NOTICE OF CHANGE

NOT MESASUREMENT SENSITIVE

MIL-STD-331B
NOTICE 8
28 NOVEMBER 2000

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NEW PAGE	DATE	SUPERSEDED PAGE	DATE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	28 November 2000	v	1 March 1977 (Notice 7)
vi	1 October 1995	vi	Reprinted Without Change (Notice 6)
F3-1 thru F3-10	28 November 2000	F3-1 thru F3-9	1 August 1995 (Notice 5)

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.

Custodians:
Army – AR
Navy – OS
Air Force – 22

Review activities:
Army – EA, MI, MT, TE

Preparing activity:
Army – AR

(Project 13GP-0072)

AMSC N/C

FSC 13GP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

CONTENTS - Continued

FIGURES

TEST F3.1

ELECTROMAGNETIC RADIATION HAZARDS (HERO)

F3.1 <u>PURPOSE.</u> This is a laboratory safety and reliability test simulating Electromagnetic Radiation (EMR) which may impinge upon the fuzes containing Electro-explosive Devices (EEDs) during their life cycle. Fuze EEDs must withstand the high levels of electromagnetic radiation which may be encountered during storage, transportation, handling, loading and launching.

F3.2 <u>DESCRIPTION.</u>

F3.2.1 <u>General.</u> This test evaluates the effect of subjecting bare and packaged unarmed fuzes to high EMR environments. Bare fuzes are exposed to the EMR environment which they are expected to encounter during handling, loading and launching. Packaged fuzes are exposed to the EMR environment which they are expected to encounter during storage and transportation.

F3.2.1.1 <u>Storage and transportation HERO test.</u> This test shall be conducted on packaged fuzes to evaluate their safety and reliability during and after exposure to a high EMR environment while in storage and transportation.

F3.2.1.2 <u>Handling, loading and launching HERO test.</u> This test shall be conducted on bare fuzes to evaluate their safety and reliability when exposed to a high EMR field during handling, loading and launching.

F3.2.2 <u>Storage and transportation EMR environment.</u> Service requirements for storage and transportation EMR environments vary somewhat though MIL-STD-464 is generally accepted. Army procured items have an additional requirement to withstand a minimum of 200 Vrms/m at all frequencies.

F3.2.3 <u>Fuze configuration</u>. 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 measure the effect of the EMR environment on the EED.

F3.2.4 <u>Applicable publications</u>. 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

Supersedes page F3-1 of Notice 5.

MIL-HDBK-1512, MIL-STD-464, MIL-I-23659, TOP 1-2-511, and ADS-37 which have specific applications.

F3.2.5 Number of test items. A single test item is sufficient for an instrumented HERO test. However, more than one may be required to facilitate instrumentation.

F3.2.6 Test documentation. Test plans, performance records, equipment, conditions, results, and analysis shall be documented in accordance with 4.8 of the general requirements to this standard. The following unique requirements also apply.

F3.2.6.1 Analyses. EMR coupling analyses shall be performed for all known storage, transportation, and handling configurations for the fuze. The analyses should determine and provide the most significant life cycle configurations, test configurations and orientations; the type of fuze instrumentation to be used for the test; the determination of the parameters to be monitored; the expected stress levels and the .1% probability 95% confidence no-fire characteristics of all EEDs.

F3.2.6.2 Test Plan. The formulation of an appropriate test plan shall be based on the analysis of F3.2.6.1. 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:

(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.

(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.

Supersedes page F3-2 of Notice 5.

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.

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 length of time of each exposure to an EMR environment and the data recording procedure.

F3.2.6.3 Test report. The test report shall contain the analyses of F3.2.6.1; 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. The responses of the EED instrumentation to the EMR environment.

b. 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.

c. A detailed description of the instrumentation calibration procedures and complete calibration data for all sensors used to monitor EED responses.

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

e. A detailed description of how the raw data was analyzed and compared with EMR environment characteristics and EED no-fire characteristics to determine what safety factors were achieved.

f. A summary of results to include a presentation of the worst case safety factors for each configuration tested. Graphical representation of the data is encouraged to increase the clarity of results.

g. 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.

F3.3 CRITERIA FOR PASSING TEST.

F3.3.1 Fuze condition. The fuze EEDs must remain safe and reliable when exposed to the appropriate EMR environments to be encountered during storage, transportation, handling, loading, and launching.

F3.3.2 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 is met:

a. For EEDs within fuzes configured in a manner that their premature function will cause the initiation of a main charge or removal of a safety feature, no more than the no-fire characteristics of that EED reduced by 16.5 dB shall be induced in it due to exposure to the specified EMR environment.

b. For EEDs within fuzes configured in a manner that their premature function will cause the munition to fail to function reliably, no more than the no-fire characteristics of that EED reduced by 6.9 dB shall be induced in it due to exposure to the specified EMR environment.

