NATO STANDARD

AECTP-300

CLIMATIC ENVIRONMENTAL TESTS

Edition E, Version 1

JUNE 2025

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED ENVIRONMENTAL CONDITIONS AND TEST PUBLICATIONS

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

3 June 2025

1. The enclosed Allied Environmental Conditions and Test Publication AECTP-300, Edition E, Version 1, CLIMATIC ENVIRONMENTAL TESTS, which has been approved by the nations in the LIFE CYCLE MANAGEMENT GROUP (AC/327 LCMG), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4866.

2. AECTP-300, Edition E, Version 1, is effective upon receipt and supersedes AECTP-300, Edition D,Version 1, which shall be destroyed in accordance with the local procedure for the destruction of documents.

3. This NATO standardization document is issued by NATO. In case of reproduction, NATO is to be acknowledged. NATO does not charge any fee for its standardization documents at any stage, which are not intended to be sold. They can be retrieved from the NATO Standardization Document Database (https://nso.nato.int/nso/) or through your national standardization authorities.

4. This publication shall be handled in accordance with C-M(2002)60.

Thierry POULETTE
Major General, FRA (A)
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Documents Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Documents Database for the complete list of existing reservations.

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RECORD OF SIGNIFICANT CHANGES

General	Updated the entire document format to match the most recent NATO AP Template. Corrected various typographical errors.
Method 305	Method 305 updated. This includes the update of Table 1: Spectral Power Distribution.
Method 317	Method 317 updated – near complete re-write.
Method 318	Removed, this is now covered in Method 317.

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ALLIED ENVIRONMENTAL CONDITIONS AND TEST PUBLICATIONS (AECTP)

AECTP-300 – CLIMATIC ENVIRONMENTAL TESTS

AECTP-300 is one of two documents included in STANAG 4866. It provides a series of climatic test methods for use during the design, development, and qualification of materiel. The test severities are derived from the environmental conditions defined in AECTP-230. AECTP-100 should be read before any other AECTP series documents.

The AECTP series 230 and 300 were formerly covered by STANAG 4370. The AECTPs are now organised as follows:

- STANAG 4370 – Environmental Testing:
  - AECTP-100 – Environmental Guidelines for Defence Materiel
  - AECTP-600 – The Ten-step Method for Evaluating the Ability of Materiel to Meet Extended Life Requirements and Role and Deployment Changes

- STANAG 4866 – Climatic Environmental Conditions and Test Methods:
  - AECTP-230 – Climatic Conditions
  - AECTP-300 – Climatic Environmental Tests

- STANAG 4867 – Mechanical Environmental Conditions and Test Methods:
  - AECTP-240 – Mechanical Conditions
  - AECTP-400 – Mechanical Environmental Tests

- STANAG 4868 – Electrical & Electromagnetic Environmental Conditions and Test Methods:
  - AECTP-250 – Electrical & Electromagnetic Environmental Conditions
  - AECTP-500 – Electromagnetic Environmental Effects Tests and Verification

AECTP-300 should be used in conjunction with STANAG 4370.

METHOD	TITLE
300	GENERAL GUIDANCE AND REQUIREMENTS
301	LOW PRESSURE
302	HIGH TEMPERATURE
303	LOW TEMPERATURE
304	THERMAL SHOCK
305	SOLAR RADIATION
306	HUMID HEAT
307	IMMERSION
308	MOULD GROWTH
309	SALT FOG
310	RAIN/WATERTIGHTNESS
311	ICING
312	Reserved for Future Use
313	SAND AND DUST
314	CONTAMINATION BY FLUIDS
315	FREEZE / THAW
316	EXPLOSIVE ATMOSPHERE
317	TEMPERATURE / HUMIDITY / ALTITUDE
318	Reserved for Future Use
319	ACIDIC ATMOSPHERE

METHOD 300
GENERAL GUIDANCE AND REQUIREMENTS

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CHAPTER 1 SCOPE

1.1. PURPOSE

1. This document provides general guidance related to the climatic test methods of AECTP-300. It also defines the general test conditions and associated tolerances used with the test methods of AECTP-300. Its purpose is to provide general guidance and requirements for preparing the Environmental Test Program (captured within the Test Plan or Test Procedures).

2. The conditions and tolerances of this document are set for standardisation purposes and are intended to be generally applicable where no specific advice is supplied. However, where different conditions and tolerances are stated in the applicable test methods of AECTP-300 or in the relevant Environmental Test Specification, they shall take precedence over those stated in this document.

1.2. APPLICATION

This method includes information which should be considered when adapting the generic test methods of AECTP-300 for any specific environmental test program. Method 300 provides information relative to the following:

a. Test program development.

b. Test parameter values.

c. Exposure duration.

d. Test item configuration.

e. Information required prior to and following testing.

f. Test parameter tolerances.

g. Characteristics of test facilities.

h. Temperature stabilization.

i. Test controls.

j. Test interruption.

k. Functional Test Points:

(1) Pre-Test.

(2) During-Test.

(3) Post-Test.

1.3. LIMITATIONS

1. The primary limitation of the Methods within AECTP-300 is that they are largely intended to simulate the natural environments; however, they cannot fully replicate all the synergistic effects of the natural conditions. General limitations relevant to the application of the Climatic Test Methods include the following:

a. Identification of all the relevant environmental conditions.

b. Limited ability to operate and evaluate the test item as required in service.

c. Limited environmental data (response or input).

d. Inability of test facilities to replicate and / or apply the climatic elements as they occur in the service environment.

e. Impracticality of performing tests for durations comparable to field exposure.

f. This standard only addresses natural environments found within the atmosphere up to 30,000 m (98,425 ft). Beyond this, other standards addressing non-terrestrial / space environments should be considered, for example (not an exhaustive list), the following:

(1) The U.S. Range Commanders Council (RCC) Series.

(2) The European Cooperation for Space Standardization (ECSS) Publications.

(3) ECSS-E-ST-10-04C – Space Environment.

(4) BS ISO 17851:2016 Space systems. Space environment simulation for material tests. General principles and criteria.

2. These limitations should be addressed in the preparation of the Test Plan and Test Procedures for the specific application (see AECTP-100).

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CHAPTER 2 NOMINAL AND STANDARD CONDITIONS

2.1. STANDARD LABORATORY CONDITIONS

1. When Standard Laboratory Conditions are specified in the test procedures of this standard, the test facility conditions shall fall within the ranges set out below. (These conditions are comparable to the “Standard Atmospheric Conditions for Measurement and Tests” given in International Electrotechnical Commission [IEC] 60068-1.)

Temperature	15 °C to 35 °C
Relative Humidity	25 percent to 75 percent
Air Pressure	86 kPa to 106 kPa (860 mbar to 1,060 mbar)

2. Variations should be kept to a minimum during a series of measurements carried out as a part of one test on one test item.

3. Where it is considered impracticable to carry out additional measurements within the Standard Laboratory Conditions during test, a record of the prevailing conditions should be kept.

2.2. CONTROLLED / NOMINAL (REFERENCE) CONDITIONS

1. During measurement, functional tests or performance assessments, it may be necessary to adopt Controlled / Nominal (Reference) Atmospheric Conditions to ensure accurate and / or repeatable measurements. The atmospheric conditions stated below, are reference conditions to be used if the parameters to be measured are dependent upon temperature, pressure and humidity and the law of dependence is unknown.

Temperature	21 °C to 25 °C
Relative Humidity	45 percent to 55 percent
Air Pressure	86 kPa to 106 kPa (860 mbar to 1,060 mbar)

2. They may also be used where no other atmospheric conditions are specified, but where the environment needs to be controlled. Some commodities may use different nominal conditions, and these are tabulated in Table 1.

Table 1: Controlled / Nominal (Reference) Conditions

Temperature (°C)			Relative Humidity (%)		Air Pressure		Note
Nominal Value	Close Tolerance	Wide Tolerance	Close Range	Wide Range	kPa	mbar	
20	±1	±2	63 to 67	60 to 70	86 to 106	860 to 1060	1
23	±1	±2	48 to 52	45 to 55	86 to 106	860 to 1060	1
25	±1	±2	48 to 52	45 to 55	86 to 106	860 to 1060	2, 3
27	±1	±2	63 to 67	60 to 70	86 to 106	860 to 1060	1
23		±2		45 to 55	86.45 to 103.05		4

Note 1: These values are those published in IEC 60068-1, ISO 554, and ISO 3205.

Note 2: These values are those published in IEC 60068-1, but do not appear in ISO 554 or ISO 3205.

Note 3: The value of 25 °C is included primarily because of the interest for the testing of semiconductor devices and integrated circuits.

Note 4: These values are those published in Military Standard (MIL-STD)-810.

3. The close tolerances in Table 1 may be used for reference measurements. The wider tolerances may be used only when specified in the relevant Test Plan or Test Instructions. Relative Humidity may be disregarded when it is known to have no influence on the accuracy of results or the repeatability of measurements.

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CHAPTER 3 TEST TOLERANCES AND DEVIATIONS

3.1. TEST TOLERANCES

Unless otherwise specified in the individual test methods of AECTP-300 or the test instructions, the overall tolerances on test conditions shall be as given in Table 2.

Table 2: Test Tolerances

Parameter (and usual units if applicable)	**Tolerance** (of specified value unless stated otherwise)
Temperature (°C)	±2 °C
Relative Humidity (%)	±5 percent
Pressure (Pa)	±5 percent
Time (s, m, & hr)	-0 percent / +1 percent up to a maximum of 15 minutes
Rate of change of temperature (°C/min)	±20 percent, averaged between 10 percent and 90 percent of the total temperature change
Air velocity / wind speed (m/s)	±15 percent
Rate of change of air pressure (Pa/s)	±10 percent, averaged between 10 percent and 90 percent of the total pressure change.

3.2. INSTRUMENTATION AND CALIBRATION

The accuracy of all instrumentation and test apparatus used to control or monitor the test parameters should be verified at regular periods. All instruments and test apparatus used shall:

a. Be subject to regular calibration traceable to National Standards.

b. Have a measurement uncertainty that is no greater than one half, but should ideally be no greater than one third of the tolerance of the test parameter to be measured. However, if this cannot be achieved, then refer to the appropriate International or National Standards. Further, measurement uncertainty should include all uncertainty values associated with the sensor and the data acquisition system.

c. Not significantly influence the response of the test item to the test environment it is being subjected to.

d. Not significantly influence the test environment.

3.3. DEVIATIONS

1. If the required tolerances cannot be met then, with the agreement of the Test Specifier, the following deviations to the tolerances are permitted:

a. For test items with a volume greater than 0.5 m^3, the temperature tolerance may be increased to ±3 °C.

b. For temperature modifying test items (e.g., those generating their own heat during test), the temperature tolerance may be increased to ±3 °C.

c. For higher temperatures, more than 100 °C, the temperature tolerance may be increased to ±5 °C.

2. Any other deviation from the stated conditions and tolerances shall be agreed with the Test Specifier and recorded in the Environmental Test Report along with the reasons for the deviation.

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CHAPTER 4 GUIDANCE ON GENERAL CONDITIONS

4.1. PRE-CONDITIONING AND TEMPERATURE STABILISATION

1. For many of the test procedures within AECTP-300 there is a requirement to climatically pre-condition the test item / specimen. This includes stabilising the specimen before commencing the test, to either; a specified temperature, Standard Laboratory Conditions, or to establish a stable temperature cycle. The following paragraphs offer guidance on how to achieve temperature stabilisation for both cyclic and fixed temperature regimes.

2. All test items should be pre-conditioned to ensure the equipment begins the testing in the condition it would be close to in the natural or operational environment, ensuring test repeatability. The minimum period of climatic pre-conditioning should be sufficient for the test item to stabilise at the required conditions; however, this will also depend upon the thermal characteristics of the equipment (e.g., thermal capacity, physical size, and thermal transfers).

a. Non-Operating:

(1) For constant temperatures. Temperature stabilisation is reached when that part of the test item which has the longest thermal lag reaches the required temperature within the stated test tolerances.

(2) For cyclic temperatures. The minimum number of cycles is predicated on achieving repeated test item thermal response within 2 °C (or the stated test tolerances) between successive cycles, at that part of the test item which has the longest thermal lag.

> **NOTE:** In some cases, instrumenting the location of longest thermal lag may not be feasible or appropriate. Multiple points on a test item may need to be monitored to assess stabilization including those components that will experience peak response conditions, critical components, and where necessary, components with the longest thermal lag. In some cases, a thermal survey or analysis should be performed to determine the conditions and duration that the test item should be exposed, to reach stabilisation.

b. Operating:

(1) Unless otherwise specified, operating temperature stabilisation is reached when the temperature of the functioning part(s) of the test item (including heat dissipating components) with the longest thermal lag is changing at a rate of no more than 2 °C per hour.

3. If the conditioning time is unknown, impractical to measure and / or where there is uncertainty in the thermal analysis; additional conditioning may be necessary, but this is dependent upon the type of materiel. Most materiel can withstand the temperature pre-conditioning and stabilisation periods arising from the procedures within the methods of AECTP-300. Certain materiel however, particularly energetic materials, may become unstable or unsafe if subjected to prolonged periods of pre-conditioning and stabilisation. In such cases, the Environmental Test Specification should state the maximum pre-conditioning and stabilisation periods.

4. The nominal air temperature rate of change for pre-conditioning test items is less than 3 °C per minute. Unless specified otherwise, the rate of change of temperature of the test chamber should be kept below 10 °C per minute. Otherwise the temperature change may be closer to a thermal shock and in extreme cases could endanger the test item. In some instances, to shorten the pre-conditioning time, it may be desirable to force the conditioning rate by setting the chamber temperature at a greater extreme than the requirement. This should only be considered with prior agreement of the Test Specifier. In such cases, it becomes more important to accurately control the rate of change of the test item.

5. Certain equipment may have an agreed conditioning duration for stabilisation. These are not always accurate as they depend upon the initial condition of the test item and assumes all equipment in the family have equivalent thermal capacity, physical size and thermal transfer characteristics. Therefore, it is good practice to validate the agreed conditioning duration for stabilisation.

6. For test programs where a consistent and controlled temperature is required throughout the test item; a thermal survey or thermal analysis should be performed to determine the soak time required to achieve stabilization. The thermal survey would include a test item with instrumented internal components subjected to the required air temperatures. The air speed in the chamber should be considered, as convection is likely to be the primary mode of heat transfer. For materiel containing energetic materials, it is recommended that representative inert / simulated materials are used for the thermal survey, as prolonged thermal exposure may cause the energetics to become unstable or unsafe. The inert / simulated materials should have similar:

a. Mass and volume.

b. Thermo-mechanical behaviour.

c. Heat transfer coefficients.

4.2. VARIATION OF CLIMATIC CONDITIONS

1. During any series of measurements, function or performance assessments, variations in temperature, pressure and humidity should be kept to a minimum during the measurement or assessment period. Where this is impractical, such as during a diurnal cycle, the Environmental Test Report should state what the actual conditions were over the period.

2. Every climatic chamber has a useful working volume which is smaller than the actual chamber volume. The size of the working volume will depend upon the type of test being undertaken, whether the equipment can modify the temperature and the flow of air within the chamber. The ratio between chamber size and equipment size can create considerable variability in the temperature and humidity within the working volume of the chamber. If the equipment is too large for the working volume of the chamber it may not be possible to adequately control the temperature within the working volume because the test item is absorbing, dissipating and / or radiating too much heat. Guidance on the calculation of uncertainty of conditions in climatic test chambers can be found in IEC 60068-3-11.

3. When testing heat dissipating test items, air flow around or over the test item can modify the temperatures experienced. This is particularly true of test items being subjected to solar radiation testing. Therefore, when testing such test items, the air flow around or over the test item should be known to ensure that the conditions approximate as close as possible typical free air conditions or those conditions expected when the equipment is in use.

4. Non-uniform heat sources of a test chamber should be located so that the test item is not subjected to direct radiant heat unless this is a requirement of the test, as for example in the solar radiation test.

4.3. MONITORING OF HIGH-TEMPERATURE EXPOSURE

1. High temperature conditioning may accelerate the chemical degradation of certain materials and can have detrimental effects. Uncovering such degradation may be a desired outcome of the test, but care must be taken not to overexpose the test item. Specifically, hazardous or energetic materials can become unstable and unsafe if subject to excessive elevated temperature during a sequential programme.

2. When testing equipment that may be degraded by exposure to high temperatures, it is necessary to apply limits to the total period of pre-conditioning occurring within the test programme. Additionally, a record should be taken at sufficient intervals to characterise the temperature of the test item throughout the test programme. Typically, the temperature should be recorded at intervals not greater than 5 minutes.

4.4. POST-TEST CLIMATIC RECOVERY

1. After undertaking the prescribed environmental test, the test item should normally be allowed to return to Standard Laboratory Conditions and stabilise at those conditions before undertaking any Post-Test examinations, functional tests, performance tests, or any test item characterisation work. Unless the Environmental Test Specification specifies otherwise, the rate of change of temperature of the test item should be kept below 3 °C per minute. The test item should be allowed to stabilise at Standard Laboratory Conditions in the same manner as stated earlier in this chapter.

2. If recovery and any Post-Test examinations, functional tests, performance tests, or any test item characterisation work is performed in separate chambers, the combination of temperature and humidity conditions should be such that condensation on the surface of the test items does not occur when the test item is transferred between chambers. Additionally, care should be taken to avoid thermal shock with the rate of change of temperature kept to the tolerance described in paragraph 4.1.4.

4.5. POST-TEST NATURAL DRYING CONDITIONS

A Post-Test natural drying regime for the test item may be required, before undertaking any Post-Test examinations, functional tests, performance tests or any test item characterisation work. Where natural drying conditions are required, the test item should be allowed to dry in Standard Laboratory Conditions. Unless otherwise specified the drying period should be not less than 6 hours.

4.6. POST-TEST ASSISTED DRYING CONDITIONS

1. In some instances Post-Test assisted drying for the test item may be required, before undertaking any Post-Test examinations, functional tests, performance tests or any test item characterisation work. Where assisted drying is required, the conditions stated below should be used for a period of 6 hours, unless otherwise specified.

Temperature	55 ±2 °C
Relative Humidity	Not exceeding 20 percent
Air Pressure	86 kPa to 106 kPa (860 mbar to 1,060 mbar)

NOTE:

1. These conditions are comparable to IEC 60068-1.

2. The temperature used should not exceed the maximum operating temperature of the test item.

2. After assisted drying, the test item should be allowed to stabilise within Standard Laboratory Conditions, before undertaking any Post-Test examinations.

3. If it is impracticable to carry out assisted drying under the conditions detailed above in paragraph 4.6.1, the actual drying conditions shall be detailed in the Environmental Test Specification and it should be noted in the test report.

4.7. POST-TEST CONTROLLED RECOVERY

1. In some instances the test item may need to be subjected to controlled recovery conditions before undertaking any Post-Test examinations, functional tests, performance tests or any test item characterisation work. Controlled recovery conditions are needed to prevent moisture being absorbed or lost by the test item. Controlled recovery conditions are only necessary if the parameters to be measured are liable to change rapidly. For example, if insulation resistance is liable to rise soon after removal of the test items from a humidity chamber (ca. within 1–2 hours).

2. If controlled recovery conditions are needed, acceptable controlled recovery conditions are set out below. The recovery conditions should begin within 10 minutes of the completion of the test and the required Post-Test measurements should be completed within 30 minutes of removal of the test item from the recovery conditions.

Temperature	The prevailing laboratory temperature may be within the limits of 15 °C to 35 °C. The measurement accuracy shall be within ±1 °C.
Relative Humidity	The prevailing laboratory Relative Humidity may be within the limits of 25 to 75 percent. The measurement accuracy shall be within ±2 percent.
Air Pressure	The prevailing laboratory pressure may be within the limits of 86 kPa to 106 kPa.

NOTE: These conditions are comparable to IEC 60068-1.

4.8. WATER PURITY

1. The water used for Method 306 (Humid Heat), Method 310 (Rain / Watertightness), Method 315 (Freeze / Thaw), Method 317 (Temperature / Humidity / Altitude), and Method 318 (Vibration / Temperature / Humidity / Altitude) should be fresh tap water of good quality. To prevent clogging of nozzles the water should be filtered and may be demineralised.

2. Water used for humidity measurement (water vapour and wet bulb socks) as well as that used for Method 308 (Mould Growth) and Method 309 (Salt Fog), should not introduce contaminants or unintended products. Chemicals commonly found in commercial water supplies, such as chlorine, may have unintended corrosive effects on test items or affect fungus germination. Soluble materials, such as calcium

carbonate (lime), as well as insoluble materials can also cause nozzles to clog and can leave deposits. Water with a non-neutral pH could cause unintended effects on equipment. Rather than impose unrealistic water purity requirements, the recommend water used for these tests, should be relatively clean of impurities and chemicals, and have a pH in the range of 6.5 to 7.2 at 25 °C, at the time of the test. Water resistivity in the range of 0.15 MΩ.cm to 5 MΩ.cm, is recommended. Water used that is outside this range should be documented. Water within this range can be produced using distillation, demineralization, reverse osmosis, or deionization.

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CHAPTER 5 TEST CONSIDERATIONS

5.1. TEST ITEM CONFIGURATION

The test item should be installed within the test facilities in the required orientation and configuration, as specified in the Environmental Test Specification. The configuration should, as far as possible, be the in-service configuration of the equipment when it is in storage, in transit, in operation or during use. As a minimum, the following configurations should be considered for the test item:

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

b. Protected or unprotected.

c. In its normal operating and thermal configuration (representative or to the extent practical).

d. Modified with kits for special applications.

5.2. MOUNTING OF TEST ITEM

1. Many of the climatic test methods of AECTP-300, either specify or imply a method of mounting a test item. Where this is not the case, the method of mounting a test item for undertaking environmental climatic testing, should be specified in the Environmental Test Specification.

2. Mounting of the test item in the test facility should simulate, as closely as practicable, the installation arrangements that exist in normal in-service use. Unrepresentative orientations, structural frames, thermal screening, mixing of incompatible material, etc., that could influence the outcome of the test should be minimised.

3. The method of mounting a test item when undertaking climatic tests at temperatures other than ambient, can be important because heat transfer depends on the thermal characteristics of mounting and other connections. Moreover, heat dissipating equipment is commonly intended to be mounted on heat sinks or other heat conducting arrangements. Consequently, when assessing heat dissipating test items or when the effects of thermal conduction is to be assessed, the Environmental Test Specification should define the thermal characteristics of the in-service equipment mounting. These characteristics should be reproduced during testing.

4. If equipment can be mounted in several ways when in-service, with mounting arrangements having different values of thermal conductivity, then:

a. The mounting arrangement with the lowest thermal conductivity should be used for heat dissipating test items when undertaking high temperature tests.

b. The mounting arrangement with the highest thermal conductivity should be used for non-heat dissipating test items when undertaking high temperature tests and when undertaking low temperature tests with or without heat dissipation.

5. If more than one test item is in the same chamber, it is necessary to ensure that all the test items experience the same test temperatures and have identical mounting conditions. Unless otherwise specified, install the test item in the chamber in a manner that will simulate service use to the maximum extent practicable, with test connections made and instrumentation attached as necessary. For example:

a. If the item to be tested consists of several individually packaged units / subsystems, these units / subsystems may be tested separately, provided the functional aspects are maintained as defined in the Environmental Test Specification.

b. If units are being tested together and the mechanical, electrical, and Radio Frequency (RF) interfaces permit, position units at least 15 cm (6 inches) from each other and / or from the test chamber surfaces to allow for consistent and controlled air circulation. For heat dissipating equipment, ensure that one product does not influence another.

5.3. SUPPLIES AND SERVICES

Supplies and services (electrical power, air, hydraulics, etc.) required for operating or monitoring the test item should, where practicable, be derived from or simulated by sources identical to, or typical of, those provided for in-service use. Consideration should also be given to any changes in the physical properties or characteristics of the supplies and services which may arise when operating in extreme environments (e.g., higher or lower working pressures, reduced cranking amperage on batteries, etc.). These effects may need to be replicated to properly evaluate operation of the test item.

5.4. CHAMBER REQUIREMENTS

1. To optimise the conditions of heat transfer between a test item and the surrounding chamber, the following guidance should be considered:

a. Volume and Size: a minimum volume ratio of 5 to 1, between the internal chamber volume and the test item volume. To ensure adequate airflow, there should also be sufficient distance between the test item and the walls of the test chamber or other test items. A minimum distance around each test item of 150 mm (6”) is recommended.

b. Radiative: the temperature of the chamber's (internal) walls should not differ more than 3 percent from that of the chamber's air temperature (expressed in degrees Kelvin). The emissivity of the chamber's walls should be minimized as much as possible.

c. Conductive: the temperature of the support surface on which the test item is placed / mounted should be approximately equal to that anticipated during the life cycle of the materiel.

d. Convective: the air flow around or over the test item should ensure that the conditions approximate as close as possible typical free air conditions or those conditions expected when the equipment is in use. However, consult the specific test method for further specifications.

2. In the case of convective flow-field, it may not be necessary to match in-service conditions. Airflow tends to primarily be of concern for heat dissipating equipment, evaporative processes, and situations where radiative heat exchange is important. In all other cases, ensuring a consistent and controlled temperature around the test item is sufficient, so long as excessive temperature gradients are avoided (in the air and in the product).

3. The following chamber parameters should also be considered:

a. The chamber should have sufficient heating and cooling capacity to maintain test conditions when operating heat dissipating materiel.

b. The chamber should have sufficient means and capability of detecting and exhausting noxious fumes and / or volatile compounds when testing items which may emit said gases; particularly when personnel may need to enter the chamber.

5.5. TEST MONITORING

1. It is good scientific and engineering practice to monitor test conditions to ensure the test parameters are correct and the desired environmental conditions are being maintained within specified tolerances throughout the duration of the test. Therefore:

a. Install sufficient sensors to determine test item and chamber conditions (these will be required for Pre-, During- and Post-Test). Ensure sensors are adequate to:

(1) Determine temperature stabilisation.

(2) Establish chamber working volume air conditions.

(3) Monitor critical positions associated with the test item response.

b. See paragraphs 6.2.b and 6.2.c for additional requirements.

2. Sufficient sensors should be used to monitor all the specific conditions created by the specific test, ensuring the sensors are adequate for the purpose. These shall include, but are not limited to, the following:

a. Test item response to environmental conditions and monitoring of critical positions associated with the test item response.

b. Monitoring of test facility environmental conditions specific to the test (e.g., Temperature, Relative Humidity, Wind Speed, etc.).

3. Establish an alarm system to be triggered by parameter levels which go outside of acceptable limits. These alarms are prudent (when monitoring) to ensure that the test environment is being applied appropriately. These alarms are critical when monitoring parameters that may result in unsafe conditions for personnel.

5.6. FUNCTIONAL TESTS

If any Pre-, During- or Post-Test functional tests are required, conduct said test as appropriate with the advice provided in the specific test Method and as detailed within the Environmental Test Specification.

5.6.1. Pre-Test

Unless specified otherwise in the Environmental Test Specification, a Functional Pre-Test standard ambient check should be conducted to provide functional baseline data for all test items.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Visually examine the test item with special attention to stress areas and document observations including appropriate photographs and sensor positions.

(2) Insert the test item into the chamber in the required test configuration. Ensure that all cable connections have been made; that unused electrical (or other) connections have been adequately covered to simulate the actual operational environment, and that other similar requirements for proper operation have been accomplished.

(3) Conduct any required functional tests.

(4) If the test item operates in accordance with the requirements, proceed to the appropriate test procedure. If not, document observations, resolve the problems, and restart the Pre-Test.

5.6.2. During-Test

Unless specified otherwise in the Environmental Test Specification, monitoring should be undertaken throughout the test to ensure that test specification has been met and that no deviation has occurred.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Performance check. Monitoring and recording of test item's critical performance parameters is required before and after all tests. If the test item is required to function during the conditions of the test, conduct any required functional tests as detailed within the Environmental Test Specification.

(2) If the test item operates in accordance with the Environmental Test Specification, continue with the test as required in the test method.

(3) If the item has not functioned as expected; document the observations, refer to the Environmental Test Specification for guidance, and if necessary, stop the test. For test interruptions, see Chapter 7 and the guidance within the specific test method.

NOTE: Where appropriate (for items containing energetic / volatile materials (e.g., weapons), these checks should be conducted remotely, where personnel should not physically enter the test chamber or examine the item under test whilst the test is in progress. If personnel are required to directly operate or manipulate the test item during the test (i.e., for functional tests), then this shall be detailed in the Environmental Test Specification. The safety of personnel to enter the chamber, however, may be limited by the potentially hazardous nature of the specific test and / or specific test item. Therefore, the hazard should be understood prior to conducting the test and referenced within the Environmental Test Specification. Particularly, care shall be given to exhausting any noxious fumes (from combustion or off gassing) as well as monitoring the air quality inside the chamber. Data from these checks should be included within the Test Report.

5.6.3. Post-Test

Unless specified otherwise in the Environmental Test Specification, a post test check should be conducted to provide data for all test items. After completing the environmental test, examine the test item in accordance with the Environmental Test Specifications.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Before returning to the test item, ensure the test facility safety procedures and any specific requirements within the Environmental Test Specification are followed (which may vary depending upon the item), and that the item is safe to approach.

(2) Undertake visual inspection of the test item, and document findings and observations with a written record, photographs, and if appropriate, videography. If significant hazards or safety issues are found, these should be reported to the relevant test facility authority and the test facility safety procedures followed.

(3) If required and appropriate, a functional test of the test item may be undertaken to obtain Post-Test data. Compare the results with the Pre-Test data.

NOTE: Climatic testing is generally looking for subtle changes caused by the environment. These tend to be observed by comparing the Pre-, During- and Post-Test functional test data. Functional tests should be designed to exercise critical functions (operational and safety). These should include worst-case conditions (i.e., extremes of the performance envelope for a given environment), especially relating to heat transfer, power draw, etc. Repeated functional tests may be necessary to characterise variability in the results, due to either operational variability and / or human operator error.

5.7. PRE- AND POST-TEST EXAMINATION

1. Prior to conducting, and at the completion of the tests, the condition of each test item shall be established as follows:

a. Basic. This consists of visual examination supported by photography as necessary (wide angle and close detail).

b. Intermediate. Encompasses 'Basic' but may also include radiography and / or additional non-destructive techniques (e.g., tomography, ultrasonic, etc.).

c. Full. Encompasses 'Basic' and 'Intermediate' but may also include disassembly for internal examination. This is typified by destructive examination, and assessment of the chemical and physical properties of the materials contained within the test item.

2. For additional and / or other specific instructions for Pre- and Post-Test Examination, consult the Environmental Test Specification.

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CHAPTER 6 INFORMATION REQUIRED

6.1. INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTIONS

For each of the AECTP-300 Methods, the following information is required in the test instructions (where applicable). The individual AECTP-300 Methods may contain additional requirements to augment this list.

a. Purpose of the test (i.e., a demonstration of performance, survival, or ageing).

b. The test method to be used and appropriate test procedure, where more than one is available.

c. Test severities (i.e., type, number of cycles, and appropriate change rates).

d. The tolerances to be applied.

e. Test item identification (manufacturer, lot and serial number, etc.), test item configuration and the number of test items is required. This should also include whether the test item is to be tested in its normal packaging, or unpackaged, as well as the state the test item is to be tested in (e.g., valves, hatches, covers, and doors open or closed, power on or off, and restraints in place if necessary).

f. Method of mounting and orientation of the test item within the chamber.

g. Estimated dimensions and volume occupied by the test item / required, and actual working volume in the chamber.

h. Type and location of control and monitoring sensors, including locations at which stabilization is to be measured on the test item (i.e., known critical components). The component used to determine the stabilization point should be detailed in the Environmental Test Specification, with appropriate justification provided.

i. If functional performance is to be assessed:

(1) The phases of the test when the test item is to operate and be assessed.

(2) The levels of performance required.

j. Whether any visual or other examinations are required. If they are, the phases of the test that they are to be conducted at and the requirements to be met.

k. Whether natural or assisted drying is required and the duration of any recovery period before final visual inspection or assessment of performance.

l. Any additional parameters to be recorded, or instrumentation installed.

m. Any permitted deviations from the test procedure.

n. Any other known safety concerns (e.g., engine exhaust requirements).

6.2. INFORMATION REQUIRED FOR VERIFICATION

For each of the AECTP-300 Methods, the following shall be provided, so the test can be verified at the completion of the test, with the requirements included within the test instructions and reported within the test reports.

a. Measurements shall be undertaken to enable a verification process to be completed; to demonstrate that the required test severities have been achieved and within the specified tolerance bands.

b. The frequency of monitoring may vary depending on the data requirements and how the data are to be used. Measurements shall be taken of the applicable test parameters immediately prior to the test at sufficient locations to characterise the variability within the working space of the chamber. Test parameters such as temperature, humidity, and pressure should be recorded at suitable intervals, typically not greater than 10 minutes or one 100th of the overall period, including any required preconditioning and any Post-Test recovery periods, whichever is smaller. The specified recording intervals, preconditioning, and recovery period durations should be detailed within the Environmental Test Specification.

c. In determining appropriate monitoring requirements, the following aspects should be considered:

(1) The frequency of monitoring will depend upon the type of climatic test and its data requirements. Test conditions should be monitored at intervals that are appropriate for the test item and at a rate which ensures the prescribed severities can be maintained, within the required tolerances, by the test facilities. Other minimum intervals may be set to capture transient events that may occur at any time during the test.

(2) Monitoring may involve real-time continuous recording, periodic recording, or other agreed techniques.

(3) The test item should be monitored to verify its physical condition or performance. This will ensure that pertinent changes in the condition of the test item is recorded throughout the conditioning, enabling meaningful analysis to be performed.

(4) The format and measurement accuracy used in the presentation of the verification process results should be the same as those specified in the Environmental Test Specification. The verification data should be presented in an agreed digital format.

NOTE:

1. Monitoring equipment, such as thermocouples or other sensors, should not modify or attenuate the materiel's temperature and / or thermal conductivity.

2. Original (raw) data captured during the test shall be preserved to ensure that there is an unmodified source of test data.

In addition to the information within the chapter and specific to the AECTP-300 test method, the following information is required to verify the completion of the test(s) described in the method. This shall be provided within the Environmental Test Specification and / or recorded in the test report.

6.2.1. Pre-Test

Unless specified otherwise in the Environmental Test Specification, a Pre-Test standard ambient check should be conducted to provide baseline data for all test items.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Test item identification (manufacturer, model / serial number, etc.).

(2) Test equipment identification, including accessories and calibration information.

(2) Description, with photographs, of the test item's configuration and orientation within the test chamber for each test procedure.

(4) List of all sensor (thermocouples, hygrometers, etc.) placement locations, with photographs.

(5) Identification of the components / assemblies / structures to be used for measuring the response and evaluating the test item(s).

(6) If required, a record of the test item temperature-versus-time during any Pre-Test functional tests.

(7) If required, a record of the ambient temperature and humidity during any Pre-Test functional test.

(8) Results of functional test.

6.2.2. During-Test

Unless specified otherwise in the Environmental Test Specification, monitoring should be undertaken throughout the test to ensure the test specification has been met and that no deviation has occurred.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Record of the test conditions-versus-time for the entire test duration including Pre-Test and Post-Test conditions.

(2) Documentation of when stabilization of the test item was achieved for evaluating the duration of test condition exposure.

(3) Any changes to the installation, configuration, or orientation of the test item within the test chamber during testing.

(4) Documentation of test item operating and non-operating periods as well as any functional tests completed.

(5) Results of functional test.

6.2.3. Post-Test

Unless specified otherwise in the Environmental Test Specification, a post-test check should be conducted to provide data for all test items. After completing the environmental test, examine the test item in accordance with the Environmental Test Specifications.

a. General: Record the basic information, including required information from each Test Method.

b. For each Test Method in AECTP-300:

(1) Results of any visual inspections and any functional tests performed.

(2) If required, a record of the test item temperature-versus-time during any Post-Test functional tests.

(3) If required, a record of the ambient temperature and humidity during any Post-Test functional tests.

(4) The actual test sequence (programme) used.

(5) Performance data collected on the same parameters at the same operational levels as those of the Pre-Test.

(6) Other data specified in individual methods or requirements document(s).

(7) List of any test interruptions and deviations from the test plan, ensuring that the guidance within Chapter 7 was followed, including the provision of the explanation of the interruption / deviation, and documented approval from the Test Specifier / Stakeholder Panel.

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CHAPTER 7 TEST INTERRUPTION GUIDANCE

7.1. DEFINITION

1. An interruption is defined as the occurrence of out-of-tolerance test conditions. Unless otherwise specified in the Environmental Test Specification, the procedures set out below, in addition to the requirements found within the specific Test Method, should be followed when a test is interrupted. For hazardous materials, appropriate non-destructive testing of the materials may be necessary.

2. All interruption criteria shall be detailed in the test item's Environmental Test Specification. In the event of an interruption:

a. Consult the guidance within this Method.

b. Consult the guidance within the specific Test Method.

c. Inform the relevant Stakeholder Panel to obtain approval of the required course of action.

3. Figure 1 provides a simplified guide of how to proceed following an interruption. In addition to Figure 1, the specific sections below should be reviewed and understood prior to proceeding.

7.2. UNDER-TEST INTERRUPTION

If the effect of the interruption resulted in the test conditions becoming less severe than those required:

a. Re-establish the prescribed conditions (e.g., chamber temperature, humidity, etc.).

b. Re-establish any required pre-conditioning (e.g., test item conditioning temperature).

c. Continue the test from the point of the interruption.

d. Any identified deviation must be explained in the test report, with the cause determined and the impact on the test items explained.

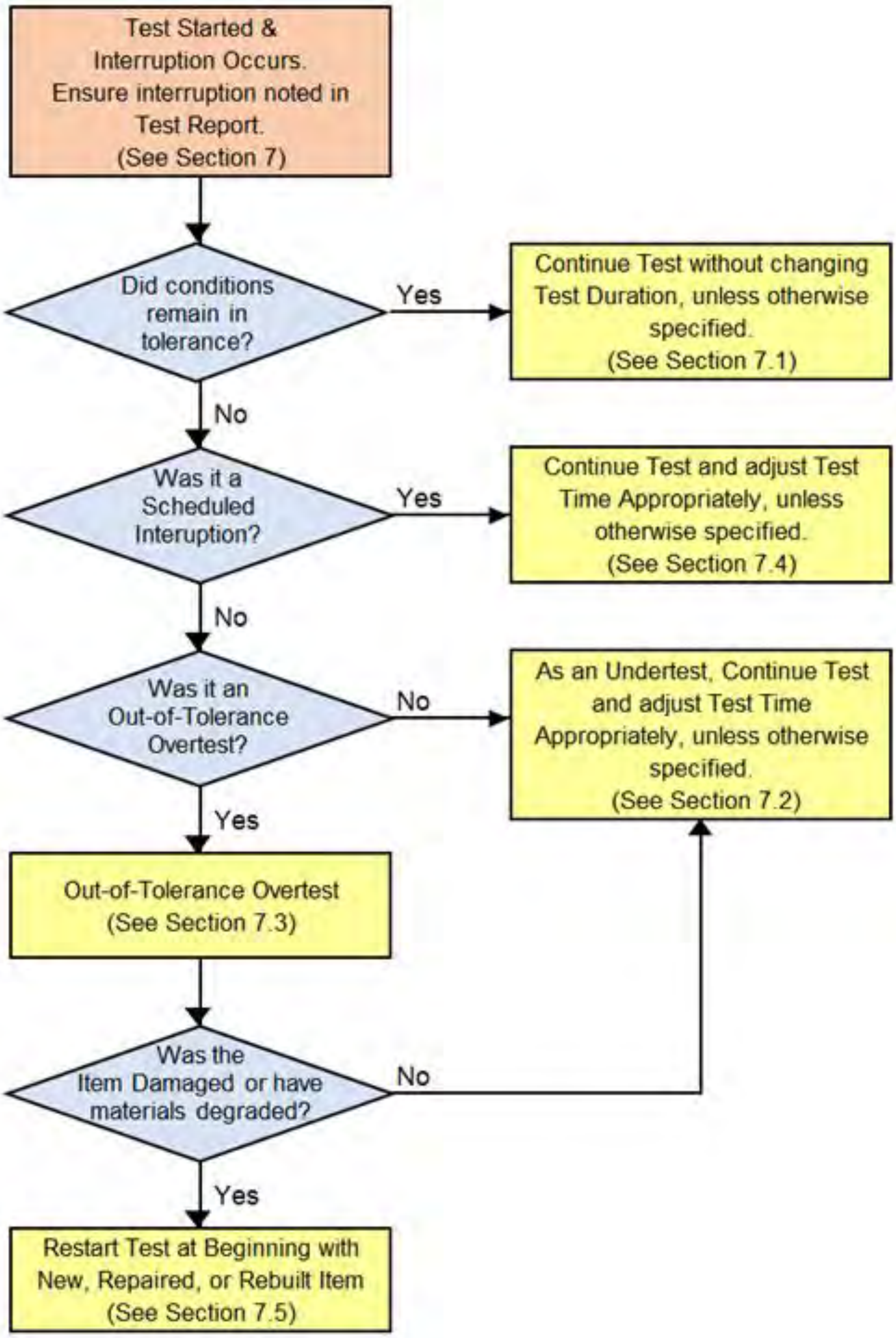

Figure 1: Simplified Guide for Interruption Procedure

7.3. OVER-TEST INTERRUPTION

When the effect of the interruption resulted in the test conditions becoming more severe than those required, the preferable course of action is to terminate the test and reinitiate testing with a new test item. However, there would be a loss of the cumulative and / or synergistic effects from the previous testing, see Chapter 8 paragraph 8.6. Therefore, the following should be considered:

a. Stop the test and conduct an operational and visual check of the test item.

b. If no defects are revealed, re-stabilise the test item at the test conditions that correspond to the point of interruption and continue the test.

c. If a defect is revealed, restart the test from the beginning with a new test item.

d. Any identified deviation must be explained in the test report, with the cause determined and the impact on the test items explained.

e. Consider the time at over-test conditions as valid test time. The consequences of any over-test should be considered, with guidance provided in Chapter 9.

7.4. SCHEDULED INTERRUPTION

1. If the interruption is due to scheduled maintenance or repair of the test equipment or the test item:

a. Stop the test and conduct an operational and visual check of the test item.

b. Re-establish any required pre-conditioning.

c. Re-establish the prescribed conditions.

d. Continue the test from the point of the interruption.

e. Any identified deviation must be explained in the test report, with the cause determined and the impact on the test items explained.

2. Scheduled test interruptions should be avoided and may not be allowed for some test methods due to the time required to re-establish an equivalent response / condition in the test item.

7.5. INTERRUPTIONS DUE TO TEST ITEM FAILURE

An interruption could occur where the test item has suffered a structural failure or has failed to operate during functional tests. For guidance on the types of failure and remedial actions to undertake in the event of said failure, see Chapter 9.

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CHAPTER 8 GUIDANCE ON TEST PROGRAMME DEVELOPMENT

8.1. TEST REQUIREMENTS

1. The purpose of this document is to provide general guidance related to the climatic test methods of AECTP-300, defining the general test conditions and associated tolerances used with the test methods of AECTP-300. Advice on the selection of environmental tests, the derivation of the sequence in which those tests should be undertaken and the preparation of test specifications by indicating which test methods are preferred however, is provided in greater detail within AECTP-230.

2. AECTP-230 complements, amplifies, and extends the information contained in AECTP-300 by:

   a. Identifying potential damaging effects that natural and induced environmental conditions have on materiel.

   b. Providing guidance on the selection of suitable test methods.

   c. Providing a detailed description of the natural and induced environments.

3. For the assessment of munitions (in particular) reference should also be made to the guidance contained in STANAG 4297 Edition 2.

8.2. TESTING IN THE NATURAL ENVIRONMENT

Testing in the natural environment is the most realistic approach. However, since it is not possible to control the natural environment, it is rarely possible to ensure that the required extreme environment is available for the test. Where testing in the natural environment is impractical, laboratory testing becomes essential, but it should be accepted that the full synergistic effect of the natural environment may not be accurately replicated in all aspects.

8.3. TAILORING

The tailoring process (as described in AECTP-100, "Guidelines on the Management of Environmental Testing of Defence Materiel", or equivalent national documents) shall be used to determine the appropriate tests and test variables based upon the Life Cycle Environmental Profile (LCEP). Whenever possible, data obtained under actual end-use conditions should be used to define test parameters. When measured data are not available, analytical derivations and data from similar applications may be used. The requirements documents must, in all cases, define the anticipated operational scenarios for the test item, so that the environmental test conditions can be derived.

8.4. SEQUENCE

The sequence of tests should normally reflect the sequence of environments that the materiel is expected to experience during its lifecycle. Practically, limitations such as time, scheduling and resources may require modification to this approach. There are, in some situations, specific guidelines or recommendations for test sequence. These are identified in the individual test methods.

8.5. COMBINED ENVIRONMENTS

The tailoring process (AECTP-100) may identify a need to apply combined environments to the test item. Such combinations as temperature and altitude, temperature and vibration, or temperature and shock may produce a more realistic representation of the effects of the environment than a series of single tests. Combined environment testing is encouraged, and the appropriate test procedures should be blended by the environmental engineering specialist to provide the required simulation.

8.6. SYNERGISTIC EFFECTS

Materiel will frequently experience two or more environmental stresses either simultaneously or consecutively, producing cumulative or synergistic effects that do not occur due to a single stress event. Accordingly, it is recommended that, to the maximum extent possible, the same test item(s) be used throughout the test sequence for both climatic and dynamic tests. Exceptions to this guidance are provided in the individual test methods as appropriate.

8.7. SELECTION OF CLIMATIC CONDITIONS

1. The climatic test parameter values shall be based upon actual measurements, documentation containing climatic data such as AECTP-230 Leaflet 2311, similar national documents, or data banks.

2. In determining parameters, consideration shall be given to the following:

    a. Natural (Meteorological) climatic conditions: The naturally occurring ambient environmental conditions anticipated for the areas of use, which are not modified by the structure in or on which the materiel is placed.

    b. Induced environment: The ambient environmental conditions resulting from the modification of the natural climatic conditions due to the structure in or on which the materiel is used. Examples of values that may be considered if no specific data are available, are given in AECTP-230, Leaflet 2310.

c. Controlled (constant) environment: The steady state conditions that exist in environments that are relatively controlled (e.g., aircraft cargo bays, maintenance rooms, inside storage areas, or other conditioned enclosures).

3. Where there is any likelihood of differential stressing from thermal cycling being significant, it may be appropriate to use cyclic temperature testing or, in some instances, thermal shock testing. For other situations, constant temperature testing is appropriate.

4. When the materiel is intended to be used throughout the world, allowance should be made for the conditions encountered in the most extreme climatic zones. However, there may be short periods of time during which Service conditions exceed the environmental extremes presented in these methods and, during which, proper materiel functioning may be inhibited. Once an acceptable frequency of occurrence of a climatic element has been determined, the corresponding climatic value can be ascertained from the climatic data documentation. Appropriate diurnal cycles are given in AECTP-230, and Leaflets 2310 and 2311. Care should be taken when considering occurrences exceeding 87 hours per year (1 percent of the duration of one month) because of under-design possibilities. For worldwide low temperatures, consideration should be given to the possibility of the materiel entering the C3 category. Since the C4 category only covers the coldest areas of Greenland and Siberia, it is only necessary to consider this for specialised materiel. If the materiel is likely to enter C3, then 51 °C is an appropriate low temperature to use for design and test purposes. For other cold categories, appropriate cycles are provided in AECTP-230, and Leaflets 2310 and 2311.

8.8. EXPOSURE DURATION

The duration of exposure to severe temperatures may have a significant impact on materiel and its component materials. Normal diurnal cycling will involve thermal lag for which the most severe test item response is normally achieved within 7 cycles. Constant (non-cyclic) conditions will generally produce thermal stabilisation in a shorter period. Actual exposure durations should take into consideration the LCEP.

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CHAPTER 9 EVALUATION OF TEST RESULTS

9.1. FAILURES

1. Failure of a test item to operate as required during functional tests, or a failure of the item's structure and / or components presents a situation with several possible options. Failure of subsystems often has varying degrees of importance in evaluation of the test materiel integrity.

2. Any one of the following conditions shall normally constitute a test item failure:

   a. Deviation of monitored functional parameter levels beyond acceptable limits established in the requirements document.

      (1) Degraded performance at specified environmental extremes is permissible if identified in the test plan. Degraded performance is a failure if either of the following occur:

         (a) Degradation exceeds the permissible limits.

         (b) Specified performance is not restored upon removal of the environmental extreme.

   b. Non-fulfilment of safety requirements or the development of safety hazards.

   c. Non-fulfilment of specific test item requirements.

   d. Changes to the test item that could prevent it from meeting its intended service life or maintenance requirements. (For example: Corroded oil drain plug cannot be removed with commonly available tools or without damaging the surrounding components.)

3. All failure criteria shall be detailed in the test item's Environmental Test Specification. In the event of a failure of the test item to function as required during operational checks, consult the Environment Test Specification and inform the relevant Stakeholder Panel to confirm the required course of action.

9.2. RETESTS

1. Test items with parts or assemblies that have been replaced, repaired or redesigned should be re-tested to the complete test environment. It is recommended that one of the following options is undertaken:

OPTION A. The preferable option is to replace the test item with a 'new' item and restart the entire test.

OPTION B. Replace / repair the failed or non-functioning component or assembly within the test item, with one that functions as intended and restart the entire test. If the non-functioning component or subsystem is a Line Replaceable Unit (LRU) whose life cycle is less than that of the system test being conducted, it may be possible to substitute the LRU and proceed from the point of interruption. However, the following should be considered:

(1) If the component is one which contains energetic materials (e.g., an igniter from a rocket motor), then replacing the component may not be appropriate as this would void any cumulative and / or synergistic effects from the testing done previously and increase uncertainty in the life of the assembly.

(2) The life of the "system" would be limited to that of the component which failed, unless an appropriate life extension or maintenance programme is planned to replace the life limiting component.

OPTION C. For system level tests involving unique materials / materiel, it may not be possible to acquire additional hardware for re-test based on a single subsystem failure. For such cases, the organization responsible for the system under test, in conjunction with other relevant stakeholders, should perform a risk assessment to determine if replacement of the failed subsystem is feasible and resumption of the test is an acceptable option. Subject to Stakeholder Panel approval, the failed component could be retested at the component level (see paragraph 9.2.2.b).

2. Caution for Retest.

a. For Option B:

(1) If the test item contains energetic / volatile materials, repeating the test from the start (following the replacement / repair of other components or assemblies) may cause any original energetic / volatile materials to degrade beyond their design limits. This could cause an unrepresentative failure to occur and / or cause the energetic materials to become unstable and hazardous.

(2) Non-energetic materials could also fail if the duration of the test programme exceeds the design limits of the materiel.

b. For Options B and C:

(1) Component testing is not usually appropriate when its boundary conditions are significantly influenced by adjacent components or the overall system, such that they affect the component's thermal behaviour or its safety-critical functional response. When the component characteristics are affected, then testing should normally be conducted as an integral part of the overall system or as part of a major sub-assembly.

(2) Component testing is appropriate when the boundary conditions are well defined and there is no significant influence from the overall system that is likely to affect the components thermal behaviour, or its safety-critical functional response.

(3) Safety and Suitability for Service environmental testing, whether at complete assembly or component level, needs to demonstrate that all necessary failure modes have been exercised. This intrinsically means that the thermal conditions experienced by the components are fully representative of those experienced during operational use.

9.3. EXCEPTIONS

The following conditions by themselves need not necessarily constitute a failure of the test item, although a re-test would normally be necessary.

a. Failure of a test tool, fixture or other associated support equipment.

b. Operator error.

c. Mishandling or improper assembly during troubleshooting or maintenance of the test item.

d. Failure of associated Government Furnished Equipment (GFE) / Contractor Furnished Equipment (CFE).

e. Test item failures induced by test tools, fixtures, GFE / CFE, and associated support equipment.

f. Failure of test item elements or assemblies during retest (at conditions more extreme than those detailed in the deployment scenario) that have previously met environmental testing requirements.

g. Failures induced by the failure of test item elements or assemblies during retest that have previously met environmental testing requirements outside the extremes specified in the equipment specification.

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CHAPTER 10 REFERENCES AND RELATED DOCUMENTS

a. IEC 60068 Part 1, Environmental testing – General and guidance, 2014.

b. IEC 60068 Part 3-11, Environmental testing – Supporting documentation and guidance – Calculation of uncertainty of conditions in climatic test chambers, 2007.

c. ISO 554, Standard atmospheres for conditioning and/or testing, 1976.

d. ISO 3205, Preferred test temperatures, 1976.

e. STANAG 4297, Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces.

f. STANAG 4370 AECTP-100, Environmental guidelines for defence materiel, May 2009.

g. STANAG 4370 AECTP 230 Section 2311 Leaflet 2310, Environmental guidelines for defence materiel - Climatic conditions - Worldwide extreme climatic & environmental conditions for defining design/test criteria - Climatic categories and their geographical location.

h. STANAG 4370 AECTP 230 Section 2311 Leaflet 2311, Environmental guidelines for defence materiel - Climatic conditions - Worldwide extreme climatic & environmental conditions for defining design/test criteria - World-wide ambient air temperature and humidity conditions and levels of direct solar radiation.

i. MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests.

j. DEF STAN 00-035 Environmental Handbook for Defence Material.

k. The U.S. Range Commanders Council (RCC) Series.

l. European Cooperation for Space Standardization (ECSS) Publications.

m. ECSS-E-ST-10-04C – Space Environment.

n. BS ISO 17851:2016 Space systems. Space environment simulation for material tests. General principles and criteria.

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METHOD 301
LOW PRESSURE (ALTITUDE)

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

Low-pressure (altitude) tests are performed to determine if materiel can withstand and / or operate in a low-pressure environment and / or withstand rapid pressure changes.

1.2. APPLICATION

Specific applications are to determine if:

a. The materiel can be stored and operated at high ground elevation sites.

b. The materiel can be transported or operated in pressurized / unpressurized areas of aircraft.

c. The materiel can survive a rapid or explosive decompression and, if not, to determine if it will damage the aircraft or present a hazard to personnel.

d. The materiel can withstand external carriage on aircraft.

1.3. LIMITATIONS

This method is not intended to be used to test materiel to be installed in space vehicles, aircraft, or missiles that fly at altitudes above 30,000 m.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

In addition to thermal effects (see Method 303), examples of problems that could occur as a result of exposure to reduced pressure are shown below. Exposure to high humidity immediately following flight can draw moisture into items, but if it is necessary to evaluate such combined effects, other test methods (such as Method 317 of this AECTP) should be used. The list below is not intended to be all-inclusive and some of the examples may overlap the categories:

2.1.1. Physical / Chemical

a. Leakage of gases or fluids from gasket-sealed enclosures.

b. Deformation, rupture or explosion of sealed containers.

c. Change in physical and chemical properties of low-density materials.

d. Overheating of materiel due to reduced heat transfer.

e. Evaporation of lubricants.

f. Erratic starting and operation of engines.

g. Failure of hermetic seals.

2.1.2. Electrical

Erratic operation or malfunction of materiel resulting from arcing or corona.

2.2. CHOICE OF TEST PROCEDURE

See Method 300 Chapters 1 and 8. Four test procedures are included within this Method: storage, operation, rapid decompression, and explosive decompression. Based on the test data requirements, determine which of the test procedures or combination of procedures is applicable.

2.2.1. Procedure I: Storage / Air Transportation

Procedure I is appropriate if the materiel is to be stored at high ground elevations or transported in its shipping / storage configuration.

2.2.2. Procedure II: Operation / Air Carriage

Procedure II is used to determine the performance of the materiel under low pressure conditions and may be preceded by procedure I, procedure III, procedure IV, or all three. If there are no low-pressure storage, rapid, or explosive decompression requirements, this procedure can stand alone.

2.2.3. Procedure III: Rapid Decompression

Procedure III is used to determine if a rapid decrease in pressure of the surrounding environment will cause a materiel reaction that would endanger nearby personnel or the aircraft in which it is being transported. This procedure may be preceded by either the storage or the operational test.

2.2.4. Procedure IV: Explosive Decompression

Procedure IV is similar to Procedure III except that it involves an "instantaneous" decrease in the pressure of the surrounding environment.

2.3. SEQUENCE

See Method 300 Chapter 8.

Other testing may contribute significantly to the effects of low pressure on the test item (see paragraph 2.1), and may have to be conducted before this method. For example:

a. Low-temperature and high-temperature testing may affect seals.

b. Dynamic tests may affect the structural integrity of the test item.

c. Aging of non-metallic components may reduce their strength.

2.4. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8.

After the test procedure is chosen, determine the test parameters such as test pressure and temperature, rate of change of pressure (and temperature if appropriate), duration of exposure, and test item configuration.

2.4.1. Test Pressure and Temperature

Base determination of the specific test pressures and temperatures on the anticipated deployment or flight profile of the test item.

a. Ground areas. If measured data are not available, temperatures may be obtained for appropriate ground elevations and geographical locations from Leaflet 2311. The highest elevation currently contemplated for NATO ground military operations (equipment operating and non-operating) is 4,570 m with an equivalent air pressure of 57 kPa.

b. Transport aircraft cargo compartment pressure conditions. Table I provides the minimum cargo compartment pressures for various aircraft used to transport cargo. These pressures can occur as a result of failure of the automatic pressurization system. Redundant systems prevent rapid loss of pressure unless explosive decompression occurs. Testing to the 4,570 m equivalent altitude will assure that the materiel shipped by air will successfully withstand the low-pressure environment. The range of temperatures associated with the various low-pressure situations is such that identification of same in this document is impractical. Test temperatures should be obtained from measured data or from appropriate national sources.

c. Maximum flight altitude for explosive decompression testing: 12,200 m (18.84 kPa). When it is known that other altitudes will be encountered, test the materiel for the known elevation.

2.4.2. Altitude Change Rate

If a specific rate of altitude change (climb / descent rate) is not known or specified in the requirements document, the following guidance is offered: In general, and with the exception of the explosive decompression test, the rate of altitude change should not exceed 10 m/s unless justified by the anticipated deployment platform. In a full military power takeoff, military transport aircraft normally have an average altitude change rate of 7.6 m/s.

Table 1: Minimum Normal Cargo Compartment Pressures

Aircraft	Minimum Cargo Compartment Pressure (kPa)	Equivalent Altitude (m)
C-130	56.8	4,570
C-141	59.1	4,270
C-5A	60.1	4,110
DC-8/707/DC-9-80	56.8	4,570
DC-10/747/KC-10	56.8	4,570
L-1011/767	56.8	4,570
C-160 Transall	59.1	4,270
VC-10	79.2	1,980
A-300/C	74.6	2,400

2.4.3. Rapid Decompression Rate

There are several conditions for which the rapid rate of decompression may vary. These include the following:

a. Massive damage to the aircraft, but the aircraft survives and decompression is virtually instantaneous.

b. Relatively small holes caused by foreign objects through which decompression could occur at a slower rate than above.

c. Relatively gradual loss of pressure due to loosening of aircraft structure (including seals).

Explosive decompression should be accomplished in 0.1 second or less; rapid decompression should not take more than 15 seconds.

2.4.4. Test Duration

For Procedure I, the test duration should be representative of the anticipated service environment but, if this is determined to be extensive, a test duration of at least 1 hour is considered adequate for most materiel. Once the test pressure has been reached and any required functions performed, Procedures II, III, and IV do not require extended periods at the test pressure.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

See Method 300 Chapters 4 and 6.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5.

4.2. CONTROLS

Unless otherwise specified, the altitude change rate shall not exceed 10 m/s.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7. To achieve the desired effects, the test item must be subjected to the full duration of the low-pressure test without interruption.

4.4. PROCEDURES

The following test procedures, alone or in combination, provide the bases for collecting the necessary information concerning the test item in a low-pressure environment. Unless otherwise specified, the chamber temperature shall be maintained at the anticipated service environment temperature.

4.4.1. Preparation for Test

Before starting any of the test procedures, determine the information specified in Method 4 and 6 as well as altitude change rates, and perform the test preparation procedure specified in Method 300 Chapter 2.

4.4.2. Procedure I: Storage / Air Transportation

Step 1. Place the test item in its storage / transit configuration and position it in the test chamber.

Step 2. If appropriate, stabilise the test item to the required test temperature.

Step 3. Adjust the chamber air pressure to the required test altitude, at an altitude change rate as specified in the test plan.

Step 4. Maintain the conditions for a minimum of 1 hour unless otherwise specified in the test plan.

Step 5. Adjust the chamber air to standard ambient conditions at the rate specified in the test plan.

Step 6. Visually examine the test item to the extent possible and conduct an operational check. Document the results.

4.4.3. Procedure II: Operation / Air Carriage

Step 1. With the test item in its operational configuration, adjust the chamber air pressure (and temperature if appropriate) to the required equivalent operational altitude at a rate not to exceed that specified in the test plan.

Step 2. Conduct an operational check of the test item in accordance with the requirements documents, and document the results.

Step 3. Adjust the chamber air to standard ambient conditions at the rate specified in the test plan.

Step 4. Visually examine the test item to the extent possible and conduct an operational check. Document the results.

4.4.4. Procedure III: Rapid Decompression

Step 1. With the test item in the storage or transit configuration, adjust the chamber air pressure (and temperature if appropriate) at the rate specified in the test plan to the maximum equivalent altitude of the anticipated aircraft (cabin pressure) (from Table 1).

Step 2. Reduce the chamber air pressure to an equivalent altitude of 12,200 m (18.8 kPa), or as otherwise specified in the test plan, in 10 ± 5 seconds. Maintain this stabilised reduced pressure for at least 10 minutes.

Step 3. Adjust the chamber air to standard ambient conditions at the rate specified in the test plan.

Step 4. Visually examine the test item to the extent possible and conduct an operational check. Document the results.

4.4.5. Procedure IV: Explosive Decompression

Step 1. With the test item in the storage or transit configuration, adjust the chamber air pressure (and temperature if appropriate) at the rate specified in the test plan to the maximum equivalent altitude of the anticipated aircraft (cabin pressure).

Step 2. Reduce the chamber air pressure to an equivalent altitude of 12,200 m (18.8 kPa), or as otherwise specified in the test program, in not more than 0.1 seconds. Maintain this stabilised reduced pressure for at least 10 minutes.

Step 3. Adjust the chamber air to standard ambient conditions at the rate specified in the test plan.

Step 4. Visually examine the test item to the extent possible and conduct an operational check. Document the results.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9. For Procedure IV, the test item fails only if explosive decompression causes a hazard to the aircraft or to the personnel; the test item need not show satisfactory post-test performance unless otherwise specified.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. STANAG 4044, Adoption of a Standard Atmosphere, 10 April 1969, (ICAO Standard Atmosphere).

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METHOD 302
HIGH TEMPERATURE

TABLE OF CONTENTS

CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The purpose of the High Temperature test method is to help evaluate the effects of high temperature conditions on materiel safety, integrity, and performance.

1.2. APPLICATION

This method is used when the requirements documents state that the materiel is likely to be stored or operated in areas where high temperatures occur. Further information on the prevalence of high temperatures is provided in AECTP-230, “Climatic Conditions”. Although not written for such, this method may be used in conjunction with the shock and vibration tests in AECTP 400, “Mechanical Environmental Tests”, to evaluate the effect of dynamic events (e.g., transport, handling, and shock) on materiel exposed to high temperature.

1.3. LIMITATIONS

This method is generally not practical for the following:

a. Characterizing the response of materiel exposed to significant sources of thermal radiation. Method 305, “Solar Radiation”, should be used to evaluate the effects of solar radiation.

b. Evaluating aerodynamic heating. Simulating frictional heating from highspeed airflow requires unique test equipment and procedures not covered in this method.

c. Evaluating the time-dependent chemical or mechanical degradation (ageing) of materials from the long-term exposure to high temperatures. Arrhenius-type accelerated ageing studies require an understanding of the relevant degradative processes and their chemical kinetics within the materials under test. The background knowledge and data required to conduct such studies are beyond the scope of this method.

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CHAPTER 2 TEST GUIDANCE

2.1. USE OF MEASURED DATA

This method provides test severities suitable for use when measured data are not available. Any derived test cycle that is based upon measured data needs to include a sufficient safety margin to allow for variations in both environmental conditions and materiel deployment. Overly specific test cycles may severely limit operational flexibility as well as life extension potential, particularly if used in safety and suitability assessments.

2.2. SEQUENCE

Use the anticipated Life-Cycle Environmental Profile (LCEP) as a general guide for test sequencing (see Method 300, “General Guidance and Requirements”). Consideration should be given to materials which are likely to be permanently modified in either their physical or chemical characteristics when exposed to high temperature environments. For materiel that may be exposed to high induced temperatures during storage and transport in uncontrolled environments, the High Temperature Storage or Transport test is usually performed prior to other operational tests, in order to maximize the likelihood of disclosing synergetic effects from sequential environmental exposure. As an example, prior high temperature exposure may significantly impact the results obtained when low pressure testing polymeric seals.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials.

2.3. EFFECTS OF THE ENVIRONMENT

High temperature may either temporarily or permanently impair the performance of materiel by changing its properties. The following are examples of problems that could result from high temperature exposure. The list is not intended to be all-inclusive and some of the examples may overlap categories:

2.3.1. Physical

a. Melting and other phase changes.

b. Dimensional changes and exudation, particularly in extruded solid propellants.

c. Distortion, binding, failure of bearings, shafts, and packings.

d. Gaskets and seals deteriorating, developing permanent set.

e. Differential thermal expansion, particularly for non-metallic materials against metallic (e.g., explosives, propellants in sealed containers, or casings).

f. Development of internal pressure.

g. Changes in physical properties such as modulus and strength.

h. Lubricants becoming less viscous; joints may seize from the outward flow of lubricant.

i. Unintentional functioning of thermally activated devices.

j. Failure of insulation protection.

k. Increased occurrence of cavitation.

l. Difficulty in handling.

2.3.2. Chemical

a. Increased rates of diffusion.

b. Increased rates of reaction, including more rapid ageing caused by reaction with oxygen, water, or other contaminants, leading to failure, cracking, crazing, or discolouring. Increased burning rates of explosives and propellants.

c. Failure of chemical agent protection.

d. Release of vapours leading to corrosion.

e. Out-gassing of composite materials or coatings (e.g., volatile organic compounds (VOCs), carbon-monoxide (CO), and phthalates).

CAUTION: Vapours released may present a health hazard to personnel. Precautions should be taken to minimize exposure to same.

2.3.3. Electrical

a. Resistors and other components changing in value.

b. Variations in circuit characteristics, electric, electronic, or optical.

c. Failure or reduced life expectancy of electronic components.

d. Altering of operating or release margins of electromechanical devices.

e. Overheating of electrical components during operation.

2.4. CHOICE OF TEST PROCEDURE(S)

The high temperature test procedures in this method should be selected based on the materiel's anticipated LCEP. In many cases, one or more of the test procedures will apply. Consider all high temperature environments anticipated for the materiel during its LCEP, both in its logistic and operational modes. As a minimum, consider the potential high temperature environments associated with the following materiel configurations:

a. Within a storage container, shipping package, or transit case.

b. In stacked or palletized configurations.

c. Unprotected or semi-protected (e.g., under canopy, canvas, etc.) in the exposed environment.

d. Installed within an enclosure, machinery room, or electronic bay.

e. Installed or transported within a vehicle, aircraft, or ship.

f. In its stand-by and normal operating configurations.

g. Modified with kits for special applications.

There are three types of test procedures included in this method. While all three procedures involve temperature conditioning, they differ in the temperature load prior to and during any functional tests.

2.4.1. Procedure I: High Temperature Storage or Transport

This procedure is used to evaluate the effects of high temperature during storage or transport on subsequent materiel performance. The procedure is intended to evaluate the effect of short-term storage or transport within uncontrolled environments.

2.4.2. Procedure II: High Temperature Operation

This procedure is used to evaluate the effects of high temperature on materiel performance during use.

2.4.3. Procedure III: High Temperature Tactical Standby to Operational

This procedure is used to evaluate the ability of materiel to soak at induced high temperature conditions and then become operational, within a relatively short period of time, at meteorological high temperature conditions. This procedure is not a substitute for the solar radiation testing described in Method 305.

> **NOTE:** The materiel's LCEP may reveal other high temperature scenarios that are not specifically addressed by the procedures outlined in this method. Tailor the procedures as necessary to capture the LCEP variations, but do not reduce the basic test requirements or severities reflected within this method.

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CHAPTER 3 TEST SEVERITIES

3.1. GENERAL

Having selected this method and the relevant procedure(s), complete the tailoring process by identifying appropriate test severities for each procedure based on the materiel's requirements documents and the materiel's anticipated LCEP. The test severities are the air temperature(s) (with low humidity, if applicable) and the exposure duration at the high temperature(s).

