NOTICE OF CHANGE

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MIL-STD-810F
NOTICE 1
1 November 2000

DEPARTMENT OF DEFENSE
TEST METHOD STANDARD

ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS

TO ALL HOLDERS OF MIL-STD-810F:

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

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
511.4-1	1 November 2000	511.4-1	1 January 2000
511.4-2	1 January 2000	511.4-2	Reprinted without change
511.4-7	1 November 2000	New page	
511.4-8	1 November 2000	New page	
511.4-9	1 November 2000	New page	
511.4-10	1 November 2000	New page.	

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

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

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METHOD 511.4

EXPLOSIVE ATMOSPHERE

NOTES: 1. The Procedure II - Explosion containment test of MIL-STD-810E, Method 511.3, remains in effect. See pages 511.4-7 through 511.4-10.

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

1. SCOPE.

1.1 Purpose.

The explosive atmosphere test is performed to demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition.

1.2 Application.

This method applies to all materiel designed for use in the vicinity of fuel-air explosive atmospheres associated with aircraft, automotive, and marine fuels at or above sea level. Use other explosive atmosphere safety tests (e.g., electrical or mine safety) if more appropriate.

1.3 Limitations.

a. This test utilizes an explosive mixture that has a relatively low flash point which may not be representative of some actual fuel-air or aerosol (such as suspended dust) mixtures.

b. The explosive atmosphere test is a conservative test. If the test item does not ignite the test fuel-air mixture, there is a low probability that the materiel will ignite prevailing fuel-vapor mixtures in service. Conversely, the ignition of the test fuel-air mixture by the test item does not mean the materiel will always ignite fuel vapors that occur in actual use.

c. This test is not appropriate for test altitudes above approximately 16km where the lack of oxygen inhibits ignition.

d. This method is not appropriate for determining the capability of sealed materiel to contain an explosion.

2. TAILORING GUIDANCE.

2.1 Selecting the Explosive Atmosphere Method.

After examining requirements documents and applying the tailoring process in Part One of this standard to determine where explosive atmospheres are foreseen in the life cycle of the test item, use the following to confirm the need for this method and to place it in sequence with other methods.

2.1.1 Effects of explosive atmosphere environments.

Low levels of electrical energy discharge or electrical arcing by devices as simple as pocket transistor radios can ignite mixtures of fuel-vapor and air. A "hot spot" on the surface of the case of a hermetically sealed, apparently inert materiel case can ignite fuel-air mixtures. Fuel vapors in confined spaces can be ignited by a low energy discharge such as a spark from a short circuited flashlight cell, switch contacts, electrostatic discharge, etc.

2.1.2 Sequence among other methods.

a. General. See Part One, paragraph 5.5.

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b. Unique to this method. Considering the approach to conserve test item life by applying what are perceived to be the least damaging environments first, generally apply the explosive atmosphere test late in the test sequence. Vibration and temperature stresses may distort seals and reduce their effectiveness, thus making ignition of flammable atmospheres more likely. Recommend the test item(s) first undergo vibration and/or temperature testing.

2.2 Selecting Procedure Variations.

This method has one procedure. However, the test procedure may be varied. Before conducting this test, complete the tailoring process by selecting specific procedure variations (special test conditions/techniques for this procedure) based on requirements documents, Life Cycle Environmental Profile, Operational Environment Documentation (see Part One, figure 1-1), and information provided with this procedure. Consider the following in light of the operational purpose and life cycle of the materiel.

2.2.1 Fuel.

Unless otherwise specified, use n-hexane as the test fuel, either reagent grade or 95% n-hexane with 5% other hexane isomers. This fuel is used because its ignition properties in flammable atmospheres are equal to or more sensitive than the similar properties of both 100/130-octane aviation gasoline, JP-4 and JP-8 jet engine fuel. Optimum mixtures of n-hexane and air will ignite from hot-spot temperatures as low as 223°C, while optimum JP-4 fuel-air mixtures require a minimum temperature of 230°C for auto-ignition, and 100/130 octane aviation gasoline and air requires 441°C for hot-spot ignition. Minimum spark energy inputs for ignition of optimum fuel-vapor and air mixtures are essentially the same for n-hexane and for 100/130-octane aviation gasoline. Much higher spark energy input is required to ignite JP-4 or JP-8 fuel and air mixtures. Use of fuels other than hexane is not recommended.

