whether the equipment is to operate for a specified period of time during exposure. Consideration shall be given to using this method of test as an alternative to performing the high temperature test of 3.1.1.

3.9.3 Guidelines for test conditions.

3.9.3.1 Application. Apply this test method when the test item is likely to be exposed to solar radiation in the open in hot climates during its life cycle, and when the effects mentioned in 3.9.1 are of concern. In most cases, this method should replace the high temperature test of 3.1.1.

3.9.3.2 Restrictions. This test method is not to be used to simulate the heating effects that result from enclosed or covered storage conditions. The solar spectrum and energy levels are those that are received at sea level. The ultraviolet portion is simulated only in a general way, but is considered adequately representative of levels in most geographic areas.

3.9.3.3 Configuration. The test item configuration should be the same as its configuration during exposure to solar radiation. The orientation of the test item relative to the direction of radiation will have a significant impact on the heating effects, as will its mounting (on supports or on a substrate of specified properties, e.g., a layer of concrete of specified thickness or a sand bed of certain reflectivity).

3.9.4 Apparatus.

3.9.4.1 Test facility. The required facility consists of a chamber or cabinet, auxiliary instrumentation, and a solar lamp bank. This apparatus must be capable of maintaining and monitoring the required conditions of temperature, airflow, and irradiation.

3.9.4.1.1 Test chamber. The volume of the test chamber shall be a minimum of 10 times that of the envelope volume of the test item.

3.9.4.1.2 Solar lamp bank. The solar radiation source area shall be such that the length and width of the test item shall be no more than one-half the same dimensions of the lamp bank and shall be composed of lamps that simulate the solar spectrum.

a. The irradiance shall have a maximum intensity of 1120 Watts per meter squared (W/m^2)(±10%), and the radiation falling on the test item shall be uniform to within ±10 percent of the desired value, with the spectral distribution given in Table IV. Where thermal effects only are to be assessed, deviation from this spectral distribution is permitted, but the irradiance must be adjusted to give an equivalent heating effect. In order to calculate this adjustment, it is necessary to know: the spectral reflectance or transmittance of the irradiated surfaces; and the spectral energy distribution of the particular lamps being used (and also the effect of any associated reflectors or glasses).

b. The radiation shall be directed onto the test item and shall irradiate the entire surface of the test item facing the solar radiation source. This value of 1120 W/m^2 shall include any radiation reflected from the test chamber walls and received by the test item, but it should not include long-wave infrared radiation emitted by the chamber walls. The radiation-measuring device shall be calibrated in the wavelength range of the test source radiations.

c. The radiation source shall be located at least 30 inches away from any other surface of the test item.

3.9.4.1.3 Light source. Tests conducted for degradation and deterioration of materials due to actinic effects, as well as heat buildup within the test items, must satisfy the full spectrum of Table IV and may use one of the following acceptable radiation sources:

TABLE IV. Spectral energy distribution and permitted tolerances.

	Spectral region			
	Ultraviolet			
Characteristic	Min.	Max.	Visible	Infrared
Bandwidth	0.28 to 0.32 micrometer (µm)	0.32 to 0.40 µm	0.40 to 0.78 mm	0.78 to 3.00 mm
Irradiance	5 W/m^2	63 W/m^2	517 to 604 W/m^2	492 W/m^2
Tolerance	±35%	±25%	±10%	±20%

NOTE: The amount of radiation wavelength shorter than 0.30 µm reaching Earth's surface is insignificant

a. Xenon arc or mercury xenon arc (used singly) lamps with suitable reflector.

b. Combination of high pressure sodium vapor and improved mercury vapor lamps with suitable reflectors.

c. High-intensity multivapor, mercury vapor (with suitable reflectors), and incandescent spot lamps.

d. Carbon arc lamps with suitable reflectors.

NOTE: Other combinations of the lamps listed above and in e through k below may be used if it is proven that the combination produces the spectrum of Table IV.

e. Mercury vapor lamps (internal reflector type only).

f. Combination of incandescent spot lamps and tubular-type mercury vapor lamps with external reflectors.

g. Combination of incandescent spot lamps and mercury vapor lamps with internal reflectors.

h. Metal halide lamps.

i. Mercury xenon arc lamps with suitable reflectors.

j. Multivapor lamps (clear or coated bulb) with suitable reflectors.

k. Tungsten filament lamps.

The preceding list is not intended to exclude new lamps made available by advanced technology.

3.9.4.2 Controls.

3.9.4.2.1 Temperature. Chamber air temperature shall be maintained in accordance with the general requirements of 1.2.1 and measured (with adequate shielding from radiated heat) at a point or points in a horizontal plane 0 to 2 inches below the prescribed irradiation plane, at half the distance between the test item and the wall of the chamber or at 40 inches from the test item, whichever is smaller. This is to ensure reasonable control of the envelope of air surrounding the test item.