3.2. TEMPERATURE SEVERITIES

1. The temperature severities experienced by materiel will vary according to the ambient daily and seasonal climatic conditions, the immediate environment surrounding the materiel (including any external heat sources or restrictions to heat transfer), and the operating (heat dissipating) characteristics of the materiel. Factors which may influence a materiel's thermal environment include the following:

   a. Direct or indirect exposure to solar radiation (see Method 305).

   b. Type of shelter or packaging employed (in storage, transport, or operation).

   c. Exposure to, or shelter from, natural wind or other air circulation.

   d. Ambient air density.

   e. Neighbouring equipment such as stacked materiel or equipment racks.

   f. Heat-dissipating operations (e.g., mechanical friction, electrical resistance, or chemical reaction).

   g. External heat sources (through conduction, convection, or radiation) such as heaters, boilers, engines / motors, exhaust plumes, fluid lines, electronics, lamps, etc.

   h. Controlled or semi-controlled temperature environments.

2. The temperature severities should be derived from climatic data documents such as AECTP 230, national climatic documents, or from other environmental data banks. Temperature severities may be characterized as either meteorological or induced conditions. These conditions, in turn, may be either cyclic (such as diurnal cycles) or constant.

3.2.1. Meteorological Conditions

1. These conditions represent the air temperature within the natural outdoor environment. The meteorological temperature is the free air temperature shielded from the direct influence of solar radiation or any other temperature modifying factors. It is the temperature obtained from standard weather observation equipment (e.g., a Stevenson screen) and reported by meteorological agencies.

2. Materiel experience meteorological conditions in the open outdoor environment or within well-ventilated enclosures, while sheltered from the effects of solar radiation. Temperature severities that should be considered are provided as "Meteorological Conditions" for three climatic categories (A1, A2, and A3) in Table A-1 of Annex A. These data were extracted from AECTP-230.

3.2.2. Induced Conditions

1. All environments which differ from the prevailing meteorological conditions are considered to be induced conditions. Naturally occurring induced conditions arise when the heating effects of solar radiation cause the air temperature within less-than-fully ventilated shelters or enclosures to rise above the prevailing outdoor meteorological air temperature. Other induced conditions may arise due to heat-generating sources from neighbouring equipment or from within the materiel. Materiel may experience the following induced conditions during storage, transport, or operation:

a. Within unventilated enclosures, shipping containers, storage bins, tents, shelters, or under tarpaulin.

b. Inside vehicles, ships, or aircraft.

c. Near heat-generating sources (engines, radiators, lights, and electronics).

2. Induced conditions are difficult to characterize because of the numerous variables involved (volume of the enclosure, degree of solar intensity, enclosure surface reflectivity, degree of insulation, heat sources, etc.). These conditions are best determined through actual measurements. For naturally occurring induced conditions, caused by solar radiation incident on unventilated enclosures, examples of temperature severities that may be considered are provided as “Induced Conditions” for three climatic categories (A1, A2, and A3) in Table A-2 of Annex A. These data were extracted from AECTP-230.

NOTE: Temperatures exceeding those given in AECTP-230 have been measured under certain extreme induced conditions. Unventilated compartments with transparent panels (e.g., cockpits, vehicle cabs, etc.) under solar radiation may experience induced air temperatures significantly higher than 71 °C.

3.2.3. Procedure I: High Temperature Storage or Transport

Select either cyclic or constant temperature conditions which represent the most severe storage or transport conditions within the materiel's anticipated LCEP. Storage and transport conditions typically involve induced thermal environments, as such the guidance on Induced Conditions (paragraph 3.2.2.) should be employed as appropriate. Unless otherwise justified by the materiel's requirements documents, the cyclic (diurnal) temperature profiles in Table A-2 of Annex A should be used, with the most severe climatic category selected in accordance with the materiel's anticipated LCEP.

3.2.4. Procedure II: High Temperature Operation

Select either cyclic or constant temperature conditions which represent the most severe operating conditions within the materiel's anticipated LCEP. Operating conditions typically involve meteorological environments; however, induced thermal environments are possible for certain materiel installations. The guidance on Meteorological Conditions (paragraph 3.2.1.) or Induced Conditions (paragraph 3.2.2.) should be employed as appropriate. Unless otherwise justified by the materiel's requirements documents, temperature profiles in Table A-1 or A-2 of Annex A should be used, with the most severe climatic category selected in accordance with the materiel's anticipated LCEP.

3.2.5. Procedure III: High Temperature Tactical Standby to Operational

Select the constant temperature conditions which represent the most severe transition between stand-by (storage or transport) and the materiel's operating environment within the materiel's anticipated LCEP. Stand-by conditions typically involve induced thermal environments, while the operating conditions typically involve meteorological environments. The guidance on both Meteorological Conditions (paragraph 3.2.1.) and Induced Conditions (paragraph 3.2.2.) should be employed as appropriate.

3.3. TEST DURATION

Determine the duration of exposure that the materiel will experience for each of the exposure conditions identified in the materiel's anticipated LCEP. The duration of exposure to high temperature(s) is as important as the temperature itself.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials.

3.3.1. Procedure I: High Temperature Storage or Transport

During storage or transport testing, it is important to measure the temperature of any critical sub-systems or components in addition to the parts of the test item with the longest thermal lag. The total test duration may ultimately depend on the time required for the test item to reach test temperature stabilization (see Method 300). The test duration will depend on the choice of the temperature profile chosen:

a. Cyclic (Diurnal) Temperature Exposure. If the 24-hour temperature cycles from Table A-2 in Annex A are selected, the minimum number of cycles for the storage test is seven. For other cycles, justification shall be obtained from the requirements documents, subject to an anticipated minimum of seven 24-hour cycles.

b. Constant Temperature Exposure. The minimum duration is the time required for the test item to reach test temperature stabilization, plus two hours. To provide confidence that an extended exposure can be survived, longer test exposure periods will be needed. The duration and temperature chosen will depend on the purpose of the test and should ensure that all likely failure modes will be evaluated. This typically requires an understanding of the relevant thermo-chemical degradation processes within the materials under test, which are often difficult to ascertain before test. Moreover, constant temperature exposure may result in failure modes not typically observed during service.

NOTE: For the High Temperature Storage or Transport Test, constant temperature exposure is not a substitute for situations in which diurnal cycling is typical in the materiel's LCEP.

3.3.2. Procedure II: High Temperature Operation

During operational testing, it is important to measure the temperature of any critical sub-systems or components, any heat dissipating components, and the parts of the test item with the longest thermal lag. The total test duration may ultimately depend on the time required for the test item to reach test temperature stabilization (see Method 300), as well as the additional time required to perform any functional tests and to re-establish steady-state thermal conditions during operation (for heat dissipating materiel). The test duration will depend on the choice of temperature profile chosen:

a. Cyclic (Diurnal) Temperature Exposure. The minimum number of cycles is predicated on achieving repeated test item thermal response within 2 °C between successive cycles. Three cycles are normally sufficient for the test item to reach its maximum response temperature. A maximum of seven cycles is suggested when repeatable temperature response is difficult to obtain. Once repeated thermal response is obtained, functional tests should be conducted at the test item's peak response temperature or at the worse-case operating environment for the materiel (if known). Additional thermal cycles may be required to complete all functional tests.

b. Constant Temperature Exposure. The minimum duration is the time required for the test item to reach temperature stabilization followed by additional time required to complete any functional tests. The test item shall be conditioned for a minimum of two hours after it has reached temperature stabilization, before conducting any functional tests. For heat dissipating materiel, functional tests should be continued until steady-state thermal conditions in the test item are re-established and the test item temperature does not vary by more than 2 °C per hour.

3.3.3. Procedure III: High Temperature Tactical Standby to Operational

During tactical standby to operational testing, it is important to measure the temperature of any critical sub-systems or components, any heat dissipating components, and the parts of the test item with the longest thermal lag. The total test duration may ultimately depend on the time required for the test item to reach test temperature stabilization at the standby test temperature, as well as the additional time required to transition to the operational test temperature followed by any functional tests. The test item shall be held at the standby temperature for a minimum of two hours after it has reached temperature stabilization, before transitioning to the operational test temperature. The transition from standby to operational test temperatures shall be conducted as quickly as possible, but at a rate no less than 2 °C per minute. Unless otherwise specified in the test plan, functional tests shall be conducted as soon as the test chamber has reached the operational test temperature.

3.4. HUMIDITY

In certain cases, low relative humidity (less than 10 percent) can have a significant effect on the physical or electrostatic properties of certain types of materials (e.g., electronic equipment, polymeric composites, and rubber seals). In such instances, controlling the relative humidity to the values listed in Tables A-1 or A-2 of Annex A should be conducted for the appropriate climatic category. If the materiel is not sensitive to dry environments, relative humidity control during the high temperature tests is not necessary.

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CHAPTER 4 INFORMATION REQUIRED

4.1. INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTIONS

1. In addition to the information found within Method 300, the following information is required to conduct the test(s) described in this method and shall be recorded in the test instructions:

a. The test procedure(s) selected from this method.

b. The test temperature severities (cyclic profiles or steady-state values) for each test procedure selected.

c. The test duration (time or number of cycles) at high temperature for each test procedure selected.

d. A description of the test item(s) configuration (storage, transport, operation, and / or standby) including any packaging, stacking, or racking requirements applicable to each test procedure selected.

e. A list of any heat dissipating components, critical components, and functional parameters to be measured and recorded during testing.

f. The location(s) on the test item(s) where temperature stabilization will be evaluated.

g. Any known safety issues related to high temperature (e.g., volatiles, energetic materials, etc.).

2. The following information may be required to conduct the test(s) and shall be recorded in the test instructions when applicable:

a. Relative humidity control and monitoring requirements.

b. Functional test instructions, including time period(s) of operation and test item performance requirements for each test procedure selected.

c. Details of any external cooling provisions such as fans or heat sinks, as applicable to the materiel's in-service installation.

d. Details of any restrictions to heat transfer, such as thermal isolation mounts or restrictions to airflow (convection), as applicable to the materiel's in-service installation.

e. Any additional parameters to be measured and recorded.

f. Necessary variations in the basic test procedures to accommodate environments identified in the materiel's LCEP.

4.2. INFORMATION REQUIRED FOR VERIFICATION

In addition to the information found within Method 300, the following information is required to verify the completion of the test(s) described in this method and shall be recorded in the test report:

4.2.1. Pre-Test

a. General. Information listed in Method 300.

b. Specific to this method.

(1) Description, with photographs, of the test item's configuration and orientation within the test chamber for each test procedure.

(2) List of all thermocouple placement locations, with photographs.

(3) Identification of the components / assemblies / structures to be used for measuring the thermal response and evaluating the temperature stabilization of the test item(s).

(4) If required, a record of the test item temperature-versus-time during any pre-test functional tests.

(5) If required, a record of the ambient temperature and humidity during any pre-test functional test.

(6) Results of any pre-test functional tests.

4.2.2. During-Test

a. General. Information listed in Method 300.

b. Specific to this method.

(1) Record of the test chamber temperature-versus-time (including relative humidity, if controlled) for the entire test duration including pre-test chamber heating and post-test chamber cooling periods.

(2) Record of the test item temperature-versus-time for the entire test duration including all pre-test and post-test conditioning periods.

(3) Documentation of where and when thermal stabilization of the test item was achieved for the purpose of evaluating the duration of high temperature exposure.

(4) Any changes to the installation, configuration, or orientation of the test item within the test chamber during testing.

(5) Documentation of test item operating and non-operating periods as well as any functional tests completed.

(6) Results of any functional tests.

(7) For Procedure III, a record of the time required for the test item to become operational following transition to the operational high temperature.

(8) List of any test interruptions or deviations from the original test plan.

4.2.3. Post-Test

a. General. Information listed in Method 300.

b. Specific to this method.

(1) Results of any visual inspections and any functional tests performed.

(2) If required, a record of the test item temperature-versus-time during any post-test functional tests.

(3) If required, a record of the ambient temperature and humidity during any post-test functional tests.

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CHAPTER 5 TEST CONDITIONS AND PROCEDURES

5.1. PREPARATION FOR TEST

In addition to the instructions found within Method 300, determine the information specified in paragraph 4.1 and ensure that plans are in place to gather the information required by paragraph 4.2 before starting any test procedure.

5.2. TEST FACILITY

1. The test facility shall have an environmental conditioning chamber, along with auxiliary equipment, capable of maintaining and monitoring the required conditions of high temperature (and low humidity, where required) throughout an envelope of air surrounding the test item(s). The chamber shall have sufficient heating and cooling capacity to maintain the test temperature(s) during materiel operation (with consideration given to heat dissipating materiel) as well as when test personnel are operating within the chamber (as applicable).

2. For test materiel with engines (e.g., vehicles) that are required to operate during testing, the test facility shall be capable of monitoring and exhausting noxious fumes, such as carbon-monoxide (CO) and nitrogen oxides (NOx). Similar safety equipment should be used if testing materials that off-gas volatile organic compounds (VOCs) at high temperatures.

5.3. INSTALLATION CONDITIONS OF TEST ITEM

See Method 300 and consider the following.

5.3.1. Test Item Orientation

1. The orientation of the test item in the test chamber should, as much as possible, simulate the actual configuration of the materiel in its storage, transport, or operational use, as applicable to each test procedure. For heat dissipating materiel, consideration to the impact of the test item's orientation on the convective (forced or natural) flow patterns shall be made to ensure that heat transfer is not being artificially enhanced or restricted by the test set-up. This is particularly important for materiel with exhaust plumes, fans, and heat exchangers as well as for stacked materiel.

2. Where heat exchange by radiation is significant, the orientation of the test item relative to other radiative bodies is critical, along with their surface radiative properties. The orientation (view factors) may have to be adjusted to simulate actual deployment conditions (see Method 305 for further guidance on testing where radiative heat exchange is predominant).

5.3.2. Test Item Substrate

The test item should be mounted either on raised supports or on a substrate of specified properties, with a thermal diffusivity representative of actual deployment. Caution should be given to not artificially create either a heat-sink or insulator that is not representative of actual deployment.

5.3.3. External Loads

If the materiel is subjected to external forces (such as stacking configurations, or suspended / cantilever installations) in service, replication or simulation of such loading during the test may be important. High temperature may affect a materiel's ability to withstand loading, particularly for polymeric materials where high temperature may accelerate creep and stress relief phenomena.

5.3.4. Instrumentation

1. Temperature measuring sensors should be mounted on the test item at sufficient locations to allow evaluation of the test item's thermal response to the test environment. The parts of the test item with the slowest thermal response (longest thermal lag) should be instrumented in order to establish temperature stabilization during testing. Temperature stabilization is generally important to ensure reproducible test conditions. Stabilizing test item elements critical for operational requirements (i.e., components, sub-assemblies, etc.) is normally more important than stabilizing temperatures of structural members, unless they directly influence the materiel's operational performance. In some instances, it may not be possible or practical to directly measure the part(s) of the test item with the longest thermal lag. In such instances, additional time at the test temperature may be required to ensure complete stabilization of the test item. Alternatively, a thermal survey of the test item could be completed before the start of testing to identify suitable temperature monitoring locations.

2. Heat dissipating components should be measured to evaluate the temperature rise above ambient during operation. In all instances, sensors and their mounting configuration should be selected to minimize attenuation of the test item's response to the test environment.

5.4. TOLERANCES

See Method 300.

5.5. CONTROLS

In addition to the instructions found within Method 300, consider the following instructions specific to this method:

5.5.1. Temperature

Maintain the chamber air temperature as specified in the test plan and within the specified test tolerances. Keep the air temperature uniform in the immediate vicinity of the item. To adequately measure the temperature of the air surrounding the test item, it is recommended to place verification sensors at representative points around the test item and as close to the test item as possible, while avoiding boundary layer influences. Unless otherwise specified, use a rate of temperature change no greater than 3 °C per minute to prevent thermal shock.

5.5.2. Airflow

Ensure sufficient airflow around the test item to maintain a uniform air temperature in the immediate vicinity of the test item. For heat dissipating materiel that will be sheltered from sources of external airflow (either enclosed items or items likely to encounter negligible wind) it is recommended that the test item be likewise sheltered from airflow during testing in order to accurately evaluate the test item's peak response temperature.

5.6. TEST INTERRUPTIONS

Following any test interruption scenario, consider the following instructions specific to this method in addition to the instructions found within Method 300. All relevant stakeholder(s) should be consulted following a test interruption and prior to continuing testing.

5.6.1. Under-Test Interruptions

For an unscheduled test-interruption that causes the test conditions to fall out of allowable tolerances toward standard ambient conditions (i.e., environmental stress less severe than specified) the test may be resumed as follows:

a. <u>For Cyclic (Diurnal) Temperature Exposure</u>. Re-stabilise the test item at the required test conditions and continue the test from the end of the last successfully completed cycle. Extend the test as necessary to achieve the required number of high temperature cycles specified in the test plan.

b. <u>For Constant Temperature Exposure</u>. Re-stabilise the test item at the required test conditions and continue the test from the point when test conditions fell out of tolerance. Extend the test as necessary to achieve the required duration at high temperature specified in the test plan.

5.6.2. Over-Test Interruptions

If an over-test condition occurs (i.e., environmental stress more severe than specified), follow the instructions provided in Method 300. If, after inspection and analysis by a failure review team, it is deemed acceptable to continue the high temperature evaluation of the original test item, follow the test re-starting instructions in paragraph 5.6.1, as applicable to either Cyclic or Constant Temperature Exposure.

> **CAUTION:** When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials.

5.6.3. Scheduled Interruptions

See Method 300.

5.6.4. Interruptions Due to Test Item Failure

See Method 300.

5.7. TEST PROCEDURES

5.7.1. Pre-Test Standard Ambient Functional Test

Conduct a pre-test standard ambient functional test to obtain baseline performance data. Unless otherwise directed by the test plan, the pre-test standard ambient functional test shall be conducted before the start of each test procedure as follows:

Step 1. Conduct a visual examination of the test item with special attention to stress areas, such as corners of moulded cases, and document the results.

Step 2. Prepare the test item in its operating configuration. Install temperature sensors in, on, and around the test item to evaluate the test item’s temperature response.

Step 3. Unless otherwise specified in the test plan, conduct a functional test at standard ambient conditions and record the results. For test items not requiring a functional test, proceed to Step 1 of the selected test procedure

Step 4. If the test item operates satisfactorily, proceed to Step 1 of the selected test procedure. If not, resolve the problems and restart at Step 1 of the pre-test standard ambient functional test.

5.7.2. Procedure I: High Temperature Storage or Transport

Step 1. Place the test item in its storage or transport configuration, as applicable, and install it in the test chamber (see guidance in paragraph 5.3). Install any additional sensors as required by the test plan. Document the set up and include photographs (see instructions in Chapter 4).

Step 2. Adjust the chamber air temperature (and humidity, if applicable) to the required initial conditions of the high temperature storage or transport profile specified in the test plan (see Chapter 3 for guidance on test severities). The rate of temperature change shall be no greater than 3 °C per minute. Maintain the initial profile conditions until temperature stabilization of the test item is achieved.

Step 3. Expose the test item to the high temperature (and low humidity, if applicable) storage or transport profile specified in the test plan. Continue the cyclic or constant temperature exposure for the duration specified in the test plan (see Chapter 3 for guidance on test severities).

Step 4. Unless otherwise specified in the test plan, at the completion of Step 3, adjust the chamber air temperature to standard ambient conditions at a rate not to exceed 3 °C per minute and maintain the conditions until temperature stabilization of the test item.

Step 5. Visually examine the test item (and packaging if applicable) to the greatest extent practical to identify any changes from pre-test conditions. Document the condition of the test item and include photographs (see instructions in Chapter 4).

Step 6. Unless otherwise specified in the test plan, place the test item in an operational configuration and conduct a functional test of the test item to identify any changes from pre-test conditions. Document the results (see instructions in Chapter 4).

5.7.3. Procedure II: High Temperature Operation

CAUTION: If the test environment is intended to be occupied during exposure to high temperature, it is recommended that sensors are installed to detect VOCs, CO, and phthalates from potential out-gassing of materiel.

Step 1. Place the test item in its operational configuration and install it in the test chamber (see guidance in paragraph 5.3). Unless otherwise specified in the test plan, the test item should be physically in an operational configuration, but not operating (i.e., powered off). Install any additional sensors to determine test item stabilization, as well as to evaluate any temperature changes during operation. Ensure all heat dissipating components are monitored. Install any additional sensors as required by the test plan. Document the set up and include photographs (see instructions in Chapter 4).

Step 2. Adjust the chamber air temperature (and humidity, if applicable) to the required initial conditions of the high temperature operation profile specified in the test plan (see Chapter 3 for guidance on test severities). The rate of temperature change shall be no greater than 3 °C per minute. Maintain the initial profile conditions until temperature stabilization of the test item is achieved.

Step 3. If performing the cyclic temperature exposure, go to Step 4. For constant temperature exposure, go to Step 5.

Step 4. Cyclic temperature exposure:

a. Expose the test item to the high temperature (and low humidity, if applicable) operation profile. Continue the cyclic temperature exposure until repeatability in the test item's thermal response is achieved or for the duration specified in the test plan (see Chapter 3 for guidance on test severities). Document the maximum test item response temperature and the time when the maximum was achieved.

b. Conduct as thorough a visual examination of the test item as possible considering chamber access limitations, and document the results for comparison with pre-test data.

c. Unless otherwise specified in the test plan, conduct a functional test of the test item at the test item's peak response temperature or at the worst-case operating environment for the test item (if known).

d. Repeat temperature cycles and functional tests until completed or as directed by the test plan. Document the results for comparison with pre-test data.

e. Proceed directly to Step 6.

Step 5. Constant temperature exposure:

a. Maintain the test item at the operational test temperature for a minimum of two hours after temperature stabilization of the test item, or as directed by the test plan.

b. Conduct as thorough a visual examination of the test item as possible considering chamber access limitations, and document the results for comparison with pre-test data.

c. Unless otherwise specified in the test plan, conduct a functional test of the test item as specified in the test plan. For heat dissipating materiel, operate the test item until the temperature of critical components re-stabilise or as directed by the test plan. Document the results for comparison with pre-test data.

Step 6. Adjust the chamber air temperature to standard ambient conditions at a rate not to exceed 3 °C per minute and maintain until temperature stabilization of the test item.

Step 7. Visually examine the test item to the greatest extent practical to identify any changes from pre-test conditions. Document the condition of the test item and include photographs (see instructions in Chapter 4).

Step 8. Unless otherwise specified in the test plan, conduct a functional test of the test item to identify any changes from pre-test conditions. Document the results (see instructions in Chapter 4).

5.7.4. Procedure III: High Temperature Tactical Standby to Operational

Step 1. Place the test item in its tactical standby, storage, or transport configuration, as applicable, and install it in the test chamber (see guidance in paragraph 5.3). Install any additional temperature sensors to determine test item stabilization as well as to evaluate any temperature changes during operation. Ensure all heat dissipating components are monitored. Install any additional sensors as required by the test plan. Document the setup, including photographs (see instructions in Chapter 4).

Step 2. Adjust the chamber air temperature to the maximum storage or transport temperature identified in the test plan. The rate of temperature change shall be no greater than 3 °C per minute. Maintain the conditions until temperature stabilization of the test item is achieved plus a minimum of two additional hours.

Step 3. Conduct as thorough a visual examination of the test item as possible considering chamber access limitations, and document the results for comparison with pre-test data.

Step 4. Adjust the chamber air temperature to the maximum operating temperature identified in the test plan as quickly as possible (at a rate no less than 2 °C per minute).

Step 5. Unless otherwise specified in the test plan, as soon as the chamber air temperature reaches the high operating temperature, conduct a functional test of the test item. Continue the functional test until completed or as directed by the test plan. Document the results for comparison with pre-test data. For multiple exposure cycles, repeat Steps 2–5 as required by the test plan.

Step 6. Adjust the chamber air temperature to standard ambient conditions at a rate not to exceed 3 °C per minute and maintain until temperature stabilization of the test item.

Step 7. Visually examine the test item to the greatest extent practical to identify any changes from pre-test conditions. Document the condition of the test item, including photographs (see instructions in Chapter 4).

Step 8. Unless specified otherwise in the test plan, conduct a functional test of the test item to identify any changes from pre-test conditions. Document results (see instructions in Chapter 4).

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CHAPTER 6 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9.

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CHAPTER 7 REFERENCES AND RELATED DOCUMENTS

7.1. REFERENCED DOCUMENTS

a. STANAG 4370, AECTP-300, Method 300, General Guidance and Requirements.

b. STANAG 4370, AECTP 230, Climatic Conditions.

c. STANAG 4370, AECTP-300, Method 305, Solar Radiation.

d. Army Regulation (AR) 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions, U.S. Army, 15 Sep 1979.

ANNEX A HIGH TEMPERATURE DIURNAL CYCLES

Table A-1: Meteorological High Temperature Diurnal Cycles (from AECTP-230)

Meteorological Air Conditions						
Time of Day	**A1**		**A2**		**A3**	
	Air Temperature °C	Relative Humidity (RH) %	Air Temperature °C	Relative Humidity (RH) %	Air Temperature °C	Relative Humidity (RH) %
01:00	35	6	33	36	30	69
02:00	34	7	32	38	29	72
03:00	34	7	32	43	29	74
04:00	33	8	31	44	28	76
05:00	33	8	30	44	28	78
06:00	32	8	30	44	28	78
07:00	33	8	31	41	29	74
08:00	35	6	34	34	30	67
09:00	38	6	37	29	31	59
10:00	41	5	39	24	34	51
11:00	43	4	41	21	36	47
12:00	44	4	42	18	37	45
13:00	47	3	43	16	38	44
14:00	48	3	44	15	38	43
15:00	48	3	44	14	39	43
16:00	49	3	44	14	39	44
17:00	48	3	43	14	38	46
18:00	48	3	42	15	37	48
19:00	46	3	40	17	35	50
20:00	42	4	38	20	34	53
21:00	41	5	36	22	34	56
22:00	39	6	35	25	32	59
23:00	38	6	34	28	32	63
24:00	37	6	33	33	31	66

Table A-2: Induced High Temperature Diurnal Cycles (from AECTP-230)

Induced Air Conditions						
Time of Day	**A1**		**A2**		**A3**	
	Air Temperature °C	Relative Humidity[1] (RH) %	Air Temperature °C	Relative Humidity[1] (RH) %	Air Temperature °C	Relative Humidity (RH) %
01:00	35	6	33	36	31	See Note 2
02:00	34	7	32	38	29	
03:00	34	7	32	41	29	
04:00	33	8	31	44	28	
05:00	33	8	30	44	28	
06:00	33	8	31	43	29	
07:00	36	8	34	47	31	
08:00	40	6	38	30	35	
09:00	44	6	42	23	40	
10:00	51	5	45	17	44	
11:00	56	4	51	14	50	
12:00	63	4	57	8	54	
13:00	69	3	61	6	56	
14:00	70	3	63	6	58	
15:00	71	3	63	5	58	
16:00	70	3	62	6	56	
17:00	67	3	60	6	53	
18:00	63	3	57	6	50	
19:00	55	3	50	10	46	
20:00	48	4	44	14	41	
21:00	41	5	38	19	37	
22:00	39	6	35	25	34	
23:00	37	6	34	28	33	
24:00	35	6	33	33	32	

[1] Relative humidities for the A1 and A2 induced conditions were obtained from Army Regulation (AR) 70-38, 15 September 1979.

[2] Relative humidities for the A3 induced condition vary too widely between different situations to be represented by a single set of values.

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METHOD 303
LOW TEMPERATURE

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The main objectives of low temperature tests are to determine if:

a. The safety of the materiel is affected as a result of exposure to low temperature, or

b. The materiel can be stored, manipulated and operated within the specified requirements during and after exposure to low temperature that it is expected to encounter during its service life, or

c. The materiel experiences physical damage during or after its exposure to low temperature.

1.2. APPLICATION

a. This Method is used when the requirements documents state that the materiel is likely to be deployed in regions in which the climatic conditions will induce low temperatures (below standard ambient) within the materiel. If the effects of low temperature on the materiel are being determined during other tests for the required extremes and durations (including manipulation), it is not necessary to perform this test.

b. Although not written for such, this Method may be used in conjunction with shock and vibration tests (AECTP 400) to evaluate the effects of dynamic events (e.g., shipping, handling, and shock) on cold, embrittled materiel.

1.3. LIMITATIONS

a. This Method is not intended to be used to simulate temperature-altitude effects that will be experienced by aircraft-mounted equipment.

b. This Method does not address temperature cycling through 0 °C.

c. This Method does not address the effects of snow, ice or wind as encountered during natural low temperature exposure.

d. This Method does not intentionally address the effects of frost, because this would require a controlled source of moisture.

1.4. DEFINITION

For the purpose of this document, manipulation is defined as the actions necessary to convert the materiel from a storage to an operational configuration, operate it, and return it to its storage configuration.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

Exposure to constant or cyclic (diurnal) low temperatures may either temporarily or permanently impair the operation of materiel by changing the physical properties or dimensions of its construction materials. Examples of problems that could occur as a result of exposure to cold are as follows, but the list is not intended to be all-inclusive and some of the examples may overlap the categories.

2.1.1. Physical

a. Phase changes (solid / solid, solid / liquid / gas).

b. Dimensional changes.

c. Distortion, binding, failure of bearings, shafts and packings.

d. Failure of seals.

e. Differential thermal contraction, particularly non-metallic against metallic (e.g., explosives) propellants in cases.

f. Changes in physical properties such as modulus, strength and elongation (leading particularly to embrittlement).

g. Lubricant failure due to viscosity change.

h. Static fatigue of restrained glass.

i. Freezing (expansion) of water, and condensation of water vapor.

j. Failure of bonding materials.

k. Stiffening of shock and vibration mounts.

l. Difficulty of manipulation.

2.1.2. Chemical

Reduced rates of reaction:

a. Burning rates of explosives and propellants reduced.

b. Igniters failing to operate.

2.1.3. Electrical

a. Resistors and other components changing in value and life expectancy.

b. Variations in circuit characteristics.

c. Altering of operating / release margins of electrochemical devices.

d. Batteries generating insufficient power.

e. Breakdown due to shrinkage of insulation or potting.

f. Changes in performance of transformers.

g. Excessive static electricity.

h. Difficulty in obtaining or maintaining good earthing (grounding).

2.2. CHOICE OF TEST PROCEDURE

See Method 300 Chapters 1 and 8. There are three test procedures in this method: storage, operation, and manipulation. All three tests can be conducted if appropriate.

2.2.1. Procedure I: Storage Test

This procedure is used to assess the possible effect of storage of the materiel at low temperatures upon its performance and safety in use. The test can be carried out in two different ways:

a. Exposure to an essentially constant low temperature.

b. Exposure to cyclic low temperature (change of at least 9 °C as in category C2 of AECTP 200, Leaflet 2311) below freezing.

2.2.2. Procedure II: Operational Test

This procedure is used to assess the possible effect of exposure to low temperature upon the operational performance of the materiel and upon safety in use. This test will, in most cases, be preceded by a storage test, and may also be preceded by or combined with a manipulation test. The test can be carried out in two different ways as in paragraph 2.2.1.

2.2.3. Procedure III: Manipulation Test

For this test, the test item is exposed to the same temperatures as for the constant temperature operating test. This procedure is used to:

a. Test the suitability of the materiel for handling in operation, assembly, disassembly, and installation by personnel equipped to withstand cold.

b. Determine if the materiel can be assembled and disassembled at low temperatures safely and without damage.

2.3. CHOICE OF TEST PARAMETERS

See Method 300 Chapter 1, 4, and 8.

The most significant parameters used in this test method are temperature and exposure time. It is also important in this test procedure to specify the operational configuration of the test item, as well as whether or not the test item is heat-dissipating during operation. Although the natural low temperature environment is normally cyclic, in some instances it is acceptable to use a constant low temperature test. In those instances where design assessment suggests that exposure to varying low temperatures may be important, the appropriate cold cycles from AECTP-200, Category 230 are recommended. Typical low temperature data extracted from AECTP-200, Category 230 (for consideration if measured data are not available) are provided in Table 1. These data should not be used without reference to source documents (AECTP-200, Category 230 or equivalent national documents) that provide guidance on their significance. Consideration should be given to the need or otherwise for operation of materiel at very low temperatures (i.e., below -46 °C).

CAUTION: When temperature conditioning, ensure the total test time at the most severe temperature does not exceed the life expectancy of any material. See Method 300 Chapter 4.

2.3.1. Storage Test

Derive the time of materiel exposure to low temperatures from the deployment requirements and consider it in conjunction with the materiel characteristics. There is evidence that prolonged storage of restrained glass and organic plastics may result in deterioration. Static fatigue of restrained glass, for example, has been documented[1,2] after long periods of low temperature exposure. Data from these sources suggest that the breaking stress for glass will be reduced by approximately 50 percent in 72 hours. For such material, a minimum storage test of 72 hours following stabilization of the test item is recommended. For other materials, there is no evidence to support deterioration following temperature stabilization. Prolonged storage testing following stabilization may not be necessary; a 4-hour soak following stabilization of the test item should be sufficient. If it is considered that thermomechanical stressing may present a significant problem, cyclic temperature testing may be appropriate. The number of cycles should be sufficient to reproduce the low temperature response of the previous cycle within 2 °C. Use of a greater number of cycles may give information on low temperature aging characteristics of the materiel or, for example, on the effects of leakage around seals between dissimilar materials.

2.3.2. Operational Test

As a general rule, the operational test will take place after the storage, and during or after the manipulation test, but this may vary because of life cycle considerations. Although cyclic temperatures are normal, the application of cyclic testing at low temperature levels (except near the freezing point of water) rarely provides any known advantage over steady state testing. However, if the test item is exposed to temperature cycles, a minimum of three cycles will normally be required to achieve maximum response of the test item.

2.3.3. Manipulation Test

The conditions for this test will depend upon how the materiel is used and the test item configuration. The important issue is that the test item is exercised at the low operating temperature.

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[1] *Glass Engineering Handbook, 2nd Edition, E.B. Shand, 1958, McGraw-Hill Book Company, New - York.*
[2] *The Properties of Glass, 2nd Edition, G.W. Morey, 1954, Reinhold Publ.Corp.*

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

See Method 300 Chapters 4 and 6.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5.

4.2. CONTROLS

See Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

4.4. PROCEDURES

The following test procedures, alone or in combination (see Figure 1), may be used to determine the performance of the materiel in a cold environment. Conduct the operational checks after both the storage and manipulation tests for comparison with pre-test data. For situations in which cyclic low temperatures are desired, replace the steady state steps with the cyclic temperature exposure related to the real-life exposure of the materiel at the low anticipated temperature for either storage or operation (whichever is appropriate).

NOTE: Unless otherwise specified or required for operation or manipulation, opening of the chamber door at any point in these test procedures is not recommended because of possible frost formation and associated problems.

4.4.1. Preparation for Test

Before starting any of the test procedures, determine the information specified in Method 300 Chapters 4 and 6, and perform the test preparation procedure specified in Method 300 Chapter 2. Ensure that any fluids included as part of the test item are those appropriate for the temperature range of the test.

4.4.2. Procedure I: Storage Test

Step 1. Place the test item in its storage configuration and install it in the test chamber. If appropriate, the configuration may include loading (actual or simulated) to simulate normal stacking configurations.

Step 2. Adjust the chamber air temperature to the required initial temperature for constant or cyclic temperature storage conditions.

Step 3a. For constant temperature: following temperature stabilization of the test item, maintain the storage temperature for a period as specified in the test plan.

Step 3b. For cyclic temperature: perform the required number of temperature cycles.

Step 4. If required, visually examine the test item to the extent practical, while at the lowest temperature from Step 3.

Step 5. If low temperature operation with no manipulation (no reconfiguration for operation) is required, proceed to paragraph 4.4.3; if reconfiguration is necessary for low temperature operation, proceed to paragraph 4.4.4; otherwise, proceed to Step 6 below.

Step 6. Stabilise the test item at standard ambient conditions.

Step 7. Visually examine the test item to the extent practical.

Step 8. If appropriate, conduct an operational check of the test item and document the results.

4.4.3. Procedure II: Operational Test

4.4.3.1. Procedure IIa: Constant Temperature

Step 1. With the test item in its operating configuration, adjust the chamber air temperature to the low operating temperature of the test item as specified in the test plan. Maintain until temperature stabilization of the test item has been achieved.

Step 2. Visually examine the test item to the extent practical.

Step 3. Conduct an operational check of the test item and document the results.

Step 4. Stabilise the test item at standard ambient conditions.

Step 5. Visually examine the test item to the extent practical.

Step 6. Conduct an operational check similar to that in Method 300 Chapter 2, and document the results for comparison with the pre-test data.

4.4.3.2. Procedure IIb: Cyclic Temperature

Step 1. With the test item in its operating configuration, adjust the chamber air temperature to the initial temperature of the specified cycle and maintain until the test item has stabilised.

Step 2. Expose the test item (non-operating) to the temperature level specified for the operational cycle for at least three cycles, or as necessary to obtain repeated test item response within 2 °C.

Step 3. From the exposure data, determine the lowest response temperature of the test item. This will be the operational temperature for Step 4.

Step 4. Adjust the chamber air to the operational temperature. Maintain the chamber in a steady state condition until temperature stabilization of the test item has been achieved.

Step 5. Visually examine the test item to the extent practical.

Step 6. Conduct an operational check of the test item in accordance with the approved test plan, and document the results.

Step 7. With the test item not operating, stabilise the test item at standard ambient conditions.

Step 8. Conduct an operational check similar to that in Method 300 Chapter 2, and document the results for comparison with the pre-test data.

NOTE: During a long sequence of operations, temperature re-stabilisation may be required at intervals.

4.4.4. Procedure III: Manipulation Test

Step 1. With the test item in the test chamber in its storage configuration, stabilise the test item at its low operating temperature derived, if necessary, from paragraph 4.4.3.2.

Step 2. While maintaining the low operating temperature, place the test item in its normal operating configuration using one of the following options based on the type of test chamber available:

a. Option 1 - To be used when a "walk-in" type chamber is available: With personnel clothed and equipped as they would be in a low-temperature tactical situation, assemble or install the test item into its operational configuration as would be done in the field.

b. Option 2 - To be used when non-walk-in chambers are used: Perform the Option 1 procedure by reaching through chamber access holes or the open door while wearing heavy gloves such as would be required in service. (Note: Opening the chamber door is not recommended because it may cause frost to form on the test item as well as cause a gradual warming of the test item.) In order to maintain the test item external temperature within the required tolerance as specified in Method 300 Chapter 3, limit the door-open periods by performing the manipulation in stages.

Step 3. If operation of the test item is required at low temperatures, perform the checkout and document the results for comparison with Method 300 Chapter 2.

Step 4. Restabilise the test item at the low operating temperature.

Step 5. With the test item still in the chamber, repeat the options of Step 2 above while disassembling the test item and repacking it in its normal shipping / storage container(s), transit case, or other mode and configuration. It is not necessary to replace any stacking loads.

Step 6. Adjust the chamber air conditions to standard ambient and stabilise the test item.

Step 7. Visually examine the test item to the extent practical.

Step 8. Conduct an operational check of the test item similar to that in Method 300 Chapter 2, and document the results for comparison with pre-test data.

NOTE: During a long sequence of operations / manipulations, temperature re-stabilisation may be required at intervals.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter

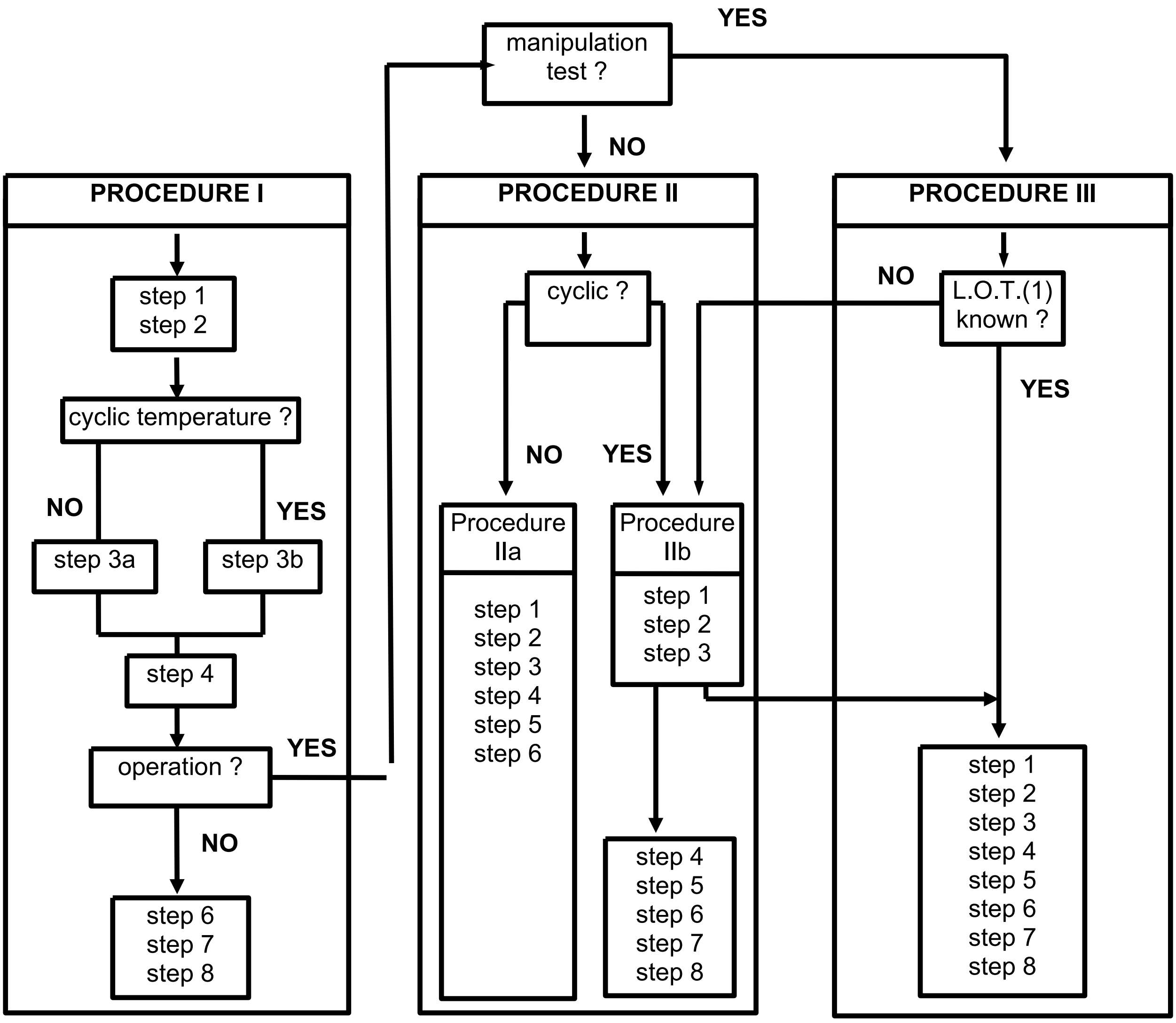
CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

Table 1: Typical Low Temperature Data (from AECTP-200, Category 230)

Climatic Category (*)	Meteorological		Induced	
	Temperature (°C)	**Relative Humidity (%)**	**Temperature (°C)**	**Relative Humidity (%)**
C0	-6 to -19	Tending toward saturation	-10 to -21	Tending toward saturation
C1	-21 to -32		-25 to -33	
C2	-37 to -46		-37 to -46	
C3	-51		-51	
C4	-57		-57	

(*) These categories are described in AECTP-200, Category 230 and are comparable to those found in national standards.



(1) Low Operating Temperature

Figure 1: Low Temperature Procedures

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METHOD 304
AIR TO AIR THERMAL SHOCK

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The main objectives of the thermal shock test are to determine if:

a. The safety of the materiel is affected as a result of exposure to sudden, extreme changes of temperature.

b. The materiel can be handled and operated within the specified requirements during and after sudden temperature changes (greater than 10 °C per minute) likely to be associated with actual service conditions.

c. The materiel experiences physical damage during or after experiencing temperature shock.

1.2. APPLICATION

This test method is used when the requirements documents specify that the materiel is likely to be deployed where sudden significant changes of air temperature may be experienced (see paragraph 2.3.1). This Method is only intended to evaluate the effects of sudden temperature changes of the outer surfaces of materiel, items mounted on the outer surfaces, or internal items situated near the external surfaces. Typically, this addresses:

a. The transfer of materiel between heated areas and low temperature environments.

b. Ascent from a high temperature ground environment to high altitude via a high-performance vehicle (hot to cold only).

c. Air drop at high altitude / low temperature from aircraft enclosures when **only** the external material (packaging or materiel surface) is to be tested.

This method may also be used to reveal safety problems and potential flaws in materiel normally exposed to less extreme conditions, as long as the design limitations of the materiel are not exceeded.

1.3. LIMITATIONS

a. This Method is not intended for materiel that will not experience sudden extreme air temperature changes because of its packaging, installed location, or other such configurations that would shield the materiel from significant temperature changes.

b. This Method is inappropriate if the actual transfer time in a service environment will not produce a significant thermal shock. Additionally, it is not to be used to assess performance characteristics after lengthy exposure to extreme temperatures, as are the low and high temperature methods.

c. This Method has not been designed to address the temperature shock experienced by materiel that is transferred between air and liquid or between two liquids, materiel that is exposed to rain following solar heating, or materiel that is exposed to heat from a fire and then cooled with water.

d. This Method does not address the thermal shocks produced by the internal generation of heat.

e. This Method does not address the thermal shock caused by rapid warm-up by engine compressor bleed air.

f. This Method does not address aerodynamic heating or cooling due to wind.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

Sudden temperature changes may either temporarily or permanently impair the performance of the materiel by changing the physical properties or dimensions of its construction materials. Examples of problems that could occur as a result of exposure to thermal shock are shown below, but the examples are not intended to be comprehensive.

2.1.1. Physical

a. Shattering of glass vials and optical equipment.

b. Binding or slackening of moving parts.

c. Cracking of solid pellets or grains in explosives.

d. Differential contraction or expansion of dissimilar materials.

e. Deformation or fracture of components.

f. Cracking of surface coatings.

g. Leakage from sealed compartments.

h. Failure of insulation.

2.1.2. Chemical

a. Separation of constituents.

b. Failure of chemical agent protection.

2.1.3. Electrical

a. Changes in electrical and electronic components.

b. Electronic or mechanical failures due to rapid water or frost formation.

c. Excessive static electricity.

2.2. TEST PROCEDURE

1. See Method 300 Chapters 1 and 8. There are two procedures. Procedure I employs constant temperature at each of the extreme shock conditions because, in many instances, the thermal shock itself so outweighs the other thermal effects that the test may be performed using two constant temperatures. This is particularly the case when more severe shocks are desired, such as for evaluation of safety or initial design and when extreme values will be used. When a careful simulation of a real environment is required, Procedure II can be used because the upper temperature follows part of an appropriate diurnal cycle. The test conditions that are used during either procedure are determined from:

a. The expected exposure temperatures in service.

b. The materiel's logistic or deployment configuration.

2. The function (operational requirement) to be achieved by the materiel and a definition of the circumstances responsible for the thermal shock should be determined from the requirements documents.

2.3. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8. The test conditions as presented in this procedure are intended to be in general agreement with other extremes described in this document. The primary purpose in establishing these levels is to provide realistic conditions for the transfer between the two temperature extremes. The temperature of the test item before transfer must be the most realistic extreme that would be encountered during the specific operation. Response temperatures achieved when materiel is exposed to the conditions of the various climatic categories may be obtained from the test results of high temperature exposure for either the operational or storage configuration (see Method 302). The latter assumption must consider the induced effects of solar radiation during storage and transit in various climates.

2.3.1. Temperature Levels

Both the total temperature change expected in service and the materials involved must be evaluated to determine the need to perform this test. The temperature levels are determined in relation to the use of materiel that has been previously defined. They may be obtained from special measurements (response temperatures from the High and Low Temperature operational tests), or extracted or derived from AECTP-200, Leaflet 2311 or equivalent national standards. For safety or design evaluation, temperature levels may have more extreme values than these.

2.3.2. Transfer Time

The transfer time must reflect the time associated with the actual thermal shock in the life cycle profile. If the transfer takes more than one minute, the extra time must be justified.

2.3.3. Humidity

For most test programs, relative humidity is not controlled. Relative humidity may have a significant influence on some materiel (e.g., cellulosic materials that are typically porous, into which moisture can migrate and then expand upon freezing) during the thermal shock test. This must be considered and special measurements (if available) or the data of AECTP-200, Leaflet 2311 should be used as a basis.

2.3.4. Stabilisation

Since this method is intended to evaluate those portions of materiel that can respond rapidly to external temperature changes, expose the test item to the temperature extremes for a duration representative primarily of the realistic worst case (lifecycle profile), but also taking into account the time taken to achieve thermal stabilisation of the areas on or near the external surfaces of the test item.

2.3.5. Number of Shocks

For a test item that is likely to be exposed only rarely to thermal shock, one shock is recommended for each appropriate condition. There is little available data to substantiate a specific number of shocks when more frequent exposure is expected. In lieu of better information, a minimum of three shocks should be applied at each condition, the number depending primarily on the anticipated service events.

2.4. EVALUATION OF EFFECTS

The nature of this test precludes extensive performance evaluation while thermal shock conditions exist. Operational evaluation will, in most cases, be limited to irreversible effects or simple "go / no-go" performance indications that can be quickly observed.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to that specified in Method 300 Chapters 4 and 6, document the actual transfer times from the time that the chamber door is opened, to the time that the door of the second test section is closed.

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CHAPTER 4 TEST CONDITION AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test conditions, test facility, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5.

Unless otherwise specified or impractical due to the thermal mass of the test item, the chamber(s) or compartments to be used must be equipped so that after transfer of the test item, the desired test air temperature within the chamber can be achieved within 5 minutes. Chamber airflows of up to 6 m/s may be required in order to optimize heat transfer rates.

4.2. CONTROLS

See Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

If an interruption occurs during the transfer, the test item must be re-stabilised at the previous temperature and then transferred.

4.4. PROCEDURES

The procedures depicted in Figures 1 and 2 arbitrarily begin with the lower temperature, but could be reversed to begin with the higher temperature if it is more realistic. Specific points in Figures 1 and 2 (in parentheses) are referenced in the following text.

4.4.1. Preparation for Test

Before starting either of the test procedures, determine the information specified in Method 300 Chapters 4 and 6, and perform the test preparation procedure specified in Method 300 Chapter 2.

4.4.2. Procedure I: Shock from Constant Extreme Temperatures (See Figure 1)

Step 1. With the test item in the chamber, adjust the chamber air temperature to the low temperature extreme specified in the test plan (a) at a rate not exceeding 3 °C per minute. Maintain this temperature for a period as determined in the test plan (a-b).

Step 2. Transfer the test item in no more than one minute (b-c) to an atmosphere at temperature T2 that will produce the thermal shock specified in the test plan, and maintain this temperature as specified in the test plan (c-e).

Step 3. If required in the test plan, evaluate the effects of the thermal shock on the test item to the extent practical (see paragraph 2.4).

Step 4. If other cycles in reversed directions are required, transfer the test item to the T1 environment in no more than one minute (e-f) and stabilise as required in the test plan (f-b), evaluate the thermal shock effects (if required), and continue as in Steps 2 and 3 above. If other one-way shocks are required, return the test item to the T1 environment at a rate not exceeding 3 °C per minute and repeat Steps 1–3. If no other shocks are required, go to Step 5.

Step 5. Return the test item to standard ambient conditions.

Step 6. Examine the test item and, if appropriate, operate. Record the results for comparison with pre-test data.

4.4.3. Procedure II: Shock to / from Cyclic High Temperatures (See Figure 2)

Step 1. With the test item in the chamber, adjust the chamber air temperature to the low temperature extreme specified in the test plan (a). Maintain this temperature for a period as determined in the test plan (a-b).

Step 2. Transfer the test item to the maximum air temperature of the high temperature cycle (c) (as specified in the test plan) in no more than one minute. As soon as the chamber door is closed and the high temperature is restored, cycle the chamber through part of the appropriate diurnal cycle until the chamber reaches the test item response temperature (d) (obtained according to Method 302, paragraph 2.3.2). Maintain this temperature as specified in the test plan (d-e).

Step 3. If no other cycles are required, return the test item to standard ambient conditions and proceed to Step 7; otherwise proceed to Step 4.

Step 4. Transfer the test item to the lower temperature environment (f) in no more than one minute and stabilise as required in the test plan (f-h). If other cycles are required, proceed to Step 6.

Step 5. If no other cycles are required, return the test item to standard ambient conditions, and proceed to Step 7.

NOTE: Unless the requirements documents indicate otherwise, if the test procedure is interrupted because of work schedules, etc., maintaining the test item at the test temperature for the period of the interruption will facilitate resumption of the test. If the temperature is changed, before continuing the test restabilise the test item at the temperature of the last successfully completed period before the interruption.

Step 6. Repeat Steps 2, 3, and 4 as specified in the test plan.

Step 7. Examine the test item and, if appropriate, operate. Record the results for comparison with pre-test data.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9.

CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

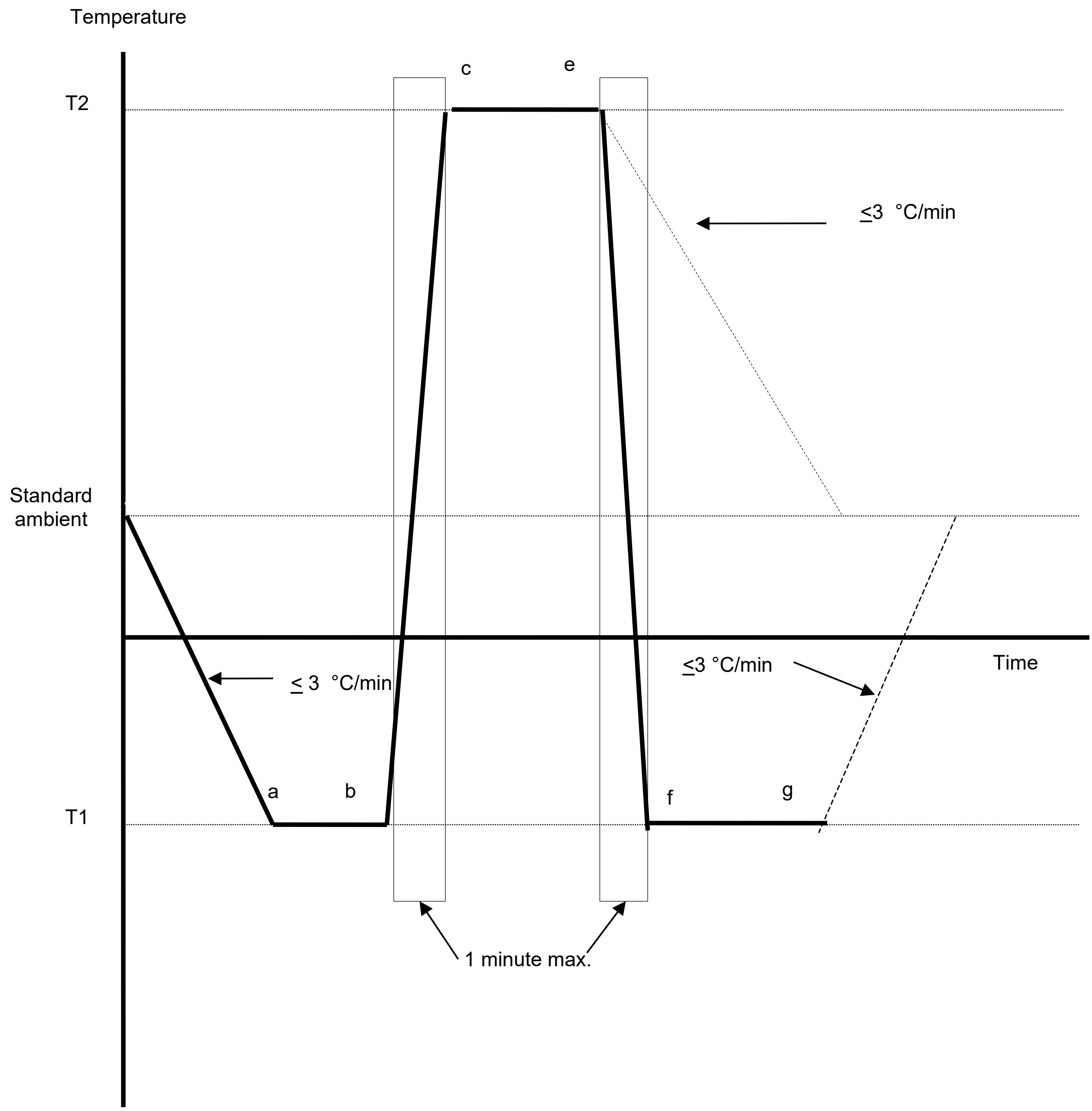

Figure 1: Shocks From Constant Extreme Temperature (Procedure I)

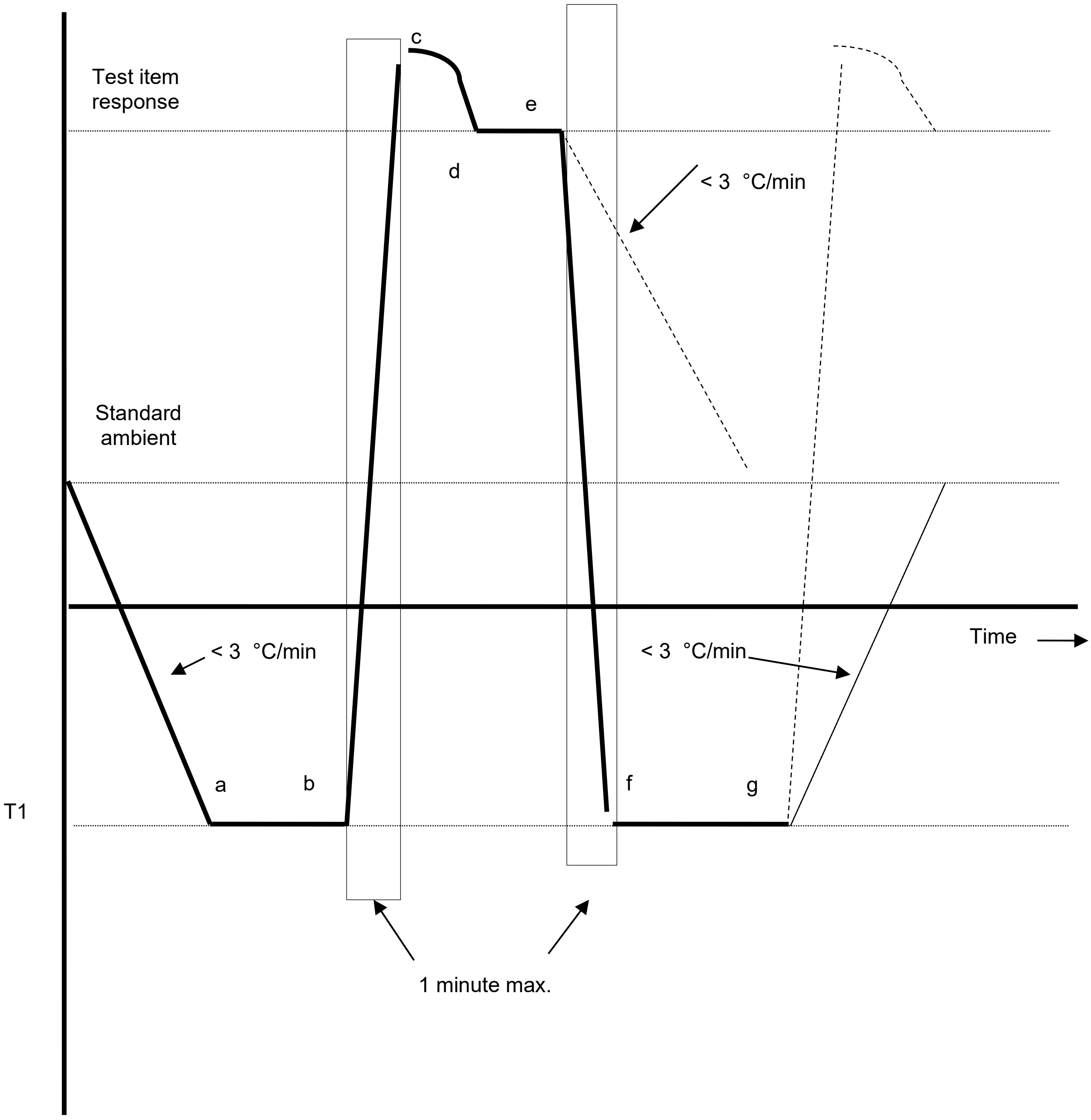

Figure 2: Shocks From Cyclic High Temperature (Procedure II)

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METHOD 305
SOLAR RADIATION

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The purpose of this solar radiation test is to determine heating and actinic (photo degradation) effects of solar radiation on materiel when exposed to sunshine during operation or unsheltered storage at ground level.

1.2. APPLICATION

1. This Method is applicable to materiel likely to be directly exposed to solar radiation. This method is intended for use when close simulation of the spectral distribution of solar radiation is required, such as for the assessment of materiel degradation or a combination of degradation and / or thermal response.

2. If the installed configuration for an item is within an enclosure, then the enclosure shall be provided to properly characterize the environment and associated heating effects on the item. Once the enclosed environment (response temperature) has been characterized, further testing could be done using Method 302 High Temperature.

1.3. LIMITATIONS

1. This test Method does not consider all the effects related to the natural environment and therefore it may be necessary to also test materiel at appropriate natural sites.

2. This Method is not intended to be used for space applications due to the change in irradiance.

3. See Method 300 for other general limitations.

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CHAPTER 2 TEST GUIDANCE

2.1. USE OF MEASURED DATA

The solar radiation spectrum and irradiance has remained stable according to historical data. Different temperature parameters are available for selection depending on the expected region of deployment for the materiel. This method sets out test severities suitable for use when measured data are not available with additional guidance and categories provided in AECTP-230, Climatic Conditions.

2.2. SEQUENCE

1. Apply the solar radiation test at any stage in the test program. However, high temperatures or actinic effects could affect material's strength or dimensions that could, in turn, affect the results of subsequent tests such as vibration.

2. If the peak solar response temperature will be used for Method 302 High Temperature storage or operations testing, then the solar radiation test should be performed early on so that the peak response temperatures can be determined.

2.3. MAXIMUM THERMAL RESPONSE TEMPERATURE

1. In this method, the maximum thermal response temperature is defined as the highest temperature the materiel will reach and repeat, following subsequent cycles of solar loading. The maximum thermal response temperature is considered achieved when the peak test item temperature, from two consecutive cycles, is within 2 °C.

2. If conducting both Procedure I and II, consider using separate test items for each procedure. Determine the maximum thermal response during Procedure I.

2.4. EFFECTS OF THE ENVIRONMENT

Solar radiation has two types of effects on materiel: thermal and actinic.

2.4.1. Heating Effects

1. The heating effects of solar radiation differ from those of high air temperature alone in that solar radiation generates directional heating and thermal gradients. In the solar radiation test, the amount of heat absorbed or reflected depends primarily on the absorptive or reflective surface properties (e.g., roughness, colour, etc.) on which the radiation is incident. If a glazing system (glass, clear plastic, or translucent media such as a windshield) is part of the test item configuration, the amount of heat absorbed will be dependent on the transmissibility of the glazing system. For these reasons, it is important to use a full spectrum light source.

2. In addition to the differential expansion between dissimilar materials, changes in the intensity of solar radiation may cause components to expand or contract at different rates that can lead to severe stresses and loss of structural integrity. In addition to those identified in Method 302, consider the following examples to help determine if this method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

a. Jamming or loosening of moving parts.

b. Weakening of solder joints and glued parts.

c. Change in strength and elasticity.

d. Loss of calibration or malfunction of linkage devices.

e. Loss of seal integrity.

f. Changes in electrical or electronic components.

g. Premature actuation of electrical contacts.

h. Fading of surface colours and labels.

i. Change in the properties of elastomers and polymers.

j. Blistering and scaling of paints and other finishes.

k. Softening of plastic materials.

l. Pressure variations.

m. Sweating of composite materials and explosives.

n. Difficulty in handling.

2.4.2. Actinic Effects

Certain portions of the solar spectrum are known to cause degradation of materials, particularly the ultraviolet. Some examples of deterioration caused by actinic effects include the following:

a. Deterioration of natural and synthetic elastomers and polymers through photochemical reactions initiated by shorter wavelength radiation. High strength polymers such as Kevlar are noticeably affected by the visible spectrum.

b. Fading of fabric colour.

c. Checking, chalking, and fading of paints.

2.5. CHOICE OF TEST PROCEDURE

2.5.1. Selecting a Test Procedure

1. When selecting the procedures applicable to the Life Cycle Environmental Profile (LCEP), consider the following:

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 (climatic regions) 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.

2. While both procedures I and II involve exposing test items to simulated solar radiation, they differ based on timing and level of solar loads.

3. Prior to conducting Procedure II, the maximum response temperature from Procedure I or field / fleet data are required.

2.5.2. Procedure I: Heating Effects

1. This procedure is primarily used to evaluate the thermal effects of solar radiation on materiel when exposed to meteorological cycles of solar radiation with high ambient temperature conditions.

2. Although Procedure I can be performed using simple heat-generating lamps (providing the guidance in paragraph 5.4.1 is followed), limited evaluation of actinic effects is possible if full spectrum lamps are used instead. It is preferable to use the solar radiation test (as opposed to Method 302 High Temperature) when the materiel could be affected by differential heating (see paragraph 2.4.1) or when the intensity or mechanisms of heating caused by solar radiation are unknown (this encompasses almost all materiel).

2.5.3. Procedure II: Actinic Effects

1. Use Procedure II to investigate the actinic effects on materiel over long periods of exposure to sunshine. The accelerated approach detailed in Procedure II is designed to reduce the time to reproduce cumulative effects of long periods of exposure. This procedure exposes materiel to cycles of intensified solar loads (approximately 2.5 times the total energy of Procedure I) to accelerate actinic effects, interspersed with dark periods, that would be accumulated over a longer period of time under normal solar loads.

2. 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 that the failure mechanisms follow the path expected in the real environment.

3. The 4-hour lights-off period of each 24-hour cycle allows for test item conditions (physical and chemical) to return towards a state of equilibrium and provide some degree of thermal stress exercising. The key to using Procedure II successfully is maintaining enough cooling air to prevent the test item from exceeding peak response temperatures that would be attained under natural conditions or Procedure I.

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CHAPTER 3 TEST SEVERITIES

3.1. GENERAL

Test severities should be based on the expected area of deployment of the materiel being tested; see AECTP-230 for guidance. Temperature and test duration are primarily the parameters that are tailored; however, humidity and overall irradiance may also be considered. It is not recommended to exceed an irradiance of 1120 W/m^2.

3.2. TEMPERATURE AND SOLAR RADIATION

1. Temperature and solar radiation levels can vary greatly from one location to another. Latitude, longitude, altitude, and time of year (seasonality) can contribute to these variations. The climatic categories discussed in AECTP-230 will assist in determining the temperature severity based on the operational requirements of the materiel.

2. The conditions discussed and provided in this method, for general testing, is a representation of the real environment at sea level. The solar spectrum provided in this method is recommended for use at both sea level and high altitudes up to 4.5 km (15,000 ft), which is the limitation for soldier operated systems.

3. For this method, the lamp array shall conform to the spectrum identified in Table 1. Deviations from Table 1 may be justified if the test requirements are based on a tailoring process or if a specific frequency band is of concern.

4. Any deviation shall be detailed and justified. Any deviations from the spectral distribution in Table 1 will require a thermal analysis to be performed which considers the spectral absorptivity and reflectivity of the test item to evaluate the potential difference in the total energy absorbed by the test item between exposure to the required spectral power distribution and any modified spectrum. The difference in total energy absorbed must not differ by the total energy tolerances specified in this Method. Consideration must also be made to spectrally selective photo-chemical degradation modes in the material under test, to ensure that any modified spectrum does not create an over- or under-test condition.

Table 1: Spectral Power Distribution

<table>
<tr><th>Spectral Region</th><th>Bandwidth (nm)</th><th>Irradiance (W/m²)</th><th>Spectral Region Irradiance (W/m²)</th><th>Spectral Region Tolerance (%)</th></tr>
<tr><td>Ultraviolet – B</td><td>280 – 320</td><td>5.6</td><td>5.6</td><td>±35</td></tr>
<tr><td rowspan="2">Ultraviolet – A</td><td>320 – 360</td><td>26.9</td><td rowspan="2">62.7</td><td rowspan="2">±25</td></tr>
<tr><td>360 – 400</td><td>35.8</td></tr>
<tr><td rowspan="3">Visible</td><td>400 – 520</td><td>200.5</td><td rowspan="3">580.2</td><td rowspan="3">±10</td></tr>
<tr><td>520 – 640</td><td>185.9</td></tr>
<tr><td>640 – 800</td><td>193.8</td></tr>
<tr><td>Infrared</td><td>800 – 3000</td><td>471.5</td><td>471.5</td><td>±20</td></tr>
<tr><td colspan="2">Totals</td><td>1120</td><td>1120</td><td>±10</td></tr>
</table>

NOTE:
i) Total Irradiance: sum of energy for all spectral bandwidths at a single measurement point on the diurnal curve (±4 percent or ±15 W/m² (whichever is greater) of the target irradiance.
ii) The required tolerance is ±4 percent unless otherwise defined by the environmental test specification but should not exceed 10 percent.

