NOTICE OF CHANGE

NOT MEASUREMENT SENSITIVE

MIL-STD-810F
NOTICE 3
5 May 2003

DEPARTMENT OF DEFENSE
TEST METHOD STANDARD

ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS

TO ALL HOLDERS OF MIL-STD-810F:

1. THE FOLLOWING PAGES OF MIL-STD-810F HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
Part One-3	5 May 2003	Part One-3	30 August 2002
Part One-4	30 August 2002	Part One-4	REPRINTED WITHOUT CHANGE
Part One-23	5 May 2003	Part One-23	30 August 2002
Part One-24	5 May 2003	Part One-24	30 August 2002
501.4-3	1 January 2000	501.4-3	REPRINTED WITHOUT CHANGE
501.4-4	5 May 2003	501.4-4	30 August 2002
505.4-3	5 May 2003	505.4-3	30 August 2002
505.4-4	30 August 2002	505.4-4	REPRINTED WITHOUT CHANGE
506.4-1	30 August 2002	506.4-1	REPRINTED WITHOUT CHANGE
506.4-2	5 May 2003	506.4-2	1 January 2000
506.4-3	5 May 2003	506.4-3	30 August 2002
506.4-4	30 August 2002	506.4-4	REPRINTED WITHOUT CHANGE
506.4-7	5 May 2003	506.4-7	30 August 2002
506.4-8	30 August 2002	506.4-8	REPRINTED WITHOUT CHANGE
506.4-9	30 August 2002	506.4-9	REPRINTED WITHOUT CHANGE
506.4-10	5 May 2003	506.4-10	1 January 2000
507.4-1	30 August 2002	507.4-1	REPRINTED WITHOUT CHANGE
507.4-2	5 May 2003	507.4-2	30 August 2002
507.4-3	5 May 2003	507.4-3	1 January 2000
507.4-4	1 January 2000	507.4-4	REPRINTED WITHOUT CHANGE
507.4-5	1 January 2000	507.4-5	REPRINTED WITHOUT CHANGE
507.4-6	5 May 2003	507.4-6	30 August 2002
507.4-7	5 May 2003	507.4-7	30 August 2002
507.4-8	1 January 2000	507.4-8	REPRINTED WITHOUT CHANGE

AMSC N/A AREA ENVR

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
508.5-1	5 May 2003	508.5-1	30 August 2002
508.5-2	1 January 2000	508.5-2	REPRINTED WITHOUT CHANGE
508.5-3	1 January 2000	508.5-3	REPRINTED WITHOUT CHANGE
508.5-4	5 May 2003	508.5-4	1 January 2000
508.5-9	5 May 2003	508.5-9	30 August 2002
508.5-10	30 August 2002	508.5-10	REPRINTED WITHOUT CHANGE
509.4-1	5 May 2003	509.4-1	1 January 2000
509.4-2	1 January 2000	509.4-2	REPRINTED WITHOUT CHANGE
509.4-7	5 May 2003	509.4-7	30 August 2002
509.4-8	1 January 2000	509.4-8	REPRINTED WITHOUT CHANGE
510.4-5	5 May 2003	510.4-5	1 January 2000
510.4-6	1 January 2000	510.4-6	REPRINTED WITHOUT CHANGE
510.4-9	1 January 2000	510.4-9	REPRINTED WITHOUT CHANGE
510.4-10	5 May 2003	510.4-10	30 August 2002
514.5-5	5 May 2003	514.5-5	1 January 2000
514.5-6	1 January 2000	514.5-6	REPRINTED WITHOUT CHANGE
514.5A-3	1 January 2000	514.5A-3	REPRINTED WITHOUT CHANGE
514.5A-4	5 May 2003	514.5A-4	1 January 2000
514.5A-5	5 May 2003	514.5A-5	1 January 2000
514.5A-6	30 August 2002	514.5A-6	REPRINTED WITHOUT CHANGE
514.5A-13	5 May 2003	514.5A-13	1 January 2000
514.5A-14	30 August 2002	514.5A-14	REPRINTED WITHOUT CHANGE
514.5C-1	1 January 2000	514.5C-1	REPRINTED WITHOUT CHANGE
514.5C-2	5 May 2003	514.5C-2	1 January 2000
514.5C-3	5 May 2003	514.5C-3	1 January 2000
514.5C-4	30 August 2002	514.5C-4	REPRINTED WITHOUT CHANGE
514.5C-5	5 May 2003	514.5C-5	30 August 2002
514.5C-6	5 May 2003	514.5C-6	1 January 2000
514.5C-7	5 May 2003	514.5C-7	30 August 2002
514.5C-8	30 August 2002	514.5C-8	REPRINTED WITHOUT CHANGE
514.5C-9	5 May 2003	514.5C-9	30 August 2002
514.5C-10	1 January 2000	514.5C-10	REPRINTED WITHOUT CHANGE
516.5-27	5 May 2003	516.5-27	1 January 2000
516.5-28	5 May 2003	516.5-28	1 January 2000
518-1	5 May 2003	518-1	1 January 2000
518-2	5 May 2003	518-2	1 January 2000
518-3	5 May 2003	518-3	1 January 2000
518-4	5 May 2003	518-4	1 January 2000
518-5	5 May 2003	518-5	1 January 2000
518-6	5 May 2003	518-6	1 January 2000
520.2-11	5 May 2003	520.2-11	30 August 2002
520.2-12	1 January 2000	520.2-12	REPRINTED WITHOUT CHANGE
520.2A-3	5 May 2003	520.2A-3	30 August 2002
520.2A-4	1 January 2000	520.2A-4	REPRINTED WITHOUT CHANGE .

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-810F will verify that page changes indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the standard is completely revised or canceled.

Custodians:
Army – TE
Navy – AS
Air Force – 11

Preparing activity:
Air Force – 11
(Project ENVR-0051)

Review activities:
Army – AR, AT, AV, CE, CR, GL, MI, MT, SM
Navy – CH, EC, MC, OS, SH, YD
Air Force – 13, 19

THIS PAGE INTENTIONALLY BLANK

2. APPLICABLE DOCUMENTS

2.1 General.

The documents listed in this paragraph are referenced in Part TWO of this standard. There are other documents cited in Part TWO of this standard that are recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they should consider all specified requirements documents and tasks cited in paragraph 4 of this standard.

2.2 Government documents

2.2.1 Specifications, standards, and handbooks.

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. When applying a portion of this standard that contains one of these references, cite the particular edition of the document that is listed in the current Department of Defense Index of Specifications and Standards (DoDISS), or in the DoDISS that was in effect at the time of solicitation. Unless otherwise specified, the issues of these documents are those listed in the issue of the DoDISS and supplement thereto, cited in the solicitation (see paragraph 6.2).

SPECIFICATIONS

MIL-S-901	Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for

STANDARDS

MIL-STD-331	Fuze and Fuze Components, Environmental and Performance Tests for
MIL-STD-882	Standard Practice for System Safety

HANDBOOKS

MIL-HDBK-310	Global Climatic Data for Developing Military Products

(Copies of the above documents are available from the Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia PA 19111-5094; http://assist.daps.dla.mil.)

2.2.2 Other government documents.

The following other Government documents and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DIRECTIVES, INSTRUCTIONS, AND MANUALS

DoDD 5000.1	The Defense Acquisition System
DoDI 5000.2	Operation of the Defense Acquisition System
DoD 5000.2-R	Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs

(Copies of the above documents may be downloaded from www.deskbook.osd.mil.)

PUBLICATIONS

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

(Copies of the above document are available from the U.S. Army Publications Distribution Center, 1655 Woodson Rd., St. Louis MO 63114-6181; telephone [314] 263-7305.)

2.3 Non-government documents.

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents that are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

SUPERSEDES PAGE PART ONE-3 OF NOTICE 2 TO MIL-STD-810F.

STANAG 2895	Extreme Climatic Conditions and Derived Conditions for Use in Defining Design Test Criteria for NATO Forces Materiel
STANAG 4242	Vibration Tests for Munitions Carried in Tracked Vehicles
STANAG 4370	Environmental Testing
QSTAG 360	Climatic Environmental Conditions Affecting the Design of Military Materiel
AECTP 100	Allied Environmental Conditions and Test Publication (AECTP) 100, Environmental Guidelines for Defence Materiel (under STANAG 4370)
AECTP 200	Allied Environmental Conditions and Test Publication (AECTP) 200, Environmental Conditions (under STANAG 4370)
AECTP 300	Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests (under STANAG 4370)
AECTP 400	Allied Environmental Conditions and Test Publication (AECTP) 400, Mechanical Environmental Tests (under STANAG 4370)

(Copies of the above documents are available from the Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia PA 19111-5094; http://assist.daps.dla.mil.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

National Conference of Standards Labs (NCSL)

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) STANDARDS

ISO 10012-1	Quality Assurance Requirements for Measuring Equipment - Part I: Meteorological Confirmation System for Measuring Equipment First Edition

(Copies of the above documents are available from American National Standards Institute (ANSI), 25 West 43rd Street, 4th Fl, New York NY 10036-7406 ; telephone [212] 642-4900; www.ansi.org.)

2.4 Order of precedence.

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS.

3.1 Terms.

This terminology section is meant to define the general terminology as it is used in this standard. In certain cases the terminology use may be somewhat different from its use in the general engineering community. No attempt has been made to be complete, therefore limiting the glossary to such terms as are found in the standard and that are important to the application of the standard. Terminology unique to a particular method is defined, as appropriate, in that method.

NOTE: A continuation of this terminology section that contains terminology more closely related to the dynamic (mechanical) test methods such as vibration, shock, gunfire vibration, etc., is in Part One Appendix D.

a. Accelerated test. A test designed to shorten the controlled environmental test time with respect to the service use time by increasing the frequency of occurrence, amplitude, duration, or any combination of these of environmental stresses that would be expected to occur during service use.

b. Aggravated test. A test in which one or more conditions are set at a more stressful level than the materiel will encounter during service use.

degradation. Other minimum intervals may be set to capture transient events that may occur at any time during the test.

5.18.3 Total High Temperature Exposure Duration.

The total materiel temperature conditioning exposure duration time for the test program should be less than the life expectancy time of any component material. Determine the total exposure time from the sum of the pre-conditioning time, plus any standby time, plus actual laboratory testing time. A total exposure duration greater than the materiel life limit can create an accelerated material failure mode or materiel degradation that is unrelated to the simulated environmental test condition. In particular, use caution during testing of energetic or chemically-reactive materials that degrade under elevated temperature conditions. To determine the total exposure time, the test program engineer must consider each phase of environmental testing, mechanical climatic and electrical, and any additional standby time prior to final operational or performance tests. Standby or pre-conditioning time, such as maintaining the item at conditioned temperature over a weekend, can have a significant impact. The actual test conditions concern the duration for high temperature storage and operational tests, high temperature soaks during vibration, and possibly solar radiation tests.

6. NOTES.

(This paragraph contains information of a general or explanatory nature that may be helpful.)

6.1 Intended use.

This standard is intended to organize and standardize the approach within the materiel acquisition process for considering how environmental stresses affect materiel design, test, and evaluation. It emphasizes tailoring materiel to withstand the stresses it is intended to experience during its life cycle, and testing such materiel accordingly. The intended result is to eliminate over- and under-designed/tested materiel with respect to environmental stresses, to ensure environmental considerations are addressed systematically, to ensure test plans are tailored realistically as well as thoroughly, to ensure test execution adheres to tailored test plans, and to ensure test reports are complete and meaningful.

6.2 Issue of DoDISS.

When this standard is used in acquisition, the applicable issue of the DoDISS must be cited in the solicitation (see paragraphs 2.2.1 and 2.3).

6.3 Subject term (key word) listing. (Also see Subject Index, page Index-1.)

Acceleration
Acidic Atmosphere
Acoustic Noise
Climatic Environment
Dust
Environmental Life Cycle
Environmental Test Procedures
Environmental Test Report
Explosive Atmosphere
Fluid Contamination
Fungus
Gunfire Vibration
Humidity
Immersion
Induced Environment
Low Pressure (Altitude)
Natural Environment

SUPERSEDES PAGE PART ONE-23 OF NOTICE 2 TO MIL-STD-810F.

Rain
Salt Fog
Sand
Shock
Solar Radiation
Temperature
Temperature Shock
Vibration

6.4 International Standardization Agreement.

Certain provisions of this standard are the subject of international standardization agreements STANAG's 2895, 4242, and 4370. When proposed amendments, revisions, or cancellation of this standard will modify the international agreement concerned, the Preparing Activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.5 Changes from previous issue.

This document is a complete rewrite of MIL-STD-810E. Due to the extensive modifications, asterisks or vertical lines are not used to identify changes from the previous issue. Changes to MIL-STD-810F will be published in Change Notices.

Custodians:
Army – TE
Navy – AS
Air Force – 11

Preparing activity:
Air Force – 11

Project No.
ENVR-0045

Review activities:
Army – AR, AT, AV, CE, CR, GL, MI, MT, SM
Navy – CH, EC, MC, OS, SH, YD
Air Force – 13, 19

International interest (See paragraph 6.4.)

SUPERSEDES PAGE PART ONE-24 OF NOTICE 2 TO MIL-STD-810F.

e. Other significant heat sources that could affect the materiel such as motors, engines, power supplies, or exhaust air.

2.2.2 Difference between procedures.

While both procedures involve temperature conditioning and performance testing, they differ on the basis of the temperature load prior to and during performance tests. The storage procedure assesses the effects of high temperature storage on subsequent materiel performance. The operation procedure assesses the effects of high temperatures during performance.

a. Procedure I - Storage. Use Procedure I to investigate how high temperatures during storage affect the materiel (integrity of materials, and safety/performance of the materiel). This test procedure includes exposing the test item to high temperatures (and low humidity where applicable) that may be encountered in the materiel's storage situation, followed by a performance test at standard or high temperature ambient conditions.

b. Procedure II - Operation. Use Procedure II to investigate how high ambient temperatures may affect materiel performance while it is operating. There are two ways to perform Procedure II:

(1) Expose the test item to cyclic chamber conditions with the test item operating either continuously or during the period of maximum response (highest item temperature).

(2) Expose the test item to a constant temperature and operate the test item when its temperature stabilizes.

2.3 Determine Test Levels and Conditions.

Having selected this method and relevant procedures (based on the test item's requirements documents and the tailoring process), complete the tailoring process by identifying appropriate parameter levels and applicable test conditions and techniques for these procedures. Base these selections on the requirements documents, the Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, figure 1-1), and information provided with this procedure. Consider the following when selecting test levels.

2.3.1 Climatic conditions.

Identify the appropriate climatic conditions for the geographic areas in which the materiel will be operated and stored. There are two climatic categories where high temperatures are typically encountered: Hot Dry and Basic Hot (Part One, Appendix C, figure C-1). Data for these areas are shown in tables 501.4-I, -II, and -III. Determine high temperature levels with respect to:

a. Climatic area of concern.

b. Exposure to solar radiation: Is this exposure directly on the materiel, shipping container, protective package shelter, etc.?

c. Analysis of the path of heat transfer from the ambient air and solar radiation to the materiel.

2.3.2 Exposure conditions.

Before determining the levels at which to set test temperatures, determine the way in which the materiel is exposed to heat in normal storage and operational circumstances. Review the LCEP to help make this determination. Consider at least the following exposure conditions:

a. Deployment configuration.

(1) Exposed. Of interest are the most severe conditions that materiel would experience when deployed in any climatic area of the world without the benefit of a protective cover or sheltering enclosure.

(2) Sheltered. Of interest are the most severe conditions that materiel would experience when deployed in any climatic area of the world when under cover or inside a sheltering enclosure. The amount of ventilation available and the presence of adjacent shade can significantly affect the temperature of the air surrounding sheltered materiel. Examples of these situations are provided below. (Note: If

REPRINTED WITHOUT CHANGE.

field data are not available, the conditions for this exposure may be approximated using MIL-HDBK-310 or NATO STANAG 2895. The outdoor ambient air temperature and humidity conditions described in this reference are those measured in standard meteorological shelters at a height of 1.2 to 1.8 m (4 to 6 ft) above the ground.)

(a) Inside unventilated enclosures.
(b) Within enclosed vehicle bodies.
(c) Within aircraft sections having surfaces exposed to solar heating.
(d) Inside of tents.
(e) Under closed tarpaulins.
(f) Located above, on, or below the surface of the Earth.

b. Special conditions. Although high temperature testing is generally based on the average temperature of the air envelope surrounding the materiel, significant localized heating can occur because of special heating conditions. This localized heating can be well above the average surrounding air and therefore can significantly affect the evaluation of the materiel's thermal behavior and performance. When these conditions exist (as described below), include or simulate them in the high temperature test setup to the extent practical.

(1) Aggravated solar. When materiel is located behind glazed or transparent panels or within confined, unventilated compartments behind thin metallic skins, direct solar impingement may temporarily raise local air temperatures in excess of those shown in tables 505.4-I and -II. Use caution when applying extreme temperatures because of increased damage potential. In these circumstances base testing on actual field measurements. (Applicable conditions for such testing may indicate using method 505.4 separately or in conjunction with this method.)

(2) Man-made sources. Man-made heat-producing devices (motors, engines, power supplies, high-density electronic packages, etc.) may significantly raise the local air temperature near the materiel; either by radiation, convection, or impingement of exhaust air.

2.3.3 Exposure duration.

Determine the duration of exposure that the materiel will experience for each of the exposure conditions identified. Exposure may be constant or cyclic, in which case, also identify the number of times that the exposure occurs.

Caution: When temperature conditioning, ensure the total test time at the most severe temperature does not exceed the life expectancy of any material (see Part One, paragraph 5.19).

2.3.3.1 Constant temperature exposure.

For constant temperature exposure, soak the test item until its temperature has stabilized and maintain the test temperature at least two hours following stabilization.

2.3.3.2 Cyclic temperature exposure.

For cyclic exposure, determine the test duration based on an estimate of the number of cycles required to satisfy the design requirements and the guidance below. The duration of high temperature exposure may be as significant as the temperature itself. Because Procedures I and II could expose the test items to cyclic temperatures, the number of cycles is critical. (Cycles are 24-hour periods unless otherwise specified.)

a. Procedure I - Storage. The number of cycles for the storage test is set at a minimum of seven to coincide with the one percent frequency of occurrence of the hours of extreme temperatures during the most severe month in an average year at the most severe location. (The maximum temperature occurs for approximately one hour in each cycle.) When considering extended storage, critical materials, or materials determined to be very sensitive to high temperature, increase the number of cycles to assure the design requirements are met.

b. Procedure II - Operation. The minimum number of cycles for the operational exposure test is three. This number is normally sufficient for the test item to reach its maximum response temperature. A maximum of seven cycles is suggested when repeated temperature response is difficult to obtain.

NOTE: This maximum response temperature is referenced in several other methods of this standard such as Method 503.4.

SUPERSEDES PAGE 501.4-4 OF NOTICE 2 TO MIL-STD-810F.

2.2 Selecting Procedures.

This method includes two test procedures, Procedure I (Cycling (thermal effects)) and Procedure II (Steady State (actinic effects)). Determine the procedure(s) to be used. Either procedure may be used to determine actinic effects, but procedure II reduces the test duration.

2.2.1 Procedure selection considerations.

When selecting procedures, consider:

a. The operational purpose of the test item. Physical degradation that occurs during exposure may produce adverse effects on materiel performance or reliability. Based on the purpose of the materiel, determine functional modes and test data needed to evaluate the performance of the test item during and after exposure to solar radiation.

b. The anticipated areas of deployment.

c. The test item configuration.

d. The anticipated exposure circumstances (use, transportation, storage, etc.).

e. The expected duration of exposure to solar radiation.

f. The expected problem areas within the test item.

Caution: When temperature conditioning, ensure the total test time at the most severe temperature does not exceed the life expectancy of any material (see Part One, paragraph 5.19).

2.2.2 Difference between procedures.

While both procedures involve exposing test items to simulated solar radiation, they differ on the basis of timing and level of solar loads, and the focus of the procedure (analyzing heat versus actinic effects). Procedure I (Cycling (thermal effects)) focuses on the effects of heat produced by solar radiation, exposing materiel to continuous 24-hour cycles of simulated solar radiation (or thermal loading) at realistic maximum levels typical throughout the world. Procedure II (Steady State (actinic effects)) is designed to accelerate photo degradation effects produced by solar radiation. This procedure exposes materiel to cycles of intensified solar loads (approximately 2.5 times normal levels) interspersed with dark periods to accelerate actinic effects that would be accumulated over a longer period of time under normal solar loads. Actual acceleration ratios are material dependent, and 2.5 times the natural solar exposure may not provide equal acceleration. This could, however, provide a more rapid test provided the failure mechanisms follow the path expected in the real environment. The key to using either procedure successfully is maintaining enough airflow to prevent the test item from exceeding temperatures that would be attained under natural conditions. However, do not use so much airflow that it produces unrealistic cooling.

a. Procedure I – Cycling (heating effects). Use Procedure I to investigate response temperatures when materiel is exposed in the open in realistically hot climates and is expected to perform without degradation during and after exposure. Although Procedure I can be performed using simple heat-generating lamps, limited evaluation of actinic effects is possible if Procedure II lamps are used instead. It is preferable to use the solar radiation test (as opposed to the High Temperature test, method 501.4) when the materiel could be affected by differential heating (see paragraph 2.1.1.1) or when the levels or mechanisms of heating caused by solar radiation are unknown (this encompasses almost all materiel). Exercise caution if using infrared lamps because infrared-reflecting paints will reflect the total energy and not cause heating. Only materials that are of the same or like color and structure should be analyzed using an infrared source. If a glazing system is incorporated in the materiel, verify that the infrared transmission is not affected when using an infrared source. Otherwise, use a full-spectrum source.

b. Procedure II – Steady State (actinic effects). Use Procedure II to investigate the effects on materiel of long periods of exposure to sunshine. Actinic effects usually do not occur until materiel surfaces receive large amounts of sunlight (as well as heat and moisture). Therefore, it is inefficient to use the repeated, long cycles of normal levels of solar radiation (as in Procedure I) to generate actinic effects. Using Procedure I for this purpose could take months. The approach, therefore, is to use an accelerated test that is designed to reduce the time to reproduce cumulative effects of long periods of exposure. The 4-hour "lights-off" period of each 24-hour cycle allows for test item conditions (physical and chemical) to return toward "normal" and provide some degree of thermal stress exercising.

SUPERSEDES PAGE 505.4-3 OF NOTICE 2 TO MIL-STD-810F.

2.3 Determine Test Levels and Conditions.

Having selected this method and relevant procedures (based on the materiel's requirements documents and the tailoring process), complete the tailoring process by identifying appropriate parameter levels, special test conditions and techniques for these procedures such as the diurnal cycle, test duration, test item configuration, relative humidity, and any additional appropriate conditions. Base these test parameter levels on the requirements documents, Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, figure 1-1), and information provided with this method. Consider the following in light of the operational purpose and life cycle of the materiel.

