# METHOD 520.5

# COMBINED ENVIRONMENTS

## CONTENTS

## FIGURES



## TABLES

# METHOD 520.5

# COMBINED ENVIRONMENTS

> **NOTE:** The example profiles provided in this method do not represent specific platform/mission scenarios and are not to be used as default profiles. Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4.2.2, and Annex C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard.

**Due to extensive revision to this method, no change bars have been provided.**

## 1. SCOPE.

### 1.1 Purpose.

The purpose of this test is to help determine the synergistic effects of combinations of temperature, altitude, humidity, input electrical power, and vibration on airborne electronic and electro-mechanical materiel with regard to safety, integrity, and performance during ground and flight operations. The synergistic effects may induce failures that would not be exhibited during individual environment testing. New to this method is the addition of input electrical power as an environment; to include voltage/frequency variations, and transients (if applicable) which are inherent to the system. While it is virtually impossible to replicate the complex mix of environments which can be seen during transport, storage, operation, and maintenance, the intent is to apply representative combinations of stresses to the materiel to determine performance and capabilities.

### 1.2 Application.

> **NOTE: This Method is not intended to be used in lieu of Method 507 due to the cyclic and cumulative exposure required for Humidity testing. Additionally, this Method is not intended to be used in lieu of 500, 501, 502, and/or 514 unless properly tailored and authorized in the requirements documents.**

a. This Method was developed and based on rotor or fixed wing aircraft/platforms. The test procedures are applicable to all aircraft equipment. However, with tailoring, this method may also be applicable to other commodities; i.e., ground vehicles, support equipment, man-mounted equipment, etc.

b. Use this Method to evaluate materiel to be deployed in/on aircraft or ground support equipment where temperature, altitude, humidity, input electrical power, and vibration, or any combination of these, may induce failures.

c. 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.

d. Use this Method to provide an option for use of vibration in combination with the climatic elements, or for use of the climatic tests in combination with each other. This is often noted throughout the text. Generally, the combined environment test simulates those synergistic environmental effects that occur for the majority of the deployment life.

### 1.3 Limitations.

a. Limit use of this Method to evaluating the combined effects of three or more of the following environments: temperature, altitude, humidity, input electrical power, and vibration.

b. This Method does not normally apply to unpowered materiel transported as cargo in an aircraft.

c. 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.

d. This Method is not intended to be used for temperature/vibration testing, unrelated to the synergistic environmental test combinations detailed in paragraph 2.2.3. Refer to Method 514.

e. This Method is not intended to be used to test materiel to be installed or operated in space vehicles, aircraft or missiles that fly at altitudes above 21,300 m (70,000 ft).

## 2. TAILORING GUIDANCE.

### 2.1 Selecting the Combined Environments Method.

After examining requirements documents, apply the tailoring process in Part One of this Standard to determine where these combined forcing functions of temperature, altitude, humidity, input electrical power, and vibration are foreseen in the life cycle of the materiel in the real world. Use this Method to evaluate the synergistic stresses based on detailed analysis as defined in the Life Cycle Environmental Profile (LCEP), mission profile, and the platform requirements/specification. If appropriate, tailor non-operational environments into the combined environmental cycle. Use the following to aid in selecting this Method and placing it in sequence with other methods.

#### 2.1.1 Effects of Combined Environments.

Temperature, altitude, humidity, input electrical power, and vibration can combine synergistically to produce the following equipment failures. The synergistic effects may induce failures that would not be exhibited during individual environment testing. In addition to unique effects, the synergistic environments may amplify the stress effects when compared to the effects of individual environments, to include power effects. The following examples are not intended to be comprehensive. For additional information refer to the individual 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.

l. If the material is powered, component over-temperature failures.

m. Printed Circuit Card failures due to short circuiting.

n. Failure of Electromagnetic Interference (EMI) filters.

o. Errors due to input electrical power frequency variances.

#### 2.1.2 Sequence Among Other Methods.

a. General. Use the anticipated life cycle sequence of events as a general sequence guide (see Part One, paragraph 5.5).

b. Unique to this Method. Procedure I is intended to be used before final materiel designs are fixed. If vibration is performed separately from the remaining combined environments, vibration shall be performed first.

### 2.2 Selecting Procedures.

**Note: For risk reduction it is recommended that single environment tests be performed prior to these procedures to verify system performance under discrete environmental parameters.**

This Method includes three procedures:

a. Procedure I - Engineering Development.

b. Procedure II - Flight or Mission Support.

c. Procedure III - Platform Envelope.

#### 2.2.1 Procedure Selection Considerations.

The choice of test procedure is determined by the developmental phase of the equipment (Design, Specific Mission, Troubleshooting, or Envelope Verification).

#### 2.2.2 Difference Among Procedures.

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:

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 UUT 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.

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.

##### 2.2.2.1 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 duration shall be based on time required to induce expected failure modes, such as those listed in paragraph 2.1.1. 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. This procedure is not a substitute for Environmental Stress Screening (ESS) or Highly Accelerated Life Test (HALT) testing. Given these cautions, perform the Procedure I steps specified in the Test Parameter Selection/Profile Development Table (Table 520.5-VIII).

##### 2.2.2.2 Procedure II - Flight or Mission Support.

This procedure is performed in preparation for a specific mission scenario or functional testing; and 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 520.5-VIII).

**2.2.2.3 Procedure III - Platform Envelope.**

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 as determined by the LCEP, specification, and developmental maturity of the materiel. Include in the platform envelope test the maximum amplitude of each stress and any unique combinations of stress types. Use caution in the application of maximum amplitude combinations that would expose the materiel to unrealistic conditions. The intent is to demonstrate maximum conditions that a specific platform may expose the materiel to. Use a test duration of a minimum of 10 cycles. For power cycling the input power shall be cycled such that the electrical stresses are balanced throughout the test. Cycling shall start at nominal, then high voltage, low voltage, etc.; ending with nominal. 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. Perform the Procedure III steps specified in the Test Parameter/Profile Development Table (Table 520.5-VIII).

**2.2.3 Selecting Combined Environments.**

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 relevant environments are temperature, altitude, humidity, input electrical power, and vibration. However, this method can be tailored to perform a series of combined environmental tests providing that all synergistic effects can be evaluated. An example of a series of combined tests would be the performance of a temperature, altitude, humidity, input electrical power test, and vibration. Apply the guidance in section 2.3. Each combined environment test shall be completed in single climatic chamber to maintain materiel conditions and eliminate unintended environmental stresses. Test items shall not be transferred between chambers due to combined environment equipment capability limitations.

**2.2.4 Environmental Stresses.**

a. Determine environmental stresses including temperature, supplemental cooling, altitude, humidity, and input electrical stresses, and vibration.

b. Determine test levels (based on measured data, if available, or from the LCEP) for each stress from the mission profile information in the manner described in paragraphs 2.2.4.1 through 2.2.4.5. Other information, such as engine rpm or data on the platform's system environmental control system (ECS) may be needed.

**2.2.4.1 Thermal Stress.**

The thermal stresses that materiel experiences during a mission is dependent upon the localized ambient temperature, induced/contributing thermal influences (solar, reflected radiation, adjacent heat producing equipment, etc.), altitude and humidity conditions in the equipment location. This 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 found in MIL-HDBK-310. The ground level 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 utilized. In addition to the highest/lowest recorded values, MIL-HDBK-310 also includes the 1, 5, 10, and 20 percent frequency of occurrence 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. Systems comprised of multiple line replaceable units (LRU) may be tested concurrently in one chamber if the LRUs all have the same local operational environment. Likewise, systems comprised of multiple LRUs shall be tested separately if the LRUs have different local environments.

c. The thermal stress test parameters to be used in performance of Procedure II - Flight or Mission 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 is 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 analyze 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% frequency of occurrence temperature for day or night as starting points for ground conditions of start-up, taxi, takeoff, 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.

