METHOD 500.6

LOW PRESSURE (ALTITUDE)

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NOTE: 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.

1. SCOPE.

1.1 Purpose.

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

1.2 Application.

Use this method to evaluate materiel likely to be:

a. stored and/or operated at high ground elevation sites.

b. transported or operated in pressurized or unpressurized areas of aircraft (also consider Method 520.5 for actively-powered materiel operated at altitude).

c. exposed to a rapid or explosive decompression and, if so, to determine if its failure will damage the aircraft or present a hazard to personnel.

d. carried externally on aircraft.

1.3 Limitations.

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). Recommend the test be to the maximum altitude (minimum pressure) normally reached by the appropriate mode of transportation.

Procedure IV is not intended to be used for materiel transported in a cargo bay. For example, analysis for a C-5 aircraft indicates that to go from a cabin altitude of 2438 m (8,000 ft) to an ambient altitude of 12192m (40,000 ft) in 1 second would require a hole of approximately 33.4 m^2 (360 ft^2). Instantaneous creation of a hole that large in the side of the airplane would be catastrophic to the airplane. Please note that the 33.4 m^2 (360 ft^2) hole is for a <u>1-second depressurization</u>. To depressurize in one tenth of a second would require a hole ten times as large.

2. TAILORING GUIDANCE.

2.1 Selecting the Low Pressure (Altitude) Method.

After examining the requirements documents, and applying the tailoring process in Part One of this Standard to determine where low pressure is foreseen in the life cycle of the materiel, use the following to aid in selecting this Method and placing it in sequence with other methods. Based upon the LCEP, there may be a requirement to conduct this Method in combination with other Methods within this standard (i.e., high temperature, low temperature, or vibration).

2.1.1 Effects of Low Pressure Environments.

In addition to thermal effects (see Methods 501.7 and 502.7), consider the following typical problems to help determine if this Method is appropriate for the materiel being tested. This list is not intended to be all-inclusive and some of the examples may overlap the categories.

2.1.1.1 Physical/Chemical.

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

b. Deformation, rupture or explosion of sealed containers.

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

d. Overheating of materiel due to reduced heat transfer.

e. Evaporation of lubricants.

f. Erratic starting and operation of engines.

g. Failure of hermetic seals.

2.1.1.2 Electrical.

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

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. Normally, this Method is performed early in a test sequence because of both its limited damage potential, and its generally early occurrence in the life cycle. However, other testing may contribute significantly to the effects of low pressure on the test item (see paragraph 2.1.1), and may have to be conducted before this Method. For example:

   (1) Low temperature and high temperature testing may affect seals.

   (2) Dynamic tests may affect the structural integrity of the test item.

   (3) Aging of non-metallic components may reduce their strength.

2.2 Selecting Procedures.

This Method includes four low pressure tests: Procedure I (Storage); Procedure II (Operation); Procedure III (Rapid Decompression), and Procedure IV (Explosive Decompression). Based on the test data requirements, determine which of the test procedures or combination of procedures is applicable.

NOTE: For Procedure II, Method 520.5 may be used in addition to this Method when considering the potential synergistic and/or flight safety effects. However, Method 520 is NOT a substitute for Method 500.

2.2.1 Procedure selection considerations.

Differences among the low pressure test procedures are explained below. Select the procedure that represents the most severe exposure anticipated. When selecting a procedure, consider:

a. The materiel configuration.

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

c. The operational purpose of the materiel.

d. The test data required to determine if the operational purpose of the materiel has been met.

e. Procedure sequence.

f. Whether the cargo compartment is pressurized.

2.2.2 Difference among procedures.

a. Procedure I - Storage/Air Transport. Procedure I is appropriate if the materiel is to be transported or stored at high ground elevations or transported by air in its shipping/storage configuration. Evaluate the materiel with respect to known effects of low pressure (paragraph 2.1.1) and the LCEP (Part One, paragraph 4.2.2.3.1) to determine if this procedure is appropriate.

b. Procedure II - Operation/Air Carriage. Use Procedure II to determine the performance of the materiel under low pressure conditions. It may be preceded by Procedure I. If there are no low pressure storage, rapid, or explosive decompression requirements, this procedure can stand alone.

c. Procedure III - Rapid Decompression. Use Procedure III to determine if a rapid decrease in pressure of the surrounding environment will cause a materiel reaction that would endanger nearby personnel or the platform (ground vehicle or aircraft) in which it is being transported. This procedure may be preceded by Procedure I and/or Procedure II.

d. Procedure IV - Explosive Decompression. (See paragraph 1.3.) Procedure IV is similar to Procedure III except that it involves an "instantaneous" decrease in the pressure of the surrounding environment. NOTE: This procedure is more appropriate for items such as sealed cockpit equipment whose failure could endanger cockpit personnel. Since one purpose of this test is to ensure failure of the materiel does not endanger personnel, and a catastrophic failure severe enough to cause an explosive decompression of the cargo compartment would, most likely, bring down the aircraft, carefully consider the appropriateness of application of this procedure for large cargo items. This procedure may be preceded by Procedure I and/or Procedure II.