3.9.4.2.2 Surface contamination. Dust and other surface contamination may significantly change the absorption characteristics of irradiated surfaces. Unless otherwise required, specimens should be clean when they are tested. However, if effects of surface contamination are to be assessed, the relevant specification should include the necessary information on preparation of surfaces.

3.9.4.2.3 Instrumentation.

ITEM	TOLERANCE
Pyranometer or pyrheliometer	Total irradiation (direct and scattered) to ±47 W/m^2 (±14 British thermal units per foot squared per hour (Btu/ft^2/hr))
Spectroradiometer or filtered pyranometer	±5% of reading.

NOTE: Values may be assumed to represent plus or minus two standard deviation; thus, the stated tolerances should not be exceeded in more than 1 measurement out of 20. Solar radiation intensity shall be measured with a pyranometer or pyrheliometer. Spectral distribution of irradiance as a function of wavelength shall be measured with a spectral radiometer or filtered pyranometer.

3.9.4.2.4 Calibration of chamber. Because of the variety of permissible lamps and chamber designs, it is particularly important that the chamber be calibrated to assure that the proper levels of radiant infrared energy are impacting the test area when heat alone is of concern and that the proper intensity and spectral distribution of solar radiation are impacting the test area when actinic effects are of concern. Over the area covered by the test item, the radiation intensity must be within ±10 percent. As the lamps age, their spectral output changes. To ensure that solar radiation chambers meet established specifications, a check on spectral distribution, intensity, and uniformity shall be performed at intervals not exceeding 500 hours of operation to ensure that the facilities continue to meet established specifications. This value is based on the manufacturer's guarantee for minimum bulb life.

3.9.5 Preparation for test.

3.9.5.1 Preliminary steps. Before initiating any testing, determine from the test plan:

a. Which test procedures are required.

b. The diurnal cycle to be used.

c. Other variables, such as number of cycles, etc.

3.9.5.2 Pretest standard ambient checkout. All items require a pretest standard ambient checkout to provide baseline data. Conduct the checkout as follows:

a. Install the test item in the chamber and stabilize it at standard ambient conditions (general requirements, 1.2.1) and in a manner that will simulate service usage, unless the storage configuration is specified. Position the test item in accordance with the following:

   (1) As near the center of the test chamber as practical and so that the surface of the item is not closer than 1 ft to any wall or 30 in. to the radiation source when the source is adjusted to the closest position it will assume during the test.

   (2) Oriented, within realistic limits, to expose its most vulnerable parts to the solar radiation, unless a prescribed orientation sequence is to be followed.

   (3) Separated from other items that are being tested simultaneously, to ensure that there is no mutual shading or blocking of airflow.

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

c. Prepare the test item in accordance with the test item configuration of 3.9.3.4 and with the temperature sensors necessary to determine test item response.

d. Conduct an operational checkout in accordance with the approved test plan and record results.

e. If the test item operates satisfactorily, place it in its test configuration (if other than operational). If not, resolve the problem and restart at step a. Position the test item in accordance with step a preceding and proceed to the first test as specified in the test plan.

3.9.6 Procedures. The following test procedure provides the basis for evaluating the performance of the test item in a solar radiation environment. Cycling and solar radiation shall be in accordance with Figure 9.

a. Adjust the solar radiation source to a radiant energy rate of 1120 ± 47 W/m^2 (355 ± 14 $Btu/ft^2/hr$), or as specified in the equipment specification, and a temperature of 120°F.

b. Maintain these conditions for 20 hours. If required, operational checks should be conducted during the last 4 hours of each 20-hour exposure when test temperatures are maximized.

c. Measure and record the test item temperatures.

d. Turn off the solar radiation source for 4 hours.

e. Repeat steps a thru d for the number of cycles specified in the equipment specification.

f. Conduct a performance check and visual examination as in 3.9.5.2 steps b and d and document the results.

3.10 Cleaning spray. The cleaning spray test is performed to determine the resistance of equipment to cleaning spray that will be encountered during vehicle cleaning under storage and service conditions.

3.10.1 General effects. The force combined with the distance of application of cleaning spray may cause physical damage to the part or to the packing or gaskets of the part. Damage to the packings or gaskets integral to the part or used for interfacing the part with the vehicle could cause leaks that would be detrimental to personnel and hardware operation under adverse environmental conditions.

3.10.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: required pretest data; failure criteria; surface area coverage rate, nozzle size, pressure at the nozzle and cleaning media; and distance of application of the spray from the equipment surface.

3.10.3 Procedures. Proceed as follows depending on whether the equipment under test is to be mounted external or internal to the vehicle.

NOTE: For equipment mounted both external and internal to a vehicle (e.g., a periscope), the procedure applying to the respective portions shall be followed.