**2.2.4.1.1 Bay Conditions.** (Reference MIL-STD-2218)

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 regards to the cool down ramps and temperatures. See Table 520.5-I 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. Utilize 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 520.5A-I, 520.5A-II, and 520.5A-III).

$T_{eff}$ = 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, utilize 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 systems that are open to the external environment, the mass flow rate shall be system temperature and mass flow rate parameters.)

**Table 520.5-I. 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 | -54 (-65) | -40 (-40) | 60 (140) | 54 (129) | | --- |
| Ram Air Cooled | -54 (-65) | -40 (-40) | 60 (140) | 54 (129) | 75% at 43°C | --- |
| Unconditioned | -54 (-65) | -40 (-40) | 60 (140) | 54 (129) | | --- |
| CREW STATION | | | | | | |
| Open Areas | -54 (-65) | -40 (-40) | 60 (140) | 25 (77) | | --- |
| Behind Instrument Panels | -54 (-65) | -40 (-40) | 100 (212) | 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 |

**2.2.4.2 Altitude Stress.**

Use altitude simulation to evaluate the effect of various pressures (high or low) across the platform envelope throughout the LCEP. Method 500 addresses the effects of low pressure as an individual forcing function. Method 520 addresses high and low pressure and its effects in conjunction with high/low temperatures and high/low humidity forcing functions, as well as the effects of the altitude ramp rate. Vibration may also be added as a forcing function.

For airborne materiel the pressure altitude has a direct effect on the thermal performance of the materiel (See paragraph 2.2.4.1.1 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 520.5A-I thru 520A-III) in which the materiel is to be operated during its life cycle. For world wide deployment the combined worst case parameters shall be used. See paragraph 2.2.4.3 for the description of the synergistic altitude /humidity effects.

Changes in atmospheric pressure and air density may also effect 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 520.5-II. Pressure vs Altitude Conversion Equations.**

| **Equations for Pressure Versus Altitude** | |
|---|---|
| **Altitude** | **Pressure Equation** |
| 0 km < H ≤ 11 km<br><br>(0 ft < H ≤ 36.1 kft) | $P(Pa) = 101325\left[\frac{288.15 - 6.5(H)}{288.15}\right]^{5.2558}$<br><br>$\left(P(Pa) = 101325\left[\frac{288.15 - 1.9812 \cdot H}{288.15}\right]^{5.2558}\right)$ |
| 11 km < H ≤ 20 km<br><br>(36.1 kft < H ≤ 65.62 kft) | $P(Pa) = 22632.41 \cdot exp\left[-\frac{(H - 11)}{6.34162}\right]$<br><br>$\left(P(Pa) = 22632.41 \cdot exp\left[-\frac{(H - 36.089)}{20.806}\right]\right)$ |
| 20 km < H ≤ 32 km<br><br>(65.62 kft < H ≤105 kft) | $P(Pa) = 5475.052\left[\frac{216.65}{216.65 + (H - 20)}\right]^{34.16}$<br><br>$\left(P(Pa) = 5475.052\left[\frac{216.65}{216.65 + (0.3048 \cdot H - 20)}\right]^{34.16}\right)$ |

Reference U.S. Standard Atmosphere (1976)

**2.2.4.3 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 part of dry air (ppm). Data for the highest and lowest worldwide absolute humidity is found in MIL-HDBK 310, along with data for absolute humidity at altitude. 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.

The effects of ambient humidity on materiel depends on the humidity levels, temperature, pressure, and duration of exposure. For long term exposure effects see MIL-STD-810, method 507. The effects of interest in this test method pertain to effects due to condensation and freezing of water vapor when the dew point is reached during materiel operation and also effects due to absorption and intrusion of water within material. Note that the materiel temperature may be lower than the ambient environment due to black body radiation.

When deployed in a Warm/Moist environment, materiel and the materiel enclosures (equipment bays, cockpit, cabins, etc.) will experience the absolute humidity of the ambient environment. Upon transition to a cold environment (aircraft climb to altitude) the water vapor will condense when the temperature drops to the dew point. This may result in liquid water pooling within electronic equipment; with the potential to create short circuits, sneak circuits, and other adverse effects. The water may subsequently freeze. The expansion of water during freezing may damage components, degrade seals, and lead to delamination of material.

Humidity stresses also occur during transition from a Cold/Dry environment to a Warm/Moist environment (aircraft descent from altitude). In this case the materiel temperature transition lags the transition of the ambient environment. Humidity from the Warm/Moist environment will then condense on, and within, the cold surfaces of the materiel. This may result in liquid water pooling within electronic equipment; with the potential to create short circuits, sneak circuits, and other adverse effects. If the materiel surface temperature is below the freeze point the water may subsequently freeze. The expansion of water during freezing may damage components, degrade seals, and lead to delamination of material.

During environmental testing the intent is to simulate the ascent and descent of the aircraft within, and through, the varying atmospheric temperature and humidity levels. During transitions from high altitude /cold to low altitude/warm/moist, the humidity ramp rate shall be sufficient to induce moisture condensation and frost on the test material.

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 system 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 2.2.4.1.1 b.

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 520.5A-II For the hot environment, dew point temperatures will be less or equal to values in Annex Table 520.5A-I. For the Warm/Moist day, dew point temperatures will be greater than or equal to the values in Annex Table 520.5A-III 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 520.5-II. If the platform has an ECS, the design specifications for the Warm/Moist day apply.

**2.2.4.4 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. (Reference STANAG 3456 Edition 7). 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. In addition, 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 standardized 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. See Part One, Section 5.1.c, Test Conditions, Input Power for guidance to available sources of voltage and frequency characteristics or Tables 520.5-IV, 520.5-V and 520.5-VI that contain steady state voltage and frequency conditions.

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).

**2.2.4.4.1 AC & DC System Normal Operation Stresses.**

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 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.

See Tables 520.5-IV, 520.5-V and 520.5-VI for normal input power parameters. Additional data may be found in MIL-STD-704, RTCA-DO160, and MIL-STD-1275. For shipboard power refer to MIL-STD-1399, Part 300.

A suggested input voltage and frequency variation schedule is provided in Table 520.5-III.

**Table 520.5-III: 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 520.5-IV: 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. Refer to STANAG 3456, ISO 1540, or EN 2282 for NATO member aircraft electrical power characteristics.

Note 6. For the C-130, F-22, and U-2 aircraft platforms, contact the appropriate Platform Program Office for electrical power conditions.

**Table 520.5-V. Ground Vehicle 28 VDC Characteristics**

| Department of Defense MIL-STD-1275 Military Ground Vehicles 28Volt 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.

