



DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
U.S. ARMY LOGISTICS INTEGRATION AGENCY
5001 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22333-0001



LOIA-LS

30 JUN 2000

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Safety Evaluation For Ammunition Automatic
Identification Technology (AIT) Integration

1. The U.S. Army Logistic Integration Agency in coordination with the Operations Support Command, the Combined Arms Support Command, the Military Traffic Management Command, and the United States Army, Europe is implementing the Ammunition AIT Project to streamline and automate support processes from wholesale through transportation to retail supply. To improve current capabilities, Radio Frequency Identification (RFID) technology is used to provide in-transit and in-the-box visibility of assets.
2. To ensure safe operation of new RFID technology, the Naval Surface Warfare Center, Dalgran Division conducted Hazards of Electromagnetic Radiation to Ordnance (HERO) Safety evaluation tests and reported safe operating distances corresponding to each AIT equipment tested. The HERO Safety Evaluation Tests of Army AIT AMMO Tracking Equipment report, 20 June 00 is enclosed. The enclosed report provides test results and recommendations for the application of RFID.
3. My POC for this action is Mr. John Waddick, DSN 767-7079 or COMM (703) 617-7079.

FOR THE DIRECTOR:

Encl

J. A. Bush
JOSEPH A. BUSH
Chief, Logistics
Systems Division

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SUBJECT: Safety Evaluation For Ammunition Automatic
Identification Technology (AIT) Integration.

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**DEPARTMENT OF THE NAVY**

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DAHLGREN DIVISION
17320 DAHLGREN ROAD
DAHLGREN, VIRGINIA 22448-5100

IN REPLY REFER TO

10550

J52-6457ZAN

JUN 20 2000

From: Commander, Dahlgren Division, Naval Surface Warfare Center
To: Integration Logistic Agency
Attn: LOIA-LF (John Yates)
5001 Eisenhower Ave.
Alexandria, VA 22333-5001

Subj: HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO)
SAFETY EVALUATION TESTS OF ARMY AUTOMATIC IDENTIFICATION
TECHNOLOGY (AIT) AMMO TRACKING EQUIPMENT

Ref: (a) MIL-STD-461D Requirements for the Control of
Electromagnetic Interference Emissions and
Susceptibility
(b) MIL-STD-462D Measurement of Electromagnetic
Interference Characteristics

Encl: (1) Hazards of Electromagnetic Radiation to Ordnance
(HERO) Safety Evaluation Test Results for the Army
Automatic Identification Technology (AIT) Ammo
Tracking Equipment

1. As requested by the Army Integration Logistics Agency (AILA)/Mr. John Yates, Code LOIA-LF, HERO safety evaluation tests were conducted on three items of the Army Automatic Identification Technology (AIT) ammo tracking equipments (herein-after referred to as AIT equipment). These evaluations were conducted during the period of 21 through 24 June 1999. The evaluations for each item were based on the results of an analysis of the output signal spectrum characterization. Radiated Emissions (RE102) tests were first conducted to the requirements of reference (a) in order to determine the bandwidth and magnitude of potential emissions. Where appropriate, the tests were accomplished in accordance with procedures specified in reference (b). The AIT equipments subjected to test and evaluation were as follows:

a. Savi MobileReader 410R - Model No. SMR-410R-300, Serial No. 10001 - Portable Hand held RF interrogator w/bar code and RFDC capabilities.

b. Savi RF Relay - Model RFR-100, Serial No. 61702.

c. Savi RF Relay - Model RFR-200, Serial No. 71701.

Subj: HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO)
SAFETY EVALUATION TESTS OF ARMY AUTOMATIC IDENTIFICATION
TECHNOLOGY (AIT) AMMO TRACKING EQUIPMENT

2. The results of the output signal spectrum analysis, RE102 tests, as well as the conclusions and recommendations which are based on those results are presented in enclosure (1).

