METHOD 510.7

SAND AND DUST

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METHOD 510.7
SAND AND DUST

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.

Sand and dust environments include a wide range of materials and particulate size distributions. Method 510 defines dust as particulates less than 150 µm in diameter. Sand is defined as particulates in the range from 150 to 850 µm in diameter. The test method includes two procedures:

a. Dust (< 150 µm) procedure. This test is performed to evaluate the ability of materiel to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings, and joints, and to evaluate the effectiveness of filters.

b. Sand (150 to 850 µm particle size) procedure. This test is performed to evaluate the ability of materiel to be stored and operated in blowing sand conditions without degrading performance, effectiveness, reliability, and maintainability due to abrasion (erosion) or clogging effects of sharp-edged particles.

1.2 Application.

Use this Method to evaluate all mechanical, optical, electrical, electronic, electrochemical, and electromechanical devices (to include, but not limited to, platform mounted and man-portable) likely to be exposed to dry blowing sand or blowing dust-laden atmospheres.

1.3 Limitations.

This Method is not suitable for determining the effects of a buildup of electrostatic charge. Additionally, because of control problems, this Method does not address sand or dust testing outdoors. This Method doesn't address settling dust.

When a requirement exists for weapon system components such as windows/radomes, nose cones, airframes, leading edges, control surfaces, thermal protection systems, and fuzes to operate during weather encounter to include flight through abrasive particles, such as sand, dust and volcanic ash, a tailored test approach must be utilized based on the system configuration, trajectories, and system specific statistically based weather occurrence. Abrasive particles (sand, dust, ash) may vary depending on the global region and must be defined prior to ground test and evaluation. Traceability must be addressed between realistic flight through weather and ground test methods to ensure adequate performance characterization is achieved. Ground test methods include the use of sand/dust erosion facilities, multiple particle impact facilities, whirling-arm impact, ballistic gun ranges to induce high speed/hypersonic integrated sand, dust, and ash erosion effects on flight components. For hypersonic item testing consider utilizing the methods described in Technical Report AMR-PS-08-01. For Rotor Blade Material testing consider utilizing the method described in MIL-STD-3033.

2. TAILORING GUIDANCE.

2.1 Selecting the Sand and Dust Method.

After examining requirements documents and applying the tailoring process in Part One of this Standard to determine where sand and dust environments are foreseen in the life cycle of the materiel, use the following to confirm the need for this Method and to place it in sequence with other methods.

2.1.1 Effects of Sand and Dust Environments.

The blowing sand and dust environment is usually associated with hot-dry regions. It exists seasonally in most other regions. Naturally-occurring sand and dust storms are an important factor in the deployment of materiel, but the induced environment created by the operational (battlefield, training, etc.) environment can be more severe. Consider the following typical problems to help determine if this Method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

a. Abrasion and erosion of surfaces.

b. Penetration of seals.

c. Degraded performance of electrical circuits.

d. Obstruction/clogging of openings and filters.

e. Physical interference with mating parts.

f. Fouling/interference of moving parts.

g. Reduction of heat transfer.

h. Interference with optical characteristics.

i. Overheating and fire hazard due to restricted ventilation or cooling.

j. Wear (increased fretting due to imbedding between mating surfaces).

k. Increased chaffing between non-mating contacting surfaces.

l. Weight gain, static/dynamic balance.

m. Attenuation of signal transmission.

2.1.2 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. This Method will produce a dust coating on, or severe abrasion of, a test item that could influence the results of other MIL-STD-810 methods such as Solar Radiation (Method 505.7), Humidity (Method 507.6), Fungus (Method 508.8), and Salt Fog (Method 509.6). Therefore, use judgment in determining where in the sequence of tests to apply this Method. Additionally, results obtained from the Solar Radiation Test (Method 505.7) may be required to define temperature parameters used both in this Method and in High Temperature (Method 501.7). On the other hand, the presence of dust in combination with other environmental parameters can induce corrosion or mold growth. A warm humid environment can cause corrosion in the presence of chemically aggressive dust.

2.2 Selecting Procedures.

This Method includes two test procedures, Procedure I - Blowing Dust, and Procedure II - Blowing Sand. Determine the procedure(s) to be used. If settling dust is of concern, concentration levels can be obtained from International Electrotechnical Commission (IEC) 60721-2-5, and test procedures for settling dust can be obtained from IEC 60068-2-68 Test Lb. For outdoor testing, guidance is provided in Test Operations Procedure (TOP) 01-2-621 Outdoor Sand and Dust Testing.

2.2.1 Procedure Selection Considerations.

When selecting procedures, consider:

a. The operational purpose of the materiel. From the requirements documents, determine the functions to be performed by the materiel in a sand or dust environment and any limiting conditions such as storage.

b. The natural exposure circumstances.