**Table 520.5-VI. RTCA DO-160 Power Characteristics**

| Commercial Standard RTCA DO-160 Power Input Characteristics | | | |
|---|---|---|---|
| RTCA-DO-160 Version | **DO-160E** | **DO-160F** | **DO-160G** |
| Published Date | 09-December-2004 | 06-December-2007 | 08-December-2010 |
| **115 Line to Neutral (rms) 400Hz** | | | |
| Normal Voltage Steady State | 100-122 | 100-122 | 100-122 |
| Frequency Steady State | 390-410 | 390-410 | 390-410 |
| Abnormal Voltage Steady State | 97-134 | 97-134 | 97-134 |
| Abnormal Frequency Steady State | 370-430 | 370-430 | 370-430 |
| **28 VDC mean** | | | |
| Normal Voltage Steady State | 22-30.3 | 22-30.3 | 22-30.3 |
| Normal Ripple Voltage | ≤4V pk to pk | ≤4V pk to pk | ≤4V pk to pk |
| Abnormal Voltage Steady State | 20.5-32.2 | 20.5-32.2 | 20.5-32.2 |
| Emergency Voltage | 18 | 18 | 18 |
| **270 VDC mean** | | | |
| Normal Voltage Steady State | N/A | 235-285 | 235-285 |
| Ripple Voltage | N/A | ≤16 pk to pk | ≤16 pk to pk |
| Emergency Voltage | N/A | 235 | 235 |

Note 1: Refer to DO-160, Section 16.0 for further information concerning electrical power characteristics.

**2.2.4.4.2 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.

**2.2.4.5 Vibration Stress.**

Method 514 contains guidance for characterizing the vibration environment through measured data and laboratory vibration specification development, with Operational Tailoring Guidance provided in Annex D. Default vibration profiles are provide in Method 514, Annex D, for use when measured data are unavailable. Caution should be used when applying the default vibration profiles in Method 514 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 Method 514, Annex F, paragraph 9.2.1. The resulting levels will typically be more representative of the maximum service levels for use in the functional vibration test. Reference Method 514, Annex A, paragraph 2.1.2.1.

Note that conservatism factors in the Method 514 default vibration profiles are imposed for various reasons (see Method 514, paragraph 2.1b) 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 514 and Table 520.5-VII).

   (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, maneuver-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 514.

   (2) In all cases, field/fleet flight vibration data should be defined in accordance with Method 514 following the vibration characterization guidance in paragraph 2.3.

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 514, Annex D, are used to determine vibration conditions except as modified in Table 520.5-VII.

**Table 520.5-VII. Default Functional Vibration Test Criteria.**

| Aircraft Type | Default Vibration Profiles | Notes Regarding Default Vibration Profiles |
|---|---|---|
| Fixed Wing Jet Aircraft | Method 514, Table 514.8 D-I | As stated in Method 514, Annex D, default vibration profiles for fixed wing jet aircraft 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 at the amplitudes computed from Table 514.8–D-I for sufficient time to fully verify equipment functionality. |
| Fixed Wing Propeller Aircraft | Method 514, Tables 514.8 D-II | As stated in Method 514, Annex D, Paragraph 2.2d, default functional test vibration levels for fixed wing propeller aircraft can be derived by scaling the endurance ASD levels described in Table 514.8D-II. |
| Helicopters | Method 514, Tables 514.8D-III | As stated in Method 514, Annex D, Paragraph 2.3e(4), default functional test vibration levels for helicopters can be derived by scaling the endurance levels described in Table 514.8D-III. |

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 514), with temperature, altitude, and humidity environments combined separately.

i. 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 514. 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.

j. 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 514.

(1) Determine the vibration level, $W_o$ ($g^2$/Hz), for each mission segment using the altitude and Mach number plots for each mission.

> **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 0.001$g^2$/Hz. For test purposes, segments of the mission with calculated values of $W_o$ less than 0.001$g^2$/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 Method 514, Annex A, paragraph 2.2, but the synergistic effects in combination with temperature may be misapplied.

**2.3 Determine Test Levels and Conditions.**

Having selected this Method (see paragraph 2.1), and relevant procedures (see paragraph 2.2), 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 LCEP, and information provided with this procedure.

This section provides the guidance to determine the materiel functions and the combined environments in which the materiel is designed to be employed, such as temperature, cooling airflow, altitude, humidity, input electrical power, vibration, rates of change, and stress durations.

Use Table 520.5-VIII referenced throughout this paragraph, to develop a test schedule. Specific guidance for the individual stresses are found in paragraph 2.2.4.

**2.3.1 Test Cycle Development.**

A test cycle is defined in this method as a series of test segments simulating different climatic/dynamic/power input conditions. 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 life cycle conditions encompassing the materiel design/specification requirements and arranged to encompass all expected combinations of potential mission environments (Figures 520.5-3a, 520.5-3b and Table 520.5-VIII). 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 takeoff, cruise, combat, maneuvering, landing, maintenance, etc., with each segment replicating the climatic/dynamic/power input conditions representative of that mission segment (Figure 520.5-2).

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 stabilize, and to allow for performance verification.

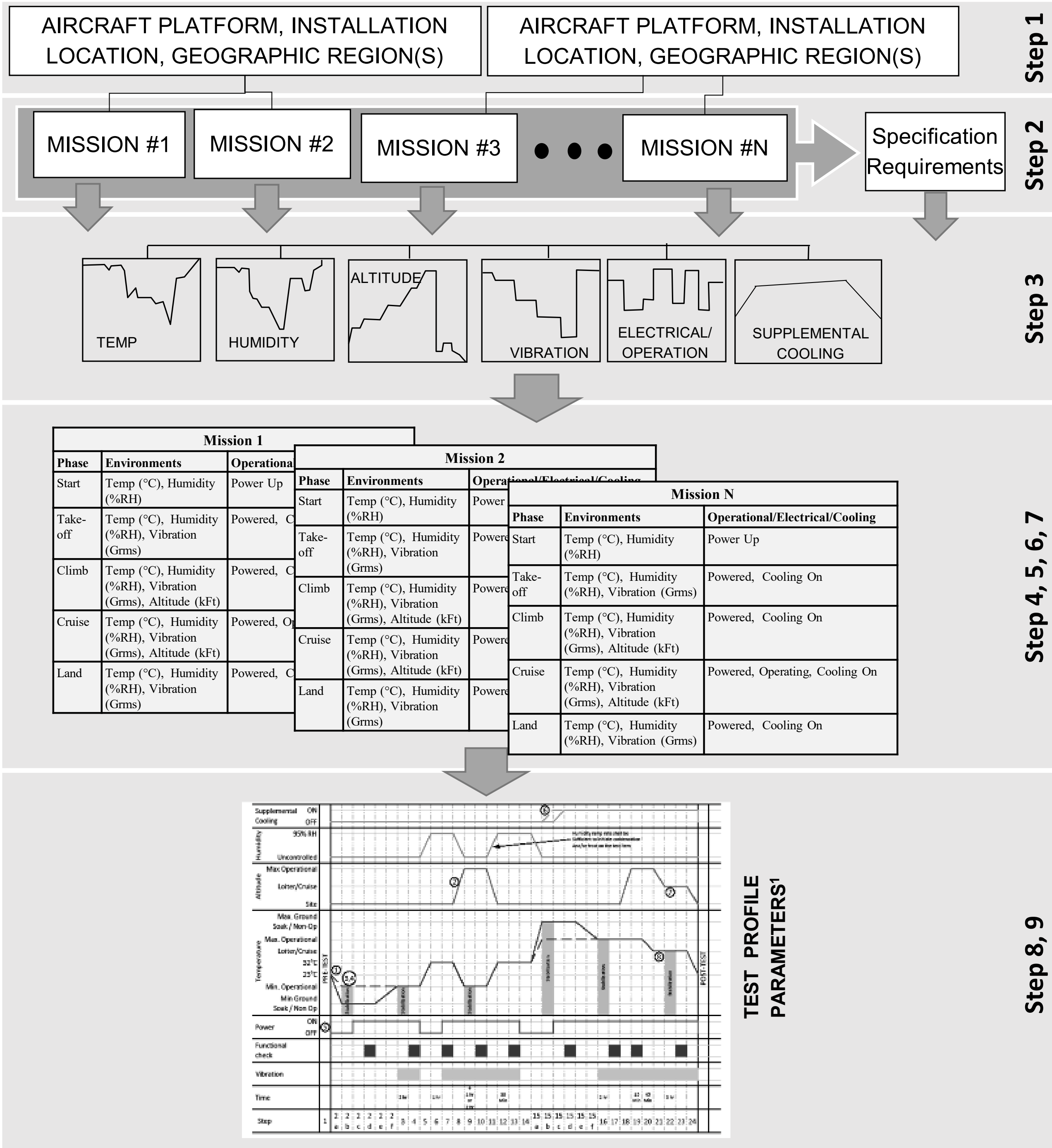
When performing Procedure II, the test parameters are derived from the specific mission parameters as per the portion of the LCEP that defines this specific mission. Use of measured platform data, if available, from the specific equipment location is essential. If measured data is not available, parameter 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, humidity) and induced environments (vibration, power, supplemental cooling). Using this data develop a mission profile inclusive of taxiing, take-off, cruise, combat, maneuvering, 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 is 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.