3. Please direct any questions, or comments, to Benton C. Zander Code J52, commercial (540) 653-3435 or DSN 249-3435.

William P. Lucado
WILLIAM P. LUCADO
By direction

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Crane, Indiana 47522-5001

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J52-6457ZAN



**HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE
(HERO) SAFETY EVALUATION TEST RESULTS
FOR THE
ARMY AUTOMATIC IDENTIFICATION TECHNOLOGY (AIT)
AMMO TRACKING EQUIPMENT**

April 2000

Distribution authorized to DOD personnel and DOD Contractors only; Test and Evaluation; April 2000. Other request for this document must be referred to Commander, Dahlgren Division, Naval Surface Warfare Center, Code J52, 17320 Dahlgren Road, Dahlgren, Virginia 22448-5100

Encl (1)

**HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY
EVALUATION TEST RESULTS FOR THE ARMY AUTOMATIC IDENTIFICATION
TECHNOLOGY (AIT) AMMO TRACKING EQUIPMENT**

Ref: (a) MIL-STD-461D
(b) MIL-STD-462D
(c) Hazards of Electromagnetic Radiation to Ordnance
(HERO) Safety Evaluation Test Plan for the Army's
Automatic Identification Technology (AIT) Ammo Tracking
Equipment

I. GENERAL

1. During the period of 21 through 24 June, tests and analysis were performed to determine the output signal spectrum characteristics, and/or the Radiated Emissions (RE102) of three items of the US Army's AIT equipments. The tests, to determine the output signal spectrum characteristics of the AIT equipments, were conducted as a means of evaluating the safety of using these AIT equipments in the proximity of ordnance. The RE102 tests and evaluations were conducted as a baseline to determine the bandwidth and magnitude of potential emissions, and to determine the potential for the AIT equipments to affect the operation of other sensitive electronic equipments. The RE102 tests were conducted, to the extent possible, as specified in the requirements and procedures delineated in references (a) and (b). The tests were conducted in accordance with reference (c), which is included as attachment (1) for information purposes.

2. The AIT equipments evaluated were as follows:

a. Savi MobileReader 410R - Model No. SMR-410R-300, Serial No. 100001 - Portable Hand held RF interrogator w/bar code and RFDC capabilities.

b. Savi RF Relay - Model RFR-100, Serial No. 61702.

c. Savi RF Relay - Model RFR-200, Serial No. 71701.

3. The AIT equipments subjected to tests and evaluation, are intentional transmitters, which are intended for use in the proximity of ordnance items. Therefore, it was considered essential that the safe separation distance for each AIT item be determined. In the case of the hand held interrogator, it was determined that it would normally be operated at a distance of 4 to 12 inches from ordnance items to scan a bar code label and "write" the data to a SaviTag using the on-board transmitter of the hand held interrogator.

4. The Electro-Explosive Devices (EEDs) used in Army and Navy

ordnance vary considerably (depending upon the application) in the Maximum No Fire Stimulus (MNFS) that they can withstand without firing. MIL-STD-464, DEPARTMENT OF DEFENSE INTERFACE STANDARD, Electromagnetic Environmental Effects Requirements for Systems, states that "Ordnance shall have a margin of at least 16.5 dB of maximum no-fire stimulus (MNFS) for safety assurances and 6 dB of MNFS for other applications." This requirement categorizes RF currents induced in an EED which exceed 15% of the MNFS as a potential safety concern, and 50% of the MNFS as being a potential reliability concern.

5. Since some EEDs may have a "Maximum No Fire Current" (MNFC) of as low as 30 mA, it is essential that the MNFC, or MNFS of ordnance in the area be given due consideration before operating any electronic/electrical equipment, or intentional transmitter in the proximity of ordnance. If this information is unknown at the time of the operation, it should be assumed that the ordnance in the inventory area contains the most sensitive EED (those requiring the lowest MNFC current or MNFS).

II. TEST CONFIGURATION

1. RE102 Test Configuration: All AIT equipments are subjected to the RE102 test requirements of reference (a) as a precursor to output signal spectrum analysis. The test configuration required by reference (b) was modified to more closely reflect the manner in which the AIT equipment would be configured and used in the field. For example the ground plane (copper top bench) was not used for this testing, since the AIT equipments tested are portable, or are expected to be installed in an outdoor area. However, RE102 measurements were taken at a distance of one meter with any cables to/from the AIT equipment under test arranged in such a manner as to allow lengths of cable representing a significant portion of a wavelength, at the unit's operating frequency, to be included in the measurement. The RE102 test configuration for the Savi MobileReader, RFR-100 and RFR-200 are shown in figures 1 and 2.



