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NOTICE OF CHANGE

MIL-STD-331B
NOTICE 7
1 March 1997

MILITARY STANDARD
FUZE AND FUZE COMPONENTS, ENVIRONMENTAL AND PERFORMANCE TESTS FOR

TO ALL HOLDERS OF MIL-STD-331B:

1. THE FOLLOWING PAGES OF MIL-STD-331B HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
v	1 March 1997	v	1 October 1995 (Notice 6)
vi	1 October 1995	vi	Reprinted without change (Notice 6)
vii	1 March 1997	vii	1 August 1995 (Notice 5)
viii	1 March 1997	viii	1 October 1995 (Notice 6)
F4-1 thru F4-6	1 March 1997	None	New Pages

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

3. Holders of MIL-STD-331B will verify that page changes and additions 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 military standard is completely revised or canceled.

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TABLES

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TEST F4

ELECTROMAGNETIC RADIATION, OPERATIONAL (EMRO)

F4.1 PURPOSE

This is a laboratory safety and reliability test simulating Electromagnetic Radiation (EMR) which may impinge upon the fuzes containing Electro-explosive Devices (EEDs) and electronics during their life cycle. Fuze electronics must withstand the high levels of electromagnetic radiation which may be encountered during storage, transportation, handling, loading, launching and travel to target.

F4.2 DESCRIPTION

F4.2.1 General. This test evaluates the effect of high EMR environments on the electronics of bare, operating fuzes. Bare fuzes are exposed to the tactical EMR environment which they are expected to encounter from the time power is normally applied to the point of function. Bare fuzes with non-interrupted explosive trains are additionally exposed to the EMR environment which they are expected to encounter during storage and transportation with inadvertent power applied.

F4.2.1.1 Handling, loading and launching EMRO test. This test shall be conducted on all bare fuzes to evaluate their safety and reliability when exposed to a high EMR field during handling, loading, launching and functioning.

F4.2.1.2 Storage and transportation EMRO test. This test shall be conducted on fuzes with non-interrupted explosive trains to evaluate their safety and reliability during and after exposure to a high EMR environment associated with storage and transportation. Power is applied to simulate the inadvertent application of power while in this environment. This test is performed without protective packaging as a worst-case test of the robustness of the electronics.

F4.2.2 Electromagnetic environments.

F4.2.2.1 Handling, loading and launching EMR environment. The handling, loading and launching EMR environments are considered to be those which are defined in the specification for the munition.

F4.2.2.2 Storage and transportation EMR environment. The minimum storage and transportation test environment is considered to be 200 Vrms/m from 100 kHz to 40 GHz.

F4.2.3 Fuze configuration. The fuzes shall be completely assembled except that lead and booster charges may be omitted to facilitate testing. If any explosive elements are removed, care should be exercised to preserve electromagnetic equivalency of the resulting configuration. All EEDs shall be replaced with appropriate instrumentation to monitor the functioning of the electronic subsystems. For fuzes with non-interrupted explosive trains, instrumentation shall be installed to measure the voltage generated on firing capacitors during the test. For fuzes with non-interrupted explosive trains, testing shall be performed with tactical cables/lengths, representative grounding, and simulated loads at cable end. System level tests shall include the full up system with all cables and other electronics.

F4.2.4 Applicable publications. All standards, specifications, drawings, procedures and manuals which form a part of this test are listed in Section 2 of the introduction to this standard. Special attention is directed to MIL-STD-1385, MIL-I-23659, TOP 1-2-511, and ADS-37 which have specific applications.

F4.2.5 Number of test items. A single test item is sufficient for an instrumented EMRO test. However, more than one may be required to facilitate instrumentation or to gain knowledge of round to round variations in hardness levels.