2.3.1 Diurnal cycle.

For Procedure I, there are three high temperature diurnal cycles included that correspond to the maximum meteorological conditions in the three climatic categories, A1, A2, and A3 of MIL-HDBK-310. Although usually not as significant, in addition to these climatic categories, consider marine environments (M1and M2 in STANAG 2895) as appropriate in the life cycle profile. Figure 505.4-1 shows the daily cycles of temperature and solar radiation corresponding to categories A1-A3 for Procedure I. Choose the conditions for the test according to the planned climatic categories for use of the materiel:

a. Worldwide deployment. Cycle A1 has peak conditions of 1120 W/m^2 (355 BTU/ft^2/hr) and 49°C (120°F), and represents the hottest conditions exceeded not more than one percent of the hours in the most extreme month at the most severe locations that experience very high temperatures accompanied by high levels of solar radiation--namely, hot, dry deserts of north Africa; parts of the Middle East; northern India; and the Southwestern USA.

b. Cycle A2 has peak conditions of 1120 W/m^2 and 44°C (111°F) and represents less severe conditions at locations that experience high temperatures accompanied by high levels of solar radiation and moderately low humidity--namely, the most southerly parts of Europe; most of the Australian continent; south central Asia; northern and eastern Africa; coastal regions of north Africa; southern parts of the USA; and most of Mexico. Use this cycle when the materiel is to be used only in geographical locations described in categories A2 or A3, but not in category A1.

c. Cycle A3 has peak conditions of 1120 W/m^2 and 39°C (102°F) and represents only those locations which experience moderately high temperatures and moderately low humidity for at least part of the year. It is particularly representative of conditions in Europe except the most southern parts, Canada, the northern USA, and the southern part of the Australian continent. However, for the purposes of this document, category A3 is considered to apply to all land masses except those designated as category A1 or A2. Use this cycle when the materiel is to be used only in the geographical locations described in category A3 but not category A1 or A2. Figure 505.4-2 shows the corresponding temperature and solar radiation levels for Procedure II.

2.3.2 Test duration.

a. Procedure I. Expose the test item to continuous 24-hour cycles of controlled simulated solar radiation and dry bulb temperature as indicated on figure 505.4-1 or as identified in the requirements documents. A goal of this test is to establish the highest temperature that the test item will reach during repeated cycles. In many cases three cycles are adequate to establish this maximum temperature. Perform at least three continuous cycles. The variation in solar energy may be applied continuously or incrementally, with a minimum of four levels (preferably eight levels) for each side of the cycle, provided that the total energy of the cycle is maintained. If the maximum temperature is not reached (within 2°C (3.6°F) of the peak response temperature achieved during the previous 24-hour cycle) during the three cycles, perform four to seven cycles. Stop the test when the maximum test item temperature is established or at the end of the seventh cycle. In the absence of other guidance, recommend the maximum test duration of seven cycles because the peak high temperature for the selected climatic region occurs approximately seven hours in the most extreme month. If more exact simulation is required, meteorological data for the particular areas under

REPRINTED WITHOUT CHANGE.

METHOD 506.4

RAIN

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

1. SCOPE.

1.1 Purpose.

The purpose of this method is to help determine the following with respect to rain, water spray, or dripping water:

a. The effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel.

b. The capability of the materiel to satisfy its performance requirements during and after exposure to water.

c. Any physical deterioration of the materiel caused by the rain.

d. The effectiveness of any water removal system.

e. The effectiveness of protection offered to a packaged materiel.

1.2 Application.

Use this method to evaluate materiel likely to be exposed to rain, water spray, or dripping water during storage, transit, or operation. If the materiel configuration is the same, the immersion (leakage) test (Method 512.4) is normally considered to be a more severe test for determining if water will penetrate materiel. There is generally no need to subject materiel to a rain test if it has previously passed the immersion test and the configuration does not change. However, there are documented situations in which rain tests revealed problems not observed during immersion tests due to differential pressure. Additionally, the immersion test may be more appropriate if the materiel is likely to be placed on surfaces with significant amounts of standing water. In most cases, both tests should be performed if appropriately identified in the life-cycle profile.

1.3 Limitations.

Where a requirement exists for determining the effects of rain erosion on radomes, nose cones, fuzes, etc., consider using a rocket sled test facility or other such facility. Since any test procedure involved would be contingent on requirements peculiar to the materiel and the facility employed, a standardized test procedure for rain erosion is not included in this method. Because of the finite size of the test facilities, it may be difficult to determine atmospheric rain effects such as on electromagnetic radiation and propagation. This method is not intended for use in evaluating the adequacy of aircraft windshield rain removal provisions, nor does it address pressure washers or decontamination devices. Additionally, this method may not be adequate for determining the effects of extended periods of exposure to rain, or for evaluating materiel exposed to only light condensation drip rates (lower than 140 $L/m^2/hr$) caused by an overhead surface. For this latter case, the aggravated humidity cycle of method 507.4 will induce a significant amount of free water on both inside and outside surfaces.

2. TAILORING GUIDANCE.

2.1 Selecting the Rain Method.

After examining the requirements documents and applying the tailoring process in Part One of this standard to determine where rain is foreseen in the life cycle of the materiel, use the following to aid in selecting this method and placing it in sequence with other methods. The term “rain” encompasses the full range of “free water” (blowing, steady-state, drip) tests included in this method.

REPRINTED WITHOUT CHANGE.

2.1.1 Effects of rain environments.

Rain (when falling, upon impact, and as deposited as pooled water) has a variety of effects on materiel. Consider the following typical problems to help determine if this method is appropriate for the materiel being tested. This list is not intended to be all-inclusive and some of the examples may overlap the categories.

2.1.1.1 In the atmosphere.

In the atmosphere the effects resulting from exposure to these environments include:

a. Interference with or degradation of radio communication.

b. Limited radar effectiveness.

c. Limited aircraft operations due to restricted visibility and decreased lift from wing surfaces (excessive rain rates only).

d. Damage to aircraft in flight.

e. Effect on artillery and missile launching.

f. Degradation or negation of optical surveillance.

g. Decreased effectiveness of personnel in exposed activities.

h. Premature functioning of some fuses.

i. Inhibited visibility through optical devices.

2.1.1.2 On impact.

On impact it erodes surfaces.

2.1.1.3 After deposition and/or penetration.

After deposition and/or penetration, the effects resulting from exposure to these environments include:

a. Degraded strength/swelling of some materials.

b. Increased corrosion potential, erosion, or even fungal growth.

c. Increased weight.

d. Electrical or electronic apparatus become inoperative or unsafe.

e. Malfunction of electrical materiel.

f. Freezing inside materiel that may cause delayed deterioration and malfunction by swelling or cracking of parts.

g. Modified thermal exchange.

h. Slower burning of propellants.

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.

b. Unique to this method. This method is applicable at any stage in the test program, but its effectiveness in determining the integrity of an enclosure is maximized if it is performed after the dynamic tests.

2.2 Selecting Procedures.

This method includes three rain-related test procedures: Procedure I (Rain and Blowing Rain), Procedure II (Exaggerated), and Procedure III (Drip). Before conducting the test, determine which test procedure(s) and test conditions are appropriate.

SUPERSEDES PAGE 506.4-2 OF MIL-STD-810F.

2.2.1 Procedure selection considerations.

Differences among rain test procedures are explained below. Select the procedure that represents the most severe exposure anticipated for the materiel commensurate with materiel size. When selecting a procedure, consider:

a. The materiel configuration.

b. The logistical and operational requirements (purpose) of the materiel.

c. The operational purpose of the materiel and data to verify it has been met.

d. The natural exposure circumstances.

e. Procedure sequence.

2.2.2 Difference among procedures.

a. Procedure I - Rain and Blowing Rain. Procedure I is applicable for materiel which will be deployed out-of-doors and which will be unprotected from rain or blowing rain. The accompanying wind velocity can vary from almost calm to extremely high. Consider using Procedure II for materiel that cannot be adequately tested with this procedure because of its (large) size.

b. Procedure II - Exaggerated. Consider Procedure II when large (shelter-size) materiel is to be tested and a blowing-rain facility is not available or practical. This procedure is not intended to simulate natural rainfall but will provide a high degree of confidence in the watertightness of materiel.

c. Procedure III - Drip. Procedure III is appropriate when materiel is normally protected from rain but may be exposed to falling water from condensation or leakage from upper surfaces. There are two variations to the drip test: (1) for materiel that may experience falling water (generally from condensation), and (2) for materiel that may be subjected to heavy condensation or leaks from above.

2.3 Determine Test Levels and Conditions.

Having selected this method and relevant procedures (based on the materiel's requirements documents and the tailoring process), it is necessary to complete the tailoring process by selecting specific parameter levels and special test conditions/techniques for these procedures based on requirements documents, Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, Figure 1-1), and information provided with this procedure. From these sources of information, determine the functions to be performed by the materiel in rain environments or following storage in rain environments. Then determine the rainfall levels of the geographical areas and micro-environments in which the materiel is designed to be employed. Variables under each test procedure include the test item configuration, rainfall rate, wind velocity, test item exposure surfaces, water pressure, and any additional appropriate guidelines in accordance with the requirements document.

2.3.1 Test item configuration.

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

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

b. Protected or not protected.

c. In its operational configuration.

d. Modified with kits for special applications.

NOTE: Do not use any sealing, taping, caulking, etc., except as required by the design specification for the materiel. Unless otherwise specified, do not use test items that have surface contamination such as oil, grease, or dirt, which could prevent wetting.

2.3.2 Rainfall rate.

The rainfall rate used in Procedure I may be tailored to the anticipated deployment locale and duration. Although various rainfall intensities have been measured in areas of heavy rainfall, recommend a minimum rate of 1.7 mm/min (4 in/hr) since it is not an uncommon occurrence and would provide a reasonable degree of confidence in the materiel. MIL-HDBK-310 contains further information.

SUPERSEDES PAGE 506.4-3 OF NOTICE 2 TO MIL-STD-810F.

2.3.3 Droplet size.

Nominal drop-size spectra exist for instantaneous rainfall rates but for the long-term rainfall rates they are meaningless since rates are made up of many different instantaneous rates possessing different spectra (reference b). For Procedures I and II, use droplet sizes predominantly in the range of approximately 0.5 mm in diameter [1/] (which is considered to be mist or drizzle rather than rain (reference e), to 4.5 mm in diameter (reference i). For drip tests using dispensing tubes (figure 506.4-1), polyethylene tubing sleeves added to the dispensing tubes will increase the droplet size to its maximum.

NOTE: Observations have shown that water droplets introduced into a high velocity air stream tend to break up over distance (references j and k). Accordingly, recommend introducing the droplets as close as possible to the test item while assuring the droplets achieve the required velocity prior to impact with the test item.

2.3.4 Wind velocity.

High rainfall intensities accompanied by winds of 18 m/s (40 mph) are not uncommon during storms. Unless otherwise specified or when steady-state conditions are specified, recommend this velocity. Where facility limitations preclude the use of wind, use Procedure II.

2.3.5 Test item exposure surface (orientation).

Wind-blown rain will usually have more of an effect on vertical surfaces than on horizontal surfaces, and vice versa for vertical or near-vertical rain. Expose all surfaces onto which the rain could fall or be driven to the test conditions. Rotate the item as required to expose all vulnerable surfaces.

2.3.6 Water pressure.

Procedure II relies on pressurized water. Vary the pressure as necessary to comply with the requirement's documents, but a minimum value of 276 kPa (40 psig) nozzle pressure is given as a guideline based on past experience. This value will produce water droplets traveling at approximately 64 km/h (40 mph) when a nozzle as specified in paragraph 4.1.2 is used.

2.3.7 Preheat temperature.

Experience has shown that a temperature differential between the test item and the rainwater can affect the results of a rain test. When specified for nominally sealed items, increasing the test item temperature to about 10°C higher than the rain temperature at the beginning of each exposure period to subsequently produce a negative pressure inside the test item will provide a more reliable verification of its watertightness. Ensure the heating time is the minimum required to stabilize the test item temperature, and not sufficient to dry the test item when not opened between exposures.

2.3.8 Exposure duration.

Determine the exposure duration from the life-cycle profile, but do not use a duration less than that specified in the individual procedures. For items made of material that may absorb moisture, the duration may have to be significantly extended to reflect real life-cycle circumstances and, for drip tests, the drip rate appropriately reduced. With certain materials, the water penetration, and thus the degradation, is more a function of time (length of exposure) than the volume or rain/drip rate exposure.

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct rain tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9; and Appendix A, Task 405, of this standard.

[1/] Observations show there are no drops of less than roughly 0.5 mm diameter during intense rains (reference c).

REPRINTED WITHOUT CHANGE.

4.4.2 Procedure I - Rain and blowing rain.

Step 1. If the temperature differential between the water and the test item is less than 10°C, either heat the test item to a higher temperature than the rain water (see paragraph 2.3.7) such that the test item temperature has been stabilized at 10 ±2°C above the rain water temperature at the start of each exposure period (see paragraph 2.3.7), or cool the water. Restore the test item to its normal operating configuration immediately before testing.

Step 2. With the test item in the facility and in its normal operating position, adjust the rainfall rate as specified in the test plan.

Step 3. Initiate the wind at the velocity specified in the test plan and maintain it for at least 30 minutes.

Step 4. If required, operate the test for the last 10 minutes of the 30-minute rain.

Step 5. Rotate the test item to expose it to the rain and blowing wind source to any other side of the test item that could be exposed to blowing rain in its deployment cycle.

Step 6. Repeat Steps 1 through 5 until all surfaces have been tested.

Step 7. Examine the test item in the test chamber (if possible); otherwise, remove the test item from the test facility and conduct a visual inspection. If water has penetrated the test item, judgment must be used before operation of the test item. It may be necessary to empty water from the test item (and measure the quantity) to prevent a safety hazard.

Step 8. Measure and document any free water found inside the protected areas of the test item.

Step 9. If required, operate the test item for compliance with the requirements document, and document the results.

4.4.3 Procedure II - Exaggerated.

Step 1. Install the test item in the test facility with all doors, louvers, etc., closed.

Step 2. Position the nozzles as required by the test plan or as indicated on figure 506.4-2.

Step 3. Spray all exposed surfaces of the test item with water for not less than 40 minutes per face.

Step 4. After each 40-minute spray period, inspect the interior of the test item for evidence of free water. Estimate its volume and the probable point of entry and document.

Step 5. Conduct an operational check of the test item as specified in the test plan, and document the results.

4.4.4 Procedure III - Drip.

Step 1. Install the test item in the facility in accordance with Part One, paragraph 5.8 and in its operational configuration with all connectors and fittings engaged. Ensure the temperature differential between the test item and the water is 10°C or greater. If necessary, either raise the test item temperature or lower the water temperature to achieve the differential in paragraph 2.3.7, and restore the test item to its normal operating configuration immediately before testing.

Step 2. With the test item operating, subject it to water falling from a specified height (no less than 1 meter (3 feet)) as measured from the upper main surface of the test item at a uniform rate for 15 minutes or as otherwise specified (see figure 506.4-1 or figure 506.4-3). Use a test setup that ensures that all of the upper surfaces get droplets on them at some time during the test. For test items with glass-covered instruments, tilt them at a 45° angle, dial up.

Step 3. At the conclusion of the 15-minute exposure, remove the test item from the test facility and remove sufficient panels or covers to allow the interior to be seen.

Step 4. Visually inspect the test item for evidence of water penetration.

Step 5. Measure and document any free water inside the test item.

Step 6. Conduct an operational check of the test item as specified in the test plan, and document the results.

SUPERSEDES PAGE 506.4-7 OF NOTICE 2 TO MIL-STD-810F.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results. Analyze any failure of a test item to meet the requirements of the materiel specifications and consider related information such as follows.

5.1 Operational Failures.

a. Degradation allowed in the performance characteristics because of rainfall exposure.

b. Necessity for special kits for special operating procedures.

c. Safety of operation.

5.2 Water Penetration.

Based on the individual materiel and the requirements for its non-exposure to water, determine if one of the following is applicable:

a. Unconditional failure. Any evidence of water penetration into the test item enclosure following the rain test.

b. Acceptable water penetration. Water penetration of not more than 4 cm^3 per 28,000 cm^3 (1 ft^3) of test item enclosure provided the following conditions are met:

(1) There is no immediate effect of the water on the operation of the materiel.

(2) The test item in its operational configuration (transit/storage case open or removed) can successfully complete the aggravated temperature/humidity procedure of method 507.4.

6. REFERENCE/RELATED DOCUMENTS.

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

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

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

d. Army Materiel Command Pamphlet AMCP-706-116, Engineering Design Handbook, Environmental Factors.

e. Huschke, R. E. (ed.), Glossary of Meteorology. Boston: American Meteorological Society, 1970.

f. RTCA/DO-160D, Environmental Conditions and Test Procedures for Airborne Equipment.

g. Tattelman, P.I., and Sissenwine, N., Extremes of Hydrometers at Altitude for MIL-STD-210B: Supplement Drop Size Distributions (1973), AFCRL-TR-73-0008, AFSG 253.

h. R.M. Clayton et al, Rain Simulation for High-Intensity Acoustic Noise Cavities. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, Report NPO-17237/6745.

i. Rogers, R.R., Short Course in Cloud Physics, Pergamon Press, Oxford; 1979.

j. STANAG 4370, Environmental Testing.

k. Allied Environmental Conditions and Test Publication 300, Climatic Environmental Testing (under STANAG 4370).

REPRINTED WITHOUT CHANGE.

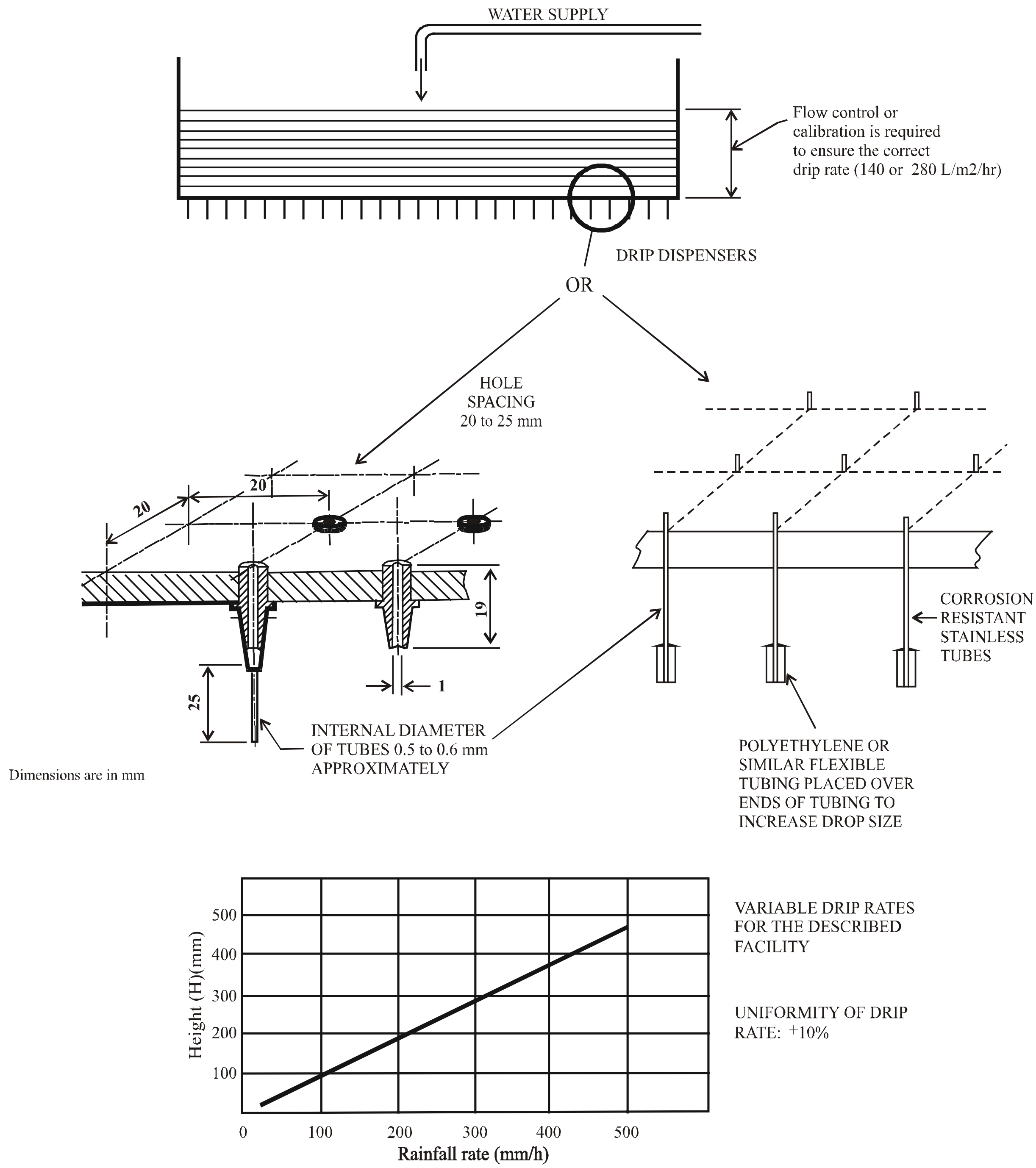
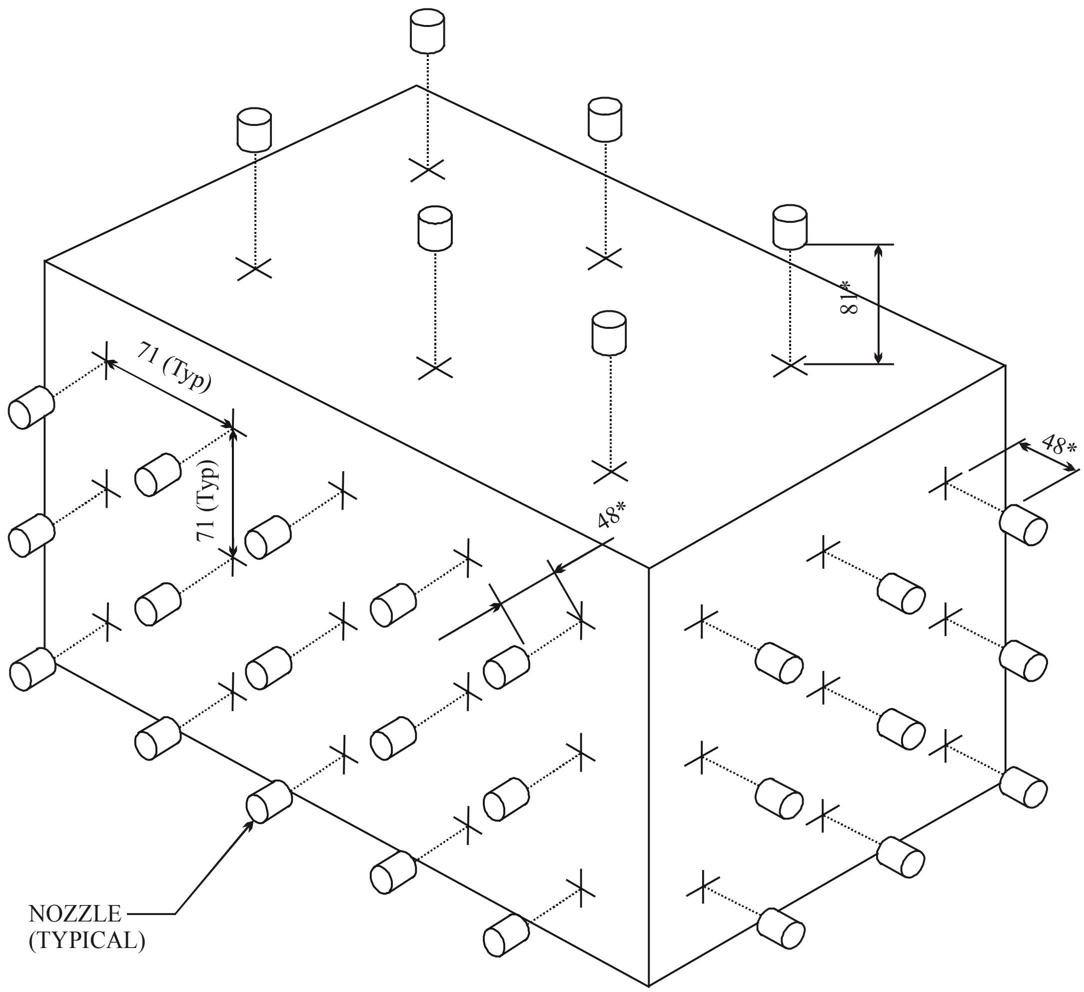


FIGURE 506.4-1. Sample facility for steady-state rain or drip test.