3.10.3.1 Externally mounted equipment. Mount the assembly so that each of the surfaces that normally could be subjected to the full force of the spray are accessible. Then, perform surface cleaning at a rate of 1.0 square foot per minute for a minimum of 10 minutes (or as otherwise specified in the equipment specification) followed by a cold water jet rinse of equal duration as follows: apply a steam and water jet spray with cleaning agents conforming to P-C-437 perpendicular to and at a distance of 1.0 ± 0.5 foot from the surfaces being cleaned; then, using a nozzle having an orifice diameter of 0.25 inch and a nozzle pressure of 110 psig, apply a cold water jet spray perpendicular to and at a distance of 5.0 ± 0.5 feet from the surfaces being rinsed. Following test, operate and inspect the test item and obtain results in accordance with 1.2.3.4.

3.10.3.2 Internally mounted equipment. Mount the assembly so that each of the surfaces that normally could be subjected to the full force of the spray are accessible. Using a nozzle having an orifice diameter of 0.25 inch and a nozzle pressure of 25 psig, apply a cold water jet spray perpendicular to and at a distance of 1.0 ± 0.5 foot from the surface being sprayed; clean at the rate of 1.0 square foot per minute for a minimum of 10 minutes (or as otherwise specified in the equipment specification). Following test, operate and inspect the test item and obtain results in accordance with 1.2.3.4.

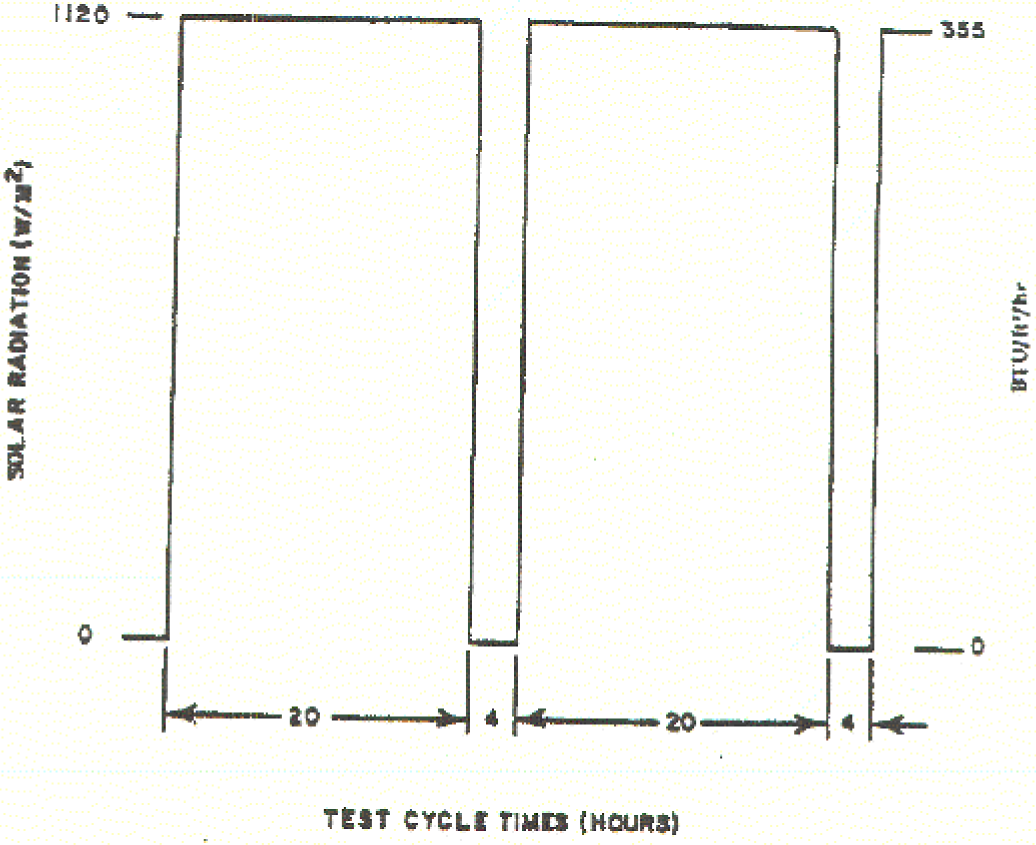


FIGURE 9. Solar radiation test cycles.

3.11 Submergence. The submergence test is performed to determine the adequacy of the equipment seals to protect the equipment interior from contaminants that will be encountered during storage and service conditions.

3.11.1 General effects. Improper sealing of equipment could allow the entrance of contaminants into the assembly that will adversely affect equipment performance. E.g., moisture or dust particles within an optics device could obscure the users vision; moisture entering an electronics unit could cause component shorting; etc.

3.11.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: required pretest data; failure criteria; differential pressure and depth to which the unit is to be submerged, and duration of test.

3.11.3 Apparatus. A vessel capable of holding clean water of sufficient depth to allow covering the assembly completely as specified in the equipment specification is required. In the case of the procedure of 3.11.4.2, the vessel shall be capable of introducing and sustaining a differential pressure, in the form of a vacuum, as specified in the equipment specification.