Refer to Table 520.5-VIII for guidance on test parameter selection. Reference the LCEP.

**Table 520.5-VIII: 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 para 2.2.4 and sub paragraphs. |
| 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 2.2.4.1 and 2.2.4.1.1). |
| 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, take off, climb, cruise, loiter, combat, maneuver, 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 520.5-IX and Figures 520.5-3a and 520.3b) |
| | 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 520.5-1. Test profile generation flow diagram**

**2.4 Test Item Configuration.**

See Part One, paragraph 5.8.

**3. INFORMATION REQUIRED.**

**3.1 Pretest.**

The following information is required to perform a combined environments test adequately.

a. General. Information in Part One, paragraphs 5.7, 5.9, and 5.12; and in Part One, Annex A, Task 405 of this Standard.

b. Specific to this Method.

(1) Purpose of the test, e.g., engineering development, flight or operation support, platform envelope verification, etc.

(2) LCEP defining the combination of three or more of the following environments: temperature, altitude, humidity, input electrical power, and vibration to be applied simultaneously.

(3) Test item platform envelope and/or mission profile(s).

(4) Test item installed location within the respective platform and any specifics associated with the installed location (to include power, cooling, fixturing, etc.)

(5) Climatic/Dynamic Sensor Locations: Mapping of control and response sensors' locations in relation to the test item and test chamber.

(6) 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.

c. Tailoring. The test profile shall be tailored to simulate the LCEP requirements to the greatest extent possible within facility limitations.

**3.2 During Test.**

a. General. See Part One, paragraphs 5.10 and 5.12; and information in Part One, Annex A, Tasks 405 and 406 of this Standard.

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) Complete record of materiel function correlated with test profile sequence.

**3.3 Post-Test.**

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

a. General. Information listed in Part One, paragraph 5.13; and in Part One, Annex A, Task 406 of this Standard.

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) Environmental parameter versus time data plots (temperature, altitude, humidity, input electrical power, and vibration). Sufficient detail is required to verify that all test parameters are met, including temperature and altitude ramp rates, etc.

(4) Out of tolerance conditions, test interruptions, data gaps, etc. shall be annotated and fully described.

(5) Document any modifications/interruptions to the test profile sequence. Refer to the paragraphs 4.4 and 5.0 for analysis of any effects due to the profile changes.

(6) Functional Test Data, including Pass/Fail criteria.

(7) Operator Test Logs.

(8) Pre, During, and Post Photos of test item and any observed anomalies.

## 4. TEST PROCESS.

### 4.1 Test Facility.

Use a facility that can provide the required combination of three or more environmental elements. Verify that the facility is capable of meeting 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 of Methods 500, 501, 502, 507, and 514. Ensure the facility satisfies the requirements of Part One, paragraph 5.

#### 4.1.1 Power Supplies.

Use power supplies which have sufficient power capacity to account for start-up 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. 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). If power characteristics, such as transients or interrupts, are required, use programmable power supplies as necessary.

### 4.2 Controls / Tolerances.

Ensure calibration procedures are consistent with the guidance provided in Part One 5.3.2. Ensure test tolerance procedures are consistent with the guidance provided in Method 514 Paragraph 4.2.2

### 4.3 Test Interruption.

Test interruptions can result from two or more situations, one being from failure or malfunction of test chambers or associated test laboratory equipment. The second type of test interruption results from failure or malfunction of the test item itself during functional tests.

#### 4.3.1 Interruption Due To Facility Malfunction.

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

b. Specific to this Method.

(1) Undertest interruption. Refer to the interruption guidance for the individual test elements, i.e., temperature, altitude, humidity, input electrical power, and vibration.

(2) Overtest interruption. Refer to the interruption guidance for the individual test elements, i.e., temperature, altitude, humidity, input electrical power, and vibration.

(3) 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 Part One, paragraph 5.11 of this Standard.

#### 4.3.2 Interruption Due To Test Item 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 section 5 for additional guidance.)

a. The preferable option is to replace the test item with a “new” one and restart from Step 1.

b. A second option is to replace/repair the failed or non-functioning component or assembly with one that functions as intended, and restart the entire test from Step 1.

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.

**4.3.3 Scheduled Interruptions.**

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 so as 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 stabilized at the values immediately preceding the interruption. See also Part One paragraph 5.11.4. 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-torqueing 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.

**4.4 Test Execution.**

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

**4.4.1 Preparation For Test.**

**4.4.1.1 Preliminary Steps.**

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

**4.4.1.2 Pretest Standard Ambient Checkout**.

All test items require a pretest 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 molded 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 is being recorded.

Step 6: Conduct a functional test (Part One, paragraph 5.8.2) at standard ambient conditions (Part One, paragraph 5.1) as described in the plan and record the results.

Step 7: If the test item operates satisfactorily, proceed to paragraph 4.4.2, 4.4.3, or 4.4.4 as appropriate. If not, resolve the problems and repeat Step 5 thru 6 above. If resolution requires replacement of the item, or removal, of sensors in order to repair, then repeat Steps 1 through 6 above.

#### 4.4.2 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 520.5-VIII. 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.

#### 4.4.3 Procedure II – Flight or 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. 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 is 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 is 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.

##### 4.4.3.1 Non-Operational/ Ground Soak.

Measured data is 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 installation (solar loading, heating from adjacent material, etc.) (Stabilize to the mission ground soak temperature; day or night mission.) See Section 2.2.4.1 (Thermal Stress).

b. Altitude: Site altitude of the deployment location. See Section 2.2.4.2 (Altitude Stress)

c. Humidity: Measured humidity at the deployment location. See Section 2.2.4.3 (Humidity Stress).

##### 4.4.3.2 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 2.2.4.1 (Thermal Stress) and Section 2.2.4.1.1 (Bay Conditions).

b. Altitude: Site altitude of the deployment location. See Section 2.2.4.2 (Altitude Stress)

c. Humidity: Measured humidity at the deployment location. See Section 2.2.4.3 (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 trouble shooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 2.2.4.4 (Electrical Stress).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS system. For ECS systems open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 2.2.4.1 (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 2.2.4.5 (Vibration Stress) and Method 514, annex A, paragraph 2.1.2.1 (Functional Vibration Definition).