REPRINTED WITHOUT CHANGE.



* Adjust as necessary to get spray overlap

NOTE: Dimensions are in cm. Ensure nozzles are perpendicular to the surface(s) and situated such that each surface (especially vulnerable areas) is sprayed.

FIGURE 506.4-2. Typical nozzle setup for exaggerated test, Procedure II.

SUPERSEDES PAGE 506.4-10 OF MIL-STD-810F.

METHOD 507.4

HUMIDITY

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

1. SCOPE.

1.1 Purpose.

The purpose of this method is to determine the resistance of materiel to the effects of a warm, humid atmosphere.

1.2 Application.

This method applies to materiel that is likely to be stored or deployed in a warm, humid environment; an environment in which high levels of humidity occur; or to provide an indication of potential problems associated with humidity. Although it is preferable to test materiel at appropriate natural environment sites, it is not always practical because of logistical, cost, or schedule considerations. Warm, humid conditions can occur year-round in tropical areas, seasonally in mid-latitude areas, and in materiel subjected to combinations of changes in pressure, temperature, and relative humidity. Other high levels of humidity can exist worldwide. Further information on high temperatures and humidity is provided in AR 70-38 or NATO STANAG 2895.

1.3 Limitations.

This method may not reproduce all of the humidity effects associated with the natural environment such as long-term effects, nor with low humidity situations. This method does not attempt to duplicate the complex temperature/humidity environment but, rather, it provides a generally stressful situation that is intended to reveal potential problem areas in the materiel. Therefore, this method does not contain natural or induced temperature/humidity cycles as in previous editions. Specifically, this method does not address:

a. Condensation resulting from changes of pressure and temperature for airborne or ground materiel.

b. Condensation resulting from black-body radiation (e.g., night sky effects).

c. Synergistic effects of humidity or condensation combined with biological and chemical contaminants.

d. Liquid water trapped within materiel or packages and retained for significant periods.

e. This method is not intended for evaluating the internal elements of a hermetically sealed assembly since such materiel is air-tight.

2. TAILORING GUIDANCE

2.1 Selecting the Humidity Method.

After examining requirements documents and applying the tailoring process in Part One of this standard to determine if warm temperature/humidity conditions are anticipated in the life cycle of materiel, use the following to confirm the need for this method and to place it in sequence with other methods.

2.1.1 Effects of warm, humid environments.

Humidity has physical and chemical effects on materiel; the temperature and humidity variations can also trigger condensation inside materiel. Consider the following typical problems to help determine if this method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

a. Surface effects, such as:

REPRINTED WITHOUT CHANGE.

(1) Oxidation and/or galvanic corrosion of metals.

(2) Increased chemical reactions.

(3) Chemical or electrochemical breakdown of organic and inorganic surface coatings.

(4) Interaction of surface moisture with deposits from external sources to produce a corrosive film.

(5) Changes in friction coefficients, resulting in binding or sticking.

b. Changes in material properties, such as:

(1) Swelling of materials due to sorption effects.

(2) Other changes in properties.

(a) Loss of physical strength.

(b) Electrical and thermal insulating characteristics.

(c) Delamination of composite materials.

(d) Change in elasticity or plasticity.

(e) Degradation of hygroscopic materials.

(f) Degradation of explosives and propellants by absorption.

(g) Degradation of optical element image transmission quality.

(h) Degradation of lubricants.

c. Condensation and free water, such as:

(1) Electrical short circuits.

(2) Fogging of optical surfaces.

(3) Changes in thermal transfer characteristics.

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.

b. Unique to this method. Humidity testing may produce irreversible effects. If these effects could unrealistically influence the results of subsequent tests on the same item(s), perform humidity testing following those tests. Also, because of the potentially unrepresentative combination of environmental effects, it is generally inappropriate to conduct this test on the same test sample that has previously been subjected to salt fog, sand and dust, or fungus tests.

2.2 Selecting Procedure Variations.

This method has one procedure. Possible variations are described below.

2.2.1 Test duration.

The minimum number of 24-hour cycles for the test is ten. This has historically proven adequate to reveal potential effects in most materiel. Extend the test as specified in the test plan to provide a higher degree of confidence in the materiel to withstand warm, humid conditions.

2.2.2 Temperature/humidity levels.

Although the combined 60°C and 95% RH does not occur in nature, this combination of temperature and relative humidity has historically provided an indication of potential problem areas in materiel.

2.2.3 Operational checkout.

If the test item is intended to be operated in a warm, humid environment, perform at least one operational checkout every five cycles during the period shown on figure 507.4-1. The earlier any problems are identified, the more test time can be saved.

SUPERSEDES PAGE 507.4-2 OF NOTICE 2 TO MIL-STD-810F.

2.3 Test Variations.

The most important ways the test can vary are in the number of temperature-humidity cycles, relative humidity, and temperature levels and durations, test item operation and performance monitoring, and test item ventilation.

2.4 Philosophy of Testing.

The purpose of the test procedure described in this method is to produce representative effects that typically occur when materiel is exposed to elevated temperature-humidity conditions in actual service. (See paragraph 2.1.1, above, for categories and examples of these effects.) Accordingly, this procedure does not reproduce naturally occurring or service-induced temperature-humidity time histories, nor is it intended to produce humidity effects that have been preceded by solar effects. It may induce problems that are indicative of long-term effects. Test item failures do not necessarily indicate failures in the real environment.

2.5 Alternative Tests.

Materiel specification documents may suggest using natural or induced cycles as in AR 70-38 or NATO STANAG 2895 during laboratory tests. The complex temperature/humidity/solar radiation environment with its associated antagonistic elements such as microbial growth, acidic atmosphere, and other biological elements produce synergistic effects that cannot be practically duplicated in the laboratory. Coupled with the test data interpretation problems are the extensive durations of real-world environments that, in most cases, are too lengthy to realistically apply in the laboratory. Before undertaking such laboratory testing, consider testing in the natural tropic environment. Otherwise, exercise caution in applying such cycles and in interpreting test results.

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct humidity tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9, and Appendix A, Task 405 of this standard.

b. Specific to this method.

(1) Any sealed areas of the test item to be opened during testing or vice versa.

(2) Periods of materiel operation or designated times for visual examinations.

(3) Operating test procedures, if appropriate.

3.2 During Test.

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Record of chamber temperature and humidity versus time conditions.

(2) Test item performance data and time/duration of checks.

3.3 Post Test.

The following post test information is required.

a. General. Information listed in Part One, paragraph 5.13, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Previous test methods to which the test item has been subjected.

(2) Results of each performance check (before, during, and after test) and visual examination (and photographs, if applicable).

SUPERSEDES PAGE 507.4-3 OF MIL-STD-810F.

(3) Length of time required for each performance check.

(4) Exposure durations and/or number of test cycles.

(5) Test item configuration and special test setup provisions.

4. TEST PROCESS.

4.1 Test Facility.

Ensure the apparatus used in performing the humidity test includes the following:

4.1.1 General description.

The required apparatus consists of a chamber or cabinet, and auxiliary instrumentation capable of maintaining and monitoring (see Part One, paragraph 5.18) the required conditions of temperature and relative humidity throughout an envelope of air surrounding the test item. (See Part One, paragraph 5.)

4.1.2 Facility design.

Unless otherwise specified, use a test chamber or cabinet with a test volume and the accessories contained therein constructed and arranged in such a manner as to prevent condensate from dripping on the test item. Vent the test volume to the atmosphere to prevent the buildup of total pressure and prevent contamination from entering.

4.1.3 Test sensors and measurements.

Determine the relative humidity by employing either solid-state sensors whose calibration is not affected by water condensation, or by an equivalent method such as fast-reacting wet-bulb/dry-bulb sensors or dew point indicators. Sensors that are sensitive to condensation, such as the lithium chloride type, are not recommended for tests with high relative humidity levels. A data collection system, including an appropriate recording device(s), separate from the chamber controllers is necessary to measure test volume conditions. If charts are used, use charts readable to within ±0.6°C. If the wet-wick control method is approved for use, clean the wet bulb and tank and install a new wick before each test and at least every 30 days. Ensure the wick is as thin as realistically possible to facilitate evaporation (approximately 1/16" thick) consistent with maintaining a wet surface around the sensor. Use water in wet-wick systems that is of the same quality as that used to produce the humidity. When physically possible, visually examine the water bottle, wick, sensor, and other components making up relative humidity measuring systems at least once every 24 hours during the test to ensure they are functioning as desired.

4.1.4 Air velocity.

Use an air velocity flowing across the wet-bulb sensor of not less than 4.6 meters/second (900 feet/minute), and ensure the wet wick is on the suction side of the fan to eliminate the effect of fan heat. Maintain the flow of air anywhere within the envelope of air surrounding the test item between 0.5 and 1.7 meters/second (98 to 335 feet/minute).

4.1.5 Humidity generation.

Use steam or water injection to create the relative humidity within the envelope of air surrounding the test item. Use water as described in Part One, paragraph 5.16. Verify its quality at periodic intervals (not to exceed 15 days) to ensure its acceptability. If water injection is used to humidify the envelope of air, temperature-condition it before its injection to prevent upset of the test conditions, and do not inject it directly into the test section. From the test volume drain and discard any condensate developed within the chamber during the test.

4.1.6 Contamination prevention.

Do not bring any material other than water into physical contact with the test item(s) that could cause the test item(s) to deteriorate or otherwise affect the test results. Do not introduce any rust or corrosive contaminants or any material other than water into the chamber test volume. Achieve dehumidification, humidification, heating and cooling of the

REPRINTED WITHOUT CHANGE.

air envelope surrounding the test item by methods that do not change the chemical composition of the air, water, or water vapor within that volume of air.

4.2 Controls.

a. Ensure the test chamber includes an appropriate measurement and recording device(s), separate from the chamber controllers.

b. Test parameters. Unless otherwise specified, make continuous analog temperature and relative humidity measurements during the test. Conduct digital measurements at intervals of 15 minutes or less.

c. Capabilities. Use only instrumentation with the selected test chamber that meets the accuracies, tolerances, etc., of Part One, paragraph 5.3.

4.3 Test Interruption.

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

b. Specific to this method.

(1) Undertest interruption. If an unscheduled interruption occurs that causes the test conditions to fall below allowable limits, the test must be reinitiated at the end of the last successfully completed cycle.

(2) Overtest interruptions. If the test item(s) is exposed to test conditions that exceed allowable limits, conduct an appropriate physical examination of the test item and perform an operational check (when practical) before testing is resumed. This is especially true where a safety condition could exist, such as with munitions. If a safety condition is discovered, the preferable course of action is to terminate the test and reinitiate testing with a new test item. If this is not done and test item failure occurs during the remainder of the test, the test results may be considered invalid. If no problem has been encountered, reestablish pre-interruption conditions and continue from the point where the test tolerances were exceeded.

4.4 Test Setup.

a. General. See Part One, paragraph 5.8.

b. Unique to this method. Verify that environmental monitoring and measurement sensors are of an appropriate type and properly located to obtain the required test data.

4.5 Test Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item in a warm, humid environment.

4.5.1 Preparation for test

4.5.1.1 Preliminary steps.

Before starting the test, determine the test details (e.g., procedure variations, test item configuration, cycles, durations, parameter levels for storage/operation, etc.) from the test plan.

4.5.1.2 Pretest standard ambient checkout.

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

Step 1. Install the test item into the test chamber and conduct an operational checkout (if appropriate) in accordance with the test plan.

REPRINTED WITHOUT CHANGE.

Step 2. Prepare the test item in its required configuration in accordance with Part One, paragraph 5.8.1.

Step 3. Conduct a thorough visual examination of the test item to look for conditions that could compromise subsequent test results.

Step 4. Document any significant results.

Step 5. Conduct an operational checkout (if appropriate) in accordance with the test plan, and record results.

4.5.2 Procedure.

This test consists of a 24-hour conditioning period (to ensure all items at any intended climatic test location will start with the same conditions), followed by a 24-hour temperature and humidity cycle for the number of cycles specified in the test plan.

Step 1. With the test item installed in the test chamber in its required configuration, adjust the temperature to 23 ± 2°C and 50 ± 5% RH, and maintain for 24 hours.

Step 2. Adjust the chamber temperature to 30°C and the RH to 95%.

Step 3. Expose the test item(s) to at least ten 24-hour cycles (figure 507.4-1) or as otherwise determined in paragraph 2.2.1. Recommend conducting test item performance checks (for the minimum time required to verify performance) near the end of the fifth and tenth cycles, or as otherwise specified in the test plan, during the periods shown, and document the results. If the test item fails to operate as intended, stop the test and go to Step 5 below. Otherwise, continue with Step 4.

Step 4. In order to prevent unrealistic drying, within 15 minutes after Step 3 is completed, conduct an operational performance check, if applicable, and document the results. If the check cannot be completed within 30 minutes, recondition the test item at 30°C and 95% RH for one hour, and then continue the checkout.

Step 5. Adjust the temperature and humidity conditions to standard ambient conditions. Perform a final operational performance check for comparison with pretest data.

Step 6. Perform a thorough visual examination of the test item and document any conditions resulting from humidity exposure.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results.

a. Allowable or acceptable degradation in operating characteristics.

b. Possible contributions from special operating procedures or special test provisions needed to perform testing.

c. Whether it is appropriate to separate temperature effects from humidity effects.

6. REFERENCE/RELATED DOCUMENTS.

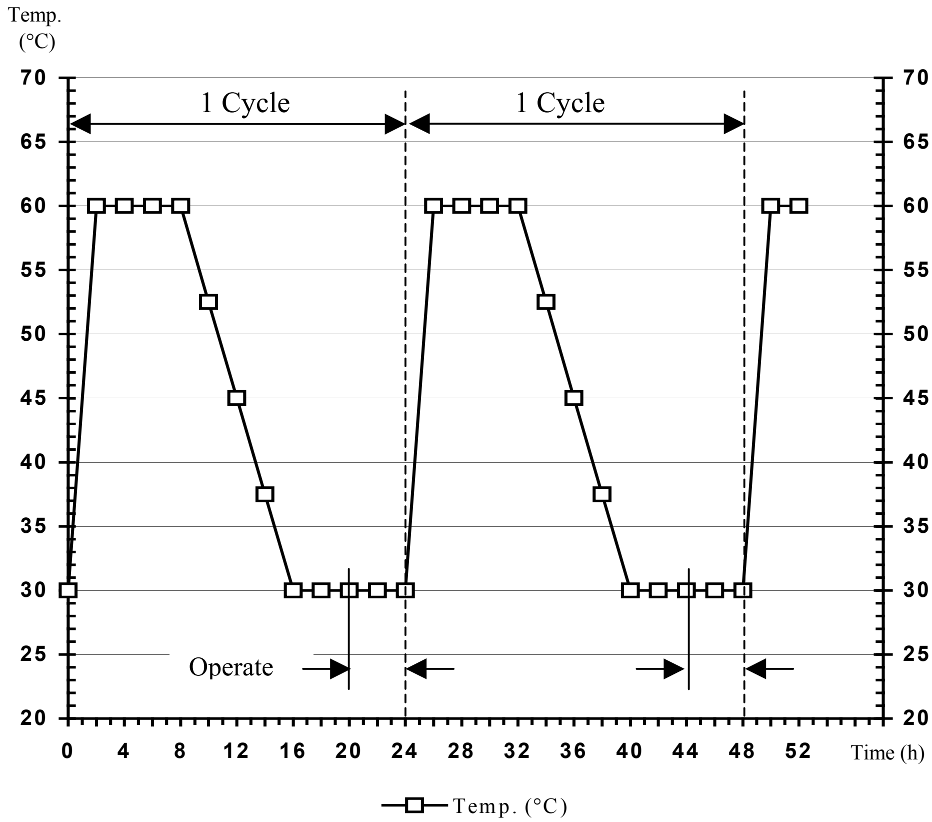
a. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.

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

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

d. STANAG 2895, Climatic Environmental Conditions Affecting the Design of Materiel for Use of NATO Forces.

SUPERSEDES PAGE 507.4-6 OF NOTICE 2 TO MIL-STD-810F.



NOTES:

1. Maintain the relative humidity at 95 ±4% at all times except that during the descending temperature periods the relative humidity may drop to as low as 85%.

2. A cycle is 24 hours.

FIGURE 507.4-1. Aggravated temperature-humidity cycle.

SUPERSEDES PAGE 507.4-7 OF NOTICE 2 TO MIL-STD-810F.

THIS PAGE INTENTIONALLY BLANK

REPRINTED WITHOUT CHANGE.

METHOD 508.5

FUNGUS

NOTE: Tailoring is essential. Select methods, procedures and parameter levels based on the tailoring process described in Part One, paragraph 4, and Appendix C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard.

1. SCOPE.

1.1 Purpose.

The purpose of this fungus test is to assess the extent to which materiel will support fungal growth and how any fungal growth may affect performance or use of the materiel. The primary objectives of the fungus test are to determine:

a. if the materials comprising the materiel, or the assembled combination of same, will support fungal growth, and if so, of what species.

b. how rapidly fungus will grow on the materiel.

c. how fungus affects the materiel, its mission, and its safety for use following the growth of fungus on the materiel.

d. if the materiel can be stored effectively in a field environment.

e. if there are simple reversal processes, e.g., wiping off fungal growth.

1.2 Application.

Since microbial deterioration is a function of temperature and humidity and is an inseparable condition of hot, humid tropics and the midlatitudes, consider it in the design of all standard, general-purpose materiel. This method is used to determine if fungal growth will occur and, if so, how it may degrade/impact the use of the materiel.

NOTES: 1. This test procedure and the accompanying preparation and post-test analysis involve highly-specialized techniques and potentially-hazardous organisms. Use only technically-qualified personnel (e.g., microbiologists) to perform the test.

2. Although the basic (documented) resistance of materials to fungal growth is helpful in the design of new materiel, the combination of materials, the physical structure of combined materials, and the possible contamination of resistant materials necessitate laboratory or natural environment tests to verify the resistance of the assembled materiel to fungal growth.

1.3 Limitations.

This test is designed to obtain data on the susceptibility of materiel. Do not use it for testing of basic materials since various other test procedures, including soil burial, pure culture, mixed culture, and plate testing are available.

2. TAILORING GUIDANCE.

2.1 Selecting the Fungus Method.

After examining requirements documents and applying the tailoring process in Part One of this standard to determine where fungal growth is anticipated in the life cycle of materiel, use the following to confirm the need for this method and to place it in sequence with other methods.

2.1.1 Effects of fungus growth.

Fungal growth impairs the functioning or use of materiel by changing its physical properties.

SUPERSEDES PAGE 508.5-1 OF NOTICE 2 TO MIL-STD-810F.

2.1.1.1 Detrimental effects.

The detrimental effects of fungal growth are summarized as follows:

a. Direct attack on materials. Nonresistant materials are susceptible to direct attack as the fungus breaks the materials down and uses them as nutrients. This results in deterioration affecting the physical properties of the material. Examples of nonresistant materials are:

(1) Natural material. Products of natural origin are most susceptible to this attack.

(a) Cellulosic materials (e.g., wood, paper, natural fiber textiles, and cordage).

(b) Animal- and vegetable-based adhesives.

(c) Grease, oils, and many hydrocarbons.

(d) Leather.

(2) Synthetic materials.

(a) PVC formulations (e.g., those plasticized with fatty acid esters).

(b) Certain polyurethanes (e.g., polyesters and some polyethers).

(c) Plastics that contain organic fillers of laminating materials.

(d) Paints and varnishes that contain susceptible constituents.

b. Indirect attack on materials. Damage to fungus-resistant materials results from indirect attack when:

(1) Fungal growth on surface deposits of dust, grease, perspiration, and other contaminants (that find their way onto materiel during manufacture or accumulate during service) causes damage to the underlying material, even though that material may be resistant to direct attack.

(2) Metabolic waste products (i.e., organic acids) excreted by fungus cause corrosion of metals, etching of glass, or staining or degrading of plastics and other materials.

(3) The products of fungus on adjacent materials that are susceptible to direct attack come in contact with the resistant materials.

2.1.1.2 Physical interference.

Physical interference can occur as follows:

a. Electrical or electronic systems. Damage to electrical or electronic systems may result from either direct or indirect attack. Fungi can form undesirable electrical conducting paths across insulating materials, for example, or may adversely affect the electrical characteristics of critically adjusted electronic circuits.

b. Optical systems. Damage to optical systems results primarily from indirect attack. The fungus can adversely affect light transmission through the optical system, block delicate moving parts, and change nonwetting surfaces to wetting surfaces with resulting loss in performance.

2.1.1.3 Health and aesthetic factors.

Fungus on materiel can cause physiological problems (e.g., allergies) or be so aesthetically unpleasant that the users will be reluctant to use the materiel.

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.

b. Unique to this method. Because of the potentially unrepresentative combination of environmental effects, it is generally inappropriate to conduct this test on the same test sample previously subjected to salt fog, sand and dust, or humidity tests. However, if it is necessary, perform the fungus test before the salt fog or sand and dust tests. A heavy concentration of salt may affect the germinating fungus growth, and sand and dust can provide nutrients, thus leading to a false indication of the biosusceptibility of the test item.

REPRINTED WITHOUT CHANGE.

2.2 Selecting Procedure Variations.

This method has one procedure. Since the combination of temperature and humidity is critical to microbial growth, it is essential that these be maintained as specified in the procedure. However, other possible variations are described below.

2.2.1 Test duration.

Twenty-eight days is the minimum test period to allow for fungus germination, breakdown of carbon-containing molecules, and degradation of material. Since indirect effects and physical interference are not likely to occur in the relatively short time frame of the fungus test, consider extension of the exposure period to 84 days if a greater degree of certainty (less risk) is required in determining the existence or effect of fungus growth.

2.2.2 Choice of fungus.

Two groups of fungus (U.S. and European) are commonly used and are listed in table 508.5-I. Use one group or the other and, if necessary, adjust it as in paragraph 2.2.2b. These organisms were selected because of their ability to degrade materials, their worldwide distribution and their stability. To aid in selection of a species to supplement the selected group, the organisms have, where possible, been identified with respect to the materials to which they are known to attack, and should be selected accordingly.

a. Because the test item is not sterile before testing, other microorganisms will be present on the surfaces. When the test item is inoculated with the selected group of fungi, both these and the other organisms will compete for available nutrients. It is not surprising to see organisms other than the test fungi growing on the test item at the end of the test.

b. Add additional species of fungus to those required in this test method. However, if additional fungi are used, base their selection on prior knowledge of specific material deterioration. For example, *Aureobasidium pullulans* was once employed because of its known specificity for degrading paints. (It has since been deleted from the suggested European species because of mutations to the strain.)

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct fungus tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9, and Appendix A, Task 405 of this standard.

b. Specific to this method.

   (1) Which set of fungi to be used (U.S. or European).

   (2) Additional species to be added.

3.2 During Test.

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

   (1) Record of chamber temperature and RH versus time conditions.

   (2) Evidence of fungus growth on the cotton control strips at the 7-day check.

   (3) Location of any fungal growth.

3.3 Post Test.

The following post test information is required.

REPRINTED WITHOUT CHANGE.

a. General. Information listed in Part One, paragraph 5.13, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Evidence of fungus growth at the end of the test. If growth is found, identify the species.

