

**DEPARTMENT OF THE NAVY**

NAVAL SURFACE WARFARE CENTER
DAHLGREN DIVISION
17320 DAHLGREN ROAD
DAHLGREN, VIRGINIA 22448-5100

IN REPLY REFER TO

10550
J52-6535ZAN

APR 23 2001

From: Commander, Dahlgren Division, Naval Surface Warfare Center
To: Savi Technology
(Attn: Eugene Schlindwein)
615 Tasman Drive
Sunnyvale, CA 94089

Subj: ELECTROMAGNETIC COMPATIBILITY (EMC) TESTS AND HAZARDS
OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY
EVALUATION OF THE SAVITAG 412

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) EMC Tests and HERO Safety Evaluation Test Results for
the SaviTag 412 Automated Identification Technology
(AIT) Equipment

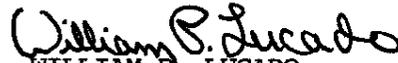
1. As requested by Savi Technology/Mr. Eugene Schlindwein, EMC tests and HERO safety evaluation tests were conducted, during the period of 28 November through 01 December 2000, on the SaviTag, Model ST-412-1U, Serial Number 400081, Automated Information Technology equipment. These efforts were accomplished in compliance with a "Work For Others Agreement" NSWCDD-WFO-01-09, between NSWCDD and Savi Technology.

2. Radiated Emission (RE102) tests were first conducted to the requirements of reference (a) in order to determine: (a) the bandwidth and magnitude of potential emissions; and (b) the potential for those emissions to effect other sensitive electronic equipment. Where appropriate, the tests were accomplished in accordance with the procedures specified in reference (b). The HERO evaluation was based on the results of an analysis of the radiated emissions spectrum characterization.

3. The results of the EMC (RE102) tests, radiated emissions spectrum analysis, as well as the conclusions and recommendations which are based on those results are presented in enclosure (1).

Subj: ELECTROMAGNETIC COMPATIBILITY (EMC) TESTS AND HAZARDS
OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY
EVALUATION OF THE SAVITAG 412

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


WILLIAM P. LUCADO
By direction

10550
J52-6535ZAN



**ELECTROMAGNETIC COMPATIBILITY (EMC)
AND
HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE
(HERO) SAFETY EVALUATION TEST RESULTS
FOR THE SAVITAG 412
AUTOMATED IDENTIFICATION TECHNOLOGY
(AIT) EQUIPMENT**

December 2000

Distribution authorized to DoD personnel and DoD Contractors only; Test and Evaluation; December 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

Enclosure (1)

**ELECTROMAGNETIC COMPATIBILITY (EMC) TESTS AND HAZARDS OF
ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY
EVALUATION TEST RESULTS FOR THE SAVITAG 412**

Ref: (a) MIL-STD-461D
(b) MIL-STD-462D
(c) Electro-Magnetic Compatibility (EMC) and Hazards of
Electromagnetic Radiation to Ordnance (HERO) Safety
Evaluation Test Plan for the SaviTag 412 Automatic
Identification Technology (AIT) Ammo Tracking
Equipment

I. GENERAL

1. During the period of 28 November through 01 December 2000, EMC (RE102) tests, and a Hazards of Electro-Magnetic Radiation to Ordnance (HERO) safety evaluation were performed on the SaviTag, Model Number ST-412-1U, Serial Number 400081 Automated Identification Technology (AIT) equipment (here-in-after referred to as "the SaviTag"). The Radiated Emissions (RE102) tests and evaluations were conducted first to determine the bandwidth and magnitude of both intentional and unintentional emissions, and the potential for the SaviTags to effect the operation of other sensitive electronic equipment. The RE102 tests were conducted to the extent possible, as specified in the requirements and procedures delineated in references (a) and (b). The HERO safety evaluation was then conducted to determine the potential for the SaviTag to effect ordnance. The tests and evaluation were conducted in accordance with reference (c), which is included as attachment (1) for information purposes.