5. The internationally agreed spectrum shown in Table 1 comes from Table 2.1 in the International Commission on Illumination (CIE) No. 20, “Recommendations for the Integrated Irradiance and the Spectral Distribution of Simulated Solar Radiation for Testing Purposes”, published in 1972. This document was superseded by CIE 085 in 1989 and then by CIE 241 in 2020. The latter standard is under review. See Annex A for further information.

6. The temperature severities should be derived from climatic data documents such as AECTP-230, Climatic Conditions, national climatic documents, or from other environmental data. For Procedure I, unless otherwise justified by the materiel’s requirements documents, the cyclic (diurnal) temperature and solar irradiance profile in Annex B Figure B-1 should be used. Figure B-1 shows the daily cycle of temperature and solar radiation corresponding to category A1. Temperature severities are characterized as meteorological conditions. If a specific simulation is required, consult meteorological data for the areas under consideration, however any deviation from the standard conditions shall be detailed and justified in the test report.

3.3. DURATION

The test durations are expressed in numbers of 24-hour cycles in both test procedures.

3.3.1. Procedure I: Thermal Effects (Heating) (Annex B Fig. B-1)

1. Expose the test item to continuous 24-hour cycles of controlled simulated solar radiation and temperature as indicated in Annex B Figure B-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. Perform at least three continuous cycles. If the maximum of the peak response temperature of the third cycle is not within 2 °C of the previous 24-hour cycle, continue the cycles until repeated the peak temperatures from two consecutive cycles are within 2 °C, or for seven cycles, whichever comes first.

2. The test item operation may also extend the number of cycles to achieve a period of operation that adequately addresses service use. See paragraph 3.4 for additional information.

3. In the absence of other guidance, the maximum test duration of seven cycles was chosen because the peak high temperature for the selected climatic region occurs approximately one hour in each of seven cycles in the most extreme month.

3.3.2. Procedure II: Actinic Effects (Annex B Fig. B-4)

1. Procedure II produces an acceleration factor of approximately 2.5 as far as the total energy received by the test item is concerned; i.e., one 24-hour cycle as shown in Annex B Figure B-4 provides approximately 2.5 times the solar energy experienced in one 24-hour (meteorological) diurnal cycle plus a 4-hour lights-off period to allow for alternating thermal stressing and for the so-called "dark" processes to occur.

2. The recommendation is ten, 24-hour cycles (as in Annex B Figure B-4) for materiel that is occasionally used outdoors, such as portable test items, etc. For materiel continuously exposed to outdoor conditions, the recommendation is 56 or more 24-hour cycles.

3. Do not increase the irradiance above 1120 W/m^2. Presently there is no indication that attempting to accelerate the test in this way gives results that correlate with materiel response under natural solar radiation conditions.

3.4. TEST ITEM OPERATION

1. Based on the requirements document and / or test plan, the test item may either be non-operating or operating. Operating could be continuous or intermittent and should reflect the LCEP. Unless otherwise specified, conduct a functional test of the test item at the test item’s peak response temperature or at the worst-case operating environment for the test item (if known). Use thermocouples affixed to critical points of the test item to determine the time and value of peak temperature.

2. Functional tests may need to be conducted over multiple periods that include the peak solar radiation, the peak chamber temperature, and the peak in thermal response of the product to fully evaluate the materiel. Functional tests that are long in duration may need to be conducted over multiple diurnal cycles to verify all functions during peak thermal conditions.

3. When it is necessary to operate the test item, use the following guidelines for establishing test operating procedures unique to this Method.

a. Include operating modes that consume the most power (generate the most heat).

b. Include the required range of input voltage conditions, if changes in voltage could affect the test item thermal dissipation or response (e.g., power generation or fan speed).

c. Introduce any cooling media that normally would be applied during service use (e.g., forced air or liquid coolant). Consider using cooling medium inlet temperatures and flow rates that represent both typical and worst-case degraded temperature and flow conditions.

d. Consider monitoring for hazardous Volatile Organic Compounds (VOCs) that may be emitted during high temperature solar conditions. These VOCs emitted can be irritable and create a health hazard. Knowledge of the materials under test could influence the decision for air / gas monitoring. Polyvinyl Chloride (PVC) is a material often used for portable shelters and is known to off-gas at high temperature.

3.5. HUMIDITY

If the materiel is known or suspected to be sensitive to the combined effect of solar radiation and humidity (high or low), then use the climatic categories within AECTP-230 and include it in the Procedure I test requirements.

3.6. AIR VELOCITY

1. Airflow will significantly impact the thermal response of the test item. The following provides guidance for air velocity control.

2. For Procedure I, use an airspeed of 1.5 to 3.0 m/s unless otherwise specified. If the deployed environment will subject the item to either limited or no wind speed (shielded from natural wind), then use a minimum air speed, no less than 0.25 m/s, when conducting Procedure I. Generally, an airflow of as little as 1 m/s can cause a reduction in temperature rise of over 20 percent as compared to still air. To ensure test repeatability, the airspeed around the test item (especially near the top horizontal surfaces) shall be measured and recorded during the pre-test set-up with the test item installed in the test chamber. These measurements shall be provided in the test report.

3. For Procedure II, use the minimum airspeed required to maintain the maximum thermal response as measured in the natural environment or Procedure I. Considerations with respect to air velocity over the surface of the test item should be made to both control the maximum thermal response of the test item but to also avoid unrealistic cooling.

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CHAPTER 4 INFORMATION REQUIRED

4.1. INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTIONS

1. In addition to the information found within Method 300, the following information is required to conduct the test(s) described in this method and shall be recorded in the test instructions:

a. The test procedure(s) selected from this method.

b. The temperature and solar test severities for each test procedure selected.

c. The test duration (time or number of cycles) for each test procedure selected.

d. A description of the test item(s) configuration (storage, transport, operation and / or standby) including any packaging, stacking, or racking requirements applicable to each test procedure selected.

e. A list of any heat dissipating components, critical components, and functional parameters to be measured and recorded during testing.

f. The location(s) on the test item(s) where temperature stabilisation will be evaluated.

g. Any known safety issues related to high temperature (e.g., volatiles, energetic materials).

h. Chamber spectrum power distribution and irradiance uniformity measurements.

i. Temperature / radiation measurement techniques and locations.

j. Substrate or method of test item mounting.

k. Verification of air velocity measurements in the vicinity of the test item (see section 5.5.3).

2. The following information may be required to conduct the test(s) and shall be recorded in the test instructions when applicable:

c. Relative humidity control and monitoring requirements.

d. Functional test instructions, including period(s) of operation and test item performance requirements for each test procedure selected.

e. Details of any external cooling provisions such as fans or heat sinks, as applicable to the materiel's in-service installation.

f. Details of any restrictions to heat transfer, such as thermal isolation mounts or restrictions to airflow (convection), as applicable to the materiel's in-service installation.

g. Any additional parameters to be measured and recorded.

h. Necessary variations in the basic test procedures to accommodate environments identified in the materiel's LCEP.

4.2. INFORMATION REQUIRED FOR VERIFICATION

In addition to the information found within Method 300, the following information is required to verify the completion of the test(s) described in this method and shall be recorded in the test report:

4.2.1. Pre-Test

a. General. Information listed in Method 300.

b. Specific to this Method.

(1) Description, with photographs, of the test item's configuration and orientation within the test chamber for each test procedure.

(2) List of all instrumentation placement locations, with photographs.

(3) Identification of the components / assemblies / structures to be used for measuring the thermal response and evaluating the temperature stabilisation of the test item(s).

(4) If required, a record of the test item temperature-versus-time during any pre-test functional tests.

(5) If required, a record of the ambient temperature and humidity during any pre-test functional test.

(6) Results of pre-test functional tests.

4.2.2. During-Test

Collect the following information during conduct of the test:

a. General. Information listed in Method 300.

b. Specific to this Method.

(1) The chamber temperatures (and humidity if required) and irradiance versus time conditions for the entire test duration including pre-test chamber heating and post-test chamber cooling periods.

(2) The test item temperature-versus-time data for the duration of the test including all pre-test and post-test conditioning periods.

(3) Documentation of where and when peak temperature or thermal stabilisation of the test item was achieved for the purpose of evaluating the test duration or number of cycles completed and remaining.

(4) Documentation of test item operating and non-operating periods as well as any functional tests completed.

(5) Detailed record of any functional tests performed.

(6) List of any test interruptions or deviations from the original test plan.

(7) Record of airflow velocity sustained during test. See section 5.5.3 for additional information on air velocity measurement.

4.2.3. Post-Test

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

a. General. Information listed in Method 300.

b. Specific to this Method.

(1) Results of any visual inspections and any functional tests performed pre-test, during test, and post-test.

(2) Chamber temperature, solar irradiance, and test item response temperatures (and humidity if required), and number of diurnal cycles or exposure periods.

(3) Record of airflow velocity.

(4) Spectral power distribution of the source lighting (e.g., to reproduce conditions of a previous test).

(5) Photographs of test setup to include test item configuration, sensor locations, lamp placement, solar lamp array identification, etc.

(6) Any test interruptions or deviations from the original test plan.

(7) Any deviation from the required spectral power distribution as stated in Table 1, and justification.

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CHAPTER 5 TEST CONDITIONS AND PROCEDURES

5.1. PREPARATION FOR TEST

In addition to the instructions found within Method 300, determine the information specified in paragraph 4.1 and ensure that a suitable plan has been derived to gather the information required in paragraph 4.2 prior to starting any test procedure.

5.2. TEST FACILITY

1. The facility requirements consist of a chamber or cabinet, auxiliary instrumentation, and a solar lamp array. This apparatus must be capable of maintaining and monitoring the required conditions of temperature, airflow, and irradiation.

2. Full spectrum lamps are recommended for both procedures, however, Procedure I can be performed using lamps that do not meet the spectral energy distribution of Table 1, provided the guidance in paragraph 5.4.1 is followed.

3. For both procedures consider the possible cooling effects of airflow over the test specimens. Caution is advised on the use of low airspeed; rarely do high solar and high temperature events occur in nature without accompanying winds.

   a. Procedure I: Unless otherwise justified, use an airspeed between 1.5 to 3.0 m/sec (300 to 600 ft/min). See paragraph 5.5.3 for additional details.

   b. Procedure II: Unless otherwise justified, use an airflow rate sufficient enough to maintain the test item response temperature that was either determined from Procedure I or obtained from field data.

4. To minimize or eliminate re-radiation from chamber surfaces, experience has shown that the best method is when the volume of the test chamber is a minimum of 10 times that of the envelope volume of the test item. (Consider the beam angles of the light source hitting the walls of the test chamber.)

5. The solar radiation target area will be verified as meeting uniformity and irradiance levels over the targeted area. These measurements will be recorded at a specified height or distance from the solar lamps prior to test (see Annex D.3 paragraph c.). The test item should never extend beyond the verified target area and maintain the appropriate distance from the solar lamps.

5.3. INSTALLATION CONDITIONS OF THE TEST ITEM

See Method 300 and consider the following:

5.3.1. Test Item Orientation

The orientation of the test item relative to the direction of solar radiation (view factor) will have a significant impact on the heating effects. In cases where the test item components are known to be sensitive to solar effects, consider the solar radiation source orientation to simulate a natural diurnal cycle. Whenever possible, mount the test item so that its configuration is representative of actual deployment, as provided in the requirements document. This mounting may include supports or a substrate of specified properties (e.g., a layer of concrete of specified thickness or a sand bed of certain reflectivity). (See paragraph 5.3.3.)

5.3.2. Surface Contamination

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

5.3.3. Test Item Mounting and Substrate

The test item should be installed either on raised supports with dimensions and thermal properties that replicate the fielded configuration or on a substrate of specified properties to replicate the ground surface conditions. Examples of common substrates are a layer of concrete of specified thickness or a sand bed of a conductivity and reflectivity representative of actual deployment and should be provided in the requirements documents.

Caution shall be given to not artificially create either a thermal-sink or thermal-isolator that is not representative of actual deployment.

5.3.4. Instrumentation

1. Instrumentation specific to this Method will include:

    a. A spectrometer or filtered pyranometer used to verify the spectral energy distribution of the solar lamp array prior to test.

    b. Pyranometer(s) or radiometer(s) used to record the total irradiance of the solar lamp array during test.

    c. Thermocouples required to verify the environment and operation of the test item in the environment. Thermocouples that are directly exposed to the solar irradiance should be shielded sufficiently.

    d. An anemometer used to record windspeed across the test item and in the target area.

2. See sections 5.4 and 5.5 for guidance on tolerance and control.

3. Temperature measuring sensors should be mounted on the test item at sufficient locations to allow evaluation of the test item’s thermal response to the test environment. The parts of the test item with the slowest thermal response (longest thermal lag) should be instrumented in order to establish temperature stabilisation during testing. Temperature stabilisation is generally important to ensure reproducible test conditions. Stabilising test item elements critical for operational requirements (e.g., components, sub-assemblies, etc.) is normally more important than stabilising temperatures of structural members, unless they directly influence the materiel’s operational performance. In some instances, it may not be possible or practical to directly measure the part(s) of the test item with the longest thermal lag. In such instances, additional time at the test temperature may be required to ensure complete stabilisation of the test item. Alternatively, a thermal survey of the test item could be completed before the start of testing to identify suitable temperature monitoring locations.

4. Surface temperatures directly exposed to the light source should not exceed the natural environment response temperature. For Procedure II, response temperatures from Procedure I may be used. Surface temperatures can vary from one test item to another due to variables such as absorptivity and reflectivity of the surface finish, the distance from the surface to the light source, the relative angle of the light source, and the airflow over the surface. Monitor the surface temperatures with the highest response temperature and apply engineering judgment to the test setup if temperatures are excessive.

5. Heat dissipating components should be measured to evaluate the temperature rise above ambient during operation. In all instances, sensors and their mounting configuration should be selected to minimize attenuation of the test item’s response to the test environment.

5.4. TOLERANCES

Method 300 provides guidance on general test tolerances. Tolerance values specific to this method can be found below in Table 2.

5.4.1. Solar Radiation Source

1. Full spectrum lamps are recommended for both procedures.

2. Use a maximum irradiance intensity of 1120 W/m^2 (± 4 percent). Ensure the radiation across the upper surface of the test item target area is uniform to within ± 10 percent of the desired value, see Annex D.

3. The diurnal variation in solar energy may be applied continuously (see Annex B Figure B-1) or incrementally (see Annex B Figures B-2 and B-3), with a minimum of eight levels, provided that the total energy of the cycle is maintained.

4. Where only heating effects are being assessed (Procedure I) it is essential to maintain at least the visible and infrared portions of the spectrum as detailed within Table 1. However, if deviating from the spectral distribution is necessary, adjust the irradiance to give an equivalent heating effect. Document any deviation from the solar power distribution (Table 1) and record it in the test report. If using infrared lamps, exercise caution because infrared-reflecting / absorbing coatings will reflect or absorb energy based on spectrum and an infrared light system may not produce realistic heating effects when various material colours and structures are under evaluation. If a glazing system is incorporated in the materiel (see paragraph 2.4.1), verify that the infrared transmission is not affected when using an infrared source. Use a full spectrum source if attenuating coatings, glazing, or other systems are used in / on the test item significantly affect spectral reflection / absorption. In order to determine the amount of adjustment necessary, use either of two methods below and document it in the test report.

a. Mathematically calculate the adjustment using the spectral reflectance or transmittance of the irradiated surfaces, and the spectral energy distribution of the particular lamps being used (and also the effect of any associated reflectors or glasses).

b. Empirically determine the adjustment by conducting a pre-test on samples that are representative of the materiel (the most important characteristics are material composition, colour, and surface roughness). Measure the temperature rise above ambient air temperature of test samples under natural solar radiation conditions (the climatic category identified in the LCEP as the most extreme) and compare the results with the temperature rise above ambient (chamber) air temperature of test samples under simulated solar radiation. Gather an adequate amount of data under the natural condition portion of the test to account for the cooling effects of airflow over the samples (i.e., outdoor conditions rarely provide zero wind), and extrapolate the temperature rise at zero wind conditions to be comparable to results from chamber samples. This process requires the use of extensive multi-year stable data sets to establish a statistically viable analysis.

5. Where actinic effects are to be assessed, (Procedure II), ensure the spectral distribution of the light source adheres to the distribution given in Table 1 (within the given tolerances).

6. Direct the radiation onto the test item and irradiate the entire surface of the test item facing the solar radiation source. To provide the highest degree of confidence in the measurements, the value of 1120 W/m^2 theoretically includes all radiation received by the test item, including any radiation reflected from the chamber walls and any long-wave infrared radiation (but not greater than 3 µm) emitted by the chamber walls. Radiation reflected or emitted from the chamber walls is generally substantially lower than the radiation emitted directly from the light source, and a measurement device

with a measurement range of 285–2800 nm should be sufficient to measure direct and reflected radiation. Additionally, if the intent of the test is to determine thermal heat loading use a radiation measuring device that has the capability to measure infrared energy, and calibrate the radiation measuring device in the full wavelength range it is designed to measure.

7. To prevent localized effects such as unintentional heating from individual bulbs, locate the radiation source at least 76 cm (30 in) away from any surface of the test item. Spot lamps (as opposed to flood lamps) may produce a non-uniform exposure.

8. Light source. The following lists are not intended to exclude new lamps made available by advanced technology. It may be necessary to use filters to make the spectrum comply with that specified in Table 1. Further guidance is given in Annex A.

a. Tests conducted for degradation and deterioration of materials due to actinic effects as well as heat buildup within the test items must satisfy the full spectrum of Table 1 and may use one of the following acceptable radiation sources:

(1) Metal halide lamps (designed for full-spectrum application).

(2) Xenon arc or mercury xenon arc (used singularly) with suitable reflector.

(3) Combination of high-pressure sodium vapor and improved mercury vapor with suitable reflectors.

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

b. Use the appropriate lamps from the following list for tests conducted to assess heating effects alone (and not actinic effects):

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

(2) Combination of incandescent spot and tubular-type mercury vapor lamps with external reflectors.

(3) Combination of incandescent spot lamps and mercury vapor lamps with internal reflectors.

(4) Metal halide.

(5) Xenon arc or mercury xenon arc lamps with suitable reflectors.

(6) Multi-vapor (clear or coated bulb) with suitable reflectors.

(7) Tungsten filament lamps.

(8) Any other heat producing lamp.

5.4.2. Measurement of Spectral Distribution

Use of a pyranometer with suitable filters or a spectroradiometer is required to measure the spectral distribution of the radiation imposed on the test item. A filtered pyranometer can only provide an approximate measurement of the spectral distribution. However, a spectroradiometer, although more delicate to employ, can provide a precise measurement of the spectral distribution. Use other measuring instruments only if they can satisfy the required specifications.

Table 2: Test Parameters and Tolerances

TEST PARAMETER	DESCRIPTION	TOLERANCE
Total Irradiance	Sum of energy for all spectral bandwidths at a target irradiance level on the test profile (diurnal curve or constant irradiance).	±4 percent or ±15 W/m^2 (whichever is greater) of the target irradiance.
Spectral Energy Distribution	Energy within each spectral bandwidth at a single measurement point.	See Table 1 for tolerance at each bandwidth.
Irradiance Uniformity	Deviation between the measured and target irradiance at all measurement points on the target plane. The number of points shall be adequate to define irradiance variation across the target plane(s) to meet the specific test requirement.	±10 percent deviation from the target irradiance

5.4.3. Measurement Accuracy

The required measurement accuracy of these different instruments is given in Table 3.

Table 3: Measurement Accuracy

MEASUREMENT INSTRUMENT	PARAMETER MEASURED	ACCURACY
Pyranometer	Total radiation (Direct & diffuse)	Secondary standard in accordance with ISO 9060
Spectroradiometer / Pyranometer& Filters	Spectral distribution	± 4 percent over the specified radiometric band

5.5. CONTROLS

In addition to the instructions found within Method 300, consider the following instructions specific to this method.

5.5.1. Temperature Measurement

1. Maintain the chamber air temperature (as specified in the test plan) in accordance with Method 300. Chamber air control should be located upstream of the test item to avoid heating from the test item.

2. To adequately measure and control the temperature of the air surrounding the test item, measure it (with adequate shielding from radiated heat; see Annex A, paragraph A.4.2) at a point or points in a horizontal reference plane, at the approximate elevation of the upper surface of the test item, and as close as possible to the test item making adequate provision for shielding from the effects of radiant heat from the test item. This tactic would ensure reasonable control of the envelope of air surrounding the test item. The temperature sensors used to measure the thermal response of the test item will also be affected by direct radiation of the light source. When practical, mount these sensors to the inside surface of the external case (upper surface) of the test item, appropriate for a relatively thin surface and high thermal conductivity.

5.5.2. Measurement of Solar Radiation (Irradiance)

Measurement of the total radiated energy can be made using a pyranometer. These sensors should be placed level with the target plane and normal to the solar lamp array. Detailed guidance is provided in Annex D.

5.5.3. Air Velocity Measurement

Air velocity measurements can be made using a calibrated anemometer to verify wind speeds of 1.5 to 3.0 m/s (300 to 600 ft/min) across the test item.

Airflow has a significant impact on the thermal response of the test item. Section 3.6 provides guidance for air velocity parameters. The airflow may require shielding or increased air velocity in the immediate area of the test item dependent on chamber size. Ensure that artificial shielding does not unrealistically alter the effects of the solar radiation test levels. Consideration with respect to air velocity over the surface of the test item should be made to both control the maximum thermal response of the test item, but to also avoid unrealistic cooling. To ensure test repeatability, the air speed shall be measured and recorded in the test report.

5.6. TEST INTERRUPTIONS

Following any test interruption scenario, consider the following instructions specific to this method in addition to the instructions found within Method 300. All relevant stakeholder(s) should be consulted following a test interruption and prior to continuing testing.

5.6.1. Under-Test Interruptions

1. For an unscheduled test interruption that causes the test conditions to fall out of allowable tolerances toward standard ambient conditions (i.e., environmental stress less severe than specified) the test may be resumed as follows:

2. Procedure I (Heating Effects).

    a. If an interruption occurs before the maximum thermal response has been determined, then re-start the procedure from the beginning.

    b. If an interruption occurs after the maximum thermal response has been determined, re-stabilise the materiel at the required test conditions and continue the test from the end of the last successfully completed cycle. Extend the test as necessary to achieve the maximum thermal response, prior to conducting any required functional tests.

> **CAUTION:** When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials.

    c. If an interruption occurs after 19:00 of the last cycle of Procedure I, the test shall be considered complete (at least 92 percent of the test would have been completed and the probability of a failure is low during the remaining reduced levels of temperature and solar radiation). However, this is not an excuse to terminate testing at 19:00 hours of the last cycle during normal test procedures (i.e., where no interruption has occurred); the test should always be completed when the test chamber is operating as required without interruption.

3. Procedure II (Actinic Effects). The test rationale is based on the total cumulative effect of the solar environment. Any under-test interruption should be followed by re-stabilisation at the specified conditions and continuation of the test from the point of the interruption.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures does not exceed the life expectancy of any safety-critical materials. This is particularly applicable to energetic materials.

5.6.2. Over-Test Interruptions

If an over-test condition occurs (i.e., environmental stress more severe than specified), follow the instructions provided in Method 300. If, after inspection and analysis by a failure review team, it is deemed acceptable to continue testing with the original test item, follow the test re-starting instructions in section 5.6.1 as applicable to either cyclic or steady state temperature exposure.

5.6.3. Interruption Due to a Scheduled Event

1. Scheduled test interruptions shall be avoided. Any unavoidable scheduled interruptions shall be pre-approved in the Test Plan.

2. For Procedure I and II, follow the instructions in paragraph 5.6.1 accordingly.

5.6.4. Interruption Due to Test Item Failure

1. Failure of the test item(s) to function as required during mandatory or optional performance checks during testing presents a situation with several possible options. See Method 300. All relevant stakeholder(s) should be consulted following a test interruption and prior to continuing testing.

NOTE: When evaluating interruptions due to test item failure, consider prior testing on the same test item and consequences of such.

5.7. TEST PROCEDURES

5.7.1. Preliminary Steps

Before starting the test, review pre-test information in the test plan to determine test details (e.g., procedures, item configuration, cycles, durations, parameter levels for storage / operation, etc.) have been gathered. (See chapter 4 above.)

5.7.2. Pre-Test Standard Ambient Functional Test

Conduct a pre-test standard ambient functional test to obtain baseline performance data. Unless otherwise directed by the test plan, the pre-test standard ambient functional test shall be conducted before the start of each test procedure as follows:

Step 1. Conduct a visual examination of the test item with special attention to stress areas, such as corners of moulded cases, and document the results.

Step 2. Prepare the test item in its operating configuration. Install temperature sensors in, on, and around the test item to evaluate the test item's temperature response.

Step 3. Unless otherwise specified in the test plan, conduct a functional test at standard ambient conditions and record the results. For test items not requiring a functional test, proceed to Step 1 of the selected test procedure.

Step 4. If the test item operates satisfactorily, proceed to Step 1 of the selected test procedure. If not, resolve the problems and restart at Step 1 of the pre-test standard ambient functional test.

5.7.3. Procedure I: Heating Effects (Annex B Figure B-1)

Step 1. Install the test item in the chamber and stabilise it at standard ambient conditions and in a manner that will simulate service use, unless the storage configuration is specified. Position the test item in accordance with the following. The test item shall be:

a. As near the centre of the test chamber as practical and so that the surface of the item is not closer than 30 cm to any wall or 76 cm to the radiation source when the source is adjusted to the closest position it will assume during the test.

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

c. Separated from other items that are being tested simultaneously, to ensure that there is no mutual shading or blocking of airflow unless this, also, is representative of the materiel's field use.

d. Test item may be operating or non-operating. Refer to section 3.4 “Test Item Operation” for guidance.

Step 2. Adjust the chamber temperature and stabilise the test item to the conditions shown in the appropriate climatic category (zone A1) for time 0000. Starting at a different point in the cycle may be negotiated with all stake holders in order to facilitate operator schedules. It is recommended to start in the lower levels of diurnal cycle. Stabilise the test item at the chosen starting conditions.

Step 3. Expose the test item to continuous 24-hour cycles of controlled simulated solar radiation and dry-bulb temperature as indicated in Annex B Figure B-1 or as identified in the requirements document, while measuring and recording test item temperatures throughout the exposure period. If the test facility is unable to perform the continuous curve of Figure B-1, increase and decrease the solar radiation intensity in a minimum of eight levels (see Annex B, Figures B-3 and B-4 for the stepped levels) for each side of the cycle, provided the total energy of the cycle as well as the spectral power distribution is maintained. Perform at least three continuous cycles. If the maximum of the peak response temperature of the previous 24-hour cycle is not reached (± 2 °C (± 3.6 °F)) during the three cycles, continue the cycles until repeated peak temperatures are reached, or for seven cycles, whichever comes first.

Step 4. Adjust the chamber air temperature to standard ambient conditions and maintain until temperature stabilisation of the test item has been achieved.

Step 5. Conduct a complete visual examination of the test item and document the results. For comparison between pre- and post-test items, photograph the test item and take material samples (if required).

Step 6. Conduct an operational checkout of the test item as in paragraph 5.7.2, Step 3. See section 6 for analysis of results.

Step 7. Compare these data with the pre-test data.

5.7.4. Procedure II: Actinic Effects (Annex B Figure B-4)

> **NOTE:** If procedure has not been previously performed and no field / fleet data are available, conduct a preliminary test carried out in accordance with procedure I (absolute minimum of three complete cycles) to determine the approximate maximum response temperature of the test item.

Step 1. Adjust the chamber air temperature to the maximum temperature shown in the appropriate climatic zone (zone A1) as indicated on Annex B Figure B-4 or the temperature identified in the test plan. Starting at a different point in the cycle may be negotiated with all stake holders in order to facilitate operator schedules. It is recommended to start in the lower levels of diurnal cycle. Stabilise the test item to the chosen conditions.

Step 2. Adjust the solar radiation source to a radiant energy rate of 1120 W/m^2 or as identified in the test plan. Use sufficient air speed to maintain the test item temperature to the peak response temperature obtained in Procedure I or obtained from field data.

Step 3. Maintain these conditions for 20 hours, measuring and recording the test item temperatures. If required, conduct visual inspection and functional tests early in the lights on period and after achieving maximum thermal response. If the test item fails the visual inspection or functional tests, follow the guidance in paragraph 5.6.4 for test item failure.

Step 4. Turn off the solar radiation source for four hours.

Step 5. Repeat Steps 1–4 for the number of cycles identified in the test plan with visual inspections and functional tests performed at the midpoint, for tests up to 10 cycles, or a minimum of once every 7 cycles for longer durations.

Step 6. At the end of the last radiation cycle, allow the test item to return to standard ambient conditions.

Step 7. Conduct a visual examination and a functional check as described in Step 3 paragraph 5.7.2 and document the results. Take photographs of the test item and material samples (if required) for comparison between pre- and post-test items. See section 6 for analysis of results.

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CHAPTER 6 EVALUATION OF THE TEST RESULTS

In addition to the guidance provided in Method 300, the following information is provided to assist in the evaluation of the test results. Analyse any failure of a test item to meet the requirements of the materiel specifications.

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CHAPTER 7 REFERENCES AND RELATED DOCUMENTS

a. See Method 300 for a list of current National documents.

b. Commission Internationale de L'Eclairage, (CIE)-241:2020, Recommended Reference Solar Spectra for Industrial Applications, 1 September 2020.

c. Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS), version 2.9.5, https://www.nrel.gov/grid/solar-resource/smarts.html.

d. Deutsches Institut Für Normung **(DIN) 75220, Testing for Aging of Automotive Components in Solar Simulation, 1992.**

e. Commission Internationale de L'Eclairage, CIE No. 20, Recommendations for the Integrated Irradiance and the Spectral Distribution of Simulated Solar Radiation for Testing Purposes, 1972.

f. Commission Internationale de L'Eclairage, (CIE)-085-1989, Solar Spectral Irradiance, 1989.

ANNEX A DETAILED GUIDANCE ON SOLAR RADIATION TESTING

A.1. INTRODUCTION

This Annex describes methods of simulation designed to examine the effects of solar radiation on equipment. The main quantities to be simulated are the spectral energy distribution of the sun as observed at the Earth's surface and the intensity of received energy, in combination with controlled temperature conditions. However, it may be necessary to consider a combination of solar radiation—including sky radiation—with other environments (e.g., humidity, air velocity, etc.)

A.2. IRRADIANCE AND SPECTRAL DISTRIBUTION

The effect of radiation on the materiel will depend mainly on the level of irradiance and its spectral distribution.

A.2.1. Irradiance

The irradiance by the sun on a plane perpendicular to the incident radiation outside the Earth's atmosphere at the mean Earth-sun distance is known as the solar constant 'I_0' (Ref. 12). The irradiance at the surface of the Earth is influenced by the solar constant and the attenuation and scattering of radiation in the atmosphere. For test purposes, a maximum intensity of 1120 W/m^2 is specified to simulate the global (total) radiation at the surface of the Earth from the sun and the sky with the sun at zenith, based on a solar constant I_0 = 1350 W/m^2 (Ref. 22). The true solar constant is thought to be about 1365-1370 W/m^2.

A.2.2. Spectral Distribution: Sea Level Versus High Altitude

At high altitude, solar radiation contains a greater proportion of damaging UV radiation than at sea level. The internationally agreed spectrum (see Table 1), recommended for general testing, is a representation of the real environment at sea level. This spectrum is recommended for use at both sea level and at high altitude.

A.3. SOLAR RADIATION SOURCES

A.3.1. General

The radiation source may comprise one or more lamps and their associated optical components (e.g., reflectors, filters, etc.), to provide the required spectral distribution and irradiance. The high-pressure xenon arc lamp with filters can provide the best spectral match. Mercury vapor and xenon-mercury lamps have considerable deficiencies in matching that would lead to error. If already covered in test method characteristics of these sources, features of filters, optical arrangements, etc., are covered in the following paragraphs. The following general information about several light sources may be helpful.

1. Xenon lamps. The configuration and size of the lamp(s) used will depend on the test required. The relative spectral distribution of the xenon arc radiation has been found to be substantially independent of lamp power. However, variation of lamp power will change the temperature of the electrodes and hence the spectral distribution of their radiation. With long arc lamps, it is relatively simple to mask off the electrode radiation. The form of construction of the short arc lamp leads to considerably wider manufacturing variation compared with the long arc, a point particularly important when replacement becomes necessary. Routine replacement of either type of lamp will be needed, since the emission will change continuously with life, and there may be wide variations of the life characteristic from lamp to lamp.

2. Metal Halide (HMI). Metal Halide lamps that are properly filtered and using proper electrical power supply to the lamp can meet the defined spectral requirements. Care must be taken regarding lamp age and lamp power adjustment as spectral shifting can occur leading to changes in spectrum (critical for Procedure II testing).

A.3.2. Filters

Liquid filters have certain disadvantages such as the possibility of boiling, the temperature coefficient of spectral transmission, and long-term drift in spectral characteristics. The present preference is for glass filters to be used, although the characteristics of glass filters are not as accurately reproduced as those of a chemical solution filter. Some trial and error may be necessary to compensate for different optical densities by using different plate thicknesses. Glass filters are proprietary articles and manufacturers should be consulted concerning the choice of filters suitable for particular purposes. The choice will depend on the source and its methods of use. For example, a xenon source may be test-compensated by a combination of infrared and ultraviolet absorbing filters. Some glass infrared filters may be prone to rapid changes in spectral characteristics when exposed to excessive ultraviolet radiation. This deterioration may be largely prevented by interposing the ultraviolet filter between the source and the infrared filter. Interference type filters, that function by reflecting instead of absorbing the unwanted radiation, (thus resulting in reduced heating of the glass), are generally more stable than absorption filters.

A.3.3. Uniformity of Irradiance

Due to the distance of the sun from the Earth, solar radiation appears at the Earth's surface as an essentially parallel beam. Artificial sources are relatively close to the working surface and means of directing and focusing the beam must be provided with the aim of achieving a uniform irradiance at the measurement plane within specification limits (i.e., 1120 W/m^2 (see Table A1)). This is difficult to achieve with a short-arc xenon lamp with a parabolic reflector because of shadows from the lamp electrodes and supports. Also, the incandescence of the anode can produce considerable radiation at a much lower colour temperature, slightly displaced from the main beam, if only the arc itself is at the focus of the reflector. Uniform irradiation is more readily achieved with a long arc lamp mounted in a parabolic 'trough' type reflector. However, by employing very elaborate mounting techniques, it is possible to irradiate, with some degree of uniformity, a large surface by a number of short arc xenon lamps. It is generally advisable to locate radiation source(s) outside the test enclosure or chamber. This avoids possible degradation of the optical components (e.g., by high humidity conditions) and contamination of test items by ozone that has been generated by xenon and other types of arc lamps. Precise collimation of the radiation beam is not normally required except for testing special materiel such as solar cells, solar tracking devices, etc. However, some of the simulation techniques developed for space research purposes could be adapted for Earth surface solar radiation studies.

A.4. MEASUREMENTS

A.4.1. Measurement of Spectral Distribution

Total intensity checks are readily made, but detailed checks on spectral characteristics are more difficult. Major spectral changes can be checked by inexpensive routine measurements, using a pyranometer in conjunction with selective filters. For checking the detail spectral distribution characteristics of the facility, it would be necessary to employ sophisticated spectroradiometric instrumentation. However, there seems to be no practical instrumentation obstacle to prevent this calibration being done either as a service by the facility manufacturer or by a visit from a national calibration centre. Achieve correlation between the filter / pyranometer and spectroradiometric methods at regular intervals. Changes in the spectral characteristics of lamps, reflectors and filters may occur over a period of time that could result in the spectral distribution being seriously outside the permitted tolerances. Manufacturing tolerances may mean that lamp replacement could result in unacceptable changes in both the level of irradiation and spectral distribution compared with that initially set up. Regular monitoring is therefore essential, but monitoring of the detailed spectral distribution within the test facility may not be possible while an item is undergoing test. A method of measuring the intensity of radiation below 320 nm based on the exposure of polysulphone film and that would permit the monitoring of this wavelength range within the test facility is now established. Lower cost commercially available spectrometers provide reasonable results, however extreme care must be taken when measuring the ultraviolet range. Unless properly calibrated and evaluated, values in the ultraviolet range may be unreliable.

A.4.2. Measurement of Temperature

Because of the high level of radiation, it is essential that temperature sensors are adequately shielded from radiant heating effects. This applies both to measuring air temperatures within the chamber, and monitoring test item temperatures. When monitoring test item temperatures, sensors (e.g., thermocouples) should be located on the inside surfaces of the external case and should not be attached to the outside surfaces, unless the surface temperature is of concern. Temperature-indicating paints and waxes are unsuitable for monitoring the temperature of irradiated surfaces, since their absorption characteristics will not be the same. Commercially available self-adhesive surface mount thermocouples can be used if properly insulated from the source radiation.

Table A1: Test Parameters and Tolerances

TEST PARAMETER	DESCRIPTION	TOLERANCE
Total Irradiance	Sum of energy for all spectral bandwidths at a target irradiance level on the test profile (diurnal curve or constant irradiance).	±4 percent or ±15 W/m^2 (whichever is greater) of the target irradiance.
Spectral Energy Distribution	Energy within each spectral bandwidth at a single measurement point.	See Table 1 for tolerance at each bandwidth.
Irradiance Uniformity	Deviation between the measured and target irradiance at all measurement points on the target plane. The number of points shall be adequate to define irradiance variation across the target plane(s) to meet the specific test requirement.	±10 percent deviation from the target irradiance

A.5. PREPARATION OF TEST FACILITY AND MATERIEL UNDER TEST

A.5.1. Test Facility

Ensure that the optical parts of the facility, lamps, reflectors, filters, and so forth are clean. The level of irradiation over the specified measurement plane must be measured immediately prior to each test. Throughout the test continually monitor any additional environmental conditions, and other parameters as specified in the main body of this Method, paragraphs 4.1 and 4.2d.

A.5.2. Materiel Under Test

The method of mounting and the orientation of the test item relative to the direction of radiation will have marked influences on the heating effects. The test item will probably be required to be mounted either on raised supports or on a substrate of specified properties (e.g., a layer of concrete of specified thickness or a sand bed of certain thermal conductivity and reflectivity). Include all this and the attitude of the test item in the relevant specification. Special attention must be paid to the surface conditions of the test item to see that its finish is clean or in accordance with the relevant requirements. The heating effect on the test item will be largely affected by the condition of its external surfaces. Care must therefore be exercised in handling the test item, especially in avoiding oil films and in ensuring that the surface finish and its underlay are fully representative of production standards. Attach temperature sensors to the test item as required.

A.5.3. Ground Reflected Radiation

In some cases, such as with a white sand or snow ground cover, and the test item in close association with this surface, significant reflected radiation can be applied to the test item. This effect can be measured using a radiometer designed to measure the albedo radiation. This sensor primarily consists of an upward-facing radiometer and a downward facing radiometer. If the test item is to be substantially used in an environment where ground reflected radiation is a concern, consider the albedo radiation in the test design with radiation provided to the lower surface of the test item by auxiliary lighting, or the use of similar reflective material in the test setup.

A.6. HAZARDS AND PERSONNEL SAFETY

A.6.1. General

Solar radiation testing will require skilled technicians and test staff for operation and maintenance of the complex equipment, not only to ensure the prescribed performance of the test, but also because of the various health and safety hazards that have to be considered.

A.6.2. Ultraviolet Radiation

The most obvious dangers that have to be guarded against are those associated with the harmful effects of high intensity radiation in the near ultraviolet region. In natural sunlight, the eyes are protected in the following two ways: the brightness of the sun makes it almost impossible to look directly at it and the ultraviolet radiation is considerably attenuated by the atmosphere. These protections may not apply to artificial sources. Due to the point sources and high UV component of these sources, the eyes must be protected by filtered goggles or viewing apertures, particularly when setting up the equipment. All test personnel shall be made aware of the possibility that severe eye damage can result from only short exposure to unfiltered radiation from arc-type lamps. Serious erythema (sunburn) of exposed skin will also occur. Koller (paragraph 6.1, reference c) states that the ultraviolet radiation from sunlight is a major contributing factor for developing skin cancer. The use of suitable protective clothing including protection of the head and hands is highly recommended, even when working in test chambers irradiated by filtered sources.

A.6.3. Ozone and Harmful Fumes

Another serious health hazard arising from the use of xenon and other arc lamps is the possible buildup of local toxic concentrations of ozone during the testing period. However, the maximum production of ozone occurs at the initial switching on of the lamp, and thereafter the hot envelope of the lamp tends to degrade the ozone back to oxygen. Where forced-air cooling is employed, this cooling air should be removed from the building and not blown into the lamp housing. In this way, the ozone hazard can be largely eliminated. Suitable detecting and measuring equipment are commercially available.
The combined effects of heat and ultraviolet radiation on certain plastics (e.g., melamine laminates) may also produce toxic fumes. Take particular care in the choice

of materials used in the construction of a test facility.

A.6.4. Risk of Lamp Explosions

The use of high-pressure xenon discharge lamps as the primary radiation source can also result in serious accidents unless a well-planned code of practice for the handling of these arc discharge tubes has been specified and is adhered to. All such lamps (whether hot or cold, or used or new) have a liability to explode violently by reason of the considerable internal pressure (two to three atmospheres when cold, but up to twenty atmospheres when hot). There should be no visible dirt or oil on the envelope, so regular cleaning with detergent and alcohol is necessary using cotton gloves and face protection during such cleaning. When cold lamps are to be stored, the effects of explosion may be limited by two layers of 0.25 mm thick polycarbonate sheet. Particular care must be taken to limit the spread of chain reaction breakdowns in multi-lamp equipment. It is possible to use armour plate glass for the dual purpose of protection against lamp explosions and as a corrective filter. Individual lamp records should be kept as a matter of routine so as to be able to detect abnormal voltage / current behaviour.

A.6.5. Electric Shock

Normal electric shock preventive measures shall be adopted, particularly in the case of the high voltage igniter systems used with arc lamps. In some xenon lamps, the arc ignition pulse exceeds 60 kV, and an interlock system is therefore essential.

ANNEX B IRRADIANCE AND TEMPERATURE CURVES

B.1. PROCEDURE I: HEATING EFFECTS (TABLE B-1)

Table B-1: Procedure 1: A1 Heating Effects Test
Temperatures in °C, Solar Radiation in W/m²

Time	Temperature (°C)	Solar Radiation (W/m^2)
1	35	0
2	34	0
3	34	0
4	33	0
5	33	0
6	32	55
7	33	270
8	35	505
9	38	730
10	41	915
11	43	1040
12	44	1120
13	47	1120
14	48	1040
15	48	915
16	49	730
17	48	505
18	48	270
19	46	55
20	42	0
21	41	0
22	39	0
23	38	0
24/0	37	0

Values are from AECTP-230 - Temperatures of category A1 in °C, solar radiation in W/m²

B.1.1. Procedure I: Heating Effects (Continuous)

Time (h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A1	37	35	34	34	33	33	32	33	35	38	41	43	44	47	48	48	49	48	48	46	42	41	39	38	37
W	0	0	0	0	0	0	55	270	505	730	915	1040	1120	1120	1040	915	730	505	270	55	0	0	0	0	0

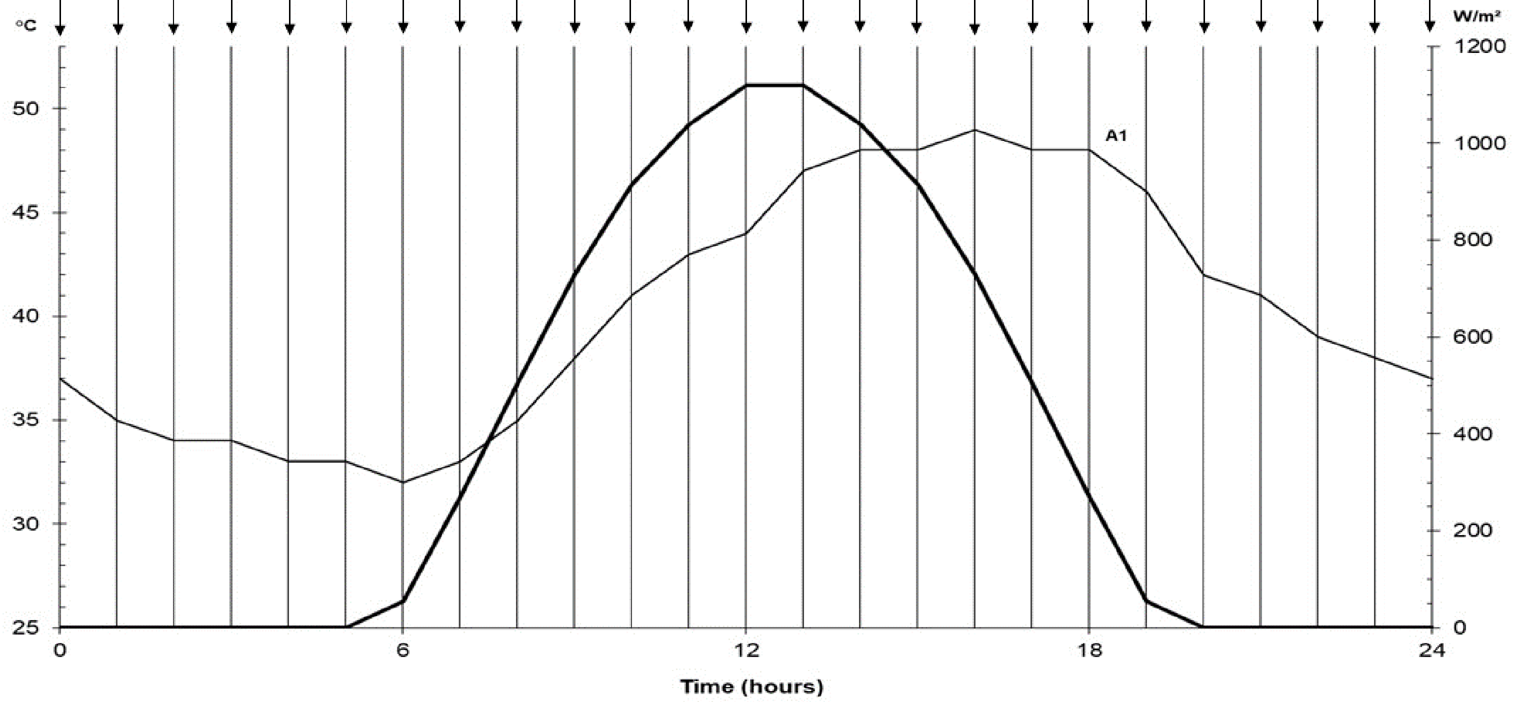

Figure B-1: Procedure I: Heating Effects Test (Continuous)

B.1.2. Procedure I: Heating Effects (1-Hour Steps)

Time (h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A1	37	35	34	34	33	33	32	33	35	38	41	43	44	47	48	48	49	48	48	46	42	41	39	38	37

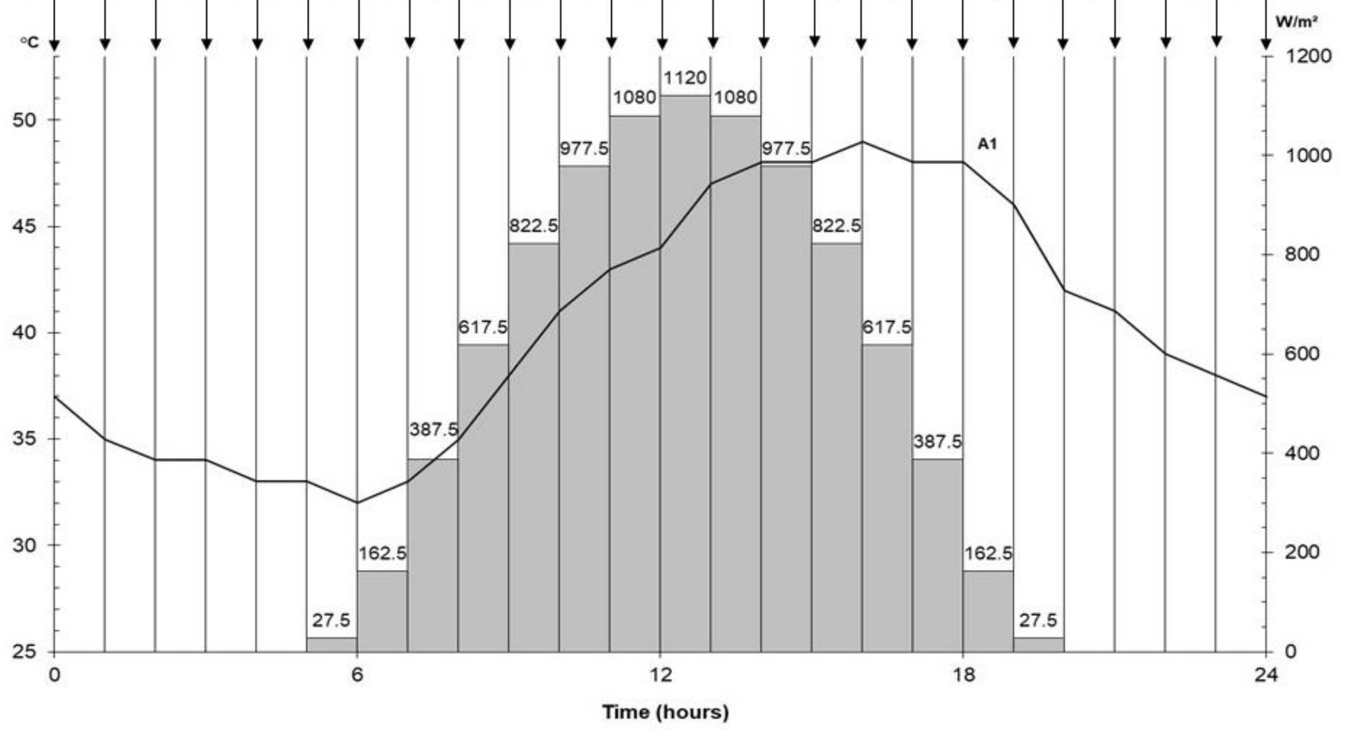

Figure B-2: Procedure I: Heating Effects Test Profile for Conducting Procedure I with Solar Radiation Controlled in One-Hour Steps

B.1.3. Procedure I: Heating Effects Chart (Half-Hour Steps)

Time (h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A1	37	35	34	34	33	33	32	33	35	38	41	43	44	47	48	48	49	48	48	46	42	41	39	38	37

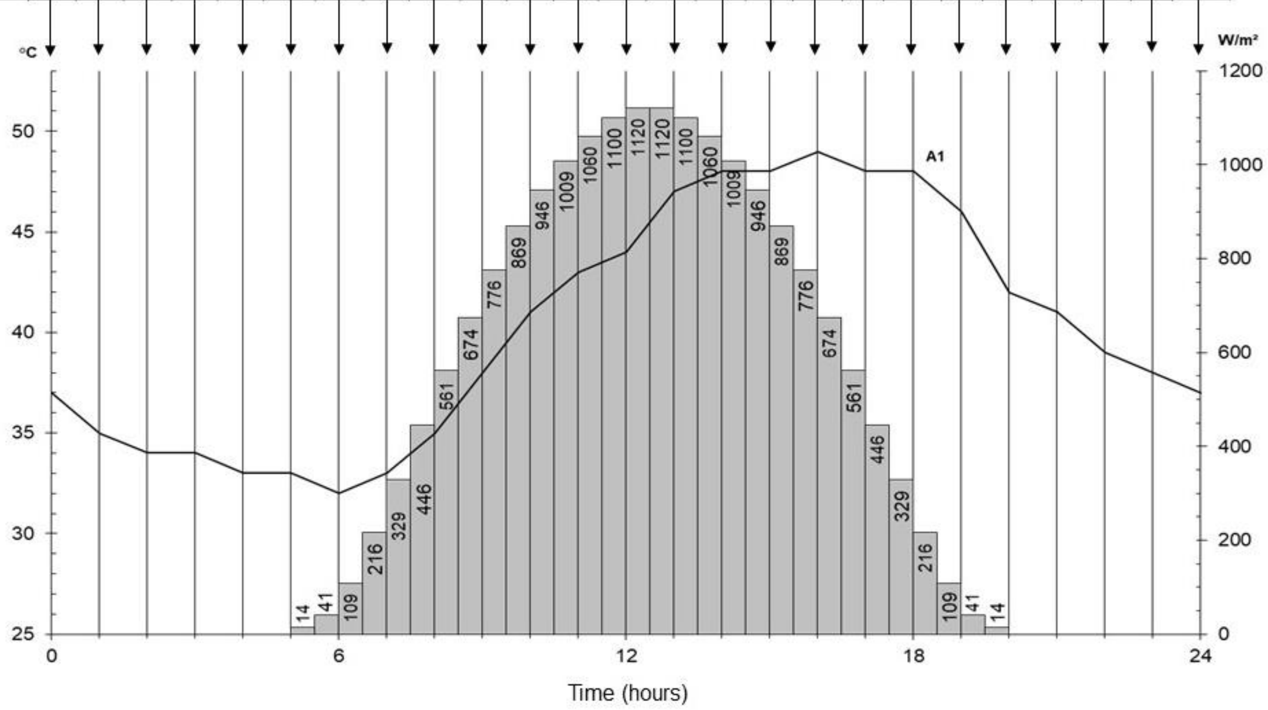

Figure B-3: Procedure I: Heating Effects Test Profile for Conducting Procedure I with Solar Radiation Controlled in Half-Hour Steps

B.2. PROCEDURE II: ACTINIC EFFECTS

Time (h)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A1	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
W	0	0	0	1120																			0	0	0

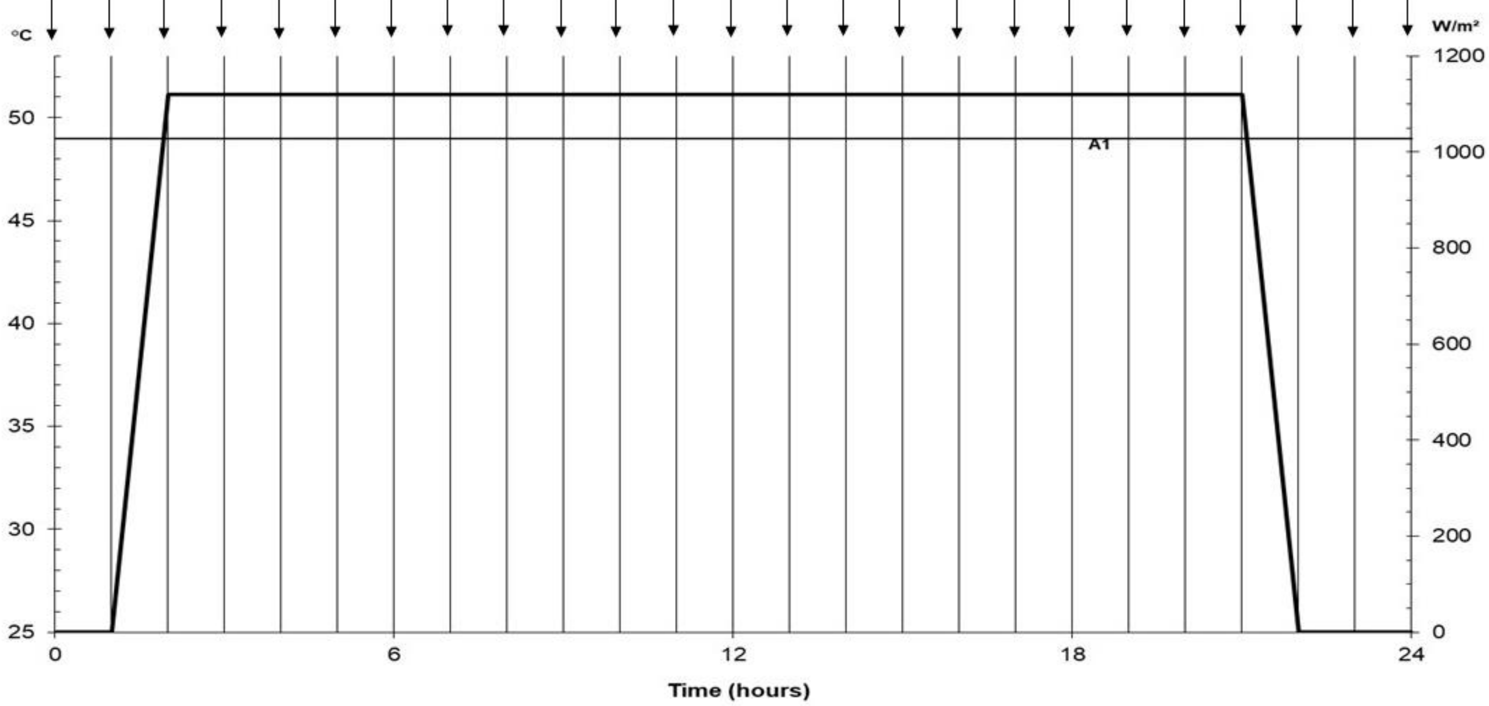

Figure B-4: Procedure II: Actinic Effects Test

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ANNEX C INSTRUMENTATION INSTALLATION, PLACEMENT, AND GUIDANCE INSTRUMENTATION

C.1. MEASUREMENT OF IRRADIANCE

The type of instrument considered most suitable for measuring / monitoring the irradiance during test set up and test operation is the pyranometer. The pyranometer is designed for measuring the irradiance (radiant-flux, W/m^2) on a plane surface that results from direct solar radiation and from the diffuse radiation incident from the hemisphere above. ISO-9060 (paragraph 6.1, reference d) provides additional information regarding definitions, design criteria, and proper use.

C.1.1. Pyranometer Classifications

1. Referring to ISO-9060, the pyranometer used for testing should be critically selected based on the specific internal requirements for internal tractability / calibration certification, and the ability of the selected pyranometer to meet the requirements of the test and test process (see ISO 9060, Table 1 for classification details, paragraph 4.3.2, “Classification Criteria”).

2. In tests where a direct traceability chain is required, it is recommended that a pyranometer meet the classification of secondary standard. For typical test set-up and operation, a classification of First-Class Instrument is generally sufficient. As a minimum, calibrate all instruments on an annual basis.

C.1.2. Pyranometer Use Guidelines

1. Pyranometers are used for validating irradiance values during test set-up, for pre-test, during the test, and post-test to confirm the specified radiant energy values are maintained. It is recommended that the interval used for radiant energy level verification during a test be conducted once per day, or as required based on historical statistical charting showing test compliance for longer periods. For Procedure I, in addition to recording the pre-test calibration, it is recommended to record the intensity level at a sufficient interval to verify that the proper radiative intensity is achieved throughout the cycle. For Procedure II, in addition to recording the pre-test calibration, it is recommended that the radiative intensity is recorded once per-cycle and verify the UVa and UVb portions of the spectrum every seventh cycle.

2. If pyranometers are continuously exposed to the solar radiation source, consider thermal drift of the radiant energy values provided by the pyranometer. Some pyranometers require a thermal offset value based on temperature, while others have internal offset characteristics that minimize thermal drift.

3. Periodic calibration certification of pyranometers is required, typically once per-year or as specified by the pyranometer manufacturer. The pyranometer calibration is to be certified in accordance with ISO-9847, paragraph 6.1, reference e, or ASTM E-824, paragraph 6.1, reference f.

4. Proper mounting, the mounting location, and the horizontal placement of the pyranometer are critical to achieving proper evaluation of the test item. The testing parties must agree to the mounting of the pyranometer for the test, with mounting location and method recorded as part of the permanent test record.

C.2. EVALUATION OF SPECTRAL POWER DISTRIBUTION (SPD)

Measuring and monitoring SPD of the lamp demonstrates compliance with Table 1. Ensure the SPD measurement system is calibrated and operating properly for accuracy, especially in the ultraviolet range. Instrumentation accuracy can be found in Table C-1. Spectral power distribution evaluation guidelines are as follows:

a. Accurate SPD measurements are critical for simulated solar testing. The pre- and post-test results should be documented in the final test report.

b. Often SPD measurement devices are limited to a maximum range of 800 nm to 1100 nm, and the pyranometer reading is used to algebraically calculate the energy in the infrared range (780 nm to 3000 nm).

Table C-1: Instrumentation Accuracy

MEASUREMENT INSTRUMENT	PARAMETER MEASURED	TOLERANCE
Pyranometer / Pyrheliometer	Total irradiation (direct and scattered)	Secondary Standard in accordance with ISO 9060
Spectroradiometer or Filtered Pyranometer	Spectral distribution	+4 percent over the specified radiometric band

ANNEX D GUIDANCE ON TABLES AND FIGURES

D.1. GENERAL

1. The following (Table D-1) is a copy of Table 1 in the main body of this Method. Inserting it here facilitates discussion on its use in calculating points on the curve in Annex B Figure B-1.

Table D-1 (Table 1): Spectral Power Distribution

SPECTRAL REGION	BANDWIDTH (NM)	IRRADIANCE (W/M^2)	SPECTRAL REGION IRRADIANCE (W/M^2)	SPECTRAL REGION TOLERANCE (%)
Ultraviolet – B	280 – 320	5.6	5.6	±35
Ultraviolet – A	320 – 360	26.9	62.7	±25
	360 – 400	35.8		
Visible	400 – 520	200.5	580.2	±10
	520 – 640	185.9		
	640 – 800	193.8		
Infrared	800 – 3000	471.5	471.5	±20
	Totals	1120	1120	±4

NOTE:
i) Total Irradiance: sum of energy for all spectral bandwidths at a single measurement point on the diurnal curve (±4 percent or ±15 W/m2 (whichever is greater) of the target irradiance.
ii) The required tolerance is ±4 percent unless otherwise defined by the environmental test specification, but should not exceed 10 percent.

2. The current spectrum has an increased UV proportion than is given in more recent CIE and ASTM standards. This increased UV content may have been the reason that in some standards this spectrum is stated as being representative of higher elevations and in others as representative of sea level which is what was originally intended in CIE No. 20. The spectrum in Table 1 may be used as a general spectrum for both sea level and high ground elevations. In some applications, such as an item with specialized coatings or specific geographic installation locations, selecting a spectrum and corresponding irradiances level that is representative of the installed location should be considered. The Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) program, version 2.9.5, is recommended for use in generating a tailored spectrum.

D.2. COMPLIANCE

1. Compliance to solar radiation requirements covers two main elements, providing the recommended spectral power distribution of the light source, and providing the correct irradiance levels over the specified surface of the test item. The information in Table 1 is used to determine the capability of the artificial light source to produce a satisfactory spectrum for use in solar simulation testing. Table 1 provides guidance for on-sample test level simulated solar radiation intensity and uniformity target values.

2. Definition: Spectral Power Distribution is the relative power emitted by a source as a function of wavelength.

D.3. EXAMPLES

1. The following examples are to illustrate possible test configurations and instrument placement (Figure D-1). As each test is performed to accomplish specific evaluations and address specific system performance criteria, actual test configuration should be performed according to the test plan and as agreed upon between the contractual parties.

2. When setting up a solar radiation test the following steps can be employed:

   a. Establish a ±10 percent uniformity value over an established test plane appropriate for the test item. A grid pattern appropriate for the size of the test item is established, and the solar radiation system is adjusted to provide a uniform exposure over the test plane. During this process, either multiple radiometers or a single radiometer is used and moved to positions required for solar radiation uniformity verification.

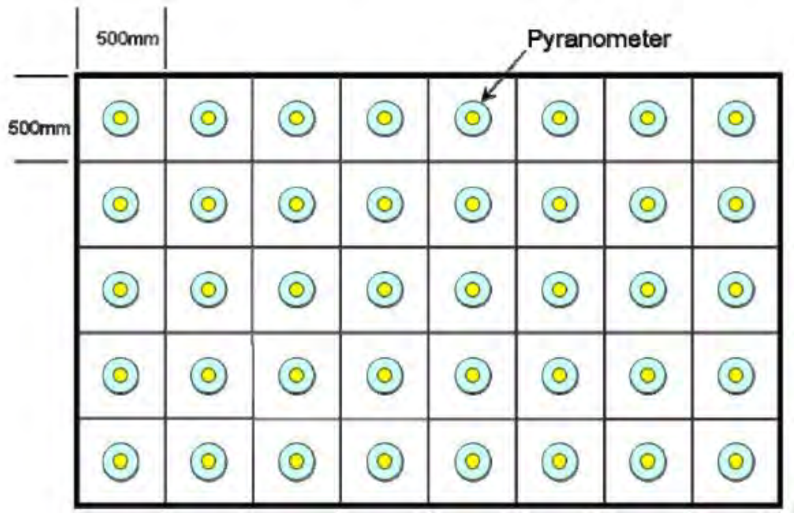

Figure D-1: Example Of Establishing Target and Uniformity Levels Over Surface Target Plane

NOTE: iii) Grid size is typically unique to the chamber dimensions and solar simulator design.
iv) Irradiance Uniformity: deviation between the measured and target irradiance at all measurement points on the target plane. The number of points shall be adequate to define irradiance variation across the target plane(s) to meet the specific test requirement (±10 percent deviation from the target irradiance).

b. If the test item is available, the test can be run using an established test plane or the actual surface of the test item. The test plane approach is best if the test item surfaces are in a reasonably horizontal plane with minimal height differences. When the actual test surface is used for test set-up, a grid pattern is applied to the primary surfaces to establish solar radiation uniformity and, if desired, radiometers are placed at reference locations during the test to record and monitor radiation levels during the test. See figures D-2–D-4 for examples.