2.2.2 Fuel-vapor mixture.

Use a homogeneous fuel-air mixture in the correct fuel-air ratios for the explosive atmosphere test. Fuel weight calculated to total 3.8 percent by volume of the test atmosphere represents 1.8 stoichiometric equivalents of n-hexane in air, giving a mixture needing only minimum energy for ignition. This yields an air/vapor ratio (AVR) of 8.33 by weight (reference f).

a. Required information to determine fuel weight:
   (1) Chamber air temperature during the test.
   (2) Fuel temperature.
   (3) Specific gravity of n-hexane (see figure 511.4-1).
   (4) Test altitude: ambient ground or as otherwise identified.
   (5) Net volume of the test chamber: free volume less test item displacement expressed in liters.

b. Calculation of the volume of liquid n-hexane fuel for each test altitude:
   (1) In metric units:

   Volume of 95 percent n-hexane (ml) =

$$\left(4.27 \text{ x } 10^{-4}\right)\left[\frac{\left(\text{net chamber vol}\left(\text{liters}\right)\right) \text{ x } \left(\text{chamber pressure}\left(\text{pascals}\right)\right)}{\left(\text{chamber temp } \left(\text{K}\right)\right) \text{ x } \left(\text{specific gravity of n} - \text{hexane}\right)}\right]$$

   (2) In English units:

   Volume of 95 percent n-hexane (ml) =

$$\left(150.41\right)\left[\frac{\left(\text{net chamber vol}\left(\text{ft}^3\right)\right) \text{ x } \left(\text{chamber pressure}\left(\text{psia}\right)\right)}{\left(\text{chamber temp } \left(\text{R}\right)\right) \text{ x } \left(\text{specific gravity of n} - \text{hexane}\right)}\right]$$

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EXPLOSIVE ATMOSPHERE TEST

SECTION II

II-1 APPARATUS. A test chamber capable of producing the required test conditions shall be used. Appendix A describes one type of chamber that may be used.

II-1.1 Fuel. Unless otherwise specified, n-hexane (i.e., normal hexane) of at least 95 percent purity shall be used.

II-2 PREPARATION FOR TEST. The test item shall be prepared in accordance with General Requirements, 5.2.2.

II-2.1 Procedure I - Operation in explosive atmosphere.

Step 1. The test item shall be installed in the test chamber in such a manner that normal electrical operation is possible and mechanical controls may be operated through the pressure seals from the exterior of the chamber. External covers of the test item shall be removed or loosened to facilitate the penetration of the explosive mixture. Large test items may be tested one or more units at a time by extending electrical connections through the cable port to the remainder of the associated equipment located externally.

Step 2. The equipment shall be operated to determine if it is functioning properly and to observe the location of any sparking or high temperature components which could cause an explosion.

Step 3. Mechanical loads on drive assemblies and servomechanical and electrical loads on switches and relays may be simulated when necessary if proper precaution is given to duplicating the normal load in respect to torque, voltage, current, inductive reactance, etc. In all instances, it is preferable to operate the equipment as it normally functions in the system during service use.

Step 4. A thermocouple shall be placed on the most massive component of the test item.

Step 5. At least two thermocouples shall be placed on the inside of the test chamber walls. These thermocouples (from steps 4 and 5) should be instrumented for monitoring outside the test chamber when the chamber is sealed.

II-2.2 Procedure II - Explosion containment test.

Step 1. The equipment, or a model of the equipment of the same volume and configuration, shall be placed within the case and the case installed in the explosion chamber.

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Step 2. Make provision to circulate the fuel-air mixture into the case being tested. In the case of forced-air-cooled equipment, the cooling air must contain the proper fuel-air mixture. For equipment not using forced-air cooling, it is necessary to drill the case for insertion of a hose from a blower. Take adequate precautions to prevent ignition of the ambient mixture by backfire or release of pressure through the supply hose. Any modification to facilitate the introduction of ignitable vapor shall not alter the case internal volume by more than ±5%.

Step 3. Provide a positive means of igniting the explosive mixture within the case. The case may be drilled or tapped for a spark gap, or a spark gap may be mounted internally. Points of ignition should not be more than 0.5 inch from any vent holes or flame arresting devices, and as many of such ignition sources should be installed within the case as there are vent holes or flame arresting devices. Where the design of equipment makes this impractical, use as many points of ignition as are practical.

Step 4. A thermocouple inserted into the case and attached to a sensitive galvanometer outside the test chamber may be used to detect explosions within the case.

Step 5. Ensure that the air within the test chamber has a water vapor dewpoint lower than 10°C (50°F).

Step 6. If the site atmospheric pressure at the test location is less than 633mm Hg, make provisions to pressurize the test chamber to at least 633mm Hg. Ground level pressures referred to in II-3.2 step 5 shall consist of pressures from 633 to 800mm Hg, inclusive.