2. As the SaviTags are intentional transmitters, which are intended to be mounted on ordnance shipping containers and/or pallets of ordnance, it was determined that they may be mounted, and operated as close as four (4) inches from ordnance or ordnance components. Therefore, it was considered essential that the safe separation distance between HERO UNSAFE/SUSCEPTIBLE ordnance and operating SaviTags be determined.

3. The Electro-Explosive Devices (EED)s used in Military ordnance vary considerably (depending upon the application) in the Maximum No Fire Stimulus (MNFS) that they can withstand without detonating. 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 percent of the MNFS, as being a potential safety concern, and those that exceed 50 percent 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 the 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 or MNFS).

II. TEST CONFIGURATION

1. RE102 Test Configuration: The SaviTag was subjected to the RE102 test requirements of reference (a) as a precursor to the radiated emissions spectrum analysis. The test configuration required by reference (b) was modified to more closely reflect the manner in which the SaviTag would be configured and used in the field. For example the ground plane (copper top bench) was not used for this testing, since the SaviTags may be mounted on a non-conductive shipping container or pallet. For the RE102 measurements the SaviTag was mounted on a wooden block, for support, and interrogated by a Savi MobileReader, Model #SMR-410R-200, S/N 2550-9900418, handheld RFID interrogator. The Savi MobileReader was located in the anteroom, and the signal was coupled through the shielded room wall via tune stub antennas on the outside and inside of the wall. The RE102 measurement configuration for the SaviTag was as shown in figure 1.

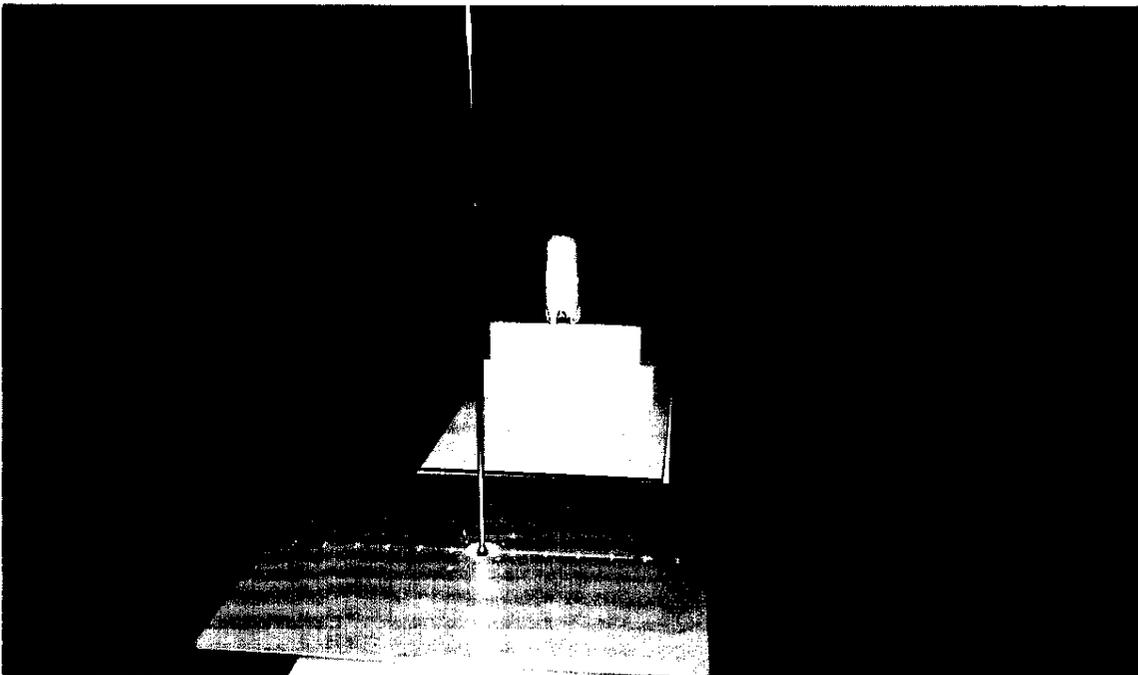


Figure 1. SaviTag 412 configured for RE102 tests.