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

d. Procedure sequence. If both sand and dust procedures are to be applied to the same test item, it is generally more appropriate to conduct the less damaging first, i.e., blowing dust and then blowing sand.

2.2.2 Difference Among Procedures.

While both procedures involve sand and/or dust, they differ on the basis of particle size and type of movement. These test procedures are tailorable to the extent that the user must specify the test temperature, sand and/or dust composition, test duration, and air velocity.

a. Procedure I - Blowing Dust. Use Procedure I to investigate the susceptibility of materiel to concentrations of blowing dust (< 150 µm).

b. Procedure II - Blowing Sand. Use Procedure II to investigate the susceptibility of materiel to the effects of blowing sand (150 µm to 850 µm).

2.3 Determine Test Levels and Conditions.

Having selected this Method and relevant procedures (based on the materiel's requirements documents and the tailoring process), it is necessary to complete the tailoring process by selecting specific parameter levels and special test conditions/techniques for these procedures based on requirements documents, Life Cycle Environmental Profile (LCEP), and information provided with this Method. From these sources of information, determine the functions to be performed by the materiel in sand and dust environments, or following storage in such environments. Then determine the sand and dust levels of the geographical areas and micro-environments in which the materiel is designed to be employed. To do this, consider the following in light of the operational purpose and life cycle of the materiel.

2.3.1 Identify Climatic Conditions.

Identify the appropriate climatic conditions for the geographic areas in which the materiel will be operated and stored, and whether or not test item needs to be operated during the test.

2.3.2 Determine Exposure Conditions.

Base the specific test conditions on field data if available. In the absence of field data, determine the test conditions from the applicable requirements documents. If this information is not available, use the configuration guidance in paragraph 2.3.3, as well as guidance provided in paragraphs 4.1.1 and 4.2.1 for procedures I and II, respectively.

2.3.3 Test Item Configuration.

Use a test item configuration that reproduces, as close as possible, the anticipated materiel configuration during storage or use, such as:

a. Enclosed in a shipping/storage container or transit case.

b. Protected or unprotected.

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

3. INFORMATION REQUIRED.

3.1 Pretest.

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

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

b. Specific to this Method.

(1) Applicable for both procedures in this Method:

(a) Test temperature(s).

(b) Composition of the dust or sand.

(c) Concentration of the dust or sand.

(d) Operating requirements.

(e) Test item orientation (incident angle).

(f) Exposure time per orientation.

(g) Methods of sand or dust removal used in service.

(h) Air velocity.

(i) Procedures for determining the test item's degradation due to abrasion (if required).

(j.) Operational Test Instructions including time period of operation and test item performance (if required).

(k.) Any additional parameters to be measured and recorded, if required. (i.e., Weight, balance, fluid contamination)

(2) Specific to Procedure I (Dust): Relative humidity.

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. General. Information listed in Part One, paragraph 5.10; and in Annex A, Tasks 405 and 406 of this Standard.

b. Specific to this Method.

(1) Applicable for both procedures in this Method.

a. Air velocity calibration of fan settings (if the velocity is not continuously measured and recorded). Any calibrations of feed rates or chamber checkouts required to prove proper application of the applied environment.

b. Pretest photographs of the item and test setup.

c. Photographic documentation prior to and following each change in test item orientation or cleaning.

d. Any deviations from the test plan.

e. Photographic documentation showing the orientation of the test item with respect to the air flow.

f. Documentation of operating and non-operating periods as well as any functional tests conducted.

g. Document when thermal stabilization of the test item was achieved for the purpose of evaluating the duration of high temperature exposure.

(2) Specific to Procedure I (Dust).

a. Relative humidity vs. Time.

b. Dust Concentration vs. Time

c. Wind Speed vs. Time or record of measurements performed to calibrate wind speed just prior to the testing.

(3) Specific to Procedure II (Sand).

a. Sand Concentration vs. Time or record of measurements performed to calibrate sand concentration just prior to the testing.

b. Wind Speed vs. Time or record of measurements performed to calibrate wind speed just prior to the testing.

3.3 Post-Test.

The following post 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) Applicable for both procedures in this Method.

(a) Initial test item orientation and any orientation change during test.

(b) Values of the test variables for each section of the test (temperature, air velocity, sand or dust concentrations, humidity and duration).

(c) Results of each visual inspection.

(d) Any deviations from the test plan.

(e) Composition of the dust or sand.

(f) Detailed post test photographs.

(g) Documentation of abrasion areas.

(h) Documentation of any sand or dust intrusions.

(i) Documentation of the cleaning methods performed. Detailed photographs before and after cleaning methods are applied.

4. TEST PROCESS.

4.1 Procedure I – Blowing Dust.

4.1.1 Test Levels and Conditions.

4.1.1.1 Temperature.

Unless otherwise specified, conduct the blowing dust tests with the test item at standard ambient and the high operating or storage temperature. In the absence of this information, perform the tests at the maximum ambient air temperature for the A1 climatic category induced or ambient, as required.