NOTE: After either decompression test, a potential safety problem could exist that is not obvious. Exercise caution during the post-test operational check.

2.3 Determine Test Levels and Conditions.

Having selected this Method and relevant procedures (based on the materiel's requirements documents and the tailoring process), it is necessary to complete the tailoring process by selecting specific parameter levels and special test conditions/techniques for these procedures based on requirements documents and Life Cycle Environmental Profile (LCEP), (see Part One, Figure 1-1), and information provided with this procedure. From these sources of information, determine the functions to be performed by the materiel in low pressure environments or following storage in low pressure environments. Determine the test parameters such as test pressure and temperature, rate of change of pressure (and temperature if appropriate), duration of exposure, and test item configuration.

2.3.1 Test Pressure (Altitude) and Temperature.

Base determination of the specific test pressures (altitude) and temperatures on the anticipated deployment or flight profile of the test item. See Method 520.5, Table 520.5-2, for pressure versus altitude conversion equations.

a. Ground areas. If measured data are not available, temperatures may be obtained for appropriate ground elevations and geographical locations from STANAG 4370, AECTP 230 (paragraph 6.1, reference b). The highest elevation currently contemplated for ground military operations (materiel operating and non-operating) is 4,572 m (15,000 ft), with an equivalent air pressure of 57.2 kPa (8.3 psia) (see paragraph 6.1, reference c).

b. Transport aircraft cargo compartment pressure conditions. The test pressure used for each of the four procedures in this Method will vary greatly for each test item. Compartments normally pressurized may not be in certain situations. There are many different types of cargo transport aircraft on which materiel could be transported, and many different types of pressurization systems. Most pressurization systems provide outside atmospheric pressure in the cargo compartment (no pressure differential between the inside and outside of the aircraft) up to a particular altitude, and then maintain a specific pressure above that altitude. The pressure inside the cargo department is known as “cabin altitude.” Subject the test item to the most likely anticipated conditions. Unless the materiel has been designed for transport on a particular aircraft with unique cabin altitude requirements, use the following guidance:

   (1) For Procedures I and II, unless otherwise identified, use 4,572 m (15,000 ft) for the cabin altitude (corresponding pressure in a standard atmosphere: 57.2 kPa or 8.3 psia).

   (2) For Procedures III and IV, use 2,438m (8,000 ft) for the initial cabin altitude (75.2 kPa or 10.9 psia), and 12,192 m (40,000 ft) for the final cabin altitude after decompression (18.8 kPa or 2.73 psia).

NOTE: Cargo aircraft may transport cargo in either pressurized or un-pressurized conditions for various reasons including fuel economy

c. Transport aircraft cargo compartment temperature conditions. The range of temperatures associated with the various low pressure situations varies widely, primarily depending on the capabilities of the environmental control system within the cargo compartment of the various aircraft. Obtain the test temperatures from measured data or from appropriate national sources.

d. Transport aircraft cargo compartment humidity conditions. The humidity exposure associated with the various low pressure situations will also vary widely. If humidity has been identified as an environment of concern in the LCEP, humidity levels should come from measured data or from appropriate national sources.

2.3.2 Altitude Change Rate.

If a specific rate of altitude change (climb/descent rate) is not known or specified in the requirements document, the following guidance is offered: In general, and with the exception of the explosive decompression test, do not use a rate of altitude change that exceeds 10 m/s (32.8 ft/sec.) unless justified by the anticipated deployment platform. In a full military power takeoff, military transport aircraft normally have an average altitude change rate of 7.6 m/s (25 ft/sec.). Use the value of 10 m/s (32.8 ft/sec.) for ground deployment tests (for standardization purposes) unless otherwise specified.