2. Radiated Emissions Spectrum Characterization

Configuration: 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 item and the 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 inch 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 SaviTag, with it's supporting block, was placed on the fixture, and forced to transmit continuously by repeated interrogation by a Savi MobileReader. The configuration of the SaviTag for this analysis was as presented in figure 2.

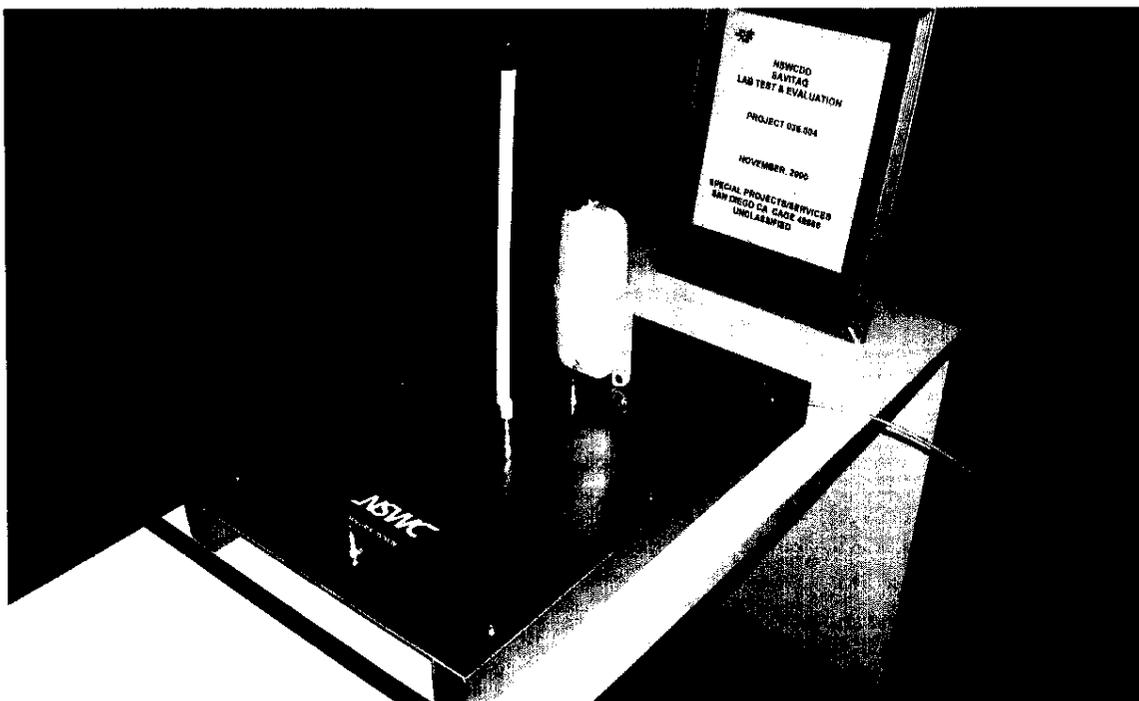


Figure 2. SaviTag 412 configured for Output Signal Spectrum Analysis.

III. TEST METHODOLOGY

1. **RE102 Tests:** These tests were conducted, to the extent possible, in accordance with the requirements of reference (b). The SaviTag was subjected to RE102 emissions measurements in

accordance with reference (b), to determine its potential to effect other sensitive electronic equipments, and establish a baseline for analysis of the radiated emissions spectrum characterization. For the RE102 measurements, the SaviTag was forced to operate continuously by programming a Savi MobileReader to repeatedly interrogate the SaviTag. The configuration of the SaviTag and supporting equipment for the RE102 measurements were as described in section II, paragraph 1, above.

2. **Radiated Emissions Spectrum Characterization:** For these efforts, the SaviTag configuration was 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 equipments under test (EUT)s, 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 HP8566B spectrum analyzer.