F4.2.6 Test documentation. Test plans, performance records, equipment, conditions, results, and analysis shall be documented in accordance with Section 4.8 of the general requirements to this standard. The following unique requirements also apply:

F4.2.6.1 Analyses. EMR coupling analyses shall be performed for all known storage, transportation, and handling configurations for the fuze. The analyses should determine and identify the most significant life cycle configurations, test configurations and orientations; the type of fuze instrumentation to be used for the test and the parameters to be monitored. The analyses should also determine what specific modulation types and frequencies are most likely to have an adverse effect on the fuze electronics and must include pulse modulation at the transformer charging frequency for fuzes with non-interrupted explosive trains (see F4.7.2).

F4.2.6.2 Test plan. The formulation of an appropriate test plan shall be based on the analyses of F4.2.6.1. The test plan shall include:

a. Identification of the fuze items to be tested at the applicable level of component integration (i.e., system, munition, fuze, subsystem, etc.), and the following pertinent information:

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(1) The physical condition of the fuze items to be tested.

(2) The test points and supporting rationale for choices.

(3) A description of the instrumentation installed in the fuze for response measurements and the minimum sensitivity requirements to ensure the appropriate safety factors can be demonstrated in the test EMR environment when applicable.

(4) The specific data to be recorded.

(5) The method of operation and monitoring of the equipment.

b. A description of the test facilities to be employed to include instrumentation and transmitter characteristics, environment measurement techniques, and calibration procedures.

c. A description of the test environment including field intensity, polarization, frequency range, number of test frequencies, rationale for frequency selection, and any modulation characteristics employed. Swept frequency testing is encouraged to identify resonance points for follow-on discrete frequency testing. Note that for discrete frequency tests, no fewer than the minimum number of frequencies per band specified in Table F4-I should be selected. Testing should be accomplished from the frequency at which the maximum dimension of the test item (i.e., launcher including host vehicle, munition, fuze, subsystem, etc.) is 1/4 wavelength to 40 GHz (or the maximum available at the test facility, if at least 18 GHz).

TABLE F4-I. Minimum number of test frequencies for discrete frequency testing.

Frequency Range (MHz)	Minimum Number of Test Frequencies
0.01 - 2	10
2 - 32	20
32 - 100	20
100 - 1,000	10
1,000 - 18,000	20
18,000 - 40,000	5

d. A description of how the test environment differs from the threat environment and the methodology for extrapolating the test results to those that would result by exposing the system to the threat environment.

e. A description of the specific procedures to be utilized during the test including the configuration of the test items, their orientation(s) with respect to the test field, the detailed procedure used to operate the fuze, the length of time of each exposure to an EMR environment and the data recording procedure.

F4.2.6.3 Test report. The test report shall contain the analyses of F4.2.6.1; the test plan; and all the raw data, reduced data, results and conclusions resulting from the tests delineated in the test plan. In particular the test report shall provide:

a. For fuzes with non-interrupted explosive trains:

A detailed description of the instrumentation calibration procedures and complete calibration data for all sensors used to monitor current and voltage levels.

A detailed description of how the raw data was analyzed and compared with EMR environment characteristics and firing capacitor voltage limits to determine what safety factors were achieved.

b. For all fuzes:

The responses of the instrumentation with the fuze in the EMR environment.

A statement of how the test environments were measured including the type of field probes used and placement of the probes with respect to the fuze tested.

A description of how the actual test procedures differed from those in the test plan.

A statement of what conclusions can be drawn from the results regarding the safety and reliability of the fuze when exposed to the EMR environments to be encountered during its life cycle.

F4.3 CRITERIA FOR PASSING TEST

F4.3.1 Fuze condition. Fuzes with non-interrupted explosive trains must remain in a safe condition when exposed to worst-case storage and transportation EMR environments with power applied to electronics. All fuzes must operate reliably in their tactical EMR environment.

F4.3.2 Decision basis. An analysis of the test data will form the basis for determining if the fuze has passed or failed this test. Data shall be analyzed for each configuration to determine if the following criteria are met:

a. For fuzes with non-interrupted explosive trains, no more than 75 Volts (after extrapolation from the test field intensity levels to the levels specified in MIL-STD-1385) is permitted to be generated on

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the firing capacitors prior to the point of intentional charging.

b. The electronics of all fuzes must operate reliably and function normally when exposed to the tactical EMR environment specified for the system.

