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				5c. PROGRAM ELEMENT NUMBER	
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Occupational and Environmental Health Dept Consultative Services Division 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2015-0024	
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14. ABSTRACT This health risk assessment (HRA), conducted 5-6 May 2015, was requested to verify safe exposure levels of electromagnetic frequency radiation (EMFR) at this Air Force (AF) facility. At the request of the Air Force Research Laboratory (AFRL), the U.S. Air Force School of Aerospace Medicine, Consultative Services Division assessed AFRL's Newport Antenna Measurement Facility. This HRA included measurements for potential exposures to EMFR as well as an evaluation for compliance with AF standards. EMFR operations at the Newport Antenna Measurement Facility are compliant with the current AFI 48-109 and IEEE C95.1. No exposures on or around the Newport facility exceed either the upper or lower tier maximum permissible exposure limits. Engineering and administrative controls are consistent with AF requirements and provide sufficient safety for all personnel at and near the facility. Any changes to the layout or procedures at the Newport facility will require a new survey.					
15. SUBJECT TERMS EMF, MPE, HRA, Newport, Rome Laboratory, AFRL					
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a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

15 July 2015

MEMORANDUM FOR AFRL/RIOCV

ATTN: WILLIAM BRAIN
150 ELECTRONIC PARKWAY
ROME, NY 13441

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2015-0024, EMFR HRA of the Newport Antenna Measurement Facility

1. INTRODUCTION:

a. *Purpose:* This health risk assessment (HRA), conducted 5-6 May 2015, was requested to verify safe exposure levels of electromagnetic frequency radiation (EMFR) at this Air Force (AF) facility.

b. *Background:* At the request of the Air Force Research Laboratory (AFRL), the U.S. Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC) assessed AFRL's Newport Antenna Measurement Facility. This HRA included measurements for potential exposures to EMFR as well as an evaluation for compliance with AF standards.

(1) The New York Department of Health was notified in advance and asked to observe this survey. In response, the NY Department of Health sent two personnel to the Newport Antenna Measurement Facility to observe operations and USAFSAM survey procedures.

(2) Exposure to EMFR may pose health risks due to its ability to heat body tissue enough to cause damage. Absorbed energy causes body temperatures to rise due to the body's inability to dissipate the added energy.

(3) USAFSAM performed this HRA in accordance with Air Force Instruction (AFI) 48-109, *Electromagnetic Field Radiation (EMFR) Occupational and Environmental Health Program*, and the Institute of Electrical and Electronics Engineers (IEEE) C95.1, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields*. Maximum permissible exposure (MPE) limits for this evaluation are based on the upper tier limits from these standards. Upper tier limits are defined, in these standards, as limits for people who are knowledgeable of the EMFR transmissions. The survey team compared measured

results of this evaluation to the lower tier limits to ensure compliance with all standards. Lower tier limits are defined in these standards as limits for people without knowledge of the EMFR transmissions.

(4) The Newport Antenna Measurement Facility is located 30 miles southeast of Rome, NY, near Newport, NY. The facility is split between two hilltop locations: Irish Hill and Tanner Hill. The hilltops are separated by a distance of 1.5 miles with a 400-foot-deep intervening valley. The antenna range is used to measure antenna radiation patterns, antenna-to-antenna isolation, full up radio frequency performance, and the development of state-of-the-art antenna measurement technologies.

(5) The site has various EMF systems as seen in Figure 1. This facility has operated in this configuration for approximately 30 years. Its systems include continuous wave emitters that transmit through various size antennas. See Table 1 for an inventory of emitters found at the Newport facility. Not all of these emitters are currently functional, as indicated in Table 1.