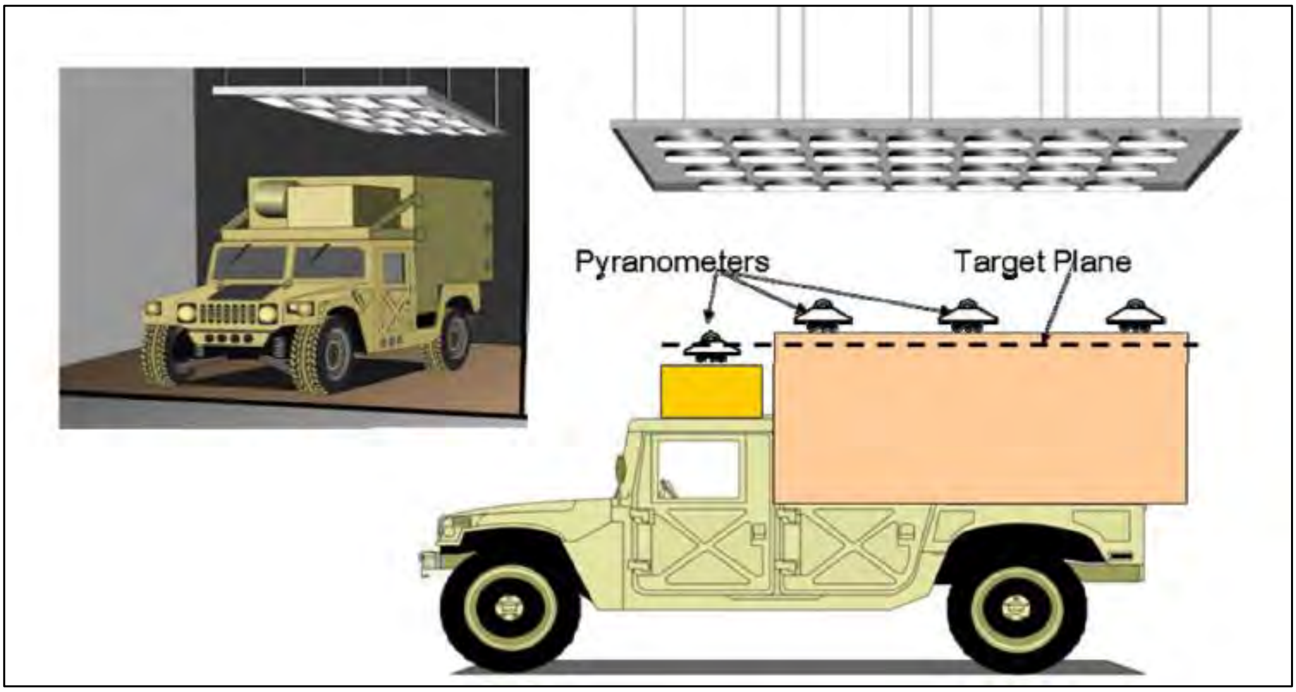

Figure D-2: Example 1: Flat-Surface Exposure

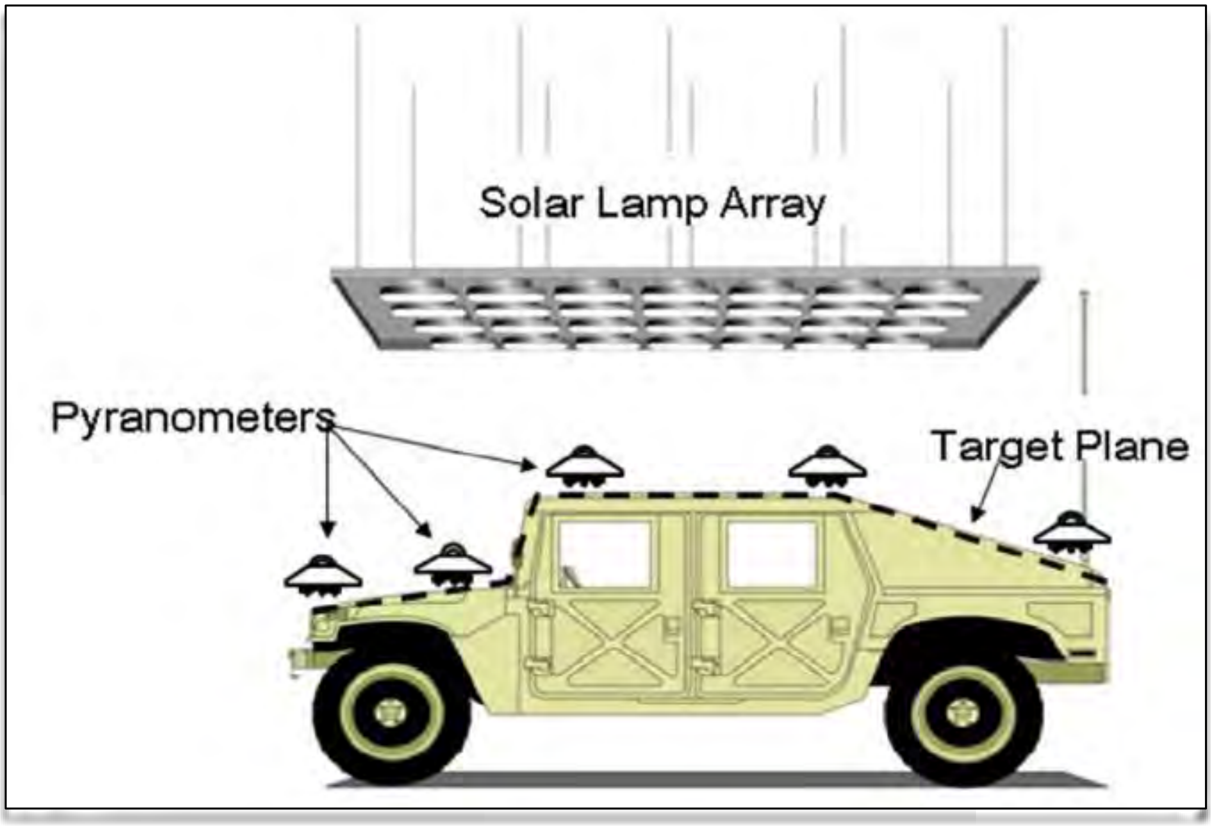

Figure D-3: Example 2: Test Item Surface Shape Exposure

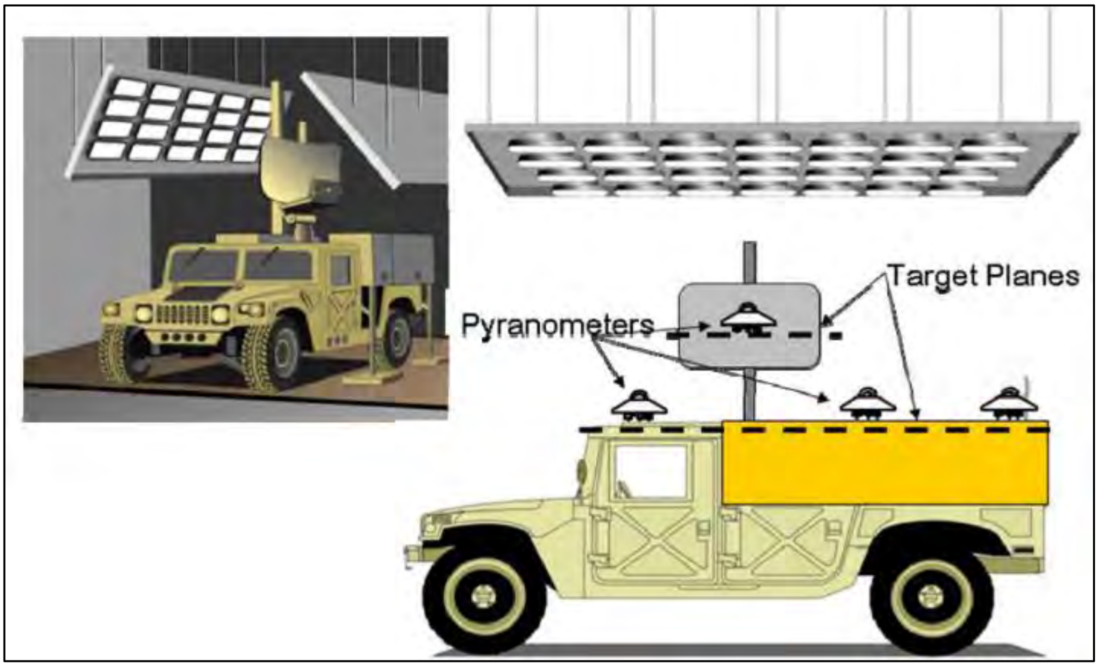

Figure D-4: Example 3: Multiple Solar Surface Target Planes

c. Test items with extreme height differences may require multiple test planes. For example, if a system has a raised antenna and an electronics enclosure at a lower height, a multiple test plane configuration would allow the best test results. In this case the upper test plane will receive the proper radiation by the main overhead simulated solar source, and an auxiliary simulated solar source is needed to provide the correct radiation level to the secondary test plane. Other possibilities could include adjustments to lamp intensity, mechanical filtration, or other engineering solutions.

d. Table D-2 is an example of how to calculate the Spectral Power Distribution at a given total irradiance level with reference to Table 1.

Table D-2: Example Calculation of Spectral Energy Distribution and Permitted Tolerance

SPECTRAL REGION	BANDWIDTH (NM)	NATURAL RADIATION (% of total)	TOLERANCE (% of Total)		IRRADIANCE (W/M^2)	SPECTRAL REGION IRRADIANCE (W/M^2)
			MIN	MAX		
Ultraviolet – B	280 – 320	0.5	0.3	0.7	5.6	5.6
Ultraviolet – A	320 – 360	2.4	1.8	3	26.9	62.7
	360 – 400	3.2	2.4	4.4	35.8	
Visible	400 – 520	17.9	16.1	19.7	200.5	580.2
	520 – 640	16.6	14.9	18.3	185.9	
	640 – 800	17.3	12.8	19	193.8	
Infrared	800 – 3000	42.1	33.7	50.5	471.5	471.5
Totals					1120	1120

NOTE: v) The sum of energy in all spectral bands shall not exceed ±4 percent of total irradiance or ±15 W/m2 (whichever is greater).
vi) The values in columns 2 through 5 were obtained from CIE-85 and DIN 75220, Table 1.

3. Spectral compliance is determined by measurement of individual bandwidth energy. The right-hand side of Table D-2 provides calculated maximum and minimum bandwidth energy for the fifth step of Figure B-2 Procedure 1 cycle test with a total energy of 822.5 W/m2. Individual bandwidth energy may be greater or less than the nominal value, however the irradiance sum must also be within ±4 percent of the total nominal irradiance. Application of the ±4 percent tolerance to the target irradiance of 822.5 W/m2 results in the required product between 789.6 to 855.4 W/m2. Spectral compliance must be evaluated based on a single measurement point, not an average or composite of multiple points. The natural radiation energy / bandwidth percentage is the same for each diurnal cycle step as shown by comparison with Table 1.

4. The equations below in Figure D-5 are applicable to calculate energy in a partial bandwidth region for any total irradiance. The individual bandwidth energy minimum and maximum can be used to evaluate lamp degradation or the influence of multiple lamp types on spectral compliance.

For each bandwidth:

$$\text{Nominal Irradiance} = Total\_Irradiance \times \frac{Natural\_Radiation\_(\%\_of\_total)}{100\%}$$

$$\text{Min Irradiance} = Total\_Irradiance \times \frac{Tolerance\_(\%\_of\_total)\_Min}{100\%}$$

$$\text{Max Irradiance} = Total\_Irradiance \times \frac{Tolerance\_(\%\_of\_total)\_Max}{100\%}$$

Therefore, for a total irradiance of 822.5 W/m² the tolerances for the Ultraviolet-B (UVB) band would be:

$$\text{Nominal Irradiance} = 822.5\,{}^{W}\!/\!{}_{m^2} \times \frac{0.5\%}{100\%} = 4.1125\,{}^{W}\!/\!{}_{m^2} \cong 4.1\,{}^{W}\!/\!{}_{m^2}$$

$$\text{Min Irradiance} = 822.5\,{}^{W}\!/\!{}_{m^2} \times \frac{0.3\%}{100\%} = 2.4675\,{}^{W}\!/\!{}_{m^2} \cong 2.5\,{}^{W}\!/\!{}_{m^2}$$

$$\text{Max Irradiance} = 822.5\,{}^{W}\!/\!{}_{m^2} \times \frac{0.7\%}{100\%} = 5.7575\,{}^{W}\!/\!{}_{m^2} \cong 5.8\,{}^{W}\!/\!{}_{m^2}$$

Figure D-5: Irradiance Calculation Example

5. The second criterion is a uniform irradiance across a test item surface area (target plane). Method 305 uses the term “uniformity”, other documents may reference “non-uniformity”. Both terms define a deviation between measured and desired irradiance across positions on a measurement grid. A test item may have multiple grids or intensity requirements, but the basic evaluation is the same. The uniformity evaluation can be performed without the test item if distance from light source to target plane(s) is known or with the test item in place if pre-test irradiance exposure is acceptable. In either case, documentation of measurement grid points and irradiance is required to validate the test setup uniformity. The indicated grid configuration is for illustration only, actual testing must be performed according to the test plan and as agreed between the contractual parties.

6. The central 3 x 4 target plane in Figure D-6 represents a measurement surface. Each pyranometer represents one portion of the target plane area. One or more pyranometer is moved between grid locations or a simultaneous multi-point irradiance measurement performed. The test plane is a larger area around the target plane with solar exposure, but generally without an irradiance requirement. Higher uniformity accuracy may be possible for a small component versus a complete vehicle test. A flat target plane is preferable because the irradiance is proportional to the distance from

the lamp, but variable heights or non-rectangular grid orientation can be used if required. Modification of the lamp or test item vertical height may be desirable for irradiance adjustment rather than lamp power.

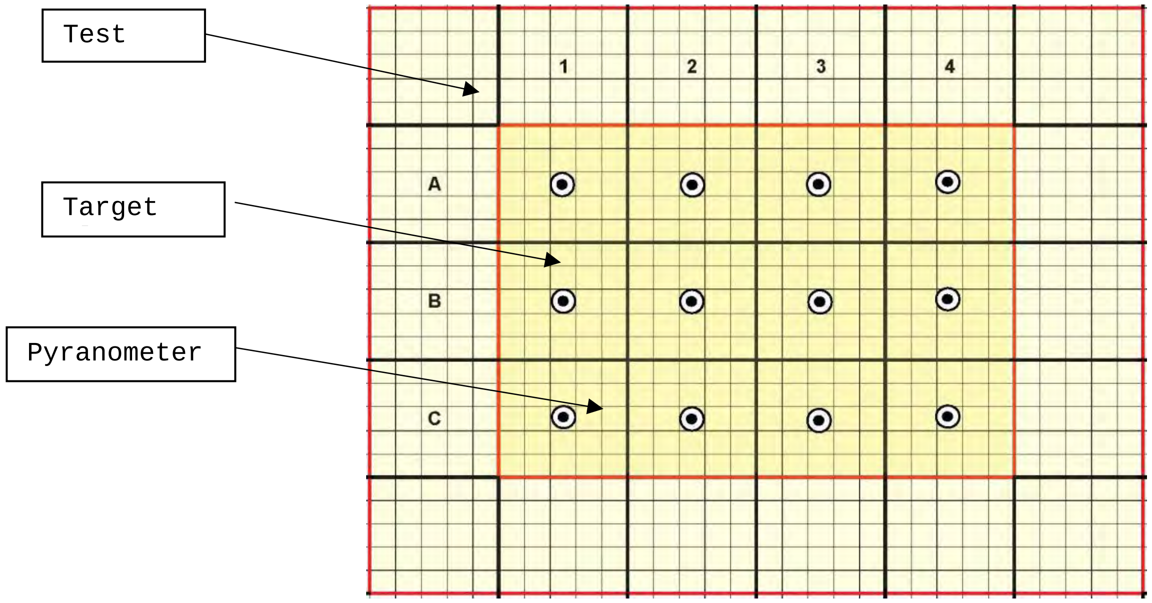

Figure D-6: Establishing Uniformity Levels in Target Plane

7. Table D-3 summarizes an example of target plane irradiance measurements following final lamp position and power adjustment to achieve an 1120 W/m^2 on the 3 x 4 target plane. The table right side of the table indicates linear percentage deviation at each measurement point. The Method 305 uniformity requirement is a maximum of ±10 percent deviation between the measured and desired irradiance at all measurement points, as indicated in the following equation:

Uniformity calculation at each measurement grid point:

$$\text{Measured irradiance} = ((I_{\text{MEASURED}} - I_{\text{TARGET}}) / I_{\text{TARGET}}) * 100 \leq 10 \text{ percent}$$

Table D-3: Uniformity Calculation

Measured Irradiance, W/M^2						Point Error, % ($I_{MEASURED} - I_{TARGET}$)				
Row/ Column	1	2	3	4		Row/ Column	1	2	3	4
A	1068	1123	1110	1096		A	- 4.6	0.3	- 0.9	- 2.1
B	1061	1125	1105	1085		B	- 5.3	0.4	-1.3	-3.1
C	1064	1115	1101	1093		C	- 5.0	- 0.4	-1.7	- 2.4
Irradiance Minimum (B1), W/m^2				1061		Minimum Error (B2), %				0.4
Irradiance Maximum (B2), W/m^2				1125		Maximum Error (B1), %				-5.3
Irradiance Average, W/m^2				1095.5		Irradiance Uniformity, %				5.3

8. Alternatively, for an 1120 W/m^2 target irradiance, the allowable measurement range is 1008 to 1232 W/m^2. Position B1 has the largest deviation; the overall measurement uniformity is 5.3 percent. The maximum point to point deviation is location B1 to B2, 5.7 percent; however, the uniformity is still 5.3 percent.

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METHOD 306
HUMID HEAT

TABLE OF CONTENTS

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The high humidity tests are used to determine the effects of high humidity and temperature on materiel in storage or use.

1.2. APPLICATION

This Method is applicable to materiel likely to be stored or used wherever high levels of relative humidity can exist, or to provide an indication of potential problems associated with humidity. Further information on high temperatures and humidity is provided in AECTP-200, Category 230.

1.3. LIMITATIONS

This Method does not consider all of the effects related to the natural environment and, therefore, it is preferable to test materiel at appropriate natural sites. Not all of the "aggravated" test procedures necessarily simulate any naturally-occurring climatic condition, but may have a relationship to high temperature and humidity conditions anticipated in enclosed areas. The relationship of the procedures in this Method to the effects on non-metallic materials has not been evaluated. This document does not address condensation resulting from changes of altitude for airborne equipment. Additionally, it does not include the synergistic effects of high humidity combined with biological and chemical contaminants, nor does it consider situations in which liquid water may be trapped within packages and retained for substantial periods.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

1. Humidity has physical and chemical effects on materiel; the temperature and humidity variations can also trigger condensation inside the materiel. Typical effects of humid heat include the following:

a. Swelling or deterioration of materials due to water absorption.

b. Drop in mechanical strength.

c. Change in thermal and electrical characteristics of insulating materials.

d. Electrical short circuits due to condensation.

e. Seizing of moving parts due to corrosion and contamination of lubricants.

f. Galvanic corrosion of metals.

g. Micro-environments caused by trapped moisture.

h. Loss of elasticity.

i. Acceleration of chemical reactions.

j. Acceleration of biological actions.

k. Deterioration of electrical and electronic components.

2. Some of these effects can only be observed after a sufficient lapse of time or are simply initiated by humid heat.

2.2. DISCUSSION

All of the procedures in this Method include a degree of compromise as explained below. It may be that a complete understanding of the test item in the service environment may only be possible by exposure to the actual service environment.

2.2.1. Synergism

The naturally-occurring, highly complex environment associated with the tropic and sub-tropic areas of the world and other areas in which combinations of high temperature and relative humidity are found, cannot be duplicated in a laboratory chamber. Bacteria, fungus, chemical contaminants, etc. combine to form an environment that is unique to warm, humid climates. Exaggerated synergistic effects can also exist within closed containers / spaces and may include contamination from various sources.

2.2.2. Exposure Duration

Two test duration approaches are included. The first is to expose the test item to realistic combinations of temperature and humidity for periods of time directly corresponding to the service exposure. While this has the advantage giving some correlation between laboratory and service results, test durations may become prohibitively long. The next alternative is to expose the test item to exaggerated temperature and humidity conditions for a relatively short test duration. This approach using test time compression has the disadvantage of not being able to determine if laboratory test results correspond to actual service exposure.

2.2.3. Test Time Compression

In some situations, equipment will be exposed to highly humid environments, occasionally or periodically rather than constantly. In these situations, a period of laboratory exposure may be equivalent to a greater period of service. Based on the life cycle environmental profile, the degree of time compression should be estimated in order to establish a realistic perspective for the laboratory's test results.

2.3. TEST TYPES

See Method 300 Chapter 1.

The following two types of testing are available for this Method:

2.3.1. Test Type I: Cyclic

This test simulates the temperature and humidity variations for the number of 24-hour cycles specified in the test program. It represents the storage and transit cycles of the B2 (wet-hot) and B3 (humid-hot coastal desert) climatic areas detailed in AECTP-200, Leaflet 2311. The cycles proposed for conducting this test are the so-called "induced" conditions when the materiel is used or stored in these regions in places having little or no ventilation (closed light-duty shelter, for example), but are influenced by diurnal variations. Another cycle that is more severe than the induced cycles is also proposed. It is used when it is necessary to detect quickly the potential weak points in the materiel. The cyclic test is more suitable for revealing the effects of condensation and breathing (see Annex A).

2.3.2. Test Type II: Steady State

This test simulates the relatively stable temperature and humidity conditions of the natural environment observed in some warm tropical, wooded, and very rainy areas characteristic of the B1 (wet-warm) climatic area detailed in AECTP-200, Category 230. It is also used to simulate the conditions encountered inside certain poorly ventilated enclosed spaces. Steady state testing is more suitable for revealing the effects of absorption and adsorption phenomena (see Annex A).

2.3.3. Choice of Test Type

The choice of the test type and its associated parameters can be made based on the environmental requirements for the materiel, the zone and the expected use circumstances, the safety and criteria for acceptability of the materiel to be tested, and the expected duration of the exposure to humid heat. Test type 1 should be selected if the materiel is exposed to a cyclic thermal environment, and test type 2 when the thermal environment is essentially unchanging.

> **NOTE:** When making this choice it is important to review all the foreseeable cases of use of the materiel in order to select only the most severe environments / tests.

2.4. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8.

2.4.1. Temperature-Humidity

2.4.1.1. Cycling Test

a. For the hot, humid climatic regions of the world, the cycle should be chosen from Table 1 for category B2 (cycle 1) and B3 (cycle 2), that represent diurnal temperature and humidity conditions encountered when the thermal effects of the sun must be considered, when humidity is high, and when ventilation is inadequate.

b. The aggravated cycle (cycle 3) is shown in Figure 1. This cycle does not attempt to simulate the meteorological cycle. It yields information more quickly on the effects of humid heat on materiel. The temperature and associated humidity levels are generally higher than those encountered in nature, and the duration of exposure to high humidity is longer in each cycle. This cycle helps to identify the parts of the materiel having potential weaknesses.

Table 1: Diurnal Cycles for Category "B" Environmental Conditions

Transit and Storage Conditions			
B2 (Cycle 1)		B3 (Cycle 2)	
Induced Air Temperature (°C)	RH (%)	Induced Air Temperature (°C)	RH (%)
33	69	35	67
32	70	34	72
32	71	34	75
31	72	34	77
30	74	33	79
31	75	33	80
34	64	36	70
38	54	40	54
42	43	44	42
45	36	51	31
51	29	57	24
57	22	62	17
61	21	66	16
63	20	69	15
63	19	71	14
62	20	69	16
60	21	66	18
57	22	63	21
50	32	58	29
44	43	50	41
38	54	41	53
35	59	39	58
34	63	37	62
33	58	35	63

2.4.1.2. Constant Temperature and Humidity Test

Relatively constant warm or hot highly humid conditions occur both naturally and as a result of inadequate ventilation in enclosed areas where cyclic solar loading is not a factor. For enclosed spaces, measured parameters should be used. For tests when measured data may not be available, the following parameters (from IEC Publication 68, Part 2.1, Test Ca) are recommended: Temperature: 55 °C, Relative humidity: 95 percent. These parameters do not necessarily simulate any real environment, but will create a relatively severe environment that may be used to reveal potential problem areas.

2.4.2. Test Duration

1. Two methods for the determination of test duration are given. The first (preferred) method (paragraphs 2.4.2.a & b) requires knowledge of chemistry together with some expertise in the type of materiel under consideration. The second method (paragraph 2.4.2.c) involves an arbitrary choice of test duration from a table for which

some guidance is given. It is recommended that the second method be used only if the relevant knowledge and / or expertise are not available, or it is not necessary to assess the life of the materiel.

> **NOTE:** For materiel that is expected to be used often, frequent test item checks are recommended (especially during long-duration tests) for the early identification of problems, so that testing may be stopped without wasted test time. This approach is not recommended for materiel likely to be subjected to long, dormant periods.

a. Materiel failures normally arise as a result of a chemical reaction or sequence of reactions sometimes associated with mechanical stress. In such a sequence, one chemical step is likely to determine the rate of the overall sequence. Where these criteria apply, the test duration should be derived as follows:

(1) Establish the likely failure modes.

(2) Determine the activation energies for the rate-determining chemical steps in these failure modes. (The activation energy controls the way in which a reaction rate varies with temperature.)

(3) Apply the lowest of these activation energies in the Arrhenius equation below:

$$Acceleration\ factor = \frac{k_1}{k_2} = e^{-\frac{E}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]}$$

Where:

E = activation energy (J mol^{-1})
R = universal gas constant (8.314 J mol^{-1} K^{-1})
T_1 = test temperature (K)
T_2 = average storage temperature (K)
k_1 = rate of reaction at temperature T_1
k_2 = rate of reaction at temperature T_2

Acceleration factor = ratio of required storage life to test duration

2. If moisture penetration is assessed as being the rate-determining step and no measured activation energy is available for that particular system, a value for E of 70,000 J mol^{-1} is recommended. As written, this equation requires constant test and storage temperatures. Storage temperatures, however, may be averaged with little loss of accuracy, and a short computer program may be used to solve the Arrhenius equation where T varies cyclically.

b. In most cases, the test cycle conditions compare with the worst natural conditions. They can, therefore, only be considered an accelerated test when compared with average year-round conditions for the same climatic area. In such cases, acceleration factors of 2 to 5 are appropriate, the actual factor depending on the likely failure mode(s) (see above together with probability data given in AECTP-200, Category 230). Where all or most of the storage is to be in significantly less severe conditions than those of the test, higher acceleration factors are appropriate.

c. For cycle 3 (Figure 1: aggravated) - used primarily where insufficient information is available to carry out the analysis in paragraph 2.4.2a above, or where it is not necessary to assess the life of the materiel, arbitrary numbers of cycles are given in Table 2. Selection from these should consider the consequences of failure and the anticipated duration of exposure.

Table 2: Durations

Severity	No. of Cycles
A	6
B	12
C	21
D	56

(1) Time severity "A" is intended to demonstrate the short-term effects of a humid environment, including those arising from condensed surface moisture. It is, therefore, applicable to materiel that is normally protected, whether in a fully conditioned building or by a fully desiccated container, but that may be subjected to occasional exposure to high humidities outside their normal protected environment.

(2) Test severity "B" should be applied to equipment that is used in semi-protected conditions but that may occasionally be exposed to a humid atmosphere for longer periods of time. Severity "C" should be applied to materiel that is in exposed locations or subject to a humid atmosphere in its normal use location (e.g., field equipment), equipment mounted in unconditioned cabins, armoured vehicle equipment, etc.

(3) Severity "D" is applicable mainly to package testing or materiel prepared for long-term storage, but the test duration may be extended to a period approaching real (life) time requirements derived as in paragraph 2.4.2.a above.

d If it is determined that the test item may become unsafe on exposure to high temperature and relative humidity conditions, consideration should be given to extending the length of the test and / or increasing the number of items to be tested.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

See Method 300 Chapters 4 and 6.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

4.1. TEST FACILITY

See Method 300 Chapter 5. The inside of the enclosure must be designed in such a way as to prevent condensation from falling on the test item from the ceiling or walls. The enclosure must be vented to the atmosphere to prevent pressure buildup inside the enclosure.

4.2. CONTROLS

See Method 300 Chapters 3 and 4, and:

a. Monitoring and control of the humidity inside the test enclosure must be accomplished by using psychrometric systems or with sensors that are not affected by condensation.

b. The speed of the air across the psychrometric sensors must be at least 4.5 m/s in order to achieve the required evaporation and sensor response. (Diffusers can be used to obtain this speed in the vicinity of the probe.) Deflectors or screens can be installed around the test item if necessary. In order to prevent heating of the psychrometer sensors, the sensors shall be either installed upstream of any fan used to create the air velocity, or far enough downstream to not be affected by fan heat.

c. The humidity and temperature recordings shall be made from sensors separate from hose used to control the chamber environment.

d. Water used for both generating humidity and for wet bulb socks must be essentially free of contaminants. Follow the guidance provided in Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTIONS

See Method 300 Chapter 7.

4.4. TEST PROCEDURE

See Method 300 Chapter 3.

4.4.1. Preparation for Test

Before beginning the test, determine the information specified in Method 300 Chapters 4 and 6, and conduct the test preparation procedure specified in Method 300 Chapter 2.

4.4.2. Procedure I: Cycling

This test consists of a 24-hour conditioning period (to ensure all items at any intended climatic location will start with the same conditions), followed by a repeating 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 percent RH, and maintain for 24 hours.

NOTE: This step may be omitted if the number of cycles to be carried out during the test is sufficient to make the conditioning irrelevant.

Step 2. Adjust the temperature and relative humidity conditions to those specified for the minimum temperature of the appropriate cycle.

Step 3. Perform the required temperature and humidity cycle for the number of cycles specified in the test plan.

Step 4. Conduct test item performance checks as required by the test plan and at the specified temperature-humidity conditions, and record the results.

Step 5. At the end of the required number of cycles, adjust the temperature and humidity conditions to standard ambient conditions.

Step 6. Conduct an operational check and record the results for comparison with pre-test data.

4.4.3. Procedure II: Steady State

This test consists of a 24-hour conditioning period (to ensure all items at any intended climatic location will start with the same conditions), followed by subjecting the test item to stabilised temperature and humidity conditions for a given period of time.

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 percent RH, and maintain for 24 hours.

Step 2. Adjust the temperature and humidity levels to those specified.

Step 3. Maintain the required test conditions for the time specified in the test plan.

Step 4. If required, operate the test item and record the results.

Step 5. Stabilise the temperature and humidity at standard ambient conditions.

Step 6. Conduct an operational check and record the results for comparison with pre-test data.

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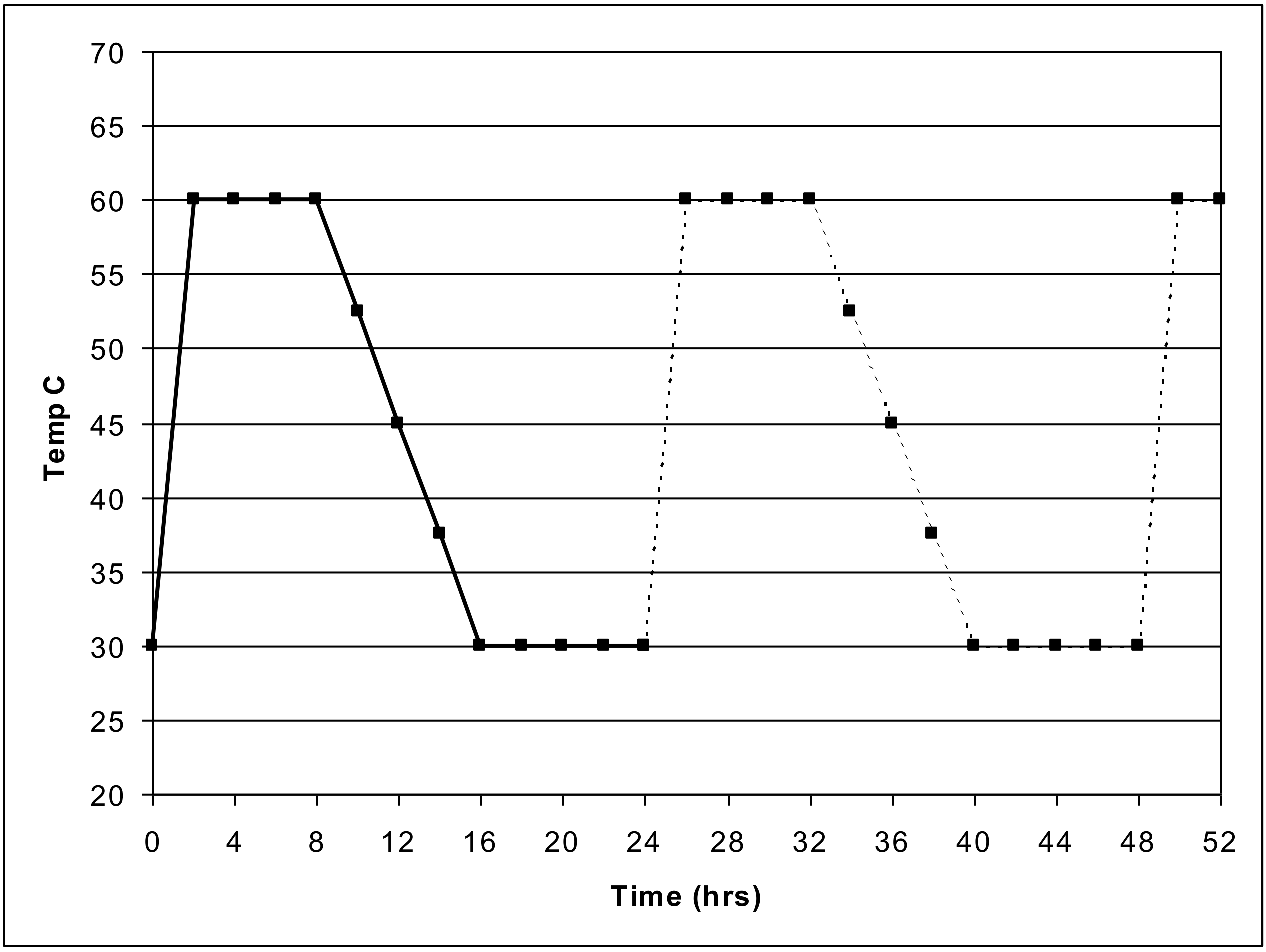
CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9.

CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.



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

Figure 1: Aggravated Cycle (Cycle 3)

ANNEX A PHYSICAL PHENOMENA ASSOCIATED WITH HUMIDITY

A.1. CONDENSATION

Condensation is precipitation of water vapor on a surface whose temperature is lower than the dew point of the ambient air. As a consequence, the water is transformed from the vapor state to the liquid state.

a. The dew point depends on the quantity of water vapor in the air. The dew point, the absolute humidity and the vapor pressure are directly interdependent.

b. Condensation occurs on a test item when the temperature at the surface of the item placed in the test chamber is lower than the dew point of the air in the chamber. As a result, the item may need to be preheated to prevent condensation.

c. If the test item has a low thermal constant, condensation can only occur if the air temperature increases abruptly, or if the relative humidity is close to 100 percent.

d. Slight condensation may be observed on the inside surface of box structures resulting from a decrease in the ambient temperature.

e. Generally speaking, condensation can only be detected with certainty by visual inspection. This, however, is not always possible, particularly with small objects having a rough surface.

A.2. ADSORPTION

Adsorption is adherence of water vapor molecules to a surface whose temperature is higher than the dew point. The quantity of moisture that can adhere to the surface depends on the type of material, its surface condition, and the vapor pressure. An estimation of the effects due solely to adsorption is not an easy matter because the effects of absorption, which occurs at the same time, are generally more pronounced.

A.3. ABSORPTION

Absorption is the accumulation of water molecules within a material. The quantity of water absorbed depends in part on the water content of the ambient air. The process of absorption occurs continuously until equilibrium is reached. The penetration speed of the molecules in the water increases with temperature.

A.4. DIFFUSION

Diffusion is the movement of water molecules through a material caused by a difference in partial pressures. An example of diffusion often encountered in electronics is the penetration of water vapor through organic coatings such as those on capacitors or semiconductors, or through the sealing compound in the box.

A.5. BREATHING

Breathing is air exchange between a hollow space and its surroundings caused by temperature variations. This commonly induces condensation inside the hollow space.

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METHOD 307
IMMERSION

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

Immersion or fording tests are conducted to determine if materiel can withstand immersion or partial immersion in water and operate as required during or following immersion.

1.2. APPLICATION

This method is applicable to materiel that may be exposed to partial or complete immersion, with or without operation. The immersion test has traditionally been considered more severe than the rain test (Method 310) for determining the penetrability of materiel. The immersion test may, in some cases, be used to verify watertightness in lieu of a rain test provided that the materiel configuration would be the same for both situations and the method of water ingress is well understood. However, there are documented situations in which the impact of rain causes pumping of water across seals during the rain test that does not occur during the immersion test, as seals are held tight against the backing plate by static pressure. Therefore, in most cases both tests should be carried out.

1.3. LIMITATIONS

Immersion tests are not intended to be used for buoyant items unless the life cycle profile identifies specific applications where restraints (including stacking) could hold the materiel under water.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

Penetration of water into materiel or packaging enclosures can result in problems such as:

a. Fouling of lubricants between moving parts.

b. Formation of electrically conductive paths that may cause electrical or electronic equipment to malfunction or become unsafe to operate.

c. Corrosion due to direct exposure to the water or to the relatively high humidity levels caused by the water.

d. Impairment of the burning qualities of explosives, propellants, fuels, etc.

e. Failure of vehicle engines to operate.

2.2. GENERAL

See Method 300 Chapters 1 and 8.

2.3. SEQUENCE

See Method 300 Chapter 8. Performing the immersion test before and after structural tests such as shock and vibration will aid in determining the test item's resistance to dynamic tests.

2.4. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8. This method incorporates the following variable parameters to be used as appropriate:

a. Conditioning temperature.

b. Depth of immersion or fording.

c. Duration of immersion.

d. Water temperature with respect to the test item’s temperature.

2.4.1. Conditioning

This test usually includes heating of the test item to establish a pressure differential (on cooling) to determine whether the seals or gaskets leak under relatively low-pressure differential, and to induce expansion / contraction of materials.

a. Three options are provided for the conditioning of the test item:

(1) 27 °C above the water temperature to represent exposure to solar heating immediately prior to immersion.

(2) 10 °C above the water temperature to represent a typical temperature difference between materiel and water.

(3) Equal to the water temperature to represent situations in which little or no temperature differential exists. This may also be used for items for which large enough conditioning facilities are not available provided that the depth of immersion is adjusted to result in the same pressure differential.

b. It is recommended that the duration of conditioning immediately prior to immersion be at least two hours following temperature stabilization of the test item.

2.4.2. Depth of Immersion

2.4.2.1. Complete Immersion

For testing the integrity of a test item, a 1 m representative covering depth should be chosen, or an equivalent pressure be applied. The relevant depth / pressure equation is as follows:

$$P = 9.8d$$

Where: d = depth of the water in metres, and

P = pressure in kPa.

NOTE: The equivalent head of seawater is 0.975 times the head of fresh water for the same pressure difference.

2.4.2.2. Partial Immersion

Where materiel is unlikely to be completely immersed either due to anticipated water depths or to its ability to float, and being unlikely to be restrained, a partial immersion test may be appropriate. In this case, depths should be specified as being measured from the base of the materiel rather than from the top as in paragraph 2.4.2.1.

2.4.3. Depth of Fording

The depth of fording test severities for vehicles should be the more severe of those found in the LCEP and STANAG 2805, "Fording and Flotation Requirements for Combat and Support Ground Vehicles", as applicable.

2.4.4. Materiel Fording

Materiel designed to be transported on open vehicles and trailers (such as equipment trailers) should be capable of withstanding partial immersion as anticipated during fording exercises. Examples of fording depths for this type of materiel are as follows:

a. S-280 shelter: 53 cm

b. S-250 shelter: 76 cm

2.4.5. Duration of Immersion or Exposure

The duration of immersion should typify that anticipated during use. If this duration is unknown, a 30-minute immersion period is considered adequate to develop leakage if it is to occur. Fording durations (other than as specified in the LCEP or STANAG 2805) should be a minimum of one hour, and may be extended if justified by the anticipated lifecycle profile.

2.4.6. Temperature

Experience has shown that a temperature differential between the test item and the water can affect the outcome (leakage) of an immersion test. Increasing the test item temperature above the water temperature may be more realistic and will give a more reliable verification of its watertightness. Establishing a specific temperature differential for fording tests is often impractical due to the size of the materiel.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information specified in Method 300 Chapters 4 and 6, the water and test item temperatures are required, as well as fording / immersion depths and durations.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

In addition to that specified in Method 300 Chapter 5, the following apply:

a. For immersion tests, in addition to a chamber or cabinet capable of conditioning the test item to the required temperature, the required test apparatus should include a water container that can achieve a covering depth of 1 m (or other required depth) of water over the uppermost point of the test item and maintain the test item at that depth. To represent greater depths, it may be necessary to apply air pressure to the surface of the water.

b. For fording tests, the facility should be equipped with a tie-down capability to prevent buoyant test items from floating.

c. A water-soluble dye such as fluorescein may be added to the water to aid in locating water leaks.

4.2. CONTROLS

See Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTION

See Method 306 Chapter 7. Treat an interruption that results in less severe conditions than specified as a "no test." The test item should be dried and the entire test procedure repeated from the beginning. Any failure discovered during an undertest condition should be treated as a failure. If more severe conditions than intended are applied and a failure results, the test shall be repeated, if possible, on a replacement item. If no failure occurs, the test need not be repeated.

4.4. TEST PROCEDURE

See Method 300 Chapter 6.

4.4.1. Preparation for Test

Before starting the test procedure, determine the information specified in Method 300 Chapters 4 and 6, and perform the test preparation procedure specified in Method 300 Chapter 2.

> **NOTE:** No sealing, taping, caulking, etc. shall be used except as required in the design specification for the test item.

a. When testing a shipping / storage container or transit case without the test items enclosed, if possible, remove all dunnage, packing, padding material, etc. that may absorb water, before the test so leakage can be detected. This option may not provide an adequate test of the container if the seals are not representatively stressed because of the absence of the contents.

b. Items that may experience immersion when mounted on or secured to a carrying platform should be secured representatively. If representative of the real-life situation, stacking is an acceptable method of restraining items underwater.

4.4.2. Procedure I: Immersion

Step 1. If weight gain is likely to be an acceptable method of determining leakage, weigh the test item.

Step 2. Three times immediately before the test, open and close (or remove and replace) any doors, covers, etc. that would be opened during normal use to ensure that any seals are functioning properly and are not adhering to the sealing surfaces.

Step 3. Measure and record the immersion water temperature.

Step 4. Condition the test item as in paragraph 2.4.1 and record the conditioning temperature and duration. The test item's sealed areas (where appropriate) shall remain open throughout the conditioning cycle. Also, materiel occasionally incorporates valves or venting devices that may or may not be opened in normal service use. If the test item incorporates such devices, open them throughout the conditioning portion of the test.

Step 5. Close all sealed areas and valves; assemble the test item in its test configuration and, as quickly as possible, immerse the test item in water so that the uppermost point of the test item is 1 ± 0.1 m below the surface of the water, or as otherwise required by the test plan. The orientation of the test item should represent that of its expected in-service orientation. If several orientations are possible, the most vulnerable shall be selected for this test.

Step 6. Following a 30-minute immersion period (or as otherwise specified in the test plan), remove the test item from the water, wipe the exterior surfaces dry (giving special attention to areas around seals and relief valves), and, if applicable, equalize the air pressure inside by activating any manual valves.

Step 7. If appropriate, re-weigh the test item.

Step 8. Open the test item and examine the interior and contents for evidence of and quantity of leakage, and for probable areas where the leakage occurred.

Step 9. If appropriate, conduct an operational check of the test item.

4.4.3. Procedure II: Fording

1. The fording test may be conducted in one of the following two ways: by towing or driving the test item through water at the appropriate depth, or by securing the test item in a tank and flooding the tank to the required depth.

Step 1. If weight gain is likely to be an acceptable method of determining leakage, weigh the test item.

Step 2. With the test item in its fording configuration, ensure that any drain plugs or apparatus are closed, and either:

a. Tow or drive the test item into the water at the required depth.

b. Secure the test item in a watertight tank.

2. In either case, the orientation of the test item should represent that of its expected in-service orientation, including the angle of entry and exit during fording. If several orientations are possible, the worst case shall be selected for this test.

Step 3. If using the tank method, flood the tank to the required height above the bottom of the test item.

Step 4. Maintain the test item in the water for a duration as determined in paragraph 2.4.4.

Step 5. Either remove the test item from the water, or drain the water from the facility and inspect the interior of the test item for evidence of free water.

Step 6. Measure and record the amount of free water, and the probable point(s) of entry. If appropriate, re-weigh the test item.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

In addition to that specified in Method 300 Chapter 9, any evidence of water penetration into the test item following this test must be assessed for its short- and long-term effects. Consideration should be given to the effects of free water as well as to the increase of relative humidity in closed containers following the evaporation of any free water.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. STANAG 2805, Fording and Flotation Requirements for Combat and Support Ground Vehicles.

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METHOD 308
MOULD GROWTH

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CHAPTER 1 SCOPE

> **NOTE:** Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The purpose of this mould growth test is to assess the extent to which the materiel will support mould growth or how the mould growth may affect performance or use of the materiel. The term "mould" as used throughout this document is synonymous with "fungus". The primary objectives of the mould growth test are to determine:

a. If the materials comprising the materiel, or the assembled combination of same, will support mould growth and, if so, what species. (See Table 1 for the types of moulds.)

b. How rapidly moulds will grow on the materiel.

c. How any mould growth affects the materiel, its mission, and its safety for use following the growth of mould 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 mould 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 mid-latitudes, it must be considered in the design of all standard, general-purpose materiel. This method is used to determine if mould growth will occur and, if so, how it may degrade / impact the use of the materiel.

> **NOTE 1:** This test procedure and the accompanying preparation and post-test analysis involve highly specialized techniques and potentially hazardous organisms. Only technically qualified personnel (e.g., microbiologists) should perform the test.

NOTE 2: Although the basic (documented) resistance of materials to mould growth is helpful in the design of new equipment, the combination of materials, the physical structure of combined materials, and the possible contamination of resistant materials can result in the growth of fungus on materiel that would otherwise be considered resistant. Care must therefore be exercised when using documented evidence to justify waiving laboratory or natural environment tests.

1.3. LIMITATIONS

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

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CHAPTER 2 GUIDANCE / REQUIREMENTS

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF MOULD GROWTH

Mould growth impairs the functioning or use of equipment by changing its physical properties.

2.1.1. Detrimental Effects

The detrimental effects of mould growth are summarized as follows:

2.1.1.1. Direct Attack on Materials

Non-resistant materials are susceptible to direct attack as the moulds break the materials down and use them as nutrients. This results in deterioration affecting the physical properties of the material. Examples of non-resistant materials are:

a. Natural material. Products of natural origin are most susceptible to this attack.

   (1) Cellulosic materials (e.g., wood, paper, natural fibre textiles, and cordage).

   (2) Animal-based and vegetable-based adhesives.

   (3) Grease, oils, and many hydrocarbons.

   (4) Leather.

b. Synthetic materials:

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

   (2) Certain polymers (e.g., polyesters, polyurethane, and some polyethers).

   (3) Plastics that contain organic laminating materials or fillers.

   (4) Paints and varnishes that contain susceptible constituents.

2.1.1.2. Indirect Attack on Materials

Damage to mould-resistant materials results from indirect attack when:

a. Mould 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.

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

c. The products of mould growth on adjacent materials that are susceptible to direct attack come in contact with the resistant materials.

2.1.2. 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. Mould growth 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 mould growth can adversely affect light transmission through the optical system, block delicate moving parts, and change non-wetting surfaces to wetting surfaces with resulting loss in performance.

2.1.3. Health and Aesthetic Factors

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

2.2. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8.

The essential parameters for defining the test include temperature and humidity, test duration, and test item configuration.

2.2.1. Temperature and Humidity

Since the combination of temperature and humidity is critical to microbial growth, it is essential that these be maintained as specified in the procedure.

2.2.2. Test Duration

Twenty-eight days is the minimum test period to allow for mould 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 mould test, extension of the exposure period to 84 days should be considered if a greater degree of certainty (less risk) is required in determining the existence or effect of mould growth.

2.3. CHOICE OF TEST MOULD

1. Two groups of moulds (U.S. and European) are commonly used and are listed in Table 1. One group or the other should be used *in toto*, and adjusted, if necessary, as in paragraph 2.3.b. The U.S.' five species of test moulds are included in the U.S. National standard on environmental testing, MIL-STD-810, and seven in the European standards. 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 must 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 moulds, both these and the other organisms will compete for available nutrients. It is not surprising to see organisms other than the test moulds growing on the test item at the end of the test.

   b. Additional species of moulds may be added to those required in this test method. However, if additional moulds are used, their selection shall be based on prior knowledge of specific material deterioration. For example, <u>penicillium funiculosum</u> can be employed because of its known specificity for degrading textiles.

2. In addition to the sequence guidance provided in Method 300 Chapter 8, the following is applicable: This method should not be conducted after a salt fog (Method 309) test or a sand and dust test (Method 313). A heavy concentration of salt may affect the germinating mould growth, and sand and dust can provide nutrients, thus leading to a false indication of the biosusceptibility of the test item.

Table 1: Test Moulds

Mould	Mould Sources Identification n°.		Standard	Materials Affected
	USDA(1)	ATCC(2)		
Aspergillus niger	QM 458	ATCC 6275	Eur.	textiles, vinyl, etc.; resistant to tanning salts
Aspergillus terreus	QM 82j	ATCC 10690	Eur.	haversack, paperboard, paper
Paecilomyces varioti		IAM 5001	Eur.	plastics, leather
Penicillium funiculosum		IAM 7013(3)	Eur.	textiles
Penicillium ochro-chloron	QM 477	ATCC 9112	Eur.	plastics, textiles
Scopulariopsis brevicaulis		IAM 5146	Eur.	rubber
Trichoderme viride		IAM 5061	Eur.	plastics, textiles
Aspergillus flavus	QM 380	ATCC 9643	U.S.	leathers, textiles
Aspergillus versicolor	QM 432	ATCC 11730	U.S.	leather
Penicillium funiculosum	QM 474	ATCC 11797	U.S.	plastics, cotton fabric.
Chaetomium globosum	QM 459	ATCC 6205	U.S.	cellulose
Aspergillus niger	QM 386	ATCC 9642	U.S.	conformal coatings and insulation

*1/ U.S. Department of Agriculture Collection
Northern Regional Research Center
ARS Culture Collection
1815 North University Street
Peoria, Illinois 61604*

(The mould may be distributed in a lyophilized state or on agar slants.)

*2/ American Type Culture
2301 Parklawn Drive
Rockville, Maryland 20852*

*3/ Institute of Applied Microbiology
University of Tokyo
Tokyo, Japan*

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to that specified in Method 300 Chapters 4 and 6, record the following information:

a. Evidence of mould growth on the control cotton strips at the 7-day check and at the end of the test (see paragraph 4.4.7).

b. Location of mould.

c. Narrative description of growth, including colours, areas covered, growth patterns, and density of growth (and photographs, if necessary). See Table 2.

d. Effect of moulds on performance or use:

(1) As received from chamber.

(2) After removal of mould, if appropriate.

e. Physiological or aesthetic considerations.

f. Types of moulds used.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5.

4.1. TEST FACILITY

See Method 300 Chapter 5. Also see Annex A of this method for pre-test and post-test decontamination guidance. In addition to the standard requirements for test chambers, the following apply to chambers to be used for mould tests:

a. Construct the chamber and accessories in such a manner as to prevent condensation from dripping on the test item.

b. Filter-vent the chamber to the atmosphere to prevent the buildup of pressure and release of spores into the atmosphere.

c. Monitoring and control of the humidity inside the test enclosure must be accomplished with psychrometric systems or with sensors that are not affected by condensation.

d. The speed of the air across the psychrometric sensors must be at least 4.5 m/s in order to achieve the required evaporation and sensor response. (Diffusers may be used to obtain this speed in the vicinity of the probe.) Deflectors or screens can be installed around the test item if necessary. In order to prevent heating of the psychrometer sensors, the sensors shall either be installed upstream of any fan used to create the air velocity or far enough downstream not to be affected by fan motor heat.

e. The humidity and temperature recordings shall be made from sensors separate from those used to control the chamber environment.

4.2. CONTROLS

(See also paragraph 4.4.)

In addition to that provided in Method 300 Chapters 3 and 4, the following controls apply to this test:

4.2.1. Humidity

In addition to the requirements appropriate for Method 506, humid heat, 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. Lithium chloride sensors are not recommended 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.

b. In order to produce the evaporation necessary for sensor measurement of wet bulb temperature, the air velocity across the wet bulb shall not be less than 4.5 m per second.

c. Because heat from fan motors may affect temperature readings, do not install wet- and dry-bulb sensors close to the discharge side of any local fan or blower used to create the requirement of paragraph 4.2.1.b.

4.2.2. Air Circulation

Maintain free circulation of air around the test item and keep the contact area of fixtures supporting the test item to a minimum.

4.2.3. Steam Injection

Do not inject steam directly into the test chamber working space where it may have an adverse effect on the test item and microbial activity.

4.2.4. Chemicals

Unless otherwise specified:

a. All reagents shall conform to the specifications of the committee on analytical reagents of the American Chemical Society, where such specifications are available.

b. References to water shall be understood to mean water essentially free of contaminants. Follow the guidance in Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

1. The mould test, unlike other environmental tests, involves living organisms. If the test is interrupted, the fact that live organisms are involved must be considered.

a. If the interruption occurs during the first ten days of the test, the test should be restarted from the beginning with either a new or cleaned test item.

b. If the interruption occurs late in the test cycle, examine the test item for evidence of mould growth. If the test item is biosusceptible, there is no need for a retest. If the controls exhibit viable growth but there is no evidence of mould growth on the test item, follow the guidance given below.

(1) Lowered temperature. A lowering of the test chamber temperature generally will retard mould growth. If the relative humidity has been maintained, reestablish the test conditions and continue the test from the point where the temperature fell below the prescribed tolerances. If not, see (3) below.

(2) Elevated temperature. Elevated temperatures may have a drastic effect on mould growth. A complete re-initiation of the test is required if one of the following occurs:

(a) The temperature exceeds 40 °C.

(b) The temperature exceeds 31 °C for 4 hours or more.

(c) There is evidence of deterioration of the mould growth on the control strips.

(3) Lowered humidity. A complete retest is required if one of the following occurs:

(a) The relative humidity drops below 50 percent.

(b) The relative humidity drops below 70 percent for 4 hours or more.

(c) There is evidence of deterioration of the mould colonies on the control strips.

2. Otherwise, re-establish test conditions and continue the test from the point of interruption.

4.4. TEST PROCEDURE

4.4.1. Cleaning

Although it is preferable to use a new test item, the same test item as used in other tests may be used. If cleaning is required, conduct the cleaning at least 72 hours before test initiation in order to allow evaporation of any volatile materials. Cleaning should follow typical production cleaning methods. The test item shall be prepared in accordance with paragraph 4.4.6.1. Place new cotton control strips in the test chamber and inoculate both the test item and the controls with the test moulds.

4.4.2. Water Purity

Water used for generating humidity and for wet bulb socks must be essentially free of contaminants. Follow guidance provided in Method 300 Chapters 3 and 4.

4.4.3. Miscellaneous

a. This method is designed to provide optimal climatic conditions and all of the basic inorganic minerals needed for growth of the mould species used in the test. The group of mould species was chosen for its ability to attack a wide variety of materials commonly used in the construction of military materiel. Optional species may be added to the inoculum if required (see paragraph 2.3.b).

b. This test must be performed by trained personnel at laboratories specially equipped for microbiological work.

c. The presence of moisture is essential for spore germination and growth. Generally, germination and growth will start when the relative humidity of the ambient air exceeds 70 percent. Development will become progressively more rapid as the humidity rises above this value, reaching a maximum in the 90 to 100 percent relative humidity range.

d. The specified temperature of 30 ± 1 °C, is most conducive to the growth of the test moulds.

e. Control items specified in paragraph 4.4.5 are designed to:

(1) Verify the viability of the mould spores used in the inoculum.

(2) Establish the suitability of the chamber environment to support mould growth.

f. Although this procedure can provide information on the susceptibility of materials to mould growth, the testing of materials and piece parts will not reveal potential mould growth situations. These can result due to the complexities involved in assemblages. Examples are induced conditions created by coatings and protective wrappings, deterioration of protective coatings due to bimetallic reactions, and other situations that would not be encountered with the testing of components.

4.4.4. Test Preparation

a. Preparation of mineral salts solution.

(1) Using clean apparatus, prepare the mineral salts solution to contain the following:

Potassium dihydrogen orthophosphate (KH_2PO_4)........... 0.7 g

Potassium monohydrogen orthophosphate (K_2HPO_4)..... 0.7 g

Magnesium sulphate heptahydrate ($MgSO_4 \cdot 7H_2O$)......... 0.7 g

Ammonium nitrate (NH_4NO_3).. 1.0 g

Sodium chloride (NaCl)... 0.005 g

Ferrous sulphate heptahydrate ($FeSO_4 \cdot 7H_2O$)............. 0.002 g

Zinc sulphate heptahydrate ($ZnSO_4 \cdot 7H_2O$).................. 0.002 g

Manganous sulphate monohydrate ($MnSO_4 . H_2O$)........ 0.001 g

Distilled water.. 1000 ml

(2) The pH of the mineral salts solution must be between 6.0 and 6.5.

b. Preparation of mixed spore suspension.

NOTE (Precautions): Although the exact strains of moulds specified for this test are not normally considered to present a serious hazard to humans, certain people may develop allergies or other reactions. Therefore, standing operating procedures for safety should be employed. Also, the tests should be conducted by personnel trained in microbiological techniques.

(1) Use aseptic techniques to prepare the spore suspension containing at least the test moulds determined from paragraph 2.3.

(2) Maintain pure cultures of these moulds separately on an appropriate medium such as potato dextrose agar, but culture chaetomium globosum on strips of filter paper overlaid on the surface of mineral salts agar. Prepare the mineral salts agar by dissolving 15.0 g of agar in a litre of the mineral salts solution described in paragraph 4.4.5.2.a.

NOTE: Do not keep the stock cultures for more than 4 months at 6 ± 4 °C after that time, prepare subcultures and use them for the new stocks.

(3) Verify the purity of mould cultures before the test.

(4) Make subcultures from the pure stock cultures and incubate them at 30 ± 1 °C for 10 to 21 days.

Most moulds will develop within 10 to 14 days and may show signs of deterioration after longer incubation. Some moulds such as chaetomium globosum require 21 days or longer to develop.

(5) Prepare a spore suspension of each of the required test moulds by pouring into one subculture of each mould 10 ml of an aqueous solution containing 0.05 g per litre of a nontoxic wetting agent such as sodium dioctyl sulphosuccinate (sulfosuccinate) or sodium lauryl sulphate (sulfate).

(6) Use a rounded glass rod or a sterilized platinum or nickel chrome wire to gently scrape the surface growth from the culture of the test organisms.

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

(8) Shake the flask vigorously to liberate the spores from the fruiting bodies and to break the spore clumps.

(9) Filter the dispersed mould spore suspension into a flask through a 6 mm layer of glass wool contained in a glass funnel.

NOTE: This process should remove large mycelial fragments and clumps of agar.

(10) Centrifuge the filtered spore suspension and discard the supernatant liquid.

(11) Re-suspend the residue in 50 ml of water and centrifuge. Wash the spores obtained from each of the moulds in this manner at least three times (until the supernatant is clear).

(12) Dilute the final washed residue with mineral salts solution in such a manner that the resultant spore suspension shall contain 1,000,000 ± 20 percent spores per millilitre as determined with a counting chamber.

(13) Repeat this operation for each organism used in the test.

(14) Perform a viability check for each organism in accordance with paragraph 4.4.5.1.

(15) Blend equal volumes of the resultant spore suspension to obtain the final mixed spore suspension.

NOTE: The spore suspension should be prepared fresh. If not freshly prepared, it must be held at 6 ± 4 °C for not more than 14 days.

4.4.5. Control Items

Two types of control tests are required. Using the procedure of paragraph 4.4.5.1, verify the viability of the spore suspension and its preparation. Using the procedure of paragraph 4.4.5.2, verify the suitability of the chamber environment.

4.4.5.1. Viability of Spore Suspension

a. Before preparing the composite spore suspension, inoculate sterile potato dextrose or another nutrient agar plates with 0.2 to 0.3 ml of the spore suspension of each of the individual mould species. Use separate agar plates for each species.

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

c. Incubate the inoculated potato dextrose agar plate at 30 ± 1 °C for 7 to 10 days.

d. After the incubation period, check the mould growth.

NOTE: The absence of copious growth of any of the test organisms over the entire surface in each container will invalidate the results of any tests using these spores.

4.4.5.2. Test Chamber Environment

a. Prepare the following solution:

(1) 10.0 g glycerol.

(2) 0.1 g potassium dihydrogen orthophosphate (KH_2PO_4).

(3) 0.1 g ammonium nitrate (NH_4NO_3).

(4) 0.025 g magnesium sulphate (sulfate) heptahydrate ($MgSO_4 \cdot 7H_2O$).

(5) 0.05 g yeast extract.

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

(7) 0.005 g of a nontoxic wetting agent such as sodium dioctyl sulphosuccinate (sulfosuccinate) or sodium lauryl sulphate (sulfate).

(8) HCl and NaOH to adjust the final solution pH to 5.3.

b. Prepare control strips from unbleached, plain weave, 100 percent cotton cloth that has been cut or torn into strips about 3 cm wide. The strips shall be devoid of fungicides, water repellents, and sizing additives. To aid in removing any possible treatment materials, boiling in distilled water is recommended. Dip the strips into the above solution. After dipping, remove the excess liquid from the strips and hang them to dry before placing them in the chamber and inoculating. Ensure that the strips have been thoroughly wetted.

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

d. These strips are installed and inoculated along with the test item to ensure that proper conditions are present in the incubation chamber to promote mould growth.

4.4.6. Test Performance

4.4.6.1. Preparation for Incubation

Step 1. Assure that the condition of the test items is similar to their condition as delivered by the manufacturer or customer for use, or as otherwise specified. Any cleaning of the test item shall be accomplished at least 72 hours before the beginning of the mould 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 percent but less than 100 percent) for at least 4 hours immediately before inoculation.

Step 4. Inoculate the test item and the cotton fabric chamber control items with the mixed mould 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. Personnel with appropriate knowledge of the test item should be available to aid in exposing its interior surfaces for inoculation.

NOTE: In spraying the test and control items with composite spore suspension, take care to 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.

4.4.6.2. Incubation of the Test Item

Step 1. Except as noted in Step 9 below, incubate the test items at constant temperature and humidity conditions of 30 ± 1 °C and a relative humidity above 90 percent but below 100 percent for the test duration (28 days, minimum).

Step 2. After 7 days, inspect the growth on the control cotton strips (paragraph 4.4.5.2.b) 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.

4.4.7. 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.

4.4.8. 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 4.4.7. 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.

4.4.9. Decontamination

Because of the potentially hazardous nature of this test, extreme caution must be taken to ensure that the test item, the PPE and the test facility are properly decontaminated. Annex A provides guidance on a procedure for decontamination.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

In addition to Method 300 Chapter 9 the following information is provided to assist in the evaluation of the test results.

a. Any mould growth on the test item must be analysed to determine if the growth is on the test item material(s) or on contaminants.

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

(1) The extent of growth on susceptible components or materials. Use Table 2 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).

CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

a. MIL-STD-810, Test Method Standard for Environmental Engineering Considerations and Laboratory Tests.

Table 2: Evaluation Scheme for Visible Effects[1]

Amount of Growth	Rating	Comments
None	0	Substrate is devoid of microbial growth.
Trace	1	Scattered, sparse or very restricted microbial growth.
Light	2	Intermittent infestations or loosely spread microbial colonies on substrate surface. Includes continuous filamentous growth extending over the entire surface, but underlying surfaces are still visible.
Medium	3	Substantial amount of microbial growth. Substrate may exhibit visible structural change.
Heavy	4	Massive microbial growth.

[1] Use this scheme as a guide, but exceptions may occur that require a more specific description

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ANNEX A DECONTAMINATION OF TEST EQUIPMENT AND TEST ITEMS AFTER EXPOSURE TO FUNGUS

Decontamination of test equipment, materials, and test items that have been subjected to a fungus test is paramount when the test items are to be sent back to the users, manufacturer, or material management office for further evaluation or reuse. Many test items are too expensive to scrap and must be decontaminated.

a. Decontamination and disinfection of the test chamber.

(1) Initially, good housekeeping procedures should be followed for all testing, especially those tests involving live cultures.

(2) Prior to any testing, the climatic chamber should be thoroughly cleaned inside with a hot, soapy water (or Lysol®-type cleaner) solution.

(3) With no items in chamber, high heat (at least 60 °C / 140 °F) is applied for at least 2 hours (no humidity required). Cool the chamber to ambient prior to placing the test items in the chamber for fungus testing.

(4) After testing is complete and the items have been examined / pictures taken, the items and the chamber can be initially sterilized with high heat as above and at least 90 percent relative humidity for at least 2 hours. The humidity keeps the surfaces wet until the spores are destroyed. (Note: The items must be able to withstand the high temperature chosen for initial sterilization without damage. Check the test item user's manual for the storage temperature before proceeding). After heat sterilization, the chamber can be washed with a sodium or calcium hypochlorite solution at 5000 ppm concentration (wear appropriate personal protective equipment [PPE] when using any chemical solutions). A phenolic disinfectant spray can also be used. Copious flushing with water to rinse the chamber is needed to limit the chlorine contact on the metal's surfaces.

(5) If the test items are washable, follow the instructions for each item and launder in a machine, if possible.

(6) If the items cannot be washed with a solution, wipe with a damp cloth that has been sprayed with a phenolic solution (disinfectant spray) and label the items appropriately with precautions on handling items that have been subjected to fungus testing. Personnel trained in microbiological techniques and who conduct these tests should have general operating procedures in place for handling fungus cultures and test items after exposure.

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METHOD 309
SALT FOG

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

This salt fog test is designed to give a set of repeatable conditions to determine the relative resistance of materiel to the effects of an aqueous salt atmosphere.

1.2. APPLICATION

All military materiel will be exposed to some form of salt during its lifecycle that may affect its performance. The primary value of the proposed test procedure lies in testing coatings and finishes on materiel. Additionally, it can be used to locate potential design problems such as incompatible materials.

1.3. LIMITATIONS

a. It should be noted that the test has limitations regarding the simulation of real-life conditions and successful compliance with the test does not guarantee that particular items of materiel will satisfactorily resist all saline conditions to which they may be subjected in service. In particular, the procedure does not duplicate all the effects of a marine atmosphere and it has not been demonstrated that a direct relationship exists between the salt fog test corrosion and corrosion occurring in the natural environment. There is no quantitative relationship between time spent in the chamber and time in the field, so the test has proven to be generally unreliable for predicting the service life of different materials or coatings.

b. This test is not a substitute for evaluating corrosion caused by humidity and fungus because their effects differ from salt fog effects and this test is not intended for testing piece parts such as bolts, wires, transistors and integrated circuits, and material coupons.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

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. In coastal regions, this exposure is intensified; in a marine environment the exposure reaches a maximum. The procedure can be used in a relatively short period of time to locate potential problem areas, design flaws, incompatibility of materials, etc. that are exacerbated by exposure to a salt atmosphere.

2.1. EFFECTS OF THE ENVIRONMENT

The effects of exposure of materiel to an environment in which salt is present can be divided into the following three broad categories: physical effects, chemical effects, and electrical effects. The following examples of problems that could occur as a result of exposure to such an environment are not intended to be all-inclusive, and some of the examples may overlap the categories. They do indicate the importance of the test item adequately simulating the system (i.e., the materiel in its intended service role) such that the important effects of exposure are tested.

2.1.1. Physical

a. Clogging or binding of moving parts of mechanical components and assemblies.

b. Blistering of paint as a result of electrolysis.

2.1.2. Chemical

a. Corrosion due to electrochemical reaction.

b. Accelerated stress corrosion.

c. Formation of acidic / alkaline solutions following salt ionization in water.

2.1.3. Electrical

a. Impairment of electrical equipment due to salt deposits.

b. Production of conductive coatings.

c. Attack of insulating materials and metals.

2.2. TEST PROCEDURE

See Method 300 Chapters 1 and 8.

2.3. SEQUENCE

See Method 300 Chapter 8. Sand and dust testing should not precede salt fog testing because dust deposits may inhibit salt corrosion. Salt fog testing should not come before mould (fungus) or humidity testing because salt deposits may inhibit mould growth, nor should it precede humidity tests because residual salt deposits could accelerate chemical reactions.

2.4. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1, 4, and 8. Variations for the test procedure are limited to the salt concentration, the test duration, the cycling of exposure and drying periods, and the salt composition. Test item configuration is also an important factor to consider.

2.4.1. Salt Composition

Studies have shown that, for the purpose of evaluating corrosion, a sodium chloride solution provides as realistic effect as any synthetic seawater solution (reference a, paragraph 7). Do not use sodium chloride containing anti-caking agents because such agents may act as corrosion inhibitors.

2.4.2. Salt Concentration

Concentrations exceeding 20 percent are known to occur. However, the testing community have standardised on a 5 ± 1 percent solution because test results have shown this to be an effective test concentration to demonstrate the ability of material to resist corrosion (reference b).

2.4.3. Cycling

Experience has shown that alternating periods of salt fog exposure and drying conditions provides a more realistic exposure and a higher damage potential than does continuous exposure to a salt atmosphere. Because the rate of corrosion is much higher during the transition from the wet to dry, it is critical to closely control the rate of drying if corrosion levels from test to test are to be compared. The test item should be dried for at least 24 hours unless there is clear (and documented) evidence that the materiel is dry in less time. For large or complex items this drying time may need to be longer than 24 hours. The number of cycles may be increased to provide a higher degree of confidence in the ability of the materials involved to withstand a corrosive environment.

2.4.4. Salt Solution pH

Temperature affects the pH of a salt solution that has been made from water saturated with carbon dioxide at room temperature. If the pH of the solution is adjusted at room temperature and then the solution atomised at 35 °C, the pH of the collected solution will be higher due to loss of carbon dioxide. Therefore, pH adjustment should be by one of the following methods:

a. Take a 50 ml sample of the salt solution and boil for 30 seconds. Cool the sample and determine the pH. When the pH of the salt solution is adjusted to 6.6 to 7.2 by this procedure, the pH of the atomised and collected solution at 35 °C will come within this range.

b. Heat the salt solution to boiling and then cool to 35 °C and hold at this temperature for 48 hours. Adjust the pH of the solution and it will not materially change when atomised at 35 °C.

c. Heat the water from which the salt solution will be made to 35 °C or above to expel the carbon dioxide. Adjust the pH of the solution and it will not materially change when atomised at 35 °C.

2.5. 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.

b. Outside of its shipping / storage container but provided with an effective environmental control system that partly excludes the salt fog environment.

c. Outside of its shipping / storage container and set up in its normal operating mode.

d. Modified with kits for special applications or to compensate for mating components that are normally present, but are not used for this specific test.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to that specified in Method 300 Chapters 4 and 6, measure the salt solution fallout rate ($ml/cm^2/h$), pH, and specific gravity.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5.