3.11.4 Procedures. Proceed as follows depending on whether the equipment under test is equipped with or without air plugs or valves.

3.11.4.1 Equipment with air plugs or valves. Remove the air plug from the assembly and install a suitable pressure adapter into the open port; if there is a Schrader air valve, remove the valve cap. Install mating connectors on all non-hermetically sealed electrical connectors and pressurize the assembly to the level specified in the equipment specification. Totally submerge the assembly in clear water to the depth specified in the equipment specification (submergence depth shall be measured between the water surface and top surface of the assembly) and monitor the assembly for a minimum of 5 minutes (or as otherwise specified in the equipment specification) for leakage as evidenced by any air bubbles escaping from the interior of the assembly (be careful not to misconstrue bubbles from the assembly surface as air escaping from the unit). Any evidence of leakage shall be cause for rejection. Following the test interval, remove the assembly from the water, dry the assembly exterior surfaces, vent the assembly interior to atmospheric pressure, reinstall the air plug or valve cap, and operate and inspect the test item obtaining results in accordance with 1.2.3.4.

3.11.4.2 Equipment without air plugs or valves. Install mating connectors on all non hermetically sealed electrical connectors. Place the assembly into a vessel that is filled with clear water and that is capable of introducing and sustaining a differential pressure (vacuum) as specified in the equipment specification. Submerge the assembly to the depth specified in the equipment specification (submergence depth shall be measured between the water surface and top surface of the assembly) and apply the differential pressure for a minimum of five minutes. Monitor the assembly for leakage as evidenced by any air bubbles escaping from the interior of the assembly (be careful not to misconstrue bubbles from the assembly surface as air escaping from the unit). Any evidence of leakage shall be cause for rejection. Following the test interval, remove the assembly from the vessel and operate and inspect the equipment obtaining results in accordance with 1.2.3.4.

3.12 Chemicals. Testing is performed to determine the resistance of equipment to the vapors of and in direct contact with various chemicals that will be encountered during vehicle storage and service conditions.

3.12.1 General effects. Chemicals can cause deterioration of protective coatings, damage seals, and physically destroy parts. Damage to seals could cause leaks that could be detrimental to personnel and hardware operation under adverse environmental conditions. Damage to finishes can result in shortened component life.

3.12.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies the following as a minimum: required pretest data; failure criteria; chemicals to be used; and duration of test if other than that specified herein.

3.12.3 Procedure. Mount the assembly so that each of the surfaces that would be normally exposed to the chemicals are accessible. Then expose the assembly to the vapors of and in "direct contact" with each of the chemicals specified in the equipment specification for a period of 48 hours minimum. By "direct contact," it is not necessarily meant that the item need be totally immersed in a fluid, but rather that it be covered as if by a spill of fluid over its surfaces; reapply the fluid periodically during the 48 hour period should evaporation cause a drying of the fluid during the chemical exposure. After exposure, clean the external surfaces, as applicable, inspect the equipment for physical damage, and obtain results in accordance with 1.2.3.4.

3.13 Bench handling shock. Bench handling shock testing is performed to determine the ability of equipment to withstand shocks that may inadvertently occur during such handling.

3.13.1 Equipment specification data required. Before proceeding, verify that the equipment specification specifies pretest data required.

3.13.2 Procedures. If the equipment is an enclosure, covers and/or panels shall be removed as if for servicing the equipment. The assembly to be tested shall be placed in a suitable position for servicing on a horizontal, solid wooden bench top at least 1-5/8 inches thick. The test shall then be performed as follows:

a. Without the equipment operating during test and using one edge as a pivot, lift the opposite edge of the chassis until one of the following conditions occurs (whichever occurs first):

(1) The chassis forms an angle of 45 degrees with the horizontal bench top.

(2) The lifted edge of the chassis has been raised 4 inches above the horizontal bench top.

(3) The lifted edge of the chassis is just below the point of perfect balance.

b. With the edge lifted, let the assembly drop freely to the horizontal bench top. Repeat the procedure using other practical edges of the same horizontal face as pivot points for a total of four drops onto the surface.

c. Repeat steps a and b with the test item resting on other faces until it has been dropped for a total of four times on each face on which the test item could be practically placed during servicing.

d. At the conclusion of the test, inspect the item for physical damage and obtain results in accordance with 1.2.3.4.

3.14 Temperature shock. The temperature shock test is conducted to determine the effects on equipment of sudden changes in temperature of the surrounding atmosphere.

3.14.1 General effects. Adverse effects could occur in service due to, for example, rapid altitude changes during shipments and airdrops.

3.14.2 Equipment specification data required. Before proceeding, verify that the equipment specification specifies required pre-test data and failure criteria.

3.14.3 Procedure. Using a high temperature chamber and a low temperature chamber, proceed as follows:

a. Prepare the test item in accordance with the General Requirements of 1.2 and raise the internal chamber temperature to 160°F. Maintain for a period of not less than 4 hours or until the test item stabilizes.