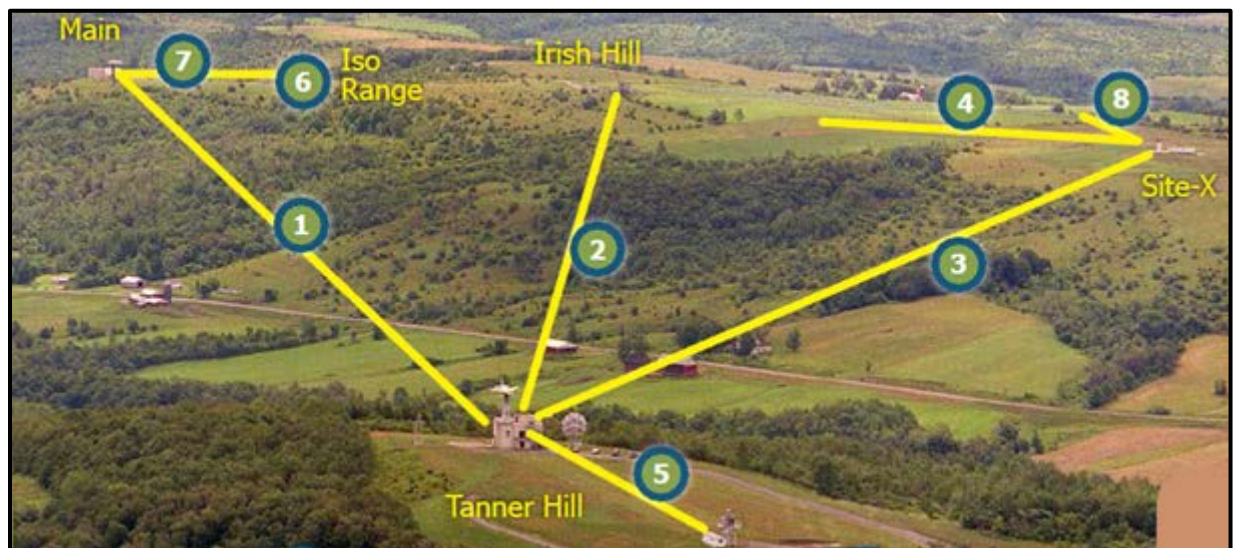


Figure 1. Newport Antenna Measurement Facility

Table 1. Newport Facility Emitter Inventory

Emitter Model and Antenna Size	Emitter Location	Quantity	Emitter Functional? (Yes/No)
Scientific Atlanta Inc. 15-ft Reflector	Tanner Hill Bldg 1600 Tower on Roof	1	YES
Scientific Atlanta Inc. 28-ft Reflector	Tanner Hill Left & Right of Transmit Bays	3	YES (2 of 3)
Scientific Atlanta Inc. 10-ft Reflector	Tanner Hill Upper & Lower Transmit Bays	3	YES
Scientific Atlanta Inc. 8-ft Reflector	Tanner Hill Upper & Lower Transmit Bays	2	YES
Scientific Atlanta Inc. 6-ft Reflector	Tanner Hill Upper & Lower Transmit Bays	2	YES
Scientific Atlanta Inc. 4-ft Reflector	Tanner Hill Upper & Lower Transmit Bays	2	YES
Scientific Atlanta Inc. 10-ft Reflector	Irish Hill Site X 1400-ft Transmit Range	1	YES
Scientific Atlanta Inc. 15-ft Reflector	Irish Hill Site X 1400-ft Range	1	YES
Scientific Atlanta Inc. 10-ft Reflector	Irish Hill Bldg 1620 Transmit Bay	1	NO
Scientific Atlanta Inc. 8-ft Reflector	Irish Hill Bldg 1620 Transmit Bay	1	NO
Log-Periodic Antenna	Irish Hill – Mobile	1	YES

c. *Survey Personnel:*

- (1) Health Physicist, USAFSAM/OEC
- (2) Health Physics Technician, USAFSAM/OEC

d. *Personnel Contacted:*

- (1) Occupational Safety Manager, AFRL/RIOCV
- (2) Newport Site Manager, AFRL/RITE
- (3) Director, Bureau of Environmental Radiation Protection, New York State
Department of Health
- (4) Research Scientist, Bureau of Environmental Radiation Protection, New York State
Department of Health

e. *EMF Measurement Equipment:*

- Narda Broadband Field Meter NBM-520 (SN A-0063, Calibrated December 2013, Calibration Due December 2015)
- Narda Broadband Field Meter NBM-550 (SN B-0858, Calibrated December 2013,

Calibration Due December 2015)

- Narda Electric Field Probe Model EF5092 (SN 1003, Calibrated December 2013, Calibration Due December 2015)
- Narda Shaped Probe Model EB 5091 (SN 01032, calibrated December 2013, Calibration Due December 2015)