Figure 1. Savi MobilReader 410R configured for RE102 tests.

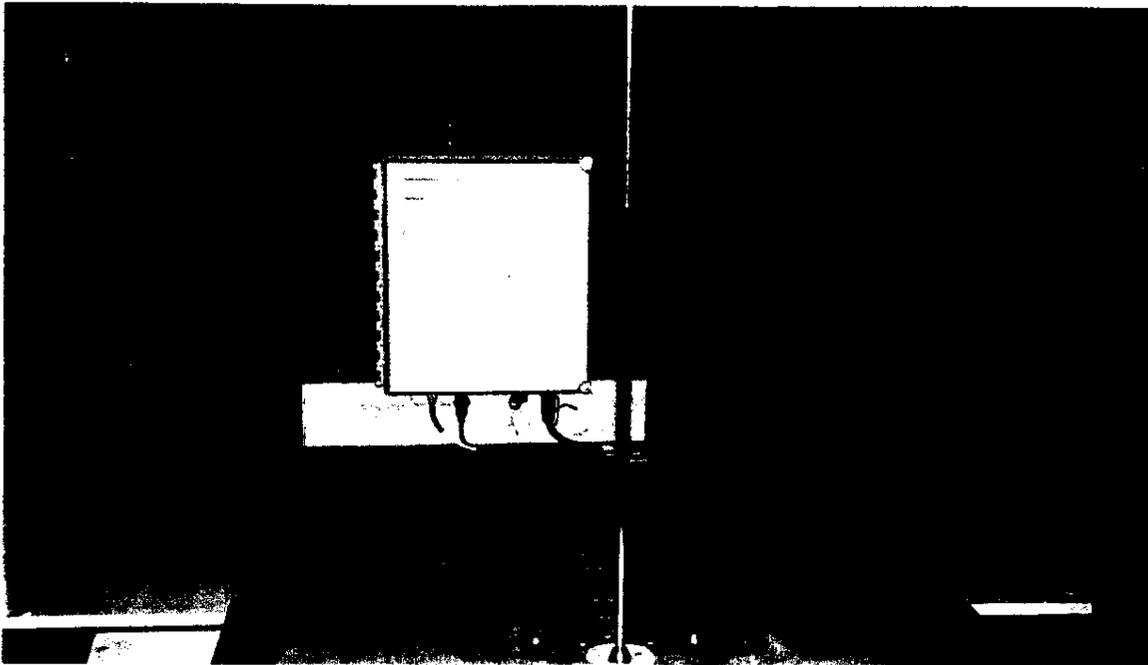


Figure 2. Savi RF Relays RFR-100/200 configuration for RE102 tests.

2. Output Signal Spectrum Analysis Configuration: The analysis of the output signal spectrum was conducted on the Savi MobileReader (410R-300), Savi RF Relay - Model RFR-100, and Savi RF Relay - Model RFR-200 output signals. A special antenna test fixture, which had been constructed to facilitate the analysis of the output signal spectrum characteristics of AIT equipments, was utilized for these efforts. The antenna test fixture, here-in-after referred to as "the fixture," was designed and constructed to establish a fixed measurement distance, between the radiating and receptor antennas, of either four inches or twelve inches. The fixture consists of a .125"x 14"x 21" aluminum plate, with three antenna ports set at four and twelve inches apart. The aluminum plate is mounted on 1 3/4" wood spacers to allow space, beneath the plate, for the connection of low-loss cables to/from the antenna ports, and to the spectrum analyzer.

For the analysis, the Savi MobileReader 410R, Mod. #SMR-410R-300 was programmed to repeatedly scan a bar code label, transmit the data to a SaviTag, query the Tag to ensure that the data was "written" in its memory, and store the data to be downloaded at a later time. The SaviTag was placed on the far side of the shield room, at a distance of approximately twelve feet.