F4.4 EQUIPMENT

F4.4.1 Transmitter. The transmitting equipment used for the test must have sufficient stable power output over the EMR environment frequency range to ensure that tactical field levels can be maintained for the duration of the test. Transmitting equipment used for testing fuzes with non-interrupted explosive trains should be able to generate 200 V/m rms over the test frequency range. Frequency output should be controllable to within a nominal 2% of each desired test frequency. Laboratory transmitting equipment normally consists of a series of RF signal generators and wideband power amplifiers which amplify the output of the signal source to hundreds or thousands of watts. Some U.S. military test facilities have transmitting equipment with a peak power capability exceeding 100,000 watts.

F4.4.2 Antennas. Antennas used to perform EMRO testing must convert the output of the transmitting equipment to an electromagnetic field which is repeatable and reasonably uniform over the test volume. As a rule, at frequencies below 1 GHz, the field intensity over the test item volume should not vary by more than 6 dB. At frequencies over 1 GHz, this is commonly not practical and the item must be moved in the field to ensure that all cracks, seams, and other penetrations are fully illuminated with the specified EMR environment.

F4.4.3 Field measurements. The field intensity must be measured using appropriate field measurement techniques. Field measurements should be made using equipment with an absolute accuracy of at least 2 dB. Any of the following techniques may be used to ensure a calibrated field measurement.

F4.4.3.1 Direct field measurement prior to test. One method of measuring the field intensity applied to a test item is to measure the applied field at the test location with the test item absent. With a field meter at the test location, raise the transmitter output until the desired test field level is reached. Measure the actual power output of the transmitter using a directional coupler and power meter or some other technique capable of measuring high power level. Annotate the transmitter power which produces this field intensity at the test volume. For test objects of significant size, the field should be measured at various points within the test volume to assess the field uniformity. Continue this process for each frequency and polarization to be tested. During the test, set the transmitter output power to that level annotated during the calibration procedure.

F4.4.3.2 Relative field measurement prior to test. This method is generally used when testing is to be accomplished at more than one field intensity level or when the test field level is beyond the dynamic range of the field measurement equipment. The field intensity applied to a test item may be determined based upon field intensity measurements made in the empty test volume prior to the test. With a field meter at the test location, raise the transmitter output until a predetermined field level is reached. Measure the actual power output of the transmitter using a directional coupler and power meter or some other technique capable of measuring high power level. Annotate the transmitter power which produces this field intensity at the test volume and calculate and record the total transmission system gain. For test objects of significant size, the field should be measured at various points within the test volume to assess the field uniformity. Continue this process for each frequency and polarization to be tested. During the test, the test field intensity can be calculated using the transmitter output power and the system gain. If using this method, care must be taken to ensure that all power measurement equipment is linear from the calibration level through the test power level.

F4.4.3.3 Direct field measurement during test. The most direct approach to determining the field intensity on a fuze item is by placing field probes in the test volume during the test. In this way, field intensity can be measured directly during the test. If this method is used, care must be taken to ensure that the field measurement equipment does not interfere with the field significantly, the field probes are not interfered with by the test item (for example, there is an apparent field intensification near the ends of cylindrical objects), and that the field probes are close enough to the test item to closely approximate the field on the test item. As the requirements are somewhat conflicting, this method requires technical judgments to be made. Due to the difficulty in obtaining repeatable, accurate measurements with this method, it should be avoided if at all possible.