2. METHODOLOGY:

a. *Site Layout:* The primary focus of this survey is to evaluate the various emitter systems located on Tanner Hill. There are 10 functional antennas and 1 nonfunctional antenna located in and adjacent to building 1600 (see Figures 2 through 5). Building 1600 has upper and lower transmit bays. The upper transmit bay houses four antennas, and the lower transmit bay houses three antennas. These antennas vary between 4, 6, 8, and 10 feet in diameter. There is currently one 15-foot antenna located on the roof and two 28-foot antennas located on either side of the building. Irish Hill has additional emitters that operate when needed. These systems include 10- and 15-foot antennas as well as a log-periodic antenna (see Figures 6 through 8). The site contains various aircraft. Some aircraft are actual airframes to test antennas, while other aircraft were full scale models used to mimic the real aircraft. These aircraft do not contain their normal working components. Aircraft are placed on positioners that rotate the aircraft to test antenna patterns. See Figure 9 for an example test configuration.

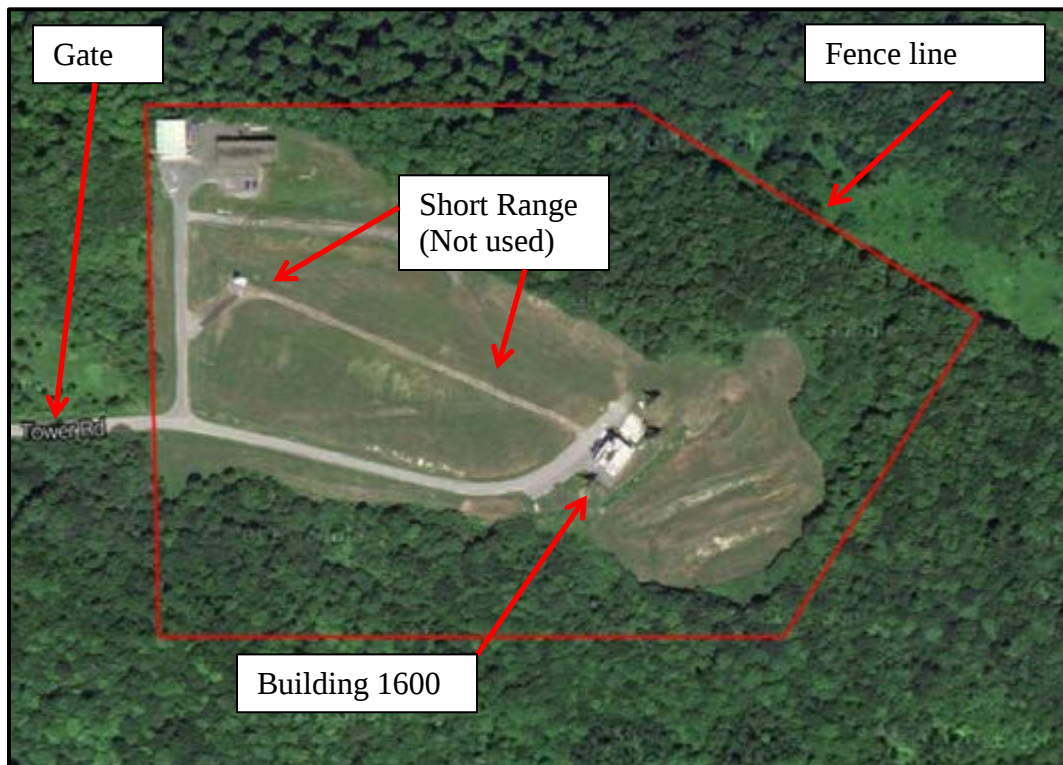


Figure 2. Tanner Hill

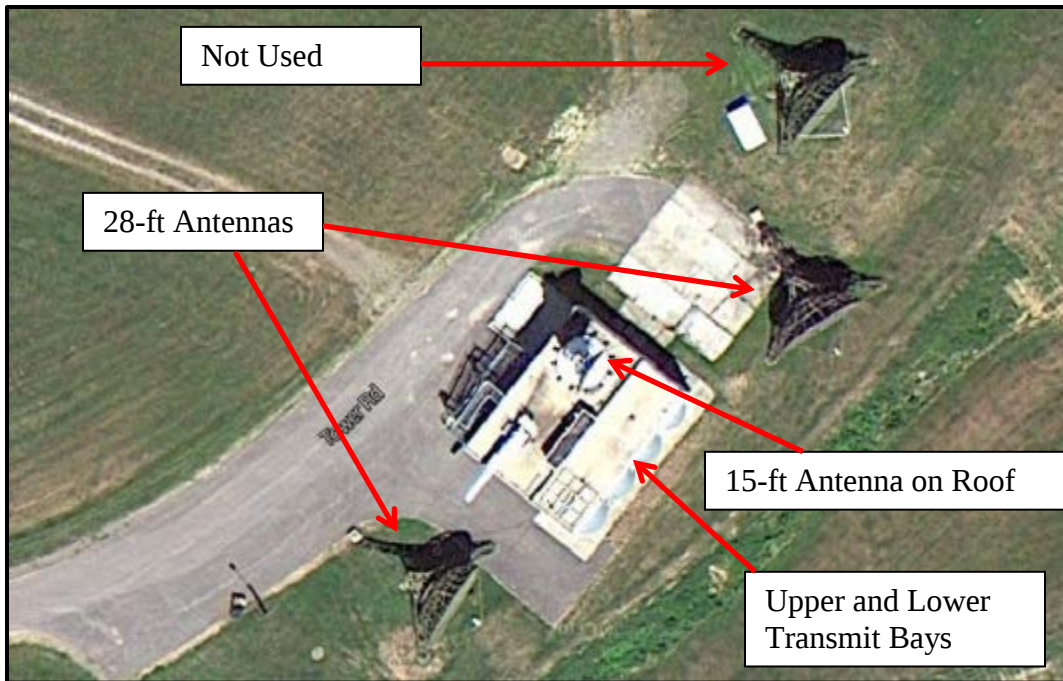


Figure 3. Building 1600 Layout

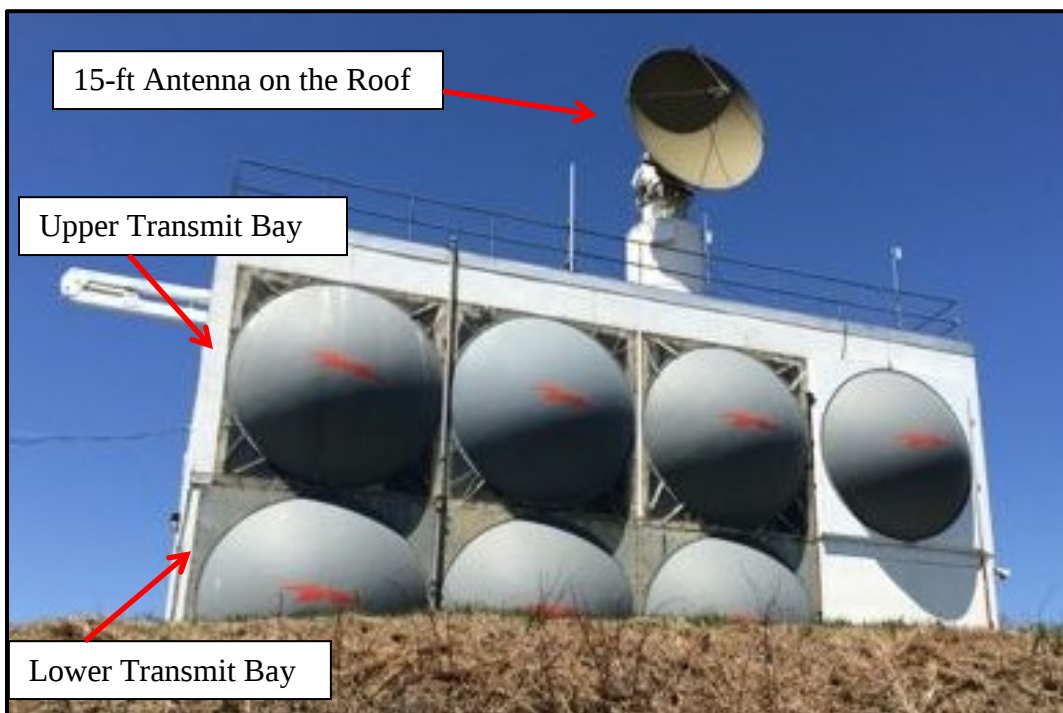


Figure 4. Building 1600 Upper and Lower Transmit Bays and Roof Antenna



Figure 5. Building 1600 28-Foot Antenna (Typical)