2.3.3 Decompression Rate.

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

a. Sufficient damage to the aircraft cockpit or other critical small compartments causing virtually instantaneous decompression (explosive decompression -- to be accomplished in 0.1 second or less). This procedure is not intended to be used for materiel transported in the cargo bay.

b. Relatively minor damage caused by foreign objects through which decompression could occur at a slower rate than above (rapid decompression -- not more than 15 seconds).

2.3.4 Test Duration.

For Procedure I, use a test duration representative of the anticipated service environment but, if this is extensive, use a test duration of at least one hour that has historically been considered adequate for most materiel. Once the test pressure has been reached and any required functions performed, Procedures II, III, and IV do not require extended periods at the test pressure. In some cases, there may be a need to tailor Procedure II to account for test item stabilization (see Part One, paragraph 5.4.1).

2.3.5 Test Item Configuration.

Determine the test item configuration based on the realistic configuration(s) of the materiel as anticipated for transportation, storage, or operation. As a minimum, consider the following configurations:

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

b. In its normal operating configuration (realistic or with restraints, such as with openings that are normally covered).

2.3.6 Humidity.

Although various levels of humidity commonly exist in the natural environment, there is no requirement to include it in this Method because of the complexities involved in controlling combinations of temperature, air pressure, and relative humidity. However, this Method may be tailored to accommodate temperature and humidity if so identified in the LCEP as a non-operational environment of concern. Method 520.5 does include this combination for an operational environment and which requires the development of a tailored test profile. MIL-HDBK-310 (paragraph 6.1, reference a) includes data on humidity at altitude.

3. INFORMATION REQUIRED.

3.1 Pretest.

The following information is required to conduct the low pressure tests adequately.

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

b. Specific to this Method.

(1) Test altitude and corresponding pressure.

(2) Altitude change rates (or pressurization schedule if a particular aircraft and flight environment are known).

(3) Test temperature and/or humidity (if controlled).

(4) Test item configuration.

(5) Test duration.

(6) Test item sensor location(s) if applicable

c. Tailoring. Necessary variations in the basic test procedures to accommodate environments identified in the LCEP.

3.2 During Test.

Collect the following information during conduct of the test:

a. See Part One, paragraph 5.10, and Annex A, Tasks 405 and 406 of this Standard.

b. Record of the chamber pressure (altitude)-versus-time data for the duration of the test.

c. Record of the chamber and test item temperature versus time conditions (if applicable).

d. Record of the chamber humidity versus time conditions (if applicable).

3.3 Post Test.

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

a. General. Information listed in Part One, paragraph 5.13, and in 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) Time-versus pressure data.

(3) Any deviations from the original test plan.

(4) Time versus temperature and humidity (if applicable).

4. TEST PROCESS.

4.1 Test Facility.

a. The required apparatus consists of a chamber or cabinet together with auxiliary instrumentation capable of maintaining and monitoring (see Part One, paragraph 5.18) the required environmental condition(s).

b. Record chamber pressure and, if required, temperature and/or humidity at a sufficient rate to capture data necessary for post-test analysis (see Part One, paragraph 5.18).

4.2 Controls.

For standardization purposes:

a. Altitude change rate. Unless otherwise specified (as in the explosive decompression procedure), do not use an altitude change rate in excess of 10 m/s (32.8 ft/sec.). (See paragraph 2.3.2.)

b. Charts. When using a chart recorder, ensure charts can be read with a resolution within two percent of full scale.

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 operational checks.

4.3.1 Interruption Due to Chamber Malfunction.

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

b. Specific to this Method. To achieve the desired effects, subject the test item to the full duration of the low pressure test without interruption; i.e., for either overtest or undertest interruptions, restart the test from the beginning. See paragraph 4.3.2 for test item operational failure guidance.

4.3.2 Interruption Due to Test Item Operation Failure.

Failure of the test item(s) to function as required during operational checks presents a situation with several possible options.

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.

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

4.4 Test Setup.

See Part One, paragraph 5.8.

4.5 Test Execution

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the materiel in a low pressure environment. Unless otherwise specified, maintain the chamber temperature at standard ambient.

4.5.1 Preparation for test.

4.5.1.1 Preliminary steps.

Before starting the test, review pretest information in the test plan to determine test details (e.g., procedures, test item configuration, test altitude, altitude change rate, duration, parameter levels for storage/operation, etc.).

4.5.1.2 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 If required, install temperature sensors in or on the test item as described in the test plan. If required, install humidity sensor(s) in the chamber.

Step 3 Conduct an operational checkout (Part One, paragraph 5.8.2) at standard ambient conditions (Part One, paragraph 5.1) and as described in the test plan, and record the results.