F4.4.4 Fuze instrumentation. The fuze being tested must be instrumented to monitor the functioning of the electronics during the test. Additionally, fuzes with non-interrupted explosive trains must have instrumentation to measure the voltage buildup on the firing capacitors during the test. Care must be taken when instrumenting a fuze so that the instrumentation provides an accurate measure of voltage or other response without significantly affecting the result. The primary concerns are that the shielding integrity of the fuze not be altered by the instrumentation and that the instrumentation not form an additional inadvertent antenna with different characteristics than that of the fuze electronic circuits. Some method of monitoring

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the electrical signals within the fuze/munition using fiber optics is used almost exclusively in order to achieve these goals. Some acceptable instrumentation methods which can be used to monitor current pulses are explained in Test F3 of this standard. Specific instrumentation for any fuze EMRO test will by nature be quite unique.

F4.4.5 Ancillary equipment. Almost always, some additional electronic equipment will be required in order to test the functioning of the fuze in operational configurations. Many fuzes require a switch closure (accomplished tactically by launch-related setback or spin forces) and/or other physical/electrical/electromagnetic stimuli to simulate the normal operation of the fuze from launch to the point of intended function during testing. Care should be taken in the design of this special purpose circuitry that the electromagnetic properties of the fuze are not altered.

F4.5 PROCEDURE

The specifics of the test procedure will vary from test to test due to the uniqueness of the fuzes being tested. However, the basic procedures should closely resemble the following:

a. Place the instrumented fuze in the test area in the configuration to be tested.

b Orient the fuze to the source antenna as prescribed in the test plan.

c. Turn on the transmitter tuned to the frequency and modulation specified for test.

d. Gradually increase the field intensity until either the specified EMR environment is reached or the fuze demonstrates an undesirable response.

e. When applicable, perform any necessary actions on the test items (apply power, close spin switch, close crush switch, apply acceleration profile, etc.).

f. Record the field level, frequency, polarization, test item orientation, configuration, and whether the fuze operated properly. For non-interrupted explosive trains, record the highest voltage measured on the firing capacitors prior to intentional charging. If no voltage is detected by the instrumentation, record the minimum detectable level.

g. Repeat steps a through f for all configurations, orientations, polarizations, and frequencies in the test plan.

Note that for testing non-interrupted explosive trains in the shipping and storage configuration with power applied to the electronics, the fuze should be exposed to the field during each trial for at least 30 seconds. Alternately, if swept frequency testing is used, the sweep rate should not exceed 120 seconds per octave. If there is a measurable system response that continues to increase during field exposure, the exposure time should be increased (or the sweep rate decreased, as appropriate) until the maximum system response has been obtained.

F4.6 ALTERNATE AND OPTIONAL TESTS

None

F4.7 RELATED INFORMATION

F4.7.1 Data analysis

F4.7.1.1 Handling, loading and launching testing of all fuzes. Fuze functioning information when exposed to the specified EMR environment should be recorded and compared with the fuze's normal functioning to determine if safety and reliability have been affected.

F4.7.1.2 Shipping and storage testing of fuzes with non-interrupted explosive trains. Voltages measured on the firing capacitors when exposed to the 200 V/m test environment should be extrapolated to the MIL-STD-1385 field levels. The fuze is considered safe if less than 75 volts is obtained under these circumstances. See section F4.7.3 for a discussion of the validity of this extrapolation.

F4.7.2 Background for non-interrupted explosive train test requirements. Traditionally, fuzes have contained a physical barrier between the primary and secondary explosives. The intent of the barrier was to prevent an inadvertent functioning of the initiator from propagating to the main charge. This was proven out through a series of explosive tests which demonstrate the effectiveness of the barrier to interrupt the explosive train with a high degree of confidence. In general, this physical barrier, together with two independent locks on the barrier provided a level of safety of better than one in a million.

More recently a new concept in fuzing has emerged which holds promise to greatly improve the operational effectiveness and reliability of many weapons systems. Fuzes with non-interrupted explosive trains typically contain few or no moving parts and, as a rule, no physical barrier in the explosive train between the initiator and the main charge. This is made possible through the use of initiators that contain only secondary explosives. Specific controls have been written into the fuze safety design standard, MIL-STD-1316, which if adhered to should provide at least the same degree of safety as traditional S&As which incorporate explosive train interruption. The key safety concern of fuzes with non-interrupted explosive trains is that unintended functioning of the initiator would cause the main charge to detonate. The safety of fuzes with non-interrupted explosive trains rests on a very high degree of confidence that the initiator will not function except when intended as opposed to the traditional S&A where the

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safety is based on the effectiveness of a mechanical interrupter and its locks.