**4.4.3.3 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 2.2.4.1.1 (Bay Conditions). For materiel designed for specific geophysical locations, if measured data is not available use data from MIL-HDBK-310. See Section 2.2.4.1 (Thermal Stress). The ramp rate shall be 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 2.2.4.2 (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 2.2.4.3 (Humidity Stress).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for Climb. (If trouble shooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 2.2.4.4 (Electrical Stress).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS system. For ECS systems open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 2.2.4.1 (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 2.2.4.5 (Vibration Stress) and Method 514, annex A, paragraph 2.1.2.1 (Functional Vibration Definition).

**4.4.3.4 Cruise/Surveillance.**

a. Temperature: Maintain the cruise/surveillance temperature until the materiel has stabilized or for the duration of the platform cruise/surveillance mission. For long duration surveillance missions, such as UAS missions, a soak of 4 hours following stabilization is generally sufficient. This data may be available from the program office. See Section 2.2.4.1 (Thermal Stress).

b. Altitude: Maintain the cruise/surveillance altitude until the materiel has thermally stabilized or for the duration of the platform cruise mission. This data may be available from the program office. See Section 2.2.4.2 (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 2.2.4.3 (Humidity Stress).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for cruise. (If trouble shooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 2.2.4.4 (Electrical Stress).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS system. For ECS systems open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 2.2.4.1 (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 2.2.4.5 (Vibration Stress) and Method 514, annex A, paragraph 2.1.2.1 (Functional Vibration Definition).

**4.4.3.5 Attack.**

a. Temperature: The temperature levels in this segment will vary depending on the type of attack mission: 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 2.2.4.1 (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 2.2.4.2 (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 2.2.4.3 (Humidity Stress).

d. Input Electrical Power: Use measured data or data from the electrical loads analysis for attack. (If trouble shooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 2.2.4.4 (Electrical Stress).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS system. For ECS systems open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 2.2.4.1 (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 2.2.4.5 (Vibration Stress) and Method 514, annex A, paragraph 2.1.2.1 (Functional Vibration Definition).

**4.4.3.6 Descent/Landing.**

a. Temperature: Ramp the temperature from the high altitude cruise temperature to the site temperature for the specific geophysical location. See Section 2.2.4.1 (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 2.2.4.2 (Altitude Stress).

c. Humidity: Ramp the humidity to the measured value for the deployment site. If measured data is 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 trouble shooting, consider the effects of power transients. Attempt to replicate aircraft power.) See Section 2.2.4.4 (Electrical Stress).

e. Supplemental Cooling: If required, the supplemental cooling shall meet the temperature and mass flow rates for the specific platform ECS system. For ECS systems open to the external environment, the mass flow rate to the LRU shall be adjusted for the pressure altitude. See Section 2.2.4.1 (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 2.2.4.5 (Vibration Stress) and Method 514, annex A, paragraph 2.1.2.1 (Functional Vibration Definition).

**4.4.3.7 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 2.2.4.1 (Thermal Stress).

b. Altitude: Site altitude of the deployment location. See Section 2.2.4.2 (Altitude Stress)

c. Humidity: Measured humidity at the deployment location. See Section 2.2.4.3 (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 2.2.4.4 (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.)

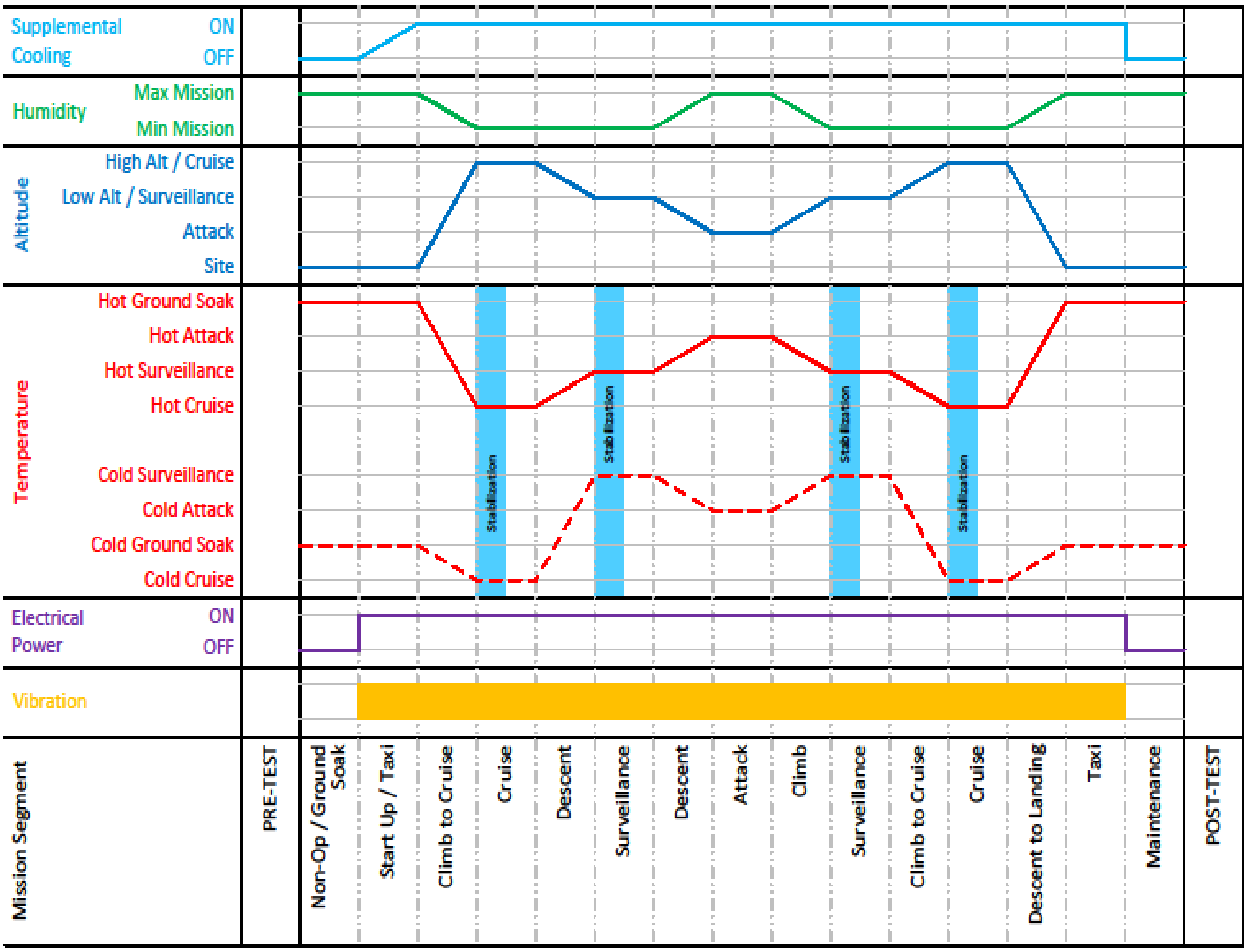



**Figure 520.5-2. Mission Specific/Troubleshooting Test Profile (Hot and Cold Day/Ground Attack) Notional Example (See notes for additional information.)**

Figure 520.5-2. 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 Deg 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 analyzed 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 520.5-III, IV, V, and VI for guidance.

b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. . See Tables 520.5-III, V, and VI for guidance.
Note: Flight critical equipment may be required to operate under abnormal and/or emergency voltage condition. See Table IV and MIL-STD-704 for the appropriate levels. See paragraph 2.2.4.4. 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 2.2.4.1.1.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.