NOTE: For steps b and c following, and when authorized by the procuring activity, large or heavy test items shall be transferred from one chamber to the other in the minimum practical times.

b. At the conclusion of the previous time period, the test item shall be transferred, within 5 minutes, to a cold chamber with an internal chamber temperature -60°F. The test item shall be exposed to this temperature for a period of not less than 4 hours, or until the test item stabilizes.

c. At the conclusion of the previous time period, the test item shall, within 5 minutes, be returned to the high temperature chamber maintained at 160°F. The test item shall be exposed to this temperature for a period of not less than 4 hours, or until the test item stabilizes.

d. Repeat steps b and c and then go to step e.

e. Repeat step b and then go to step f.

f. Return the test item to standard ambient conditions and stabilize.

g. Operate and inspect the test item and obtain results in accordance with General Requirements of 1.2.3.4.

3.15 Explosive atmosphere. The explosive atmosphere test is conducted to determine the ability of equipment to operate in the presence of an explosive atmosphere without creating an explosion or to contain an explosion occurring inside the equipment. Since equipments operate in ever changing potentially explosive atmospheres, the equipments, when being laboratory tested, must operate in the presence of the optimum fuel-air mixture which requires the least amount of energy for ignition. The equipment igniting energy may be produced electrically, thermally, or chemically.

3.15.1 Equipment specification data required. Before proceeding, verify the equipment specification specifies the following as a minimum: required pretest data; failure criteria; mechanical and/or electrical load (3.15.3.1 b); and chamber temperature condition if lower than 160°F.

3.15.2 Apparatus. A chamber capable of providing and verifying the explosion-proof test conditions. MIL-C-9435 describes one type of chamber that may be used.

3.15.2.1 Fuel. Unless otherwise specified, the fuel used shall be gasoline, grade 100/130 conforming to ASTM D910-88 or a 1.05 stoichiometric mixture of propane (C_3H_8) and air within the following limits: propane 3.85 to 4.25 percent by volume and air 96.15 to 95.75 percent by volume.

3.15.2.2 Calculation of fuel-air-vapor ratio. As an illustration of the procedure for calculating the weight of 100/130 octane gasoline required to produce the desired 13-to-1 air-vapor ratio, the following sample problem is presented:

a. Required information:

Chamber air temperature during test: 81°F.

Fuel temperature: 75°F.

Specific gravity of fuel at 61°F: 0.704.

Test altitude: 20,000 feet ($P = 6.75$ lbs./in^2).

Air-vapor ratio (desired): 13-to-1.

b. Employing the following equation, calculate the apparent air-vapor ratio:

$$AAV = \frac{AV\ (\text{desired})}{1.04\ \dfrac{P}{14.696}\ -0.04} = \frac{13}{1.04\ \dfrac{6.75}{14.696}\ -0.04} = 29.70$$

where:

AAV = Apparent air-vapor ratio

AV = Desired air-vapor ratio

P = Pressure equivalent of altitude, lbs./in^2

c. At or above 10,000 feet altitude, with chamber air temperature above 61°F and at AV ratio of 5 or greater, air-vapor ratio = air-fuel ratio (AF) for 100/130 octane fuel. Since the conditions of the explosion test under consideration will always be well above these values, AV will equal AF in all cases.

d. Since AV = AF, use Figure 10 to determine weight of air (WA) and divide by AAV to obtain uncorrected weight of fuel required (W_{FU}).

$$W_{FU} = \frac{WA}{29.68} = \frac{3.455}{29.68} = 0.116 \text{ lbs., fuel weight (uncorrected).}$$

Note: Figure 10 pertains to a specific test chamber and shall not be used for all test facilities. It is utilized herein for illustration of the method of employment only. Each test chambermust have its own chamber volume chart.

e. Knowing fuel temperatures and specific gravity at 61°F, use Figure 11 to determine specific gravity at given temperature.

f. Using Figure 12, obtain correction factor K for the specific gravity determined in step e preceding. Apply factor to obtain weight of fuel corrected (W_{FC}).

$$W_{FC} = KW_{FU} = 1.01 \times 0.116 = 0.117 \text{ lbs, fuel weight (corrected).}$$