Prior to conducting this characterization and analysis, the RE102 measurement plots were examined to identify the frequencies at which the radiated emissions may be of concern. Quarter wavelength antennas were then cut for those frequencies, and measurements were made at distances of four (4) and twelve (12) inches. The configuration of the SaviTag for this analysis was as described in section II, paragraph 2. above.

IV. TEST RESULTS AND DISCUSSION

1. **RE102 Test Results:** When measured from a distance of one meter, the radiated emissions from the SaviTag exceeded the acceptable RE102 limits of reference (a) at the units intended transmit frequency of 433.9 MHz. The highest level of radiated emissions, which exceeded the RE102 limit at this frequency was found to be 67.0 dBuV/m (or approximately 18 dBuV/m above the RE102 limit). The RE 102 plot (006 Operate) portraying the radiated emissions measured at one meter from the SaviTag unit is provided in Attachment (2).

2. **Radiated Emissions Spectrum Analysis Results:** When measured at a distance of four (4) inches, the highest level of radiated emissions from this SaviTag was found to be 78.2 dBuV, recorded at the intended output frequency of 433.858 MHz. The radiated emission from the SaviTag at a distance of twelve (12) inches was found to be 71.10 dBuV. The worst case radiated emissions spectrum characteristics of this unit at four (4) and twelve (12) inches are presented in plots (A004) and (A005) respectively in Attachment (3).

V. RECOMMENDATIONS

1. Recommendations are made with consideration to the RE102 test results, and the radiated emissions spectrum analysis.

The measured RE102 levels: from the SaviTag, at it's intended operating frequency, indicates that the potential does exists for the unit to have an effect on other sensitive electronic equipment operating at a distance of one meter.

The radiated emissions spectrum analysis results: indicate that the SaviTag, as tested, should not be considered as presenting a hazard to ordnance while operating at a distance of four (4) inches or greater from ordnance.

Shipboard EM environment: The SaviTag, as tested, should not be considered as suitable for use in the Shipboard EM environment of the Fleet, without first being subjected to, and passing Radiated Susceptibility (RS103) test and evaluation to the requirements of reference (a), as a minimum.

10550
J52-6535ZAN



**ELECTRO-MAGNETIC COMPATIBILITY (EMC)
AND
HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE
(HERO) SAFETY EVALUATION TEST PLAN
FOR THE SAVITAG 412
AUTOMATIC IDENTIFICATION TECHNOLOGY
(AIT) EQUIPMENT**

August 2000

Distribution authorized to DoD personnel and DoD Contractors only; Test and Evaluation; August 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

Attachment (1)

10550
J52-BCZ

**ELECTRO-MAGNETIC COMPATIBILITY (EMC) AND HAZARDS OF
ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY EVALUATION
TEST PLAN FOR THE SAVITAG 412 AUTOMATIC IDENTIFICATION TECHNOLOGY
(AIT)AMMO TRACKING EQUIPMENT**

Ref: (a) MIL-STD-461D
(b) MIL-STD-462D

I. GENERAL:

1. As equipments using complex state-of-the-art technology in their design is developed, and more commercial-off-the-shelf (COTS) equipment is being acquired for use in the military electromagnetic environments, it becomes much more important that the equipment/systems are thoroughly tested to ensure compatibility with their intended operational environment.

The SaviTag 412 AIT (herein after referred to as SaviTag) is intended for use in tracking of ammunition, ordnance containers, or pallets of ordnance utilizing portable battery powered radio frequency (RF) scanning devices, fixed RF scanning devices, RF Modems, and RF repeaters. Since the SaviTags are intentional RF transmitters, which are intended for use in ordnance storage, assembly, and/or production areas, they are therefore, of concern from an EMC and a Hazards of Electromagnetic Radiation to Ordnance (HERO) perspective.