The fixture was also used to facilitate spectrum analysis of the radiated emissions from the Savi RF Relays - Model RFR-100, and Model RFR-200. The test configurations with the MobileReader

in a cradle, on "the fixture", and the RF Relays adjacent to the fixture are shown in figures 3 and 4.

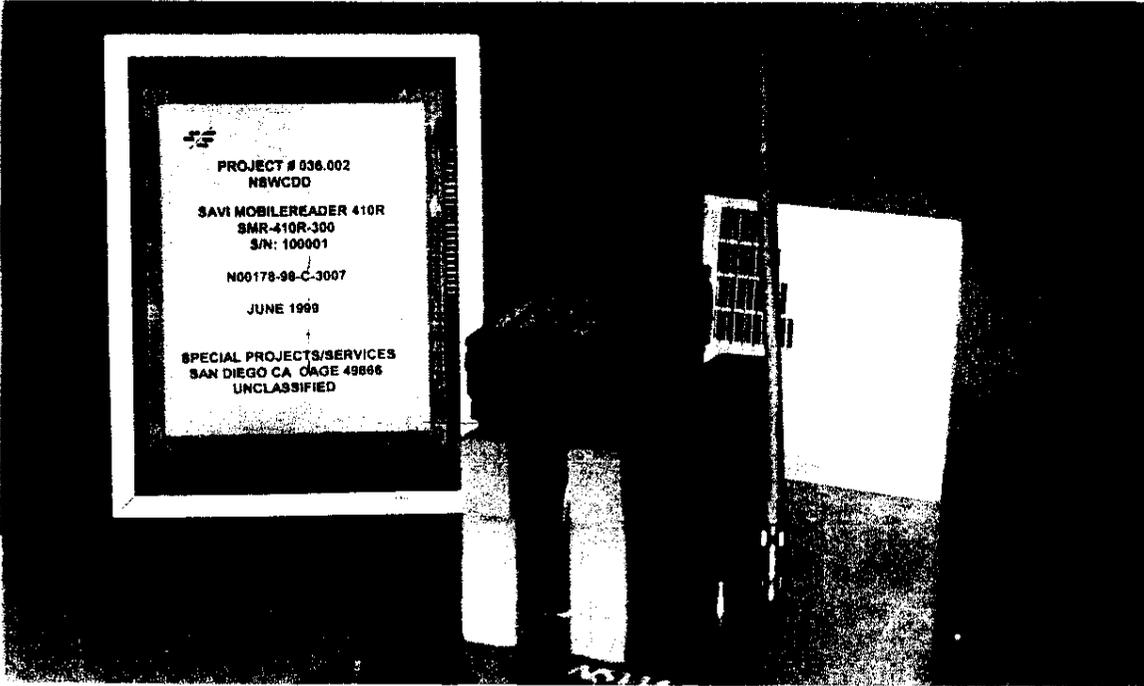


Figure 3. Savi MobileReader configured for analysis

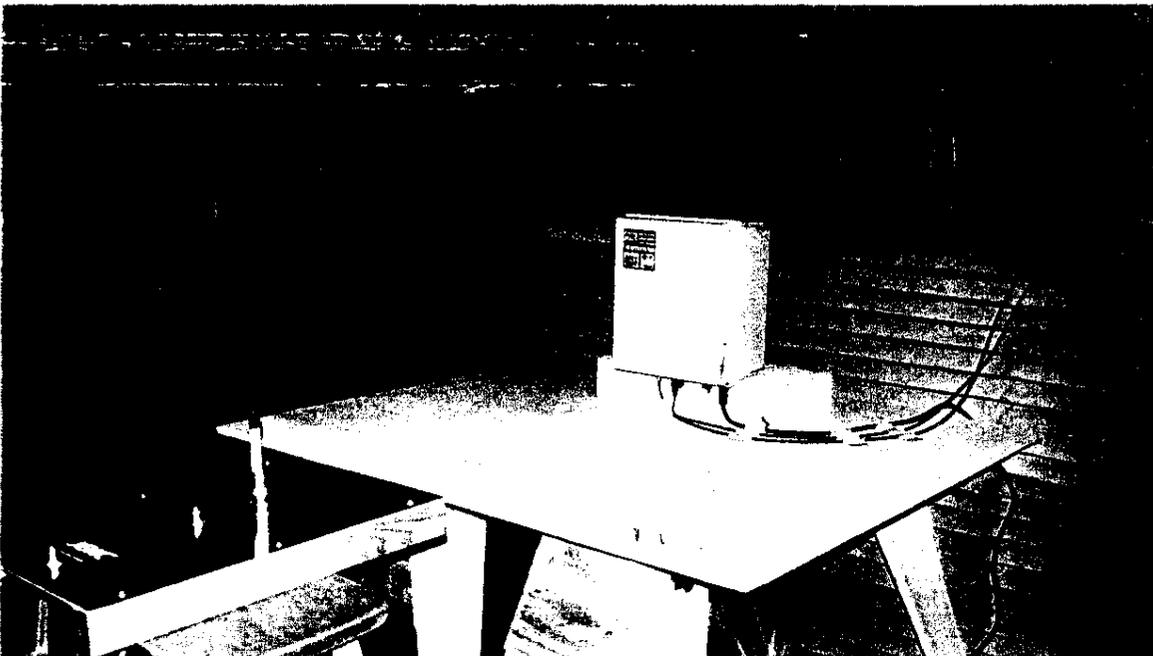


Figure 4. Savi RF Relay configured for analysis

III. TEST METHODOLOGY

1. RE102 Tests: These tests were conducted, to the extent possible, in accordance with the requirements of reference (b). The Savi MobileReader, Savi RFR-100 Radio/RF Modem Module and Savi RFR-200 RF Modem/LON Works Module were all subjected to RE102 emissions measurements in accordance with reference (b), to establish a baseline for determining the minimum safe separation distance from ordnance. For the RE102 test of the Savi RF Relay systems, the components under test were isolated from those not under test by routing the interconnecting cables through ports in the screen room wall.

2. Output Signal Spectrum Analysis: For these efforts, the Savi MobileReader and measuring equipment configuration were as described in paragraph II.2. All losses in the measurement system equipment setup, such as cable, connectors, and connector adapter losses were determined and recorded prior to making any measurements. This was accomplished by substituting a HP8648D RF Signal Generator for the Savi MobileReader, as the RF signal source, and measuring the loss resulting from all interconnecting cables and connectors to be used between the receive antenna and the HP 8566B spectrum analyzer.