(2) Narrative description of growth, including colors, areas covered, growth patterns, and density of growth (and photographs, if possible). (See table 508.5-II.)

(3) Effect of fungus on performance or use:

(a) As received from the chamber.

(b) After removal of fungus, if appropriate.

(c) Physiological or aesthetic considerations.

(4) Observations to aid in failure analysis.

4. TEST PROCESS.

4.1 Test Facility.

In addition to the standard requirements for test chambers, the following apply to chambers to be used for fungus tests.

4.1.1 Test chamber.

Construct the chamber and accessories in such a manner as to prevent condensation from dripping on the test item. Filter-vent the chamber to the atmosphere to prevent the buildup of pressure and release of spores into the atmosphere.

4.1.2 Sensors.

Monitor and control the humidity inside the test enclosure using psychrometric systems or with sensors that are not affected by condensation (see Part One, paragraph 5.18). Record the humidity and temperature using sensors separate from those used to control the chamber environment.

4.1.3 Air velocity.

Ensure the speed of the air across the psychrometric sensors is at least 4.5 m/s in order to achieve the required evaporation and sensor response. (If necessary to obtain this speed in the vicinity of the probe, use diffusers if desired.) However, control the air velocity in the vicinity of the test item and controls to between 0.5 and 1.7 m/sec (98 to 335 ft/min). Install deflectors or screens around the test item if necessary. In order to prevent heating of the psychrometer sensors, install the sensors either upstream of any fan used to create the air velocity, or far enough downstream not to be affected by fan motor heat.

4.1.4 Decontamination.

Prior to testing, ensure the chamber is decontaminated in accordance with the guidance at Annex A.

4.2 Controls.

In addition to the information provided in Part One, paragraph 5, the following controls apply to this test.

4.2.1 Relative humidity.

In addition to the requirements appropriate for method 507.4, Humidity, and water purity as described in Part One, paragraph 5.16, determine the relative humidity by employing either solid state sensors whose calibration is not affected by water condensation, or by an approved equivalent method such as fast-reacting wet bulb/dry bulb sensors. Do not use lithium chloride sensors because of their sensitivity to condensation.

a. When the wet bulb control method is used, clean the wet bulb assembly and install a new wick for each test.

SUPERSEDES PAGE 508.5-4 OF MIL-STD-810F.

(4) To ensure proper conditions are present in the incubation chamber to promote fungus growth, install these strips and inoculate them along with the test item.

4.5 Test Procedure.

4.5.1 Preparation for incubation.

Step 1. Assure the condition of the items subjected to testing is similar to their condition as delivered by the manufacturer or customer for use, or as otherwise specified. Accomplish any cleaning of the test item at least 72 hours before the beginning of the fungus test to allow for evaporation of volatile materials.

Step 2. Install the test item in the chamber or cabinet on suitable fixtures, or suspend them from hangers.

Step 3. Hold the test item in the operating chamber (at 30 ±1°C and a RH of greater than 90% but less than 100%) for at least four hours immediately before inoculation.

Step 4. Inoculate the test item and the cotton fabric chamber control items with the mixed fungus spore suspension by spraying the suspension on the control items, and on and into the test item(s) (if not permanently or hermetically sealed) in the form of a fine mist from an atomizer or nebulizer. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inoculation.

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

Step 5. In order for air to penetrate, replace the covers of the test items without tightening the fasteners.

Step 6. Start incubation immediately following the inoculation.

4.5.2 Incubation of the test item.

Step 1. Except as noted in Step 2 below, incubate the test items at constant temperature and humidity conditions of 30 ±1°C and a relative humidity above 90% but below 100% for the test duration (28 days, minimum).

Step 2. After 7 days, inspect the growth on the control cotton strips to verify the environmental conditions in the chamber are suitable for growth. At this time at least 90 percent of the part of the surface area of each test strip located at the level of the test item should be covered by fungus. If it is not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test.

Step 3. If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period from the time of inoculation as specified in the test plan. If there is no increase in fungus growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

4.5.3 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 is not completed in 8 hours, return the test item to the test chamber or to a similar humid environment for a minimum of 12 hours. Except for hermetically-sealed materiel, open the test item enclosure and examine both the interior and exterior of the test item. Record the results of the inspection.

4.5.4 Operation/use.

(To be conducted only if required.) If operation of the test item is required (e.g., electrical materiel), conduct the operation during the inspection period specified in paragraph 4.5.3. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inspection and in making operation and use decisions. Disturbance of any fungus growth must be kept to a minimum during the operational checkout.

WARNING: Because of the potential hazardous nature of this test, operation/use by personnel with appropriate knowledge of the test item will be performed under the guidance of technically-qualified personnel (e.g., microbiologists). Appropriate personal protective equipment (PPE) must be worn.

SUPERSEDES PAGE 508.5-9 OF NOTICE 2 TO MIL-STD-810F.

4.6 Decontamination.

See Annex A.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results.

a. Any fungal growth on the test item must be analyzed to determine the species, and if the growth is on the test item material(s) or on contaminants.

b. Any fungal growth on the test item material(s), whether from the inoculum or other sources, must be evaluated by qualified personnel for:

(1) The extent of growth on susceptible components or materials. Use table 508.5-II as a guide for this evaluation, but any growth must be completely described.

(2) The immediate effect that the growth has on the physical characteristics of the materiel.

(3) The long-range effect that the growth could have on the materiel.

(4) The specific material (nutrient(s)) supporting the growth.

c. Evaluate human factors effects (including health risks).

6. REFERENCE/RELATED DOCUMENTS.

None.

REPRINTED WITHOUT CHANGE.

METHOD 509.4

SALT FOG

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

1. SCOPE.

1.1 Purpose.

The salt fog method is performed to determine the effectiveness of protective coatings and finishes on materials. It may also be applied to determine the effects of salt deposits on the physical and electrical aspects of materiel.

1.2 Application.

Use this method for screening purposes only to evaluate the effectiveness and quality of protective coatings and finishes on materiel and material coupons, and to locate potential problem areas, quality control deficiencies, design flaws, etc., in a relatively short period of time. In general, only apply this method to materiel that will experience significant exposure (as opposed to infrequent or irregular) to high levels of salt in the atmosphere.

1.3 Limitations.

a. The test is not intended to duplicate the effects of a marine atmosphere due to variations in chemical composition and concentrations of the various marine and other corrosive environments.

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

c. It has not been demonstrated that withstanding the effects of this test guarantees materiel will survive under all corrosive conditions. For acidic atmosphere tests, see Method 518. Consult ASTM G85, “Standard Practice for Modified Salt Spray (Fog) Testing” for information on introducing a sulfur dioxide environment. Caution: Introducing sulfur dioxide in the salt fog chamber may contaminate the chamber for future salt fog tests.

d. This test has proven to be generally unreliable for predicting the service life of different materials or coatings.

e. This test is not a substitute for evaluating corrosion caused by humidity and fungus because their effects differ from salt fog effects and the tests are not interchangeable.

f. This test is not intended to be used for sample or coupon testing in lieu of assemblage testing.

2. TAILORING GUIDANCE.

2.1 Selecting the Salt Fog Method.

After examining requirements documents and applying the tailoring process in Part One of this standard to determine where atmospheric corrosion is anticipated in the life cycle of materiel, use the following to confirm the need for this method and to place it in sequence with other methods.

2.1.1 Effects of corrosive environments.

Salt is one of the most pervasive chemical compounds in the world. It is found in the oceans, the atmosphere, ground surfaces, and lakes and rivers. It is impossible to avoid exposure to salt. The worst effects occur, in general, in coastal regions. The effects of exposure of materiel to an environment where there is a corrosive atmosphere can

SUPERSEDES PAGE 509.4-1 OF MIL-STD-810F.

be divided into three broad categories: corrosion effects, electrical effects, and physical effects. Consider the following typical problems to help determine if this method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

2.1.1.1 Corrosion effects.

a. Corrosion due to electrochemical reaction.
b. Accelerated stress corrosion.
c. Formation of acidic/alkaline solutions following salt ionization in water.

2.1.1.2 Electrical effects.

a. Impairment of electrical materiel due to salt deposits.
b. Production of conductive coatings.
c. Corrosion of insulating materials and metals.

2.1.1.3 Physical effects.

a. Clogging or binding of moving parts of mechanical components and assemblies.
b. Blistering of paint as a result of electrolysis.

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.
b. Unique to this method. If using the same test item sample for more than one climatic test, in most cases recommend the salt fog test be conducted after the other climatic tests. Salt deposits can interfere with the effects of other tests. It is generally inappropriate to conduct the salt fog, fungus and humidity tests on the same test sample because the accumulation of effects from the three environments may be unrealistic. However, if it is necessary to do so, perform the salt fog test following the fungus and humidity tests. Although generally inappropriate, if sand and dust testing is required on the same test item, perform it following salt fog testing.

2.2 Selecting Procedure Variations.

This method has one procedure. Possible variations are described below.

2.2.1 Salt solution.

Unless otherwise identified, use a 5 ±1% salt solution concentration (reference d.). Use water as described in Part One, paragraph 5.16. The intent is to not introduce contaminants or acidic/alkaline conditions that may affect the test results. (See paragraph 4.5.1.1.b.)

2.2.2 Test item configuration.

The configuration and orientation of the test item during the exposure period of the salt fog test is an important factor in determining the effect of the environment on the test item. Unless otherwise specified, configure the test item and orient it as would be expected during its storage, shipment, or use. The listing below offers the most likely configurations that materiel would assume when exposed to a corrosive atmosphere. For test purposes, choose the most severe/critical configuration.

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

REPRINTED WITHOUT CHANGE.

Step 2. Continuously atomize a salt solution of a composition as given in paragraph 4.5.1.1.b into the test chamber for a period of 24 hours or as specified in the test plan. During the entire exposure period measure the salt fog fallout rate and pH of the fallout solution at least at 24-hour intervals[2/]. Ensure the fallout is between 1 and 3 $ml/80cm^2/hr$.

Step 3. Dry the test item at standard ambient temperatures and a relative humidity of 50% ± 5% for 24 hours or as otherwise specified. Minimize handling the test item or adjusting any mechanical features during the drying period.

Step 4. At the end of the drying period and unless otherwise specified, replace the test item in the salt fog chamber and repeat steps 2 and 3 at least once.

Step 5. After completing the physical and electrical checkout, document the results (with photographs, if necessary). Then, if necessary to aid in a follow-on corrosion examination, use a gentle wash in running water, which is at standard ambient conditions, conduct the corrosion examination, and document the results.

Step 6. Visually inspect the test item in accordance with the guidelines given in paragraph 4.5.1.2.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraphs 5.14 and 5.17, the following information is provided to assist in the evaluation of the test results.

a. Physical. Salt deposits can cause clogging or binding of mechanical components and assemblies. The extent of any deposits resulting from this test may be representative of those induced by anticipated environments.

b. Electrical. Moisture remaining after the 24-hour drying period could cause electrical malfunctions. If so, attempt to relate the malfunctions to that possible in service.

c. Corrosion. Analyze any corrosion for its immediate and potential long-term effects on the proper functioning and structural integrity of the test item.

6. REFERENCE/RELATED DOCUMENTS.

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

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

c. Army Materiel Command Pamphlet AMCP-706-116, Engineering Design Handbook, Environmental Factors.

d. Final Letter Report of Methodology Investigation on Evaluation of Test Procedures Used for Salt Fog Tests, TECOM Project 7-CO-PB7-AP1-018, Aberdeen Proving Ground, MD 21005; July 1979.

[2/] Recommend more frequent intervals. Repeat the interval if fallout quantity requirements are not met.

SUPERSEDES PAGE 509.4-7 OF NOTICE 2 TO MIL-STD-810F.

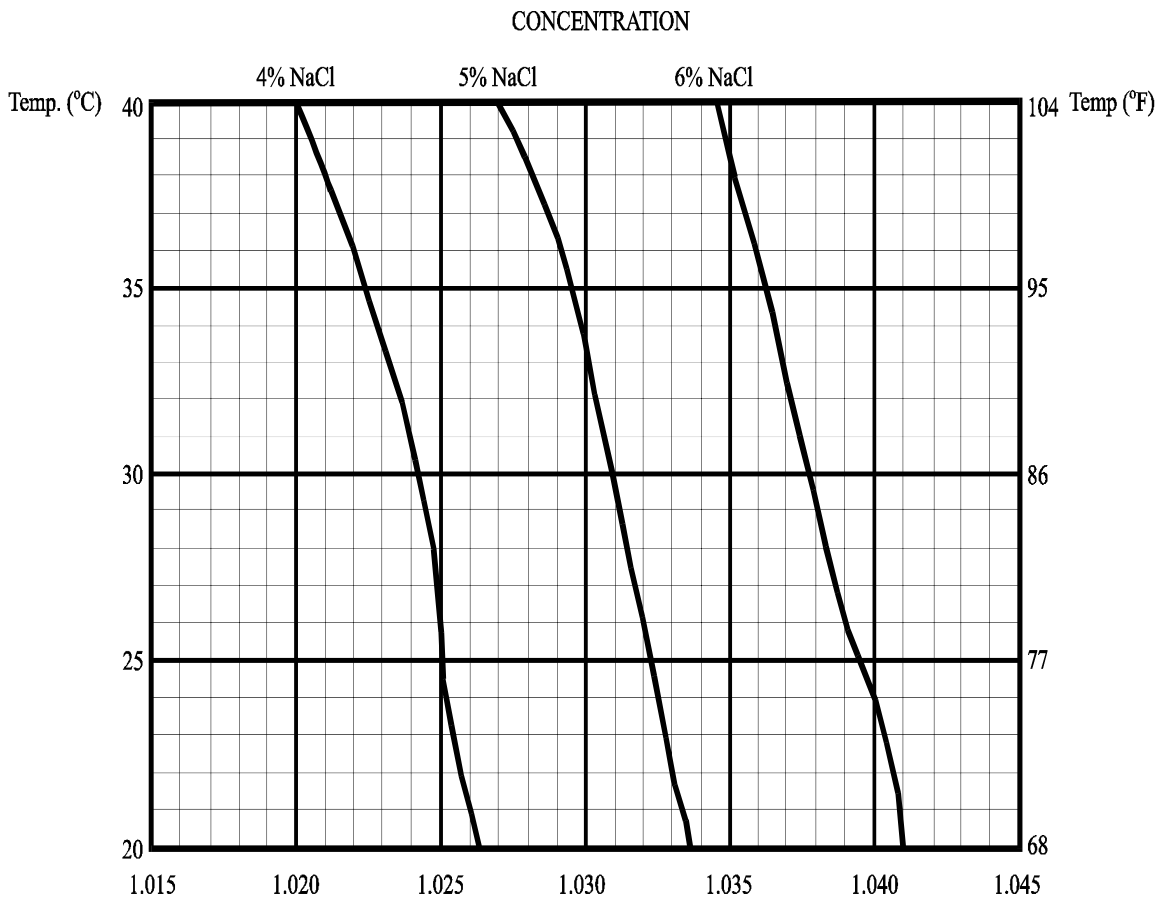


FIGURE 509.4-1. Variations of specific gravity of salt (NaCl) solution with temperature.

REPRINTED WITHOUT CHANGE.

2.3.2.6 Sand and dust concentrations.

a. Blowing dust. Unless otherwise specified, maintain the dust concentration for the blowing dust test at 10.6 ± 7 g/m^3 (0.3 ± 0.2 g/ft^3) unless otherwise specified. This concentration exceeds that normally associated with moving vehicles, aircraft, and troop movement, but has historically proven to be reliable concentration for blowing dust tests.

b. Blowing sand. Unless otherwise specified, maintain the sand concentrations as follows (reference a):

(1) For materiel likely to be used close to helicopters operating over unpaved surfaces: 2.2 ± 0.5 g/m^3 (0.06 ± 0.015 g/ft^3).

(2) For materiel never used or exposed in the vicinity of operating aircraft, but which may be used or stored unprotected nearing operating surface vehicles: 1.1 ± 0.3 g/m^3 (0.033 ± 0.0075 g/ft^3).

(3) For materiel that will be subjected only to natural conditions: 0.18 g/m^3, -0.0/+0.2 g/m^3 (0.005 g/ft^3). (This large tolerance is due to the difficulties of measuring concentrations at low levels.)

c. Settling dust. For the settling dust test, the relationship between severity (duration and concentration) is difficult to determine. Real conditions vary considerably, and this test is intended to standardize a means to demonstrate survival of the materiel, and not necessarily duplicate conditions. Consequently, only guidelines are given in order to provide guidance on the relationship between the severity levels of the test and some values from real conditions. Unless otherwise specified, use a dust settlement rate of 6 g/m^2/day. Table 510.4-I provides average dust deposits for various areas along with a rough guide to acceleration factors for the specified rates (reference d). For example, a 3-day test equates to between 51 days and 1800 days (5 years) for rural and suburban environments, and between 9 days and 18 days for an industrial environment.

TABLE 510.4-I. Settling dust quantities and acceleration factors.

AREA	DUST SETTLEMENT PER DAY (g/m^2)	ACCELERATION FACTOR (with 6 g/m^2/day)
Rural and Suburban	0.01 – 0.36	600 – 17
Urban	0.36 – 1.00	17 – 6
Industrial	1.00 – 2.00	6 – 3

2.3.2.7 Orientation.

a. Blowing dust tests. Unless otherwise specified, orient the test item such that the most vulnerable surfaces face the blowing dust. Using the specified test duration, rotate the test item (if required) at equal intervals to expose all vulnerable surfaces.

b. Blowing sand tests. Orient the test item with respect to the direction of the blowing sand such that the test item will experience maximum erosion effects. The test item may be re-oriented at 90-minute intervals.

c. Settling dust tests. Install the test item in the test chamber in a manner representative of its anticipated deployment in service.

2.3.2.8 Duration.

a. Blowing dust. Unless otherwise specified, conduct blowing dust tests for 6 hours at 23ºC and an additional 6 hours at the high storage or operating temperature. If necessary, stop the test after the first 6-hour period provided that prior to starting the second 6-hour period the chamber conditions are restabilized.

b. Blowing sand. Perform blowing sand tests for a minimum of 90 minutes per each vulnerable face.

SUPERSEDES PAGE 510.4-5 OF MIL-STD-810F.

c. Settling dust. Use a basic deposition rate of 6 g/m^2/day. This, combined with the values shown in table 510.4-I provides a rough guide to acceleration factors for the areas shown. If no specific region is identified, use a test duration of three days (for standardization purposes) to provide a reasonable severity.

2.3.2.9 Operation during test.

a. Determine the need to operate the test item during exposure to sand or dust from the anticipated in-service operational requirements. For example, operate heating/cooling test items while exposed to extreme ambient environments, but operate certain materiel, although exposed to severe environments, in an environmentally controlled shelter. If the test item must be operated during the test, specify the time and periods of operation in the test plan. Include at least one 10-minute period of continuous operation of the test item during the last hour of test, with the test item's most vulnerable surface facing the blowing sand or dust.

b. For the settling dust test, condition the test item which employs forced air cooling with the air cooling system operating to determine the effect of dust trapped in filters; operate heat-generating materiel with ventilation openings for convection cooling during the test; operate heat-generating materiel of closed construction intermittently in order to produce a breathing effect by thermal cycling, or to determine thermal increase due to insulative effects of accumulated dust.

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct sand and dust tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9, and Appendix A, Task 405 of this standard.

b. Specific to this method.

(1) Test temperature
(2) Relative humidity
(3) Air velocity
(4) Sand or dust composition
(5) Sand or dust concentration
(6) Operating requirements
(7) Test item orientation and exposure time per orientation
(8) Methods of sand and dust removal as used in service

3.2 During Test.

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Periodic dust concentrations.

(2) Periodic relative humidity levels.

REPRINTED WITHOUT CHANGE.

4.4 Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item in sand and dust environments.

4.4.1 Preparation for test.

****WARNING**** The relatively dry test environment combined with the moving air, organic dust, and sand particles may cause a buildup of electrostatic energy that could affect operation of the test item. Use caution when making contact with the test item during or following testing if organic dust is used and be aware of potential anomalies caused by electrostatic discharge during test item checkout.

4.4.1.1 Preliminary steps.

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

a. Determine from the test plan which test procedure is required.

b. Determine from the test plan specific test variables to be used.

c. Operate the test chamber without the test item to confirm proper operation.

(1) Calibrate the sand dispensing system for the sand concentration specified in the test plan.

(2) Adjust the air system or test item position to obtain the specified air velocity for the test item. See paragraph 4.1.c(2), above.

(3) For the settling dust test, verify the fallout rate over a two-hour period using a one-minute injection period each hour, followed by a 59-minute settling period.

4.4.1.2 Pretest standard ambient checkout.

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

Step 1. Position the test item as near the center of the test chamber as possible and from any other test item (if more than one item is being tested). For the blowing sand or dust procedures, orient the test item to expose the most critical or vulnerable parts to the sand or dust stream. For the settling dust test, position the test to represent its normal orientation during operation or storage.

NOTE: If required by the test plan, change the orientation of the test item as specified during the test.

Step 2. Prepare the test item in its operating configuration or as specified in the test plan.

Step 3. Ensure the test item is grounded (either through direct contact with the test chamber or with a grounding strap.)

Step 4. Stabilize the test item temperature to standard ambient conditions.

Step 5. Conduct a complete visual examination of the test item with special attention to sealed areas and small/minute openings.

Step 6. Document the results.

Step 7. Conduct an operational checkout in accordance with the test plan and record results.

Step 8. If the test item operates satisfactorily, proceed to step 1 of the test procedure. if not, resolve the problem and restart at Step 1 of pretest checkout.

4.4.2 Procedure I – Blowing dust.

**** WARNING**** Silica flour (or other dusts of similar particle size) may present a health hazard. When using silica flour, ensure the chamber is functioning properly and not leaking; if a failure of containment is noted and personnel might have been exposed, obtain air samples and compare them to the current threshold limit values of the national safety and health regulations. Make chamber repairs and/or take other appropriate action before continuing use of

REPRINTED WITHOUT CHANGE.

the chamber. Be extremely careful during all steps where exposure of personnel to the silica dust is possible. Additionally, fine dust becomes potentially explosive when its concentration in air exceeds 20 g/m^3.

Step 1. With the test item in the chamber, adjust the test section temperature to standard ambient conditions and the air velocity to the required value, determined from the test plan. Adjust the test section relative humidity to less than 30% and maintain it throughout the test.

Step 2. Adjust the dust feed control for a dust concentration of 10.6 ± 7 g/m^3.

Step 3. Unless otherwise specified, maintain the conditions of Steps 1 and 2 for at least 6 hours. If required, periodically reorient the test item to expose other vulnerable faces to the dust stream.
SEE ABOVE WARNING NOTES in paragraphs 5.4 and 5.4.2.

Step 4. Stop the dust feed. Reduce the test section air velocity to approximately 1.5 m/s and adjust the temperature to the required high operational temperature, OR as otherwise determined from the test plan.

Step 5. Maintain the step 4 conditions for 1 hour following test temperature stabilization.

Step 6. Adjust the air velocity to that used in Step 1 and restart the dust feed to maintain the dust concentration as in Step 2.

Step 7. Continue exposure for at least 6 hours or as otherwise specified. If required, operate the test item in accordance with the test plan.

Step 8. Allow the test item to return to standard ambient conditions, and the dust to settle. SEE THE WARNING AT THE BEGINNING OF THIS PROCEDURE AND IN PARAGRAPH 4.4.1, ABOVE.

Step 9. Remove accumulated dust from the test item by brushing, wiping or shaking, taking care to avoid introduction of additional dust or disturbing any which may have already entered the test item. Do not remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.