4.1.1.2 Relative Humidity.

High levels of relative humidity (RH) may cause caking of dust particles. Consequently, control the test chamber RH to not exceed 30 percent.

4.1.1.3 Air Velocity.

Use a reduced air velocity of 1.5 ±1 m/s (300 ±200 ft/min) to maintain test temperature conditions, and a higher air velocity of 8.9 ±1.3 m/s (1750 ±250 ft/min) typical of desert winds, to be used in the absence of specified values. Use other air velocities if representative of natural conditions. The lower air speed during temperature conditioning is to ensure that airborne dust within the chamber is minimized and the pressure applied to the dust laden test item due to wind speed is minimized during this period.

For typical testing, uniform wind speeds are provided across the test area. If the test item is large and at ground level some consideration should be given to account for the wind profile from the ground to the test item height.

Wind speed verification typically takes place prior to the testing. For this verification, the sampling rate for wind speed measurements will be a minimum of 4 samples per second. The steady state (sustained) wind speeds will be verified by averaging the wind speeds over 10 seconds with the wind generation equipment controls held constant.

4.1.1.4 Dust Composition.

WARNING

Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data. Exposure to silica flour (ground quartz) can cause silicosis; other material may cause adverse health effects.

a. The main mineral constituents of dust derived from soils and sediments are quartz, feldspars, calcite (carbonate), dolomite, micas, chlorite, and a variety of heavy oxides and amorphous inorganic material and organic matter. Dust can also include mixed layer clays consisting of kaolinite, illite, and smectite. In arid regions, soluble salts are common components of dust and include calcite, gypsum, and halite, as well as the mineral opal and the clay palygorskite. In some regions, the dust-related problems with materiel such as fouling, interference of moving parts, increased electrical conductivity, and corrosion can be more pronounced if there are more reactive constituents in the natural dust. Using a dust material with a chemical composition close to that of the dust in the region being considered may give a realistic simulation of some of these effects on materiel in the blowing dust test. For example, mixed layer clays swell upon contact with fluids such as lubricants, and can cause parts to stick or seize. Carbonates can enhance the formation of scale on metal alloys and can cause shorting in electrical assemblies. These compounds can also cause corrosion in humid conditions. Other components such as soluble salts will result in both corrosion and abrasion resulting in electrical and physical malfunctions.

b. For tests to realistically represent these potential failure modes, natural dust from the region should be used, or a test dust that contains a close approximation of the components in the natural dust. When it may not be practical to obtain the natural material from the region of interest, the material closest in composition should be used for the test. These test dust materials should be chosen with deliberate consideration of these reactive properties as much as possible. If necessary, compounds can be mixed in with the more inert dust materials to achieve the necessary dust composition and a more realistic test outcome. Although the silica (quartz) content is generally the primary component of natural dust, it is usually less than 80 % of the sample mass. Silica is chemically non-reactive, but it can be abrasive and will cause wear and erosion of surfaces. Some regional dust may also contain a greater amount of clay-sized particles.

c. Particle size distribution must also be considered. A particle size distribution of 100 percent by weight less than 150 μm, with a median diameter (50 percent by weight) of 20 ±5 μm has been used in prior testing and is recommended.

d. If dust from a region of interest or its analog is not available, a blowing dust test procedure may be conducted using the following dust compositions, by weight. The dust compositions are given in decreasing order of similarity to real world conditions.

(1) Red china clay has been used as a surrogate for dust commonly found worldwide and contains:

$CaCO_3$, $MgCO_3$, MgO, TiO_2, etc.	5 percent
Ferric oxide (Fe_2O_3)	10 ±5 percent
Aluminum oxide (Al_2O_3)	20 ±10 percent
Silicon dioxide (SiO_2)	remaining percentage (50 to 80 %)

(2) Silica flour, although not truly representative of dust found in the natural environment (except for particle size), has been widely used in dust testing and contains 97 to 99 percent (by weight) silicon dioxide. A 140 mesh Silica Flour (about 2 percent retained on a 140 mesh (106 microns) sieve) has a particle size distribution of 100 percent by weight less than 150 μm, with a median diameter (50 percent by weight) of 20 ±5 μm. ASTM D185-07, Standard Test Methods for Coarse Particles in Pigments, provides a method for particle size measurements by sieve analysis. If particle size measurements are carried out using techniques other than sieve analysis, it must be demonstrated that the same results are produced. This type of dust is readily available and should produce comparable

results to prior tests. Silica dust (ground quartz) has been found to provide adequate effects with regard to penetration or binding and abrasion. This is an inert compound that does not produce the effects that result from exposure to natural dust containing reactive components.