Certain design principles help to ensure that the initiator will not fire inadvertently in fuzes with non-interrupted explosive trains. Firstly, the initiator must not be capable of being fired with less than 500 Volts. This, in itself, makes it unlikely that the initiator would function due to stray electrical signals. Secondly, there are requirements for the design to incorporate interrupters to the electrical energy which could arm and fire the fuze. Additionally, it is required that one of these interrupters be dynamic in nature so that no combination of static failures could cause the fuze to fail into an unsafe state. For example, Figure F4-1 shows two static switches (closed when launch acceleration has been sensed and when the flight motor ignition has been sensed respectively) and one dynamic switch (activated upon determining that safe separation distance has been achieved) which are all required to be enabled in order for electrical energy to accumulate in the firing capacitor.

Electronic controls have increased vulnerability to electrical environments during an operational state. Weapons are operated today in uniquely hazardous electromagnetic environments. Typically, the worst electrical environment is shipboard, but experience with aircraft such as helicopters have shown the importance of designing to the severe EMR environments for many applications. Munitions that are operated on the deck of a ship; fired, dispensed, or launched from aircraft; or used in close support of sites with radar or other EMR sources typically have a need to be safe and reliable within the very high EMR environments.

In a mechanical S&A, the safety system failure mechanisms are closely related to the effectiveness of the barrier and the reliability of its locks preventing the barrier from being removed prior to intentional arming. In fuzes with non-interrupted explosive trains, the failure mechanisms are related to the effectiveness of the electrical energy interrupters in preventing firing energy from being produced in the firing capacitor. In the example diagram, the chief concerns would be that the static and dynamic switches controlled by flight motor initiation, launch acceleration, and achievement of safe separation distance could be inadvertently controlled by some other influence. Also of concern is whether high voltage and/or current levels can be achieved at the firing capacitor or initiator regardless of the operation of the switches. The most likely environments to cause any of these failure mechanisms are Electromagnetic Environmental Effects (E^3). It is critical that Fuzes with non-interrupted explosive trains be designed to be immune to unsafe upset due to E^3 just as mechanical S&As are designed to withstand jolt, jumble, drop, etc.

Tests are routinely done on a mechanical S&A which prove out its effectiveness with one of its safety features subverted in the presence of credible harsh mechanical and environmental stimuli. In the same way, ESAD's must be tested with applicable harsh environments with subverted safety features. As stated earlier, the most significant environments for fuzes with non-interrupted explosive trains are E^3(e.g., ESD, EMR, Lightning...). It must be assumed for the purpose of safety analysis that power will be inadvertently applied to fuzes with non-interrupted explosive trains during shipping and storage or some other time prior to intentional functioning of the fuze. This may be considered either a subverted safety or a credible environment but it must be considered and incorporated into the fuze's Safety test program. The unique test requirements for non-interrupted explosive trains are intended to address these issues.

The requirement for no more than 75 Volts on the capacitor was derived from 15% (the MIL-STD-1385 safety factor) of the 500 Volts minimum firing voltage required by MIL-STD-1316. It is understood that this is very conservative for many initiators which have no-fire values significantly in excess of the 500 Volt minimum requirement. However as the 75 Volt requirement is readily achievable, it was chosen as a consistent requirement, avoiding the potential confusion associated with setting different requirements for each fuze.

F4.7.3 Validity of extrapolated EMRO data. EMRH data (see test F3) is normally extrapolated from a lower test field level to a higher criterion field level. This is quite valid in most instances provided that the instrumentation used had sufficient sensitivity and the measured data can be reasonably expected to be linear over the extrapolated frequency range. EMRO data, however, is normally never extrapolated. The primary reason is that EMRO tests are run on active electronics circuits which are, by their very nature, non-linear, thus invalidating the extrapolation process. For this reason, all EMRO tests must be done at the tactical field levels.