Step 7. Perform steps 4 and 5 of II-2.1.

II-3 PROCEDURES

II-3.1 Procedure I - Operation in explosive atmosphere

Step 1. Perform the preparation for test.

Step 2. Seal the chamber with the test item mounted inside.

Step 3. Raise the ambient temperature of air inside the chamber to that determined in I-3.2.3. Wait until the temperatures of the test item and test chamber inner walls come to within 11°C of the chamber ambient air temperature.

Step 4. Adjust the chamber air pressure to simulate the test altitude plus 2000 meters, as given in I-3.2.6, to allow for introducing, vaporizing and mixing the fuel with the air.

Step 5. Slowly introduce the required quantity of n-hexane into the test chamber as determined by I-3.2.4.

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Step 6. Circulate the test atmosphere and continue to reduce the simulated chamber altitude for at least three minutes to allow for complete vaporization of fuel and the development of a homogeneous mixture.

Step 7. At 1000m above the test altitude, operate the test item. Operation shall be continuous from step 7 through step 9. Make and break electrical contacts as frequently as reasonably possible.

Step 8. Slowly decrease the simulated chamber altitude by bleeding air into the chamber. Change the simulated altitude at a rate no faster than 100 meters per minute.

Step 9. Stop the altitude change at 1000 meters below test altitude or at ground level, whichever is reached first.

Step 10. Check the potential explosiveness of the air-vapor mixture by attempting to ignite a sample of the mixture by a spark-gap or glow plug ignition source having sufficient energy to ignite a 3.82-percent hexane mixture. If ignition does not occur, return the chamber to ambient atmospheric pressure, purge the chamber of the fuel vapor, and reinitiate the test at the most recent test altitude.

Step 11.

a. If the simulated altitude reached in Step 9 is 3000 meters or greater above site level, continue testing at the next test altitude which is defined as 3000 meters below the just-completed test altitude. Repeat Steps 5-11 using the new test altitude.

b. If the simulated altitude reached in Step 9 is below 3000m, repeat Steps 5-10[1] using site level as the last test altitude, and then go to Step 12.

Step 12. Document test results per II-4.

II-3.2 Procedure II - Explosion containment test

Step 1. Perform preparation for the test as given in II-2.2.

Step 2. Seal the chamber with the test item inside.

Step 3. Raise the ambient air temperature inside the chamber.

Step 4. Wait until the temperatures of the test item and test chamber inner walls come to within 11ºC (20ºF) of the chamber ambient air temperature.

Step 5. Change the chamber air pressure to 2000 meters of simulated altitude above the site ambient pressure (i.e., ground level).

Step 6. Slowly introduce the required quantity of n-hexane into the test chamber to obtain optimum fuel -vapor/air mixture at site ambient pressure or as given in I-3.2.4b for n-hexane.

Step 7. Circulate the test atmosphere and continue to reduce the simulated chamber altitude for at least three minutes to allow for complete vaporization of fuel and the development of a homogeneous mixture within the test item and within the test chamber.

[1] It may be necessary to perform Step 4 first if insufficient altitude remains for fuel introduction.

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Step 8. Slowly decrease the simulated chamber altitude to return the pressure altitude to site ambient pressure (i.e., ground level).

Step 9. Energize the internal case ignition source and confirm the occurrence of an explosion within the test item using the installed thermocouple. If no explosion occurs, purge the chamber and the test item of all air/fuel vapor and return to step 2.

Step 10. If the explosion inside the test item's case did not propagate to the fuel/air mixture outside the test item:

a. Repeat steps 5 through 10 four times if the test item's case is not in excess of 0.02 times the chamber volume;

b. If the test item volume is equal to or greater than 0.02 times the chamber volume, purge the chamber and test item of air/fuel vapor and repeat steps 2 through 10 four times.

Step 11. Check the potential explosiveness of the air/fuel-vapor mixture by attempting to ignite a sample of the mixture by a spark or glow plug. If chamber sample does not ignite, purge the chamber of all air/fuel-vapor mixture, and repeat the entire test from step 2.

Step 12. Document the test results.

II-4 INFORMATION TO BE RECORDED

a. Test item identification (manufacturer, serial number, etc.).

b. Test procedure number.

c. Chamber pressure and temperatures at each test point (simulated altitude).

d. For Procedure II, the locations of glow plugs or spark gaps installed inside test items.

e. For Procedure II, the energy requirement for the glow plug or spark gaps for operation.

f. The quantity of fuel required at each test point.

g. The off/on cycling rate for the test equipment.

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