(3) Other materials used for dust testing are less desirable and may have a particle size distribution that falls below that in paragraph 4.1.1.4c above. However, use unique dust compositions if the compositions are known. Ensure material to be used is appropriate for the intended purpose and regions of the world being simulated; e.g., for dust penetration, ensure the particle sizes are no larger than those identified for the region. These materials for dust testing include talcum powder (talc) (hydrated magnesium silicate), fire extinguisher powder (F.E.) (composed mainly of sodium or potassium hydrogen carbonate with a small amount of magnesium stearate bonded to the surface of the particles in order to assist free-running and prevent clogging. F.E. must be used in dry conditions to prevent corrosive reaction and formation of new chemicals (paragraph 6.1, reference c)), quartz (a constituent of many dusts occurring in nature), and undecomposed feldspar and olivine (that have similar properties to quartz).

4.1.1.5 Dust Concentrations.

Unless otherwise specified, maintain the dust concentration for the blowing dust test at 10.6 ±7 g/m^3 (0.3 ±0.2 g/ft^3). This concentration exceeds that normally associated with moving vehicles, aircraft, and troop movement, but has historically proven to be a reliable concentration for blowing dust tests using silica flour (ground quartz) material. If available, use a dust concentration based on natural environment data or other historical information to accurately represent the specific service condition.

4.1.1.6 Orientation.

Unless otherwise specified, orient the test item such that the most vulnerable surfaces face the blowing dust. Using the specified test duration, rotate the test item, if required, at equal intervals to expose all vulnerable surfaces. When possible, evaluate of the airflow around the test item in-service to determine required chamber boundary conditions to create similar airflow and cooling conditions.

Consider removal of the dust accumulation during the reorientation of the test item. See section 4.1.1.9.

4.1.1.7 Duration.

Unless otherwise specified, conduct blowing dust tests for at least 6 hours at standard ambient temperature, and an additional 6 hours at the high storage or operating temperature. If necessary, stop the test after the first 6-hour period, provided that prior to starting the second 6-hour period, the test item and chamber conditions are re-stabilized. If necessary, rotate the item to expose each vulnerable side during each of the 6-hours of exposure.

If facility limitations do not allow for the coverage of an entire face of the test item, the length of overall exposure should be extended to allow for the equivalent amount of exposure that would be performed if the facility limitation did not exist. For example, if an item with four vulnerable sides is being testing, but the facility can only cover half of each face, two exposures would be needed for each face. In this case the total time of testing would be doubled.

4.1.1.8 Operation During Test.

Determine the need to operate the test item during exposure to dust from the anticipated in-service operational requirements. If the test item must be operated, specify the time and periods of operation in the test plan. Include at least one 10-minute period of operation of the test item during the last hour of the test, with the test item's most vulnerable surface(s) facing the blowing dust. If the item is to be operated throughout a dust event in the field it is recommended that the item be operated throughout the dust exposures. Ensure the period of operation includes the essential operational requirements to include proper operation of environmental conditioning units (ECUs) for enclosures.

A build-up of dust will reduce the ability of the test item to shed the thermal load generated by electronics. If dust accumulations are expected in the field, perform the operational test without removing the dust. To fully evaluate the performance of the dust laden materiel in low wind speed and high temperature conditions, consider performing a high temperature operational test on the dust laden materiel using the procedures provided in Methods 501 or 505.

Consider removal of the dust accumulation prior to operation of the test item. See section 4.1.1.9.

Consider manipulation of the test item as part of the operational test. This may uncover issues with binding or wear of moving parts. The test item should be manipulated in the same manner it would be utilized in the field in a dust laden environment. For example, the wear of hydraulic, pneumatic seals, or operator controls may not occur without repetitive use/manipulation of the equipment during testing.

4.1.1.9 Removal of Dust Accumulations.

Experience has shown that dust accumulations of 13 mm (0.5 inch) on the test item are not uncommon during the chamber dust exposure. This can create a condition that may not be experienced in the life cycle of the test item. This layer of dust may form a protective layer over the seals. Removing the dust during the reorientation of the test item may provide a more realistic application of the fielded environment. If dust removal is to be performed, the item specific dust removal procedures shall be documented prior to test in the approved test plan.

In the event of an operational test this build-up of dust will reduce the ability of the test item to shed the thermal load generated by electronics. If dust accumulations are expected in the field perform the operational test without removing the dust. If the item will be routinely maintained or exposed to other environments (high winds, rain, etc.) that will mitigate dust buildup consider removing the dust prior to operation.

Procedures for dust removal must reflect the in service use in accordance with the field manual with the tools available in the field. Remove accumulated dust from the test item by brushing or wiping taking care to avoid introduction of additional dust or disturbing any that may have already entered the test item. Do not remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.

Photographs prior to and following the dust removal must be performed.