II. EQUIPMENT REQUIRED FOR TESTS:

1. The equipments required to be provided for the tests are as follows:

a. SaviTag, Model 412.

b. An interrogating device, such as a Savi MobileReader 410R, or equivalent.

c. All software, operating instructions, battery packs, power supplies, battery chargers, and any other ancillary equipment which may be necessary for the operation of, and/or monitoring the performance of the above equipments. A person who is thoroughly familiar with the hookup, and operation of the AIT equipments will be required on site to assist with system setup and possible failure analysis.

III. TEST ENVIRONMENTS:

1. The SaviTag will be subjected to testing and evaluation to the Radiated Emission (RE102) requirements of reference (a), in accordance with reference (b). The SaviTag will be subjected to the RE102 test requirements of reference (a), as a means of evaluating the potential of other sensitive electronic systems being interfered with by the SaviTags. The RE102 limits utilized will be those depicted in reference (a) figure RE102-2, in the frequency range of 10kHz - 1GHz. The output signal spectrum characteristics of the SaviTag will also analyzed to determine the safety of operating the SaviTags, at a distances of four (4) and twelve (12) inches from HERO UNSAFE and HERO SUSCEPTIBLE ordnance.

2. The radiated emissions and output signal levels from the SaviTag will also be measured at various distances to determine the safe separation distances for operation of the SaviTag from HERO UNSAFE or HERO SUSCEPTIBLE ordnance.

3. The test environments and/or test configuration of references (a) and (b) may be modified at the discretion of the Test Engineer, based on the intended operational configuration of the equipments under test, and the data obtained at the time of the tests.

IV. TEST METHODOLOGY:

1. The SaviTag will be set up to operate, to the extent possible, as they would in their intended operational environment. During the tests and evaluations, care will be taken to assure that equipment components not under test are isolated from the test environment. Field fixes will be installed and evaluated, if appropriate, as test time permits.

2. Due to the complexity of the system, and the anticipated test configuration, the detailed test methods will be established on site at the time of the tests. The fact that the SaviTag must communicate with other RF transceivers during normal operation will require the use of innovative methods to evaluate the operation of the SaviTag in the test environments. Therefore, the detailed test methodology will be delineated in the test report.

V. REPORTING:

1. A quick look report (oral or written) will be issued within 72 hours of completion of the test and evaluation. A detailed report will be submitted within 90 days of completion of the test and evaluation.