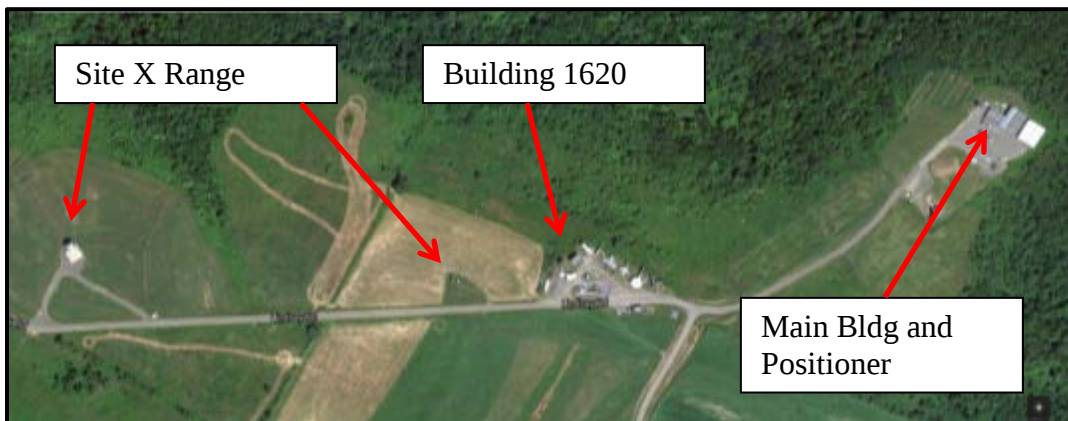


Figure 6. Irish Hill Overview

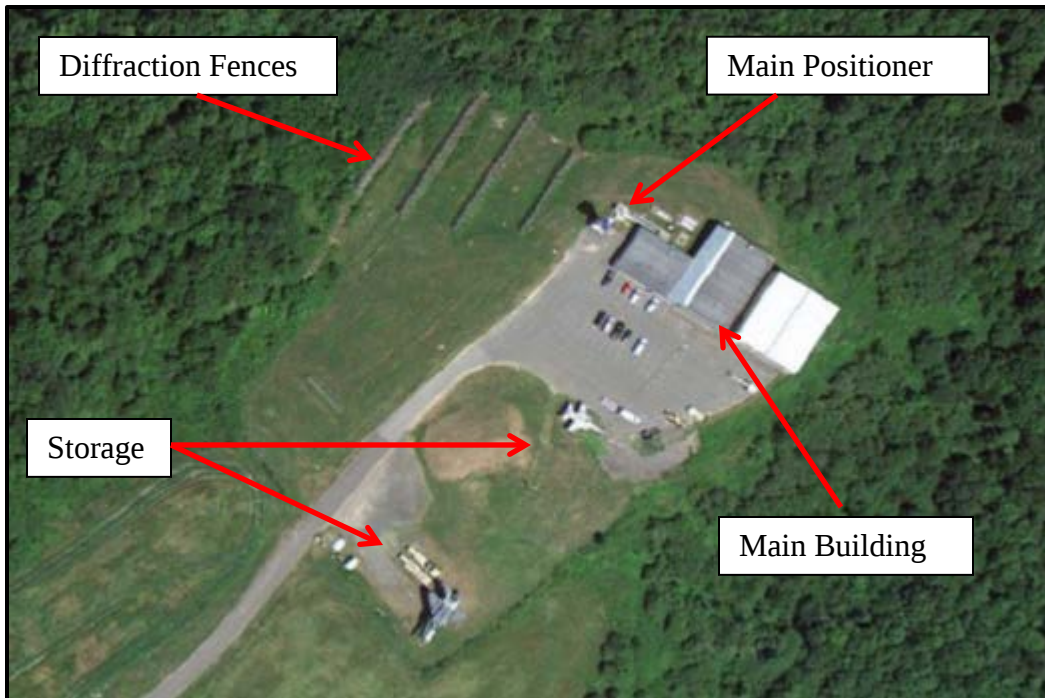


Figure 7. Irish Hill Main Building

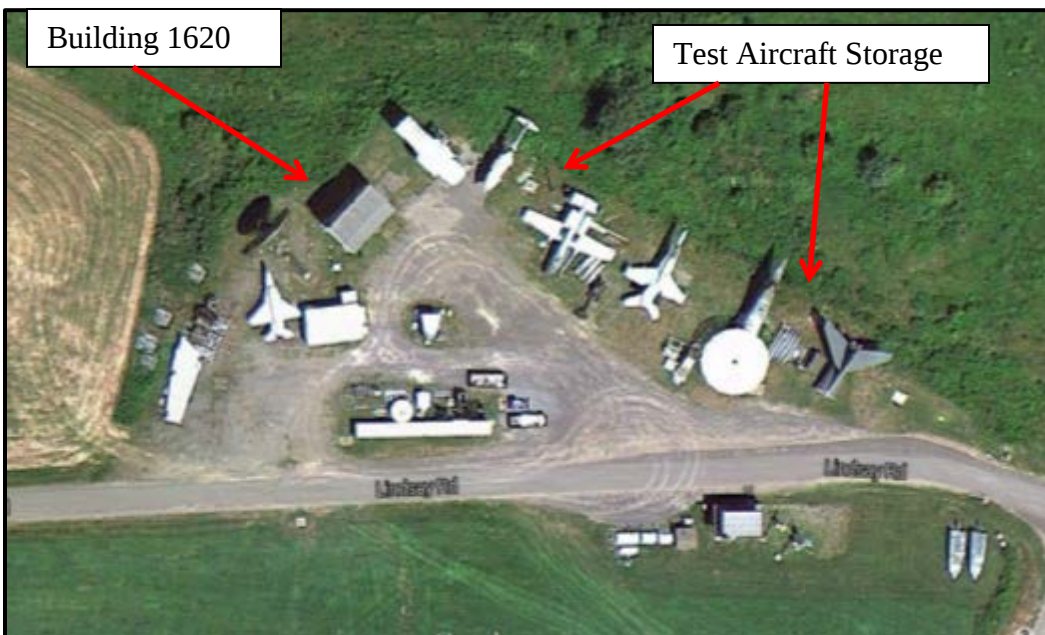


Figure 8. Irish Hill Building 1620 and Old Test Fixtures



Figure 9. Aircraft Positioner with a Full-Scale Model of an F-35

b. *Process:* All EMF engineering and administrative control measures were reviewed for compliance with AFI 48-109 and IEEE C95.1. USAFSAM/OEC performed calculations on the potential hazards of each emitter (see Attachment 1). The survey team also evaluated antenna pattern models to determine where the transmitted energy was going. USAFSAM/OEC then measured power densities in areas in front of accessible emitter systems to validate these calculations and models. Not all emitters were accessible or operational; therefore, transmitters and antenna systems were visually inspected to verify potential hazards.

c. *Hazard Distance Calculations:* An EMFR hazard distance is the distance from an emitter where transmitted energy densities can exceed MPE values. Calculations are a useful tool to predict the hazard distance of an EMFR system. Calculated hazard distances provide a worst-case scenario to begin survey work. These worst-case distances ensure no survey personnel are overexposed. Typical measured hazard distances are 50-80% of the calculated hazard distances. The differences are due to inefficiencies in the emitter system such as transmission line loss or antenna efficiency.