4.1.2 Information Required – Refer to Paragraphs 3.1 to 3.3.

4.1.3 Test Details.

4.1.3.1 Test Facility.

a. Ground the test item and facility to avoid buildup of an electrostatic charge. Verify resistance/continuity in accordance with applicable safety requirements for the materiel. Employ a data collection system to measure the test volume conditions (see Part One, paragraph 5.18). Except for gaseous nitrogen (GN_2), achieve dehumidification, heating and cooling of the air envelope surrounding the test item by methods that do not change the chemical composition of the air, dust, and water vapor within the chamber test volume air.

b. Use a test facility that consists of a chamber and accessories to control dust concentration, velocity, temperature, and humidity of dust-laden air. Ensure that the dust is uniformly distributed in the air stream. In order to provide adequate circulation of the dust-laden air, use a test chamber of sufficient size that no more than 50 percent of the test chamber's cross-sectional area (normal to airflow) and 30 percent of the volume of the test chamber is be occupied by the test item(s). Maintain and verify the concentration of dust in circulation within the chamber with suitable instrumentation such as a calibrated smoke meter and standard light source. When using this method ensure that the light source and smoke meter are kept free of dust accumulations and lens abrasion, use of a dry air purge system is a common methodology. Introduce the dust-laden air into the test space in such a manner as to allow the air to become as close to laminar as possible, but at least in a manner that prevents excessive turbulence as the flow of dust-laden air strikes the test item.

c. Use dust in this test as outlined in paragraph 4.1.1.4 above.

4.1.3.2 Controls.

a. Maintain the test chamber relative humidity (RH) at 30 percent or less to prevent caking of dust particles.

b. Record chamber temperature and humidity in accordance with Part One, paragraphs 5.2 and 5.18, and dust concentration at a sufficient rate (at least once every 5 minutes) to satisfy the post-test analysis (see Part One, paragraph 5.18).

4.1.3.3 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.

4.1.3.3.1 Interruption Due To Chamber Malfunction.

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

b. Specific to this Method.

(1) Undertest interruption. Follow any undertest interruption by reestablishing the prescribed test conditions and continue from the point of interruption.

(2) Overtest interruption. Following exposure to excessive dust concentrations, remove as much of the accumulation as possible (as would be done in service) and continue from the point of interruption. If abrasion is of concern, either restart the test with a new test item or reduce the exposure period by using the concentration-time equivalency (assuming the overtest concentration rate is known).

4.1.3.3.2 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.

4.1.4 Test Execution.

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

4.1.4.1 Preparation for Test.

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

4.1.4.1.1 Preliminary Steps.

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

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

b. Operate the test chamber without the test item to confirm proper operation. Adjust the air system or test item position to obtain the specified air velocity for the test item.

4.1.4.1.2 Pretest Standard Ambient Checkout.

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

Step 1. Conduct a complete visual examination of the test item with special attention to sealed areas and small/minute openings, and document the results.

Step 2. Prepare the test item in its operating configuration or as otherwise specified in the test plan. Install test item instrumentation as required by the test plan. When applying surface mount thermocouples, minimize the coverage of the test item surface to the greatest extent possible.

Step 3. Position the test item as near the center of the test chamber as possible and from any other test item (if more than one item is being tested). Orient the test item to expose the most critical or vulnerable parts to the dust stream. Ensure the test item is grounded (either through direct contact with the test chamber or with a grounding strap).

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

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

Step 5. Conduct an operational checkout in accordance with the test plan and record results.

Step 6. If the test item operates satisfactorily, proceed to Step 1 of the test procedure. If not, resolve the problem and restart at Step 1 of pretest checkout.

4.1.4.2 Test Procedure I. Blowing Dust.

WARNING: Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data. Exposure to silica flour (ground quartz) can cause silicosis; other material may cause adverse health effects.

NOTE: Unless the requirements documents indicate otherwise, if the following test procedure is interrupted because of work schedules, etc., maintaining the test item at the test temperature for the time required will facilitate completion of the test when resumed. If the temperature is changed, before continuing the test, re-stabilize the test item at the temperature of the last successfully completed period before the interruption.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures does not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials (see Part One, paragraph 5.19).

Step 1. With the test item in the chamber and stabilized at standard ambient temperature, adjust the air velocity to 8.9 ±1.3 m/s (1750 ±250 ft/min), or as otherwise determined from the test plan. Adjust the relative humidity to less than 30% and maintain it throughout the test.

Step 2. Adjust the dust feed control for a dust concentration of 10.6 ±7 g/m^3 (0.3 ±0.2 g/ft^3)

Step 3. Unless otherwise specified, maintain the conditions of Steps 1 and 2 for at least 6 hours. If required, periodically reorient the test item to expose other vulnerable faces to the dust stream. If required, perform dust removal when the test item is reoriented (See paragraph 4.1.1.9). **SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.** If required, operate the test item in accordance with the test plan. If the test item fails to operate as intended, follow the guidance in paragraph 4.2.3.3.2. Otherwise proceed to Step 4.