F3.4 EQUIPMENT.

F3.4.1 Transmitter. The transmitting equipment used for the test must have sufficient stable power output over the EMR environment frequency range to ensure that appropriate safety factors can be verified. 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.

F3.4.2 Antennas. Antennas used to perform HERO testing must convert the output of the transmitting equipment 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.

F3.4.3 Field Measurements. The field intensity must be measured using appropriate field measurement techniques. Field measurements should be

Supersedes page F3-4 of Notice 5.

made using equipment with an absolute accuracy of least 2 dB. Either of the following techniques may be used to ensure a calibrated field measurement.

F3.4.3.1 <u>Direct field measurement prior to test</u>. 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.

F3.4.3.2 <u>Relative field measurement prior to test</u>. 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.

F3.4.3.3 <u>Direct field measurement during test</u>. 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 judgements to be made.

F3.4.4 **Fuze instrumentation.** The fuze being tested must be instrumented to measure the response of the EEDs to the EMR environment. For EEDs utilizing bridgewires to initiate the explosives, the key parameter to be measured is current. Normally, the EED is replaced with a current sensor with similar characteristics to the EED bridgewire. Care must be taken when instrumenting a fuze so that the instrumentation provides an accurate measure of EED 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 acceptable methods are explained in the following paragraphs.

F3.4.4.1 **Vacuum Thermocouple Instrumentation.** This type of instrumentation utilizes a thermocouple mounted in close proximity to a bridgewire. The bridgewire and thermocouple are suspended in a vacuum to maintain temperature stability. The thermocouple, which is close enough to the bridgewire to respond to changes in its temperature, outputs a DC voltage proportional to the amount of energy dissipated in the bridgewire. These devices can be calibrated using DC current to determine the response to the rms current induced by RF. The technical challenge to be overcome with this type of instrumentation is to mount the sensor in place of the EED and get its DC output out of the fuze in a way that will not disturb the EMR characteristics of the fuze. The preferred method is through the use of fiber optics. The output of the thermocouple can be amplified and used to drive a Voltage Controlled Oscillator (VCO). The VCO output can then drive an LED which feeds the fiber optic output. In some instances, this instrumentation may not fit inside the fuze or munition. In those instances, the DC output of the thermocouples may be brought out of the fuze or munition to an instrumentation package using filtered feed through connectors and shielded twisted pair. Tests should be accomplished to ensure that the instrumentation external to the munition is not being interfered with by the EMR environment nor providing a significant additional antenna for the fuze.

F3.4.4.2 **Fiber optic sensor instrumentation.** There are some commercially available instruments designed specifically to overcome some of the pitfalls of HERO testing of munitions. These make use of small current sensors with a direct fiber optic output. One technology makes use of a small dot of phosphor on the bridgewire. The decay time of the phosphor is proportional to its temperature. A fiber optic line is mounted in close proximity in order to illuminate the phosphor and subsequently to measure its decay time. The sensor can be calibrated for temperature rise vs. temperature. Another technology uses a small semiconductor device which responds to current.

Supersedes page F3-6 of Notice 5.

Bridgewire is run from the posts of an EED to this semiconductor circuit. A fiber optic is mounted to monitor the status of the semiconductor. A choice of fiber optic sensor technology will depend on the parameters being measured and the instrumentation sensitivity requirement for the test.

F3.5 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 procedure 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 specified for test.

d. Gradually increase the field intensity until either the specified EMR environment is reached or the instrumentation shows a response approaching its damage level.

e. When applicable, perform any necessary actions on the test items (attaching cables in preparation for launch, etc.).

f. Record the field level, frequency, polarization, test item orientation, configuration, and instrumentation response. If no response 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.

F3.6 ALTERNATE AND OPTIONAL TESTS. None

F3.7 RELATED INFORMATION.

F3.7.1 Data Analysis.

F3.7.1.1 Extrapolation. In many test facilities the fuze's EMR environment requirements cannot be generated over all frequency ranges. A commonly accepted practice is to measure the response of the EEDs at the maximum field capability of the test facility and extrapolate those measurements to the specified field intensity. In order for this extrapolation to be valid the following requirements apply:

a. The instrumentation must be sensitive enough so that its minimum detectable level when increased by the ratio of the required field to the test field is still less than the no-fire characteristics of the EED reduced by the appropriate safety factor from F3.3.2.

b. There must be some reasonable evidence that the response of the system is linear in the region between that at which the measurements are made and that to which they are to be extrapolated.

If these two conditions are met, HERO test data can be gathered at levels readily available at most test facilities and extrapolated to high EMR specification levels.