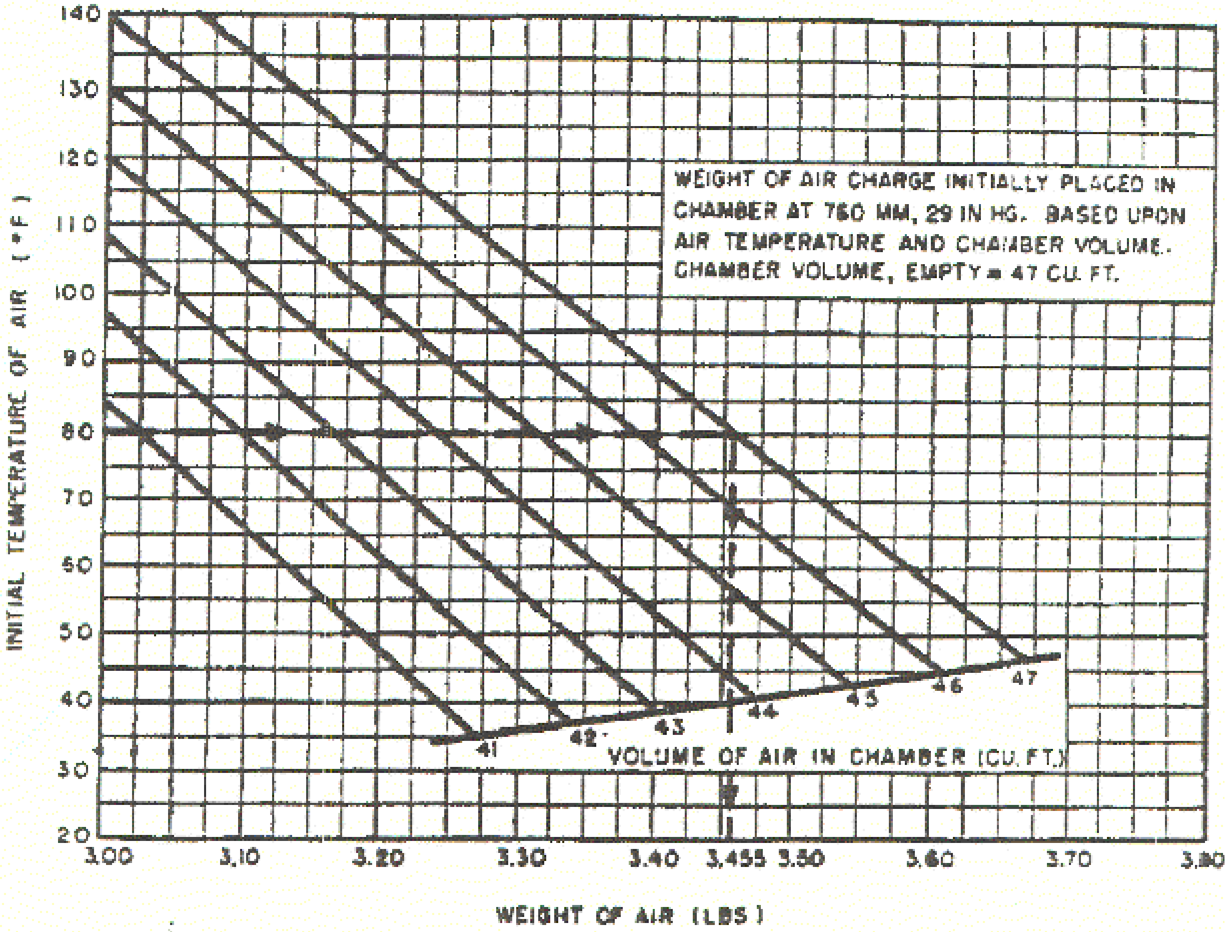


FIGURE 10. Explosive atmosphere air weight - temperature characteristics, chamber volume dependent.

g. The equipment used to vaporize the fuel for use in the explosion-proof test should be so designed that a small quantity of air and fuel vapor will be heated together to a temperature such that the fuel vapor will not condense as it is drawn from the vaporizer into the chamber.

3.15.3 <u>Procedures</u>

3.15.3.1 <u>Preparation for test</u>. The test item shall be prepared in accordance with general requirements of 1.2 and in such a manner that normal electrical operation is possible and mechanical controls may be operated through the pressure seals from the exterior of the chamber. External covers of the test item shall be removed or loosened to facilitate the penetration of the explosive mixture. Large test items may be tested, one or more units at a time, by extending electrical connections through the cable port to the balance of the associated equipment located externally.

a. The test item shall be operated to determine that it is functioning properly and to observe the location of any sparking or high temperature components which may constitute potential explosion hazards.

b. Mechanical loads on drive assemblies and servomechanical and electrical loads on switches and relays may be simulated when necessary if proper precaution is given to duplicating the normal load in respect to torque, voltage, current, inductive reactance, etc. In all instances, it shall be considered preferable to operate the test item as it normally functions in the system during service use.