Step 10. Perform an operational check in accordance with the approved test plan, and document the results for comparison with pretest data.

Step 11. Inspect the test item for dust penetration, giving special attention to bearings, grease seals, lubricants, filters, ventilation points, etc. Document the results.

4.4.3 Procedure II – Blowing sand.

Step 1. Position the test item at the required distance from the sand injection point and adjust air velocity according to test plan.

Step 2. Stabilize the test item at its high operating temperature.

Step 3. Adjust the sand feeder to obtain the sand mass flow rate determined from the pretest calibration.

Step 4. Maintain the conditions of Steps 1 through 3 for the duration specified in the test plan. If required, reorient the test item at 90-minute intervals to expose all vulnerable faces to the blowing sand and repeat Steps 1-3.

Step 5. If operation of the test item during the test is required, perform an additional test of the item during the last hour of the test and document the results. If not, proceed to Step 6.
SEE THE WARNING IN PARAGRAPH 4.4.2, ABOVE.

Step 6. Allow the test item to return to standard ambient conditions. Remove accumulated sand from the test item by using the methods anticipated to be used in service such as brushing, wiping, shaking, etc., taking care to avoid introduction of additional sand into the test item.

Step 7. Conduct an operational check of the test item in accordance with the approved test plan and record results for comparison with pretest data.

Step 8. Visually inspect the test item looking for abrasion and clogging effects, and any evidence of sand penetration. Document the results.

4.4.4 Procedure III – Settling dust.

SEE THE WARNING NOTE IN PARAGRAPH 4.4.2, ABOVE.

Step 1. With the test item and collection plates in the test chamber, adjust the test section temperature to 23ºC or as otherwise specified, and the relative humidity to less than 30%. (Maintain less than 30% relative humidity throughout the test.)

SUPERSEDES PAGE 510.4-10 OF NOTICE 2 TO MIL-STD-810F.

b. Procedure II - Loose Cargo Transportation. Use this procedure for materiel to be carried in/on trucks, trailers, or tracked vehicles and not secured to (tied down in) the carrying vehicle. The test severity is not tailorable and represents loose cargo transport in military vehicles traversing rough terrain.

c. Procedure III - Large Assembly Transportation. This procedure is intended to replicate the vibration and shock environment incurred by large assemblies of materiel installed or transported by wheeled or tracked vehicles. It is applicable to large assemblies or groupings forming a high proportion of vehicle mass, and to materiel forming an integral part of the vehicle. In this procedure, use the specified vehicle type to provide the mechanical excitation to the test materiel. The vehicle is driven over surfaces representative of service conditions, resulting in realistic simulation of both the vibration environment and the dynamic response of the test materiel to the environment. Generally, measured vibration data are not used to define this test. However, measured data are often acquired during this test to verify that vibration and shock criteria for materiel subassemblies are realistic.

d. Procedure IV - Assembled Aircraft Store Captive Carriage and Free Flight. Apply Procedure IV to fixed-wing aircraft carriage and free-flight portions of the environmental life cycles of all aircraft stores, and to the free-flight phases of ground- or sea-launched missiles. Use Procedure I, II, or III for other portions of the store's life cycle, as applicable. Steady state or transient vibration may be applied, as appropriate. Do not apply Procedure I to fixed-wing aircraft carriage or free-flight phases.

2.3 Determine Test Levels and Conditions.

Select excitation form (steady-state or transient), excitation levels, control strategies, durations, and laboratory conditions to simulate the vibration exposures of the environmental life cycle as accurately as possible. Whenever possible, acquire measured data as a basis for these parameters. Annex A includes descriptions of various phases typical of an environmental life cycle along with discussions of important parameters and guidance for developing test parameters. Annex B has further guidance in interpretation of technical detail.

2.3.1 Climatic conditions.

Many laboratory vibration tests are conducted under Standard Ambient Test Conditions as discussed in Part One, paragraph 5. However, when the life cycle events being simulated occur in environmental conditions significantly different than standard conditions, consider applying those environmental factors during vibration testing. Individual climatic test methods of this standard include guidance for determining levels of other environmental loads. Methods 520.2, "Temperature, Humidity, Vibration, Altitude," and 523.2, "Vibro-Acoustic/Temperature," contain specific guidance for combined environments testing. For temperature-conditioned environmental tests, high temperature tests of explosive or energetic materials in particular, consider the materiel degradation due to extreme climatic exposure to ensure the total test program climatic exposure does not exceed the life of the materiel. (See Part One, paragraph 5.19.)

SUPERSEDES PAGE 514.5-5 OF MIL-STD-810F.

TABLE 514.5-I. Vibration environment categories.

Life Phase	Platform	Category	Materiel Description	Level & Duration Annex A	Test [1/]
Manufacture / Maintenance	Plant Facility / Maintenance Facility	1. Manufacture / Maintenance processes	Materiel / assembly / part	2.1.1	[2/]
		2. Shipping, handling	Materiel / assembly / part	2.1.2	[2/]
		3. ESS	Materiel / assembly / part	2.1.3	[3/]
Transportation	Truck / Trailer / Tracked	4. Restrained Cargo	Materiel as restrained cargo [4/]	2.2.1	I
		5. Loose Cargo	Materiel as loose cargo [4/]	2.2.2	II
		6. Large Assembly Cargo	Large assemblies, shelters, van and trailer units [4/]	2.2.3	III
	Aircraft	7. Jet	Materiel as cargo	2.2.4	I
		8. Propeller	Materiel as cargo	2.2.5	I
		9. Helicopter	Materiel as cargo	2.2.6	I
	Ship	10. Surface Ship	Materiel as cargo	2.2.7	I
	Railroad	11. Train	Materiel as cargo	2.2.8	I
Operational	Aircraft	12. Jet	Installed Materiel	2.3.1	I
		13. Propeller	Installed Materiel	2.3.2	I
		14. Helicopter	Installed Materiel	2.3.3	I
	Aircraft Stores	15. Jet	Assembled stores	2.3.4	IV
		16. Jet	Installed in stores	2.3.5	I
		17. Propeller	Assembled / Installed in stores	2.3.6	IV/I
		18. Helicopter	Assembled / installed in stores	2.3.7	IV/I
	Missiles	19. Tactical Missiles	Assembled / installed in missiles (free flight)	2.3.8	IV/I
	Ground	20. Ground Vehicles	Installed in wheeled / tracked / trailer	2.3.9	I/III
	Watercraft	21. Marine Vehicles	Installed Materiel	2.3.10	I
	Engines	22. Turbine Engines	Materiel Installed on	2.3.11	I
	Personnel	23. Personnel	Materiel carried by/on personnel	2.3.12	[2/]
Supplemental	All	24. Minimum Integrity	Installed on Isolators / Life cycle not defined	2.4.1	I
	All Vehicles	25. External Cantilevered	Antennae, airfoils, masts, etc.	2.4.2	[2/]

[1/] Test procedure – see paragraph 4
[2/] See Annex A reference.
[3/] Use applicable ESS procedure.
[4/] See paragraph 2.3.2.

REPRINTED WITHOUT CHANGE.

Note: Annex A, paragraph 2.2.3, below, for truck/trailer large assembly cargo can be tailored to any cargo size or tiedown configuration when high accuracy of ground vehicle transport environmental measurement or test is required.

2.2.1 Category 4 - Truck/trailer/tracked - restrained cargo.

These transportation environments are characterized by broadband vibration resulting from the interaction of vehicle suspension and structures with road and surface discontinuities. Representative conditions experienced on moving materiel from point of manufacture to end-use are depicted in Part One, figure 4-2. This environment may be divided into two phases, truck transportation over U.S. highways and mission/field transportation. Mission/field transportation is further broken down into two-wheeled trailer/wheeled vehicles and tracked vehicle categories.

a. Truck transportation over U. S. highways. This involves movement from the manufacturer's plant to any continental United States storage or user installation. (Data are available for U.S. roads but not for roads in other countries.) This movement is usually accomplished by large truck and/or tractor-trailer combination. Mileage for this transportation generally ranges from 3200 to 6400 kilometers (2000 to 4000 miles) over improved or paved highways.

b. Mission/field transportation. This involves movement of materiel as cargo where the platform may be two-wheeled trailers, 2-1/2 to 10 ton trucks, semi-trailers, and/or tracked vehicles. Typical distances for this phase are 500 to 800 kilometers (300 to 500 miles). Road conditions for mission/field support differ from the common carrier in that, in addition to the paved highway, the vehicles will traverse unimproved roads and unprepared terrain (off-the-road) under combat conditions.

c. Exposure levels. Whenever possible, measure vibration on the transport vehicles using the road conditions (surfaces, speeds, and maneuvers) of the materiel's Life Cycle Environment Profile. Include realistic load configurations (approximately 75% of the vehicle load capacity by weight). Use these data to develop exposure levels (see examples in ITOP 1-2-601 (reference d)). Alternatively, derive exposure levels as discussed below.

   (1) Truck transportation over U. S. highways. Derive exposure levels from Annex C, figure 514.5C-1. These figures are based upon data measured at the cargo floor of seven different configurations of trucks and semitrailer combinations. Both conventional suspensions and air-cushioned suspensions are represented. The data were collected from typical interstate highways with rough portions as part of the database.

   (2) Two-wheeled trailer and wheeled vehicles. Exposures are shown in Annex C, figures 514.5C-2 and 514.5C-3. Both trucks and two-wheeled trailers are utilized between the Forward Supply Point (FSP) and at the Using Unit (USU). Trailer vibration levels are significantly higher; use these to represent the wheeled vehicle environment. However, when materiel is too large for the two-wheeled trailer, use the composite wheeled levels.

   (3) Tracked vehicles. A representative tracked vehicle spectrum shape is given in Annex C, figure 514.5C-4. Note that this figure is based on sweeping across the narrow band spikes as discussed in reference f that also contains detailed criteria for some tracked vehicles. Testing to this requirement will require a narrow band random-on-random vibration exciter control strategy.

d. Exposure durations. Base durations on the materiel Life Cycle Environment Profile. Annex C, table 514.5C-I shows the typical field/mission transportation scenario with the most typical vehicles.

   (1) Truck transportation over U. S. highways. The exposure duration for common carrier/truck is 60 minutes per 1609 kilometers (1000 miles) of road travel (per axis). (See ITOP 1-1-050 (reference e) for guidance.)

   (2) Two-wheeled trailer and wheeled vehicles. The exposure duration for two-wheeled trailer is 32 minutes per 51.5 kilometers (32 miles) traveled (per axis) and the exposure duration for composite wheeled vehicle is 40 minutes per 804.6 kilometers (500 miles) traveled (per axis).

REPRINTED WITHOUT CHANGE.

(3) Tracked vehicles. Use environmental life cycle durations. See reference f for further guidance.

2.2.2 Category 5 - Truck/trailer/tracked - loose cargo.

The cargo has freedom to bounce, scuff and collide with other cargo and with the sides of the vehicle. The loose cargo environment includes conditions experienced by cargo transported in a vehicle traversing irregular surfaces. This test replicates the repetitive random shock environment incurred by cargo transported under these conditions. This test does not address general cargo deck vibration or individual shocks or impacts inflicted during handling or accidents.

a. Exposure levels. This environment is a function of package geometry and inertial properties, vehicle geometry, and the complex vibratory motion of the vehicle cargo bed. No database exists for input vibration to simulate this environment. However, the test discussed below will provide a generally conservative simulation of the environment.

(1) Two methodology studies (references g and h) determined that a standard package tester (300 rpm, circular synchronous mode) (Annex C, figure 514.5C-5) provides a reasonable simulation of the loose cargo transportation environment. The movement of the package tester bed is a 2.54 cm (1.0 inch) diameter orbital path at 5 Hz (each point on the bed moves in a circular path in a plane perpendicular to the horizontal plane). The test item is allowed to collide with established test setup restraints.

(2) This test is not tailorable and cannot be directly interpreted in terms of materiel design requirements.

b. Exposure durations. A duration of 20 minutes represents 240 km (150 miles) of transportation (encompassing truck, two-wheeled trailer, and tracked vehicle), over the various road profiles found in the transport scenario from the Corps storage area to a Using Unit (see Annex C, table 514.5C-I). Scenario times in the materiel Life Cycle Environment Profile should be ratioed to define exposure times.

2.2.3 Category 6 - Truck/trailer/tracked - large assembly cargo.

For large materiel, it is necessary to recognize that the materiel and the transport vehicle vibrate as a flexible system (see Annex B, paragraph 2.4). In such cases, transportation conditions may be simulated using the actual transport vehicle as the vibration exciter. The test assemblage may consist of materiel mounted in a truck, trailer, tracked vehicle, or materiel mounted in a shelter that is then mounted on a truck, trailer, or dolly set. Ensure the materiel is mounted and secured on the transport vehicle(s) that is used during actual transport. Provide instrumentation to measure vertical vibration of the materiel mounts, cargo floor, or shelter floor. Provide additional instrumentation as needed to determine the vibration of the materiel and critical subassemblies.

Note: This procedure is suitable for measuring or testing for the transportation or ground mobile environment of materiel of any size or weight. For smaller cargo loads, the assemblage should be either the specific design cargo load or the most critical cargo load(s) for the transport vehicle as appropriate.

a. Exposure levels. The assemblage should be in its deployment configuration and mounted on the vehicle for which it was designed. If the assemblage is to be contained in a shelter, it should be installed within the shelter in the deployment configuration. The exposure consists of traversing the transport vehicle over a prepared test course. The test course and vehicle speeds should represent the transportation terrain/road conditions of the Life Cycle Environment Profile. Note that transport vehicle speeds may be limited either by the vehicle's safe operating speed over a specific course profile or by the speed limit set for the specific course. An example based on test surfaces available at the U.S. Army Aberdeen Test Center (reference b) is as follows. Drive the test vehicle over each of the following test surfaces. Operate at the specified speeds unless these exceed safe driving conditions. In this case, define and coordinate maximum safe operating speeds with the authority responsible for the environmental requirements.

SUPERSEDES PAGE 514.5A-4 OF MIL-STD-810F.

	Vehicle Speed MPH	(km/hr)	Course Length Ft.	(m)
(1) Coarse washboard (150 mm waves 2 m apart)	5	(8)	798	(243)
(2) Belgian block	20	(32)	3940	(1201)
(3) Radial washboard (50 mm to 100 mm waves)	15	(24)	243	(74)
(4) Two inch washboard (50 mm)	10	(16)	822	(251)
(5) Three inch spaced bump (75 mm)	20	(32)	764	(233)

b. Exposure durations. Ensure the durations (distances over) of each test course segment/speed combination are in accordance with the scenario(s) of the Life Cycle Environment Profile. If the LCEP in-service road information is not available, the minimum test duration is defined by operation of the vehicle five individual times on the full length of each test course above, or an equal total distance, at the indicated or test plan defined speed(s).

2.2.4 Category 7 - Aircraft - jet.

Cargo vibration environments on jet aircraft are broadband random in nature. The maximum vibrations are usually engine exhaust noise generated and occur during takeoff. Levels drop off rapidly after takeoff to lower level cruise levels that are boundary layer noise generated. These sources are discussed in Annex A, paragraph 2.3.1.

a. Low frequency vibration. Vibration criteria typically begins at 15 Hz. At frequencies below 15 Hz, it is assumed that the cargo does not respond dynamically (see Annex B, paragraph 2.4). Airframe low frequency vibration (gust response, landing impact, maneuvers, etc.) is experienced as steady inertial loads (acceleration). That part of the environment is included in method 513.5.

b. Large cargo items. Cargo items that are large relative to the airframe in dimensions and/or mass may interact with aircraft structural dynamics (see Annex B, paragraph 2.4). This is particularly true if the materiel has natural frequencies below 20 Hz. This interaction may have serious consequences with regard to aircraft loads and flutter. Evaluate materiel that fits this description by the aircraft structural engineers prior to carriage. Contact the System Program Office responsible for the aircraft type for this evaluation.

c. Exposure levels.

(1) Vibration qualification criteria for most jet cargo airplanes are available through the System Program Office responsible for the aircraft type. These criteria are intended to qualify equipment for permanent installation on the airplanes and are conservative for cargo. However, function criteria for equipment located in the cargo deck zones can be used for cargo if necessary. The guidance of Annex A, paragraph 2.3.1 can also be used to generate conservative criteria for specific airplanes and cargo.

(2) Annex C, figure 514.5C-6 shows the cargo compartment zone functional qualification levels of the C-5, C/KC-135, C-141, E-3, KC-10, and T-43 aircraft. Also, shown on the figure is a curve labeled "General Exposure." These are the recommended criteria for jet aircraft cargo. This curve is based on the worst case zone requirements of the most common military jet transports so that even though it does not envelope all peaks in the various spectra, it should still be mildly conservative for cargo. Also, since it does not allow the valleys in the individual spectra, it should cover other jet transports with different frequency characteristics. The envelope represents take-off, the worst case for cargo. Vibration during other flight conditions is substantially less.

d. Exposure durations. When Annex C, figure 514.5C-6 is used, select a duration of one minute per takeoff. Determine the number of takeoffs from the Life Cycle Environment Profile. Otherwise, take durations from the Life Cycle Environment Profile.

2.2.5 Category 8 - Aircraft - propeller.

Cargo vibration environments on propeller aircraft are dominated by relatively high amplitude, approximately sinusoidal spikes at propeller passage frequency and harmonics. Because of engine speed variations, the frequencies of the spikes vary over a bandwidth. There is wide band vibration at lower levels across the spectra. This wide band vibration is primarily due to boundary layer flow over the aircraft. These sources are discussed in Annex A, paragraph 2.3.2.

SUPERSEDES PAGE 514.5A-5 OF MIL-STD-810F.

a. Low frequency vibration. Vibration criteria typically begin at 15 Hz. At frequencies below 15 Hz it is assumed that the cargo does not respond dynamically (see Annex B, paragraph 2.4). Airframe low frequency vibration (gust response, landing impact, maneuvers, etc.) are experienced as steady inertial loads (acceleration). That part of the environment is included in method 513.

b. Large cargo items. Cargo items that are large relative to the airframe in dimensions and/or mass may interact with aircraft structural dynamics (see Annex B, paragraph 2.4). This is particularly true if the materiel has natural frequencies below 20 Hz. This interaction may have serious consequences with regard to aircraft loads and flutter. Materiel that fits this description must be evaluated by aircraft structural engineers prior to carriage. Contact the System Program Office responsible for the aircraft type for this evaluation.

c. Exposure levels. Contact the System Program Office responsible for the aircraft for vibration criteria. If no criteria are available, measurements of cargo deck vibration in the aircraft are recommended. As a last resort the guidance of Annex A, paragraph 2.3.2 can be used.

d. Exposure durations. Take durations from the Life Cycle Environment Profile.

2.2.6 Category 9 - Aircraft - helicopter.

a. Environment characterization. Vibration of cargo carried in helicopters is characterized by a continuous wideband, low-level background with strong narrowband peaks superimposed. This environment is a combination of many sinusoidal or near sinusoidal components due to main and tail rotors, rotating machinery and low-level random components due to aerodynamic flow. These sources are discussed in Annex A, paragraph 2.3.3.

b. Sling loads. Cargo carried as sling loads below a helicopter is normally subjected to low level random vibration due to turbulent flow around the cargo with narrow band peaks due to helicopter main rotor blade passage. In addition, there will be low frequency (primarily vertical) motions due to the sling suspension modes (similar to vibration isolator modes, see Annex B, paragraph 2.4.2). Choose slings based on sling stiffness and suspended mass such that suspension frequencies (f_s) do not coincide with helicopter main rotor forcing frequencies (f_i). Ensure suspension frequencies are not within a factor of two of forcing frequencies ($f_s < f_i / 2$ or $f_s > 2 f_i$). Determine main rotor forcing frequencies (shaft rotation frequency, blade passage frequency, and harmonics) for several helicopters from Annex C, table 514.5C-IV. When inappropriate combinations of cargo and slings are used, violent vibration can occur. The cargo is likely to be dropped to protect the helicopter.

c. Exposure levels.

(1) Helicopter internal cargo vibration is a complex function of location within the helicopter cargo bay and the interaction of the cargo mass and stiffness with the helicopter structure. Measurements of the vibration of the cargo in the specific helicopter are necessary to determine vibration with any accuracy. Approximate criteria may be derived from Annex A, paragraph 2.3.3. Additional tailored helicopter vibration schedules are provided in reference d.

(2) There is no current source of data to define slung cargo vibration levels. However, these levels should be low and should not be a significant factor in design of materiel that has a reasonable degree of ruggedness. Materiel that has been designed for vibration levels and durations equal to or exceeding the suggested minimum integrity test of Annex A, paragraph 2.4.1 should not be affected by this environment.

(3) Exposure durations. Take durations from the Life Cycle Environment Profile or from reference f.

2.2.7 Category 10 - Ship - surface ship.

The vibration environment of cargo carried in ships is fundamentally the same as for materiel installed on ships. See Annex A, paragraph 2.3.10.

REPRINTED WITHOUT CHANGE.

(b) In some instances, a store is carried in one configuration or position until use. Just prior to use, the configuration or position may change, for example, a weapon carried on a rotary launcher inside a weapons bay of a large bomber. The weapon moves from clock position to clock position as other weapons on the launcher are launched. The weapon is exposed to the bay open environment either each time another weapon is launched, or for a relatively long period while several are launched. Another example is a weapon that is extended out of the bay on the launch mechanism prior to launch. Here the environment will change considerably with position. A third example is an optical sensor pod. This type of store can be carried internally, extended into the air stream, configuration changed (e.g., covers over optical windows retract), operated, configuration changed back, and retracted into the closed bay many times in a lifetime. Such variations in environment and configuration must be accounted for.

Note: Door opening, position changes, configuration changes, door closing, etc., should be expected to happen rapidly. Each of these events and possibly a whole sequence of events can happen rapidly enough so that they should be treated as transient (see Annex B, paragraph 2.3.4 and Method 516.5) rather than steady state vibration.

c. Free flight. Vibration will be experienced by stores that are deployed from aircraft, ground vehicles, or surface ships. The sources of vibration for the free flight environment are engine exhaust noise, vibration and noise produced by internal equipment, and boundary layer turbulence.

(1) Generally, engine exhaust noise levels will be too low to excite significant vibration in the store. This is because the engine only operates when the ratio of the exhaust velocity to the ambient air speed is low and (except in unusual cases) the exhaust plume is behind the store.

(2) Vibration produced by onboard materiel can be severe in specific cases. Examples are ram air turbines, engines, and propellers. There is no general basis for predicting store vibrations from such sources. Each case must be evaluated individually and it is likely that measurements will be required.

(3) Boundary layer turbulence induced vibration should be as for captive carriage except that store vibration mode frequencies may shift, flight dynamic pressures may be different, and turbulence from the carrier aircraft and nearby stores will be absent.

d. Exposure levels. Select test levels and spectra for three of the vibration environments, captive flight, free flight, and buffet from Annex C, table 514.5C-V and figures 514.5C-12 and 514.5C-13. The use of these tables and figures is suggested only when there is an absence of satisfactory flight measurements. Except for buffet portions, these criteria are closely based on references u, v, and w. These document the results of an extensive study and include a large amount of information and insight. The buffet criteria are based on reference x and additional measurements and experience with the F-15 aircraft. It represents F-15 wing pylon buffet that is the worst known buffet environment. F-15 fuselage store stations buffet environments are generally less severe. Criteria for the other environments must be determined for each specific case.

e. Exposure durations. Take durations from the Life Cycle Environment Profile.