d. *Emitter Antenna Modelling:* USAFSAM utilized antenna pattern models to evaluate all emitters at the Newport site. AFRL provided models of each size antenna for evaluation. See Attachment 2 for AFRL antenna pattern models. USAFSAM validated these models with physical measurements and visual inspections of equipment to determine where EMFR energy was accessible to personnel and ensured that stray energy is not transmitted in unwanted directions.

e. *Physical Measurement Procedures:* USAFSAM/OEC performed EMF measurements at all potentially affected areas accessible to personnel during normal operations, both indoors and outdoors. USAFSAM/OEC took measurements at the highest power setting of 1 watt using a Narda broadband field meter and probe. The survey team selected Narda EF5092 and EB5091 probes since they have the appropriate frequency response and power-density detection capability. The survey team performed scans utilizing the real time monitoring capability of the Narda system. USAFSAM/OEC then corrected the raw data collected from the Narda system using calibration factors per manufacturer's recommendation. Peak measured values were multiplied by the correction factor to produce the reported measured values. See Attachment 3 for calibration correction factors. Reported exposure level measurement values were compared to the MPE levels. Emission measurements were taken from both the 28- and 6-foot antennas. The survey team took these measurements as close to the antenna as possible based on terrain restrictions. See Figures 10 and 11 for measurement scenarios.