The apparatus used in performing the salt fog test in this method is described as follows:

a. A test chamber with:

(1) Supporting racks designed and constructed so that they will not affect the characteristics of the salt fog. Construct all parts of the test chamber and the supporting racks that come into contact with the test item with material that will not cause electrolytic corrosion. Do not allow condensation to drip on the test item. No liquid that comes in contact with either the exposure chamber or the test item shall return to the salt solution reservoir. Vent the exposure chamber to prevent pressure buildup.

(2) The capability to maintain temperatures in the exposure zone at 35 °C. This temperature shall be controlled continuously during the test. The use of immersion heaters within the chamber exposure area for the purpose of maintaining the temperature within the exposure zone is prohibited. The temperature of 35 °C has been historically used and was selected as a standard to enable operation of a salt fog test chamber in almost any part of the country with a simple heating setup. It also eliminates the need for cooling (refrigeration) (reference c).

(3) A salt solution reservoir and dispenser made of material that is nonreactive with the salt solution (e.g., glass, hard rubber, or plastic), and that will not influence the pH. The reservoir provides a continuous supply to a tank normally (but not necessarily) situated inside the test section in which the salt solution level is held reasonably constant. The atomizers are connected to this tank.

(4) A means for injecting the salt fog into the test chamber and an input air humidifier to minimize clogging of the nozzles. Atomizers

used shall be of such design and construction as to produce a finely divided, wet, dense fog. Atomizing nozzles and the piping system shall be made of material that is nonreactive to the salt solution. The facility must be designed to provide the required atomization distribution and fallout.

(5) A minimum of 2 salt fog 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. Receptacles shall be placed so that they are not shielded by the test item and will not collect drops of solution from the test item or other sources.

(6) A compressed air supply that will maintain constant air pressure for the continuous, uniform atomization of the salt solution.

b. A salt fog 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).

NOTE: The apparatus described in IEC Publication 68, test Ka is among those that satisfy these requirements.

4.2. CONTROLS

In addition to that specified in Method 300 Chapters 3 and 4, the following controls apply to this test:

a. Compressed air: The oil and dirt-free compressed air used to produce the atomized solution shall be preheated (to offset the cooling effects of expansion to atmospheric pressure) (see Table 1).

Table 1: 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

b. The salt solution is to be heated to within ± 6 °C of the test section temperature before injection into the test section.

c. Test section air circulation: Air velocity in the test chambers shall be minimal (essentially zero).

d. Chamber operation verification: Immediately before the test, and with the exposure chamber empty, all test parameters shall be adjusted to those required for the test. These conditions shall be maintained for at least one 24-hour period (or until proper operation and salt fog collection can be verified). The fallout rate and pH must be measured at the end of this initial period. Monitor and record the temperature immediately prior to testing, and at least every 2 hours thereafter.

e. Water used for this test must be essentially free of contaminants. Follow the guidance provided in Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

4.4. PROCEDURE

4.4.1. Pre-Test Information

See Method 300 Chapters 4 and 6.

4.4.2. Preparation of Salt Solution

Prepare the required solution by dissolving 5 parts by weight of salt in 95 parts by weight of water. In the anhydrous state, the sodium chloride should not contain more than 0.5 percent of total impurities nor more than 0.1 percent of sodium iodide. It should contain essentially no nickel or copper. Maintain the solution within the required specific gravity range by using the measured temperature and density of the salt solution (Figure 1). Maintain the pH of the salt solution, as collected as fallout in the exposure chamber, between 6.5 and 7.2 with the solution temperature at +35 °C. Only diluted chemically pure hydrochloric acid or sodium hydroxide shall be used to adjust the pH. Make the pH measurement electrometrically or colourimetrically. Sodium tetraborate (borax) may be added to the salt solution as a pH stabilization agent in a ratio not to exceed 0.7 g sodium tetraborate to 75 litres of salt solution.

4.4.3. Preparation for Test

Perform the pre-test standard ambient check as specified in Method 300 Chapter 2. Handle the test item as little as possible, particularly on the significant surfaces, and prepare it for test immediately before exposure. Unless otherwise specified, test items shall be free of surface contamination such as oil, grease, or dirt that could cause dewetting. Do not include the use of corrosive solvents, solvents that deposit either corrosive or protective films, or abrasives other than a paste of pure magnesium oxide in the cleaning methods.

4.4.4. Test Conduct

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

Step 2. Continuously atomize the required salt solution into the test chamber for a period of 24 hours or as specified in the test plan. Measure and document the salt fog fallout throughout each 24-hour atomization period. The fallout shall be as specified in paragraph 4.1.b. The frequency of sampling should be sufficient to ensure that the fallout is maintained but the rate of corrosion will accelerate if the sample is allowed to dry significantly while the spray is off. If fallout quantity requirements are not met, that interval must be repeated. Measure the pH at least once during each spraying period. Care should be taken to ensure that there is consistency in this activity if comparative tests are to be conducted.

Step 3. Dry the test item at standard ambient temperatures and a relative humidity of 50 ± 5 percent for 24 hours or as otherwise specified in the test item specification (see paragraph 2.4.3). Minimize handling the test item or adjusting any mechanical features during the drying period.

Step 4. Repeat Steps 1–3 once or as otherwise required to reach the cycles specified in the test plan.

Step 5. At the end of the drying period, unless otherwise specified, operate the test item and document the results for comparison with pre-test data.

Step 6. Visually inspect[3] the test item for any changes (see paragraph 2.1) to the extent practical. To aid in examination, a gentle wash in running water (38 °C maximum) may be used.

Step 7. Complete any further inspections or operational checks and document the results for comparison with pre-test data.

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[3] *Visual examination of the test item should consider high stress areas; contact of dissimilar metals; electrical/electronic components; metallic surfaces; enclosed volumes where condensation may occur; components provided with corrosion protection coatings; cathodic protection systems, and mechanical systems subject to malfunction if clogged or coated with salt deposits.*

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

In addition to Method 300 Chapter 9, any corrosion must be analysed for its immediate or potential effect on the proper functioning of the test item. Satisfactory operation following this test is not the sole criterion for pass / fail.

CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. International Electrotechnical Commission (IEC), Publication 68, Basic Environmental Testing Procedures for Electronic Components and Electronic Equipment, 1974.

b. Methodology Investigation on Evaluation of Test Procedures Used for Salt Fog Tests, U.S. Army Test and Evaluation Command Project No. 7-CO-PB7-AP1-018, July 1979.

c. Junker, V.J., The Evolution of USAF Environmental Testing, AFFDL-TR-65-197, October 1965.

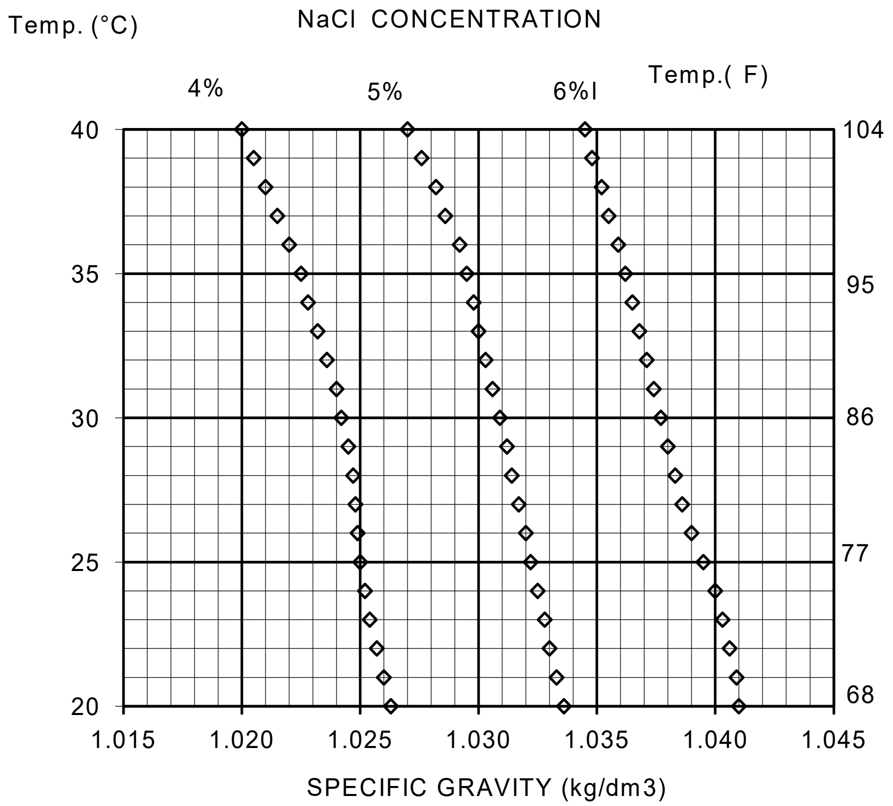

Figure 1: Salt Solution Specific Gravity Range

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METHOD 310
RAIN AND WATERTIGHTNESS

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method. additionally, annex a contains guidance on tailoring and special considerations for performing the following test procedures.

1.1. PURPOSE

These tests are conducted to determine with respect to rain, water spray, or dripping water:

a. The effectiveness of protective covers, cases, packaging, or seals.

b. The capability of the materiel to satisfy its performance requirements during or following exposure.

c. The physical deterioration of the materiel due to wetting / moisture ingress.

d. The effectiveness of the water removal systems.

1.2. APPLICATION

This method is applicable to materiel that may be exposed to rain, water spray, or dripping water. The immersion test (Method 307) was traditionally considered to be more severe than the rain test for determining the penetrability of materiel. The immersion test may, in some cases, be used to verify watertightness in lieu of a rain test provided that the materiel configuration would be the same for both situations and the method of water ingress is well understood. However, there are documented situations in which the impact of rain causes pumping of water across seals that does not occur in the immersion test because the seals are held tight against the backing plate by the static pressure. In most cases it is more appropriate to carry out both tests.

1.3. LIMITATIONS

These test procedures are not suitable for the following:

a. Determining the effects of rain erosion.

b. Determining the atmospheric rain effects on propagation of electromagnetic radiation, light, etc.

c. Evaluating the adequacy of aircraft windshield rain removal devices.

d. Evaluating materiel exposed to only light condensation drip rates (lower than 140 $L/m^2/hr$) caused by an overhead surface. For this case the aggravated humidity cycle of Method 306 will induce a significant amount of free water on both inside and outside surfaces.

e. Evaluating the effects of pressure washers or decontaminations devices.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

Rain (when falling, upon impact, and as deposited water), water spray, and dripping water have a variety of effects on materiel. Examples of effects resulting from exposure to these environments are as follows. The list is not intended to be all-inclusive and some of the examples may overlap the categories.

a. In the atmosphere, it:

(1) Inhibits visibility / detectability through optical devices.

(2) Decreases effectiveness of personnel in exposed activities.

b. After deposition and / or penetration, it:

(1) Degrades the strength / causes swelling of some materials.

(2) Increases weight.

(3) May freeze, which can cause delayed deterioration and malfunction by swelling or cracking of parts, or binding of moving parts.

(4) Causes high humidity which can, in time, encourage corrosion and mould growth.

(5) Reduces the burn rate of propellants.

(6) Modifies thermal exchanges.

(7) Can render an electrical or electronic apparatus inoperative or dangerous.

(8) Can cause flash flooding, which may result in an immersion environment.

2.2. CHOICE OF TEST PROCEDURE

See Method 300 Chapters 1 and 8.

Three test procedures are provided in this method.

2.2.1. Procedure I: Rain and Blowing / Driving Rain

The Rain and Blowing Rain test is appropriate if the anticipated environment includes rain or rain combined with wind. The Driving Rain test setup attempts to simulate blowing rain by using a pressurised nozzle arrangement but is not recommended unless facility limitations preclude wind generation, since the effects of impact velocity may not be properly addressed.

2.2.2. Procedure II: Exaggerated Rain

This procedure is not intended to simulate natural rainfall but is recommended when:

a. Large (shelter-size) materiel is to be tested and a blowing-rain facility is unavailable or impractical.

b. A high degree of confidence in the watertightness of materiel is desired.

c. The materiel will be exposed to non-natural sprays, such as road-spray or sprinkler systems.

d. The flux density of water impacting upon the item will be more severe due to extreme wind or motion of the item (e.g., an item attached to the exterior of a vehicle during a normal rainfall will experience a more intense rate of rain impact due to the velocity of the vehicle).

2.2.3. Procedure III: Drip

This procedure is appropriate when materiel is not expected to be exposed to rain, but may be exposed to dripping / falling water from severe condensation or leakage from overhead surfaces.

2.3. SEQUENCE

See Method 300 Chapter 8.

This Method is applicable at any stage in the test program, but its effectiveness is maximised if it is performed towards the end of the test program since the synergistic effects of the other tests can affect seal integrity of an enclosure.

2.4. CHOICE OF TEST SEVERITIES

See Method 300 Chapters 1, 4, and 8.

Variables include the test item configuration, rainfall rate, duration of exposure, wind velocity, test item exposure surfaces (orientation), and the water temperature with respect to the test item temperature.

2.4.1. Rainfall Rate

1. For Procedure 1, the rainfall rate and duration should be tailored to address the anticipated deployment locale, material commodity, and mission criticality. Only when rainfall intensity-frequency-duration curves, commodity failure modes, material criticality, or mission location / duration are unavailable or not well understood are the rates and durations suggested in Figure 1 recommended. Figure 1 includes the following 3 parts: an extreme 5-minute rainfall at an intensity of 14 mm/min, 25-minute rainfall at 8 mm/min, and 2-hour rainfall 1.7 mm/min. These parts, combined as one test, provide survival confidence for stationary materiel exposed for an extended period in the worst locations of the world (reference a). Procedure 1 can consist of one or more parts as required to address specific commodity, materiel / usage, or criticality issues. Small and localized rain bursts, such as during a thunderstorm, produce the heaviest rainfalls over a few hours or less, represented by the highest and mid-intensity rates in Figure 1. These parts address the ability of materiel to withstand heavy storms and adequately dissipate and drain away water, and could be omitted if, for example, the item will not be operated in heavy rain. The lower intensity long duration portion represents steady-state rain, which addresses failures such as material soaking up water over a long period of time, or the gradual buildup of water inside an item with inadequate drainage. This part could be omitted if these issues do not affect the materiel. Care must be exercised to ensure that the test adequately assesses the commodity, usage and environment over the anticipated lifecycle. Further information and guidance regarding rainfall rates may be obtained from Annex A and Leaflet 2311.

2. For Procedure II, the suggested spray rate is 40 mm/min. Tailoring is not recommended unless the specific reasons for tailoring are fully understood, as this test has been traditionally used to provide materiel confidence.

3. The recommended drip rate for Procedure III is 280 L/m^2/hr (4.67 mm/min) for an exposure duration of 15 minutes. The intention of Procedure III is to ensure that the item will survive droplets of water falling onto it at any particular location and consequently this procedure is an aggravated test whereby droplets fall repeatedly over the entire surface of the test item. This can cause difficulties with small items that are not able to drain away the flow of water produced by multiple drips. When evaluating equipment exposed only to light (lower than 140 L/m^2/hr) condensation drip rates caused by an overhead surface, the aggravated humidity cycle of Method 306 may induce similar levels of surface water. In such cases, effects of internal condensation and the lack of drop impact and splash must be considered. For known conditions where a 280 L/m^2/hr drip rate cannot occur, the product may be tested by

reducing the drip rate and proportionately increasing the test duration. For example, for a product exposed only to 140 L/m^2/hr, the rate may be appropriately reduced if the duration of the test is extended to 30 minutes to ensure the equivalent volume of water falls on the product.

2.4.2. Exposure Duration

1. The exposure duration should be determined from the life cycle profile but should not normally be less than that specified in the individual procedures. This duration is representative for a stationary item exposed for 10 years in the worst locations of the world. For materiel liable to accidental exposure, lower intensities or shorter durations may be appropriate.

2. 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. For any materiel made of material that may absorb moisture, the duration of the test may have to be significantly extended to reflect the real lifecycle. For items that do not absorb water there is likely minimal value in exceeding the recommended durations, however, the duration may be extended where concern exists.

2.4.3. Droplet Size

Although nominal drop-size spectra exist for instantaneous rainfall rates, natural rain varies intensity from moment to moment and, hence, these instantaneous spectra are effectively meaningless. For Procedure I and Procedure II, droplet sizes should not be smaller than approximately 0.5 mm in diameter which is considered to be a mist or drizzle rather than rain, or larger than 4.5 mm. For Procedure III, polyethylene tubing sleeves added to the dispensing tubes (see Figure 3) will increase the droplet size to its maximum. Procedure III is not meant to simulate rain but rather droplets of condensation or overhead leakage, and therefore droplets may be larger than 4.5 mm in diameter.

NOTE: Observations have shown that water droplets introduced into a high velocity air stream tend to break up over distance (reference b). It is recommended that the droplets be introduced as close as possible to the test item while assuring the droplets achieve the required velocity prior to impact with the test item, where applicable.

2.4.4. Wind Velocity

Rainfall accompanied by winds of 18 m/s is not uncommon during storms. This velocity is recommended unless otherwise specified or vertical rain conditions are required. Gusts exceeding 24 m/s can be associated with these winds and may be required in the test plan. Unless otherwise specified, the wind need only be applied during the 2-hour steady-state rainfall. Where test facility limitations preclude the simulation of wind, the test setup shown in Figure 4 may be used.

2.4.5. Test Item Exposure Surface(s) (Orientation)

Wind-driven rain will usually have more of an effect on vertical surfaces than on horizontal surfaces, and vice versa for vertical or near-vertical rain. Orient the test item such that the most vulnerable surfaces face the driving rain. Rotate the test item as required to expose all vulnerable surfaces or openings, with attention to locations where pooling of water may occur.

2.4.6. Temperature

Experience has shown that a temperature differential between the test item and the rainwater can affect the results of a rain test. For nominally sealed items, increasing the test item temperature approximately 10 °C above the rainwater temperature at the beginning of each exposure period will subsequently produce a negative pressure inside the test item, and will provide a more reliable verification of its watertightness.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information specified in Method 300 Chapters 4 and 6, the following are required:

a. Rainfall, spray, or drip flow rate(s) at exposure surface.

b. Exposure duration.

c. Water temperature.

d. Test item's preheat temperature.

e. Exposure surfaces detailed with respect to (a) and (b).

f. Wind velocity, operational time, and direction with respect to (e).

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITIES

See Method 300 Chapter 5. Unless otherwise specified, water used for rain tests can be from local water supply systems and shall be free from particles that can block the nozzle or tubing apertures. For the drip test, it is recommended that water from this source be filtered using a fine sediment filter to ensure particulate buildup does not block the tubing. A water-soluble dye such as fluorescein may be added to the rainwater to aid in locating water leaks. No rust or corrosive contaminants shall be imposed on the test item by the test facility. The facility temperature need not be controlled, as the water introduced as rain will significantly affect it.

4.1.1. Procedure I: Rain and Blowing / Driving Rain

The rain facility shall have the capability of producing falling rain accompanied, if required, by wind at the velocity specified. Where facility limitations preclude the generation of wind, the facility shall be capable of producing rain using the arrangement of the nozzles around the test item as shown in Figure 4. In this case, the rainfall rate will need to be increased on the appropriate materiel surface(s) to represent the effective rainfall rate that would be induced by the wind (see Annex A for details). The rain is to be produced by a water distribution device of such design that the water is homogeneously distributed in the form of droplets having a diameter range predominantly between 0.5 and 4.5 mm (see paragraph 2.4.3). Spray nozzles, or the apparatus shown in Figure 2 (with the polyethylene tubing removed), are suggested. If a dispenser is used for steady state rain, the height of the dispenser shall be sufficient to ensure that the drops approach terminal velocity (approximately 9 m/s). The wind source shall be capable of producing a horizontal wind velocity of at least 18 m/s.

4.1.2. Procedure II: Exaggerated Rain

The spray is to be produced by a water distribution device such that the water impacting the materiel is a steady spray pattern of homogeneous droplets predominantly in the range specified in paragraph 2.4.3. The nozzles used shall be arranged to ensure homogeneous wetting of the test item surfaces; one such arrangement is depicted in Figure 5. A minimum operating pressure of 377 kPa is recommended to produce the desired effects.

4.1.3. Procedure III: Drip

The dispenser arrangement shall allow a flow rate of not less than 280 L/m^2/h, but without coalescence of the drips into a stream. Alternative dispenser designs are shown in Figures 2 and 5, but other configurations may be used provided the spacing, rate, and size of individual drops are equivalently maintained. Either arrangement shown in Figure 2 is recommended over that of Figure 5 due to the simplicity of construction, maintenance, cost, and reproducibility of tests. The polyethylene tubing ensures maximum droplet size. Use a drip height representative of the actual situation being simulated; unless otherwise specified, one metre is suggested. The drip area of the dispenser should be large enough to cover the entire top surface of the test item. The dispenser shown in Figure 5 requires accurate levelling together with extensive cleaning and maintenance to ensure consistency of the drip pattern. It is recommended that de-ionised or distilled water be used to minimize contamination of the test facility, and that the test item and the dispenser be covered to prevent accumulation of dust that could clog the dispenser holes. Since facility imperfections or small amounts of contamination can affect the test, control the flow rate either by introducing water through a flow metre (preferred) or by controlling the depth of the water in the drip dispenser (after verifying that the selected depth produces the required flow) to ensure the proper drip rate.

4.2. CONTROLS

In addition to the controls specified in Method 300 Chapters 3 and 4, verify that the rainfall / spray rate and wind velocity at the position of the test item are correct before placement of the test item in the test facility. It may be necessary to measure the rainfall rate without the wind in order to ensure accurate measurement. Ensure that only separate (or discrete) drops are issuing from the dispenser. Where nozzles are used, it is not correct to measure the spray pattern of each nozzle independently as any overlap or excess spacing would not be found. Additionally, the pressure shall be at least the minimum necessary to maintain a homogeneous pattern distribution. Once the spray pattern and rate have been verified, it may be sufficient to verify the water pressure immediately before subsequent tests, so long as none of the variables of the test have been altered. For Procedure III, the flow rate must be confirmed before and after the test to ensure test tolerances are met from beginning to end of test.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

4.4. TEST PROCEDURES

4.4.1. Test Preparation

Before starting the test, determine the information to be documented in accordance with Method 300 Chapters 4 and 6, and perform the pre-test standard ambient check specified in Method 300 Chapter 2. If wind is required, position the wind source with respect to the test item in accordance with paragraph 2.4.5.

> **NOTE:** No sealing, taping, caulking, etc. shall be applied to the test item except as required by the design specification for the test item. Unless otherwise specified, test items shall be free of surface contamination such as oil, grease, or dirt, which could cause dewetting.

4.4.2. Procedure I: Rain and Blowing / Driving Rain

Step 1. For materiel intended to be opened during use or for field maintenance, open the test item.

Step 2. Heat the test item to a higher temperature than the rainwater such that the test item's temperature has been stabilised at 10 ± 2 °C above the rainwater's temperature at the start of each exposure to the rain (see paragraph 2.4.6).

Step 3. Install the test item in the rain test facility in the required test configuration. Position the test item so that when steady state or wind-driven rain is initiated, rain will be sprayed over the specified surfaces of the test item.

Step 4. Start the rain and, if appropriate, the wind at the velocity specified in the test plan, and maintain the prescribed rainfall conditions for the specified duration.

Step 5. If an operational check is required, operate the test item for the last 10 minutes (or as otherwise specified) of the rain duration selected for Step 4.

Step 6. Examine the test item for water within one hour of completion of exposure. If possible, examine the test item in the test chamber; otherwise, remove the test item from the test facility and conduct a visual inspection. Dry the exterior surface of the test item before opening for internal inspection. If a noticeable amount of free water has penetrated the test item, judgment regarding potential safety hazards shall be made before operating the test item.

It may be necessary to empty water from the test item to prevent a safety hazard. Record the approximate quantity and location of any free water found inside the test item, and identify probable area(s) of ingress.

Step 7. Repeat Steps 1–6 for all faces of the test item that could be exposed to blowing or steady state rain.

Step 8. If required, operate the test item to demonstrate compliance with the requirements document, and document the results.

4.4.3. Procedure II: Exaggerated Rain

Step 1. Install the test item in the test facility in normal operational configuration.

Step 2. Position the nozzles as required by the test plan or as indicated in paragraph 4.4.1 and Figure 5.

Step 3. If practical, heat the test item to a higher temperature than the rainwater such that the test item's temperature has been stabilised at 10 ± 2 °C above the rainwater's temperature at the start of each exposure to the rain (see paragraph 2.4.6).

Step 4. Unless otherwise specified, spray individually or in any combination all exposed surfaces of the test item with water for 40 minutes per face.

Step 5. Inspect the interior of the test item for evidence of free water. Estimate the water volume and the probable point of entry, and document.

Step 6. If required following removal of any free water, operate the test item to demonstrate compliance with the requirements documents, and document the results. Be aware of any potential electrical safety hazard.

4.4.4. Procedure III: Drip

Step 1. Heat the test item to a higher temperature than the rainwater such that the test item temperature has been stabilised at 10 ± 2 °C above the rain water temperature at the start of each exposure to the rain (see paragraph 2.4.6).

Step 2. Install the test item in the test facility in accordance with the test plan, in its operational configuration, and with all connectors and fittings engaged.

Step 3. Subject the entire top surface of the test item to water droplets falling from specified height measured from the upper main surface of the test item at the specified uniform rate for 15 minutes or as otherwise specified.

Step 4. At the conclusion of the exposure period, examine the test item in the test facility if possible. Dry the test item externally and remove sufficient panels or covers to allow the interior to be inspected.

Step 5. Visually inspect the test item for evidence of water penetration. Estimate the amount of any water inside the test item, and estimate the probable point of entry, and document.

Step 6. Conduct an operational check of the test item as specified in the test plan and document the results, but be aware of potential electrical hazards.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

1. In addition to the failure criteria specified in Method 300 Chapter 9, particular attention should be given to swelling which may cause the materiel to exceed its specified design tolerances or cause binding and / or distortion. Weight increases may indicate absorption or ingress to hidden crevasses, which may later lead to material delamination, degradation, or structural damage. In some cases, it may be insufficient to test operability of the materiel after exposure, and may be critical to test the operability of the item during exposure. Additionally, based on a risk assessment of the consequences of water penetration, determine if one of the following is applicable:

a. Watertight: any evidence of water penetration into the test item's enclosure following the rain test shall be considered a failure.

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

(1) There is no immediate or anticipated long-term 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 306.

2. This quantity of water is approximately the quantity required to raise the relative humidity of one cubic foot of air at standard ambient conditions to saturation at 49 °C. The 49 °C value is realistic for equipment exposed to higher temperature and solar radiation effects.

3. Greater water penetrability may be acceptable, provided the above conditions are met and it can be proven that safety, operability, and survivability are not affected.

CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. Kaddatz, J., “NATO Rain Characterisation and Procedure Development”, QETE Project A011401, Canadian Department of National Defence, 2003.

b. Rogers, R. R., “Short Course in Cloud Physics,” Pergamon Press, Oxford; 1979.

c. Moriceau J. Etude Technique No. 749/84/SEM, DGA/LRBA, Vernon, France.

Test Level	Rate	Duration	Wind Velocity
Extreme	14 mm/min	5 min	If specified
High	8 mm/min	25 min	If specified
Steady-State	1.7 mm/min	120 min	18 m/s

Figure 1: Procedure I, Recommended Rainfall Test Levels

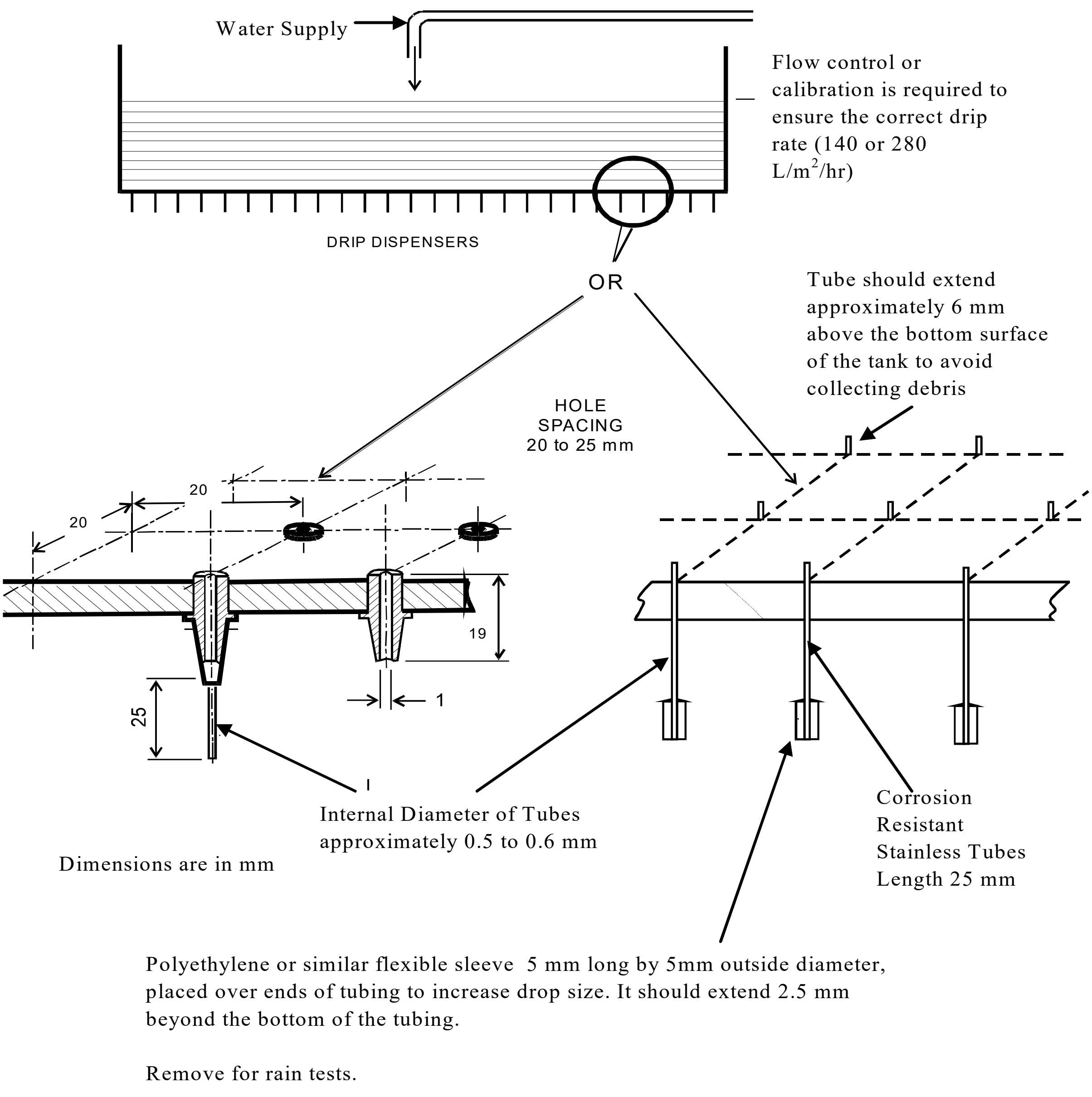
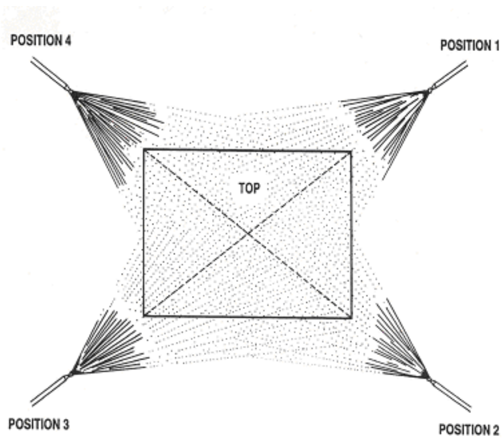


Figure 2: Sample Facility Setup for Rain or Drip Test

Figure 2. Sample facility setup for rain or drip test



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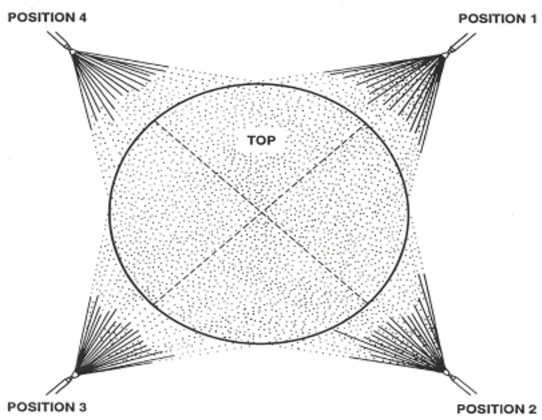

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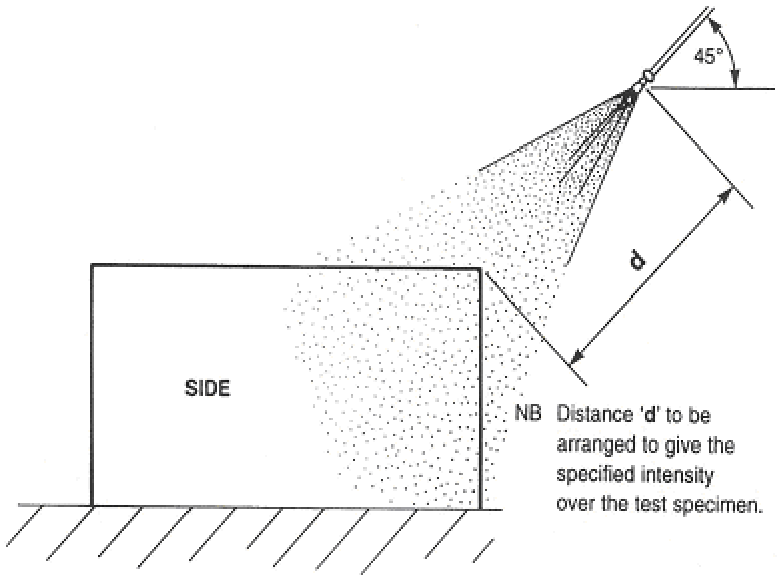
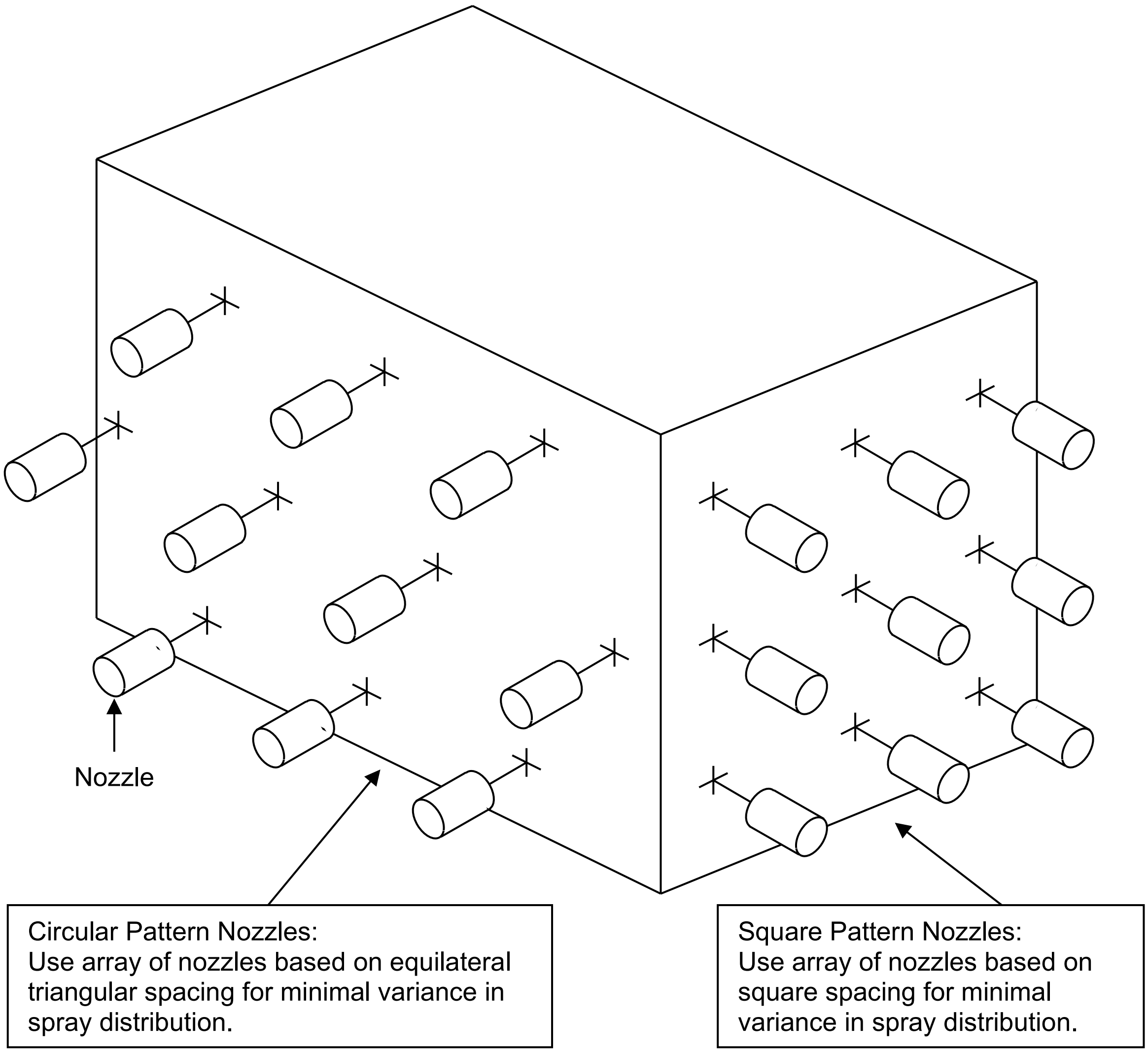


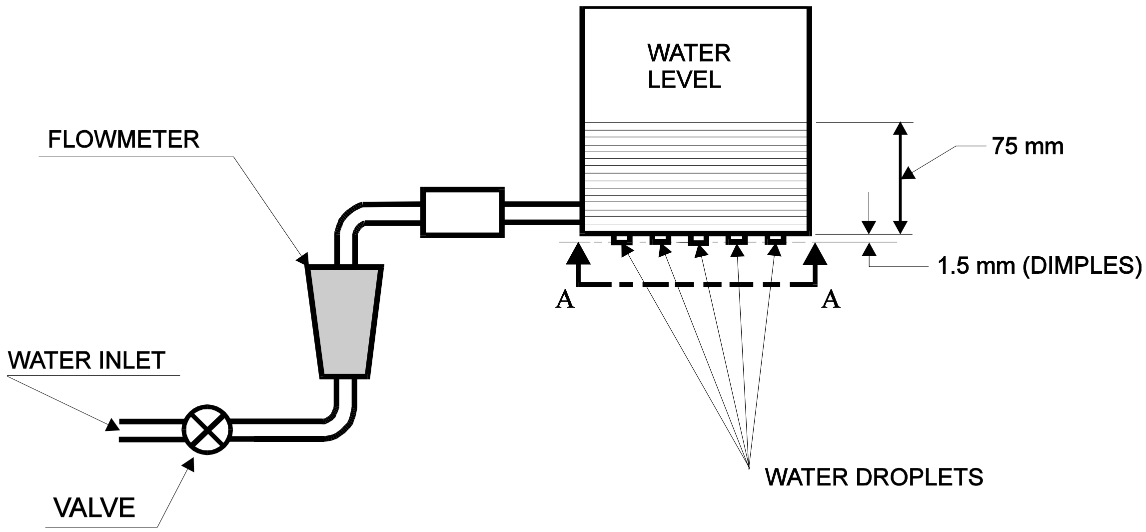
Figure 3: Nozzle Arrangement for Procedure I, Where Wind is Unavailable



*Adjust spacing and standoff as necessary to achieve spray overlap.

Note: Ensure nozzles are perpendicular to the surface(s), and situated such that each surface including top surface (and especially vulnerable areas) is sprayed.

Figure 4: Typical Nozzle Arrangement for Procedure II



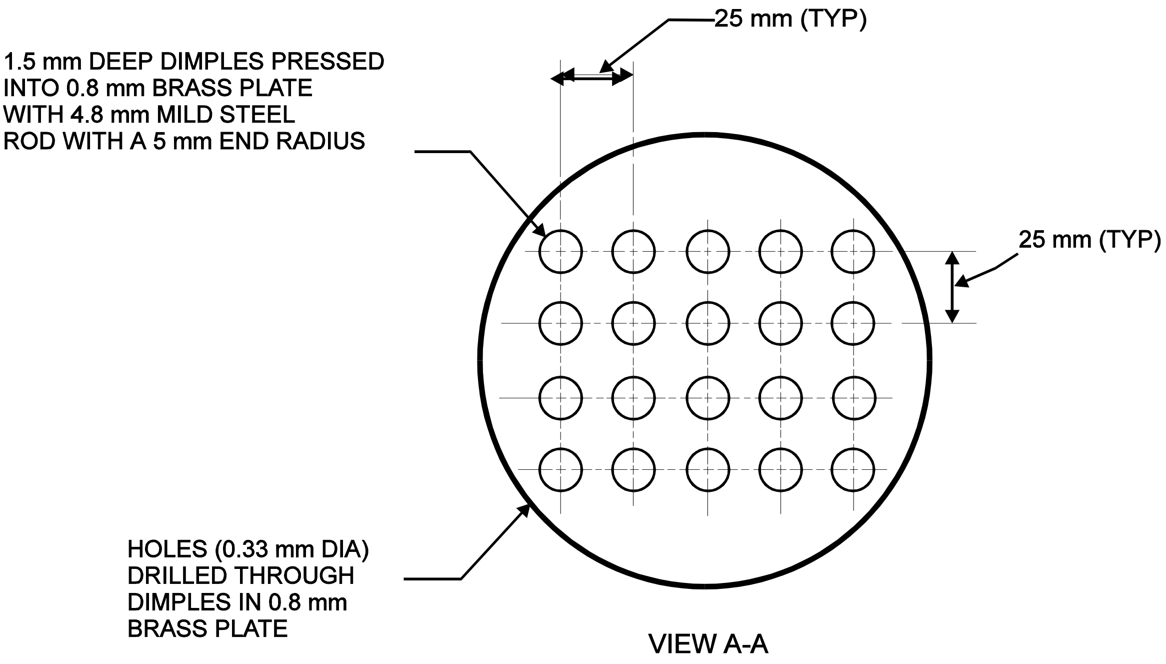


Figure 5: Details of Alternative Dispenser for Drip Test for Procedure III

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ANNEX A DETAILED GUIDANCE FOR TAILORING RAIN

A.1. INTRODUCTION

This Annex provides additional information to aid in tailoring the rain and blowing / driving rain test procedures.

A.2. INTENSITY VS. DURATION

A.2.1. Types of Rain

Rainfall is often classified according to the process causing the uplift of air initiating the rain formation; there are three main types of rain that are not mutually exclusive, and these are known as orographic, cyclonic, and convective (references a and b).

A.2.1.1. Orographic Rain

With orographic rain (Figure A1), the main cause is the forced ascent of moist air over high ground. The enhanced precipitation is often due to raindrops falling into the large amounts of low cloud formed by this ascent, giving rise to the ‘seeder / feeder’ mechanism. Orographic precipitation is often responsible for high monthly and annual rain amounts; however, windward slopes are also prone to very extreme amounts when affected by tropical storms. Due to the high rainfall on the windward slope of a mountain, the leeward side will often have lower precipitation; this condition is known as the “shadow effect”.

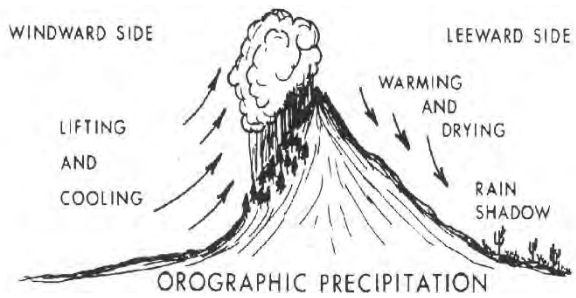

Figure A1: Orographic Rain

A.2.1.2. Cyclonic Rain

With cyclonic rainfall (Figure A2), large scale uplift is associated with features of the general weather situation, such as fronts and depressions. Tropical cyclones are responsible for most of the extreme amounts for a few hours to a few days.

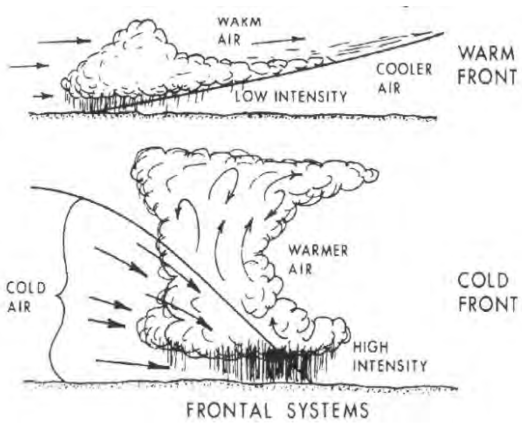

Figure A2: Cyclonic Rain

A.2.1.3. Convective Rain

Convective rain (Figure A-3) falls from a cumuliform cloud with an unstable air mass, where columns of cloudy air can rise and rapidly form raindrops. Rainfall intensity is typically greater than for cyclonic or orographic rain, but individual areas of rain are generally small (20 km diameter or less), with dry areas close by. This type of rain produces the heaviest rainfalls over periods of a few hours or less. Though heavy winds are often associated with convective rain, these typically do not occur at the core of the storm where the rain is heaviest, since the causation for heavy rain is strong downdraft.

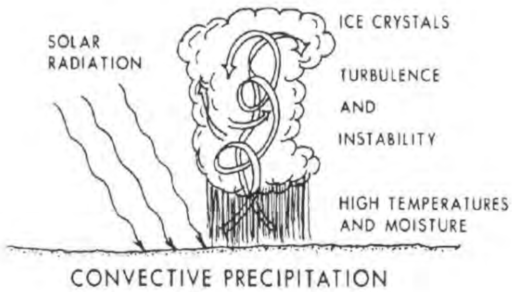

Figure A3: Convective Rain

A.2.2. Measuring Rainfall Intensity

Instantaneous rainfall intensity cannot be measured directly, but rather is an average value calculated as the volume of water per unit surface impact area per unit time (e.g., $mm^3/mm^2/min$ or $L/m^2/hr$). The measurement units can be simplified to specify rate in depth of water per unit time (e.g., mm/min), as is often the case in this test method. The volume of water collected is measured using a fluidic measurement unit (e.g., mL), converted to mm^3, divided by the surface area of the opening to the collection container, and finally divided by the time of collection. A common apparatus for measuring rainfall intensity is the tipping bucket rain gauge, however tipping buckets may not have the capacity to measure 14 mm/min, and will almost certainly not be able to measure 40 mm/min.

A.2.3. Intensity-Frequency-Duration (IFD) Curves

1. Due to the different types of rainfall, shorter rainfalls are often more intense. Climatologists and meteorologists often present this information in a simple diagram, known as IFD curves. These curves show the relationship between the intensity and duration, for different return periods. A sample IFD curve is shown in Figure A4. IFD curves will differ from one location to the next due to the differences in geographic features that influence the causation of the rainfall.

2. Standard practices for rain data collection do not often include gathering data for durations of less than one hour. When IFD curves are not available for short durations, the intensities for durations less than 1 hour may be estimated from the 1-hour value (reference c), as shown in Table A-1. These average ratios have been developed empirically from hundreds of station-years of records.

Table A-1: Ratios for Estimating Short Duration Rainfall Rates from 1-Hour Value

Duration (minutes)	5	10	15	30
Ratio (n-minutes to 60-minutes)	3.48	2.70	2.28	1.58

3. Thus, if the 100-year one-hour rainfall rate is 102 mm/hr (1.7 mm/min), the 100-year ten-minute rainfall rate would be 275 mm/hr (4.6 mm/min). Caution must be exercised when using this approach. In regions where most of the rainfall occurs in connection with thunderstorms, the above ratios would tend to yield values that are too low; in regions where most of the rainfall results from orographic influences with little severe convective activity, these ratios might tend to yield values that are too high.

4. Alternatively, the IFD curve can be derived if the mean and standard deviation of annual extreme rainfall rates for various durations are known, by analysing the data as a Gumbel double exponential distribution (Note: the Gaussian / Normal distribution does not apply and consequently the data are not entirely contained within ±3 standard deviations).

Using the method suggested in reference d,

$$x = \bar{x} + K(T)s$$

where: x is the exceedance value, $\bar{x}$ and s are the mean and standard deviation of the annual extreme rainfalls, T is the return period, and K(T) is defined by:

$$K(T) = \frac{-\sqrt{6}}{\pi}\left(0.5772 + \ln\ln\frac{T}{T-1}\right)$$

A.3. RISK ASSESSMENT

A.3.1. Return Period

1. One traditional convention for expressing frequency of occurrence is the return period, which is an average of the length of time between rainfall rates of a specific magnitude. For example, the 100-year rainfall rate occurs, on average over a large period of time (a millennium), every 100 years. This does not mean that if the event occurs on a given year that it cannot occur the following year.

2. An alternate approach to expressing this value is to state that there is a 1 in 100 (1 percent) chance that a rainfall of this magnitude could occur any given year. By applying annual probabilities in succession, the resulting probability of occurrence increases. Figure A5 relates the anticipated design life to the required return period rainfall that must be selected, in order to achieve a given probability of success. Success is defined as the condition in which the specified rainfall rate is not exceeded during the design life (duration of exposure) of the materiel.

3. Consequently, for a materiel intended for a field exposure of 10 years, the 100-year return period rainfall must be used to provide 90 percent confidence that the item will not experience rain more intense than the test condition. This success probability was used to derive the recommended values in the rain and blowing / driving rain test procedure.

A.3.2. Percentage Frequency of Occurrence

Another method traditionally used to express rainfall rate is the frequency of occurrence (reference b, reference e, and reference f). Caution must be exercised when interpreting data that uses the term frequency. Some sources refer to the percentage of time that rainfall is exceeded when raining (i.e., when the rainfall rate is greater than some threshold value, the threshold is dependent upon the source of the data); others reference the general percentage of time that the rainfall rate is exceeded, including time when it is not raining (i.e., rainfall rate = 0 mm/min). This information is extremely useful for determining if the rain test is applicable or for determining operational failure criteria; however, it can be misleading to define survivability failure criteria to rates that are exceeded only 0.5 percent of the wettest month, as this may be equivalent to annually receiving up to 3.65 hours of rain (during the specified month) in which the rainfall rate exceeds this threshold. If there is little variance in the precipitation patterns throughout the year, this could mean the materiel will experience up to 43.8 hours annually at this intensity.

A.4. RECORD INTENSITIES

1. The intensities associated with the maximum observed rainfalls (reference c) have been enveloped by the equation:

$$R = 60.4T^{-0.525}$$

where R is the rainfall rate in mm/min and T is the duration in minutes.

2. The most intense 100-year return period (10-year design life, 90 percent confidence) rainfalls have been estimated to occur in Hawaii and Puerto Rico (reference g and reference h), and these values were selected as the recommended test rain rates.

Figure A6 shows the recommended 100-year rainfall rates in comparison with the maximum observed intensities.

A.5. DROP SIZE

The velocity of water droplets is dependent upon the drop size. This is due to the fact that the air resistance is proportionate to the square of the velocity. Conversely, the velocity is dependent upon the effective surface area that this resistance acts upon which changes as the drop deforms slightly.

A.5.1. Natural Raindrop Size

1. Natural raindrop velocities for various drop sizes are shown in Table A-2. Note that these values are approximate estimates only, and do not need to be matched precisely.

Table A-2: Approximate Terminal Velocity Associated with Various Drop Sizes

Drop Diameter (mm)	Droplet Terminal Velocity (m/s)
0.5	2
1	4
2	6.5
3	8
4	9

2. Where droplets are formed and allowed to fall naturally for the rain / blowing rain procedure, the test facility must be sufficient in height to ensure terminal velocity of the droplets is reached before impact upon the test item. Test facilities using pressurised water may not require as much height, as the droplets will leave the spray nozzle with some initial velocity.

3. Drop sizes greater than 4.5 mm do not typically occur in natural rainfall, as droplets of this size will tend to break up during their descent, either due to air resistance or collision with other droplets.

A.5.2. Drip Test Drop Size

Since the drip test is not to simulate rain, the droplets do not need to reach terminal velocity. It is possible to achieve larger droplet sizes, since the air resistance may not be sufficient to cause them to break up. The largest drop size that can be achieved without coalescence is recommended.

A.6. MOTION AND FLUX DENSITY

The flux density of water droplets on the vertical surfaces of the materiel may be increased in situations where either wind or motion is involved.

A.6.1. Wind

Wind will increase the horizontal rate of water impact on vertical surfaces. Windward surfaces will receive:

$$R_{eff} = R_{nominal}\sqrt{1+\frac{v^2}{u^2}}$$

Where R_{eff} is the effective rainfall rate impacting upon the windward vertical surface (mL/m^2/min)

$R_{nominal}$ is the vertical rainfall rate without wind (mL/m^2/min)

v is the velocity of the wind (m/s)

u is the vertical velocity of rain droplets (m/s)

A.6.2. Motion

1. Where materiel is in motion, the rate of the water's impact upon the front of the materiel will increase proportionately to the square of the velocity. This is especially important on equipment mounted to the exterior of surface vehicles. For example, a vehicle traveling at 25 m/s (90 kph), the rate of surface impact on the front of the materiel can be increased by over 4 times the nominal rainfall rate.

The effective rainfall rate can be calculated:

$$R_{eff} = R_{nominal}\sqrt{1+\frac{v^2}{u^2}}$$

Where R_{eff} is the effective rainfall rate impacting upon the forward surface (mL/m^2/min)

$R_{nominal}$ is the vertical rainfall rate (mL/m^2/min)

v is the velocity of the vehicle (m/s)

u is the vertical velocity of rain droplets (m/s)

2. The theoretical angle of impact can be calculated $\theta = \tan^{-1}(v/u)$ where θ is the angle measured with respect to the horizontal plane.

3. Where wind and motion exist simultaneously, v in the above equations is the net vector summation of the vehicle speed and wind speed.

4. For example, for a materiel mounted to the exterior of a typical land vehicle travelling 100 kph (27.8 m/s) in rainfall of 2 mm/min intensity and a head wind of 65 kph (18 m/s), the resultant effective rainfall rate is:

$$R_{eff} = R_{nominal}\sqrt{1+\frac{(v_{vehicle}+v_{wind})^2}{u^2}}$$

$$R_{eff} = 2\sqrt{1+\frac{(27.8+18)^2}{9^2}}$$

R_{eff} =10.4 mm/min

Simultaneously, the wind velocity should be increased to 45.8 m/s ($v_{vehicle} + v_{wind}$) which may help alleviate concerns regarding impact velocity.

A.7. ALTITUDE

Rainfall at altitudes of up to 4 km (13000 ft) may be 25–30 percent higher than rainfall rates at sea-level (reference a and reference b). Above this altitude, the precipitation will consist partly or fully of snow or hail.

A.8. TEST SETUP CONSIDERATIONS

A.8.1. Manifold Size

1. The test setup must be of sufficient size to produce the desired effect. In procedures where wind is involved, the rate of water impacting upon the windward surface is increased as is described in paragraph 6.1; the cause for this increase originates from the fact that the wind is collecting droplets that would normally fall off to the side of the materiel and pushing them into the vertical surface. As such, there must be sufficient droplets falling to the side of the materiel during testing to recreate this phenomenon.

2. The required manifold extension, measure from the side of the materiel, is dependent upon the resultant angle of the driving rain, which is in turn dependent upon the wind velocity. The minimum required extension is:

$$d = h \cdot \frac{u}{v}$$

Where: h is the vertical distance between the apparatus producing the droplets and the lowest point on the test item (m)

u is the vertical velocity of falling rain (m/s)

v is the wind speed (m/s)

A.8.2. Pressurised Test Equipment

A.8.2.1. Nozzle Selection

Nozzle selection is not an exact science. Although nozzle companies publish flow / pressure / spray angle tables for each nozzle, even the nozzles that suggest they produce even distributions may, in fact, have a fallout rate directly under the nozzle that is significantly higher than the average over the spray area. Trial-and-error may be required to determine the optimum nozzle. Contrary to intuition, larger capacity nozzles may cause lower rainfall rates due to an increase in the spray angle, which will increase the impact surface area.

A.8.2.2. Nozzle Arrangement

For nozzles that produce a round spray pattern, an equilateral triangle manifold arrangement will result in the most even spray distribution. Nozzles that produce a square spray pattern will be most effective on a square grid arrangement.

A.8.2.2.1. Nozzle Spacing

It has been observed that using nozzles that produce a fraction of the required fallout rate, and providing significant overlap, may result in a more even and consistent spray distribution than selecting nozzles that produce the desired rainfall rate and spacing them with small overlap. Additionally, this will help ensure the rainfall rate is consistent regardless of the vertical distance away from the nozzle.

A.8.2.3. Nozzle Operating Pressure

For procedures involving pressurised water, a minimum pressure (dependent upon selected spray nozzle) is required to maintain a homogeneous spray pattern and prevent (non-obvious) streaming. Increased pressure will result in smaller droplet size, and consequently the lowest practical operating pressure is recommended. At certain pressures, some nozzles may be subject to sputtering due to resonance of the vane or some other design factor. This pressure region should be avoided, since results may lack reproducibility due to the chaotic variance. Particular attention should be given to external variables that may influence water pressure (e.g., flushing lavatory).

A.9. REFERENCES AND RELATED DOCUMENTS

a. DEF STAN 00-035 (Part 4) Chapter 6-01.

b. MIL-HDBK-310 Global Climatic Data for Developing Military Products, 23 June 1997.

c. WMO No. 168, Guide to hydrological practices: data acquisition and processing, analysis, forecasting and other applications (5th Ed.), 1994.

d. Hogg, W.D. and Carr, D.A. Rainfall Frequency Atlas for Canada, Canadian Government Publishing Centre, 1985.

e. AECTP 200, Leaflet 2311.

f. Tattleman, Paul. A Climatological Model for 1-min Precipitation Rates.

g. Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands, U.S. Department of Commerce Weather Bureau, 1962.

h. Technical Paper No. 42, Generalized Estimates of Probable Maximum Precipitation and Rainfall-Frequency Data for Puerto Rico and Virgin Islands, U.S. Department of Commerce Weather Bureau, 1961.

i. Moriceau, J., Etude Technique No. 749/84/SEM, DGA/LRBA, Vernon, France.

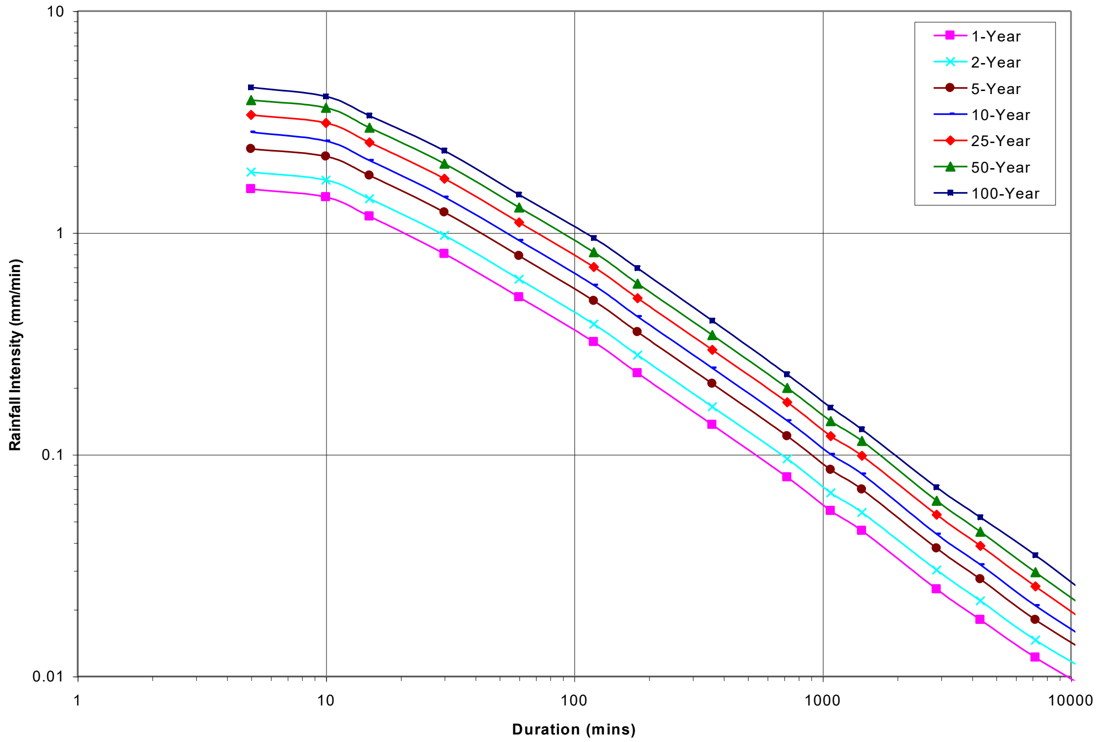

Figure A4: Sample IFD Curve

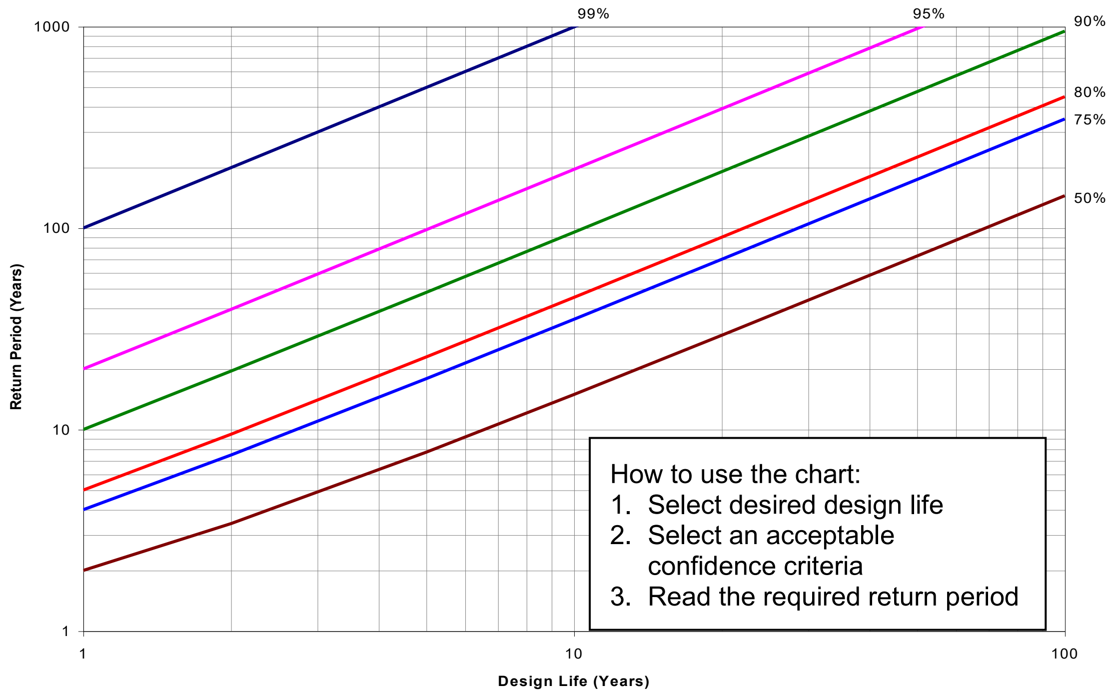

Figure A5: Risk Assessment Diagram

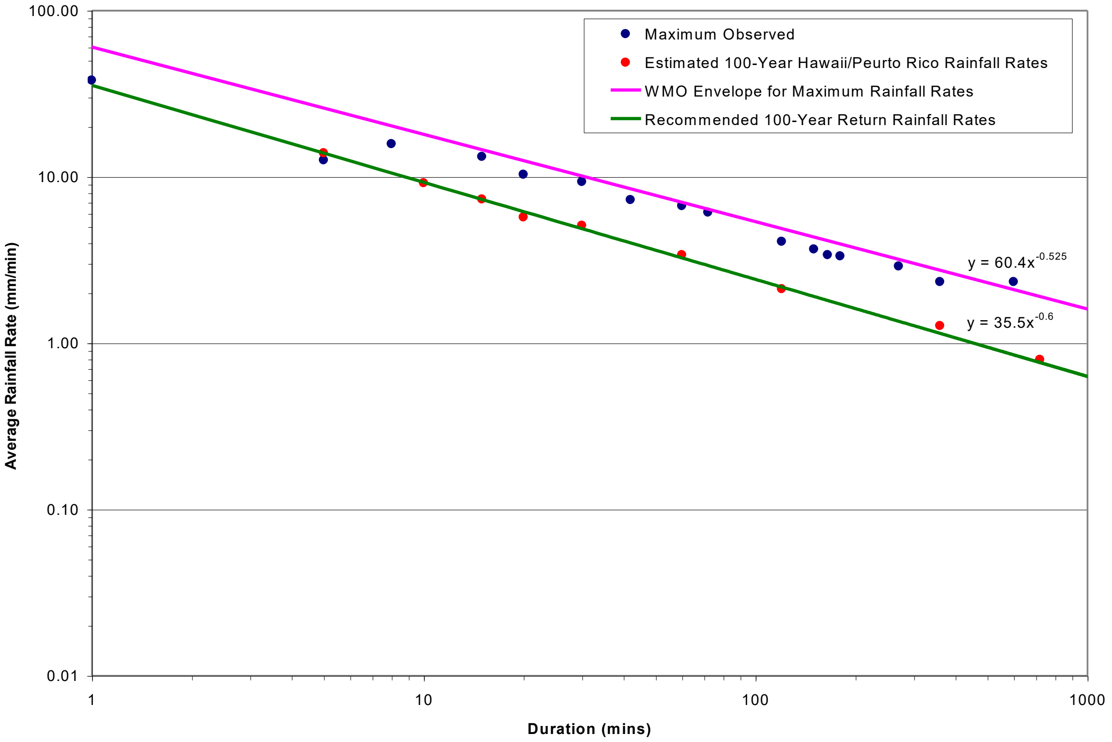

Figure A6: Maximum Observed and Recommended 100-Year Rainfall Rates

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METHOD 311
ICING

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The icing test is conducted to evaluate the effect of icing on the operational capability of materiel. This Method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field.

1.2. APPLICATION

a. This Method is applicable to materiel that may be exposed to icing such as produced by freezing rain or freezing drizzle (see paragraph 2.1.1 below).

b. This Method can be used for ice accretion from sea splash or spray, but the ice thicknesses may need to be modified to reflect the lower density of the ice.

1.3. LIMITATIONS

This Method does not simulate snow conditions or ice buildup on aircraft flying through supercooled clouds. Although frost occurs naturally, the effects are considered less significant and are not specifically addressed in this Method. This Method may not be suitable for the assessment of aerial / antenna performance, (i.e., rime ice saturated with air causes substantial signal reflection). For optional tests for testing vehicle windscreens / windshields, see EEC Directive 78/317/EEC (reference a). Also, this Method does not address icing effects from falling, blowing or recirculating snow and wet snow or slush. These are considered less severe than those in paragraph 2.2.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. ICE FORMATION

2.1.1. Principal Causes

A build-up of ice occurs in the following four principal ways:

a. From rain, drizzle, or fog falling on materiel whose surface temperature is at or below freezing.

b. From sublimation.

c. From freezing rain or freezing drizzle falling on materiel at or near freezing.

d. From sea spray and splash that coats materiel when the materiel temperature is below freezing.

2.1.2. Types of Ice

(See reference b.)

The following two types of ice are commonly encountered: rime ice (opaque / granular) and glaze ice (clear / smooth). Published extremes for ice accretion may be used for calculating design and structural evaluations, but are not considered practical for establishing test conditions due to the large thicknesses involved, unless the test is intended to provide practical confirmation of design calculations.

a. Rime ice: A white or milky and opaque granular deposit of ice formed by a rapid freezing of supercooled water drops as they impinge upon an exposed object. Rime ice is lighter, softer, and less transparent than glaze. Rime is composed essentially of discrete ice granules and has densities ranging from 0.2 g/cm^3 (soft rime) to almost 0.9 g/cm^3 (hard rime). Factors that favour rime formation are small drop size, slow accretion, a high degree of supercooling, and rapid dissipation of latent heat of fusion. The opposite effects favour glaze formation.