2.3.5 Category 16 - Aircraft stores - materiel, jet aircraft.

Materiel installed within a jet aircraft store will experience the store vibration discussed in Annex A, paragraph 2.3.4. The input exposure levels for materiel within the store are essentially the same as response levels of the store. If gunfire, cavity resonance, buffet-maneuver, and free-flight conditions occur for the store, the materiel will also be exposed to these conditions.

a. Exposure levels. Base vibration criteria on in-flight measurements when possible. If satisfactory flight measurements are not available, derive levels from Annex C, table 514.5C-V and figure 514.5C-14. Note: use input control for vibration testing of this materiel rather than response control (see paragraph 4.2.1).

b. Exposure durations. Take durations from the Life Cycle Environment Profile.

SUPERSEDES PAGE 514.5A-13 OF NOTICE 2 TO MIL-STD-810F.

2.3.6 Category 17 - Aircraft stores - assembled/materiel, propeller aircraft.

There is no known source of general guidance or measured data for the vibration of propeller aircraft stores (except gunfire induced, see Method 519.5). However, since the excitation sources are the same, it seems likely that store vibration will be similar to that of the carrying aircraft. See Annex A, paragraph 2.3.2; and Annex B, paragraph 2.3.3 for a discussion of this vibration. Maneuver buffet vibration experienced by stores of highly-maneuverable propeller aircraft should be similar to that experienced by jet aircraft stores. See the buffet vibration portion of Annex A, paragraph 2.3.4.

a. Exposure levels. There is no known source of data. For accurate definition of propeller aircraft store vibration, measurement of the actual environment is essential. The criteria of Annex C, table 514.5C-II and figure 515.5C-9, may be used to develop preliminary estimates of general vibration. The criteria of Annex C, figure 514.5C-13, may be applied for maneuver buffet vibration.

b. Exposure durations. Take durations from the Life Cycle Environment Profile.

2.3.7 Category 18 - Aircraft stores - assembled/materiel, helicopter.

Complex periodic waveforms characterize the service environment encountered by assembled stores carried externally on helicopters. Unlike stores carried on fixed-wing aircraft, externally-mounted helicopter stores receive little aerodynamic excitation, particularly when compared with the rotor-induced vibration. Thus, most of the vibratory energy reaches the store and materiel through the attachment points between the aircraft and the store. Some excitation, however, is added along the entire store structure due to periodic rotor-induced pressure fluctuations. The result is a complex response, unique to the particular aircraft-store configuration. Therefore, realistic definition of the environment depends almost totally upon the use of in-flight vibration measurements. For stores exposed to gunfire, refer to Method 519.5.

a. Exposure levels. Derive exposure levels for helicopter-carried store materiel from field measurements (reference f contains criteria for specific helicopters). When measured data are not available, initial estimates can be derived from Annex C, figures 514.5C-10 and 514.5C-11, and table 514.5C-IV, prior to acquisition of field data. These levels are intended as worst-case environments and represent environments for which it may be difficult to develop vibration sensitive materiel. Materiel costs are often strongly influenced by the performance required in a vibration environment. Consequently, field-measurement-based vibration criteria are very important. To determine levels, locate the store relative to the helicopter zones as shown in Annex C, figure 514.5C-11. Most stores will be inside a vertical projection of the main rotor disc. Source frequencies of the main rotor should be used to determine the values of A_1, A_2, A_3, and A_4 (see Annex C, table 514.5C-IV). Fundamental main rotor source frequencies of several helicopters are given in table 514.5C-IV.

b. Exposure durations. When measured data are used to establish exposure levels, take durations from the Life Cycle Environment Profile. When levels are derived from Annex C, figures 514.5C-10 and 514.5C-11, and table 514.5C-IV, use a duration of four (4) hours in each of three (3) orthogonal axes for a total time of twelve (12) hours. This represents a 2500-hour operational life. Use the fatigue relationship of Annex B, paragraph 2.2, to trade test time for exposure level. Perform the calculation separately for each sinusoid and each segment of the broadband background.

2.3.8 Category 19 - Missiles - Tactical missiles (free flight).

There is no known source of general guidance or measured data for tactical missile carriage or launch vibration environments. Environments for jet aircraft, propeller aircraft, and helicopter-carried missiles are discussed in Annex A, paragraphs 2.3.4 through 2.3.7. Tactical carriage ground environments are discussed in Annex A, paragraph 2.3.9. Free flight environments are covered in Annex A, paragraphs 2.3.4.c and 2.3.5, in regard to aircraft-carried missiles. These environments should be generally applicable to tactical missiles during free flight mission segments.

REPRINTED WITHOUT CHANGE.

ANNEX C

TABLES AND FIGURES

1. SCOPE.

1.1 Purpose.

This Annex provides tables and figures associated with the main body, Annex A, and Annex B of method 514.5.

2. TABLES.

TABLE 514.5C-I. Typical mission / field transportation scenario.

PORT STAGING AREA (PSA)	CORPS STAGING AREA (CSA)	FORWARD SUPPLY POINT (FSP)	USING UNIT (USU)	EXPENDITURE
600 km (375 miles)	200 km (125 miles)	26 km (16 miles)	26 km (16 miles)	
Trucks, Semitrailers		Two-Wheeled Trailers	Two-Wheeled Trailers or M548 Cargo Carrier	

TABLE 514.5C-II. Propeller aircraft vibration exposure.

MATERIEL LOCATION 1/, 2/, 3/, 4/	VIBRATION LEVEL Lo (g^2/Hz)
In fuselage or wing forward of propeller	0.10
Within one propeller blade radius of propeller passage plane	1.20
In fuselage or wing aft of propeller	0.30
In engine compartment, empennage, or pylons	0.60

1/ For Materiel mounted to external skin, increase level by 3 dB.
2/ f_0 = blade passage frequency (propeller rpm times number of blades) (Hz).
$f_1 = 2 \times f_0$ $f_2 = 3 \times f_0$ $f_3 = 4 \times f_0$
3/ Spike bandwidths are ± 5% of center frequency.
4/ C-130 Aircraft
3 blade propeller - f_0 = 51 Hz
4 blade propeller - f_0 = 68 Hz
6 blade propeller - f_0 = 102 Hz (C-130J)

REPRINTED WITHOUT CHANGE.

TABLE 514.5C-III. Jet aircraft vibration exposure.

$$W_0 = W_A + \sum_1^n (W_J)$$

W_0, W_A, W_J - Exposure levels in acceleration spectral density (g^2/Hz).

Aerodynamically induced vibration

$$W_A = a \times b \times c \times (q)^2$$

Jet engine noise induced vibration

$$W_J = \{[0.48 \times a \times d \times \cos^2(\theta)/R] \times [D_c \times (V_c / V_r)^3 + D_f \times (V_f / V_r)^3]\}$$

a	-	Platform / Materiel interaction factor (see Annex B, paragraph 2.4). Note that this factor applies to W_o and not to the low frequency portion (15 Hz to break) of figure 514.5C-8.
	=	1.0 for materiel mounted on vibration isolators (shock mounts) and materiel weighing less than 36 kg.
	=	$1.0 \times 10^{(0.6 - W/60)}$ for materiel weighing between 36 and 72.12 kg.(w = weight in kg)
	=	0.25 for materiel weighing 72.12 kg or more.

b	-	Proportionality factor between vibration level and dynamic pressure (SI units).
	=	2.96×10^{-6} for materiel mounted on cockpit instrument panels.
	=	1.17×10^{-5} for cockpit materiel and materiel in compartments adjacent to external surfaces that are smooth and free from discontinuities.
	=	6.11×10^{-5} for materiel in compartments adjacent to or immediately aft of external surface discontinuities (cavities, chines, blade antennae, speed brakes, etc.), fuselage aft of wing trailing edge, wing, empennage, and pylons.
c	-	Mach number correction. Note that this factor applies to W_0 and not to the low frequency portion (15 to TBD Hz at 0.04 g^2/Hz) of figure 514.5C-8. (Annex A, paragraph. 2.3.1)
	=	1.0 for $0 \le$ Mach ≤ 0.9
	=	$(-4.8M + 5.32)$ for $0.9 \le$ Mach ≤ 1.0 (where M = Mach number)
	=	0.52 for Mach number greater than 1.0
q	-	Flight dynamic pressure, kN/m^2 (lb/ft^2). (See Annex B, para. 2.6.1 and table 5145C-VI)
$\sum_1^n$	-	Jet noise contribution is the sum of the W_J values for each engine.
d	-	Afterburner factor.
	=	1.0 for conditions where afterburner is not used or is not present.
	=	4.0 for conditions where afterburner is used.
R	-	Vector distance from center of engine exhaust plane to materiel center of gravity, m (ft).
θ	-	Angle between R vector and engine exhaust vector (aft along engine exhaust centerline), degrees For $70° < \theta \le 180°$ use $70°$.
D_c	-	Engine core exhaust diameter, m (ft).
D_f	-	Engine fan exhaust diameter, m (ft).
V_r	-	Reference exhaust velocity, m/sec (ft/sec).
	=	564 m/sec
V_c	-	Engine core exhaust velocity Engine core exhaust velocity (without afterburner), m/sec (ft/sec).
V_f	-	Engine fan exhaust velocity (without afterburner), m/sec (ft/sec).

If Dimensions are in feet and pounds then:

a	=	1.0 for materiel mounted on vibration isolators (shock mounts) and materiel weighing less than 80 lb.
	=	$1.0 \times 10^{(0.60 - 0.0075 W)}$ for materiel weighing between 80 and 160 lb.
	=	0.25 for materiel weighing 160 lb. or more.
b	=	6.78×10^{-9}, 2.70×10^{-8}, or 1.40×10^{-7} in the order listed above.
V_r	=	1850 feet / second

SUPERSEDES PAGE 514.5C-2 OF MIL-STD-810F.

TABLE 514.5C-IV. Helicopter vibration exposure.

MATERIEL LOCATION	RANDOM LEVELS	SOURCE FREQUENCY (f_x) RANGE (Hz)	PEAK ACCELERATION (A_x) at f_x (GRAVITY UNITS (g))
General	W_0 = 0.0010 g^2/Hz W_1 = 0.010 g^2/Hz f_t = 500 Hz	3 to 10 10 to 25 25 to 40 40 to 50 50 to 500	0.70 /(10.70 – f_x) 0.10 x f_x 2.50 6.50 – 0.10 x f_x 1.50
Instrument Panel	W_0 = 0.0010 g^2/Hz W_1 = 0.010 g^2/Hz f_t = 500 Hz	3 to 10 10 to 25 25 to 40 40 to 50 50 to 500	0.70 /(10.70 – f_x) 0 .070 x f_x 1.750 4.550 – 0.070 x f_x 1.050
External Stores	W_0 = 0.0020 g^2/Hz W_1 = 0.020 g^2/Hz f_t = 500 Hz	3 to 10 10 to 25 25 to 40 40 to 50 50 to 500	0.70 /(10.70 – f_x) 0.150 x f_x 3.750 9.750 – 0.150 x f_x 2.250
On/Near Drive System Elements	W_0 = 0.0020 g^2/Hz W_1 = 0.020 g^2/Hz f_t = 2000 Hz	5 to 50 50 to 2000	0.10 x f_x 5.0 + 0.010 x f_x

Main or Tail Rotor Frequencies (Hz) Determine 1P and 1T from Specific Helicopter or from Table (below).			Drive Train Component Rotation Frequency (Hz) Determine 1S from Specific Helicopter and Component.	
f_1 = 1P	f_1 = 1T	fundamental	f_1 = 1S	fundamental
$f_2 = n \times 1P$	$f_2 = m \times 1T$	blade passage	$f_2 = 2 \times 1S$	1st harmonic
$f_3 = 2 \times n \times 1P$	$f_3 = 2 \times m \times 1T$	1st harmonic	$f_3 = 3 \times 1S$	2nd harmonic
$f_4 = 3 \times n \times 1P$	$f_4 = 3 \times m \times 1T$	2nd harmonic	$f_4 = 4 \times 1S$	3rd harmonic

Helicopter	MAIN ROTOR		TAIL ROTOR	
	Rotation Speed 1P (Hz)	Number of Blades n	Rotation Speed 1T (Hz)	Number of Blades m
AH-1	5.40	2	27.7	2
AH-6J	7.95	5	47.3	2
AH-6M	7.92	6	44.4	4
AH-64 (early)	4.82	4	23.4	4
AH-64 (late)	4.86	4	23.6	4
CH-47D	3.75	3	2 main rotors and no tail rotor	
MH-6H	7.80	5	47.5	2
OH-6A	8.10	4	51.8	2
OH-58A/C	5.90	2	43.8	2
OH-58D	6.60	4	39.7	2
UH-1	5.40	2	27.7	2
UH-60	4.30	4	19.8	4

SUPERSEDES PAGE 514.5C-3 OF MIL-STD-810F.

TABLE 514.5C-V. Jet aircraft external store vibration exposure.

$$W_1 = 5 \times 10^{-3} \times K \times A_1 \times B_1 \times C_1 \times D_1 \times E_1 ; \quad (g^2/Hz) \quad \underline{1}/$$

$$W_2 = H \times (q/\rho)^2 \times K \times A_2 \times B_2 \times C_2 \times D_2 \times E_2 ; \quad (g^2/Hz) \quad \underline{1}/$$

$M \le 0.90$, $K = 1.0$; $0.90 \le M \le 1.0$, $K = -4.8 \times M + 5.32$; $M \ge 1.0$, $K = 0.52$ 2/

$f_1 = 10^5 C(t/R^2)$, (Hz) 3/, 4/, 5/; $f_2 = f_1 + 1000$, (Hz) 3/

$f_0 = f_1 + 100$, (Hz) 6/, 7/

Configuration	Factors		Configuration	Factors	
Aerodynamically clean	A_1	A_2		B_1	B_2
Single store	1	1	Powered missile, aft half	1	4
Side by side stores	1	2	Other stores, aft half	1	2
Behind other store(s)	2	4	All stores, forward half	1	1
Aerodynamically dirty 8/	C_1	C_2		D_1	D_2
Single and side by side	2	4	Field-assembled sheet metal		
Behind other store(s)	1	2	fin / tailcone unit	8	16
Other stores	1	1	Powered missile	1	1
	E_1	E_2	Other stores	4	4
Jelly-filled fire bombs	1/2	1/4			
Other stores	1	1			

M – Mach number.
H – Constant = 5.59 (metric units) = 5×10^{-5} (English units).
C – Constant = 2.54×10^{-2} (metric units) = 1.0 (English units).
q – Flight dynamic pressure (see table 514.5C-VI) – kN/m^2 (lb/ft^2).
ρ – Store weight density (weight/volume) - kg/m^3 (lb/ft^3).
Limit values of ρ to $641 \le \rho \le 2403$ kg/m^3 ($40 \le \rho \le 150$ lb/ft^3).
t – Average thickness of structural (load carrying) skin - m (in).
R – Store characteristic (structural) radius m (in) (Average over store length).
= Store radius for circular cross sections.
= Half or major and minor diameters for elliptical cross section.
= Half or longest inscribed chord for irregular cross sections.

1/ – When store parameters fall outside limits given, consult references.
2/ – Mach number correction (see Annex B,
3/ – Limit f_1 to $100 \le f_1 \le 2000$ Hz
4/ – Free fall stores with tail fins, $f_1 = 125$ Hz
5/ – Limit length ratio to: $0.0010 \le C(t/R^2) \le 0.020$
6/ – $f_o = 500$ Hz for cross sections not circular or elliptical
7/ – If $f_0 \ge 1200$ Hz, then use $f_0 = 2000$ Hz
8/ – Configurations with separated aerodynamic flow within the first ¼ of the store length. Blunt noses, optical flats, sharp corners, and open cavities are some potential sources of separation. Any nose other than smooth, rounded, and gently tapered is suspect. Aerodynamics engineers should make this judgment.

Representative parameter values

Store type	Max q		ρ		f_1	f_2
	kN/m^2	(lb/ft^2)	kg/m^3	(lb/ft^3)	Hz	Hz
Missile, air to ground	76.61	(1600)	1602	(100)	500	1500
Missile, air to air	76.61	(1600)	1602	(100)	500	1500
Instrument pod	86.19	(1800)	801	(50)	500	1500
Dispenser (reusable)	57.46	(1200)	801	(50)	200	1200
Demolition bomb	57.46	(1200)	1922	(120)	125	1100
Fire bomb	57.46	(1200)	641	(40)	100	1100

REPRINTED WITHOUT CHANGE.

TABLE 514.5C-VI. Dynamic pressure calculation.

(See Annex B, paragraph 2.6.2 for definitions and details)

1. Airspeed may be used at Mach numbers less than one.
2. Mach number may be used at any airspeed.
3. Unless specifically stated otherwise, assume airspeeds to be in calibrated airspeed (K_{cas}).
4. When airspeed values are given as indicated airspeed (K_{ias}), assume K_{ias} equal K_{cas}.
5. Altitude (h) is pressure altitude and not height above terrain.

$$q = 2.5\ \rho_o \sigma V_a^2 [(1/\delta\{[1 + 0.2(V_{cas}/V_{ao})^2]^{3.5} - 1\} + 1)^{2/7} - 1]$$

$$q = 1/2\ \rho_o \sigma V_a^2 M^2 \qquad q = 1/2\ \rho_o V_{eas}^2 \qquad q = 1/2\ \rho_o \sigma V_{tas}^2$$

	$h \le 11000$ m	$11000 \le h \le 20056$ m	$h \le 36\,089$ ft	$36089 \le h \le 65800$ ft
θ	$1 - 2.2556 \times 10^{-5}\ h$	0.75189	$1 - 6.8750 \times 10^{-6} \times h$	0.75189
δ	$\theta^{5.2561}$	$0.2234\ e^{\phi}$	$\theta^{5.2561}$	$0.2234\ e^{\phi}$
σ	$\theta^{4.2561}$	$0.2971\ e^{\phi}$	$\theta^{4.2561}$	$0.2971\ e^{\phi}$
V_a	$V_{ao} \times \theta^{1/2}$	295.06	$V_{ao} \times \theta^{1/2}$	968.03
ϕ	-------	$(11000 - h) / 6342.0$	------	$(36089 - h)/20807$
ρ_o	1.2251×10^{-3}	1.2251×10^{-3}	2.377×10^{-3}	2.377×10^{-3}
V_{ao}	340.28	------	1116.4	------
T_o	288.16°K	------	518.69°R	------

V_{cas} – Calibrated airspeed, m/sec (ft/sec)
V_{ias} – Indicated airspeed, m/sec (ft/sec)
V_{eas} – Equivalent airspeed, m/sec (ft/sec)
V_{tas} – True airspeed, m/sec (ft/sec)
($V_{tas} = V_{eas} = V_{cas} = V_{ias}$ at sea level)
V_{ao} – Sea level speed of sound, m/sec (ft/sec)
V_a – Local speed of sound, m/sec (ft/sec)
M – Mach number
q – Dynamic pressure, kN/m^2 (lb/ft^2)
h – Pressure altitude, m (ft), (standard atmosphere)
T_o – Sea level atmospheric temperature °K (°R)

ρ_o – Sea level atmospheric density kg/m^3 ($slugs/ft^3$ or $lb\ sec^2/ft^4$)
δ – Ratio of local atmospheric pressure to sea level atmospheric pressure
σ – Ratio of local atmospheric density to sea level atmospheric density (standard atmosphere)
θ – Ratio of temperature at altitude to sea level temperature (standard atmosphere)
ϕ – Stratospheric altitude variable

Airspeeds are typically expressed in knots as follows:

V_{kcas} - knots calibrated air speed
V_{kias} - knots indicated air speed
V_{keas} - knots equivalent air speed
V_{ktas} - knots true air speed

[knots = nautical miles per hour (knots x 0.51478 = m/sec)(knots x 1.6889 = ft/sec)]

Calculation Check Cases

Airspeed	h = 3048 m	h = 10000 ft	h = 15240 m	h = 50000 ft
500 V_{kcas}	q = 38.5 kN/m^2	q = 804 lb/ft^2	q = 23.8 kN/m^2	q = 497 lb/ft^2
500 V_{ktas}	q = 30.0 kN/m^2	q = 626 lb/ft^2	q = 6.18 kN/m^2	q = 129 lb/ft^2
M = 0.8	q = 31.2 kN/m^2	q = 652 lb/ft^2	q = 5.20 kN/m^2	q = 109 lb/ft^2
500 V_{keas}	q = 40.6 kN/m^2	q = 848 lb/ft^2	at all altitudes	

SUPERSEDES PAGE 514.5C-5 OF NOTICE 2 TO MIL-STD-810F.

TABLE 514.5C-VII. Break points for curves of figures 514.5C-1 through 514.5C-3.

U. S. highway truck vibration exposures figure 514.5C-1

vertical		transverse		longitudinal	
Hz	g²/Hz	Hz	g²/Hz	Hz	g²/Hz
10	0.01500	10	0.00013	10	0.00650
40	0.01500	20	0.00065	20	0.00650
500	0.00015	30	0.00065	120	0.00020
1.04 g rms		78	0.00002	121	0.00300
		79	0.00019	200	0.00300
		120	0.00019	240	0.00150
		500	0.00001	340	0.00003
		0.204 g rms		500	0.00015
				0.740 g rms	

Composite two-wheeled trailer vibration exposures figure 514.5C-2

vertical		transverse		longitudinal	
Hz	g²/Hz	Hz	g²/Hz	Hz	g²/Hz
5	0.2221	5	0.0451	5	0.0536
8	0.5432	6	0.0303	8	0.1129
10	0.0420	7	0.0761	13	0.1102
13	0.0256	13	0.0127	13	0.0137
15	0.0726	15	0.0327	16	0.0303
16	0.0249	16	0.0134	18	0.0193
19	0.0464	21	0.0102	19	0.0334
20	0.0243	23	0.0261	20	0.0184
21	0.0226	25	0.0090	23	0.0369
23	0.0362	26	0.0090	27	0.0079
36	0.0416	30	0.0137	30	0.0203
41	0.0103	34	0.0053	31	0.0133
45	0.0241	36	0.0079	36	0.0060
33	0.0353	46	0.0039	49	0.0042
35	0.0237	50	0.0067	53	0.0077
36	0.0400	55	0.0042	56	0.0036
41	0.0102	104	0.0033	59	0.0062
45	0.0232	107	0.0044	62	0.0044
50	0.0113	111	0.0032	65	0.0121
94	0.0262	147	0.0029	71	0.0026
107	0.1866	161	0.0052	93	0.0115
114	0.0220	175	0.0022	107	0.1344
138	0.0864	233	0.0013	115	0.0151
145	0.0262	257	0.0027	136	0.0836
185	0.0595	314	0.0016	149	0.0261
260	0.0610	333	0.0053	157	0.0485
320	0.0104	339	0.0009	164	0.0261
339	0.0256	382	0.0017	183	0.0577
343	0.0137	406	0.0008	281	0.0030
357	0.0249	482	0.0019	339	0.0184
471	0.0026	500	0.0007	382	0.0014
481	0.0059	1.29 g rms		439	0.0051
500	0.0017			462	0.0019
3.99 g rms				485	0.0044
				500	0.0014
				2.73 g rms	

Composite wheeled vehicle vibration exposures figure 514.5C-3

vertical		transverse		longitudinal	
Hz	g²/Hz	Hz	g²/Hz	Hz	g²/Hz
5	0.2366	5	0.1344	5	0.0593
8	0.6889	7	0.1075	8	0.0499
12	0.0507	8	0.1279	15	0.0255
21	0.0202	14	0.0366	16	0.0344
23	0.0301	16	0.0485	20	0.0134
24	0.0109	17	0.0326	23	0.0608
26	0.0150	19	0.0836	25	0.0148
49	0.0038	23	0.0147	37	0.0040
51	0.0054	116	0.0008	41	0.0059
61	0.0023	145	0.0013	49	0.0016
69	0.0111	164	0.0009	63	0.0011
74	0.0029	201	0.0009	69	0.0040
78	0.0048	270	0.0051	78	0.0008
84	0.0033	298	0.0021	94	0.0020
90	0.0052	364	0.0099	98	0.0013
93	0.0034	375	0.0019	101	0.0025
123	0.0083	394	0.0073	104	0.0014
160	0.0041	418	0.0027	111	0.0024
207	0.0055	500	0.0016	114	0.0014
224	0.0139			117	0.0020
245	0.0031	1.62 g rms		121	0.0012
276	0.0129			139	0.0024
287	0.0036			155	0.0021
353	0.0027			161	0.0034
375	0.0049			205	0.0042
500	0.0010			247	0.0303
				257	0.0027
2.20 g rms				293	0.0092

SUPERSEDES PAGE 514.5C-6 OF MIL-STD-810F.