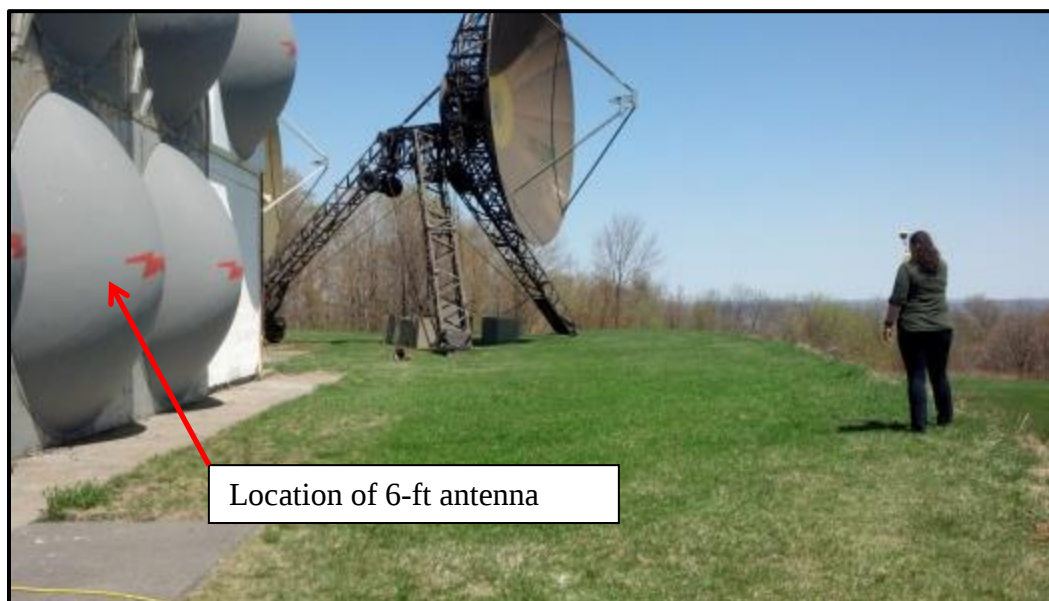


Figure 10. Measurement Scenario for a 6-Foot Antenna



Figure 11. Measurement Scenario for a 28-Foot Antenna

3. RESULTS: Table 2 summarizes the EMF evaluation at the Newport Antenna Measurement Facility.

Table 2. Summary of EMF Evaluation in and Around the Newport Antenna Measurement Facility

Emitter System	Calculated Hazard Distance (ft)	Calculated Hazard Distance Validated as Worst-Case? (YES/NO)	System Accessible During Survey (YES/NO)	Accessible Exposure Exceeds Upper-Tier MPE?	Accessible Exposure Exceeds Lower-Tier MPE?
4-ft Antenna	4.7	YES	NO	NO	NO
6-ft Antenna	4.2	YES	YES	NO	NO
8-ft Antennas	3.4	YES	NO	NO	NO
10-ft Antennas	4.4	YES	NO	NO	NO
15-ft Antennas	5.5	YES	NO	NO	NO
28-ft Antennas	8.7	YES	YES	NO	NO
Log-Periodic Antenna	0.1	YES	NO	NO	NO

a. *Physical Measurements:* All measurements were below both upper and lower tier MPE levels. Theoretical hazard distances were shown to be the worst-case scenario. Physical measurements were made on both the 28-foot system as well as a 6-foot system. This evaluation showed that AFRL antenna models are valid and that the calculated theoretical hazard distances were conservative estimates.

(1) Readings for the 28-foot antenna:

- 5.79% of the upper tier MPE at 73 feet in front of the antenna
- 38.0% of the lower tier MPE at 73 feet in front of the antenna

(2) Readings for the 6-foot antenna:

- 5.0% of upper tier MPE within 1 foot of the ray dome
- 50.0% of lower tier MPE within 1 foot of the ray dome

b. *Evaluation of Engineering Control Measures:* Various engineering controls are utilized to include key controls on emitters and physical barriers surrounding the site to restrict access.

c. *Evaluation of Administrative Control Measures:* Newport personnel implement various administrative controls to include training, warning signs, and visual monitoring.