10550
J52-6535ZAN

RADIATED EMISSIONS (RE102-2) PLOTS
OF
SAVITAG MODEL ST-412-1U, S/N 400081

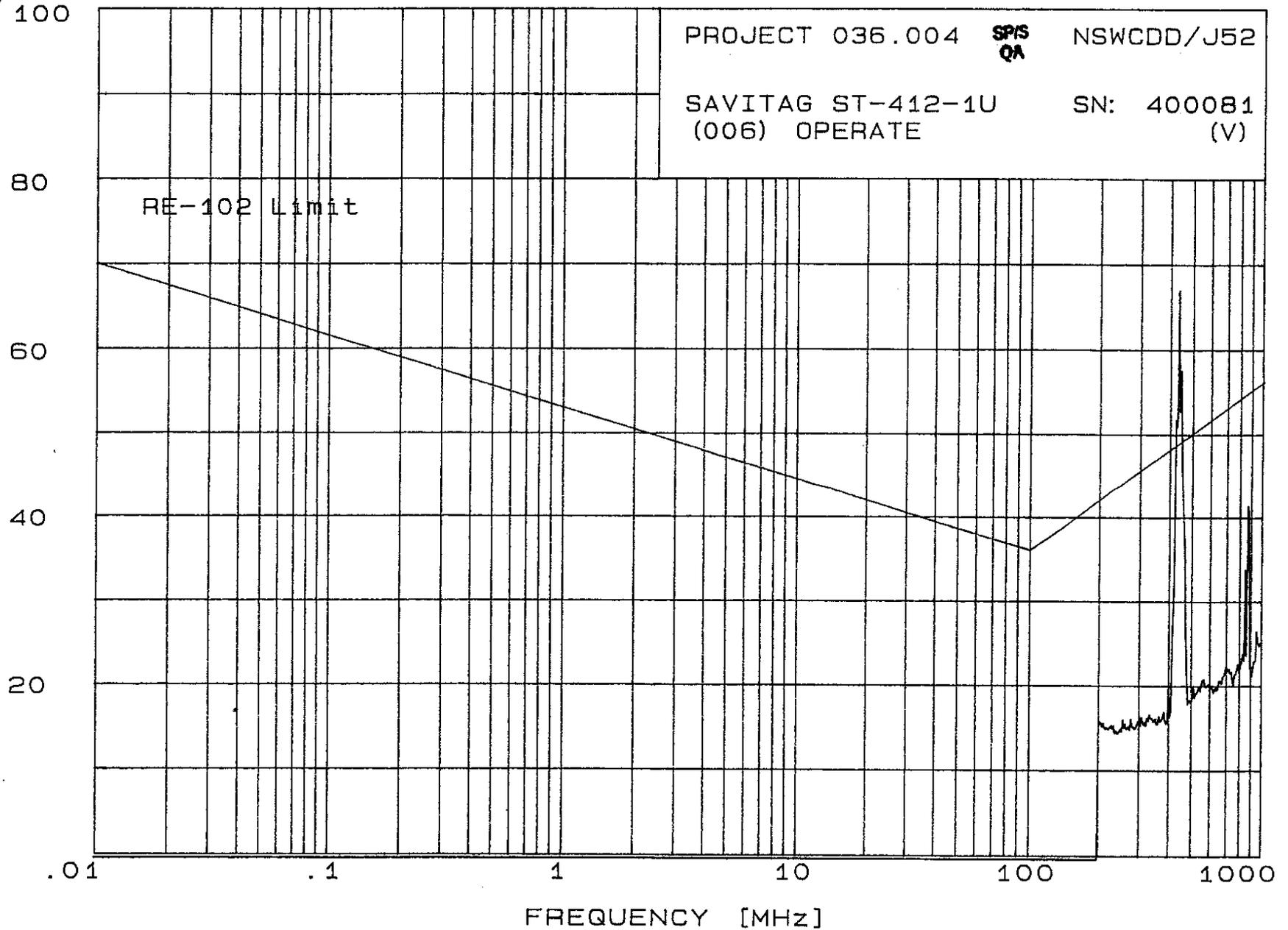
Attachment (2)

hp

SP/S SAN DIEGO CAGE 49866
EMISSION LEVEL [dBuV/m] PEAK

30 Nov 2000 17:30:38

PROJECT 036.004 SPS QA NSWCCD/J52
SAVITAG ST-412-1U SN: 400081
(006) OPERATE (V)



10550
J52-6535ZAN

RADIATED EMISSIONS SPECTRUM CHARACTERISTICS PLOTS
OF THE
SAVITAG, MODEL ST-412-1U, S/N 400081

Attachment (3)