Step 4. Stop the dust feed. (See paragraph 4.1.1.7.) If required, operate the test item in accordance with the test plan. Reduce the test section air velocity to 1.5 ±1 m/s (300 ±200 ft/min) and adjust the temperature to the required high operational temperature (see paragraph 4.1.1.1), or as otherwise determined from the test plan. The rate of temperature change shall be no greater than 3°C/min (5.4°F/min).

Step 5. Maintain the Step 4 conditions for a minimum of 1 hour following test item temperature stabilization.

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

Step 7. Continue the exposure for at least 6 hours or as otherwise specified. If required perform the following:

a. Periodically reorient the test item to expose other vulnerable faces to the dust stream.

b. Perform dust removal when the test item is reoriented. See paragraph 4.1.1.9. Take photographs prior to and following dust removal.

c. Operate and/or manipulate the test item in accordance with the test plan. If the test item fails to operate as intended, follow the guidance in paragraph 4.2.3.3.2. Otherwise proceed to Step 8.

SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.

Step 8. Stop the dust feed, stop or reduce the air speed to no greater than 2.5 m/s (500 ft/min), and allow the test item to return to standard ambient conditions at a rate not to exceed 3 °C/min (5 °F/min). Stop any air flow and allow the dust to settle (possibly up to 1 hour).

Step 9. Photograph the test item to document dust accumulation.

Step 10. Remove accumulated dust from the test item by brushing or wiping, taking care to avoid introduction of additional dust or disturbing any that may have already entered the test item. See paragraph 4.1.1.9. Do **NOT** remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service. **SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.**

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

Step 12. Perform an operational check in accordance with the approved test plan, and document the results for comparison with pretest data. See paragraph 5.1 for analysis of results.

Step 13. If required, clean the test item further to ensure that personnel that will be handling or occupying the test item are not exposed to unnecessary health hazards.

4.2 Procedure II – Blowing Sand.

4.2.1 Test Levels and Conditions.

4.2.1.1 Temperature.

Unless otherwise specified, conduct the blowing sand tests with the test item at the high operating or storage temperature. In the absence of this information, perform the tests at the maximum ambient air temperature for the A1 climatic category induced or ambient, as required.

4.2.1.2 Air Velocity.

Winds of 18 m/s (40 mph) capable of blowing the large particle sand are common, while gusts up to 29 m/s (65 mph) are not unusual. Recommend using an air velocity of 18 m/s (40 mph) or greater to ensure the blowing sand particles remain suspended in the air stream. If the induced flow velocity around the materiel in its field application is known to be outside of this range, use the known velocity.

> **NOTE:** Ensure the sand particles impact the test item at velocities ranging from 18-29 m/s (40-65 mph). In order for the particles to attain these velocities, maintain an approximate distance of 3 m (10 ft) from the sand injection point to the test item. Use shorter distances if it can be proven the particles achieve the necessary velocity at impact.

For typical testing, uniform wind speeds are provided across the test area. If the test item is large and at ground level some consideration should be given to account for the wind profile from the ground to the test item height.

The sampling rate for wind speed measurements will be a minimum of 4 samples per second. The steady state wind speeds will be verified by averaging the wind speeds over 10 seconds with the wind generation equipment controls held constant. A gust is defined as a 3 second period at the level of increased wind speed. When performing a test with gusts, a minimum of four gusts per hour is recommended. The accuracy of wind measurement devices, such as cup, propeller and hot wire anemometers, are negatively affected by the sand and dust environment, therefore wind speed measurements should be taken in clean air with these devices. Variation in wind direction, or high turbulence, can also influence cup and propeller measurement accuracy.

4.2.1.3 Sand Composition.

WARNING: Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data. Exposure to crystalline silica can cause silicosis; other material may cause adverse health effects.

Unless otherwise specified, for the sand test, use quartz sand (at least 95 percent by weight SiO_2). Use sand of sub-angular structure, a mean Krumbein number range of 0.5 to 0.7 for both roundness and sphericity, and a hardness factor of 7 Mohs. Due to the loss of subangular structure and contamination, re-use of test sand is normally not possible. If possible, determine the particle size distribution from the geographical region in which the materiel will be deployed. There are 90 deserts in the world, each with different particle size distributions. Therefore, it is impossible to specify a particle size distribution that encompasses all areas. The recommended particle size distribution for the sand test is from 150 µm to 850 µm, with a mean of 90 ±5 percent by weight smaller than 600 µm and larger than or equal to 150 µm, and at least 5 percent by weight 600 µm and larger. When materiel is designed for use in a region that is known to have an unusual or special sand requirement, analyze a sample of such sand to determine the distribution of the material used in the test. Specify the details of its composition in the requirements documents.