(1) Hard rime: Opaque, granular masses of rime deposited chiefly on vertical surfaces by dense, supercooled fog. Hard rime is more compact and amorphous than soft rime, and builds out into the wind as glazed cones or feathers. The icing of ships and shoreline structures by supercooled spray from the sea usually has the characteristics of hard rime.

(2) Soft rime: A white, opaque coating of fine rime deposited chiefly on vertical surfaces, especially on points and edges of objects, generally in supercooled fog. On the windward side, soft rime may grow to very thick layers, long feathery cones, or needles pointing into the wind and having a structure similar to that of frost.

b. Glaze ice: A coating of ice, generally clear and smooth but usually containing some air pockets, formed on exposed objects by the freezing of a film of supercooled water vapour. Glaze is denser, harder, and more transparent than rime. Its density may be as high as 0.9 g/cm^3. Factors that favour glaze formation are large drop size, rapid accretion, slight supercooling, and slow dissipation of heat of fusion. The opposite effects favour rime formation. Glaze occurs when rain or drizzle freezes on objects, and is clear and nearly as dense as pure ice. Since glaze ice is more difficult to remove, it is structurally a more significant factor and will be the focus of this test.

2.2. EFFECTS OF THE ENVIRONMENT

Ice formation can impede materiel operation and survival and affect the safety of operating personnel by creating, as example, the following problems:

a. Binding moving parts together.

b. Adding weight to radar antennas, aerodynamic control surfaces, helicopter rotors, etc.

c. Increasing footing hazards for personnel.

d. Interfering with clearances between moving parts.

e. Inducing structural failures.

f. Reducing airflow efficiency as in cooling systems or filters.

g. Impeding visibility through windshields and optical devices.

h. Affecting transmission of electromagnetic radiation.

i. Providing a source of potential damage to equipment from the employment of mechanical, manual, or chemical ice removal measures.

j. Reducing efficiency of aerodynamic lifting and control surfaces.

k. Reducing (aircraft) stall margins.

2.3. TEST PROCEDURE

See Method 300 Chapters 1 and 8.

When an icing test is deemed necessary, the procedure included in this Method is considered suitable for most materiel.

2.4. CHOICE OF TEST SEVERITIES

See Method 300 Chapters 1, 4, and 8.

The test variables are test item configuration and orientation, air and test item temperature, water delivery method, droplet size, and ice thickness. The values chosen for the variables are primarily dependent on the intended use of the materiel.

2.4.1. Configuration and Orientation

The following factors are to be considered:

a. Should the test item receive icing on all sides and on top?

b. Should the test item be in its deployment configuration? If required, perform tests in other configurations such as for shipping or outside storage.

2.4.2. Test Temperature

Test temperatures that may be used to produce the required environmental conditions are recommended in the test procedure. The recommended temperatures of the chamber and water may have to be adjusted for different size facilities to prevent premature freezing of the water droplets before they come in contact with the test item. However, the initial test item temperature should not be below 0 °C to allow water to penetrate (cracks, seams, etc.) prior to freezing.

2.4.3. Water Delivery Rate

The objective is to produce a clear, uniform coating of glaze ice. Any delivery rate that produces a uniform coating of glaze ice is acceptable. A water delivery rate of 25 mm/hr has been suggested in the test procedure and is based on data from previous testing.

2.4.4. Water Delivery Method

Any of the following water delivery systems can be used as long as the water is delivered as a uniform spray:

a. Nozzle arrays directing spray to the top, sides, front, and rear of test item.

b. Nozzle arrays that direct spray straight down onto the test item. Sidespray coverage is achieved by using wind or an additional handheld nozzle. If wind is used it should be the minimum necessary to maintain uniform ice accretion.

c. A single nozzle directing the spray over the appropriate surfaces of the test item.

2.4.5. Droplet Size

The droplet size range may have to be adjusted for different size facilities. A fine spray in the range of 1.0 to 1.5 mm diameter nominal droplet size has produced satisfactory icing in some facilities.

2.4.6. Ice Thickness

Unless specifically measured data for the anticipated situation are available, the following ice thicknesses are recommended (reference c):

a. 6 mm: represents general conditions, light loading.

b. 13 mm: represents general conditions, medium loading.

c. 37 mm: represents heavy ground loading and marine mast loading.

d. 75 mm: represents extremely heavy ground loading and marine deck loading.

2.5. OPERATIONAL CONSIDERATIONS

a. Some materiel covered with ice may be expected to operate immediately without first undergoing de-icing procedures; other materiel would not be expected to operate until some form of de-icing has taken place (e.g., aircraft ailerons (flaps) prior to flight).

b. Ice removal, if required, may include built-in ice-removal systems, prescribed means that could be expected to be employed in the field, or a combination of these.

c. The correct operation of anti-ice systems such as pre-heated surfaces.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information derived from Method 300 Chapter 6, the following are required:

a. Ice thickness to be applied.

b. Ice removal method(s) (if employed).

c. Any variations from recommended test temperatures and droplet sizes.

d. Surfaces of the test item to which ice is to be applied.

e. Velocity of any wind used.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

In addition to having the characteristics specified in Method 300 Chapter 5, the chamber and drainage system should be arranged to minimize the collection of puddles / ice in the chamber. It is not necessary to use de-ionized or distilled water for this test. No rust or corrosive contaminants shall be imposed on the test item by the test facility.

4.2. CONTROLS

See Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTIONS

See Method 300 Chapter 7.

4.4. PROCEDURE

4.4.1. Preparation for Test

Before starting any of the test procedures, determine the information to be documented from Method 300 Chapters 4 and 6, and perform the pre-test standard ambient checkout specified in Method 300 Chapter 2. In addition:

a. Clean all outside surfaces of any contamination not present during normal operation. Even thin films of oil or grease will prevent ice from adhering to the test item and change the test results.

b. To facilitate measurement of ice thickness, depth gauges such as copper bars or tubes of an appropriate size shall be mounted in places where they will receive the same general waterspray as the test item. It is recommended that the gauges be mounted on the test item, particularly for large or rounded items where this may be the only way of verifying the thickness on the item. Other suitable thickness measurement techniques may be used.

> **NOTE:** Since artificially produced ice accretion rates tend to depend upon the distance between the test item and the spraying system, structures with large height variations, such as antenna masts, should have test bars placed at the different heights.

c. Water used in the spray system should be cooled to between 0 °C and 3 °C.

d. If difficulty is experienced in producing a satisfactory layer of glaze ice, it may be necessary to vary one or more of the parameters (i.e., water or test item temperature, spray rate, distance between the nozzles and the test item, etc.).

4.4.2. Test Procedure

Step 1. Place the test item in the chamber and arrange the nozzles to produce ice on specified surfaces.

Step 2. Stabilise the test item temperature at 0 °C (-0/+2 °C).

Step 3. Deliver a uniform precooled water spray for 1 hour to allow water penetration into the test item crevices / openings (although a water temperature of 0 to 3 °C is ideal, a water temperature of 5 °C and a water delivery rate of 25 mm/hr has proven satisfactory).

Step 4. Adjust the chamber air temperature to -10 °C or as specified and maintain the waterspray rate until the required thickness of ice has accumulated on the appropriate surfaces. Wind or a side spray may be used to assist accumulation of ice on the sides of the test item.

> **NOTE:** It may be easier to stop spraying during the temperature reduction to facilitate temperature adjustment and to minimize frosting of test chamber refrigeration coils.

Step 5. Maintain the chamber air temperature for a minimum of 4 hours to allow the ice to harden. Examine for safety hazards and, if appropriate, attempt to operate the test item. Document the results (with photographs if necessary).

Step 6. If the specification allows ice removal, remove the ice. Limit the method of ice removal to that determined in paragraph 4 (e.g., built-in ice removal systems), plus expedient means that could be expected to be employed in the field. Note the effectiveness of ice removal techniques used.

Step 7. Examine for safety hazards and, if appropriate (and possible), attempt to operate the test item at the specified low operating temperature of the materiel.

Step 8. If required, repeat Steps 4–7 to produce other required thicknesses of ice.

Step 9. Stabilise the test item at standard ambient conditions and perform a post-test operational check.

Step 10. Document (with photographs if necessary) the results for comparison with pre-test data.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9.

The following guidance is provided to aid in failure analysis. In most cases the test item is considered to have failed if:

a. For materiel that must operate without ice removal, the performance of the test item has been degraded beyond that specified in the requirements document.

b. For materiel that requires ice removal before operation, the performance of the item has been degraded beyond the specified limits / requirements after normal ice-removal efforts have been undertaken.

c. Normal ice removal damages the materiel.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

In addition to the references given in Method 300 Chapter 10, the following are provided for background information:

a. EEC Directive 78/317/EEC, Motor Vehicles Defrosting and Demisting of Systems, August 1979.

b. Glossary of Meteorology, Edited by Ralph E. Huschke, Published by the American Meteorological Society (1959).

c. Letter, Cold Regions Research and Engineering Laboratory, Corps of Engineers (U.S.), CECRL-RG, 22 October 1990, SUBJECT: Ice Accretion Rates (Glaze).

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METHOD 312
LOW PRESSURE (ALTITUDE)

Method 312 has been moved to Method 301.

Method 312 is reserved for future use in subsequent editions.

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METHOD 313
SAND AND DUST

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The purpose of the Sand and Dust test method is to obtain data to evaluate the effects of the desert environmental conditions on material safety, integrity, and performance. Perform the small-particle dust ($\leq$149 μm) procedure to ascertain the ability of materiel to resist the effects of dust. Perform the blowing sand test procedure to determine if materiel can be stored and / or operated during blowing sand (150 to 850 μm particle size).

1.2. APPLICATION

This method is applicable to all materiel for which exposure to a dry, blowing sand or blowing, dust-laden atmosphere is anticipated.

1.3. LIMITATIONS

The scope of this method is laboratory testing, but can be tailored to item's specific test evaluation requirements. This method is not suitable for determining erosion of airborne (in flight) materiel because of the particle impact velocities involved, or for determining the effects of a build-up of electrostatic charge. This Method does not address sand or dust testing outdoors. Guidance for outdoor and commodity specific testing is provided in: Test Operations Procedure (TOP) 01-2-621 Outdoor Sand and Dust Testing; TOP 02-2-819 Sand Dust Testing of Wheeled and Tracked Vehicles; TOP 03-2-045 Small Arms - Hand and Shoulder Weapons and Machineguns; TOP 03-4-012 Desert Environmental (Sand and Dust) Testing of Vehicle-Mounted Primary and Secondary Automatic Weapon Systems, Up To 40mm; NATO AC/225 (LG/3-SG1)D/14 Evaluation Procedures for Future NATO Small Arms Weapon Systems. This method does not address aerosols other than dust. This method does not address settling dust. If settling dust is of concern, concentration levels can be obtained from International Electrotechnical Commission (IEC) 60721-2-5, and test procedures for settling dust can be obtained from IEC 60068-2-68 Test Lb. Human factors related to sand and dust exposure are not addressed.

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CHAPTER 2 TEST GUIDANCE

2.1. USE OF MEASURED DATA

1. 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 (LCEP), and information provided with this method. From these sources of information, determine the functions to be performed by the materiel in sand and dust environments, or following storage in such environments. Then determine the sand and dust concentrations of the geographical areas and micro-environments in which the materiel is designed to be employed. To do this, consider the following in light of the operational purpose and life cycle of the materiel.

2. Base the specific test conditions on field data if available. Consider the configuration of the test item (operational, storage, etc.) when selecting available field data. In the absence of field data, determine the test conditions from the applicable requirements documents. If this information is not available, use information in Chapter 3 and in the references of Chapter 7.

2.2. SEQUENCE

1. Use the Life Cycle Environmental Profile as a general guide, see Method 300, “General Guidance and Requirements” for additional information.

2. This method can produce a dust coating on, or severe abrasion of a test item, that could influence the results of other environmental test methods such as Solar Radiation (Method 305), Humidity (Method 306), Mould Growth (Method 308), Contamination by Fluids (Method 314), and Salt Fog (Method 309). Therefore, use judgement to determine the sequence of tests. The presence of dust in combination with other environmental parameters can induce corrosion or mould growth. A warm, humid environment can cause corrosion in the presence of chemically reactive dust.

3. If both sand and dust procedures are to be applied to the same test item, it is generally more appropriate to conduct the less damaging first (i.e., blowing dust and then blowing sand).

2.3. EFFECTS OF THE ENVIRONMENT

Although the blowing sand and dust environment is usually associated with hot-dry regions, it exists seasonally in most other regions. Naturally occurring sand and dust storms are an important factor in the deployment of materiel, but with the increased mechanisation of military operations, they can cause fewer problems than does sand and dust associated with man’s or battlefield activities.

Examples of problems that could occur as a result of exposure to blowing sand and dust are as follows; the list is not intended to be all-inclusive.

a. Abrasion and erosion of surfaces.

b. Penetration of seals.

c. Degraded performance of electrical circuits.

d. Obstruction / clogging of openings and filters.

e. Physical / interference with mating parts.

f. Fouling / interference of moving parts.

g. Reduction of heat transfer.

h. Interference with optical characteristics.

i. Overheating and fire hazard due to reduced / restricted ventilation or cooling.

j. Wear (increased fretting due to imbedding between mating surfaces).

k. Increased chaffing between non-mating contacting surfaces.

l. Weight gain, static / dynamic balance.

m. Attenuation of signal transmission.

2.4. CHOICE OF TEST PROCEDURE

This Method includes two laboratory (chamber) test procedures: Blowing Dust and Blowing Sand. Select the applicable procedure based on the materiel's intended deployment exposure and function.

2.4.1. Procedure I: Blowing Dust

Use this procedure to assess the ability of materiel to resist the effects of dust (<149 μm particle size) that may obstruct openings, abrade surfaces, penetrate into cracks, crevices, bearings and joints, and to evaluate the effectiveness of filters and protective covers that are designed to prevent dust intrusion. This method is also used to evaluate the reduction in heat transfer from dust accumulation such as fouling of cooling fins.

2.4.2. Procedure II: Blowing Sand

Use this procedure to determine if materiel can be stored and / or operated under blowing sand (150 to 850 μm particle size) conditions without degradation of performance, effectiveness, reliability, and maintainability due to the abrasion (erosion) or clogging effect of sharp-edged particles.

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CHAPTER 3 TEST SEVERITIES

3.1. GENERAL

After choosing the test procedure(s), determine the values of the test parameters and whether the test item is to operate during the test. In the absence of field data, use the following guidance.

3.2. TEMPERATURE

Unless otherwise specified, conduct the blowing sand and blowing dust tests with the test item at the high operating or storage temperature. In the absence of this information, perform the tests at, the maximum ambient air temperature for the A1 climatic category (Leaflet 2311) induced or meteorological, as required. A portion of the Blowing Dust test is also performed at Standard Laboratory Temperature to ensure that the equipment will perform across the temperature range. In some cases, the test plan may not require the test be performed at the two temperatures. In such case, it is recommended to perform the test at the higher temperature.

3.3. AIR VELOCITY

a. Blowing Dust. In the absence of specified values, the air velocities used in the blowing dust test procedure include an air velocity of no greater than 2.5 m/s to maintain test conditions, and a higher air velocity of 9 m/s ± 1.3 m/s typical of desert winds. Use other air velocities if representative of natural conditions and if the capabilities of the test chamber allow. The lower air speed during temperature conditioning is to ensure that airborne dust within the chamber is minimized and the pressure applied to the dust-laden test item due to wind speed is minimized during this period.

b. Blowing Sand. Winds of 18 m/s capable of blowing the large particle sand are common, while gusts up to 30 m/s are not unusual. If the air velocity around the materiel in its field application is known to be outside of this range, use the known velocity, otherwise select an air velocity in the range of 18 to 30 m/s for most blowing sand applications. Apply a tolerance of ±10 percent.

1. Ensure the sand particles impact the test item at velocities ranging from 18 to 30 m/s. In order for the particles to attain these velocities, maintain an approximate distance of 3 m from the sand injection point to the test item. Use other distances if it can be proven the particles achieve the necessary velocity at impact.

NOTE: For typical testing, uniform wind speeds are provided across the test area. If the test item is large and at ground level some consideration should be given to account for the wind profile from the ground to the test item height. See AECTP 230 for wind profiles found in nature.

2. Wind speed verification typically takes place prior to the testing. For this verification, the sampling rate for wind speed measurements will be a minimum of 4 samples per second. The steady state (sustained) wind speeds will be verified by averaging the wind speeds over 10 seconds with the wind generation equipment controls held constant. A gust is defined as a 3 second period at the level of increased wind speed. When performing a test with gusts, a minimum of four gusts per hour is recommended. The accuracy of wind measurement devices, such as cup, propeller, and hot wire anemometers, are negatively affected by the sand and dust environment; therefore, wind speed measurements should be taken in clean air with these devices. Variation in wind direction, or high turbulence, can also influence cup and propeller measurement accuracy.

3.4. SAND AND DUST COMPOSITION

A variety of materials are applicable for dust and sand testing, the selection depends on the test objectives (erosion, infiltration, electrical conductivity, etc.) and material availability. Material properties such as particle size, hardness, roundness. and sphericity, material composition must be considered against the test objectives. Quartz is a typical test material due to being chemically inert and available both as ground quartz (silica flour dust) and sand. Kaolinite (clay) based materials can be used to evaluate reaction with moisture or hydraulic fluids.

a. Blowing Dust

(1) Composition: Conduct the small particle (blowing dust) procedure with any of the following (by weight):

(a) Red China clay is common throughout much of the world and contains the following:

$CaCO_3$, $MgCO_3$, MgO, TiO_2, etc.	5 percent
Ferric oxide (Fe_2O_3)	10 ± 5 percent
Aluminium oxide (Al_2O_3)	20 ± 10 percent
Silicon dioxide (SiO_2)	remaining percentage

(b) Silica flour (ground quartz) has been widely used in dust testing and contains 97–99 percent (by weight) silicon dioxide (SiO_2).

(c) If other materials are used for dust testing, their particle size distribution may fall below that in paragraph 3.4.a.(2) below. Ensure material to be used is appropriate for the intended purpose and regions of the world being simulated. These materials for dust testing include:

- Talc (talcum powder) (hydrated magnesium silicate).

- F.E. (fire extinguisher powder composed mainly of sodium or potassium hydrogen carbonate with a small amount of magnesium stearate bonded to the surface of the particles in order to assist free-running and prevent clogging - must be used in dry conditions to prevent corrosive reaction and formation of new chemicals (reference c)).

- Undecomposed feldspar and olivine (that have similar properties to quartz).

- Portland cement, which must be kept dry to prevent solidification or corrosion.

WARNING: Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data. Exposure to silica flour (ground quartz) can cause silicosis; other materials may cause adverse health effects.

(2) Particle Size. Unless otherwise specified, use a particle size distribution of 100 percent of the material by weight less than 150 μm, with a median diameter (50 percent by weight) of 20 $\pm$ 5 μm. This dust is commonly referred to as a "140 mesh silica flour (ground silica)" (about 2 percent retained on a 140 mesh (106 μm) sieve), and should provide comparable results to prior test requirements. National documentation may contain other more specific distributions. ASTM D185-07, "Standard Test Methods for Coarse Particles in Pigments", provides a method for particle size measurements by sieve analysis. If particle size measurements are carried out using techniques other than sieve analysis, it must be demonstrated that the same results are produced.

a. Blowing Sand. Unless otherwise specified, for the large particle sand test, use quartz sand (at least 95 percent by weight SiO_2). Use sand with a sub-angular structure, a mean Krumbein (roundness and sphericity) number range of 0.5–0.7, and a hardness factor of 7 Mohs. If possible, determine the particle size distribution from the geographical region in which the materiel will be deployed. There are 90 deserts in the world, each with different particle size distributions. The recommended particle size distribution for the sand test is between 150 µm and 850 µm, with a mean of 90 percent ± 5 percent by weight smaller than 600 µm and larger than 149 µm, and as least 5 percent by weight 600 µm and larger. When materiel is designed for use in a region that is known to have an unusual or special sand requirement, analyse a sample of the local sand to determine the distribution of the material used in the test. Specify the details of its composition in the requirements documents.

WARNING: The same health hazard considerations as noted for the dust apply. Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data; exposure to crystalline silica can cause silicosis.

3.5. SAND AND DUST CONCENTRATIONS

a. Blowing Dust. Maintain the average dust concentration for the blowing dust test at 10.6 ± 7 g/m^3 unless otherwise specified. This concentration exceeds that normally associated with moving vehicles, aircraft, and troop movement, but has historically proven to be a reliable concentration for blowing dust tests using silica flour (ground quartz) material. If available, use a dust concentration based on natural environment data or other historical information to accurately represent the specific service condition.

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

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

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

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

NOTE: If the wind velocity is increased intermittently to simulate a gust it is permissible to allow the sand's feed rate to remain constant and the concentration to be reduced for this period of time of intermittent increase in wind speed.

3.6. ORIENTATION

a. Blowing Dust. Orient the test item such that the most vulnerable surfaces face the blowing dust. Rotate the test item as required to expose all vulnerable surfaces to equal portions of the total test time. When possible, evaluate the airflow around the test item in-service to determine required chamber boundary conditions to create similar airflow and cooling conditions. Consider removal of the dust accumulation during the reorientation of the test item. See paragraph 3.9.

b. Blowing Sand. Orient the test item with respect to the direction of the blowing sand such that the test item will experience maximum erosion effects in the fielded configuration. The test item may be re-oriented at 90-minute intervals. Consider the incident angle of sand particle impact on the severity of erosion in selecting orientations. When possible, evaluate the airflow around the test item in-service to determine required chamber boundary conditions to create similar airflow and cooling conditions.

3.7. DURATION

a. Blowing Dust. Unless otherwise specified, conduct the blowing dust test for 6 hours at standard laboratory temperatures and for 6 hours at the high storage or operating temperature. It is permissible to stop between the two 6-hour periods provided the humidity level is kept below 30 percent and all test conditions are restabilised prior to continuing. In some cases, the test plan may not require the test be performed at the two temperatures. In such case, it is recommended to perform the test for 6-hours at the higher temperature.

b. Blowing Sand. For blowing sand tests, 90 minutes per face is considered to be a minimum.

NOTE: If facility limitations do not allow for the coverage of an entire face of the test item, the length of overall exposure should be extended to allow for the equivalent amount of exposure that would be performed if the facility limitation did not exist. For example, if an item with four vulnerable sides is undergoing dust testing, but the facility can only cover half of each face, two exposures would be needed for each face. In this case the total time of testing would be doubled.

3.8. OPERATION DURING TEST

1. Determine the need to operate the test item during exposure to sand or dust from the anticipated in-service operational requirements. For example, continuously operate heat dissipating materiel while exposed to sand and dust environments if the item is expected to be operated continuously in the field. Certain materiel, although exposed to sand and dust environments while non-operating, may be operated only in an environmentally controlled shelter. Tailor the operating requirements in the test plan accordingly. Specify the time and periods of operation in the test plan. This schedule should normally contain at least one 10-minute period of continuous functioning of the test item during the last hour of the test, with the test item's most vulnerable surface facing the blowing sand or dust.

2. For test items that will be required to operate in the field for extended periods of time consider longer operational periods, up to the full period of dust exposure. Depending on the test item and the LCEP, repeated manipulation may be required between exposures to ensure proper operation. For example, the wear of hydraulic, pneumatic seals, or operator controls may not occur without repetitive use / manipulation of the equipment during testing.

3. Consider removal of the dust accumulation on the test item prior to the period of operation. See paragraph 3.9.

3.9. REMOVAL OF SAND AND DUST ACCUMULATIONS

1. Experience has shown that dust accumulations of 13 mm (0.5 inch) on the test item are not uncommon during the chamber dust exposure. This can create a condition that may not be experienced in the lifecycle of the test item. This layer of dust may form a protective layer over the seals. Removing the dust during the reorientation of the test item may provide a more realistic application of the fielded environment. If dust removal is to be performed, the item specific dust removal procedures shall be documented prior to test in the approved test plan.

2. In the event of an operational test this buildup of dust will reduce the ability of the test item to shed the thermal load generated by electronics. If dust accumulations are expected in the field perform the operational test without removing the dust. If the item will be routinely maintained or exposed to other environments (high winds, rain, etc.) that will mitigate dust build up consider removing the dust prior to operation.

3. Procedures for dust removal must reflect the in-service use in accordance with the field manual with the tools available in the field. Remove accumulated dust from the test item by brushing or wiping taking care to avoid introduction of additional dust or disturbing any that 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.

4. Photographs prior to and following the dust removal must be performed.

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CHAPTER 4 INFORMATION REQUIRED

4.1. INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTIONS

1. In addition to the information derived from Method 300, the following are required for these tests:

   a. Sand or dust composition.

   b. Sand or dust concentration.

   c. Test item orientation (incident angle).

   d. Time of exposure per orientation.

   e. Methods of sand and dust removal as used in service.

   f. Test temperatures.

   g. Air velocity.

2. The following may be required:

   a. Procedures for determining the test item's degradation due to abrasion.

   b. Operational Test Instructions including time period of operation and test item performance.

   c. Any additional parameters to be measured and recorded (i.e., weight, balance, fluid contamination, etc.).

   d. Any permitted deviations from the test procedure.

   e. Necessary variations in the basic test procedures to accommodate environments identified in the LCEP.

4.2. INFORMATION REQUIRED FOR VERIFICATION

4.2.1. Pre-Test

   a. General. Information listed in Method 300.

   b. Specific to this Method.

(1) Air velocity calibration of fan settings (if the velocity is not continuously measured and recorded). Any calibrations of feed rates or chamber checkouts required to prove proper application of the applied environment.

(2) Pre-test photographs of the item and test setup.

(3) Results of pre-test functional test. Record of air and test item temperature and humidity during pre-test functional test, if required.

(4) Thermocouple locations and photographs.

(5) Provide the composition and particle size distribution of the Sand and Dust.

4.2.2. During-Test

a. General. Information listed in Method 300.

b. Specific to this Method.

(1) Chamber Air and Test Item Temperature vs. Time for the entire test period.

(2) Photographic documentation prior to and following each change in test item orientation or cleaning.

(3) Durations of Blowing Sand or Dust exposure for each orientation.

(4) Photographic documentation showing the orientation of the test item with respect to the air flow.

(5) Documentation of operating and non-operating periods as well as any functional tests conducted.

(6) Document when thermal stabilization of the test item was achieved for the purpose of evaluating the duration of high temperature exposure.

(7) Any deviations from the original test plan.

c. Specific to Blowing Dust.

(1) Relative Humidity vs. Time.

(2) Dust Concentration vs. Time.

(3) Wind Speed vs. Time or record of measurements performed to calibrate wind speed just prior to the testing.

d. Specific to Blowing Sand.

(1) Sand Concentration vs. Time or record of measurements performed to calibrate sand concentration just prior to the testing.

(2) Wind Speed vs. Time or record of measurements performed to calibrate wind speed just prior to the testing.

4.2.3. Post-Test

a. General. Information listed in Method 300.

b. Specific to this Method.

(1) Results of each visual inspection. Detailed photographs.

(2) Documentation of the cleaning methods performed. Detailed photographs before and after cleaning methods are applied.

(3) Any deviations from the original test plan.

(4) Functional test results. Describe any anomalies.

(5) Documentation of any sand or dust intrusions.

(6) Documentation of abrasion areas.

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CHAPTER 5 TEST CONDITIONS AND PROCEDURES

See Method 300 for test facility, test conditions, and test control information.

5.1. PREPARATION FOR TEST

In addition to the information provided in Method 300, ensure the test item and facility are properly grounded to avoid build-up of an electrostatic charge and possible airborne dust explosions. Ensure that the plans are in place to gather the information required by paragraph 4.2. The following information is also appropriate.

5.2. TEST FACILITY

In order to provide adequate circulation of the sand or dust-laden air, do not occupy more than 50 percent of the test section’s cross-sectional area (normal to airflow) and 30 percent of the volume of the test chamber by the test item(s). The use of a chamber turntable reduces personnel exposure to airborne particulates when re-orienting the test item. For any test the material composition, particle shape, and particle size distribution should be documented from manufacturer supplied data or actual test facility measurement. Material properties can vary between production lots; thus, for long duration or repetitive / competitive tests the same lot should be used for successive tests.

5.2.1. Blowing Dust

a. Use a test facility that consists of a chamber and accessories to control dust concentration, velocity, temperature, and relative humidity of dust-laden air. Ensure that the dust is uniformly distributed in the air stream. Ensure that the air stream velocities are uniform. Ensure the chamber has a means of maintaining and verifying the concentration of dust in circulation. An acceptable means for doing this is by use of a properly calibrated opacity meter and standard light source. When using this method, ensure that the light source and opacity meter are kept free of dust accumulations and lens abrasion. Use of a dry-air purge system is a common methodology.

b. Use dust in this test as outlined in paragraph 3.3.

5.2.2. Blowing Sand

a. Control the sand feeder to emit the sand at the specified concentrations. To simulate the effects produced in the field, locate the feeder in such a manner as to ensure the sand is approximately uniformly suspended in the air stream when it strikes the test item. Ensure that the air stream velocities are uniform.

b. Because of the abrasive characteristics of blowing sand, it is not recommended that the sand be recirculated through the fan or air conditioning equipment. Instead, it should be separated from the air downstream from the test item.

5.3. INSTALLATION CONDITIONS OF THE TEST ITEM

1. The configuration of the test item will affect the test results. Use the anticipated configuration of the materiel in the lifecycle environmental profile. As a minimum, consider the following configurations:

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

b. Deployed in the fielded configuration.

2. Grounding of the test items should be performed to avoid buildup of electrostatic energy. If available, ground the item using existing test item ground points or those designated by the test item design documentation.

3. For the blowing sand test, calibrate the sand dispensing system for the sand concentration specified in the test plan, and adjust the air supply or test item position to obtain the specified air velocity at the test item when it is located a minimum of 3 metres from the sand injection point.

4. If not previously accomplished, measure the sand concentration and wind velocity over the test cross sectional area to ensure uniformity.

5. For blowing sand and blowing dust tests, if operation is required, this is typically performed on the face of the test item deemed most vulnerable during the final exposure at each test temperature.

5.4. TOLERANCES AND RELATED CHARACTERISTICS

The uniformity of the dust and sand in the air stream as well as the wind speeds should be measured and documented. The test tolerances in Table 1 provide the tolerances on the average of the sand concentration, dust concentration, and wind speeds measured at sufficient number of points to ensure uniformity across cross sectional test area.

Table 1: Test Tolerances

Measurement	Sand	Dust
Concentration	see paragraph 3.4	±7 g/m^3
Wind Speed	±10%	±1.3 m/s
Air Temperature	±2 °C	±2 °C
Relative Humidity	0 to 30%	0 to 30%

5.5. CONTROLS

a. In addition to the controls specified in Method 300, control the test chamber relative humidity so that it does not exceed 30 percent because higher levels may cause caking of dust particles.

b. For the blowing sand test, continuously measure the humidity and temperature during the test. Verify the air velocity and sand concentration prior to testing by determining the sand feed rate using the following formula:

Feed Rate = (Concentration) x (Area) x (Velocity)

Where:

Feed Rate = mass of sand introduced into the test chamber per set time interval

Concentration = sand concentration required by the test plan

Area = cross-sectional area of the sand laden wind stream at the test item's location

Velocity = average velocity of air across the cross-sectional area at the test item's location

5.6. TEST INTERRUPTIONS

Test interruptions can result from a number of situations that are described in the following paragraphs. See Method 300 for additional information.

5.6.1. Interruption Due to Laboratory Equipment Malfunction

1. Specific to this Method. When interruptions are due to failure of the laboratory equipment, analyse the failure to determine root cause. If the test item was not subjected to an over-test condition as a result of the equipment failure, repair the test equipment or move to alternate test equipment and resume testing from the point of interruption. Assuming test parameters are within test tolerances, the abrasion, penetration, and collection of sand and dust are cumulative effects that are not affected by premature test stoppage. Re-establish appropriate test conditions and continue from the point of interruption.

2. If the test item was subjected to an over-test condition as a result of the equipment's failure, notify the test engineer or program engineer responsible for the test materiel immediately. Following exposure to excessive sand or dust concentrations, remove as much of the accumulation as possible (as would be done in service) and continue from the point of interruption. If abrasion is of concern, either restart the test with a new test item or reduce the exposure period by using the concentration-time equivalency (assuming the over-test concentration rate is known).

5.6.2. Interruption Due to Test Materiel Operation Failure

Failure of the test materiel to operate as required during operational checks presents a situation with several possible options. Failure of subsystems often has varying degrees of importance in evaluation of the test materiel integrity. Selection of one or more options from a–c below will be test specific.

a. The preferable option is to replace the test item with a “new” one and restart the entire test.

b. An alternative is to replace / repair the failed or non-functioning component or assembly with one that functions as intended, and restart the entire test. Conduct a risk analysis prior to proceeding since this option places an over-test condition on the entire test item, except for the replaced component. If the non-functioning component or subsystem is a line replaceable unit (LRU) whose life cycle is less than that of the system test being conducted, it may be allowable to substitute the LRU and proceed from the point of interruption.

c. For many system level tests involving either very expensive or unique materiel, it may not be possible to acquire additional hardware for re-test based on a single subsystem failure. For such cases, perform a risk assessment by the organization responsible for the system under test to determine if replacement of the failed subsystem and resumption of the test is an acceptable option. If such approval is provided, the failed component should be re-tested at the subcomponent level.

> **NOTE:** When evaluating failure interruptions, consider prior testing on the same test item and consequences of such.

5.6.3. Interruption Due to a Scheduled Event

There are often situations in which scheduled test interruptions will take place. The abrasion, penetration, and collection of sand and dust are cumulative effects that are not affected by test interruptions. Document all scheduled interruptions in the test plan and test report.

5.6.4. Interruption Due to Exceeding Test Tolerances

5.6.4.1. Under-Test Interruption

Follow any undertest interruption by reestablishing the prescribed test conditions and continue from the point of interruption.

5.6.4.2. Over-Test Interruption

If the test item was subjected to an over-test condition as a result of the test equipment's failure, notify the test engineer or program engineer responsible for the test materiel immediately. Following exposure to excessive sand concentrations, remove as much of the accumulation as possible (as would be done in service) and continue from the point of interruption. If abrasion is of concern, either restart the test with a new test item or reduce the exposure period by using the concentration-time equivalency (assuming the over-test concentration rate is known).

5.7. PROCEDURES

WARNING: The relatively dry test environment combined with the moving air, 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.

5.7.1. Procedure I: Blowing Dust

WARNING: Silica flour (ground quartz) or other dusts of similar particle size may present a health hazard. When using silica flour (ground quartz), ensure the chamber is functioning properly and not leaking; if a failure of containment is noted and personnel might have been exposed, air samples should be obtained and compared to the current threshold limit values of the national safety and health regulations. Chamber repair and / or other appropriate action must be taken before continuing use of the chamber. Care should be taken during all steps where exposure of personnel to the dust is possible.

5.7.1.1. Pre-Test Standard Ambient Checkout

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

Step 1. Conduct a complete visual examination of the test item with special attention to sealed areas and small / minute openings, and document the results.

Step 2. Prepare the test item in its operating configuration or as otherwise specified in the test plan. Install test item instrumentation as required by the test plan. When applying surface-mount thermocouples, minimize the coverage of the test item surface to the greatest extent possible.

Step 3. Position the test item as near the centre of the test chamber as possible and away from any other test item (if more than one item is being tested). Orient the test item to expose the most critical or vulnerable parts to the dust stream. Ensure the test item is grounded (either through direct contact with the test chamber or with a grounding strap).

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

Step 4. Stabilise the test item temperature at standard laboratory conditions.

Step 5. Conduct a functional test in accordance with the test plan and record results.

Step 6. 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 pre-test checkout.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety-critical materials. This is particularly applicable to energetic materials. See Method 300.

5.7.1.2. Blowing Dust Test Procedure

Step 1. With the test item in the chamber and stabilised at standard laboratory temperature (see paragraph 3.2), adjust the air velocity to the required value, determined from the test plan. Adjust the relative humidity to less than 30 percent and maintain it throughout the test.

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

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. If required, perform dust removal when the test item is reoriented. See paragraph 3.9. If required, operate the test item in accordance with the test plan. Otherwise proceed to Step 4.

SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.

Step 4. Stop the dust feed. (See paragraph 3.7.) If required, operate the test item in accordance with the test plan. Reduce the test section's air velocity to no greater than 2.5 m/s and adjust the temperature to the required high temperature (see paragraph 3.2), or as otherwise determined from the test plan. The rate of temperature change shall be no greater than 3 °C/min.

Step 5. Maintain the Step 4 conditions for a minimum of 1 hour following test item 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 the exposure for at least 6 hours or as otherwise specified. If required perform the following:

a. Periodically reorient the test item to expose other vulnerable faces to the dust stream.

b. Perform dust removal when the test item is reoriented. See paragraph 3.9. Take photographs prior to and following the dust removal.

c. Operate and / or manipulate the test item in accordance with the test plan.

SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.

Step 8. Stop the dust feed, stop or reduce the air speed to no greater than 2.5 m/s, and allow the test item to return to standard laboratory conditions at a rate not to exceed 3 °C/min. Stop any air flow and allow the dust to settle.

Step 9. Photograph the test item to document dust accumulation.

Step 10. Remove accumulated dust from the test item by brushing or wiping, taking care to avoid introduction of additional dust or disturbing any that may have already entered the test item. See paragraph 3.9. Do **NOT** remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.

SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.

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

Step 12. Perform a functional test in accordance with the approved test plan, and document the results for comparison with pre-test data. See Chapter 6 for evaluation of results.

Step 13. If required, clean the test item further to ensure that personnel that will be handling or occupying the test item are not exposed to unnecessary health hazards.

5.7.2. Procedure II: Blowing Sand

5.7.2.1. Pre-Test Standard Ambient Checkout

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

Step 1. Conduct a complete visual examination of the test item with special attention to sealed areas and small / minute openings, and document the results.

Step 2. Prepare the test item in its operating configuration or as otherwise specified in the test plan. Install test item instrumentation as required by the test plan. When applying surface-mount thermocouples, minimize the coverage of the test item surface to the greatest extent possible.

Step 3. Position the test item at the required distance from the sand injection point. Orient the test item to expose the most critical or vulnerable parts to the dust stream.

Step 4. Ensure the test item is grounded (either through direct contact with the test chamber or with a grounding strap).

NOTE: If required to change the orientation during the test, ensure that the instrumentation and fixtures will allow this to occur.

Step 4. Stabilise the test item temperature at standard laboratory conditions.

Step 5. Conduct a functional test in accordance with the test plan and record results.

Step 6. 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 pre-test checkout.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials. See Method 300.

5.7.2.2. Blowing Sand Test Procedure

Step 1. Increase the chamber temperature (at a rate not to exceed 3 °C/min) and stabilise the test item at the required high temperature (see paragraph 3.2), or as otherwise determined from the test plan.

Step 2. Adjust the air velocity to that required by the test plan.

Step 3. Adjust the sand feeder to obtain the sand mass flow rate determined from the pre-test calibration.

Step 4. Maintain the conditions of Steps 1–3 for the duration specified in test plan. If required, interrupt the blowing sand and reorient the test item at 90-minute intervals to expose all vulnerable faces to the blowing sand and repeat Steps 2–4.

Step 5. If functioning of the test item during the test is required, perform a functional test of the item during the last hour of the test and document the results. The functional test should be performed during the exposure of the most vulnerable face. If not, proceed to Step 6.

SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.

Step 6. Stop the sand feed. Allow the chamber air temperature to return to standard laboratory conditions at a rate not to exceed 3 °C/min. Stabilise the test item temperature. Stop any air flow through the chamber.

Step 7. Visually inspect the item looking for clogging effects, abrasion, and sand accumulation that may impede operation of the test item.

Step 8. Photograph the sand accumulation on the test item.

Step 9. 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 10. Visually inspect the test item looking for abrasion and clogging effects, and any evidence of sand penetration. Document the results.

Step 11. Conduct a functional test of the test item in accordance with the approved test plan and record results for comparison with pre-test data.

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CHAPTER 6 EVALUATION OF THE TEST RESULTS

In addition to the guidance provided in Method 300 the following are provided to assist in the evaluation of the test results. Determine if:

a. Sand or dust has penetrated the test item in sufficient quantity to cause binding, clogging, seizure, or blocking of moving parts, non-operation of contacts or relays, or the formation of electrically conductive paths with resulting short circuits.

b. Functional performance is within the specified requirements / tolerances.

c. Protective coatings or seals were compromised.

d. Abrasion of the test item exceeds the specified requirements.

e. The test item operates as required.

f. Air filters are clogged restricting air flow.

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CHAPTER 7 REFERENCES AND RELATED DOCUMENTS

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

b. Industrial Ventilation. A Manual of Recommended Practice. Committee on Industrial Ventilation, PO Box 16153, Lansing, MI 48901.

c. International Electrotechnical Commission Publication 60068-2-68, Test L, Dust and Sand and Test Lb, Settling Dust.

d. International Electrotechnical Commission Publication 60721-2-5, Classification of Environmental Conditions, Part 2: Environmental Conditions Appearing in Nature, Section 5: Dust, Sand, Salt Mist.

e. ASTM D185-07, Standard Test Methods for Coarse Particles in Pigments, 2012.

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

h. Test Operations Procedure (TOP) 01-2-621, Outdoor Sand and Dust Testing, June 2009.

i. TOP 02-2-819, Sand Dust Testing of Wheeled and Tracked Vehicles, 18 November 2009.

j. TOP 03-2-045, Small Arms - Hand and Shoulder Weapons and Machineguns, 24 June 2016.

k. TOP 03-4-012, Desert Environmental (Sand and Dust) Testing of Vehicle-Mounted Primary and Secondary Automatic Weapon Systems, Up To 40mm, 2 September 2004.

l. NATO AC/225 (LG/3-SG/1) D/14, Evaluation Procedures for Future NATO Small Arms Weapon Systems, 6 July 2001.

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METHOD 314
CONTAMINATION BY FLUIDS

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

To determine if materiel is unacceptably affected by temporary exposure to contaminating fluids (liquids) such as may be encountered during its life cycle, either occasionally,[4] intermittently,[5] or over extended periods.[6]

1.2. APPLICATION

Select the tests described in this Method when there is a high probability of fluid contamination during the materiel's lifecycle. Contamination may arise from exposure to fuels, hydraulic fluids, lubricating oils, solvents and cleaning fluids, de-icing and anti-freeze fluids, runway de-icers, insecticides, disinfectants, coolant dielectric fluid, and fire extinguishants.

WARNING: This method requires the use of substances and / or test procedures that may have an environmental impact or be injurious to health if adequate precautions are not taken. Additional information is provided in annex a. refer to the supplier's material safety data sheet (MSDS) or equivalent for health hazard data on the various chemicals used, and coordinate with local environmental authorities**.**

1.3. LIMITATIONS

This test is not intended to demonstrate the suitability of materiel to perform during continuous contact with a fluid (e.g., an immersed fuel pump), nor should it be used to demonstrate resistance to electrolytic corrosion.

[4] *Extraordinary/unusual circumstances occurring once or twice in a year.*
[5] *Regular basis under normal operation, possibly seasonally, over the life of the materiel.*
[6] *Long periods such that materiel is thoroughly exposed*.

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CHAPTER 2 TEST GUIDANCE

See Method 300 Chapters 1 and 8.

2.1. EFFECTS OF THE ENVIRONMENT

Examples of problems that could occur as a result of exposure to contaminating fluids are as follows, but the list is not intended to be all-inclusive and some of the examples may overlap.

a. Packaging failure.

b. Crazing or swelling of plastics and rubbers.

c. Leeching of antioxidants and other soluble materials.

d. Seal or gasket failures.

e. Adhesion failures.

f. Paint / legend removal.

g. Corrosion.

2.2. CONTAMINANT FLUID GROUPS

(See paragraph 2.5.1 below.)

The following groups of fluids are listed in Table 1. In addition to the guidance provided below, consider that personnel and / or their clothing may introduce the contaminant in areas not normally considered for direct contamination.

2.2.1. Fuels

Fuels will, for the most part, be of the gasoline or kerosene type, and whereas the former may be expected to evaporate rapidly, possibly with few permanently harmful effects, the latter—being more persistent—can be damaging to many elastomers, particularly at elevated temperatures. Fuels do not normally affect paints and most plastics, but silicone resin bonded boards may tend to de-laminate after prolonged exposure. Some fuels may have additives to inhibit icing or to dissipate static charges. Where there is reason to believe that these additives may increase the severity of the test, include them in the test fluids.

2.2.2. Hydraulic Fluids

Commonly used hydraulic fluids may be of the mineral oil or ester-based synthetic type, and may be at elevated temperatures in their working states. The latter are damaging to most elastomers and to plastics; phosphate esters are especially damaging to these materials and to paint finishes.

2.2.3. Lubricating Oils

Mineral or synthetic-based lubricating oils may be at elevated temperatures in their working states. Mineral oil is damaging to natural rubber but less so to synthetics such as polychloroprene, chloro-sulphonated polyethylene and silicone rubber. Synthetic lubricants are extremely damaging to plastics such as PVC as well as to many elastomers.

2.2.4. Solvents and Cleaning Fluids

Many areas of aircraft or vehicles may require dirt or grease removal before servicing can begin. The fluids given in Table 1 are representative of those presently in use.

2.2.5. De-icing and Anti-Freeze Fluids

These fluids may be applied, often at elevated temperatures, to the leading edges, intakes, etc. of aircraft and may penetrate areas where they can contaminate components and equipment. These fluids are based, typically, on inhibited ethylene glycols.

2.2.6. Runway De-Icers

These fluids are used on runways and other areas to lower the freezing point of water. They may penetrate undercarriage and equipment bays of aircraft as a fine mist.

2.2.7. Insecticides

Aircraft flying in and through the tropics may be treated with insecticide sprays as a routine precaution. To ensure that these will not have an adverse effect on materiel, it may be necessary to make exploratory tests using proprietary insecticides.

2.2.8. Disinfectants

The primary contaminating agent is likely to be the disinfectant used, which will be a formaldehyde / phenol preparation, and its use on waste liquid from galleys and toilet compartments, where a leak may permit contamination of materiel below the leak.

2.2.9. Coolant Dielectric Fluids

These are used as thermal transfer liquids to assist cooling of certain equipment. They are usually based on silicate ester materials, and their effects on materials may be considered to be similar to the phosphate ester hydraulic fluids, although not quite as severe.

2.2.10. Fire Extinguishants

Halon (chloro bromo fluoro hydrocarbon) or similar compounds are likely to be used on aircraft and will be relatively short-lived. Ground-based extinguishants are aqueous foams derived from fluoro chemicals or fluoroproteins. Their effects will be mainly due to water or buildup of trapped residues. The necessity for testing with these products is based on the need to maintain equipment functioning after release of the extinguishant.

2.3. CHOICE OF PROCEDURAL OPTIONS

See Method 300 Chapters 1 and 8.

The following are three exposure options provided in the test procedure: occasional contamination, intermittent contamination, and extended contamination. The requirements document should specify the option to be used based on the anticipated life cycle scenario, along with the order of application of the test fluids if more than one is required.

2.4. SEQUENCE

Do not perform these tests prior to other climatic environmental tests because of potential effect of the contaminants or their removal by decontaminants.

2.5. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 1 and 8.

The most significant parameters used in this test method are the fluid to be used, the temperature and duration of exposure. It is also important in this test procedure to specify the operational configuration of the test item, as well as whether or not the test item is heat-dissipating during operation.

2.5.1. Test Fluid(s)

Select a test fluid(s) from those listed in Table 1 that is representative of that commonly encountered during the lifecycle. Each specified test fluid is the worst-case representative of a group of fluids and is the most likely to affect the performance of the materiel. In the requirements document list other fluids identified during the tailoring process as possible contaminants.

Service grades of fluids may be changed or modified with development formulations and equipment demands. Some may subsequently be found undesirable because of environmental or health and safety problems. Table 1 may be updated as necessary in the future.

2.5.2. Combination of Test Fluids

When more than one test fluid is to be applied, consider the following:

a. The need to assess the effect of the fluids individually, combined or in succession.

b. If the order of exposure to fluids in service is known, or if the order of exposure to fluids recognized as having synergistic effects is known and is realistic in service, specify this order.

c. If the test item should be cleaned between or after tests, or if a new test item should be used for each test fluid. Choice of cleaning fluid should not result in further contamination. Some of the specified test fluids may be used as cleaning fluids (e.g., aviation fuel, solvents, or cleaning fluids); otherwise, a fluid known to be used in normal cleaning procedures should be used.

2.5.3. Test Temperature

Use temperatures representative of the actual conditions under which fluid contamination can occur either intentionally or accidentally. The application of contaminating fluids could result in thermal shock as well as contamination effects.

2.5.3.1. Test Item Temperature

Use a test item temperature representative of the materiel temperature when exposed to the contaminating fluid. For example, materiel to be de-iced will most likely be at or below freezing; materiel exposed to hydraulic leaks while on tarmac may have surface temperatures above 50 °C.

2.5.3.2. Test Fluid Temperature

In most cases, use the temperature of the test fluid equal to its temperature during its most extreme operating condition. Design assessment may prove that other temperatures provide a more severe environment (e.g., longer exposure at lower temperatures because of slower evaporation). Table 1 includes worst-case test fluid temperatures.

2.5.3.3. Soak Temperature

In order for contamination effects to mature, a soak of the test item following contamination is necessary. The temperature of both the contaminating fluid and the materiel will, most likely, change during actual contamination situations. The post-contamination soak will not necessarily reflect the exposure scenario, but rather the worst-case effect(s) on the materiel. Accordingly, for the soak temperature, use the materiel's maximum life cycle temperature for the anticipated exposure situation.

2.5.4. Method of Application

The method of application of contaminating fluids should, if known, be the same as would occur during the life cycle of the materiel. If not known, consider an application no more severe than would be reasonably expected.

2.5.5. Soak Duration

Unless otherwise justified, expose the contaminated test item to the required soak temperature (paragraph 2.5.3.3) for a minimum of 96 hours.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to that provided in See Method 300 Chapters 4 and 6, following information shall be provided:

a. The test fluid(s) to be used and its temperature.

b. The method of test fluid application.

c. The soak (post-wetting) temperature and duration.

d. The cleaning / decontaminating fluids.

e. The sequence of test fluid applications and post-test cleaning instructions.

f. The type of exposure (i.e., occasional, intermittent, or extended).

g. Any requirement for long term surveillance and inspections.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions and test control information.

4.1. TEST FACILITY

In addition to the information provided in Method 300 Chapter 5, use a test facility that includes an enclosure, and a temperature-control mechanism designed to maintain the test item at a specified temperature. The contamination facility is a tank within the test enclosure (non-reactive with the contaminant) in which the test item is exposed to the selected contaminant by immersion, spraying, splashing, or brushing. Design the temperature control mechanism to maintain the test item at the specified temperature. When the flash point of the test fluid is lower than the test temperature, design the test facility to fire and explosion standards.

4.2. CONTROLS

In addition to the controls provided in Method 300 Chapters 3 and 4, ensure the test and cleaning (decontaminating) fluids are handled and disposed as required by local environmental and safety requirements. Some test fluid specifications are referenced in Table 1.

4.3. TEST INTERRUPTION

See Method 300 Chapter 11.

4.4. PROCEDURE

The following test procedure may be used to determine the resistance of the material to contaminating fluids. Conduct the operational checks after each exposure to each of the specified fluids.

4.4.1. Preparation for Test

Before starting the test procedure, determine the information specified in Method 300 Chapters 4 and 6, and perform the test preparation procedure specified in Method 300 Chapter 2. Unless otherwise specified, clean the test item to remove unrepresentative coatings or deposits of grease. If more than one fluid has been identified, determine if each is to be evaluated simultaneously or sequentially. If sequential testing is specified, specify in the requirements document any necessary cleaning method between tests for different contaminants.

4.4.2. Contamination Test Procedure

Step 1. Place the test item in its specified configuration (operational, storage, etc.) and place it in the test facility. If appropriate, the configuration may include appropriate electrical or mechanical connections.

Step 2. Stabilise the test item at the appropriate temperature for the identified contamination scenario (see paragraph 2.5.3.1).

Step 3. Stabilise the temperature of the specified fluid(s) to that determined from paragraph 2.5.3.2. If simultaneous application of more than one fluid is required, apply the fluid with the highest application temperature first, the next-highest next, and so on until all required fluids have been applied[7].

Step 4.

a. For occasional contamination, apply the specified fluid(s) (e.g., dip, spray, etc.) to the entire surface of the test item that is likely to be exposed.

b. For intermittent contamination, apply the specified fluid(s) (e.g., dip, spray, etc.) to the entire surface of the test item that is likely to be exposed. Repeat this procedure one or more times as necessary to maintain all the test item surfaces in a wetted condition for the period specified in the requirements document. If not specified, subject the test item to 3, 24-hour cycles, each cycle consisting of 8 hours in the wetted condition, followed by a drain period of 16 hours at the temperature specified in Step 2.

c. For extended contamination, immerse the test item in the specified fluid and maintain for the period specified in the requirements document. If not specified, the fluid temperature shall be as given in Table 1, and the duration of immersion shall be a minimum of 24 hours.

Step 5. Allow the test item to drain naturally. Shaking or wiping is not permitted but, if representative of service conditions, it may be rotated about any axis to allow for drainage from different positions.

[7] *Before mixing two or more fluids, ensure they are compatible and will not produce hazardous reactions.*

Step 6. Maintain the test item at the temperature determined in paragraph 2.5.3.1 for 8 hours (see Step 2).

Step 7. Stabilise the test item at standard ambient conditions.

Step 8. Visually examine the test item for degradation of materials, protective finishes and dimensional changes. Record results.

Step 9. If appropriate, conduct an operational check of the test item similar to that in Method 300 Chapter 2, and document the results for comparison with the pre-test data.

Step 10. If testing sequentially, repeat Steps 2–9 for each specified fluid.

Step 11. If specified, store the test item at standard ambient conditions to permit evaluation of any long-term effects.

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CHAPTER 5 EVALUATION OF TEST RESULTS

In addition to Method 300, Chapter 9, any contamination effects must be analysed for its immediate or potential (long term) effects on the proper functioning of the test item. Satisfactory operation immediately following this test is not the sole criterion for pass / fail.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. Defence Standard 42-40/Issue 1, Foam Liquids, Fire Extinguishing (Concentrates, Foam, Fire Extinguishing), UK Ministry of Defence.

b. Defence Standard 68-161/Issue 1, Dispensers, Insecticide Aerosol Flying Insect Killer, UK Ministry of Defence.

c. BS 6580:1992, Specification for Corrosion Inhibiting, Engine Coolant Concentrate ('Antifreeze'), British Standards Institute.

d. Defence Standard 79-17/Issue 2, Compound, Cleaning, Foaming, for Aircraft Surfaces, UK Ministry of Defence.

e. MIL-PRF-87252E, Coolant Fluid, Hydrolytically Stable, Dielectric, 21 March 2018 (U.S.).

f. Test Operations Procedure (TOP) 03-2-609, Chemical Compatibility of Nonmetallic Materials Used in Small Arms Systems, 12 February 1999; USATECOM, AMSTE-TM-T, APG, MD 21005-5055.

Table 1: Major Contaminant Fluid Groups and Test Fluids

Contaminant Fluid Group		Test Fluid	Test Fluid Temperature (±2°C) ***
Fuels	**Kerosene**	Aviation turbine fuel (JP-4 (NATO F-40), JP-5 (NATO F-44), JP-8 (NATO F-34), etc.)	**70**
	Diesel	DL-A, DL-1, DL-2 (ASTM D975)	**23**
	Gasoline (Piston engine)	ISO 1817, Test liquid B; ASTM 4814, Automotive spark ignition engine	**40***
Hydraulic oils	**Mineral oil based**	NATO H-520/NATO H-515; U.S. MIL-H-5606	**70**
	Phosphate ester based (synthetic)	ISO 1817, test liquid 103; U.S. MIL-H-46170 (FRH); NATO H-544	**70**
	Silicone based	Dimethyl silicone (ZX42; NATO S1714)	**70**
Lubricating oils	**Mineral based**	NATO 0-1176 (OMD 80); NATO Stock #4210 99 224 8369	**70**
	Internal combustion engines	MIL-PRF-2104, 15W40; NATO D-1236	**70**
	Ester based (synthetic)	ISO 1817, test liquid 101	**150**
Solvents & cleaning fluids		Propan-2-ol (isopropyl alcohol)	**50***
		1.1.1 - Trichloroethane/NATO H-515	**50**
		Denatured alcohol	**23***
		Cleaning compound for aircraft surfaces	**23**
De-icing & antifreeze fluids		Inhibited ethylene glycol (BS 6580) 80% and 50% solution in water (v/v); U.S. antifreeze MIL-A-46153 (NATO S-750)	**23**
Runway de-icers		25% urea/25% ethylene glycol in water (v/v)**	**23**
Insecticides		Insecticides	**23**
Disinfectant (heavy duty phenolics)		Clear, soluble phenolics, e.g., phenol or its derivatives dissolved in a surfactant and diluted with water to give a clear solution	**23**
		Black fluids, e.g., refined tar products dissolved in a carrier oil and emulsified with detergent	**23**
		White fluids, e.g., colloidal emulsions of refined coal tar products in water, usually containing a small amount of surfactant	**23**
Coolant dielectric fluid		Coolanol 25R (DTD 900/4931)	**70**
Fire extinguishants		Protein: NATO Stock #4210 99 224 6855	**23**
		Fluoroprotein: NATO Stock #4210 99 224 6854	**23**

* *Exceeds the critical flash 47point temperature; obtain expert advice.*
** *Subject to change; identified as environmental hazard.*
*** *See paragraph 2.5.3.2. Use these temperatures if no other information exists.*

ANNEX A ENVIRONMENTAL AND TOXICOLOGICAL CONSIDERATIONS

A.1. GASOLINE FUELS AND MINERAL / SYNTHETIC OILS

a. Open burning will produce environmental pollution.

b. Contact with the skin will promote de-fatting.

c. Ignition under certain circumstances will cause explosion.

d. Low flash point of gasoline (piston engine): -18 °C.

e. Spillage can cause contamination of waterways and underground water supplies. Three hundred litres of gasoline has the capacity to produce a surface film over one square kilometre of still water.

f. Carcinogenic chemicals such as benzene are present in fuels; oils often contain other toxic ingredients.

g. Tri alkyl phosphate is a typical synthetic hydraulic oil. Spillage can cause toxic pollution of waterways and underground water supplies.

A.2. SOLVENTS AND CLEANING FLUIDS

a. Propan-2-ol is flammable.

b. 1.1.1 Trichloroethane is currently being withdrawn from use because of its environmental impact when reacting with ozone. It is also believed to have mutagenic properties.

c. Denatured alcohol is both toxic and flammable. It is a mixture containing approximately 95 percent ethyl alcohol, 5 percent methyl alcohol, and minor ingredients such as pyridine.

d. Detergent made from biodegradable phosphates sodium sulphate and sodium carboxy methyl cellulose is a conventional laundry substance. Untreated discharge into waterways must be avoided.

A.3. DE-ICING AND ANTI-FREEZE FLUIDS

a. All aqueous solutions of ethylene glycol are toxic and the inclusion of 25 percent urea will promote the growth of algae.

b. 50 percent inhibited aqueous potassium acetate solution is commercially marketed and reputed to be a completely safe new alternative to the ethylene glycols. However, its interaction with aluminium alloys is less than satisfactory.

A.4. DISINFECTANT FORMULATIONS CONTAINING FORMALDEHYDE AND O-CRESOL (AS USED IN CHEMICAL TOILETS) WILL ATTACK AND BLISTER SKIN

A.5. COOLANT DIELECTRIC FLUID

a. Coolanol 25R is a silicate ester that can be hydrolysed to produce flammable products. The U.S. has withdrawn it from use.

b. The most recent coolants are based on polymerized alpha olefins that are both non-toxic and generally inert.

A.6. FIRE EXTINGUISHANTS

The propellant gases currently used to produce foaming are chloro fluoro hydrocarbons (CFCs). These react with ozone and are therefore environmentally destructive.

A.7. INSECTICIDES

Most insecticides may be regarded as toxic to man. If the delivery vehicle for the insecticide is a kerosene-type (fuel / oil) spray or mist, many of the features identified under paragraph 1 above will also apply.

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METHOD 315
FREEZE / THAW

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

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

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

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

1.2. APPLICATION

This test is applicable to materiel that will experience one or more excursions through freeze point while wet or in the presence of moisture (free water or vapour). See paragraph 2.2 for specific examples.

1.3. LIMITATIONS

This test is not intended to evaluate the effects of low temperature, thermal shock, rain, or icing. These may be determined by Methods 303, 304, 310, and 311 respectively.

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CHAPTER 2 TEST GUIDANCE

2.1. EFFECTS OF THE ENVIRONMENT

This test induces physical changes in or on the materiel of a transitory kind. Examples of problems that could occur during this test are as follows:

a. Distortion or binding of moving parts.

b. Failure of bonding materials.

c. Failure of seals.

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

e. Changes in characteristics of electrical components.

f. Electrical flashover / reduced insulation resistance.

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

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

2.2. TEST PROCEDURE

See Method 300 Chapters 1 and 8.

When a freeze / thaw test is deemed necessary, the procedures included in this method are considered suitable for most materiel. The following three procedures are included:

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

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

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

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

2.3. CHOICE OF TEST SEVERITIES

See Method 300 Chapters 4 and 8.

The most significant parameters to be specified for this test method are temperature, moisture level / form, test item configuration (operational or storage), and the number of freeze / thaw cycles.

2.3.1. Temperature Range

The temperatures used shall be within the storage or operational range of the test item. Normally, the temperature cycle ranges between + 5 °C and -10 °C for diurnal cycling effects, and -10 °C to standard ambient (Method 300 Chapter 3), but these can be varied as required to achieve the desired effects.

2.3.2. Moisture

Water used to create the test moisture may be drawn from local (clean) water sources. The moisture may be applied as a water vapour or free water (spray).

2.3.3. Test Item Configuration

See Method 300 Chapter 4.

2.3.4. Number of Cycles

A cycle is defined as a change from one thermal-moisture condition to another and back to the original condition. Unless otherwise specified in the test procedure, hold the test item at each condition for a minimum of one hour following temperature stabilization of the test item (Method 300 Chapter 4). Unless otherwise justified by the materiel's life cycle profile, apply the following minimum number of cycles:

a. Diurnal cycling effects (daily freeze-thaw): 5.

b. Cold-to-warm transfer (for free water or possible fogging): 3.

c. Warm-cold-warm (for freezing and melting): 1.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information derived from Method 300 Chapters 4 and 6, a brief scenario of service conditions should be provided to explain the intended simulation. Also, state the following:

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

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

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

d. The number of cycles to be used.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

In addition to the requirements specified in Method 300 Chapter 5, the use of two chambers is recommended for Procedures II and III in order to simulate the sudden temperature changes often associated with movement between outside ambient and indoor conditions. For procedures II and III, either a single chamber or combination of chambers is acceptable as long as the test procedure requirements are satisfied.

4.2. CONTROLS

See Method 300 Chapters 3 and 4.

4.3. TEST INTERRUPTIONS

See Method 300 Chapter 7.

4.4. PROCEDURES

4.4.1. Preparation for Test

a. Before starting the test procedure, determine the information specified in Method 300 Chapters 4 and 6, and perform the test preparation procedure specified in Method 300 Chapter 2.

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

c. Install thermocouples in / on the test item to measure temperature stabilization and surface temperatures.

4.4.2. Procedure I: Diurnal Cycling Effects

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

Step 2. Place the test item in the test chamber at standard ambient conditions and in the required configuration. Spray the test item sufficient to fill any horizontal pockets to simulate water collected during a rainstorm.

Step 3. Reduce the temperature inside the chamber to 10 °C below the freeze point or as otherwise specified for the initial conditions at a rate not exceeding 3 °C per minute. Maintain the condition for a minimum of one hour after the test item temperature has stabilised.

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

Step 5. When the test item surface temperature reaches 0 °C, ensure frost has formed on the test item's surfaces. If so, go to Step 6; if not, repeat Steps 3 and 4 using a faster heating rate.

Step 6. Continue raising the test chamber towards a test item's surface temperature of 4 °C (water at maximum density) until the frost just melts, then reduce the temperature linearly to 10 °C below the freeze point over a period of three hours. Maintain the conditions for a minimum of one hour following test item temperature stabilization.

Step 7. Repeat Steps 4-6 as required to complete the number of cycles identified in paragraph 2.3.4.

Step 8. Maintain the chamber and test item at the low temperature conditions until a visual examination and / or performance checks have been completed.

Step 9. Return the test item to standard ambient conditions. Perform a complete visual and operational check, and document the results.

4.4.3. Procedure II: Cold-to-Warm Transfer

Step 1. Remove unrepresentative coatings and contaminants such as oils, grease, and dirt that could affect the formation of condensation.

Step 2. Place the test item in the test chamber at standard ambient conditions and in the required configuration.

Step 3. Adjust the chamber temperature to 10 °C below the freezing point or as otherwise specified for the initial conditions at a rate not exceeding 3 °C per minute. Maintain the condition until the test item's temperature has stabilised plus 1 hour.

Step 4. Transfer the test item to another chamber (previously adjusted to the upper specified temperature) as quickly as possible such that condensation / fogging occurs. The use of insulated transport containers is recommended. This second chamber should be maintained at the specified upper temperature (usually room ambient) with a relative humidity of 95 ± 5 percent.

Step 5. Start operation and any performance tests of the test item 60 ± 15 seconds after completion of the transfer, and document results.

Step 6. Return the test item to the low temperature chamber and repeat Steps 3–5 as required to complete the number of cycles identified in paragraph 2.3.5.

Step 7. Return the test item to standard ambient conditions. Perform a complete visual and operational check, and document the results.

4.4.4. Procedure III: Rapid Temperature Change

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

Step 2. Place the test item in the test chamber at standard ambient conditions and in the required configuration.

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

Step 4. Transfer the test item as quickly as possible and in not more than 5 minutes to another chamber stabilised at 10 °C below the freeze point. The use of insulated transport containers is recommended. Stabilise the test item temperature and hold for 1 additional hour.

Step 5. Unless otherwise specified, perform an operational check.

Step 6. If more than one cycle is required, stabilise the test item at room ambient temperature and at a RH of 95 percent as in Step 3, note the presence of any free water, and repeat Step 4.

Step 7. Return the test item to above-freezing conditions as soon as possible.

Step 8. As any ice melts, note location(s) of free water.

Step 9. Perform an operational check and physical inspection, and document results.

Step 10. Adjust the test item to standard ambient conditions and repeat Steps 3–9 as necessary to verify prior results.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

See Method 300 Chapter 9.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

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METHOD 316
EXPLOSIVE ATMOSPHERE

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The explosive atmosphere test is performed to:

a. Demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition.

b. Demonstrate that an explosive or burning reaction occurring within encased equipment will be contained and will not propagate outside the test item.

1.2. APPLICATION

This method applies to all materiel designed for use in the vicinity of fuel-air explosive atmospheres associated with aircraft, automotive, and marine fuels at or above sea level. Procedure II specifically relates to atmospheres in a space in which flammable fluids or vapours exist, or can exist, either continuously or intermittently (e.g., in fuel tanks or within fuel systems). Note: Materiel tested to Procedure II is designed such that ignition of an explosive mixture is contained within the materiel without igniting the surrounding explosive atmosphere; and, during normal operation, or as a result of any fault, the temperature of any external surface will not rise to a level capable of causing ignition (including hermetically-sealed materiel). Use other explosive atmosphere safety tests (e.g., electrical or mine safety) if more appropriate.

1.3. LIMITATIONS

a. This test uses an explosive mixture that has a relatively low flash point that may not be representative of some actual fuel-air or aerosol (such as suspended dust) mixtures.

b. The explosive atmosphere test is a conservative test in that if the test item does not ignite the test fuel-air mixture, there is a low probability that the materiel will ignite prevailing fuel vapour mixtures in service. Conversely, the ignition of the test fuel-air mixture by the test item does not mean the materiel will always ignite fuel vapours that occur in actual use.

c. This test is not appropriate for altitudes above approximately 16 km where the lack of oxygen inhibits ignition.

d. Because this test is designed for electrical spark ignition, this method is not intended to demonstrate ignition due to high surface temperatures.

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CHAPTER 2 TEST GUIDANCE

2.1. EFFECTS OF THE ENVIRONMENT

Low levels of electrical energy discharge or electrical arcing by devices as simple as pocket transistor radios can ignite mixtures of fuel vapour and air. A "hot spot" on the surface of the case of a hermetically sealed, apparently inert materiel case can ignite fuel-air mixtures. Fuel vapours in confined spaces can be ignited by a low energy discharge such as a spark from a short-circuited flashlight cell, switch contacts, electrostatic discharge, etc.

2.2. CHOICE OF TEST PROCEDURE

See Method 300 Chapters 1 and 8.

2.2.1. Procedure I (Explosive Atmosphere)

May be used to determine the ability of all sealed and unsealed materiel to operate safely in a fuel-vapour laden environment.