#### 4.4.4 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 520.5-3a).

Option 2 applies to materiel which is powered “ON” during flight operations after the aircraft temperature has stabilized at its normal operational temperature. (Figure 520.5-3b)

Table 520.5-IX, 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 520.5-IX Template: Procedure I and III - Envelope test cycle (Based on Option 1)**

The following table correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 520.5-VIII. Reference Paragraph 2.3.1, Table 520.5-VIII, Step 9

| 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 |
| 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 |

**Table 520.5-IX (Con't) Template: Procedure I and III - Envelope test cycle (Based on Option 1)**

The following table correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 520.5-VIII. Reference Paragraph 2.3.1, Table 520.5-VIII, Step 9

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 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 | |
| 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 |

**Table 520.5-IX (Con't) Template: Procedure I and III - Envelope test cycle (Based on Option 1)**

The following table correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 520.5-VIII. Reference Paragraph 2.3.1, Table 520.5-VIII, Step 9

| 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.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 |
| 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 |

**Table 520.5-IX (Con't) Template: Procedure I and III - Envelope test cycle (Based on Option 1)**

The following table correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 520.5-VIII. Reference Paragraph 2.3.1, Table 520.5-VIII, Step 9

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 thru 24 as required | | | | | | | | |

**Table 520.5-IX (Con't) Template: Procedure I and III - Envelope test cycle (Based on Option 1)**

The following table correlates to the profile steps and typical mission segments. This template shall be populated with actual parameters derived from Table 520.5-VIII. Reference Paragraph 2.3.1, Table 520.5-VIII, Step 9

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 26 | Post Functional Test | Standard Ambient | Uncontrolled | Off | OFF | Site | Operating/Non-operating | Yes | Minimum Time required Post Test and power down |

Table 520.4-IX 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 Deg C/min.
3. Stabilization:
   Non-Operational Equipment: See Part One, paragraph 5.4.2
   Operational Equipment: See Part One, paragraph 5.4.1
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 520.5-III, IV, V, and VI for guidance.
   b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. . See Tables 520.5-III, V, and VI 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 2.2.4.1.1.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.