The Savi MobileReader, when "triggered", will automatically increase it's output signal level significantly if initial attempts to establish communication with a SaviTag or base station fail. Therefore, during these efforts the SaviTag was not turned on, in order to acquire the highest possible output signal levels from the Savi MobileReader.

IV. TEST RESULTS AND DISCUSSION

1. RE102 Test Results

a. Savi MobileReader 410R Mod. #SMR-410R-300, [Serial Number 100001 Hand held Bar Code Reader/RF Interrogator w/RF Identification (RFID) only @ 433.9 MHz: When measured from a distance of one meter, the radiated emissions from the Savi MobileReader 410R exceeded the acceptable RE102 limits of reference (a) in the frequency range of 48 MHz to 200 MHz. The highest level of radiated emissions above the RE102-2 limit was found to be 45 dBuV/m [or 7 dB above the acceptable RE102-2 limits of reference (a)] recorded at 49MHz. The plots portraying the measured radiated emissions from this unit are provided in Attachment (2).

b. Savi RFR-100 Radio/RF Modem Module S/N 61702. When measured from a distance of one meter, the radiated emissions from this Savi RF Relay Module exceeded the acceptable RE102-2

limits of reference (a) in the frequency range of 100 kHz to 930 MHz. The worst case emissions were found to be 67 dBuV/m [or 5 dB above the acceptable RE102-2 limits of reference (a)] recorded at 101kHz, and 50 dBuV/m [or 12 dB above the acceptable RE102-2 limits of reference (a)] recorded at a frequency of 48 MHz. The plots portraying the measured radiated emissions from this unit are provided in Attachment (2).

c. Savi RFR-200 RF Modem/LON Works Module S/N 71702.