Step 4 If the test item operates satisfactorily, proceed to the appropriate test procedure. If not, resolve the problems and repeat Steps 3 and 4. If resolution requires replacement of the item or removal of sensors in order to repair, then repeat Steps 1 through 3 above.

4.5.2 Procedure I - Storage/Air Transport.

Step 1 Adjust the test item to its storage or transport configuration and install it in the test chamber.

Step 2 If required, stabilize the test item to the required temperature and humidity (see paragraph 2.3.1). Ensure the temperature rate of change does not exceed 3°C/min (5°F/min).

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

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

Step 5 If required, adjust the chamber air to standard ambient conditions at a rate not to exceed 3°C/min (5°F/min).

Step 6 Visually examine the test item to the extent possible and conduct an operational check. Document the results, and see paragraph 5 for further guidance.

4.5.3 Procedure II - Operation/Air Carriage.

Step 1 With the test item in its operational configuration, install it in the chamber and adjust the chamber air pressure (and temperature, if required – see paragraph 2.3.1) to that which corresponds to the required operational altitude at a rate not to exceed that specified in the test plan.

Step 2 With the test item operating, maintain the conditions until the equipment reaches thermal stabilization (in accordance with Part One paragraph 5.4.1) unless otherwise specified in the test plan.

Step 3 Conduct an operational check of the test item in accordance with the requirements documents, and document the results. If the test item does not operate satisfactorily, follow the guidance in paragraph 4.3.2 for test item failure.

Step 4 If required, adjust the chamber air to standard ambient conditions at a rate not to exceed 3°C/min (5°F/min).

Step 5 Visually examine the test item to the extent possible and conduct an operational check. Document the results, and see paragraph 5 for further guidance.

4.5.4 Procedure III - Rapid Decompression.

Step 1 With the test item in the storage or transit configuration, install it in the chamber and adjust the chamber air pressure (and temperature if appropriate – see paragraph 2.3.1) at a rate not to exceed 3°C/min (5°F/min) or as otherwise specified in the test plan, to the cabin altitude (2,438 m (8,000 ft)) (see paragraph 2.3.1b).

Step 2 Reduce the chamber air pressure to that which corresponds to the required test altitude of 12,192 m (40,000 ft) (18.8 kPa (2.73 psi)), or as otherwise specified in the test plan for the maximum flight altitude, in not more than 15 seconds. Maintain this stabilized reduced pressure for at least 10 minutes.

Step 3 Adjust the chamber air to standard ambient conditions using a pressure change rate not greater than 10 m/s (32.8 ft/sec.), and if required a temperature change rate not to exceed 3°C/min (5°F/min).

Step 4 Visually examine the test item to the extent possible. Document the results. Be alert for potential safety problems (see paragraph 5).

4.5.5 Procedure IV - Explosive Decompression.

Step 1 With the test item in the configuration in which it is intended to function when installed, install it in the chamber and adjust the chamber air pressure (and temperature if required–see paragraph 2.3.1) at the rate specified in the test plan to the cabin altitude of 2,438 m (8,000 ft) (see paragraph 2.3.1b).

Step 2 Reduce the chamber air pressure to that which corresponds to the required test altitude of 12,192 m (40,000 ft) or as otherwise specified in the test program, in not more than 0.1 seconds. Maintain this stabilized reduced pressure for at least 10 minutes.

Step 3 Adjust the chamber air to standard ambient conditions using a pressure change rate not greater than 10 m/s (32.8 ft/sec.), and a temperature change rate not to exceed 3°C/min (5°F/min) if controlled.

Step 4 Visually examine the test item to the extent possible. Document the results, and be alert for potential safety problems (see paragraph 5)

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraph 5.14, the following information may assist in the evaluation of the test results. For Procedures III and IV, the test item fails only if rapid or explosive decompression causes a hazard to the aircraft or to personnel; the test item need not show satisfactory post-test performance unless otherwise specified.

6. REFERENCE/RELATED DOCUMENTS.

6.1 Referenced Documents.

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

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

c. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions; September 1979.

6.2 Related Documents.

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

b. STANAG 4370, Environmental Testing.

c. Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Testing (Edition 3) (under STANAG 4370), Method 312.

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

e. Handbook of Geophysics and Space Environments. Bedford, MA. US Air Force Cambridge Research Laboratories, Office of Aerospace Research, 1965.

f. US Standard Atmosphere, 1976. NOAA/NASA/USAF, 1976.

g. 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.

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