4.2.1.4 Sand Concentrations.

Unless otherwise specified, maintain the sand concentrations as follows (references 6.1a & b):

a. For materiel likely to be used close to helicopters and other aircraft operating over unpaved surfaces: 2.2 ±0.5 g/m^3.

b. For material never used or exposed in the vicinity of operating aircraft, but that may be used or stored unprotected near operating surface vehicles: 1.1 ±0.3 g/m^3.

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

NOTE: If the wind velocity is increased intermittently to simulate a gust it is permissible to allow the sand concentration to be reduced for this period of time of intermittent increase in wind speed.

4.2.1.5 Orientation.

Orient the test item with respect to the direction of the blowing sand such that the test item will experience maximum erosion effects. The test item may be re-oriented at 90-minute intervals. Consider the incident angle of sand particle impact on the severity of erosion in selecting orientations. When possible, evaluate of the airflow around the test item in-service to determine required chamber boundary conditions to create similar airflow and cooling conditions.

4.2.1.6 Duration.

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

4.2.1.7 Operation During Test.

Determine the need to operate the test item during exposure to sand from the anticipated in-service operational requirements. For example, in addition to items that are exposed directly to natural conditions, consider items inside environmentally controlled enclosures that should be operated while the enclosure is exposed to the blowing sand environment. This should include operation of ECUs to ensure the adverse environment does not result in a failure of the test item to meet performance requirements. If the test item must be operated during the test, specify the time and periods of operation in the test plan. Include at least one 10-minute period of operation of the test item during the last hour of the test, with the test item's most vulnerable surface facing the blowing sand. Ensure the period of operation includes the essential operational requirements.

A build-up of sand, especially in internal compartments, will reduce the ability of the test item to shed the thermal load generated by electronics. If sand accumulations are expected in the field, perform the operational test without removing the sand. To fully evaluate the performance of the sand laden materiel in low wind speed and high temperature conditions, consider performing a high temperature operational test on the sand laden materiel using the procedures provided in Methods 501 or 505.
Consider manipulation of the test item as part of the operational test. This may uncover issues with binding or wear of moving parts. The test item should be manipulated in the same manner it would be utilized in the field in a desert environment.

4.2.2 Information Required – Refer to Paragraphs 3.1 to 3.3.

4.2.3 Test Details.

4.2.3.1 Test Facility.

a. Ground the test item and facility to avoid buildup of an electrostatic charge. Verify resistance/continuity in accordance with applicable safety requirements for the materiel. Employ a data collection system–to measure the test volume conditions (see Part One, paragraph 5.18). Except for gaseous nitrogen (GN_2), achieve dehumidification, heating and cooling of the air envelope surrounding the test item by methods that do not change the chemical composition of the air, dust, sand, and water vapor within the chamber test volume air. The following information is also appropriate.

b. Test facility design considerations.

   (1) In order to provide adequate circulation of the sand-laden air, use a test chamber of sufficient size that no more than 50 percent of the test chamber's cross-sectional area (normal to airflow) and 30 percent of the volume of the test chamber is occupied by the test item(s).

   (2) Control the sand feeder to emit the sand at the specified concentrations. To simulate the effects produced in the field, locate the feeder to ensure the sand is approximately uniformly suspended in the air stream when it strikes the test item.

   (3) Because of the abrasive characteristics of blowing sand, do not re-circulate the sand through the fan or air conditioning equipment.

4.2.3.2 Controls.

Record chamber temperature and humidity in accordance with Part One, paragraphs 5.2 and 5.18 at a sufficient rate to satisfy the post-test analysis (see Part One, paragraph 5.18), and provide sand rate calculations for each test interval. Verify chamber air velocity and sand concentration prior to test. Calculate the sand feed rate and verify it by measuring the sand quantity delivered over unit time using the following formula:

Feed Rate = (Concentration)(Area)(Velocity)

where:

Feed Rate = mass of sand introduced into the test chamber per set time interval

Concentration = sand concentration required by the test plan

Area = cross-sectional area of the sand laden wind stream at the test item location.

Velocity = average velocity of air across the cross-sectional area at the test item location

4.2.3.3 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.

4.2.3.3.1 Interruption Due To Chamber Malfunction.

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

b. Specific to this Method.

(1) Undertest interruption. Follow any undertest interruption by reestablishing the prescribed test conditions and continue from the point of interruption.

(2) Overtest interruption. Following exposure to excessive sand concentrations, remove as much of the accumulation as possible (as would be done in service) and continue from the point of interruption. If abrasion is of concern, either restart the test with a new test item or reduce the exposure period by using the concentration-time equivalency (assuming the overtest concentration rate is known).

4.2.3.3.2 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.

4.2.4 Test Execution.

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

4.2.4.1 Preparation For Test.

WARNING: The relatively dry test environment combined with the moving air, sand particles may cause a buildup of electrostatic energy that could affect operation of the test item. Be aware of potential anomalies caused by electrostatic discharge during test item checkout.

4.2.4.1.1 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 4.2.1, above.)