29 NOV 00 SAULTAG ST-412-U1
SERNO 400081

4" DISTANCE, NSWCD TEST FIXTURE
10-MINUTE OBSERVATION TIME

SPS
QA

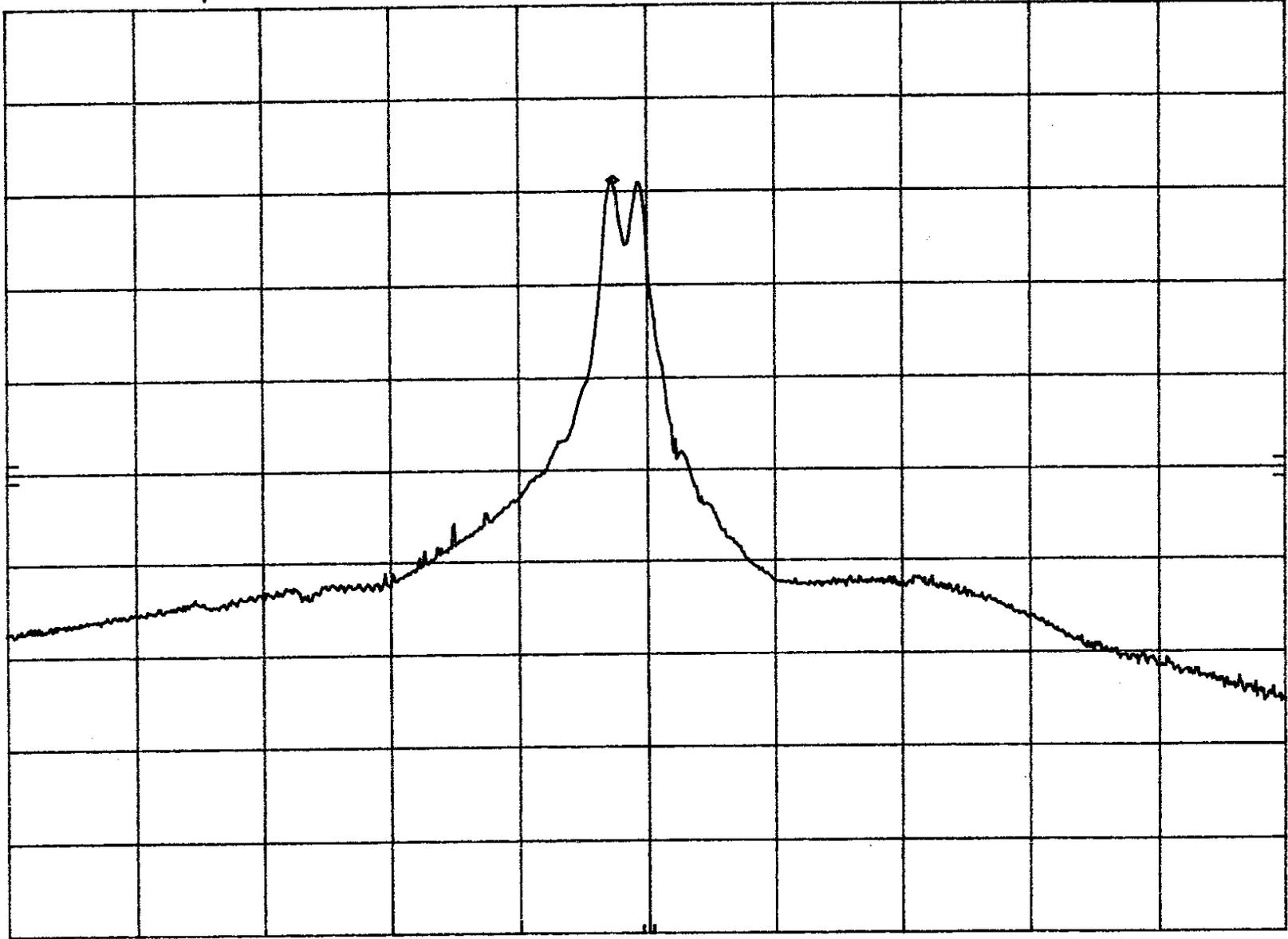
PLOT(A004)