F3.7.1.2 Data Presentation Format. There are two main methods of reducing, extrapolating, and presenting the results of HERO tests. One involves the calculation of the highest field level at which the required safety factor (see F3.3.2) is maintained and comparing it to the EMR environment specification (see F3.2.2) for the item tested. The other method is used to calculate the safety factor obtained at the specified EMR environment and compare it to the required safety factor from F3.3.2.

F3.7.1.2.1 No Fire Field Intensity (NFFI) format. When data is calculated and presented in this format, the environment in which the item is safe and reliable is readily apparent. The No Fire Field Intensity is a calculated field intensity at which the current induced in the EED is equal to the no-fire characteristic of that EED reduced by the appropriate safety factor. The NFFI is calculated using the following equation:

$$NFFI = TFI \times SF \times NFL / ML$$

where:

NFFI = No Fire Field Intensity
TFI = Test Field Intensity
SF = Safety Factor (from F3.3.2) expressed as a decimal ratio
NFL = EED .1%, 95% confidence no-fire level (current or voltage)
ML = measured level (current or voltage). If no response is measured during testing use the minimum detectable level as ML

This method would be useful for a quick evaluation of a system if the required EMR environments were to change. It also lends itself extremely well to a graphical presentation of the data which shows the systems response with

Supersedes page F3-8 of Notice 5.

respect to frequency and with respect to the EMR environment specification in a manner clearly understandable by persons not familiar with this type of testing.

F3.7.1.2.2 Safety Factor format. When data is calculated and presented in this format, the level of safety afforded at the EMR environment specification is readily apparent. The safety factor afforded at the EMR environment specified is calculated using the following equation:

$$SF = (RFI \times ML) / (TFI \times NFL)$$

where:

SF = Safety Factor at the EMR environment specified
RFI = Required Field Intensity
ML = measured level (current or voltage). If no response is measured during testing use the minimum detectable level as ML
TFI = Test Field Intensity
NFL = EED .1%, 95% confidence no-fire level (current or voltage)

This method would be useful for a quick evaluation of a system if the safety factor requirements were to change for an EED for some reason. This method does not, however, lend itself to a graphical presentation of the data in a meaningful way.

F3.7.2 Electroexplosive devices (EEDs). In order to perform an HERO test on a fuze, a basic understanding of different types of EEDs is required so that instrumentation can be used which will measure the appropriate parameters and also so that data can be analyzed correctly. The following basic types of EEDs are often found in fuzes and their peculiar characteristics should be understood by the test designer.

F3.7.2.1 Hot Bridgewire Devices. Perhaps the most common type of EEDs in fuzes is the hot bridgewire. Most piston actuators and microdetonators are of this type. This type of EED has a small explosive charge mounted on a thin resistive bridgewire. When sufficient current passes through the bridgewire (either intentionally or unintentionally), the joule heating effect causes the charge to ignite. This, in turn, ignites the rest of the energetic materiel in the EED. These devices are normally initiated by a small voltage on a relatively large capacitor. For pulse modulated fields hot bridgewire devices respond to the average current level as opposed to the peak level unless sufficient energy is contained in a single pulse to initiate the device. The thermal time constant of

Supersedes page F3-9 of Notice 5.

the device should be considered with respect to the duty cycle and pulse repetition rate when evaluating a hot bridgewire device against a specific threat environment.

F3.7.2.2 **Conductive mix devices (Carbon Bridge).** These EEDs are initiated by an explosive mix which contains conductive materiel. As voltage is applied to the leads of this type of device, very little current flows until a threshold is reached where the current can jump between conductive particles. At this point the surge of current ignites the explosive mix which then ignites the remainder of the energetics in the EED. These devices are normally fired by a relatively high voltage from a small capacitor. These devices definitely are susceptible to peak voltages created by pulse modulated fields. They also pose unique instrumentation pitfalls as they are very non-linear and their impedance changes drastically as their firing voltage is approached.

F3.7.2.3 **Exploding Foil Initiators (EFI).** These detonators are used mainly in fuzes with an uninterrupted explosive train. This type of EED has a small conductive metal foil bridge which is housed underneath a plastic layer. When a sufficient current pulse is passed through the bridge it vaporizes, throwing the plastic "flyer" into a relatively insensitive explosive charge with enough energy to cause it to detonate. Their chief characteristic is that both a high voltage and high current are required with a fast rise time and short duration in order to fire an EFI. They are normally considered insensitive to EMR and are therefore the usual choice for Electronic Safe and Arm Devices (ESADs). It is, however, within the realm of feasibility for the high peak current and sharp risetime induced by some radar environments to initiate an EFI. For this reason an EFI cannot be ignored during an HERO test and evaluation effort. Particular attention must be paid to determining the response of the device at the high peak field produced by radars and comparing them to the EFI's firing characteristics.