Limited extrapolation is permitted for the shipping and storage EMRO test of fuzes with non-interrupted explosive trains for the following reasons: 1) The MIL-STD-1385 field levels are considered a credible but improbable environment to be encountered during a munition's life cycle, 2) Most test facilities cannot generate the field levels specified by MIL-STD-1385, and 3) Although this extrapolation is not entirely technically correct, the net effect is to further limit the voltage level permitted on the firing capacitors at the test field level thus adding some additional measure of safety.

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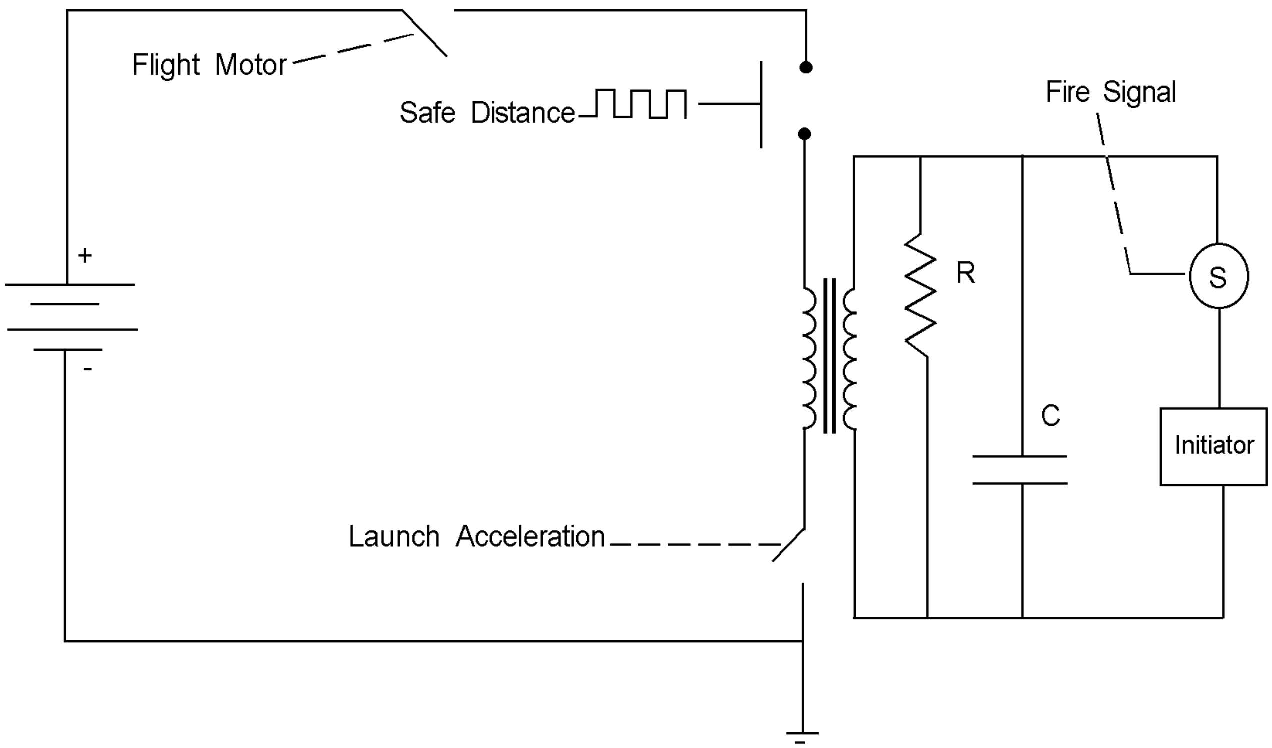

FIGURE F4-1. Simplified block diagram of a fuze with a non-interrupted explosive train.