TABLE 514.5C-VII. Break points for curves of figures 514.5C-1 through 514.5C-3 – Continued.

Composite wheeled vehicle vibration exposures figure 514.5C-3					
vertical		transverse		longitudinal	
Hz	g^2/Hz	Hz	g^2/Hz	Hz	g^2/Hz
				330	0.0116
				353	0.0231
				379	0.0083
				427	0.0220
				500	0.0014
				2.05 g rms	

TABLE 514.5C-VIII. Break points for figure 514.5C-6.

C-5			**KC-10**			**C/KC-135, E/KE-3**			**C-17**		
Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct
15	0.003		15	0.0038		10	0.002		5	0.005	
1000	0.003		1000	0.0038		66.897	0.002		66.897	0.005	
		-6			-6			6			6
2000	7.5E-4		2000	9.5E-4		150	0.01		150	0.025	
rms = 2.11 g			rms = 2.38 g			500	0.01		500	0.025	
								-6			-6
						2000	6.3E-4				
						rms = 2.80 g			2000	1.6E-3	
									rms = 4.43 g		

C-141			**T-43 (737)**			**General Exposure**		
Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct
15	0.002		10	0.015		150.01		
39.086	0.002		20	0.015		105.94	0.01	
		4			-9			6
300	0.03		34.263	0.003		150	0.02	
700	0.03		46.698	0.003		500	0.02	
		-9			9			-6
2000	0.0013		80	0.015		2000	1.3E-3	
rms = 5.01g			500	0.015		rms = 4.02 g		
					-6			
			2000	9.5E-4				
			rms = 3.54 g					

Note: C-17 levels apply to the primary cargo floor. Levels for items carried on the aft ramp are higher.

SUPERSEDES PAGE 514.5C-7 OF NOTICE 2 TO MIL-STD-810F.

3. FIGURES

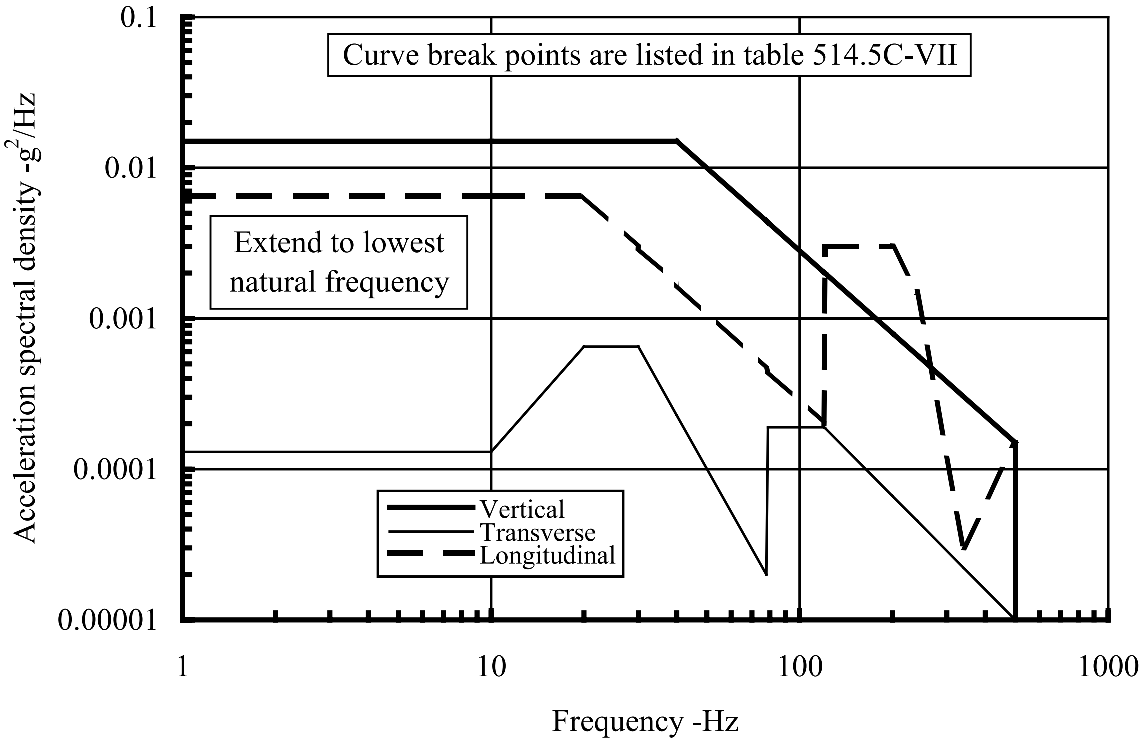


FIGURE 514.5C-1. U. S. highway truck vibration exposure.

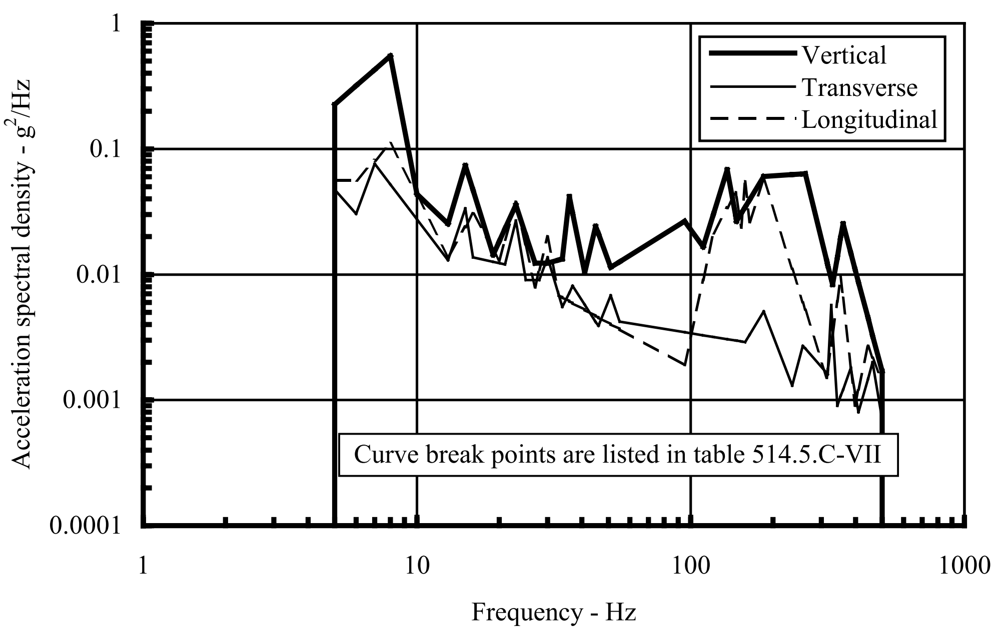


FIGURE 514.5C-2. Composite two-wheeled trailer vibration exposure.

REPRINTED WITHOUT CHANGE.

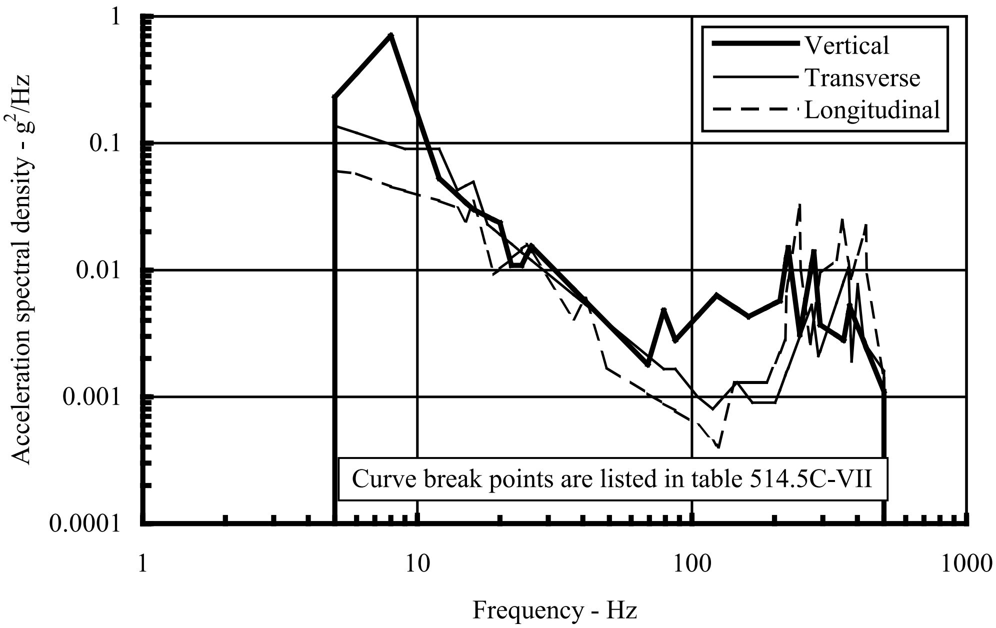


FIGURE 514.5C-3. Composite wheeled vehicle vibration exposure.

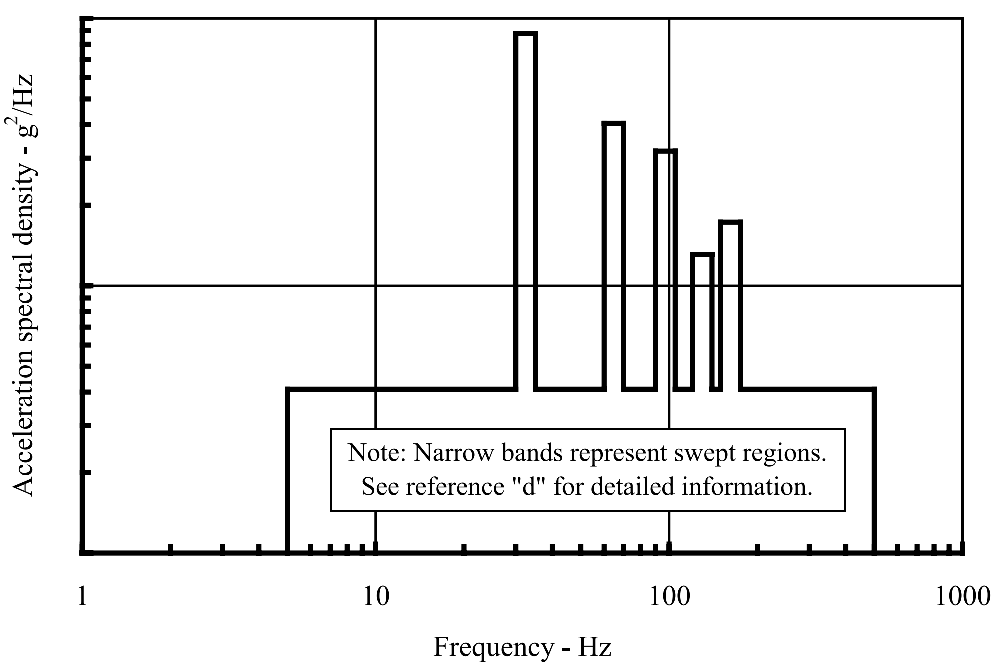


FIGURE 514.5C-4. Tracked vehicle representative spectral shape.

SUPERSEDES PAGE 514.5C-9 OF NOTICE 2 TO MIL-STD-810F.

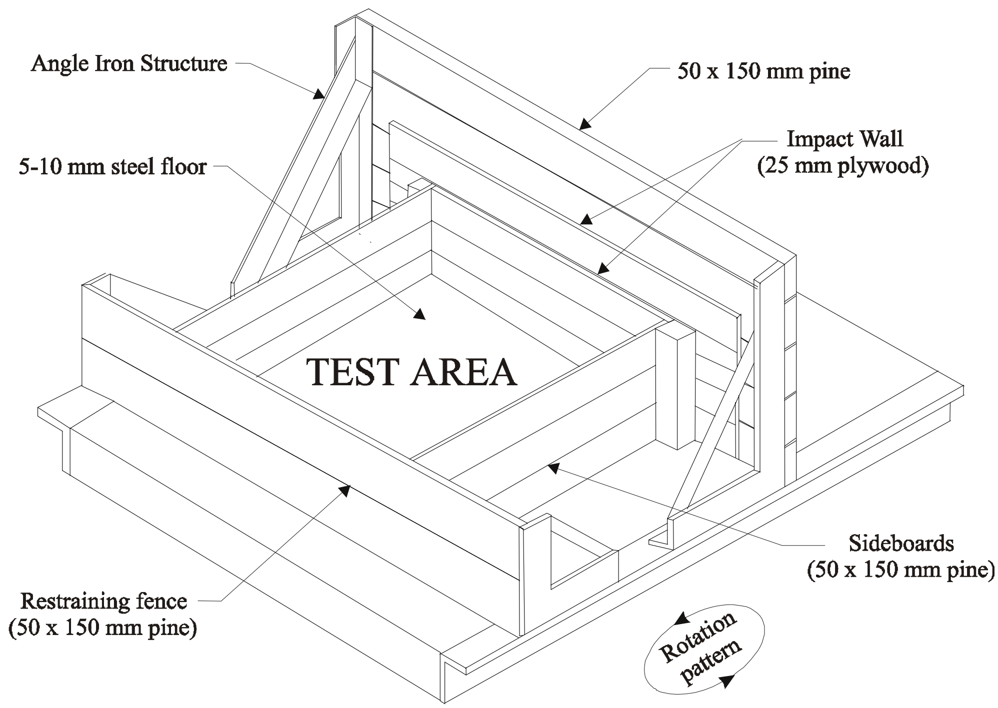


FIGURE 514.5C-5. Loose cargo test setup.

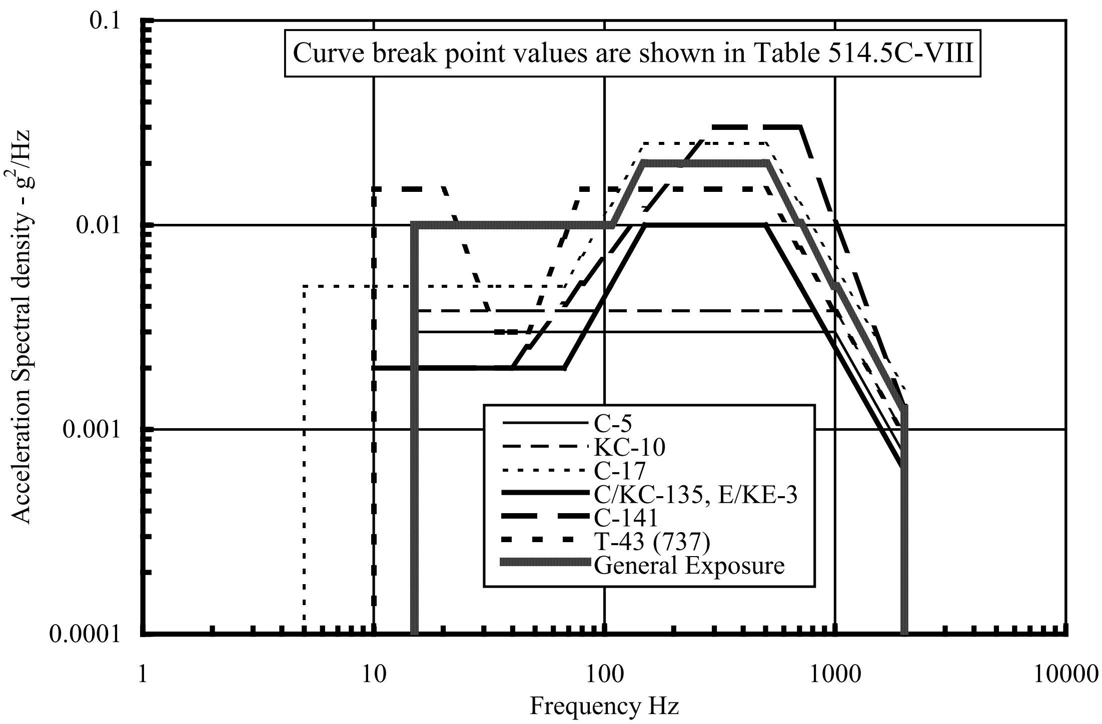


FIGURE 514.5C-6. Jet aircraft cargo vibration exposure.

REPRINTED WITHOUT CHANGE.

Step 4. Mount the test item in the fixture. Inspect and functionally test the item to document the pre-test condition.

Step 5. Perform the shock test at the selected level and examine the recorded data to assure the test maximax acceleration SRS is within tolerance.

Step 6. Visually examine and functionally test the materiel to determine if damage has occurred. If damage is found or pre-established goals have been reached, go to Step 10.

Step 7. If it is required to determine the fragility of the test item in more than one axis then proceed to test the item in the other axes (before changing the peak maximax acceleration SRS level).

Step 8. If the test item integrity is preserved, select the next predetermined peak maximax acceleration SRS level.

Step 9. Repeat steps 5 through 8 until the test objectives have been met.

Step 10. Document the results recording the peak maximax acceleration SRS to define the fragility level. If the test item is damaged in one axis during test, then replace the test item with an identically configured test item and proceed in testing starting at Step 4.

4.5.4.4 Analysis of results.

Refer to the guidance in Part One, paragraph 5.14, to assist in the evaluation of the test results. The outcome of a successful fragility test is one specified measurement level of test item failure to each test axis. Consider that if the test item fails either functionally or structurally at the lowest level of testing and there is no provision for testing at lower levels, then the test item's fragility level is indeterminate.

4.5.5 Procedure IV - Transit Drop.

The intent of this test is to determine the structural and functional integrity of the materiel to a transit drop in its transit or combination case. Perform all tests with a quick release hook or drop tester. In general, there is no instrumentation calibration for the test and measurement information is minimized, however, if measurements are made, the maximax acceleration SRS and the pseudovelocity SRS will define the results of the test, along with the measurement amplitude time history.

4.5.5.1 Controls.

Test levels for this test are shown in table 516.5-VI. Test the item in the same configuration that is used in a transportation, handling or a combat situation. For test items under 45kg (100 pounds), the 26-drop requirement (table 516.5-VI) may be divided among up to five samples of the same test item in any combination. Toppling of the item following impact will occur in the field and, therefore, toppling of the test item following its initial impact should not be restrained as long as the test item does not leave the required drop surface. Levels for this test were set by considering how materiel in the field might commonly be dropped. (For example, a light item might be carried by one man, chest high; thus it could drop 122 cm (48 inches).) Field data have shown that a typical piece of man-portable materiel will be dropped from heights up to 122 cm an average of four to six times during its life cycle. The 26-drop requirement exists to ensure each vulnerable position (faces, edges, and corners) of a typical test item receives an impact. Conduct drops for equipment -5 up to 454 Kg (1000 pounds) and having its largest dimension less than 91 cm (36 inches) using a quick release hook, or drop tester. For the floor or barrier receiving the impact use two-inch plywood backed by concrete. For equipment over 454 Kg, use a concrete floor or barrier.

4.5.5.2 Test tolerances.

Ensure the test height of drop is within 2.5% of the height of drop as specified in table 516.5-VI.

SUPERSEDES PAGE 516.5-27 OF MIL-STD-810F.

4.5.5.3 Procedure IV.

Step 1. After performing a visual inspection and operational check for baseline data, install the test item in its transit or combination case as prepared for field use (if measurement information is to be obtained, install and calibrate such instrumentation in this step.)

Step 2. From paragraph 4.5.5.1 and table 516.5-VI, determine the height of the drops to be performed, the number of drops per test item, and the drop surface.

Step 3. Perform the required drops using the apparatus and requirements of paragraph 4.5.5.1 and table 516.5-VI notes. Recommend visually and/or operationally checking the test item periodically during the drop test to simplify any follow-on failure evaluation that may be required.

Step 4. Document the impact point or surface for each drop and any obvious damage.

Step 5. Following completion of the required drops, visually examine the test item(s).

Step 6. Document the results.

Step 7. Conduct an operational checkout in accordance with the approved test plan.

Step 8. Document the results for comparison with data obtained in Step 1, above (if measurement information was obtained during the drop examine the time history traces and process them in this step according to procedures outlined in the test plan).

4.5.5.4 Analysis of results.

Refer to the guidance in Part One, paragraph 5.14, to assist in the evaluation of the test results. In general, analysis of results will consist of visual and operational comparisons for before test and after test. Measurement instrumentation and subsequent processing of acceleration time history information can provide valuable information related to response characteristics of the test item and statistical variation in the shock environment.

4.5.6 Procedure V - Crash Hazard.

The intent of this procedure is to disclose structural failures of materiel or mounts for materiel in air or ground vehicles that may present a hazard to personnel or other materiel if the materiel breaks loose from its mount during or after a vehicle crash. The test in this procedure is intended to verify that materiel mounting and/or restraining devices will not fail, and that sub-elements are not ejected during crash situations. Attach the test item to its shock fixture by its in-service mounting or tiedowns.

4.5.6.1 Controls.

Use figure 516.5-8 as the test spectrum for the axis of test with the effective shock duration, T_e, between 15 and 23 milliseconds for flight materiel, and between 8 and 13 milliseconds for ground materiel. If shock spectrum analysis capabilities are not available, the classical terminal peak sawtooth pulse on figure 516.5-10 may be used as an alternative to a complex transient waveform developed from the SRS on figure 516.5-8. Table 516.5-VII provides the parameters for the terminal peak sawtooth pulse. An aircraft crash level of 40 g's is based on the assumption that, during a survivable crash, localized g levels can approach 40 g's. Ground transportation vehicles are designed with a higher safety factor and, therefore, must sustain a much higher g level with correspondingly higher specified test levels.

SUPERSEDES PAGE 516.5-28 OF MIL-STD-810F.

METHOD 518

ACIDIC ATMOSPHERE

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

1. SCOPE.

1.1 Purpose.

Use the acidic atmosphere test to determine the resistance of materials and protective coatings to corrosive atmospheres.

1.2 Application.

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

1.3 Limitations.

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

2. GUIDANCE/REQUIREMENTS.

2.1 Effects of the Environment.

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

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

2.2 Test Procedure.

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

2.3 Sequence.

a. General. See Part One, paragraph 5.5.
b. Unique to this method. There are at least two philosophies related to test sequence. One approach is to conserve test item life by applying what are perceived to be the least damaging environments first. For this approach, generally apply the acidic atmosphere test late in the test sequence. Another approach is to apply environments to maximize the likelihood of disclosing synergetic effects. For this approach, consider acidic atmosphere testing following dynamic tests, such as vibration and shock. Perform acidic atmosphere testing after any humidity or fungus testing, and before any sand and dust testing or other

SUPERSEDES PAGE 518-1 OF MIL-STD-810F.

tests which damage protective coatings. Because this test is similar in severity to the salt fog test, recommend separate test items be used for each.