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

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

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

(2) Operate the test chamber without the test item to confirm proper operation. Adjust the air system or test item position to obtain the specified air velocity for the test item.

4.2.4.1.2 Pretest Standard Ambient Checkout.

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

Step 1. Conduct a complete visual examination of the test item with special attention to sealed areas and small/minute openings, and document the results.

Step 2. Prepare the test item in its operating configuration or as specified in the test plan. Install test item instrumentation as required by the test plan. When applying surface mount thermocouples, minimize the coverage of the test item surface to the greatest extent possible.

Step 3. Position the test item at the required distance from the sand injection point. Orient the test item to expose the first face to the sand stream.

Step 4. Ensure the test item is grounded (either through direct contact with the test chamber or with a grounding strap).

NOTE: If required to change the orientation during the test, ensure that the instrumentation and fixtures will allow this to occur.

Step 5. Stabilize the test item temperature at standard ambient conditions.

Step 6. Conduct an operational checkout in accordance with the test plan and record the results.

Step 7. If the test item operates satisfactorily, proceed to Step 1 of the test procedure. If not, resolve the problem and restart at Step 1 of pretest checkout.

4.2.4.2 Test Procedure II. Blowing Sand

WARNING:

1. **Refer to the supplier's Safety Data Sheet (SDS) or equivalent for health hazard data.**
2. **The relatively dry test environment combined with the moving air and sand particles may cause a buildup of electrostatic energy that could affect operation of the test item.**

NOTE: Unless the requirements documents indicate otherwise, if the following test procedure is interrupted because of work schedules, etc., maintaining the test item at the test temperature for the time required will facilitate completion of the test when resumed. If the temperature is changed, before continuing the test, re-stabilize the test item at the temperature of the last successfully completed period before the interruption.

CAUTION: When temperature conditioning, ensure the total test time at elevated temperatures do not exceed the life expectancy of any safety critical materials. This is particularly applicable to energetic materials (see Part One, paragraph 5.19).

Step 1. Increase the chamber temperature (at a rate not to exceed 3 °C/min (5 °F/min)) and stabilize the test item at the required high temperature (see paragraph 4.2.1.1).

Step 2. Adjust the air velocity according to test plan (see paragraph 4.2.1.2).

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

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

Step 5. If operation of the test item during the test is required, perform an operational test with the most vulnerable face exposed during the last hour of the test, and document the results. If the test item fails to operate as intended, follow the guidance in paragraph 4.2.3.3. Otherwise proceed to Step 6. **SEE THE ABOVE WARNING REGARDING HEALTH HAZARDS.**

Step 6. Stop the sand feed. Allow the chamber air temperature to return to standard ambient conditions at a rate not to exceed 3 °C/min (5 °F/min). Stabilize the test item temperature. Stop any air flow through the chamber.

Step 7. Visually inspect the item looking for clogging effects, abrasion, and sand accumulation that may impede operation of the test item.

Step 8. Photograph the sand accumulation on the test item.

Step 9. Remove accumulated sand from the test item by using the methods anticipated to be used in service such as brushing, wiping, etc., taking care to avoid introduction of additional sand into the test item.

Step 10. Visually inspect the test item looking for abrasion and clogging effects, and any evidence of sand penetration. Document the results.

Step 11. Conduct an operational check of the test item in accordance with the approved test plan, and record results for comparison with pretest data. See paragraph 5.2 for analysis of results.

5. ANALYSIS OF RESULTS.

5.1 Blowing Dust Tests.

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

Determine if:

a. Dust has penetrated the test item in sufficient quantity to cause binding, clogging, seizure or blocking of moving parts, non-operation contacts or relays, or the formation of electrically conductive bridges with resulting short circuits.

b. Air filters are clogged restricting airflow.

c. Abrasion of the test item exceeds the specified levels.

d. The test item operates as required.

5.2 Blowing Sand Tests.

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

a. Abrasion of the test item exceeds the specified requirements.

b. The test item operates as required.

c. Protective coatings or seals were compromised.

6. REFERENCE/RELATED DOCUMENTS.

6.1 Referenced Documents.

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

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

c. International Electrotechnical Commission (IEC) Publication 60068-2-68, Test L, Dust and Sand; IEC Website.

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

e. Test Operations Procedure (TOP), 01-2-621 Outdoor Sand and Dust Testing, June 2009.

f. ASTM D185-07, Standard Test Methods for Coarse Particles in Pigments, 2012.

g. MIL-STD-3033, Particle / Sand Erosion Testing of Rotor Blade Protective Materials, 28 July 2010.

h. AMR-PS-08-01, Kinetic Energy Interceptor Flight Weather Encounter Requirements Development, November 2007.

6.2 Related Documents.

a. NATO STANAG 4370, Environmental Testing.

b. Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Tests (under STANAG 4370), Method 313.

c. 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.

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