When measured from a distance of one meter, the radiated emissions from this Savi RF Relay Module exceeded the acceptable RE102-2 limits of reference (a) in the frequency range of 60 MHz to 180 MHz. The worst case emissions was found to be 52 dBuV/m [or 13 dB above the acceptable RE102-2 limits of reference (a)] recorded at a frequency of 160 MHz. The plots portraying the measured radiated emissions from this unit are provided in Attachment (2)

2. Output Signal Spectrum Analysis Results

a. Savi MobileReader 410R, Mod. #SMR-410R-300. When measured at a distance of 12 inches the output signal level of the hand held interrogator was found to be 64.8 dBuV. However, when measured at a distance of 4 inches, the output signal level of this unit was found to be 75.1 dBuV. The 433.94 MHz signal is continuously transmitted for a period of 2.6 seconds each time the transmit section of the unit is activated, and is not adjustable. The output signal spectrum characterization of this Unit at 12 inches and 4 inches are presented in plots #06229901 and #06229902 in Attachment (3).

b. Savi RFR-200 Up/Down Converter w/Antenna. When measured from a distance of 7 feet and 0.25 inches, the radiated emissions from these Savi RF Relay components were found to be 87 dBuV at the intended output frequency of 2.459 GHz. The output signal spectrum characterization of this unit is presented in plot #06229903 in Attachment (3).

c. Savi RFR-200 RF Modem/LON Works Module. When measured from a distance of 3 feet, the radiated emissions from this RF Relay Module was found to be 39.1 dBuV, recorded at the intentionally generated frequency of 911.9 MHz. The output signal characterization of this unit is presented in plot #06229905 in Attachment (3).

d. Savi RFR-100 Radio/RF Modem Module. When measured from a distance of 3 feet, the radiated emissions from this RF Relay Module was found to be 54.7 dBuV, recorded at the intentionally generated output frequency of 911.9 MHz. The output signal spectrum characterization of this unit is presented

in plot #06229907 in Attachment (3).

e. Savi RFR-100 Up/Down Converter Module w/Antenna.

When measured from a distance of 7 feet and 0.25 inches, the radiated emissions from the Up/Down Converter with the attached 9 dBi antenna were found to be 83.0 dBuV/m recorded at a frequency of 2.457 GHz. The output signal spectrum characterization of this unit is presented in plot #06239908 in Attachment (3).

V. RECOMMENDATIONS

1. Recommendations are made with consideration to the RE102 test results, and the radiated emissions spectrum analysis. As a result of the RE102 test results, none of the AIT equipments evaluated should be considered suitable for use in the proximity of other sensitive electronic equipments.

The recommendations, based on the result of the output signal spectrum analysis for each item tested, are presented individually as follows:

(a) Savi MobileReader 410R, Mod. #SMR-410R-300 - The MobileReader should not be considered as presenting a hazard to ordnance when operated at a distance of 4 inches or more from ordnance.

(b) Savi RFR-100 Radio/RF Modem Module. The test results indicate that this Module, as tested, should not present a hazard to ordnance when mounted in such a manner as to maintain a separation distance of 3 feet or more from ordnance.

(c) Savi RFR-100 Up/Down Converter Module w/Antenna. - In light of the Output Signal Spectrum Analysis of the Up/Down Converter module with the Antenna, it is recommended that both the Module and the Antenna be installed in such a manner as to maintain a minimum separation distance from ordnance of at least 7 feet.

(d) Savi RFR-200 RF Modem/LON Works Module. The test results indicate that this Module, as tested, should not be considered as presenting a hazard to ordnance when mounted in such a manner as to maintain a separation distance of 3 feet or more from ordnance.

(e) Savi RFR-200 Up/Down Converter w/Antenna. The test results indicate that this unit should not be considered as presenting a hazard to ordnance when mounted in such a manner as to maintain a minimum separation distance of 7 feet from the ordnance.