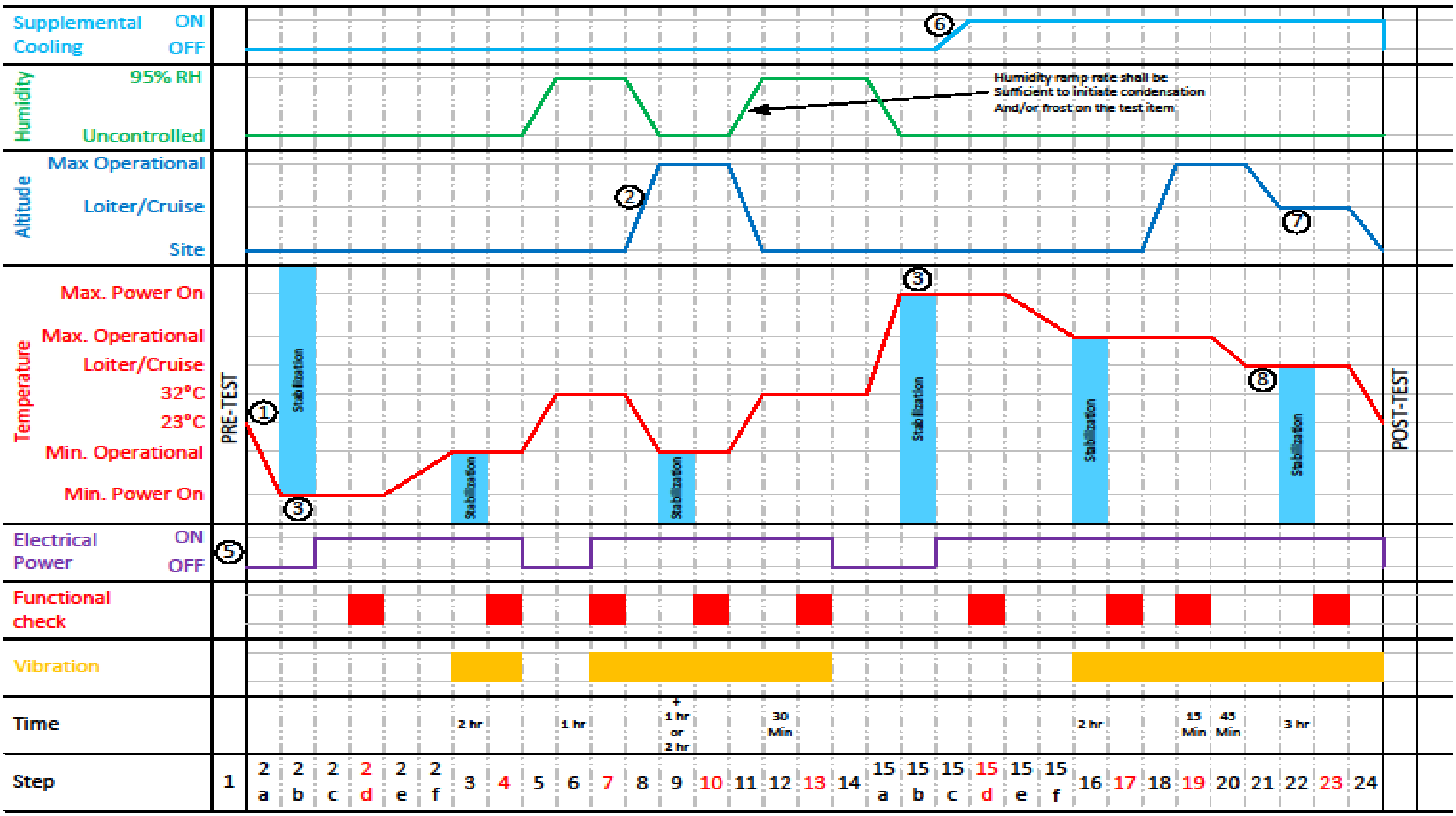



**Figure 520.5-3a. Platform Envelope Option 1 Profile Example (See notes for additional information.)**

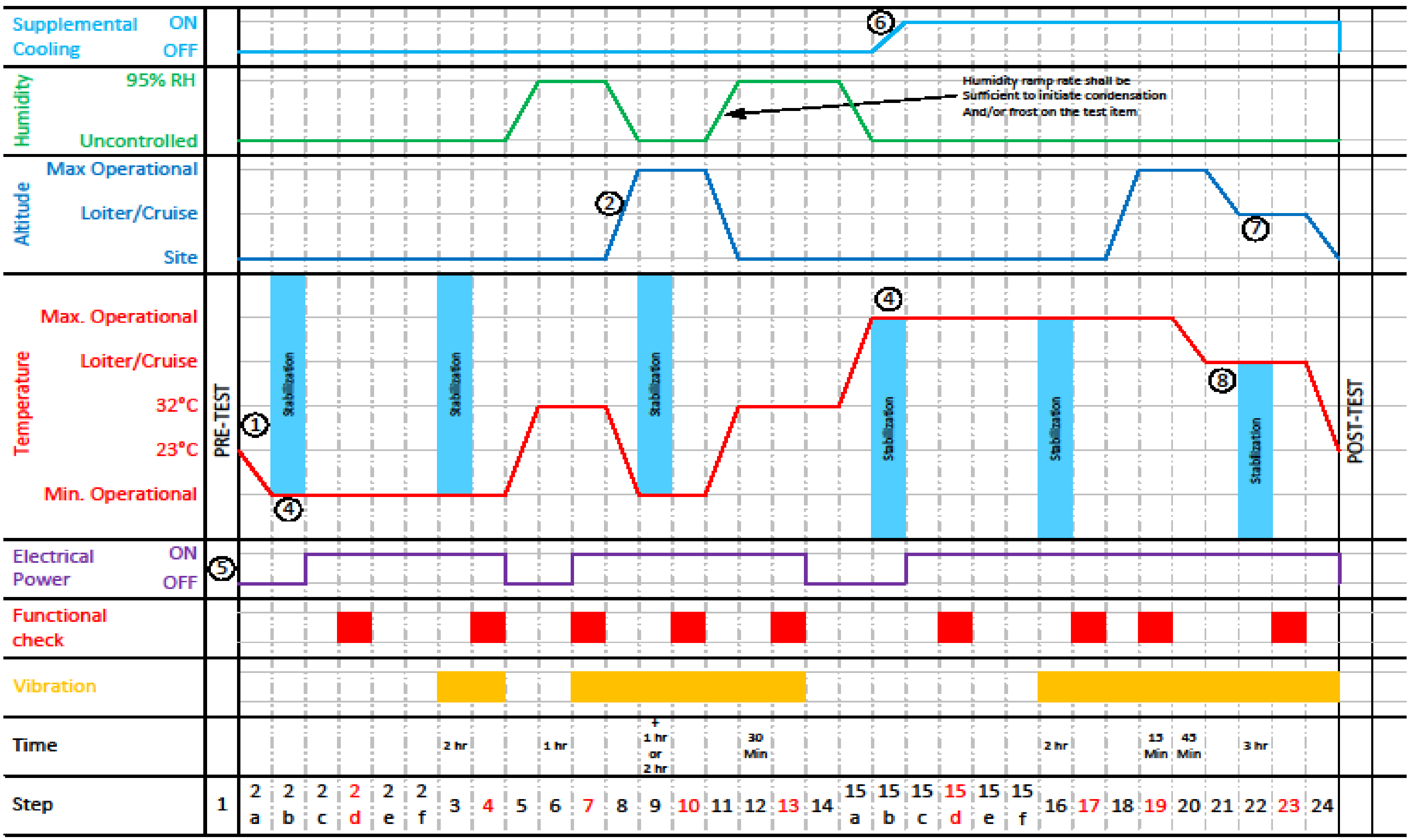



**Figure 520.5-3b. Platform Envelope Option 2 Profile Example (See notes for additional information.)**

Figures 520.5-3a and 520-3b. Notes:

1. Temperature Ramp Rate: IAW equipment or platform(s) specification. If not specified then <5 Deg 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 520.5-3a).
4. Option 2 applies to materiel which is powered "ON" during flight operations after the aircraft temperature has stabilized at its normal operational temperature. (Figure 520.5-3b)
5. Input Electrical Power:
   a. Voltage: Alternate from cycle to cycle; Nominal, High, Low, High, etc. See Tables 520.5-III, IV, V, and VI for guidance.
   b. Frequency Variation: The input electrical power frequency shall be varied from cycle to cycle. . See Tables 520.5-III, V, and VI for guidance.

   Note: Flight critical equipment may be required to operate under abnormal and/or emergency voltage condition. See Table IV and MIL-STD-704 for the appropriate levels. See paragraph 2.2.4.4. 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 2.2.4.1.1.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 External stores/munitions the solar equivalent temperature may be used to determine the high altitude temperature parameters. Referenced JOTP-012.
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.

#### 4.4.4.1 Procedure III - Steps.

Step 1: Perform Pre-Test Set-up and Functional Test at Standard Ambient conditions. See paragraph 4.4.1 and subparagraphs.

Step 2: Cold/Dry (Perform either Option 1 or Option 2)

| **Option 1: Equipment which is Powered ON at temperatures less than the normal operating temperature (Figure 520.5-3a, Note 3):** | **Option 2: Equipment Powered ON during the mission at Operational Temperature (Figure 520.5-3b, 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 5ºC/minute (9ºF/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 ºC/minute (9ºF/minute). |
| b. Cold/Dry Stabilization - Stabilize the test item at the Min Power ON temperature. Reference Part One paragraph 5.4.2. | b. Cold/Dry Stabilization - Stabilize the test item at the low operational temperature. Reference Part One paragraph 5.4.2. |
| c. Cold/Dry Warm-up - Power ON the test item at the required voltage (nominal, high, low) and frequency (See Table 520.5-III). 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 520.5-III). Maintain this condition for the minimum specified warm-up period. (Note: some equipment may require conditioned air prior to start up.) |

| Option 1 (Con't): Equipment which is Powered ON at temperatures less than the normal operating temperature (Figure 520.5-3a, Note 3): | Option 2 (Con't): Equipment Powered ON during the mission at Operational Temperature (Figure 520.5-3b, Note 4): |
|---|---|
| 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 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 two (2) hours, or until the unit stabilizes, 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 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% relative humidity (RH). Perform this temperature/humidity ramp at the following rates: Temperature - no more than 5˚C/minute (9˚F/minute); Humidity – 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% RH, and site pressure for one (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 2.2.4.5 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 520.5-II 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 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 stabilized, plus one 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 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% relative humidity (RH), and site pressure. Perform this temperature/humidity/altitude ramp at the following rates: Temperature - no more than 5 ˚C/minute (9 ˚F/minute); Humidity – maximum facility rate (Note: it is permissible to delay the humidity ramp until the chamber temperature reaches 0˚C); Altitude – 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% 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 for test item failure.

Step 14: Power OFF the test item

Step 15: Hot/Dry (Perform either Option 1 or Option 2)

| **Option 1: Equipment which is Powered ON at temperatures greater than the normal operating temperature (Figure 520.5-3a and Note 3):** | **Option 2: Equipment Powered ON during the mission at Operational Temperature (Figure 520.5-3b 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 - Stabilize the test item at the Max Power On temperature. Reference Part One paragraph 5.4.2. | b. Hot/Dry Stabilization - Stabilize the test item at the high operational temperature. Reference Part One paragraph 5.4.2. If supplement cooling is required, there shall be 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 520.5-III). 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 520.5-III). |
| 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 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 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 paragraph 5 (Analysis of Results) for failure analysis and follow the guidance in paragraph 4.3.2 for test item failure. |

| **Option 1 (Con't): Equipment which is Powered ON at temperatures greater than the normal operating temperature (Figure 520.5-3a and Note 3):** | **Option 2 (Con't): Equipment Powered ON during the mission at Operational Temperature (Figure 520.5-3b and Note 4):** |
|---|---|
| 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 step 16. |
| f. Proceed to step 16 | |

Step 16: Hot/Dry Soak – Maintain the test conditions for two (2) hours, or until the test item stabilizes, whichever is greater. If vibration is to be performed during this step, see paragraph 2.2.4.5 for requirements development. Continue vibration thru 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 paragraph 5 for failure analysis and follow the guidance in paragraph 4.3.2 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 paragraph 5 for failure analysis and follow the guidance in paragraph 4.3.2 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 forty five (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 stabilizes, 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 paragraph 5 for failure analysis and follow the guidance in paragraph 4.3.2 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 through 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 paragraph 5 for failure analysis and follow the guidance in paragraph 4.3.2 for test item failure.

## 5. ANALYSIS OF RESULTS.

### 5.1 Analysis of Test Results.

Use the guidance provided in Part One, paragraphs 5.14 and 5.17, and Part One, Annex A, Task 406 to evaluate the test results.

### 5.2 Analysis of Failures.

Analyze 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.

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?

## 6. REFERENCE/RELATED DOCUMENTS.

### 6.1 Referenced Documents.

a. Hall, P.S., Vibration Test Level Criteria for Aircraft Equipment, AFWAL-TR-80-3119, December 1980.