MKR 433.858 MHz
78.20 dBμV

hp REF 97.0 dBμV ATTEN 0 dB

10 dB/

CORR'D



START 431.900 MHz STOP 436.040 MHz
RES BW 30 kHz VBW 30 kHz SWP 20 msec

29 NOV 00

SAVI TAG ST-412-U1
SERNO 400081

12" DISTANCE, NSWCDD TEST FIXTURE
10-MINUTE OBSERVATION TIME

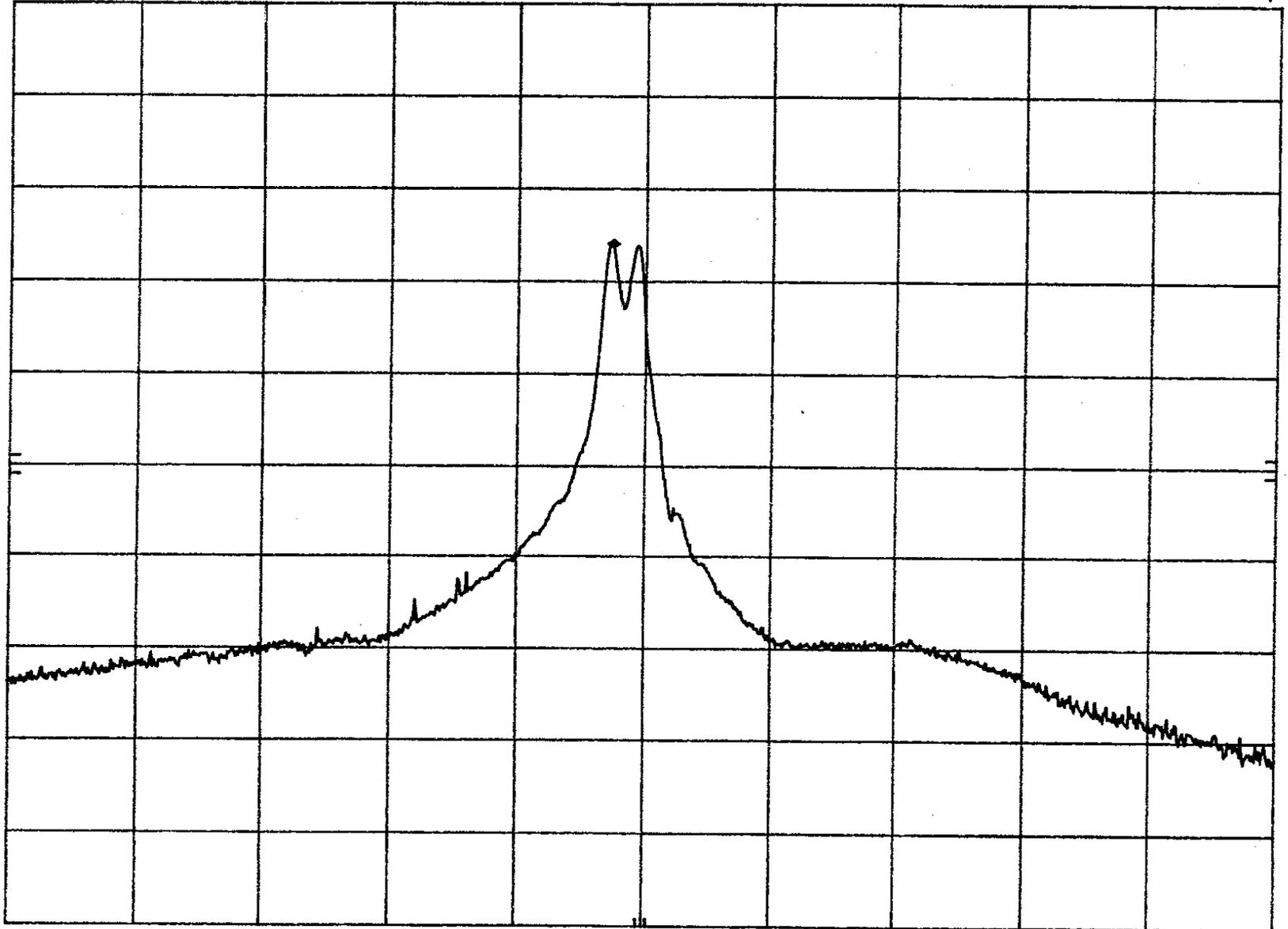
SPS
0A
PLOT (A005)

hp
10 dB/

REF 97.0 dBμV ATTEN 0 dB

MKR 433.858 MHz
71.10 dBμV

CORR'D



START 431.900 MHz

RES BW 30 KHZ

VBW 30 KHZ

STOP 436.040 MHz

SWP 20 msec