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

2.4 Determine Test Levels and Conditions.

Having selected this method and relevant procedures (based on the test item's requirements documents and the tailoring process), complete the tailoring process by identifying appropriate parameter levels and applicable test conditions and techniques for these procedures. Base these selections on the requirements documents, the Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, figure 1-1), and information provided with this procedure. Consider the essential parameters for defining the acidic atmosphere test that include exposure temperature, exposure time (duration), test item configuration, chemical composition of the test atmosphere, and concentration of the test solution.

2.4.1 Temperature severities.

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

2.4.2 Test duration.

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

a. Three 2-hour exposure periods with 22 hours storage after each.

b. Four 2-hour exposure periods with 7 days storage after each.

2.4.3 Test item configuration.

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

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

b. Protected or unprotected.

c. Deployed (realistically or with restraints, such as with openings that are normally covered).

d. Modified with kits for special applications.

2.4.4 Chemical composition and concentration.

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

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

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

SUPERSEDES PAGE 518-2 OF MIL-STD-810F.

a. Do not enter the chamber during atomization and, before entry after exposure, purge the chamber with clean air to a level that will satisfy local safety requirements. Continue purging at intervals if necessary to ensure the concentration of noxious fumes remains at a suitably low level.

b. Wear a suitable respirator and/or eye protection. Use rubber gloves to handle materiel.

c. See paragraph 4.1b for hazardous waste disposal information.

2.4.5 Operational considerations.

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

3. INFORMATION REQUIRED.

3.1 Pretest.

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

a. General. Information listed in Part One, paragraphs 5.7 and 5.9, and Appendix A, Task 405 of this standard.

b. Specific to this method.

(1) Areas of the test item visually and functionally examined and an explanation of their inclusion or exclusion.

(2) Whether the test is a demonstration of performance or survival.

(3) Whether the requirement is to demonstrate safety, safety and performance, or resistance to chemical attack after the test.

(4) If functional performance is to be assessed, the phases of the test when the test item is to function and be assessed, and the levels of performance required.

3.2 During Test.

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Record of chamber temperature versus time conditions.

(2) Fallout quantities per unit of time (see paragraph 4.1g).

(3) Fallout pH.

3.3 Post Test.

The following post test information is required.

a. General. Information listed in Part One, paragraph 5.13, and in Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Areas of the test item visually and functionally examined and an explanation of their inclusion or exclusion.

(2) Test variables:

(a) Test solution pH.

(b) Test solution fallout rate (ml/cm^2/hr).

SUPERSEDES PAGE 518-3 OF MIL-STD-810F.

(3) Results of examination for corrosion, electrical, and physical effects.

(4) Observations to aid in failure analysis.

4. TEST PROCESS.

4.1 Test Facility.

a. For construction of the chamber, supporting racks, and atomization equipment use materials inert to the acid solution being used, and that will not cause electrolytic corrosion with material with which it comes in contact.

b. Ensure the test chamber has a waste collection system so that all waste material can be tested prior to disposal. Dispose of any material determined to be hazardous waste in accordance with local, state, and federal regulations.

c. Do not reuse acidic test solution drippings from the walls and ceilings of the chamber, and from the test item. Vent the exposure chamber to prevent pressure buildup.

d. Use a chamber capable of maintaining temperatures in the exposure zone at 35 ±2°C. Continuously control this temperature during the test. Do not use immersion heaters within the chamber exposure area for the purpose of maintaining the temperature within the exposure zone.

e. Use an acid solution reservoir and dispenser made of material that is non-reactive with the acid solution, e.g., glass, hard rubber, or plastic. The reservoir provides a continuous supply to a tank normally (but not necessarily) situated inside the test section in which the acid solution level is held reasonably constant. The atomizers are connected to this tank.

f. Use a chamber with a means for injecting the acid solution into the test chamber and with an input air humidifier to minimize clogging of the nozzles. Use atomizers of such design and construction as to produce a finely divided, wet, dense fog. Use atomizing nozzles and a piping system made of material that is non-reactive to the acid solution. Use a facility designed to provide the required atomization distribution and fallout.

g. Use a test setup that includes a minimum of 2 fallout collection receptacles. One is to be at the perimeter of the test item nearest to the nozzle, and the other also at the perimeter of the test item but at the farthest point from the nozzle. If multiple nozzles are used, the same principles apply. Place the receptacles so that they are not shielded by the test item and will not collect drops of solution from the test item or other sources.

h. Constant air pressure for the continuous, uniform atomization of the acid solution using a compressed air supply, and produce a fallout such that each receptacle collects from 1 to 3 ml of solution per hour for each 80 cm^2 of horizontal collecting area (10 cm diameter).

4.2 Controls.

a. Compressed air. Preheat the oil and dirt-free compressed air used to produce the atomized solution (to offset the cooling effects of expansion to atmospheric pressure) and pre-humidify it such that the temperature is 35 ±2°C and the relative humidity is in excess of 85% at the nozzle (see table 518-I).

b. Preheating. Heat the acid solution to within ±6°C of the test section temperature before injection into the test section.

c. Test section air circulation. Use an air velocity in the test chambers that is minimal (essentially zero).

SUPERSEDES PAGE 518-4 OF MIL-STD-810F.

TABLE 518-I. Temperature and pressure requirements for operation at 35°C.

Air Pressure (kPa)	83	96	110	124
Preheat temperature (°C) (before atomizing)	46	47	48	49

4.3 Test Interruptions.

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

b. Specific to this method.

(1) Undertest interruption. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances toward standard ambient conditions, give the test item a complete visual examination and develop a technical evaluation of the impact of the interruption on the test results. Restart the test at the point of interruption and restabilize the test item at the test conditions.

(2) Overtest interruption. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances away from standard ambient conditions, stabilize the test conditions to within tolerances and hold them at that level until a complete visual examination and technical evaluation can be made to determine the impact of the interruption on test results. If the visual examination or technical evaluation results in a conclusion that the test interruption did not adversely affect the final test results, or if the effects of the interruption can be nullified with confidence, restabilize the pre-interruption conditions and continue the test from the point where the test tolerances were exceeded.

4.4 Procedure.

The following test procedure provides a basis for assessing the suitability of the test item in an acidic atmosphere environment, and has limited tailorability.

4.4.1 Pretest information.

See General Guidance and Information, paragraphs 5 and 6.1.

4.4.2 Preparation for test.

a. Prepare a test solution as specified in paragraph 2.4.4. NOTE: MAKE THE SOLUTION BY ADDING ACID TO WATER, NOT VICE VERSA.

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

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

(1) Do not enter the chamber during atomization. Before entry after atomization, purge the chamber with clean air to a level that will satisfy local safety requirements. Continue purging at intervals if necessary to ensure the concentration of noxious fumes remains at a suitably low level.

(2) Wear a suitable respirator and/or eye protection. Use rubber gloves to handle materiel.

b. Chamber performance verification: Immediately before the test and with the exposure chamber empty, adjust all test parameters to those levels required for the test. Maintain these conditions for at least one 24-hour period (or until proper operation and fallout collection can be verified). With the exception of fallout rate, continuously monitor all test parameters to verify that the test chamber is operating properly.

SUPERSEDES PAGE 518-5 OF MIL-STD-810F.

c. Conduct an operational checkout in accordance with the test plan and record the results for compliance with Part One, paragraph 5.9. Handle the test item as little as possible, particularly on the significant surfaces, and prepare it for test immediately before exposure. Unless otherwise specified, use test items free of surface contamination such as oil, grease, or dirt, which could cause dewetting. Do not include the use of corrosive solvents, solvents that deposit either corrosive or protective films, or abrasives other than pure magnesium oxide in the cleaning methods.

4.4.3 Acidic atmosphere test procedure.

Step 1. With the test item installed in the test chamber in its storage configuration (or as otherwise specified in the requirements documents), adjust the test chamber temperature to 35°C and temperature condition the test item for at least 2 hours before introducing the acid solution.

Step 2. Expose the test item to one of the two following severities as specified in the test plan. (See paragraph 2.4.2.)

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

Step 3. At the completion of Step 2, stabilize the test item at standard ambient conditions.

Step 4. Using appropriate protective clothing, visually examine the test item to the extent practical.

Step 5. If required, place the test item in an operational configuration and conduct an operational check of the test item.

Step 6. If required, test items may be cleaned by rinsing with a dilute sodium bicarbonate solution (to neutralize any acidic residue), followed by distilled/deionized water, and dried by the application of heat (up to 55°C), where this is acceptable, or by other means. Collect the rinse water and check it for hazardous substances prior to disposal (see paragraph 4.1b also).

Step 7. At the end of this test, and in conformity with the requirements documents, examine the test item for corrosion and deterioration of parts, finishes, materials, and components.

5. ANALYSIS OF RESULTS.

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

6. REFERENCE/RELATED DOCUMENTS.

a. DEF STAN 00-50, Guide to Chemical Environmental Contaminants and Corrosion Affecting the Design of Military Materiel. (UK)

b. IEC 68-2-52, 1966, Test Kb, Salt Mist, Cyclic, NaCl solution.

c. Acid Deposition in the United Kingdom, Warren Spring Laboratory, ISBN 085624 323X. (UK)

d. NATO STANAG 4370, Environmental Testing.

e. NATO Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests, Method 319, "Acidic Atmosphere."

SUPERSEDES PAGE 518-6 OF MIL-STD-810F.

4. TEST PROCESS

4.1 Test facility.

Use a facility that can provide the required combination of environmental elements. See the guidance for the facilities for the individual element tests, i.e., methods 500.4, 501.4, 502.4, 507.4, and 514.5. Ensure the facility satisfies the requirements of Part One, paragraph 5.

4.2 Controls.

Ensure calibration and test tolerance procedures are consistent with the guidance provided in Part One, paragraphs 5.3.2 and 5.2, respectively.

4.3 Test interruption.

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

b. Specific to this method.

(1) Undertest interruption. Refer to the interruption guidance for the individual test elements; i.e., temperature, humidity, low pressure, and vibration.

(2) Overtest interruption. Refer to the interruption guidance for the individual test elements; i.e., temperature, humidity, low pressure, and vibration.

4.4 Data analysis.

Detailed data analysis for verification of the input to the test item and the response monitoring of the test item are to be in accordance with the test plan.

4.5 Test execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item in a combined environment of vibration, temperature, humidity, and altitude. Begin with the first procedure specified in the test plan.

4.5.1 Preparation for test

4.5.1.1 Preliminary steps.

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

4.5.1.2 Qualification test cycle. (Figure 520.2A-3.)

Step 1. Ramp to Cold/Dry - With the test item non-operating, ramp the chamber temperature from room ambient conditions down to the extreme low operating temperature at 5°C/minute or at a maximum rate provided by the test chamber.

Step 2. Cold/Dry Soak - Allow the test item to soak at this temperature until it has reached thermal stabilization or for 4 hours (whichever is greater). If vibration is to be performed during this step, derive it from a low altitude, high Mach flight condition (combined temperature/vibration may be performed separately). Ground vehicles would use severe road/field vibration levels.

Step 3. Cold/Dry Warm-Up - Operate the test item at its minimum operating voltage. If supplemental cooling is supplied during this step, tailor cooling parameters for minimum heat removal (e.g., minimum temperature and minimum flow for air cooling at or above the minimum operating temperature). Maintain this condition for the minimum specified warm-up period.

SUPERSEDES PAGE 520.2-11 OF NOTICE 2 TO MIL-STD-810F.

Step 4. Cold/Dry Performance Check - Do a performance check immediately following Step 3 to verify the test item operates as required.

Step 5. Ramp to Cold/Dry Altitude - With the test item operating, ramp the chamber from the site pressure to the maximum cruise altitude (use the formulas on figure 520.2A-5 to derive pressure from altitude). Perform the pressure ramp at the maximum facility rate, not to exceed the predicted platform rate. Not applicable to ground vehicles.

Step 6. Cold/Dry Altitude - Maintain the maximum cruise altitude for 30 minutes. If vibration is to be performed during this step, derive it from a high altitude, high Mach flight condition. Not applicable to ground vehicles.

Step 7. Ramp to Warm/Moist - Ramp the chamber conditions from Step 6 and uncontrolled humidity to 32°C (90°F) and site pressure and 95% relative humidity (RH). Perform this temperature/humidity/altitude ramp at the maximum facility rate, not to exceed the predicted platform rate. This step simulates a quick descent from a high altitude and allows an altitude chamber to simulate a high altitude descent to a hot/humid day landing site. Not applicable to ground vehicles.

Step 8. Warm/Moist Dwell - Maintain 32°C, site pressure and 95% relative humidity for 30 minutes. If vibration is to be performed during this step, derive it from a low altitude, high Mach flight condition. Ground vehicles use an aggregate vibration schedule based on various road conditions.

Step 9. Ramp to Hot/Dry - Ramp the chamber temperature to the maximum operating temperature and the chamber humidity to less than 30% RH. Operate the test item at its maximum operating voltage. At the same time, supply supplemental cooling at the worst case thermal conditions (e.g., maximum temperature and minimum flow for air-cooling). Perform this temperature/humidity ramp at the maximum facility rate, not to exceed the predicted platform rate.

Step 10. Hot/Dry Soak - Allow the test item to soak at the maximum operating temperature until it has reached thermal stabilization or 2 hours (whichever is greater). If vibration is to be performed during this step, derive the vibration levels from the maximum of take-off/ascent or low altitude/high Mach (if appropriate). Ground vehicles use aggregate off-road vibration levels.

Step 11. Hot/Dry Performance Check - Operate the test item and record data for comparison with pretest data.

Step 12. Ramp to Hot/Dry Altitude - Ramp the chamber from site pressure to the maximum cruise altitude (use the formulas on figure 520.2A-5 to derive pressure from altitude). Perform this pressure ramp at the maximum facility rate, not to exceed the predicted platform rate. Not applicable to ground vehicles.

Step 13. Hot/Dry Altitude - With the test item operating, maintain the maximum operating temperature and maximum cruise altitude until the test item has reached thermal stabilization or 4 hours (whichever is greater). If vibration is to be performed during this step, derive it from a high (or ultra-high if applicable) altitude, high Mach flight condition. Not applicable to ground vehicles.

Step 14. Hot/Dry Altitude Performance Check - Do a performance check to verify that the test item operates as required.

Step 15. Ramp to Room Ambient - Ramp the chamber from the maximum operating temperature and maximum cruise altitude to room ambient temperature, site pressure and uncontrolled humidity. Perform this temperature/pressure ramp at the maximum facility rate, not to exceed the predicted platform rate. Return the test item to a non-operating condition and discontinue the supplemental cooling at the conclusion of the ramp.

Step 16. Repeat the cycle (Steps 1-15) as necessary to meet the test plan duration requirements or 10 cycles, whichever is greater.

4.5.1.3 Test development schedule.

Utilized for each Procedure.

Step 1. Identify the platform missions and test materiel location.

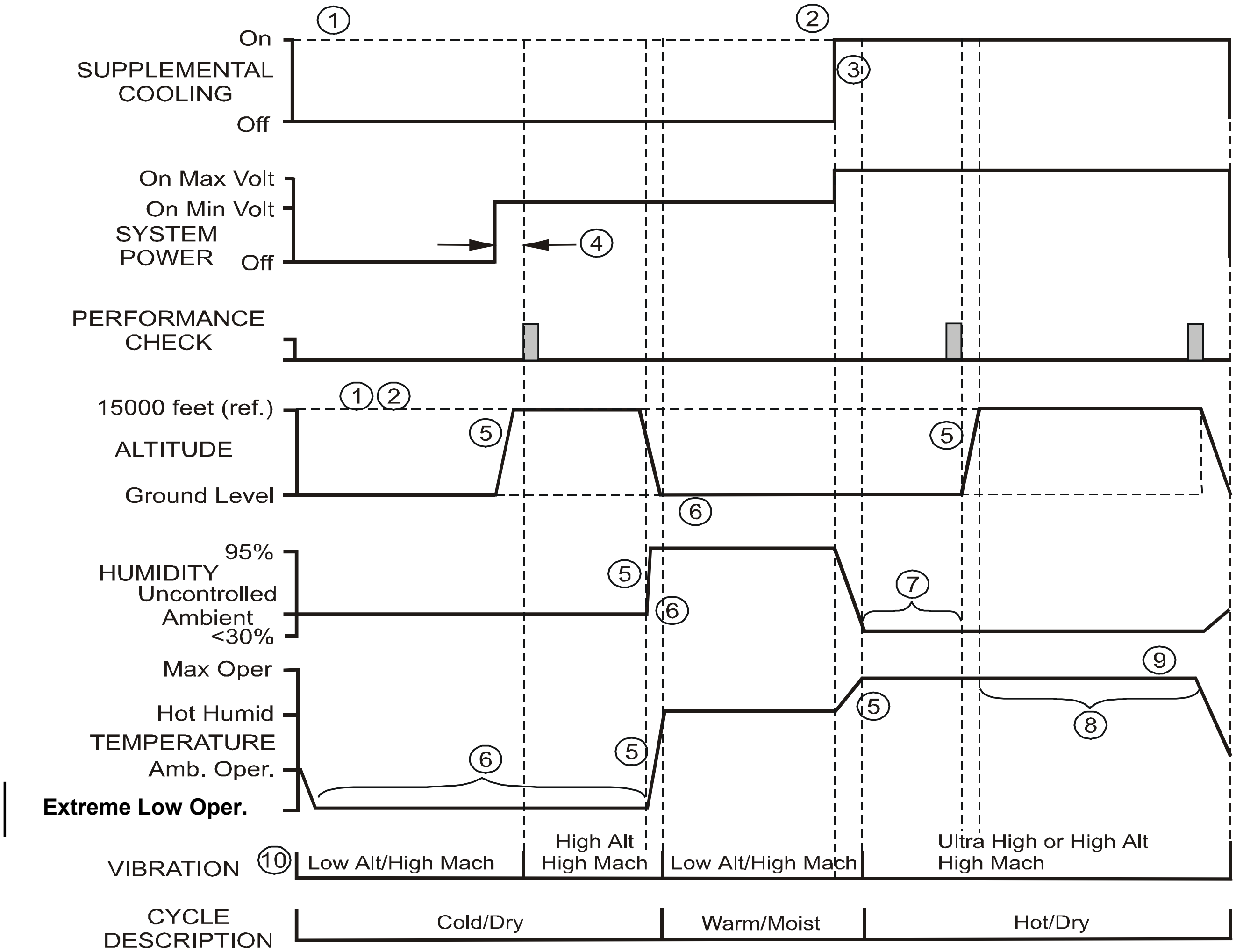
Step 2. Identify the mission profiles.

Step 3. Select the top 80% of potential mission profile. (Table 520.2-I) (Procedure III only.)

Step 4. Select most severe potential mission profile. (Exception: short term and transient events, e.g., gunfire, crash shock, etc.) (Procedures I and III).

Step 5. Identify the vibration levels by mission profile.

REPRINTED WITHOUT CHANGE.



(1) Tailor temperature and flow of supplemental cooling to provide worst case heat dissipation.

(2) Carefully tailor the platform/product specific factors.

(3) Minimum of 20°C per minute.

(4) Equipment warm-up time.

(5) Perform transition at maximum facility capability.

(6) Ideally, bleed hot/humid air into chamber (see paragraph 2.3.5b) so minimum soak follows achievement of all temperature, altitude and humidity conditions.

(7) System thermal stability or 2 hours, whichever is greater.

(8) System thermal stability or 4 hours, whichever is greater.

(9) Carefully tailor high altitude operating temperatures.

(10) Vibration may be performed separately with temperature.

FIGURE 520.2A-3. Qualification test cycle.

SUPERSEDES PAGE 520.2A-3 OF NOTICE 2 TO MIL-STD-810F.

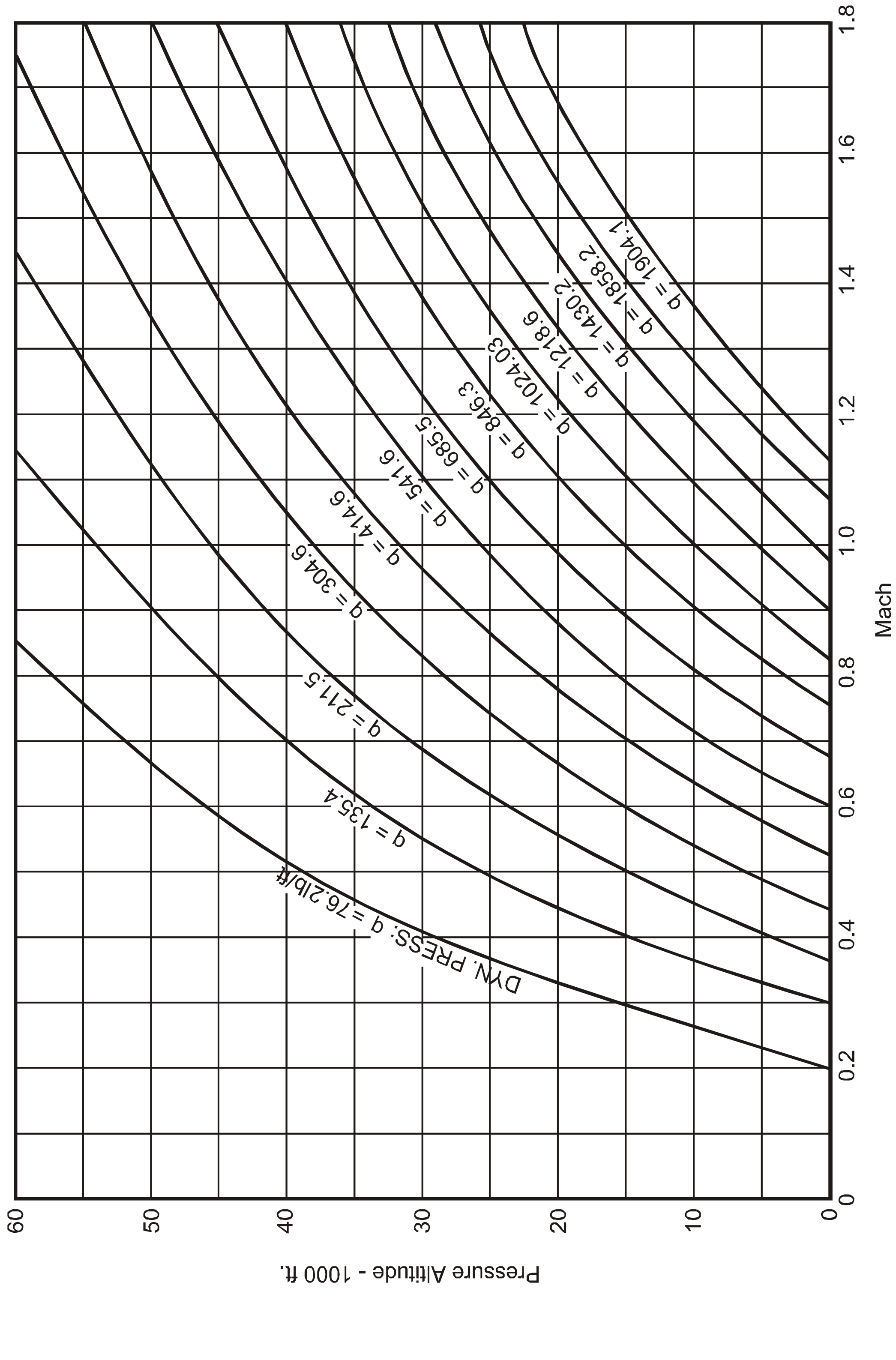


FIGURE 520.2A-4. Dynamic pressure (q) as a function of Mach number and altitude.

REPRINTED WITHOUT CHANGE.