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

c. NATO STANAG 4370, Allied Environmental Conditions and Test Publication (AECTP) 230, Climatic Conditions.

d. Aircraft Electrical Power System Characteristics, STANAG 3456, Edition 7 March 2014.

e. Joint Ordnance Test Procedure (JOTP)-012, Safety and Suitability for Service Assessment Testing for Aircraft Launched Munitions, 1 July 2013.

f. MIL-STD-704, Aircraft Electric Power Characteristics

g. MIL-HDBK-704, Guidance for Test Procedures for Demonstration of Utilization Equipment Compliance to Aircraft Electrical Power Characteristics

h. RTCA DO-160, Environmental Conditions and Test Procedures for Airborne Equipment

i. MIL-STD-1399/300B, Department of Defense Interface Standard: (Section 300B) Electric Power, Alternating Current (24 APR 2008)

j. MIL-STD-2218, Thermal Design, Analysis and Test Criteria for Airborne Electronic Equipment, 20 May 1992

**6.2 Related Documents.**

a. Sevy, R.W., Computer Program for Vibration Prediction of Fighter Aircraft Equipment, AFFDL-TR-77-101, November 1977.

b. Lloyd, A.J.P., G.S. Duleba, and J.P. Zeebenm, Environmental Control System (ECS) Transient Analysis, AFFDL-TR-77-102, October 1977.

c. Dieckmann, A.C., et al, Development of Integrated Environmental Control Systems Design for Aircraft, AFFDL-TR-72-9, May 1972.

d. Quart, I., A.H. Samuels, and A.J. Curtis, A Study of the Cost Benefits of Mission Profile Testing, AFWAL-TR-81-3028, 1981.

e. Burkhard, A.H., et al, CERT Evaluation Program Final Report, AFWAL-TR-82-3085.

f. F-15 AFDT&E High-Temperature Desert Test and Climatic Laboratory Evaluation, AFFTC-TR-75-19, October 1975, DTIC Number AD B011345L.

g. STANAG 4370, Environmental Testing.

h. Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests (under STANAG 4370), Method 317.

i. 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.

(Copies of Department of Defense Specifications, Standards, and Handbooks, and International Standardization Agreements are available online at https://assist.dla.mil.

Requests for other defense-related technical publications may be directed to the Defense Technical Information Center (DTIC), ATTN: DTIC-BR, Suite 0944, 8725 John J. Kingman Road, Fort Belvoir VA 22060-6218, 1-800-225-3842 (Assistance--selection 3, option 2), http://www.dtic.mil/dtic/; and the National Technical Information Service (NTIS), Springfield VA 22161, 1-800-553-NTIS (6847), http://www.ntis.gov/.

## METHOD 520.5, 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 520.5A-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 Method 514, Annex A, paragraph 2.6.

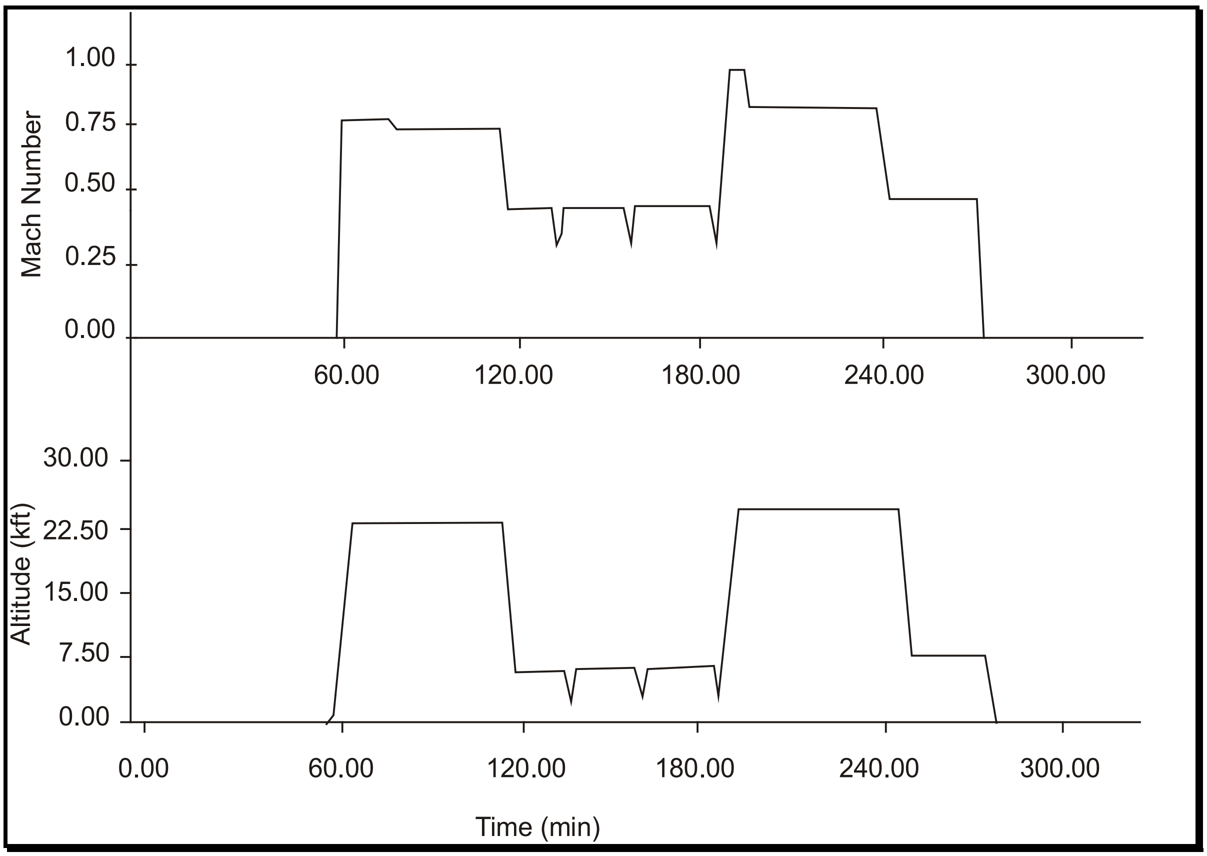



**Figure 520.5A-1. Schematic mission profile, altitude, and Mach number (F-15 ground attack example).**

The Standard Atmospheric Models presented in Tables 520.5A-I thru 520.5A-III may be used in determining the altitude, temperature, relative humidity, and dew point correlations when specific flight data is not available. Reference paragraphs 2.2.4.2 (Altitude Stress) and 2.2.4.3 (Humidity Stress).

**Table 520.5A-I. Ambient outside air temperatures.**
**HOT ATMOSPHERE MODEL**

| Altitude km | Altitude kft | World-Wide Air Operations °C | World-Wide Air Operations °F | Relative Humidity (%) | Dew Temperature °C | Dew Temperature °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 | 0 | 32 |
| 8 | 26.20 | -11 | 12 | <100 | -11 | 12 |
| 10 | 32.80 | -20 | -4 | <100 1/ | -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 520.5A-I 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 520.5A-II. Ambient outside air temperatures.**
**COLD ATMOSPHERE MODEL**

| Altitude km | Altitude kft | World-Wide Air Operations °C | World-Wide Air Operations °F | Relative Humidity (%) | Dew Temperature °C | Dew Temperature °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 520.5A-III. Ambient outside air temperatures.**
**WARM MOIST ATMOSPHERE MODEL**

| Altitude km | Altitude (kft) | World-Wide Air Operations °C | World-Wide Air Operations °F | Relative Humidity (%) | Dew Temperature °C | Dew Temperature °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 520.5A-III 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.