3.15.3.2 <u>Performance of test</u>. Except as specified below, the test shall be conducted as follows at simulated test altitudes of sea level to 5,000 feet, 10,000 feet and 15,000 feet above sea level. If the item causes an explosion at any of the test altitudes, it shall have been considered to have failed the test and no further trials need be attempted.

a. The test chamber shall be sealed and the ambient temperature within shall be raised to 160°F ± 5°F, or to the maximum temperature to which the test item is designed to operate if lower than 160°F. The temperature of the test item and the chamber walls shall be permitted to rise to within 20°F of that of the chamber ambient air prior to introduction of the explosive mixture.

b. The internal test chamber pressure shall be reduced sufficiently to simulate an altitude approximately 10,000 feet above the desired test altitude. The weight of fuel necessary to produce an air-vapor ratio of 13-to-1 at the desired test altitude shall be determined from consideration of chamber volume, fuel temperature and specific gravity, chamber air and wall temperature, test altitude, etc. If the performance of this test will expose the equipment to an altitude in excess of its specified maximum operating or nonoperating altitude, the next lower simulated test altitude shall be selected. The testing of ground equipment (equipment for operational use on the ground or aboard ship) shall be limited to an increase in the chamber altitude to 15,000 feet with the equipment nonoperating and the weight of fuel shall be admitted to the chamber while the altitude is being reduced to 10,000 feet (see 3.15.2.2). A time of 3 ± 1 minutes shall be allowed for introduction and vaporization of the fuel. Air shall be admitted into the chamber until a simulated altitude of 5,000 feet above the test altitude is attained.

c. Operation of the test item shall start at this time with all making and breaking electrical contacts being actuated. If high temperature components are present, a warmup time of 15 minutes shall be permitted. If no explosion results, air shall be admitted into the chamber so as to steadily reduce the altitude down past the desired test altitude to an elevation 5,000 feet below that altitude. If necessary, conduct tests to simulated sea level pressure by pressurizing the chamber. Tests shall not be conducted below sea level. The operation of the test item shall be continuous throughout this period of altitude reduction and all making and breaking electrical contacts shall be operated as frequently as deemed practicable. Ground equipment shall be energized at 15,000 feet and the sources of igniting energy operated until the chamber altitude is reduced to sea level.

d. If no explosion has occurred as a result of operation of the test item by the time the simulated altitude has been reduced to 5,000 feet below the test altitude (or sea level in the case of ground equipment), the potential explosiveness of the air-vapor mixture shall be verified by igniting a sample of the mixture with a spark gap or glow plug. At any altitude below 20,000 feet, the mixture sample shall ignite immediately at the point within 3,000 feet of the test altitude. If the air-vapor mixture is not found to be explosive, the test shall be considered void and the entire procedure repeated.