2.2.2. Procedure II (Explosion Containment)

Is used to determine the ability of the test item's case or other enclosures to contain an explosion or flame that is a result of an internal materiel malfunction.

2.3. SEQUENCE

See Method 300 Chapter 8.

Considering the approach to conserve test item life by applying what are perceived to be the least damaging environments first, generally apply explosive atmosphere tests late in the test sequence. Vibration, shock, and temperature stresses may distort seals and reduce their effectiveness, thus making ignition of flammable atmospheres more likely. It is recommended that the test items first undergo vibration, shock, and / or temperature testing.

2.4. CHOICE OF TEST PARAMETERS

See Method 300 Chapters 4 and 8.

2.4.1. Fuel

Unless otherwise specified, use n-hexane as the test fuel, either reagent grade or 95 percent n-hexane with 5 percent other hexane isomers. This fuel is used because its ignition properties in flammable atmospheres are equal to or more sensitive than the similar properties of both 100/130 octane aviation gasoline, JP-4, and JP-8 jet engine fuel. Optimum mixtures of n-hexane and air will ignite from hot-spot temperatures as low as 223 °C, while optimum JP-4 fuel-air mixtures require a minimum temperature of 230 °C for auto-ignition, and 100/130 octane aviation gasoline and air requires 441 °C for hot-spot ignition. Minimum spark energy inputs for ignition of optimum fuel vapour and air mixtures are essentially the same for n-hexane and for 100/130-octane aviation gasoline. Much higher spark energy input is required to ignite JP-4 or JP-8 fuel and air mixtures. Use of fuels other than hexane is not recommended.

> **WARNING:** Due to the hazardous nature of the fuels used in this test, the Test Facility Operators must ensure that they comply with Local and National Regulations, especially with respect to the personal exposure levels, pollution, and hazardous material disposal.

2.4.2. Fuel-Vapour Mixture

Use a homogeneous fuel-air mixture in the correct fuel-air ratios for the explosive atmosphere test. Fuel weight calculated to total 3.8 percent by volume of the test atmosphere represents 1.8 stoichiometric equivalents of n-hexane in air, giving a mixture needing only minimum energy for ignition. This yields an air / vapour ratio (AVR) of 8.33 by weight.

a. Required information to determine fuel weight:

   (1) Chamber air temperature during the test.

   (2) Fuel temperature.

   (3) Specific gravity of n-hexane (see Figure 1).

   (4) Test altitude: maximum operating altitude and ambient ground (nominal).

   (5) Net volume of the test chamber: free volume less test item displacement expressed in litres.

b. Calculation of the volume of liquid n-hexane fuel for each test altitude:

Volume of 95 percent n-hexane (ml) =

$$(4.27x\,10^{-4})\left[\frac{(net\ chamber\ vol\ (liters))\ \ x\ \ (chamber\ pressure\ (pascals))}{(chamber\ temp\ (K))\ \ x\ \ (specific\ gravity\ of\ n\text{-}hexane)}\right]$$

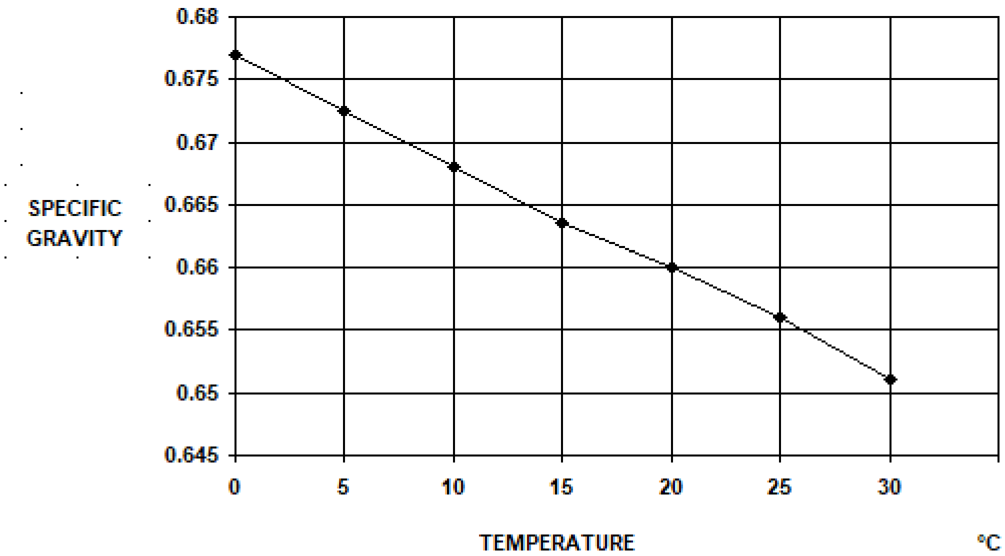

Figure 1: Specific Gravity of n-Hexane

2.4.3. Temperature

Heat the fuel-air mixture to the highest ambient air temperature at which the materiel is required to function during deployment and provide the greatest probability of ignition. Perform all testing at this maximum air temperature. For forced-air-cooled materiel, use the highest temperature at which the materiel can be operated and performance evaluated in the absence of cooling air as the test temperature.

2.4.4. Effect of Humidity on Flammable Atmosphere

The effect of humidity upon the fuel-air composition need not be considered in the test if the ambient air dewpoint temperature is 10 °C or less because this concentration of water vapour only increases the n-hexane fuel concentration from 3.82 percent to 3.85 percent of the test atmosphere. If the atmospheric pressure is cycled from an equivalent of 1525 metres above the test level to site pressure (a 17 percent change in pressure), the volume of n-hexane will decrease from 4.61 percent to 3.85 percent. This decrease will compensate for the fuel enrichment effect that results from water vapour dilution of the test air supply.

2.4.5. Altitude Simulation

The energy required to ignite a fuel mixture increases as pressure decreases. All test conditions will be met with two steps in a single explosive atmosphere test performed at the highest anticipated operating altitude of the materiel (not exceed 12,200 m where the possibility of an explosion begins to dissipate), and between 78 and 107 kPa (most ground ambient pressures).

2.5. DEFINITIONS

For the purpose of this Method, the following definitions apply:

a. Simulated altitude. Any height that is produced in the test chamber by reducing air pressure.

b. Test altitude. The nominal simulated height(s) above sea level at which the test item will be tested (i.e., the maximum altitude identified in paragraph 2.4.5).

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information specified in Method 300 Chapters 4 and 6, the following are required:

a. The fuel volume and / or weight.

b. The quantity of fuel required at each test point.

c. The off / on cycling rate for the test item.

d. Any information relative to the location of spark-emitting devices or high temperature components.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test facility, test conditions, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5.

Use a chamber with a means of igniting the fuel-air mixture such as a spark-gap device, as well as a means of determining the explosiveness of a sample of the mixture such as a spark-gap or glow plug ignition source with sufficient energy to ignite a 3.82-percent hexane mixture. An alternative method of determining the explosive characteristics of the vapour is by using a calibrated explosive gas meter that verifies the degree of explosiveness and the concentration of the fuel-air mixture.

4.2. CONTROLS

See General Guidance and Requirements, paragraph 10 and consider the following.

4.3. TEST INTERRUPTION

See Method 300 Chapter 7.

If there is an unscheduled undertest interruption, restore the chamber air pressure to ground ambient pressure and purge the chamber to remove the flammable atmosphere. Inject the required volume of n-hexane and reinitiate the test using the same test item.

4.4. PROCEDURE

4.4.1. Preparation for Test

Before starting the test procedure, determine the information specified in Method 300 Chapters 4 and 6. Perform the test preparation procedure specified in Method 300 Chapter 2, and include the following:

a. For test item’s thermal stabilization measurements for both procedures, install thermocouples on the most massive functional part of the test item, and two thermocouples attached to the inside of the test chamber to detect any temperature increase due to burning of the mixture.

b. Procedure I

(1) Install the test item in the test chamber in such a manner that it may be functioned and controlled from the exterior of the chamber via sealed cable ports. Remove or loosen the external covers of the test item to facilitate the penetration of the explosive mixture. Test items requiring connection between two or more units may, because of size limitations, have to be tested independently. In this case, extend any interconnections through the cable ports.

(2) Function the test item to determine correct operation. If possible, identify the location of any sparking or high temperature components that could cause an explosion.

(3) When necessary, simulate in-service mechanical loads on drive assemblies and servo-mechanical systems, and electrical loads on switches and relays; duplicate torque, voltage, current, inductive reactance, etc. In all instances, operate the test item in a manner representative of service use.

c. Procedure II

(1) Make provision to circulate the fuel-air mixture into the case being tested. In the case of forced-air-cooled materiel, the cooling air must contain the proper fuel-air mixture. For materiel not using forced-air cooling, drill and tap the case for insertion of a hose from a blower (to insert the fuel-air mixture), as well as for an outlet hose connection. Take adequate precautions to prevent ignition of the ambient mixture by backfire or release of pressure through the supply or vent hose. Do not alter the case internal volume by more than ± 5 percent with any modification to facilitate the introduction of ignitable vapor.

(2) Provide a positive means of igniting the explosive mixture within the case. Drill or tap the case as necessary for a spark gap, or mount a spark gap internally. Ensure points of ignition are not be more that 12.5 mm from any vent holes or flame arresting devices; and, unless the design of the materiel makes this impractical, use as many points of ignition as are practical.

(3) To detect explosions within the case, insert a thermocouple into the case and attach it to a sensitive galvanometer outside the test chamber.

(4) Ensure the air within the test chamber has a water vapor dew point lower than 10 °C (see paragraph 2.4.4).

4.4.2. Operation in Explosive Atmosphere

Step 1. With the test item installed, seal the chamber and stabilise the test item and chamber inner walls to within 10 °C below the high operating temperature of the test item.

Step 2. Adjust the chamber air pressure to simulate the highest operating altitude of the materiel (not to exceed 12,200 m) plus 2,000 m to allow for introducing, vaporising, and mixing the fuel with the air as described in paragraph 2.4.2.

Step 3. Slowly introduce the required volume of n-hexane into the test chamber.

Step 4. Circulate the test atmosphere and continue to reduce the simulated chamber altitude for at least three minutes to allow for complete vaporisation of fuel and the development of a homogeneous mixture.

Step 5. At a pressure equivalent to 1000 m above the test altitude, verify the potential explosiveness of the air-vapour mixture by attempting to ignite a sample of the mixture taken from the test chamber using a spark plug ignition source with sufficient energy to ignite a 3.82 percent hexane mixture. If ignition does not occur, purge the chamber of the fuel vapour, and repeat Steps 1–4. An alternative method of determining the explosive characteristics of the vapour is by using a calibrated explosive gas meter that verifies the degree of explosiveness and the concentration of the fuel-air mixture.

Step 6. Function the test item and continue operation from this step until completion of Step 8. Ensure electrical contacts are actuated as frequently as reasonably possible.

Step 7. To ensure adequate mixing of the fuel and air, slowly decrease the simulated chamber altitude at a rate no faster than 100 metres per minute by bleeding air into the chamber.

Step 8. Stop decreasing the altitude at 1000 m below the test altitude, perform one last functional check and switch off power to the test item.

Step 9. Verify the potential explosiveness of the air-vapour mixture as in Step 5 above. If ignition does not occur, purge the chamber of the fuel vapour, and repeat the test from Step 1.

Step 10. Adjust the chamber air pressure to simulate the altitude at the ground level where the test is being performed plus 2000 metres to allow for introducing, vaporising and mixing the fuel with the air as described in 2.4.2.

Step 11. Slowly introduce the required volume of n-hexane into the test chamber for testing at ground level. If desired, introduction of the required volume of fuel can commence at any point following completion of Step 9.

Step 12. Circulate the test atmosphere and continue to reduce the simulated chamber altitude for at least three minutes to allow for complete vaporisation of fuel and the development of a homogeneous mixture.

Step 13. At a pressure equivalent to 1000 m above the ground altitude, verify the potential explosiveness of the air-vapour mixture as in Step 5 above, and repeat the necessary steps if ignition does not occur.

Step 14. Function the test item and continue operation from this step until completion of Step 16. Ensure electrical contacts are actuated as frequently as reasonably possible.

Step 15. To ensure adequate mixing of the fuel and air, slowly decrease the simulated chamber altitude at a rate no faster than 100 metres per minute by bleeding air into the chamber.

Step 16. Stop decreasing the altitude at ground pressure, perform one last functional check and switch off power to the test item.

Step 17. Verify the potential explosiveness of the air-vapour mixture as in Step 5 above. If ignition does not occur, purge the chamber and repeat Steps 10–17.

Step 18. Document test results as per paragraph 4.

4.4.3. Explosion Containment

Step 1. Place the test item or a model of the test item of the same volume and configuration within the case, and install the case in the explosion chamber.

Step 2. Ensure that the air within the test chamber has a water vapor dew point lower than 10 °C per paragraph 2.4.4.

Step 3. Seal the chamber with the test item inside, and raise the ambient air temperature inside the chamber to high operating temperature of the test item.

Step 4. When the temperature of the both the test item and the test chamber inner walls come to within 11 °C of the chamber ambient air temperature, reduce the chamber air pressure to 2000 m of simulated altitude above the site ambient pressure (i.e., ground level).

Step 5. Slowly introduce the required quantity of n-hexane into the test chamber to obtain an optimum fuel-vapor / air mixture, and then introduce it into the interior of the test item.

Step 6. Slowly decrease the simulated chamber altitude (no faster than 100 metres per minute) to return the pressure altitude to site ambient pressure (i.e., ground level).

Step 7. Energize the internal case ignition source and confirm the occurrence of an explosion within the test item using the installed thermocouple. If no explosion occurs, purge the chamber and the test item of all air / fuel vapor and return to Step 3.

Step 8. If the explosion inside the test item's case did not propagate to the fuel / air mixture outside the test item, repeat Steps 4–10 four times if the test item's case is not in excess of 0.02 times the chamber volume. If the test item volume is equal to or greater than 0.02 times the chamber volume, purge the chamber and test item of air / fuel vapor and repeat Steps 3–10 four times.

Step 9. Check the potential explosiveness of the air / fuel vapor mixture by attempting to ignite a sample of the mixture by a spark or glow plug. If the chamber sample does not ignite, purge the chamber of all air / fuel vapor mixture, and repeat the entire test from Step 3.

Step 10. Document the test results.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

In addition to that specified in Method 300 Chapter 9 for Procedure I, ignition of test fuel vapour constitutes failure of the test item. For Procedure II, propagation of flame to, or ignition of, a flammable atmosphere surrounding the test item when the test atmosphere within the enclosure or case of the test item is intentionally ignited, constitutes failure of the test. Apply any data relative to failure of a test item to meet the requirements of the materiel specifications to the test analysis.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

a. Haskin, W.L., Explosion-Proof Testing Techniques, 1963. ASD-TDR-62-1081. DTIC number AD-400-483.

b. Zabetakis, M.G., A.L. Furno, and G.W. Jones. "Minimum Spontaneous Ignition Temperatures of Combustibles in Air," Industrial and Engineering Chemistry 46 (1954), 2173-2178.

c. Washburn, E.W., ed. International Critical Tables of Numerical Data. Chemistry and Technology. Vol. III. New York: National Research Council/McGraw-Hill, 1928. pp 27-29.

d. Kuchta, J.M. Summary of Ignition Properties of Jet Fuels and Other 1975. AFAPL-TR-75-70, pp 9-14. DTIC number AD-A021-320.

e. ASTM E 380-79. Standard for Metric Practice.

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METHOD 317
COMBINED ENVIRONMENTS

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

The purpose of this test is to evaluate the synergistic effects of combinations of temperature, altitude, humidity, input electrical power, and vibration on materiel with regard to safety, integrity, and performance. The synergistic effects may induce failures that would not be exhibited during individual environment testing. Simultaneous replication of all environments during transport, storage, operation, and maintenance can be limited by test equipment's performance; however, the intent is to apply representative combinations of stresses to the materiel.

1.2. APPLICATION

NOTE: This method is not intended to be used in lieu of method 306 due to the cyclic and cumulative exposure required for humidity testing. Additionally, this method is not intended to be used in lieu of 301, 302, 303, and / or 401 unless properly tailored and authorised in the requirements documents.

a. This method is intended to evaluate the combined effects of three or more of the following environments: temperature, altitude, humidity, input electrical power, and vibration.

b. This method can be applied to all materiel, however it was originally developed for equipment installed on rotor or fixed wing aircraft / platforms. With tailoring, this method may be applicable to other platforms such as ground vehicles, support equipment, man-mounted equipment, etc.

c. This method is intended to evaluate materiel to be deployed in / on aircraft or ground equipment where temperature, altitude, humidity, input electrical power, and vibration, or any combination of these, may induce failures.

d. This method is primarily intended for actively powered materiel operated at altitude (i.e., aircraft and missile electrical / electronic equipment, mission equipment, electro-mechanical equipment, etc.). This method may be used for engineering development, for support of developmental and / or functional testing, and for other similar purposes.

1.3. LIMITATIONS

a. This method does not normally apply to unpowered materiel transported as cargo in an aircraft. To tailor this method for this application, methods 301, 302, 303, and the LCEP will need to be consulted.

b. The tailored test cycle should not include short duration vibration events or those that occur infrequently in the test cycle. These events include firing of on-board guns, extreme aircraft motion, and shock due to hard landings. Test for these events separately using the appropriate test method.

c. This method is not intended to be used for temperature / vibration testing, unrelated to the synergistic environmental test combinations detailed in paragraph 2.4. Refer to AECTP-400.

d. This method does not address materiel to be installed or operated in space vehicles, aircraft or missiles that fly at altitudes above 21,300 m (70,000 ft).

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CHAPTER 2 TEST GUIDANCE

2.1. USE OF MEASURED DATA

Having selected this method and based on the test item's requirements documents and the tailoring process, complete the tailoring process by identifying appropriate parameter levels and special test conditions and techniques for these procedures. Base selections on the requirements documents, the Life Cycle Environmental Profile (LCEP), and information provided within this procedure.

The intent is to identify synergistic environmental combinations from the LCEP and to develop a representative test profile to verify that the materiel operates properly throughout the LCEP derived environments within a single test. The relevant environments are temperature, altitude, humidity, cooling airflow, input electrical power, and vibration.

2.2. SEQUENCE

1. Use the LCEP as a general guide, see Method 300 and 400, “General Guidance and Requirements” for additional information.

2. Procedure I is intended to be used before final materiel designs are fixed. If vibration is performed separately from the remaining combined environments, consideration should be given to the sequence based on prestressing of the components prior to the combined environments test and the vibration testing. Recall that it is often recommended to perform high and low temperature testing prior to vibration and when feasible to combine, at a minimum, temperature with vibration.

2.3. EFFECTS OF THE ENVIRONMENT

Temperature, altitude, humidity, input electrical power, and vibration can combine synergistically to produce equipment failures. These synergistic effects may induce failures that would not be exhibited during testing of individual environments. In addition to unique effects, the synergistic environments may amplify the stress effects when compared to the effects of individual environments. The following list provides some examples which is not intended to be comprehensive. For additional examples refer to the stand-alone environmental test methods.

a. Shattering of glass vials and optical materiel.

b. Binding or loosening of moving parts.

c. Separation of constituents.

d. Performance degradation in electronic components due to parameter shifts.

e. Electronic optical (fogging) or mechanical failures due to rapid water or frost formation.

f. Cracking of solid pellets or grains in explosives.

g. Differential contraction or expansion of dissimilar materials.

h. Deformation or fracture of components.

i. Cracking of surface coatings.

j. Leakage of sealed compartments.

k. Failure due to inadequate heat dissipation resulting in overheating. .

l. Printed Circuit Card failures due to short circuiting.

m. Failure of Electromagnetic Interference (EMI) filters.

n. Errors due to input electrical power frequency or voltage variances.

2.4. CHOICE OF TEST PROCEDURE

This method includes the following three procedures:

a. Procedure I: Engineering Development (Section 5.7.2).

b. Procedure II: Mission Support (Section 5.7.3).

c. Procedure III: Platform Envelope (Section 5.7.4).

While all of the procedures cover the same forcing functions, they differ on the basis of test severity, combination of forcing functions, and applicable mission(s) as defined in the following:

a. Procedures I and III: These procedures encompass the full operational envelope as defined by the equipment LCEP, the platform / equipment specification, and as further defined for the current / projected installation location(s). The stress levels used in Procedure I may exceed the LCEP parameters in order to establish design margins. The stress levels used in Procedure III would apply to a test item with a more mature design and would incorporate the specification test levels, to include the maximum range of climatic, input electrical power, vibration, and operational modes / conditions.

b. Procedure II: This procedure is constrained to the climatic, dynamic, and operational parameters defined for a specific geophysical and climatic area / model. This is further defined by the specific micro-environment in which the equipment operates (equipment bay, cockpit, etc.), local electrical power quality, and operational modes. Test results are relevant only for operation within the specified envelope.

2.4.1. Procedure I: Engineering Development

Use Procedure I to help find design defects in new or modified equipment while it is still in the development stage. A combined environment test is useful for this purpose since it will reveal synergistic failures. The primary purpose of this test is to uncover any anomaly, with the exact cause being secondary. A root cause analysis is then performed to determine the corrective action. Subsequent testing, to aid in the root cause analysis, may be enhanced by using higher stress levels than the item is likely to encounter on a regular basis in the field. Test parameters may be chosen to emphasize specific environmental effects. However, using limited environments and stressing materiel items beyond realistic limits may induce failures that would not occur under realistic conditions. Given these cautions, perform the Procedure I steps specified in the Test Parameter Selection / Profile Development Table (Table 8).

2.4.2. Procedure II: Mission Support

This procedure is performed in preparation for a specific mission scenario or functional testing; and is also for troubleshooting of fielded materiel exhibiting specific mission problems. This can include issues which only occur during specific combined environment(s), and which may be resolved when these conditions no longer exist. Its purpose is to use laboratory conditions to evaluate and resolve materiel issues pertinent to specific mission scenarios and to resolve issues prior to resumption of flight testing of developmental or fielded materiel. In addition, this procedure can be used where a standard qualification process is not feasible due to deployment schedule constraints (i.e., urgent user needs). These types of programs require performance during specific missions but normally are not required to operate to the full platform envelope.

This test is not accelerated; the damage accumulation in the test should be no faster than in operational or in-flight testing. Therefore, development hardware can be interchanged between laboratory and flight or functional testing. In general, use a test duration representative of the design mission or, if troubleshooting, sufficient to identify materiel problem (may be iterative). For troubleshooting it may be necessary to replicate the life cycle history of the materiel. This procedure is not intended to be used in lieu of Procedure III. Perform the Procedure II steps specified in the Test Parameter / Profile Development Table (Table 8).

2.4.3. Procedure III: Platform Envelope Test

The Platform Envelope test is intended to demonstrate compliance with specific platform / equipment specification requirements of combined synergetic environmental conditions. This testing emphasizes the most significant environmental stress conditions and combination of stress conditions in accordance with the operational envelope of the planned platforms as determined by the LCEP, specification, and developmental maturity of the materiel. The platform envelope test includes the maximum amplitude of each stress and any unique combinations of stress types. The intent is to demonstrate maximum conditions that the platform(s) may expose the materiel to. Use a test duration of a minimum of 10 cycles. Additional cycles may be conducted, but platforms are rarely exposed to their maximum envelope conditions and a failure discovered in subsequent cycles may be caused by unrealistic extended exposures.

CHAPTER 3 SEVERITIES

3.1. GENERAL

The intent is to identify all synergistic environmental combinations from the LCEP and to develop a representative test profile to verify that the materiel operates properly throughout the LCEP derived environments, within a single test. The typical relevant environments are temperature, altitude, humidity, input electrical power, and vibration.

The combined environment testing which includes temperature, humidity, and / or altitude change rates shall be completed in a single climatic chamber to accurately replicate the specified environment. Test items shall not be transferred between chambers due to equipment capability limitations. In addition, transfer from one chamber to another during the test may result in unintended environmental stresses.

Determine test levels for each portion of the mission profile in the manner described in paragraphs that follow. Other information, such as engine’s revolutions per minute (RPM) or data on the platform's system environmental control system (ECS) may be needed.

3.2. THERMAL STRESS

Materiel thermal stress is dependent upon the localized ambient temperature, induced / contributing thermal influences (solar, reflected radiation, adjacent heat generating equipment, test item heat generation, etc.), altitude, and humidity conditions in the equipment location. The equipment location may be either external or an internal compartment or bay. Contributing factors, such as flight conditions, power requirements, and the performance of supplemental cooling to the materiel are to be considered. Thermal stresses shall consider steady state conditions, transition temperatures, ramp rates, and extremes for both operational and non-operational conditions.

a. Ambient worldwide climatic extremes are provided in AECTP-230. The ambient temperatures are based on data from standard meteorological instrument shelters. They represent free air temperatures in the shade about 1.5 meters above the ground. The materiel ground soak temperatures in each mission are not necessarily directly correlated to the meteorological data. Ground soak temperatures are influenced by the albedo of the material, solar radiation, reflected radiation, heat from adjacent equipment, etc. Temperatures at altitude represent actual extreme high and low measurements, compiled from multiple data measurements. They may not represent conditions at a specific geophysical location. When determining air temperature change rates during ascent or descent conditions, the proper adiabatic lapse rate for the local atmospheric conditions (dry or moist,) shall be used. In addition to the highest / lowest recorded values, AECTP-230 includes the 1 percent frequency of occurrence values for high and low temperatures at altitude. Military Handbook

(MIL-HDBK)-310 provides the 5, 10, and 20 percent values. If used in preparing a thermodynamics analysis, then additional forcing functions (direct solar radiation, reflected radiation, adjacent equipment, etc.) must also be included in the analysis. The materiel thermal response during the transition from ground soak (non-operational / standby) conditions to operational conditions will demonstrate a thermal lag where the equipment temperature will lag the ambient temperature based on the equipment mass, material, and airflow conditions.

b. The environmental test conditions for any test item are dependent on the local thermal environment, including the type of local cooling (supplemental cooling air, ram air, convective cooling, etc.), induced heating from solar radiation and other thermal radiators (engines, exhaust ducts, adjacent equipment, etc.), and heated air from adjacent convectively cooled equipment.

c. The thermal stress test parameters to be used in performance of Procedure II - Mission Support are derived from the specific mission segments of the selected platform flight profile. For troubleshooting of fielded materiel exhibiting specific mission problems, select the thermal environment of the mission segment(s) in which the problem exists. For mission unique programs, which will operate in specific geophysical areas, select all of the thermal conditions throughout the entire flight profile. Use of measured temperature from the platform is preferable. Use natural temperature conditions derived from standard atmospheric models and induced temperatures due to air friction against the platform exterior and / or solar loading for materiel that is mounted externally to the platform. If data are not available for bay / compartment temperatures, perform an analysis of typical Environmental Control Systems, induced, and natural conditions or obtain / acquire measured data for the area of concern. Many modern electronic avionic equipment record internal component temperatures and can be used to analyse the temperature conditions during testing of the bay or cabin compartment. By adjusting the chamber air temperature conditions with the equipment operating in the same operational mode, match the response temperature of the equipment as it would be in-flight. Choose the climatic region, Basic, Hot, Cold, Severe Cold, and Coastal / Ocean and use the 20 percent frequency of occurrence temperature for day or night as starting points for ground conditions of start-up, taxi, take-off, and landing or measured data at the platform sight.

d. The thermal stress test parameters to be used in performance of Procedure III - Platform Envelope are derived from the equipment / platform performance specifications and the LCEP. For equipment which is operated only during specific segments of the platform envelope, use the thermal parameters corresponding to the equipment's operational envelope. For equipment that is to be used on multiple platforms, use the worst-case parameters for those platforms. Use caution, when applying parameters from multiple platforms, do not apply unrealistic combinations of environmental conditions. The duration of the thermal stresses shall be sufficient for thermal stabilization and representative of the anticipated durations determined by the LCEP.

3.2.1. Bay Conditions

The effective air temperature within equipment bays must be determined in developing a test profile. Ram air will track the external temperature. Cold air at altitude may induce thermal shocks, and this condition must be considered when developing the test profile. For Environmental Control System (ECS) cooled equipment the ECS specification requirements must be met in regard to the cool down ramps and temperatures. See MIL-STD-2218 for additional information. See Table 1 for an F-15 supplemental cooling example.

a. Ram-air-cooled compartments. Use this section to determine the bay temperature for an avionics or system in a compartment that is ram-cooled. Use thermal analysis and / or thermal surveys to determine the effective air temperature in the compartment at specific altitude and temperature conditions. Determine the thermal stress in a ram-air-cooled compartment from the following relationship:

$$T_{eff} = T_{amb}[1 + 0.2M^2]$$

where:

T_{amb} = Ambient air temperature (K) at altitude being flown (Tables A-1, A-2, and A-3)

T_{eff} = Effective air temperature (K) as modified by air velocity cooling effects and used in the test cycle

M = Mach number being flown

b. Environmental Control System conditioned supplemental-air-cooled bay. Use this section to determine the thermal stress for an avionics system located in a bay that receives its cooling from the platform ECS. To the extent possible, the effects of the ECS should be simulated in the chamber. If the ECS cannot be simulated in the chamber, use thermal analysis and / or thermal survey data to determine the effective air temperature in the compartment at specific altitude and temperature conditions. Determine the mass flow rate and temperature of supplemental air for each break point in the mission profile. Model the onboard ECS in terms of its primary components such as pressure regulators, heat exchanger, turbo machines, water separator, etc. If the heat load from these systems is significant, include the mass flow rate being injected into the bay and the location of other systems in the calculation.

c. Materiel supplemental cooling thermal stress. Use this section to determine the effect for test items that require supplemental cooling from the platform. Evaluate the component for additional supplemental cooling not mentioned in the previous section. This cooling may be direct air or liquid cooling into the materiel or through a cold plate. For ECS that are open to the external environment, the mass flow rate shall be system temperature and mass flow rate parameters.

Table 1: Supplemental Cooling Air Parameters, F-15 Platform LCEP Example

EQUIPMENT BAYS	Min Temp °C (°F)	Min Oper Temp °C (°F)	Max Temp °C (°F)	Max Oper Temp °C (°F)	Max Humidity (RH)	Mass Flow Rate (KG/Min)
Supplementally Cooled Ram Air Cooled Unconditioned	-54 (-65) -54 (-65) -54 (-65)	-40 (-40) -40 (-40) -40 (-40)	60 (140) 60 (140) 60 (140)	54 (129) 54 (129) 54 (129)	75% at 43 °C	--- --- ---
CREW STATION						
Open Areas Behind Instrument Panels	-54 (-65) -54 (-65)	-40 (-40) -40 (-40)	60 (140) 100 (212)	25 (77) 100 (212)	75% at 43 °C	--- ---
Supplemental Cooling Airflow to Materiel	-51 (-60)	-51 (-60)	-54 (-65)	-54 (-65)	75% at 43 °C	+0% of design -80% point

3.2.2. Aerodynamic or Kinetic Heating

Externally located high speed aircraft materiel, such as stores, is subject to aerodynamic heating effects. Thermal model development and validation should be performed to determine the test item temperatures in each segment of the test. See AECTP-230 and MIL-HDBK-1670 for additional guidance.

3.3. ALTITUDE STRESS

Use altitude simulation to evaluate the effect of various pressures (high or low) across the platform envelope throughout the LCEP. Method 301 addresses the effects of low pressure as an individual forcing function. This method addresses high and low pressure combined with temperature, humidity, and vibration if required.

For airborne materiel the pressure altitude has a direct effect on the thermal performance of the materiel (see paragraph 3.2.1 for additional information on bay conditions). Convective cooling is directly proportional to the density (mass per unit volume) of the surrounding air. At high altitude the air density is less; thus, the air mass available for convective cooling is diminished. This will result in higher operational temperatures. This also applies to equipment receiving cooling air via an ECS. For an open system, where the system is open to the natural environment, the air velocity may be constant; however, the air mass flow rate will be reduced in proportion to the pressure. When performing altitude tests on ECS conditioned equipment, care must be taken to match the mass flow rate with the appropriate altitude conditions. Variations in air pressure will affect both environmental and hermetic seals. Under normal operation the environmental seals will allow the passage of gases into and out of the materiel in order to equalize pressure (breathing). Rapid pressure changes may result in damage to, or complete failure, of environmental seals. Damage to Electromagnetic Interference (EMI) seals may also occur. Hermetic seals may rupture due to pressure variations. The air mass internal to the hermetic seal remains constant; however, as the external pressure drops, the pressure differential may result in the seal being ruptured. Altitude ramp rates must be controlled to avoid an over-test or under-test. Unrealistic ramp rates will result in unintended results. The ramp rates shall comply with the maximum platform altitude ramp rates. Ramp rates that do not meet these requirements will result in an invalid test.

Altitude stress in conjunction with humidity is highly dependent upon the atmospheric model(s) (reference Annex A, Tables A-1–A-3) in which the materiel is to be operated during its lifecycle. For worldwide deployment the combined worst-case parameters shall be used. See paragraph 3.4 for the description of the synergistic altitude / humidity effects.

Changes in atmospheric pressure and air density may also affect the electrical characteristics of components and between components. Changes in air density will result in a variable air dielectric field, resulting in changes in capacitance between and within components. For high voltage materiel this may result in corona effects and arcing. Some types of capacitors may swell due to decreased air pressure, resulting in changes to their capacitance.

The test site and test chamber capabilities must also be considered when performing altitude tests. Most materiel specifications require that the materiel operate from Mean Sea Level (MSL) to some maximum altitude. However, most altitude test chambers are designed such that the maximum pressure corresponds to the site ambient pressure. For pressure-sensitive material (altimeters, air data computers, pressure sensors, pressure switches, etc.), where it is required that testing be performed across the full operational pressure envelope, a test site, or test facility, shall be chosen that is capable of meeting the full pressure envelope of the material.

Table 2: Pressure vs. Altitude Conversion Equations

Equations for Pressure (P) in Pascals Versus Altitude (H)	
Altitude	Pressure Equation
0 km < H ≤ 11 km (0 ft < H ≤ 36.1 kft)	$P(Pa) = 101325 \left[\frac{288.15 - 6.5(H)}{288.15}\right]^{5.2558}$ $\left(P(Pa) = 101325 \left[\frac{288.15 - 1.9812 \cdot H}{288.15}\right]^{5.2558}\right)$
11 km < H < 20 km (36.1 kft < H < 65.62 kft)	$P(Pa) = 22632.41 \cdot exp\left[-\frac{(H - 11)}{6.34162}\right]$ $\left(P(Pa) = 22632.41 \cdot exp\left[-\frac{(H - 36.089)}{20.806}\right]\right)$
20 km < H < 32 km (65.62 kft < H <105 kft)	$P(Pa) = 5475.052 \left[\frac{216.65}{216.65 + (H - 20)}\right]^{34.16}$ $\left(P(Pa) = 5475.052 \left[\frac{216.65}{216.65 + (0.3048 \cdot H - 20)}\right]^{34.16}\right)$

Reference: U.S. Standard Atmosphere (1976)

3.4. HUMIDITY STRESS

Absolute humidity is the mass of water vapor in a specified volume of air. It may be expressed in many ways but is generally specified as grams/m^3 or parts of water vapor per million parts of dry air (ppm). Data for the highest and lowest worldwide absolute humidity is found in AECTP-230. Specific profiles for absolute humidity at altitude are found in MIL-HDBK-310. The dew point, the temperature at which condensation would occur if the air was cooled at constant pressure, is the observed meteorological element used to calculate the absolute humidity. Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity (which depends on the current air temperature). A reading of 100 percent relative humidity means that the air is totally saturated with water vapor and cannot hold any more. For a given volume of air, with a given absolute humidity, the relative humidity will increase as the temperature decreases until the dew point is reached. At that point the water vapor will condense out as liquid water.

Materiel ambient humidity effects are a function of humidity level, temperature, pressure, and exposure duration. Method 317's interest is water vapor condensation, liquid freezing, moisture absorption, and intrusion during materiel operation. Note that the materiel temperature may be lower than the ambient environment due to black body radiation. Liquid water pooling within electronic equipment has the potential to create short circuits, sneak circuits, and other adverse effects. The water may also subsequently freeze, and ice expansion may damage components, degrade seals, and lead to material delamination.

Aircraft operating in a warm / moist environment will increase retained moisture and on transition to a cold environment, climb to altitude, the water vapor will condense when the temperature drops to the dew point. Alternatively, during an aircraft transition from a cold / dry to a warm / moist environment, descent from altitude, the materiel temperature transition lags the ambient environment conditions. Ambient moisture will condense on and within the materiel cold surfaces. The intent is to simulate the aircraft ascent or descent through atmospheric temperature and humidity levels.

For materiel located within an ECS controlled environment, the efficiency of the water separator will be an important consideration during the test. ECS operation may result in high relative humidity (RH) due to chilling of the air. This will produce condensation if the dew point is exceeded. Characterization and replication of the ECS is essential in the development and validity of testing materiel in this environment. When the efficiency of the ECS is unknown, use the approximation technique in 3.2.1b.

For this test, whenever the cold day environment is being simulated, humidity will be uncontrolled, but less than or equal to the dew point temperature in Annex Table A-2. For the hot environment, dew point temperatures will be less or equal to values in Annex A-1. For the Warm / Moist day, dew point temperatures will be greater than or equal to the values in Annex Table A-3 up to 10 km (6.2 mi) altitude. Above 10 km (6.2 mi), the dew point temperature is less than or equal to the values in Annex Table A-2. If the platform has an ECS, the design specifications for the Warm / Moist day apply.

3.5. ELECTRICAL STRESS

Electrical stresses are expected deviations of the materiel's electric supply parameters from their nominal values at the materiel terminals. Every aircraft electrical power system is required to be designed to ensure the retention of the electrical characteristics as specified in the selected standard document, throughout the full range of operational and environmental conditions likely to be encountered in the aircraft in which it is installed. See STANAG 3456 for additional details. The test procedure must simulate to the required extent, all electrical stresses occurring during normal operation in service (mission profile) that contribute synergistically to the environments and appropriately demonstrate operation of the test materiel's functions at each test condition. It is not the purpose of this test to simulate extremes specified for special situations or to take the place of electrical stress tests. Simulate special conditions such as emergency operation of certain aircraft materiel within the electrical / electronic system only on request. Depending upon the requirements and the availability of data, the simulation may cover the range from the exact reproduction of the specific electric supply conditions within a special aircraft for a specific mission profile, down to a standardised simplified profile for generalized applications.

A significant percentage of the materiel life cycle occurs during maintenance operations, which may use ground power from ground support equipment. Ground support equipment normally replicates platform power, but input power measurements may be necessary if the equipment is sensitive to input power anomalies.

Consider the following conditions and effects to determine whether they affect the operation and reliability of the materiel to be tested.

a. AC system normal operation stresses.

b. Normal ON / OFF cycling of materiel operation.

c. DC system normal operation stresses.

d. Electrical stresses induced by mission-related transients within the electrical system.

e. Abnormal steady state stresses of voltage and frequency if the material is required to operate for safety of the mission or personnel.

f. Emergency steady-state stresses of voltage and frequency if the material is required to operate for safety of platform or personnel (flight-critical).

3.5.1. AC and DC System Normal Operation Stress

Voltage variations are quasi-steady changes in voltage from test cycle to test cycle. A suggested input voltage schedule would be to apply the input voltage at platform nominal voltage for the first test cycle, at the platform high normal voltage for the second test cycle, and at platform low normal voltage for the third test cycle. This cycling procedure would be repeated continuously throughout the test, with the last cycle performed at the nominal voltage. However, if troubleshooting, then use the power characteristics at which the failure or anomaly occurred, along with the other environmental conditions at the time of the anomaly.

For AC systems, the input electrical power frequency variations shall also be considered when developing the test cycle. The input power frequency will vary during normal operation due to variations in the generator’s RPM and platform power loads. The frequency variations may result in increased thermal loads leading to equipment failures or abnormal operation of equipment. Some failures, such as the failure of EMI filters, may not be obvious. This should be considered in developing the overall test development schedule. STANAG 3456, “Aircraft Electrical Power Systems Characteristics”, states electrical system(s) used in aircraft of member countries shall have the characteristics as defined in either of MIL-STD-704, ISO 1540 or EN 2282.

Table 4 provides a summary of the information in the revisions of MIL-STD-704 for aircraft. STANAG 3457, Ground Electrical Power Supplies for Aircraft, should be reviewed for the power characteristics of the portion of the operation supported by ground power. Table 5 provides a summary of the information in the revisions of MIL-STD-1275 for ground vehicles. STANAG 2601, Standardization of Electrical Systems in Tactical Land Vehicles also provides relevant information. For shipboard power refer to ANEP-100, Characteristics of Shipboard 440V/230V/115V 60 Hz, 440V/115V 400Hz and 24/28VDC Electrical Power Systems in Warships of the NATO Navies.

A suggested input voltage and frequency variation schedule is provided in Table 3.

Table 3: Input Voltage and Frequency Test Schedule

Cycle	Normal Operating Voltages	Frequency (AC systems)
1	Nominal	Nominal
2	High	Low
3	Low	High
4	Nominal	Nominal
5	High	High
6	Low	Low
7	Nominal	Nominal
8	High	High
9	Low	Low
10	Nominal	Nominal

Table 4: Aircraft Electrical Power Characteristics

Department of Defense MIL-STD-704 Aircraft Electrical Power Characteristics							
MIL-STD-704 Version	**MIL-STD-704**	**MIL-STD-704A**	**MIL-STD-704B**	**MIL-STD-704C**	**MIL-STD-704D**	**MIL-STD-704E**	**MIL-STD-704F**
Published Date	6-Oct-59	9-Aug-66	17-Nov-75	30-Dec-77	30-Nov-80	1-May-91	12-Mar-04
115 Line to Neutral (rms) 400 Hz							
Normal AEOC	**Normal Aircraft Electrical Operating Condition**						
Voltage Steady State Limit (Vrms)	107.5-119.5	108-118	108-118	108-118	108-118	108-118	108-118
Frequency Steady State	380-420	380-420	395 - 405	393-407	393-407	393-407	393-407
Abnormal AEOC	**Abnormal Aircraft Electrical Operating Condition**						
Voltage Steady State Limit (Vrms)	103 - 137	102 - 124	100 - 125	100 - 125	100 - 125	100 - 125	100 - 125
Frequency Steady State	320 - 480	370 - 430	375 - 425	380 - 420	375 - 425	380 - 420	380 - 420
Emergency AEOC	**Emergency Aircraft Electrical Operating Condition**						
Voltage Steady State Limit	105 - 122	104 - 122	102 - 124	104 - 122	104 - 122	108 - 118	108 - 118
Frequency Steady State	360 - 440	360 - 440	360 - 440	360 - 440	360-440***	393 - 407	393 - 407
28 VDC (mean)							
Normal AEOC	**Normal Aircraft Electrical Operating Condition**						
Voltage Steady State(Norm)	21 - 29	24 - 28.5	22 - 29	22 - 29	22 - 29	22 - 29	22 - 29
Ripple(1.2kHz-16.8kHz)	1.5	2.0 Peak/Mean	1.5 Peak/Avg	1.5 Peak/Avg	1.5 Peak/Avg	1.5 Peak/Avg	1.5 Peak/Avg
Abnormal AEOC	**Abnormal Aircraft Electrical Operating Condition**						
Voltage Steady State(Abn)	12 - 36	22.5 - 30	20 - 31.5	20 - 31.5	20 - 31.5	20 - 31.5	20 - 31.5
Emergency AEOC	**Emergency Aircraft Electrical Operating Condition**						
Voltage Steady State(Emg)	17 - 29	16 - 24	18 - 29	16 - 30	16 - 29	18 - 29	16 - 29
270 VDC (mean)							
Normal AEOC	**Normal Aircraft Electrical Operating Condition**						
Voltage Steady State(Norm)			250 - 280	250 - 280	250 - 280	250 - 280	250 - 280
Ripple(1.2kHz-16.8kHz)			6.0 V Peak/Avg	6.0 V Peak/Avg	6.0 V Peak/Avg	6.0 V Peak/Avg	6.0 V Peak/Avg
Abnormal AEOC	**Abnormal Aircraft Electrical Operating Condition**						
Voltage Steady State(Abn)			245 - 285	245 - 285	245 - 285	240 - 290	240 - 290
Emergency AEOC	**Emergency Aircraft Electrical Operating Condition**						
Voltage Steady State(Emg)			240 - 290	240 - 290	240 - 290	250 - 280	250 - 280
MIL-STD-704 Version Aircraft Platforms							
	C-2	E-3	None	AV-8	UH-1Y/AH-1Z	F-18 E/F/G	CH-53K
	C-9	E-2		E-6A	V-22	P-8	AH-64E
	C-5	F-18 A/B, C/D		OH-58D	AH-64D	F-35	MQ-8C
		P-3		C-17		MH-60M (VDC)	MQ-25
		H-3				UH-60M/V (VDC)	YMQ-18A
		H-53D/E				MQ-8B	PAR
		H-60				MQ-4C	
		EA-6B				MQ-1C	
		UH-1N/AH-1W				RQ-7B	
		MH-47D/G				CRH (VDC)	
		CH-47E/F				A-29	
		AH-64A				RQ-4	
		UH, HH-60A/L					
		MH-60M (VAC)					
		UH-60M/V (VAC)					
		F-15					
		F-16					
		CRH (VAC)					

Note 1. Refer to MIL-STD-704 for additional information concerning electrical power characteristics.

Note 2. The MIL-STD-704 version may have additional notices. Refer to the latest notice to find any changes. Most notices do not vary the input power steady state conditions.

Note 3. ***360 – 457 Hz (V-22) Special Frequency Range, see V-22 platform specification.

Note 4. If material is to be used on multiple platforms, use the lowest and highest levels of all applicable MIL-STD-704 versions.

Note 5. For the C-130, F-22, and U-2 aircraft platforms, contact the appropriate Platform Program Office for electrical power conditions.

Table 5: Ground Vehicle 28 VDC Characteristics

Department of Defense MIL-STD-1275 Military Ground Vehicles 28-Volt DC Characteristics					
MIL-STD-1275 Version	MIL-STD-1275A	MIL-STD-1275B	MIL-STD-1275C	MIL-STD-1275D	MIL-STD-1275E
Published Date	17-September-1996	20-November-1997	23-June-2006	29-August-2006	22-March-2013
28 VDC mean					
Normal Range Voltage	23-33, Change Notice 2	25-30	25-30	25-30	20-33
Ripple Voltage	2V pk to pk(50Hz to 200KHz)	2V pk to pk(50Hz to 200KHz)	2V pk to pk(50Hz to 200KHz)	2V pk to pk(50Hz to 200KHz)	MIL-STD-461, CS101 limits, 30Hz to 250Khz, Figure CS101-1
Initial Engagement Surge Voltage	6 for 1 second	6 for 1 second	6 for 1 second	6 for 1 second	12 for 1second
Cranking Surge Voltages	16 for 30 seconds	16 for 30 seconds	16 for 30 seconds	16 for 30 seconds	16 for 30 seconds

Note 1: Refer to MIL-STD-1275 for further information concerning electrical DC power characteristics.

3.5.2. Normal ON / OFF Cycling of Materiel Operation

Turn the materiel on and off in accordance with materiel operating procedures outlined in appropriate technical manuals, to simulate normal use.

3.6. VIBRATION STRESS

Functional testing is conducted to verify that the materiel functions as required while exposed to no less than the worst-case operational vibration for a particular segment(s) of a mission profile. Functional vibration levels typically do not include time compression but may include some level of conservatism. Tailor the vibration level for each segment of the mission profile based on measured data, when available, or derived from the operational state of the vehicle platform. This is the maximum vibration environment where the unit under test is expected to function. Fully verify function at the beginning, middle and end of each test segment. Monitor basic function at all times during each test run. In some cases, materiel that must survive severe worst-case environments may not be required to function or function at specification levels during worst case conditions. Typically, "operating" and "non-operating" envelopes are established. Tailor functional tests to accommodate non-operating portions by modifying functional monitoring requirements as appropriate.

AECTP-240 Part 10 Chapter 2 contains guidance for characterizing the vibration environment through measured data and laboratory vibration specification development. Default vibration profiles are provided in Method 401, Annex A, for use when measured data are unavailable. Caution should be used when applying the default vibration profiles in Method 401 for functional tests since the default profiles often contain significant time compression and conservatism. As a result, the default vibration levels may not be representative of the functional vibration environment. When the time compression factors are known, adjustments to the default profiles may be made by removing the time compression factor using the Miner-Palmgren Equations (i.e., Miner's Rule) discussed in AECTP-240 Part 10 Chapter 2. The resulting levels will typically be more representative of the maximum service levels for use in the functional vibration test.

Note that conservatism factors in the Method 401 default vibration profiles are imposed for various reasons (see AECTP-240 Part 10 Chapter 4) that are applicable to the functional vibration test. Thus, conservatism factors should not be removed from the default vibration profiles without careful consideration. For Procedure I the vibration levels shall replicate the materiel design / specification levels. For Procedure II the vibration levels shall be based on a particular mission profile. For Procedure III the vibration levels shall be based on the maximum performance envelope of the aircraft.

a. The vibration stresses to be considered for the test cycle are those due to both attached and separated aerodynamic airflow along the vehicle's external surfaces, jet engine noise, or pressure pulses from propeller or helicopter blades on the aircraft structure. Determine the vibration spectrum and level for each mission segment by careful use of measured data. Apply the guidance written below in those cases.

b. In many instances, field / fleet flight data are not available for the specific aircraft, materiel location in the aircraft, or flight phases. In such cases, there are several analytical techniques for vibration, spectrum, and level prediction that can be used to determine vibration test conditions (see Method 401 and Table 7).

(1) Scaling vibration test conditions from data obtained on another platform at a different materiel location, or for a different flight condition has to be done with extreme care because of the numerous nonlinear relationships involved and the limited amount of data being used. For example, manoeuvre-induced vibration conditions generally cannot be predicted from cruise vibration data. A more prudent approach is to use the linear dynamic pressure models in Method 401.

(2) In all cases, field / fleet flight vibration data should be defined in accordance with AECTP-240 Part 10.

c. Because of the nature of vibration control equipment, it may be difficult to change vibration level and spectrum shape in a continuous, smooth manner. Therefore, the mission profile may be divided into segments over which it will be assumed that the vibration level and spectrum shape is constant for test purposes. In addition, vibration specifications are typically defined in three orthogonal axes and the vibration tests are typically conducted in three sequential axis vibration tests, unless a multi-axis test apparatus is available. Ideally, each segment of the mission profile should be divided by the three axes of vibration. However, in a combined environment, changing test axes in the middle of a segment of a mission profile may be impractical and may invalidate the test results. In this case, it may be necessary to perform the functional vibration only in the worst-case axis in terms of vibration level and materiel sensitivity. Alternatively, different axes may be tested in different phases of the test cycle.

d. Unless field / fleet data exist, the appropriate tables and figures of Method 401, are used to determine vibration conditions except as modified in Table 6.

Table 6: Default Functional Vibration Test Criteria

Aircraft Type	Default Vibration Profiles	Notes Regarding Default Vibration Profiles
Fixed-Wing Jet Aircraft	Method 401, Paragraphs A.6 and A.7 (Figures A-39 through A-43); MIL-STD-810, Method 514	• Limited default guidance is provided in Method 401, Paragraphs A.6 and A.7. This guidance includes default endurance vibration profiles for items carried externally on low and medium performance jet aircraft. If determined to be appropriate for the unit under test, functional vibration levels can be derived by scaling the endurance vibration levels such that 1 hour of test is equivalent to 1 hour of flight. • Default vibration profiles in MIL-STD-810, Method 514, Annex D, are based on empirical data and time compression information is unknown. The vibration profile should be computed for each segment of the mission profile. Functional vibration tests should be conducted for sufficient time to fully verify equipment functionality. • Note that functional test requirements may not be appropriate for all flight conditions.
Fixed-Wing Propeller Aircraft	Method 401, Paragraphs A6 and A8; Figure A-44a	Default functional test vibration levels for fixed wing propeller aircraft can be derived by scaling the endurance vibration levels in Method 401 Figure A-44a such that 1 hour of test is equivalent to 1 hour of flight.

Helicopters	MIL-STD-810, Method 514; TOP 01-2-603	Default helicopter profiles in Method 401, Figure A-17 through A-20 are for cargo transportation and are not typically appropriate for development of functional vibration test criteria. • MIL-STD-810, Method 514, Annex D, contains default endurance vibration test levels for different regions of the helicopter that can be used for derivation of functional test levels per scaling guidance in Method 514. • TOP 01-2-603 contains more specific vibration profiles for certain helicopters that were developed from measured data at multiple aircraft regions. TOP 01-2-603 also contains aircraft specific scaling guidance for derivation of functional vibration test levels.

e. If it is determined that the synergistic effects of vibration / altitude or vibration / humidity have little or no impact on the performance of the materiel, vibration may be applied combined with temperature as part of vibration testing (Method 401), with temperature, altitude, and humidity environments combined separately.

f. Short-duration vibration or shock events and those that occur infrequently in the test cycle should be considered in addition to steady state vibration described in Method 401. If the synergistic effects of these events with altitude or humidity are determined to have significant impact on the performance of the materiel. Typical transient events on fixed- and rotary-wing aircraft may include firing of on-board guns, opening of bomb-bay doors, launcher ejection, adjacent missile launches, and shock due to hard landings. If the synergistic effects of these events are not significant, test for these events separately, or combined with temperature, using the appropriate test method within this Standard.

g. For those segments with similar vibration spectrum shape, use the following analysis to reduce the number of vibration test levels. The discussion is in terms of the suggested spectrum shapes for jet, rotary wing, or propeller aircraft of Method 401.

(1) Determine the vibration level, W_o (g^2/Hz), for each mission segment using the flight parameters such as altitude and Mach number for each mission and MIL-STD-810 Method 514 Annex D guidance.

> **NOTE:** For test purposes, the larger W_o due to aerodynamic forces or W_o due to jet engine noise, etc., is used at any point in time in the mission. Identify the maximum W_o value that occurs in each mission.

(2) Consider all segments of the mission that have W_o values within three dB of maximum, as having a constant W_o value of W_{oMAX}. Consider all segments of the mission that have values between W_{oMax}−3dB and W_{oMax} -6dB as having a constant W_o value of W_{oMax} −4.5dB. This process of identifying three-dB bands of dynamic vibration values, over which W_o is considered to be a constant and whose value is determined by using the dynamic vibration value of the band's midpoint, is continued until the calculated W_o value is less than 0.001g^2/Hz. For test purposes, segments of the mission with calculated values of W_o less than 0.001g^2/Hz can be set equal to 0.001. Each segment has a respective time in mission associated with it that is added together creating a T(MAX), T(-4.5), etc. Vibration is then applied for their respective times during the test. A single vibration level may be created using the test acceleration formula of AECTP-240 Part 10 Chapter 2 but the synergistic effects in combination with temperature may be misapplied.

3.7. TEST CYCLE DEVELOPMENT

A test cycle is defined in this method as a series of test segments simulating different climatic / dynamic / power input conditions. Refer to Table 7 and Figure 1 for guidance on test parameter selection. In general, a test cycle is composed of separate temperate / altitude / humidity segments: cold / dry, cold / dry / altitude, warm / moist, hot / dry, hot / dry / altitude, etc. Additional test parameters (power, vibration, supplemental cooling air, etc.) are incorporated as required to simulate the operational environment. For engineering development (Proc. I) and platform envelope (Proc. III) testing, the profile is defined as a set of lifecycle conditions encompassing the materiel design / specification requirements and arranged to encompass all expected combinations of potential mission environments (Figures 3a, 3b, and Table 8). For mission specific testing, a profile is defined as a performance-environmental condition-time history of the specific mission of concern. A specific mission profile (Proc. II) may be divided into segments such as take-off, cruise, combat, manoeuvring, landing, maintenance, etc., with each segment replicating the climatic / dynamic / power input conditions representative of that mission segment (Figure 1).

When performing Procedures I or III, the test parameters are derived from the platform / equipment performance specifications, and design documentation. Using the maximum design parameters, compile a table of the climatic and induced environments, and the combination of those environments that the equipment will be subjected to during its life cycle. Develop a test cycle that simulates each of the appropriate combined environments derived from the LCEP. Each segment of the profile should be of sufficient duration for the environmental stresses to stabilise, and to allow for performance verification.

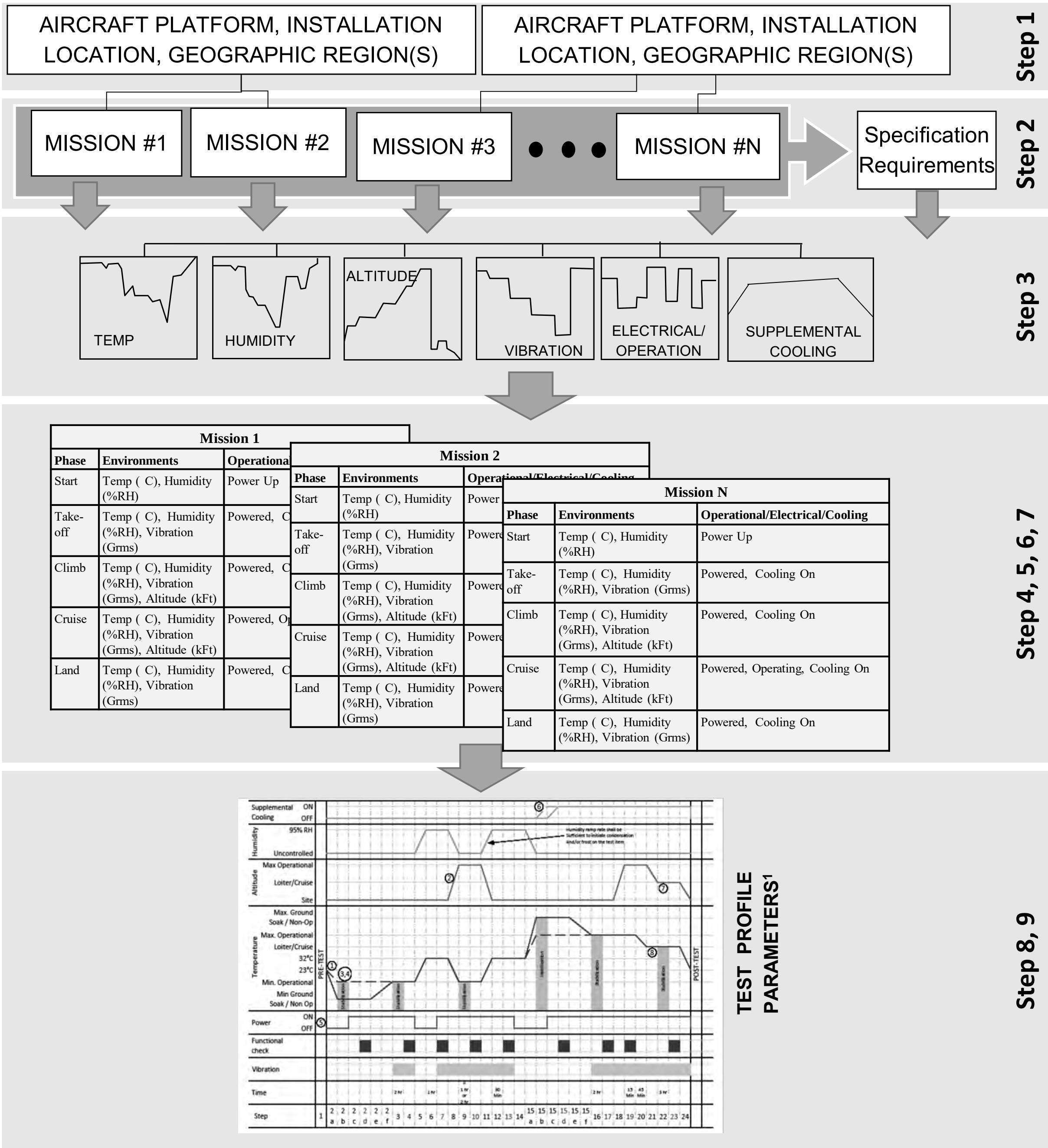
When performing Procedure II, the test parameters are derived from the specific mission parameters as per the portion of the LCEP that defines this specific mission. Use of measured platform data, if available, from the specific equipment location is essential. If measured data are not available, parameter data may be obtained from the program management office, user needs statement, etc. Identify the specific climate(s) under which the equipment is intended to operate; hot / humid (tropical), hot / dry (desert), cold / dry (desert), cold (arctic), etc. Determine the specific environmental conditions, and combinations of conditions, to which the material will be exposed during performance of the mission. This includes both climatic environments (temperature, altitude, and humidity) and induced environments (vibration, power, and supplemental cooling). Using this data develop a mission profile inclusive of taxiing, take-off, cruise, combat, manoeuvring, landing, maintenance, etc.

When Procedure II is to be used for troubleshooting, then the test parameters are derived from the specific mission conditions under which the equipment experienced a failure. This shall include performance data and measured climatic / dynamic / power data obtained during the timeframe of the failure, to the extent that the relevant data are available. Anomalies experienced during flight operations may be specific to the environmental and dynamic conditions at the time of the anomaly. The anomaly may not manifest itself upon return to ambient conditions. Due to the cumulative and synergistic effects of the various environments, the full mission profile is recommended for initial troubleshooting. As troubleshooting progresses, specific segments of the profile may be exercised to isolate and define the root cause of failure.

In the event of a failure, multiple sequential parametric evaluations of the Method 317 environment combinations can be beneficial to determine root cause. For example, preliminary steady state humidity and vibration conditions at fixed altitude may be desirable before returning to a fully combined humidity, vibration, and altitude mission scenario simulation test. The relationship between sequence and failures can be complex due to the number of variables.

Table 7: Test Parameter Selection / Profile Development

Procedure			Step	Task
I	II	III		
X	X	X	Step 1	**Identify** the platform(s), the test materiel installation location(s), and geographical deployment location(s).
X		X	Step 2	**Identify** the platform(s) / materiel specification requirements. Specification requirements should encompass all planned mission requirements.
	X		Step 2a	**Identify** the specific mission scenario(s).
X		X	Step 3	**Identify** applicable individual forcing functions (temperature, altitude, humidity, input electrical power, functional vibration, etc.). (Exception: short term and transient events, e.g., gunfire, crash shock, etc.)
	X		Step 3a	**Identify** the specific mission forcing functions that support the mission profile. (including climatic, dynamic, and electrical functions)
X	X	X	Step 4	**Identify** operational requirements of the equipment, including duty cycle, transients, and operational modes (to include all anticipated mission operational scenarios)
X	X	X	Step 5	**Identify** the temperature, altitude, humidity, input electrical power, and functional vibration levels for each segment of the test profile. See Section 3 and subsections.
X	X	X	Step 6	**Identify** the type of cooling (RAM / ECS / convective) and cooling environment for the test item for each segment (see paragraph 3.2 and 3.2.1).
X	X	X	Step 7	**Develop a table** listing all the applicable forcing functions / levels and operational requirements identified in the above steps for each mission or platform.
X		X	Step 8	**Identify** the applicable combinations of climatic / dynamic / power parameters considering the full range of platform requirements, as derived from the LCEP. This should include all anticipated combinations of thermal / altitude / humidity / vibration environment and the associated operational/power requirements for each segment of the test profile. For high performance aircraft the Mach/altitude effects shall be considered.
	X		Step 8a	**Identify** the thermal / altitude / humidity / vibration environment combinations and the associated operational / power requirements for each mission segment (start, idle, taxi, takeoff, climb, cruise, loiter, combat, manoeuvre, descent landing).
X		X	Step 9	Using the data identified in Steps 1 through 8, **develop** a representative composite table / profile for thermal, altitude, humidity, functional vibration, test item cooling, and operational power for the most severe expected environments. (see Table 8 and Figures 3a and 3b)
	X		Step 9a	Using the data identified in Steps 1 through 8, **develop** a thermal, altitude, humidity, functional vibration, test item cooling and operational power profile.



Note 1: Procedure II utilizes data from Single Mission or Subset of Missions, while Procedures I and III utilize data from the entire life cycle of missions.

Figure 1: Test Profile Generation Flow Diagram

3.7.1. Number of Test Cycles

For Procedure I, the number of cycles should be based on time required to induce expected failure modes, such as those listed in paragraph 2.3, or the maximum expected service life.

For Procedure II, the number of test cycles should be based on the objective of the test, in most cases 2–3 cycles will be sufficient.

For Procedure III, the intent is to demonstrate maximum conditions that the platform(s) may expose the materiel to. Use a test duration of a minimum of 10 cycles. Additional cycles may be conducted, but platforms are rarely exposed to their maximum envelope conditions and a failure discovered in subsequent cycles may be caused by unrealistic extended exposures.

3.8. TEST ITEM CONFIGURATION

See Method 300.

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CHAPTER 4 INFORMATION REQUIRED

4.1. INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTIONS

1. The test profile shall be tailored to simulate the LCEP requirements to the greatest extent possible within facility limitations. In addition to the information derived from Method 300, the following are required for these tests:

a. Purpose of the test (e.g., engineering development, flight or operation support, platform envelope verification, etc.).

b. LCEP defining the combination of three or more of the following environments: temperature, altitude, humidity, input electrical power, and vibration to be applied simultaneously.

c. Test item platform envelope and / or mission profile(s).

d. Test item installed location within the respective platform and any specifics associated with the installed location (to include power, cooling, fixturing, etc.).

e. Climatic / Dynamic Sensor Locations: Mapping of control and response sensors' locations in relation to the test item and test chamber.

f. Data acquisition rate: The data sampling rate shall be set to accurately record all test parameter transitions. Sample rates shall be sufficient to verify parameter tolerances and change rates.

2. The following information may be required to conduct the test(s) and shall be recorded in the test instructions when applicable:

a. Functional test instructions, including time period(s) of operation and test item's performance requirements for each test procedure selected.

b. Details of any external cooling provisions such as fans or heat sinks, as applicable to the materiel's in-service installation.

c. Details of any restrictions to heat transfer, such as thermal isolation mounts or restrictions to airflow (convection), as applicable to the materiel's in-service installation.

d. Any additional parameters to be measured and recorded.

e. Necessary variations in the basic test procedures to accommodate environments identified in the materiel's LCEP.

4.2. INFORMATION REQUIRED FOR VERIFICATION

In addition to the information found within Method 300, the following information is required to verify the completion of the test(s) described in this method and shall be recorded in the test report:

4.2.1. Pre-Test

a. General. Information listed in Method 300.

b. Specific to this method.

(1) Any calibrations of electrical power input or supplemental cooling required to prove proper application of the environment.

(2) Pre-test photographs of the item and test setup.

(3) Results of pre-test functional test. Record of air and test item temperature and humidity during pre-test functional test, if required.

(4) Photographs of Climatic / Dynamic Sensor locations.

(5) Identification of the components / assemblies / structures to be used for measuring the thermal response and evaluating the temperature stabilization of the test item(s).

(6) Description, with photographs, of the test item's configuration and orientation within the test chamber.

4.2.2. During-Test

a. General. Information listed in Method 300.

b. Specific to this method.

(1) Complete record of temperature, altitude, humidity, input electrical power, and vibration levels correlated to test profile sequence. The test data sample rate shall be sufficient to demonstrate that all ramp rate requirements (Temperature, Altitude, etc.) have been met.

(2) Documentation of operating and non-operating periods as well as any operational tests conducted. Operational Test Pass / Fail Results.

(3) List of any test interruptions or deviations from the original test plan.

(4) Any changes to the installation, configuration, or orientation of the test item within the test chamber during testing.

4.2.3. Post-Test

a. General. Information listed in Method 300.

b. Specific to this method.

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

(2) Any deviations from the original test plan.

(3) Documentation of post-test operational tests results.

(4) Pre, During, and Post Photos of test item and any observed anomalies.

(5) Operator Test Logs.

(6) Document any modifications / interruptions to the test profile sequence. Refer to the Section 5.7 and Chapter 6 for analysis of any effects due to the profile changes.

(7) Out of tolerance conditions, test interruptions, data gaps, etc. shall be annotated and fully described.

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CHAPTER 5 TEST CONDITIONS AND PROCEDURES

See Method 300 for general test facility, test conditions, and test control information.

5.1. PREPARATION FOR TEST

In addition to the information provided in Method 300, ensure that the plans are in place to gather the information required by paragraph 4.2. The following information is also appropriate.

5.2. TEST FACILITY

Use a facility that can provide the required combination of three or more environmental elements. Verify that the facility can meet all test parameters, to include specified temperature and altitude ramp rates. See the guidance for the facilities for the individual element tests (i.e., latest revision to Methods 301, 302, 303, 306, and 401).

Use power supplies which have sufficient power capacity to account for startup and operational current surges. At minimum, the power supply should be able to replicate the voltage and frequency characteristic of the platform(s) for Alternating Current sources or the voltage for Direct Current sources. The electrical characteristics are defined at the input terminals. If power characteristics, such as transients or interrupts, are required, use programmable power supplies as necessary.