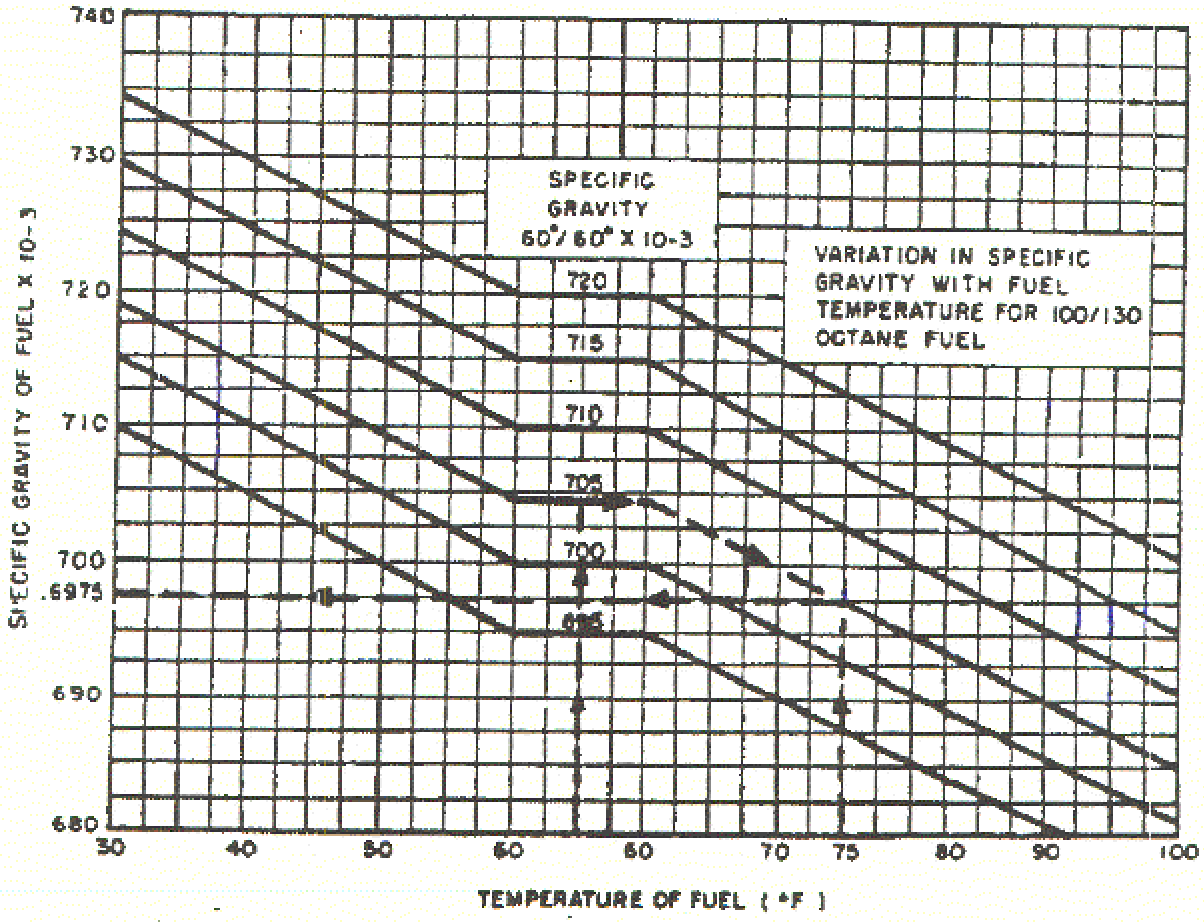


FIGURE 11. Explosive atmosphere fuel weight – temperature characteristics.

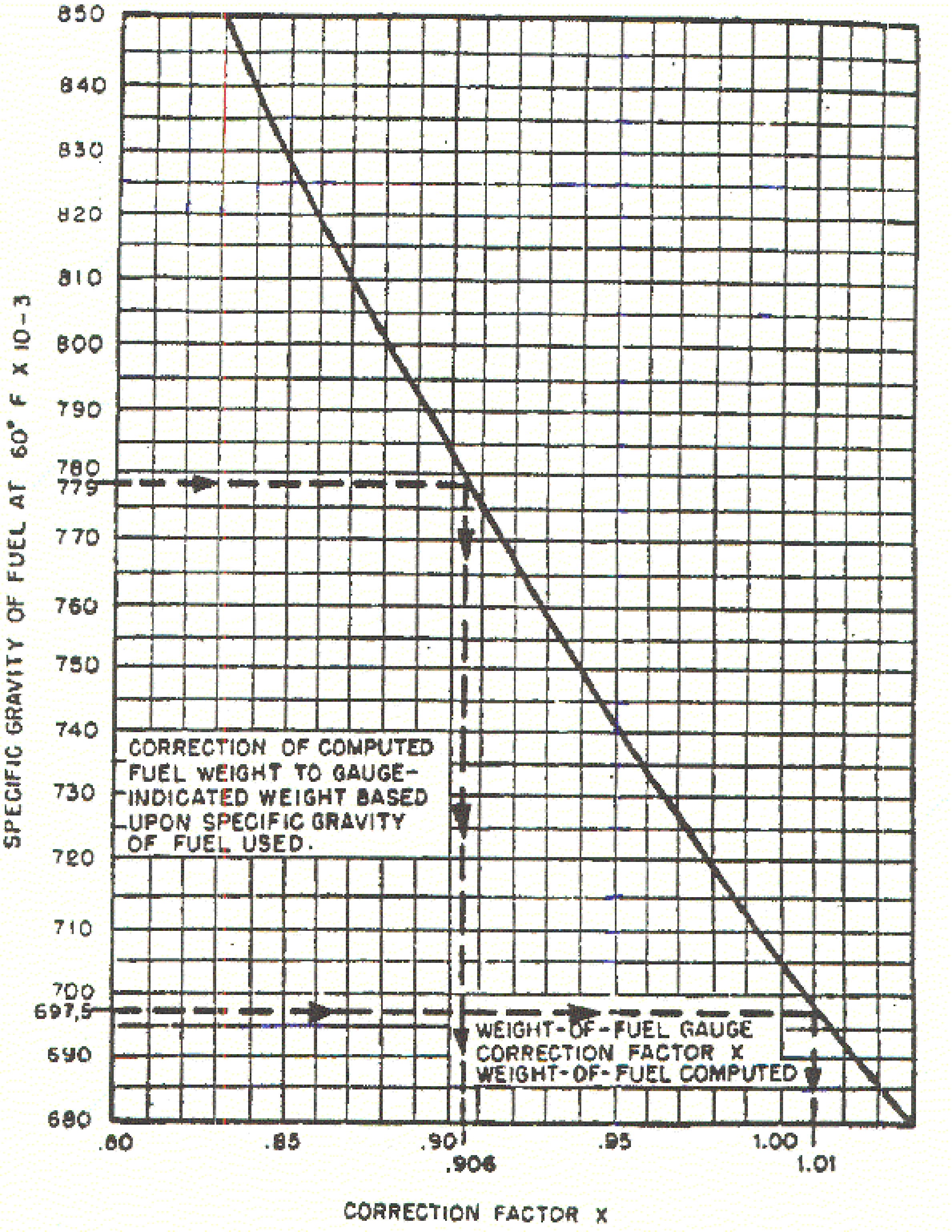


FIGURE 12. Explosive atmosphere fuel weight – temperature characteristic correction factor.