Liquid nitrogen (LN2) injection is an effective method to meet rapid cooling rate requirements; however, the injection path requires evaluation to avoid extreme temperature gradients and air density changes. Liquid carbon dioxide (LCO2) use is not recommended due to potential contamination and injection pressure differential.

5.3. INSTALLATION CONDITIONS OF TEST ITEM

5.3.1. Test Item Mounting

To the extent feasible, the test item should be mounted either on raised supports or on a substrate of specified properties, with a thermal diffusivity representative of actual deployment. Caution shall be given to not artificially create either a thermal-sink or thermal-isolator that is not representative of actual deployment. The test item substrate should be selected to minimize corrosion and prevent unrealistic cooling of water between the substrate and test item.

When vibration testing is included, design consideration should be given to the thermal mass of the fixturing and its effect on the air temperature change rates and the test item thermal response. After appropriate compensation of the excitation input device (with possibly a dynamic simulant), and prior to conducting the test, perform a pre-test checkout of the test item at standard ambient conditions to provide baseline data.

Conduct the checkout as follows:

5.3.2. Supplemental Cooling

The supplemental cooling equipment should be installed in the same manner that it would be installed in the operational configuration. See Section 3.2.1 for further information.

5.3.3. Instrumentation

a. Temperature measuring sensors should be mounted on the test item at sufficient locations to allow evaluation of the test item's thermal response to the test environment. The parts of the test item with the slowest thermal response (longest thermal lag) should be instrumented in order to establish temperature stabilization during testing. Temperature stabilization is generally important to ensure reproducible test conditions. Stabilizing test item elements critical for operational requirements (i.e., components, sub-assemblies, etc.) is normally more important than stabilizing temperatures of structural members, unless they directly influence the materiel's operational performance. In some instances, it may not be possible or practical to directly measure the part(s) of the test item with the longest thermal lag. In such instances, additional time at the test temperature may be required to ensure complete stabilization of the test item. Alternatively, a thermal survey of the test item could be completed before the start of testing to identify suitable temperature monitoring locations.

b. Heat dissipating components should be measured to evaluate the temperature rise above ambient during operation. In all instances, sensors and their mounting configuration should be selected to minimize attenuation of the test item's response to the test environment.

c. Chamber Pressure transducers should be selected to ensure they provide the adequate range, accuracy and response time to support the specified altitude and altitude change rate requirements of the test.

d. Method 401 Chapter 5 contains detailed information on accelerometer selection and installation.

e. It is highly recommended that the input electrical power characteristics be measured at the input terminals of the equipment under test (see MIL-HDBK-704, section 4, "General Information").

5.4. TOLERANCES

Unless otherwise specified in the Environmental Test Specification the tolerances on all severities, including duration, should be as set out in this chapter. Any deviation from the specified tolerances should be agreed with the test specifier and the actual tolerances achieved, and reason for the deviation, stated in the Environmental Test Report. For further information on climatic test parameter tolerances, see Method 300. Ensure test tolerances for the vibration stress are consistent with the guidance provided in Method 400 Section 4.3 and Method 401 Section 5.4. Due the wide variation in electrical power levels, these tolerances should be specified in the Environmental Test Specification.

5.5. CONTROLS

Ensure calibration procedures are consistent with the guidance provided in Method 300 Section 3.2 and Method 401 Chapter 5. The control systems for a combined environments test tend to have increased complexity and may rely on more than one control system. Ensure that the control system(s) and data acquisition systems are time-synchronized.

5.6. TEST INTERRUPTIONS

Test interruptions can result from a number of situations that are described in the following paragraphs. See Method 300 for additional information.

5.6.1. Interruption Due to Laboratory Equipment Malfunction

1. Refer to the interruption guidance for the individual test elements (i.e., temperature, altitude, humidity, input electrical power, and vibration).

2. In the case of failure of the Data Acquisition (DAQ) system (while the facilities are still working properly), take into account possible safety issues, if anything important may have been missed in the output / response of the materiel, and how much of the time DAQ was down. The test may be continued without any changes if there are no concerns or may have temporary interruption just to get DAQ working again. If there are any concerns take the appropriate action based on the test interruption information in this Method as well as in Method 300 Section 7 of this Standard.

5.6.2. Interruption Due to Test Materiel Operation Failure

Failure of the test item(s) to function as required during functional tests presents a situation with several possible options. Prior to restarting the test, the root cause of the failure shall be determined, along with the remedial action. This determination will aid in determining which of the following options is preferred. The failure analysis shall be included in the test report. (See Chapter 6 for additional guidance.)

a. Preferable option is to replace the test item with a “new” one and restart at Step 1.

b. A second option is to replace / repair the failed or non-functioning component or assembly with one that functions as intended and restart the entire test from Step 1.

c. For non-relevant anomalies, which do not affect the functionality of the unit under test, following a review of the data, the test may be resumed at the start of the cycle.

> **NOTE:** Test item failures may be the result of cumulative environmental stresses, including stresses from prior tests on the test item. When evaluating failure interruptions, evaluate prior testing on the same test item and consequences of such. This may necessitate the repetition of prior tests to validate the corrective action.

5.6.3. Interruption Due to a Scheduled Event

There are situations in which scheduled test interruptions will take place. These interruptions shall be approved by the cognizant organization and documented in the test plan and / or the test report. Interruptions shall be scheduled to have the least impact on the test conditions. Preferably these interruptions shall occur during steady state environmental conditions or at the end of a cycle. Following the interruption, all test parameters, for both the test chamber and test item, shall be stabilised at the values immediately preceding the interruption. See also Method 300 Section 7.4. Scheduled interruptions may result from the following:

a. Test Item Life Cycle Event: This would include the replacement of batteries or consumables, required reorientation of the test item during the test, etc. It also includes material operation which cannot be performed remotely. (Note: when possible, material operation shall be performed remotely via pneumatic / electrical actuators or by other means which do not compromise the test environment.)

b. Test Chamber / Support Equipment Events: These may include scheduled maintenance such as the periodic calibration of sensors, reconfiguration for alternate modes of operation, re-torquing of fixtures, etc. Foreseen inclement weather may necessitate a test suspension and / or controlled shutdown due to the potential for power interruption and / or personnel limitations.

c. Personnel Events: It is preferred that testing be performed on a 24/7 work schedule. When this is not feasible, then the test shall be interrupted at the end of the cycle. The test chamber shall be maintained at standard ambient conditions during the interruption. Interruption of the test at other points of the test profile shall require approval from the cognizant organization.

5.6.4. Interruption Due to Exceeding Test Tolerances

5.6.4.1. Under-Test Interruption

Refer to the interruption guidance for the individual test elements (i.e., temperature, altitude, humidity, input electrical power, and vibration).

5.6.4.2. Over-Test Interruption

Refer to the interruption guidance for the individual test elements (i.e., temperature, altitude, humidity, input electrical power, and vibration).

5.7. PROCEDURES

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

5.7.1. Pre-Test Standard Ambient Checkout

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

Step 1. Conduct a visual examination of the test item with special attention to stress areas, such as corners of moulded cases, and document the results.

Step 2. Install the materiel in the test chamber in its operational configuration. Verify all electrical and mechanical connections.

Step 3. In order to determine thermal response, install temperature sensors in or on the test item as described in the test plan.

Step 4. Install any additional sensors and ancillary equipment as required by the test plan.

Step 5. Conduct a test of the data acquisition system and verify all data are being recorded.

Step 6. Conduct a functional test at standard ambient conditions as described in the plan and record the results.

Step 7. If the test item operates satisfactorily, proceed to paragraph 5.7.2, 5.7.3, or 5.7.4 as appropriate. If not, resolve the problems and repeat Steps 5–6 above. If resolution requires replacement of the item, or removal, of sensors in order to repair, then repeat Steps 1–6 above.

5.7.2. Procedure I: Engineering Development

Procedure I may be used during engineering development to establish design margins and verify that the design meets its engineering requirements during exposure to the specified environments. Test profile development shall follow the guidance shown in Table 7. Test parameters should be chosen based on the intent of the engineering test. Although based on the design specification, more extreme parameters may be preferred to establish design margins. Refer to Procedure III for an example of a platform envelope. For specific engineering tests, based on suspected failure modes, a specific segment of the profile may be conducted that incorporates test parameters more extreme than the specification requirement.

5.7.3. Procedure II: Mission Support

The Procedure II test profile is intended to simulate the climatic, dynamic, input electrical power, and operational events experienced in specific missions or troubleshooting scenarios. These missions represent specific geophysical areas of operation and do not cover the full platform envelope. No one profile is appropriate for use, rather separate profiles must be developed to cover the specific mission / troubleshooting scenario. The following paragraphs discuss representative mission segments. These segments may be combined, along with the appropriate transition parameters, to develop the mission profile. If feasible, the parameters should be ramped in parallel following the expected conditions on the platform. Some segments, such as cruise and attack, may be repeated at different portions of the profile and at different levels. All segments may, or may not, be required for specific missions / troubleshooting. These segments are not all encompassing and additional segments may be required.

Measured data are essential for each of these parameters to actually replicate the exact conditions for this segment. Test parameters are to be based on measured data to the greatest extent possible. These include the geophysical climatic data, specific environmental conditions of the equipment installation, dynamic response of the platform, and input power quality. When measured data are not available, MIL-HDBK-310 may be referenced for atmospheric data.

For each segment the forcing functions described below shall be evaluated in developing the profile. The maintenance and non-op segments may represent platform non-operational periods; or may represent materiel which is not installed on the platform and is either in the logistics supply chain (storage) or undergoing maintenance in a repair facility. The duration for each segment shall be determined by the mission scenario. This list is not all inclusive; additional forcing functions may be required for specific missions. The following mission segments are generally ordered for a representative mission. This order may vary depending on the specific mission (Figure 2).

5.7.3.1. Non-Operational / Ground Soak

Measured data are essential for each of these parameters to actually replicate the exact conditions for this segment.

a. Temperature: Determine the deployment location and any induced temperatures based on the materiel's installation (solar loading, heating from adjacent material, etc.). (Stabilise to the mission ground soak temperature; day or night mission.) See Section 3.2 ("Thermal Stress").

b. Altitude: Site altitude of the deployment location. See Section 3.3 ("Altitude Stress").

c. Humidity: Measured humidity at the deployment location. See Section 3.4 ("Humidity Stress").

5.7.3.2. Start-Up / Taxi

a. Temperature: Ground soak temperature based on equipment location. (Note: Some materiel may receive conditioned air prior to start up.) Use measured data or thermal survey data. See Section 3.2 ("Thermal Stress") and Section 3.2.1 ("Bay Conditions").

b. Altitude: Site altitude of the deployment location. See Section 3.3 ("Altitude Stress").

c. Humidity: Measured humidity at the deployment location. See Section 3.4 ("Humidity Stress").

d. Input Electrical Power: Use measured data or data from the electrical loads analysis, including power transfer interrupts during transfer from ground to aircraft power. (If troubleshooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 3.6 ("Electrical Stress").

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS. For ECS open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 3.2 ("Thermal Stress"). It is imperative that the cooling system design be understood in order to properly replicate during test!

f. Vibration: Vibration levels shall be based on the functional vibration levels for the specific materiel location and the specific mission segment under test. Vibration levels may vary throughout the test. See section 3.6 ("Vibration Stress").

5.7.3.3. Climb to Cruise / Surveillance

a. Temperature: Ramp the temperature from the ground / site temperature to the High Altitude / Cruise Temperature for the specific geophysical location. For external materiel use measured data or the appropriate atmospheric lapse rate (dry / humid) for the mission geophysical location. For internal materiel use measured data or thermal analysis / survey data Section 3.2.1 (“Bay Conditions”). For materiel designed for specific geophysical locations, if measured data are not available use data from MIL-HDBK-310. See Section 3.2 (“Thermal Stress”). The ramp rate shall be in accordance with (IAW) the platform performance.

b. Altitude: Ramp the altitude from the ground / site altitude to the High Cruise altitude. For pressurized compartments perform the ramp to the specified pressure altitude. The ramp rate shall be IAW the platform performance. See Section 3.3 (“Altitude Stress”).

c. Humidity: Humidity shall be based on anticipated mission cruise altitude. (Note: For low level missions the humidity will essentially be the same as ground level.) See Section 3.4 (“Humidity Stress”).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for Climb. (If troubleshooting, consider the effects of power transients. Attempt to replicate aircraft power.) See 3.6 (“Electrical Stress”).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS. For ECS open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 3.2 (“Thermal Stress”). It is imperative that the cooling system design be understood in order to properly replicate during test!

f. Vibration: Vibration levels shall be based on the functional vibration levels for the specific materiel location and the specific mission segment under test. Vibration levels may vary throughout the test. See Section 3.6 (“Vibration Stress”).

5.7.3.4. Cruise / Surveillance

a. Temperature: Maintain the cruise / surveillance temperature until the materiel has stabilised or for the duration of the platform cruise / surveillance mission. For long duration surveillance missions, such as Unmanned Aerial System (UAS) missions, a soak of 4 hours following stabilization is generally sufficient. This data may be available from the program office. See Section 3.2 (“Thermal Stress”).

b. Altitude: Maintain the cruise / surveillance altitude until the materiel has thermally stabilised or for the duration of the platform cruise mission. This data may be available from the program office. See Section 3.4 (“Altitude Stress”).

c. Humidity: For low level cruise, the humidity will track the ground level measured humidity for the geophysical location. For high level cruise the humidity will be uncontrolled. See Section 3.5 (“Humidity Stress”).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for cruise. (If troubleshooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 3.6 (“Electrical Stress”).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS. For ECS open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 3.2 (“Thermal Stress”). It is imperative that the cooling system design be understood in order to properly replicate during test!

f. Vibration: Vibration levels shall be based on the functional vibration levels for the specific materiel location and the specific mission segment under test. Vibration levels may vary throughout the test. See section 3.7 (“Vibration Stress”).

5.7.3.5. Attack

a. Temperature: The temperature levels in this segment will vary depending on the type of attack mission, such as low-level ground attack, high altitude air-to-air, etc. External equipment may experience rapid temperature changes as the platform traverses different thermal layers of the atmosphere. Internal equipment temperatures are expected to remain relatively constant. See Section 3.2 (“Thermal Stress”).

b. Altitude: The altitude may vary rapidly, up to the maximum platform specification rate. During a mission, multiple attack scenarios / events may occur. See Section 3.3 (“Altitude Stress”).

c. Humidity: For low level attack, the humidity will track the ground level measured humidity for the geophysical location. For high level attack the humidity will be uncontrolled. See Section 3.4 (“Humidity Stress”).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for attack. (If troubleshooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 3.5 (“Electrical Stress”).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS. For ECS open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 3.2 (“Thermal Stress”). It is imperative that the cooling system design be understood in order to properly replicate during test!

f. Vibration: Vibration levels shall be based on the functional vibration levels for the specific materiel location and the specific mission segment under test. Vibration levels may vary throughout the test. See section 3.6 (“Vibration Stress”).

5.7.3.6. Descent / Landing

a. Temperature: Ramp the temperature from the high-altitude cruise temperature to the site temperature for the specific geophysical location. See Section 3.2 ("Thermal Stress"). The ramp rate shall be IAW the platform performance.

b. Altitude: Ramp the altitude from the high-altitude cruise / surveillance to the site altitude. The ramp rate shall be IAW the platform performance. See Section 3.3 ("Altitude Stress").

c. Humidity: Ramp the humidity to the measured value for the deployment site. If measured data are not available see MIL-HDBK-310. If descending into a warm / moist environment, there is the possibility that condensation will form on the materiel.

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for descent. (If troubleshooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 3.5 ("Electrical Stress").

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS. For ECS open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 3.2 ("Thermal Stress"). It is imperative that the cooling system design be understood in order to properly replicate during test!

f. Vibration: Vibration levels shall be based on the functional vibration levels for the specific materiel location and the specific mission segment under test. Vibration levels may vary throughout the test. See section 3.6 ("Vibration Stress").

5.7.3.7. Maintenance

a. Temperature: Determine for the deployment location and any induced temperatures based on the material installation (solar loading, heating from adjacent material, etc.). Additional heat may be generated through the maintenance process of replacing specific components. See Section 3.2 ("Thermal Stress").

b. Altitude: Site altitude of the deployment location. See Section 3.3 ("Altitude Stress").

c. Humidity: Measured humidity at the deployment location. See Section 3.4 ("Humidity Stress").

d. Input Electrical Power (Ground Power / Aircraft Power); repeated power cycles may occur during maintenance. Ground Power shall replicate aircraft power and be within the aircraft normal operating limits. If troubleshooting, a power survey may be required of the specific aircraft power system to characterize the power quality at the LRU input. See Section 3.5 ("Electrical Stress").

e. Temperature-Conditioned Air: When temperature-conditioned air (heating / cooling) is required for maintenance in the field, conditioned air shall be provided to simulate the field maintenance conditions. (Note: Conditioned air may not be available for all deployment locations / maintenance conditions. Test conditions should represent the actual conditions found in the field when possible.)

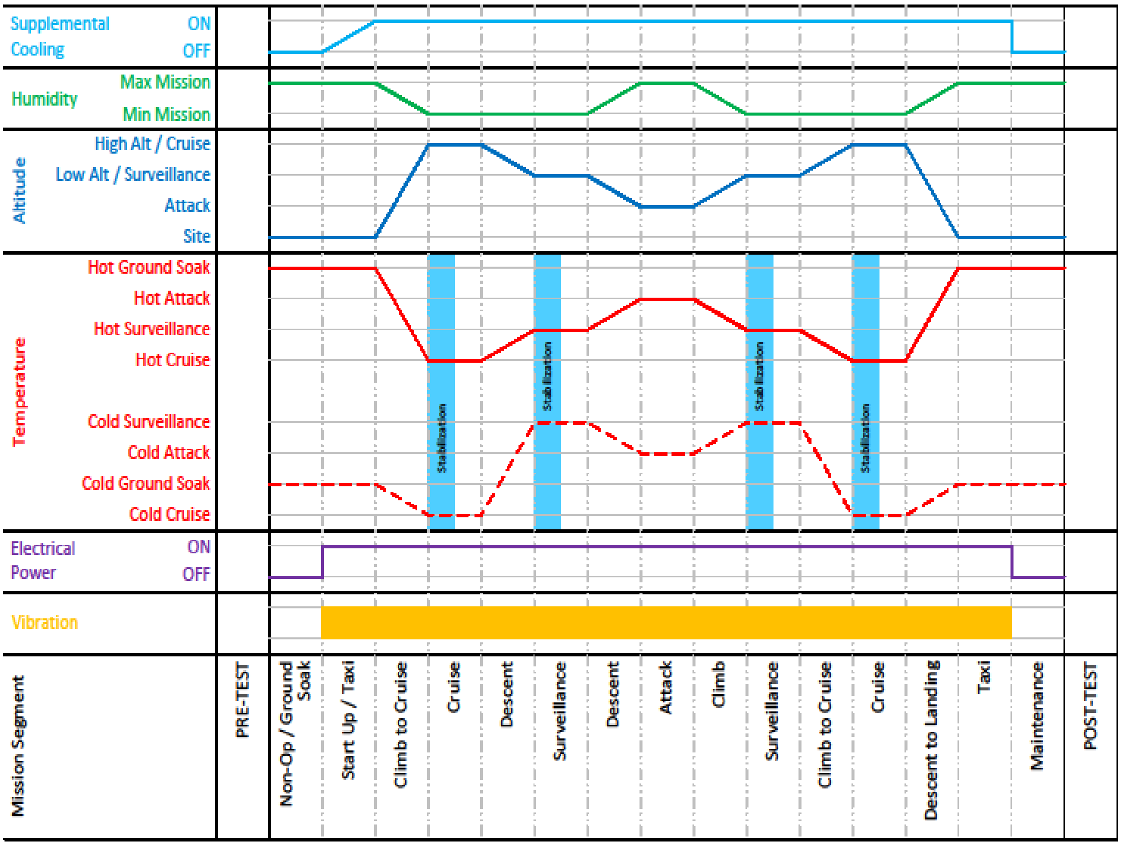

Figure 2: Mission-Specific / Troubleshooting Test Profile (Hot and Cold Day / Ground Attack) Notional Example

Figure 2 Notes:

1. Procedure II is intended for testing of unique mission profiles and troubleshooting. The profile steps must be tailored for the specific application. Steps may be added, repeated, or deleted based on the specific mission requirements.
2. Temperatures and Altitudes for troubleshooting shall be obtained from actual mission data, if possible.
3. Temperatures and Altitudes for mission specific testing shall be obtained from the relevant program office or mission needs statement based on the mission geophysical location.
4. Temperature Ramp Rate: IAW equipment or platform specification. If not specified, then <5 °C/min.
5. Altitude Ramp Rate: IAW Equipment for platform specification.
6. Humidity: The specific relationship between temperature, altitude, and humidity is highly variable and the profile should be considered as an example only. This parameter should be analysed based on the specific mission geographic and atmospheric conditions. (Note: in the attack segment, if test chamber is unable to apply humidity at altitude, then this segment may be set to site pressure to incorporate the humidity parameter. This simulates a low level attack in a humid environment.)
7. Input Electrical Power:
   a. Voltage: Alternate from cycle to cycle; Nominal, High, Low, High, etc. See Tables 3, 4, and 5 for guidance.
   b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. See Tables 3, 5, and 6 for guidance.

   Note: Flight critical equipment may be required to operate under abnormal and / or emergency voltage condition. See paragraph 3.5. for additional guidance.
8. Supplemental Cooling temperature and mass flow rate shall be IAW the platform / system specification. There shall be no ECS supplemental cooling for the first 2 minutes following power on. This shall be followed by a linear drop in the ECS supplemental cooling air temperature to the specified cooling temperature. The ECS cooling air temperature ramp rate shall be determined from the platform ECS specification. For RAM cooled compartment a thermal analysis shall be performed per the guidance in paragraph 3.2.1.a.
9. Vibration may be performed separately with temperature. Vibration is intended to be tailored for the test items specific rotorcraft and/or fixed wing application and the levels should be in accordance with the levels expected during the specific mission segments.
10. It is preferred that consecutive cycles be run continuously; however, if test chamber operations preclude continuous operation, then the transition from high altitude to site, and from loiter temperature to minimum temperature shall be completed prior to interrupting the cycles. These conditions shall be maintained until the cycle is resumed.
11. Pre-Test, Post-test and Functional tests are performed to verify consistent satisfactory performance throughout the test. Pre and Post tests are generally the same. Functional tests, especially during altitude exposure, may be dependent on chamber access. These tests should be tailored per guidance in Part One.

5.7.4. Procedure III: Platform Envelope

Procedure III is intended to verify operation across the platform envelope during exposure to multiple forcing functions. The test parameters are derived from the platform / materiel specification and tailored for the specific equipment location(s). There are two options within the procedure.

Option 1 applies materiel which, during its life cycle, is expected to be powered “ON” at temperatures either less than or greater than the normal operational temperature(s). This includes materiel that is powered “ON” concurrent with aircraft startup or that is powered “ON” while the aircraft is on the tarmac in a thermally ground soaked condition. Unless otherwise specified, the minimum and maximum start up temperatures will generally equate to the minimum and maximum ground soak temperatures (Figure 3a).

Option 2 applies to materiel which is powered “ON” during flight operations after the aircraft temperature has stabilised at its normal operational temperature (Figure 3b). Table 8, Template: Procedure III Envelope test cycle (Based on Option 1) may be used to assist in development of the test profile. During testing, the completed table may also provide a quick reference to the test conditions at specific points in the test profile.

Table 8 correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 7.

Table 8: Template for Procedure I and III - Envelope Test Cycle (Based on Option 1)

Step	Test Phase Definition	Temp °C (°F)	Relative Humidity	Supp. Cooling Air °C (°F)	Supp. Cooling Mass Flow (lbs/min)	Altitude	Test Item-Operating / Non-op.	Func Test	Duration
1	Pre-Test Set-up and Functional Test at Standard Ambient	Standard Ambient	Uncontrolled	N/A	N/A	Site	Operating / Non-operating (Note 8)	Yes	As Required
2.a	Ramp to Cold / Dry Min Power ON Temp	Ramp (Notes 1,2)	Uncontrolled	N/A	N/A	Site	Non-operating	No	As Required
2.b	Cold / Dry Stabilization	Min. Power ON Temp (Notes 1, 3)	Uncontrolled	N/A	N/A	Site	Non-operating	No	As Required (See Part One, paragraph 5.4)
2.c	Cold / Dry Warm-up	Min. Power ON Temp (Note: Conditioned Air may be required for some equipment.)	Uncontrolled	N/A	N/A	Site	Operating (Note 8)	No	Minimum time required to perform power up and specified warm-up
2.d	Cold / Dry Functional test	Min. Power ON Temp (Note: Conditioned Air may be required for some equipment.)	Uncontrolled	N/A	N/A	Site	Operating (Note 8)	Yes	Minimum time required to perform functional test
2.e	Ramp to Op Temp (Warm-up)	Ramp (Notes 1, 2)	Uncontrolled	N/A	N/A	Site	Operating	No	As required

Table 8 (Con't): Template for Procedure I and III - Envelope Test Cycle (Based on Option 1)

Step	Test Phase Definition	Temp °C (°F)	Relative Humidity	Supp. Cooling Air °C (°F)	Supp. Cooling Mass Flow (lbs/min)	Altitude	Test Item-Operating / Non-op.	Func Test	Duration
3	Cold / Dry Soak	Min. Op Temp (Note 1)	Uncontrolled	N/A	N/A	Site	Operating	No	2 hours minimum
4	Cold / Dry Functional test	Min. Op Temp (Note 1)	Uncontrolled	N/A	N/A	Site	Operating	Yes	Minimum time required to perform functional test
5	Ramp to Warm / Moist	Ramp to 32 °C (Note 2)	Ramp to ≥ 95% RH (Note 10)	N/A	N/A	Site	Non-operating	No	As Required
6	Warm / Moist Soak	32 °C (90 °F)	95% RH	N/A	N/A	Site	Non-operating	No	1 hour minimum
7	Warm / Moist Functional Test	32 °C (90 °F)	95% RH	N/A	N/A	Site	Operating	Yes	As Required
8	Ramp to Cold / Dry Altitude	Ramp to Min Op Temp (Notes 1,2)	Uncontrolled	N/A	N/A	Ramp to Max Op Alt (Notes 4, 5)	Operating	No	As Required
9	Cold / Dry Altitude Soak	Min Op Temp	Uncontrolled	N/A	N/A	Max Op Alt	Operating	No	Stabilization, plus one hour; or 2 hours, whichever is less
10	Cold / Dry Altitude Functional test	Min Op Temp	Uncontrolled	N/A	N/A	Max Op Alt	Operating	Yes	

Table 8 (Con't): Template for Procedure I and III - Envelope Test Cycle (Based on Option 1)

Step	Test Phase Definition	Temp °C (°F)	Relative Humidity	Supp. Cooling Air °C (°F)	Supp. Cooling Mass Flow (lbs/min)	Altitude	Test Item- Operating / Non-op.	Func Test	Duration
11	Ramp to Warm / Moist	Ramp to site (Note 2)	Ramp to ≥ 95% RH (Note 10)	N/A	N/A	Ramp (Note 5)	Operating	No	As Required
12	Warm / Moist Soak	+35 °C	≥ 95% RH	N/A	N/A	Site	Operating	No	30 minutes minimum
13	Warm / Moist Functional test	+35 °C	≥ 95% RH	N/A	N/A	Site	Operating	Yes	As Required
14	Power Off	+35 °C	≥ 95% RH	N/A	N/A	Site	Non-Operating	No	As Required
15.a	Ramp to Hot / Dry Max Power ON temp	Ramp (Notes 1, 2)	Ramp to <10%	N/A	N/A	Site	Non-operating	No	As Required
15.b	Hot / Dry Stabilization	Max Power ON Temp (Notes 1, 3)	<10%	N/A	N/A	Site	Non-operating	No	As Required (See Part One, paragraph 5.4)
15.c	Hot / Dry Power ON	Max Power ON Temp (Note 1)	<10%	Per Spec (Note 9)	Per Spec (Note 9)	Site	Operating (Note 8)	No	Minimum time required to perform power up

Table 8 (Con't): Template for Procedure I and III - Envelope Test Cycle (Based on Option 1)

Step	Test Phase Definition	Temp °C (°F)	Relative Humidity	Supp. Cooling Air °C (°F)	Supp. Cooling Mass Flow (lbs/min)	Altitude	Test Item-Operating / Non-op.	Func Test	Duration
15.d	Hot / Dry Functional Test	Max Power ON Temp (Note 1)	<10%	Per Spec (Note 9)	Per Spec (Note 9)	Site	Operating (Note 8)	Yes	Minimum time to perform functional test
15.e	Ramp to Operational Temperature	Ramp (Notes 1, 2)	<10%	Per Spec	Per Spec	Site	Operating	No	As Required
16	Hot / Dry Soak	Max Op Temp (Note 1)	<10%	Per Spec	Per Spec	Site	Operating	No	2 hours minimum
17	Hot / Dry Functional test	Max Op Temp (Note 1)	<10%	Per Spec	Per Spec	Site	Operating	Yes	As Required
18	Ramp to Hot / Dry Altitude	Max Op Temp	<10%	Per Spec	Ramp (Adjust Mass Flow for Alt)	Ramp to Max Op Alt (Note 5)	Operating	No	As Required
19	Hot / Dry High Altitude Functional test	Max Op Temp	<10%	Per Spec	Mass Flow adjusted for Alt	Max Op Alt	Operating	Yes	15 minutes minimum
20	Ramp to Loiter / Cruise Temp	Ramp (Max Op Temp to Cruise Op Temp) (Note 6)	<10%	Per Spec	Mass Flow adjusted for Alt	Max Op Alt	Operating	No	45 minutes minimum

Table 8 (Con't): Template for Procedure I and III - Envelope Test Cycle (Based on Option 1)

Step	Test Phase Definition	Temp °C (°F)	Relative Humidity	Supp. Cooling Air °C (°F)	Supp. Cooling Mass Flow (lbs/min)	Altitude	Test Item-Operating / Non-op.	Func Test	Duration
21	Loiter / Cruise Altitude Ramp	Cruise Op Temp (Note 6)	<10%	Per Spec	Ramp (Adjust Mass Flow for Cruise Alt)	Ramp to Cruise Alt (Note 5)	Operating	No	As Required
22	Hot / Dry Loiter/Cruise Soak	Cruise Op Temp	<10%	Per Spec	Mass Flow adjusted for Cruise Alt	Cruise Alt (Note 7)	Operating	No	3 hours minimum
23	Hot / Dry Loiter/Cruise Functional test	Cruise Op Temp	<10%	Per Spec	Mass Flow adjusted for Cruise Alt	Cruise Alt (Note 7)	Operating	Yes	As Required
24	Ramp to Site Ambient	Ramp to ambient (Note 2)	<10%	Per Spec	Per Spec	Ramp to Site (Note 5)	Operating / Non-Operating	No	As Required
25	Repeat Steps 2–24 as required								
26	Post Functional Test	Standard Ambient	Uncontrolled	Off	OFF	Site	Operating / Non-operating	Yes	Minimum Time required Post-Test and power down

Table 8 Notes:

1. Temperature parameters shall be the extreme platform envelope values for the test condition.
2. Temperature Ramp Rate: IAW equip specification. If not specified, then ≤5 °C/min.

3. Stabilization:
Non-Operational Equipment: See Method 300, Chapter 4.
Operational Equipment: See Method 300, Chapter 4.
4. Altitude parameters shall be maximum platform envelope values for the test condition.
5. Altitude Ramp Rate: IAW equipment specification.
6. Loiter / Cruise Op Temp: Localized ambient air temp with inflight atmospheric cooling effects. IAW Platform guidance. If guidance is not provided, use the maximum operational temperature.
7. Loiter / Cruise Altitude: As determined by the Program Office. This shall represent a typical long duration cruise altitude. If guidance is not provided, use the maximum operational altitude.
8. Input Electrical Power:
a. Voltage; Alternate from cycle to cycle; Nominal, High, Low, High, etc. See Tables 3, 4, and 5 for guidance.
b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. See Tables 3 and 5 for guidance.
9. Supplemental Cooling temperature and mass flow rate shall be IAW the platform / system specification. There shall be no ECS supplemental cooling for the first 2 minutes following power on. This shall be followed by a linear drop in the ECS supplemental cooling air temperature to the specified cooling temperature. The ECS cooling air temperature ramp rate shall be determined from the platform ECS specification. For RAM cooled compartment a thermal analysis shall be performed per the guidance in paragraph 3.2.1.a.
10. It is permissible to delay the humidity ramp until the chamber temperature reaches 0 °C.
11. Vibration is an integral part of the flight environment. Although not shown on the above table, when added to the test the vibration levels shall be representative of the functional vibration levels for the specific phase of the mission.

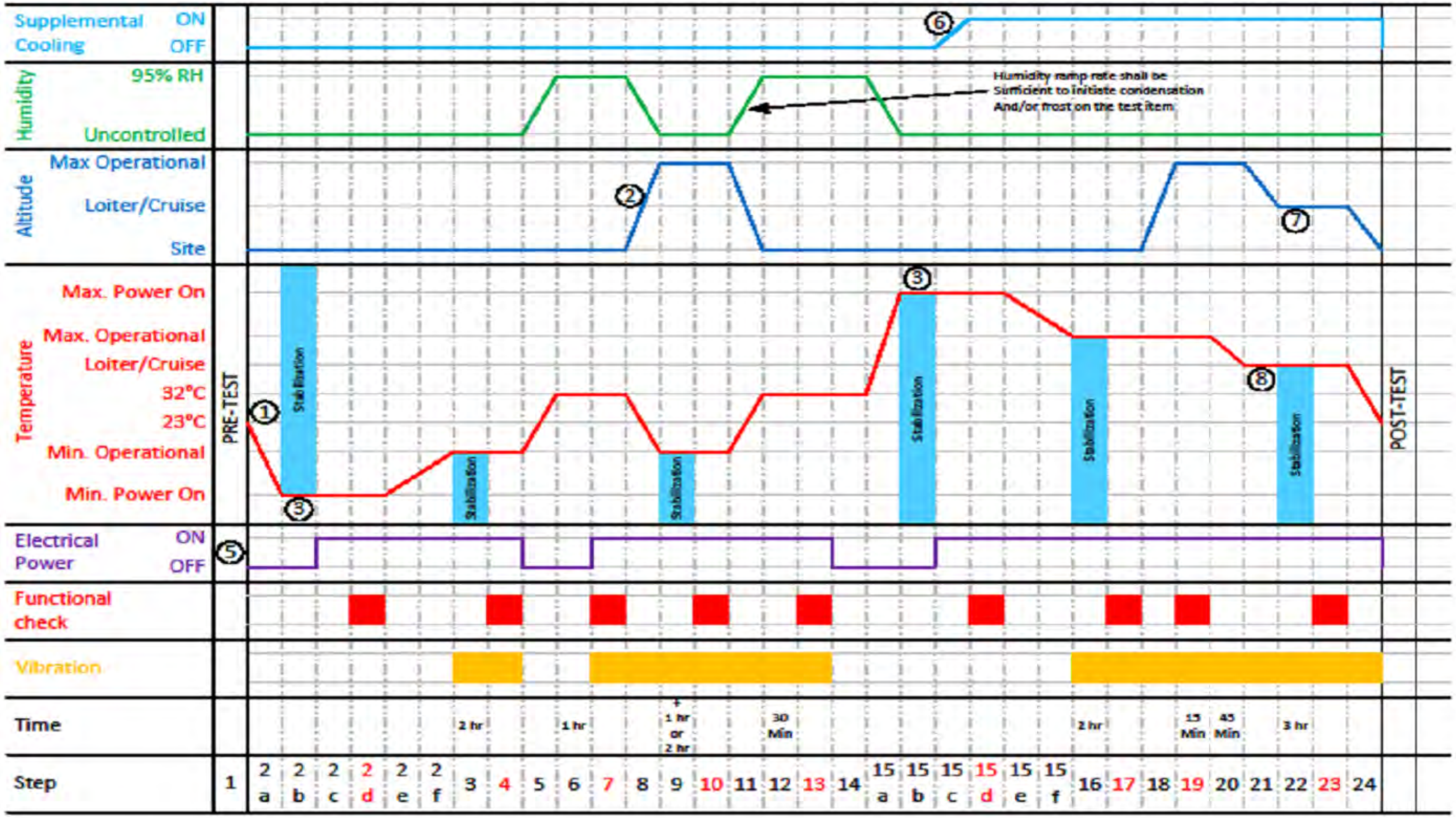

Figure 3a: Platform Envelope Option 1 Profile Example (see notes for additional information)

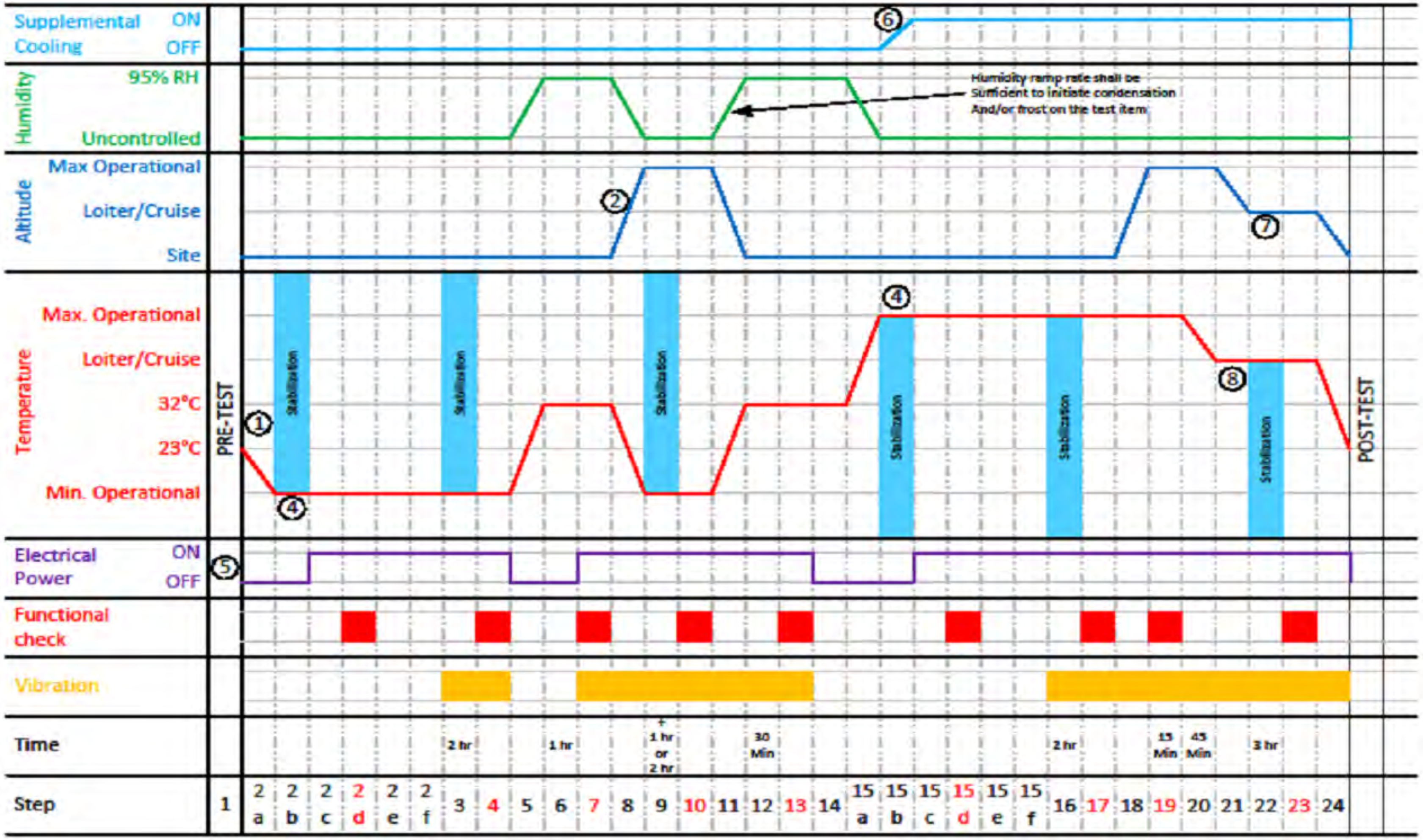

Figure 3b: Platform Envelope Option 2 Profile Example (see notes for additional information)

Figures 3a and 3b Notes:

1. Temperature Ramp Rate: IAW equipment or platform(s) specification. If not specified then <5 °C/min.
2. Altitude Ramp Rate: IAW equipment or platform(s) specification.
3. Option 1 applies materiel which, during its life cycle, is expected to be powered "ON" at temperatures either less than or greater than the normal operational temperature. This includes materiel that is powered "ON" concurrent with aircraft startup or that is powered "ON" while the aircraft is on the tarmac in a thermally ground soaked condition. Unless otherwise specified, the minimum and maximum start up temperatures will generally equate to the minimum and maximum ground soak temperatures (Figure 3a).
4. Option 2 applies to materiel which is powered "ON" during flight operations after the aircraft temperature has stabilised at its normal operational temperature. (Figure 3b)
5. Input Electrical Power:
   a. Voltage: Alternate from cycle to cycle; Nominal, High, Low, High, etc. See Tables 3, 4, and 5 for guidance.
   b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. See Tables 3 and 5 for guidance.

   Note: Flight critical equipment may be required to operate under abnormal and/or emergency voltage condition. See paragraph 3.5 for additional guidance.
6. Supplemental Cooling temperature and mass flow rate shall be IAW the platform / system specification. There shall be no ECS supplemental cooling for the first 2 minutes following power on. This shall be followed by a linear drop in the ECS supplemental cooling air temperature to the specified cooling temperature. The ECS cooling air temperature ramp rate shall be determined from the platform ECS specification. For RAM cooled compartment a thermal analysis shall be performed per the guidance in paragraph 3.2.1.a.
7. Loiter Altitude: IAW Platform guidance. If guidance is not provided, use the maximum operational altitude.
8. Loiter Temperature: IAW Platform guidance and location of equipment. If guidance is not provided, use the maximum operational temperature.
9. Vibration may be performed separately with temperature. Vibration is intended to be tailored for the test items specific rotorcraft and / or fixed-wing application and the levels should be in accordance with the levels expected during the specific mission segments.
10. It is preferred that consecutive cycles be run continuously; however, if test chamber operations preclude continuous operation, then the transition from high altitude to site, and from loiter temperature to minimum temperature shall be completed prior to interrupting the cycles. These conditions shall be maintained until the cycle is resumed.
11. Pre-Test, Post-test and Functional tests are performed to verify consistent satisfactory performance throughout the test. Pre and Post tests are generally the same. Functional tests, especially during altitude exposure, may be dependent on chamber access. These tests should be tailored per guidance in Part One.
12. For items exposed to solar radiation, evaluate the heat transfer effects on the surface and internal temperatures.
13. Humidity: The humidity ramp rate for Steps 5, 8, and 15A shall track the temperature ramp. The humidity ramp rate for Step 11 shall be sufficient to initiate condensation and / or frost on the test item.

5.7.4.1. Procedure III - Steps

Step 1. Perform Pre-Test Set-up and Functional Test at Standard Ambient conditions. See paragraph 5.7.1 and subparagraphs.

Step 2. Cold / Dry (perform either Option 1 or Option 2), as shown in table 9.

Table 9: Cold / Dry Options 1 and 2

Option 1: Equipment which is Powered ON at temperatures less than the normal operating temperature (Figure 3a, Note 3):	**Option 2: Equipment Powered ON during the mission at Operational Temperature (Figure 3b, Note 4):**
a. Ramp to Cold / Dry Min Power ON Temp: With the test item(s) non-operating, ramp the chamber temperature from standard ambient conditions to the Min Power ON temperature at a rate of no more than 5 °C/minute (9 °F/minute).	a. Ramp to Operational Cold / Dry - With the test item(s) non-operating, ramp the chamber temperature from standard ambient conditions to the low operating temperature at a rate of no more than 5 °C/minute (9 °F/minute).
b. Cold / Dry Stabilization - Stabilise the test item at the Min Power ON temperature.	b. Cold / Dry Stabilization - Stabilise the test item at the low operational temperature.
c. Cold / Dry Warm-up - Power ON the test item at the required voltage (nominal, high, low) and frequency (See Table 3). Maintain this condition for the minimum specified warm-up period. (Note: some equipment may require conditioned air prior to start up.)	c. Cold / Dry Warm-up - Power ON the test item at the required voltage (nominal, high, low) and frequency (See Table 3). Maintain this condition for the minimum specified warm-up period. (Note: some equipment may require conditioned air prior to start up.)
d. Cold / Dry Functional Test - Perform a functional test immediately following Option 1, Step 2.c, to verify the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.	d. Cold / Dry Functional Test - Perform a functional test immediately following Option 2, Step 2.c, to verify the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.
e. Ramp to Operational Temperature (Warm-up) - At the completion of the functional test, with the test item operating, ramp the chamber to the low operational temperature at a rate of no more than 5 °C/minute (9 °F/minute).	e. At the completion of the functional test, with the test item operating, proceed to Step 3.
f. Proceed to Step 3.	

Step 3. Cold / Dry Soak – Allow the test item to soak at the low operational temperature for 2 hours, or until the unit stabilises, whichever is greater. If vibration is to be performed during this step, see paragraph 2.2.4.5 for requirements development. Continue vibration through Step 4. (Note: Vibration levels may vary from step to step depending on the operational conditions.)

Step 4. Cold / Dry Functional Test – Perform a functional test immediately following Step 3 to verify the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

Step 5. Ramp to Warm / Moist – At the completion of the functional test, power OFF the test item. With the test item non-operating, ramp the chamber conditions from Step 4 to +32 °C (+90 °F) and 95 percent relative humidity (RH). Perform this temperature/humidity ramp at the following rates: Temperature is no more than 5 °C/minute (9 °F/minute); Humidity is tracking the temperature ramp. (Note: it is permissible to delay the humidity ramp until the chamber temperature reaches 0 °C.)

Step 6. Warm / Moist Soak – With the test item non-operating, maintain +32 °C (+90 °F), 95 percent RH, and site pressure for 1 hour. This step simulates an aircraft sitting on the tarmac in a warm/humid environment.

Step 7. Warm / Moist Functional Test – Power ON the test item and perform a functional check. If vibration is to be performed during this step, see paragraph 3.6 for requirements development. Continue vibration through Step 13. (Note: Vibration levels may vary from step to step depending on the operational conditions.)

Step 8. Ramp to Cold / Dry Altitude – At the completion of the functional test, with the test item operating, ramp the chamber from the conditions in Step 6 to the low operational temperature, the maximum operating altitude (use the formulas in Table 2 to derive pressure from altitude), and uncontrolled humidity. Perform this temperature altitude ramp at the maximum facility rate, not to exceed the predicted platform rate. This step simulates an ascent from a warm / humid environment to a cold / dry altitude. Document the presence of moisture / frost / ice on the test item. Photographic documentation is preferred.

Step 9. Cold / Dry Altitude Soak – With the test item operating, maintain the conditions of Step 8 until the test item has stabilised, plus 1 hour; or 2 hours, whichever is less.

Step 10. Cold / Dry Altitude Functional Test – Perform a functional test immediately following Step 9 to verify the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

Step 11. Ramp to Warm / Moist – At the completion of the functional test, with the test item operating, ramp the chamber conditions from Step 10 and uncontrolled humidity to +32 °C (+90 °F), 95 percent RH, and site pressure. Perform this temperature / humidity / altitude ramp at the following rates: Temperature is no more than 5 °C/minute (9 °F/minute); Humidity is maximum facility rate (Note: it is permissible to delay the humidity ramp until the chamber temperature reaches 0 °C); Altitude is maximum platform descent rate. This step simulates a rapid descent from a high altitude to a hot / humid day landing site. (Note: The humidity ramp rate shall be sufficient to initiate condensation and / or frost on the test item.)

Step 12. Warm / Moist Soak – With the test item operating, maintain +32 °C (+90 °F), 95 percent RH, and site pressure for 30 minutes.

Step 13. Warm / Moist Functional Test – Perform a functional test immediately following Step 12 to verify the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

Step 14. Power OFF the test item.

Step 15. Hot / Dry (perform either Option 1 or Option 2), as shown in table 10.

Table 10: Hot / Dry Options 1 and 2

Option 1: Equipment which is Powered ON at temperatures greater than the normal operating temperature (Figure 3a and Note 3):	**Option 2: Equipment Powered ON during the mission at Operational Temperature (Figure 3b and Note 4):**
a. Ramp to Hot / Dry Max Power ON temp: With the test item(s) non-operating, ramp the chamber temperature to the Max Power ON temperature at a rate of no more than 5 °C/minute (9 °F/minute).	a. Ramp to Operational Hot / Dry - With the test item(s) non-operating, ramp the chamber temperature to the high operational temperature at a rate of no more than 5 °C/minute (9 °F/minute).
b. Hot / Dry Stabilization - Stabilise the test item at the Max Power On temperature.	b. Hot / Dry Stabilization - Stabilise the test item at the high operational temperature. If supplement cooling is required, there shall be

Option 1: Equipment which is Powered ON at temperatures greater than the normal operating temperature (Figure 3a and Note 3):	**Option 2: Equipment Powered ON during the mission at Operational Temperature (Figure 3b and Note 4):**
	no supplemental cooling for the first 2 minutes of the stabilization period. This shall be followed by a linear drop in the supplemental cooling air temperature to the specified cooling temperature. The cooling air temperature ramp rate shall be determined from the platform ECS specification.
c. Hot / Dry Power ON - Power ON the test item at the required voltage (nominal, high, low) and frequency (See Table 3). If supplemental cooling is required, there shall be no supplemental cooling for the first 2 minutes following power on. This shall be followed by a linear drop in the supplemental cooling air temperature to the specified cooling temperature. The cooling air temperature ramp rate shall be determined from the platform ECS specification.	c. Hot / Dry Power ON - Power ON the test item at the required voltage (nominal, high, low) and frequency (See Table 3).
d. Hot / Dry Functional Test - Perform a functional test immediately after Power ON in option 1, Step 15.c to verify the test item operates as required and record the test data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.	d. Hot / Dry Functional Test - Perform a functional test immediately after Power ON in option 2, Step 15.c to verify the test item operates a required and record the test data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.
e. Ramp to Operational Temperature - At the completion of the functional test, with the test item operating, ramp the chamber temperature to the high operational temperature at a rate of no more than 5 °C/minute (9 °F/minute)	e. At the completion of the functional test, with the test item operating, proceed to Sep 16.
f. Proceed to Step 16.	

Step 16. Hot / Dry Soak – Maintain the test conditions for two (2) hours, or until the test item stabilises, whichever is greater. If vibration is to be performed during this step, see paragraph 3.6 for requirements development. Continue vibration through Step 24. (Note: Vibration levels may vary from step to step depending on the operational conditions.)

Step 17. Hot / Dry Functional Test – Perform a functional test to verify that the test item operates as required immediately after Step 16 and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

Step 18. Ramp to Hot / Dry Altitude – At the completion of the functional test, with the test item operating, ramp the chamber from site pressure to the maximum operating altitude (use the formulas in Table 520.5-II to derive pressure from altitude). Perform this pressure ramp at the maximum platform ascent rate.

Step 19. Hot / Dry High Altitude Functional Test – Perform a functional test immediately following Step 18 to verify that the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure. Maintain these conditions for a minimum of 15 minutes or until the functional test is complete.

Step 20. Ramp to Loiter / Cruise Temperature – At the completion of the functional test, ramp the temperature to the required Loiter temperature over a period of 45 minutes. This ramp time shall be based on expected materiel location thermal conditions and cool-down times, it may be less or more than 45 minutes.

Step 21. Loiter / Cruise Altitude Ramp – At the conclusion of Step 20, ramp the chamber pressure from the maximum operational altitude to the Loiter Cruise Altitude. Perform the ramp at the maximum platform descent rate. (Note: if the maximum operational altitude and loiter/cruise altitudes are the same, then skip this step.)

Step 22. Hot / Dry Loiter / Cruise Soak – With the test item operating, maintain the Loiter operating temperature and Loiter cruise altitude for 3 hours, or until the test item stabilises, whichever is greater.

Step 23. Hot / Dry Loiter / Cruise Functional Test – Perform a functional test immediately after Step 22 to verify that the test item operates as required and record data for comparison with pre-test and post-test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

Step 24. Ramp to Site Ambient – At the completion of the functional test, ramp the chamber from the maximum operating temperature and loiter operating altitude to site ambient temperature, site pressure, and uncontrolled humidity. Perform the temperature ramp at a rate of no more than 5 °C/minute (9 °F/minute) and the altitude ramp at the platform maximum descent rate. Return the test item to a non-operating condition and discontinue the supplemental cooling at the conclusion of the ramp.

Step 25. Repeat Steps 2–24 for the total number of cycles required. Historically a minimum of 10 cycles has been recommended. (Note: For test flight purposes, a minimum of 3 cycles has historically been required for Safety of Flight.)

Step 26. Post-Functional Test – Perform a functional test to verify that the test item operates as required and record data for comparison with pre-test and during test data. If the test item fails to operate as intended, see Chapter 6 for failure analysis and follow the guidance in paragraph 5.6.2 for test item failure.

CHAPTER 6 EVALUATION OF THE TEST RESULTS

6.1. EVALUATION OF THE TEST RESULTS

In addition to the guidance provided in Method 300 the following are provided to assist in the evaluation of the test results. Analyse in detail any failure of a test item to meet the requirements of the materiel specifications. If the test item failed the test, consider the following categories during analysis of results of this method:

a. Stress. If a failure occurred, what the immediate physical mechanism of failure may have been (e.g., fatigue, short-circuit by particulate, etc.).

b. Loading mechanism. Determine the physical loading mechanism that led to failure and the total time or number of cycles to failure (e. g., structural dynamic resonant modes, mode shapes, stress distribution, static deformation due to temperature distribution, incursion of moisture, etc.).

c. Test Compliance. Evaluate test performance, including any test plan redlines / deviations (e.g., out of tolerance test conditions, supporting equipment anomalies, facility issues, test interruptions, power interruptions / spikes, etc.).

d. Source. Failures may be induced by a specific environmental stress or a combination of environmental stresses and / or the dynamic of changing stresses. The failures may result from design flaws, faulty parts, workmanship, manufacturing process, etc. The failure may exhibit as a hard failure, intermittent failure, etc. Depending on the nature of the failure, a failure analysis / root cause analysis may be required to determine the ultimate cause and corrective action prior to resumption of testing.

e. Criticality. Does the failure impact mission and / or flight criticality?

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CHAPTER 7 REFERENCES AND RELATED DOCUMENTS

7.1. REFERENCE DOCUMENTS

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

b. AECTP-230, Climatic Conditions.

c. STANAG 3456, Aircraft Electrical Power System Characteristics.

d. MIL-STD-704, Aircraft Electric Power Characteristics.

e. MIL-HDBK-704, Guidance for Test Procedures for Demonstration of Utilization Equipment Compliance to Aircraft Electrical Power Characteristics.

f. MIL-STD-2218, Thermal Design, Analysis and Test Criteria for Airborne Electronic Equipment, 20 May 1992.

g. STANAG 2601, Standardization of Electrical Systems in Tactical Land Vehicles.

h. STANAG 3457, Ground Electrical Power Supplies for Aircraft.

i. ANEP-100, Characteristics of Shipboard 440V/230V/115V 60 Hz, 440V/115V 400Hz and 24/28VDC Electrical Power Systems in Warships of the NATO Navies.

j. MIL-HDBK-1670, Environmental Criteria and Guidelines for Air-Launched Weapons.

k. U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C., 1976.

7.2. RELATED DOCUMENTS

a. RTCA DO-160, Environmental Conditions and Test Procedures for Airborne Equipment.

b. MIL-STD-1399/300B, Department of Defense Interface Standard: (Section 300B) Electric Power, Alternating Current (24 APR 2008).

c. Hall, P.S., Vibration Test Level Criteria for Aircraft Equipment, AFWAL-TR-80-3119, December 1980.

d. Sevy, R.W., Computer Program for Vibration Prediction of Fighter Aircraft Equipment, AFFDL-TR-77-101, November 1977.

e. Lloyd, A.J.P., G.S. Duleba, and J.P. Zeebenm, Environmental Control System (ECS) Transient Analysis, AFFDL-TR-77-102, October 1977.

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g. Quart, I., A.H. Samuels, and A.J. Curtis, A Study of the Cost Benefits of Mission Profile Testing, AFWAL-TR-81-3028, 1981.

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i. F-15 AFDT&E High-Temperature Desert Test and Climatic Laboratory Evaluation, AFFTC-TR-75-19, October 1975, DTIC Number AD B011345L.

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

ANNEX A SUPPLEMENTAL TAILORING GUIDANCE

An individual platform is designed to operate within a set of specified operating mission envelopes (Mach number / altitude regime) and profiles (see Figure A-1). For example, an aircraft can fly many different missions such as training, air superiority, interdiction, ground support, etc. Often, high-threat combat will generate more extreme environments, such as increased temperature effects, dynamic pressures, vibration, condensation, etc. Reference AECTP-240 Sections 246 and 247.

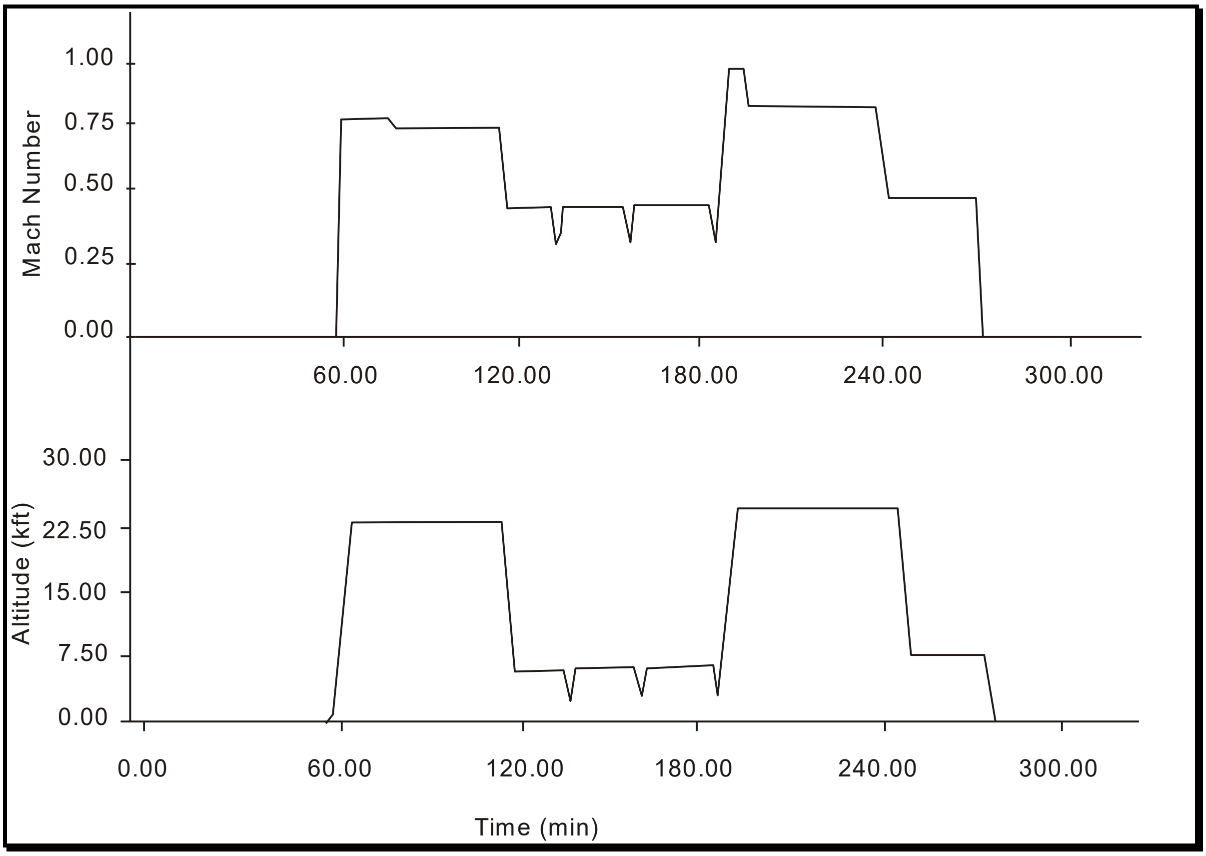

Figure A-1: Schematic Mission Profile, Altitude, and Mach Number (F-15 Ground Attack Example)

The Standard Atmospheric Models presented in Tables A-1–A-3 may be used in determining the altitude, temperature, relative humidity, and dew point correlations when specific flight data are not available. Reference paragraphs 3.3 (“Altitude Stress”) and 3.4 (“Humidity Stress”).

Table A-1: Ambient Outside-Air Temperatures

HOT ATMOSPHERE MODEL

Altitude km	kft	World-Wide Air Operations °C	°F	Relative Humidity (%)	Dew Point Temperature °C	°F
0	0.00	43	109	<10	4	40
1	3.28	34	93	<10	-2	29
2	6.56	27	81	<10	-6	21
4	13.10	12	54	<10	-17	2
6	19.70	0	32	<100 [1/]	0	32
8	26.20	-11	12	<100	-11	12
10	32.80	-20	-4	<100	-20	-4
12	39.40	-31	-24	<100	-31	-24
14	45.90	-40	-40	<100	-40	-40
16	52.50	-40	-40	<100	-40	-40
18	59.10	-40	-40	<100	-40	-40
20	65.60	-40	-40	<100	-40	-40
22	72.20	-39	-38	<100	-39	-38
24	78.70	-39	-38	<100	-39	-38
26	85.30	-39	-36	<100	-38	-36
28	91.90	-36	-33	<100	-36	-33
30	98.40	-33	-27	<100	-33	-27
Hot Ground Soak [2/]		71	160	<10	26	78

Table A-1 Notes:
[1]Uncontrolled humidity (dry as possible).
[2]Ground soak temperatures are not necessarily related to measured data but are extreme levels to reduce ground soak time.

Table A-2: Ambient Outside Air Temperatures

COLD ATMOSPHERE MODEL

Altitude km	kft	World-Wide Air Operations °C	°F	Relative Humidity (%)	Dew Point Temperature °C	°F
0	0.00	-51	-60	<100 [1/]	-51	-60
1	3.28	-49	-56	<100	-49	-56
2	6.56	-31	-24	<100	-31	-24
4	13.10	-40	-40	<100	-40	-40
6	19.70	-51	-60	<100	-52	-60
8	26.20	-61	-78	<100	-61	-78
10	32.80	-65	-85	<100	-65	-85
12	39.40	-67	-89	<100	-57	-89
14	45.90	-70	-94	<100	-70	-94
16	52.50	-82	-116	<100	-82	-116
18	59.10	-80	-112	<100	-80	-112
20	65.60	-79	-110	<100	-79	-110
22	72.20	-80	-112	<100	-80	-112
24	78.70	-80	-112	<100	-80	-112
26	85.30	-79	-110	<100	-79	-110
28	91.90	-77	-107	<100	-77	-107
30	98.40	-76	-105	<100	-76	-105
Cold Ground Soak [2/]		-54	-65	<100	-54	-65

Table A-3: Ambient Outside-Air Temperatures

WARM MOIST ATMOSPHERE MODEL

Altitude km	(kft)	World-Wide Air Operations °C	°F	Relative Humidity (%)	Dew Point Temperature °C	°F
0	0.00	32.1	90	<85	29	85
1	3.28	25.0	77	<85	22	72
2	6.56	19.0	66	<85	17	62
4	13.10	4.0	39	<85	2	35
6	19.70	-11.0	13	<85	-13	9
8	26.20	-23.0	-10	<85	-25	-13
10	32.80	-38.0	-36	<100 1//	-38	-36
12	39.40	-52.0	-62	<100	-52	-62
14	45.90	-67.0	-88	<100	-67	-88
16	52.50	-78.0	-108	<100	-78	-108
18	59.10	-73.0	-100	<100	-73	-100
20	65.60	-65.0	-85	<100	-65	-85
22	72.20	-58.0	-72	<100	-58	-72
24	78.70	-53.0	-63	<100	-53	-63
26	85.30	-48.0	-54	<100	-48	-54
28	91.90	-43.0	-45	<100	-43	-45
30	98.40	-38.0	-36	<100	-38	-36
Ground Soak 2/		43.0	109	<75	37	99

Table A-3 Notes:
[1]Uncontrolled humidity (dry as possible).
[2]Ground soak temperatures are not necessarily related to measured data but are extreme levels to reduce ground soak time.

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METHOD 318

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METHOD 319
ACIDIC ATMOSPHERE

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CHAPTER 1 SCOPE

NOTE: Method 300, General Guidance and Requirements, contains information necessary to conduct the test procedures of this method, and shall be used in combination with this test method.

1.1. PURPOSE

To determine the resistance of materials and protective coatings to acidic 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 sulphide.

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CHAPTER 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 6a. 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

See Method 300 Chapters 1 and 8.

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

See Method 300 Chapter 8.

1. Perform acidic atmosphere testing after any humidity or fungus testing, and before any sand and dust testing or other tests that damage protective coatings.

a. Sand and dust testing deposits may inhibit acid effects as well as abrade protective coatings.

b. Acid deposits may inhibit mould growth.

c. Residual deposits may accelerate chemical reactions during humidity testing.

2. Because this test is similar in severity to the salt fog test, recommend separate test items be used for each.

2.4. CHOICE OF TEST SEVERITIES

See Method 300 Chapters 4 and 8.

The essential parameters for defining the acidic atmosphere test 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

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

2.4.2. Test Duration

Two severity levels are defined (reference 6b.). 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 low acidity. Use severity "B" below to represent approximately 10 years natural exposure in a moist, highly industrial area, or a shorter period in close proximity to vehicle exhaust systems, particularly ship funnel exhausts where the potential acidity is significantly higher.

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

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

2.4.3. Test Item Configuration

See Method 300 Chapter 4.

2.4.4. Chemical Composition and Concentration

Use a test solution to be sprayed containing 0.88 g sulphuric acid / litre of solution (0.009M H_2S0_4), and 0.45 g nitric acid / litre of solution (0.007M $HN0_3$) in distilled or deionized water. This will produce a solution with a pH of 1.67 that is representative of the worst-case conditions in the vicinity of smokestacks as measured in the UK. Reference 6b. provides information regarding the more common chemical environmental contaminants, together with some consequent likely forms of corrosion which materiel 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.

a. Do not enter the chamber during spraying and, before entry after spraying, 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 test items.

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 on completion, or on completion of a representative sequence of environmental tests.

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CHAPTER 3 INFORMATION TO BE PROVIDED IN THE TEST INSTRUCTION

In addition to the information required in Method 300 Chapter 6, provide the following information:

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

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

c. The test cycle, severities, and durations to be used.

d. If functional performance is to be assessed, the phases of the test when the test item is to operate and be assessed, and the levels of performance required.

e. Whether the test item is to be tested in its normal packaging or unpackaged.

f. The method of mounting the test item.

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CHAPTER 4 TEST CONDITIONS AND PROCEDURES

See Method 300 Chapters 3, 4, and 5 for test conditions, test facility, and test control information.

4.1. TEST FACILITY

See Method 300 Chapter 5. Additionally:

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

b. Do not respray 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.

c. 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.

d. 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 where the acid solution level is held reasonably constant. The atomizers are connected to this tank.

e. 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.

f. 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.

g. Maintain 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

In addition to that specified in Method 300 Chapters 3 and 4, the following controls apply to this test:

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 percent at the nozzle (see Table 1).

Table 1: 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

b. 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).

4.3. TEST INTERRUPTIONS

See Method 300 Chapter 7.

4.4. PROCEDURE

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

4.4.1. Pre-Test Information

See Guidance on Test Programme Development, Method 300 Chapter 6.

4.4.2. Preparation for Test

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

WARNING: Make the solution by adding acid to water, not vice versa. Failure to do so could cause a violent reaction.

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

c. Perform the pre-test standard ambient check as specified in Method 300, Chapter 2. 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 de-wetting. 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 spraying periods with 7 days storage after each.

b. Three 2-hour spraying periods with 22 hours storage after each.

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

Step 4. 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 in distilled / deionized water and dried by the application of heat (up to 55 °C), where this is acceptable, or by other means.

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.

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CHAPTER 5 EVALUATION OF THE TEST RESULTS

In addition to the failure criteria in Method 300 Chapter 9, any corrosion must be analysed for its immediate or potential effect on the proper functioning of the test item. Satisfactory operation following this test is not the sole criterion for pass / fail.

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CHAPTER 6 REFERENCES AND RELATED DOCUMENTS

See Method 300 Chapter 10.

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

b. Acid Deposition in the United Kingdom, Warren Spring Laboratory SBN 085624 323X.

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