4. DISCUSSION:

a. No surveyed areas exceeded the applicable EMFR MPEs. All final EMFR measurements were less than 5.7% of the worst-case upper tier MPE values and less than 50% for lower tier MPE values (see Attachment 1 for MPE values). Due to the low powers, frequencies, and directionality of the EMFR systems, no hazardous levels of EMFR measurements were expected or existed in areas accessible to personnel.

b. USAFSAM could not evaluate all emitters with physical measurements. Some emitters were not operational and others were not accessible due to their elevated positions above the ground. For these systems, USAFSAM verified the transmitter specifications and compared these systems to similar equipment at the site to validate the calculated hazard distances provided in this report. The survey team was able to visually inspect all transmitters and antennas on the site. USAFSAM observed that the same low-power transmitter system was utilized to operate each of the antennas to create a complete system. For systems not physically measured, personnel will not be allowed within the calculated hazard distances. This restriction will provide protection against the transmissions at or near the site.

c. Various aircraft are subjected to radiation from the test antennas. The aircraft systems operate in receive mode only; therefore, no evaluation was required.

5. CONCLUSIONS AND RECOMMENDATIONS:

a. EMFR operations at the Newport Antenna Measurement Facility are compliant with the current AFI 48-109 and IEEE C95.1.

b. No worker or public exposures on or around the Newport facility exceed either the upper or lower tier MPEs.

c. Engineering and administrative controls are consistent with AF requirements and provide sufficient safety for all personnel at and near the facility.

d. Any changes to the layout or procedures at the Newport facility will require a new survey.

6. If you have any questions regarding this report, please contact the ESOH Service Center at Commercial 937-938-3764 (DSN 798-3764) or esoh.service.center@us.af.mil.



BRET Z. ROGERS
Department of the Air Force
Radiation Consultant

3 Attachments:

1. Hazard Distance Calculations
2. Newport Antenna Pattern Models
3. Calibration Certificates for Narda Equipment

cc:
AFMSA/SG3PB
AFMC/SGPB
66 MDS/SGOJ

Attachment 1
Hazard Distance Calculations

A1. USAFSAM calculated the worst-case hazard distances per methods published in AFI 48-109 and IEEE C95.1 (see Equation A1-1). Parameters for each antenna are entered into the equation to find a calculated theoretical hazard distance. See Table A1-1 for emitter parameters. USAFSAM selected MPE from IEEE C95.1. MPE values vary based on frequency; therefore, the lowest and most restrictive MPE was selected to provide a worst-case theoretical hazard distance. See Table A1-2 for worst-case MPE and associated hazard distance.

$$D(meters) = \sqrt{\frac{P_{ave}(watts) G_{abs}}{4 \pi MPE \left(\frac{W}{m^2}\right)}} \quad \text{Equation A1-1}$$

Where:

$G_{abs} = \log-1[\text{Gain(dBi)}/10]$

P_{ave} = average power

MPE = either upper or lower tier MPE taken from IEEE C95.1

Table A1-1. Newport Emitter Parameters

Emitter System	Frequency Range (MHz)	Average Power (Watts)	Worst Case Antenna Gain (dBi)
4-ft Antenna	12400-18000	1.0	44.5
6-ft Antenna	8000-12400	1.0	43.5
8-ft Antennas	4000-8000	1.0	41.5
10-ft Antennas	1000-4000	1.0	39.0
15-ft Antennas	1000-2000	1.0	41.0
28-ft Antennas	400-1000	1.0	41.0
Log-Periodic Antenna	500	1.0	7.5

Table A1-2. Newport Emitter MPEs and Calculated Hazard Distances

Emitter System	Upper Tier		Lower Tier	
	Worst-Case MPE from IEEE C95.1 (W/m²)	Calculated Hazard Distance (ft)	Worst-Case MPE from IEEE C95.1 (W/m²)	Calculated Hazard Distance (ft)
4-ft Antenna	100.0	4.7	10.0	15.0
6-ft Antenna	100.0	4.2	10.0	13.3
8-ft Antennas	100.0	3.4	10.0	10.6
10-ft Antennas	33.3	4.4	5.0	11.2
15-ft Antennas	33.3	5.5	5.0	14.2
28-ft Antennas	13.3	8.7	2.0	22.4
Log-Periodic Antenna	16.7	0.1	2.5	0.1

Attachment 2
Newport Antenna Pattern Models

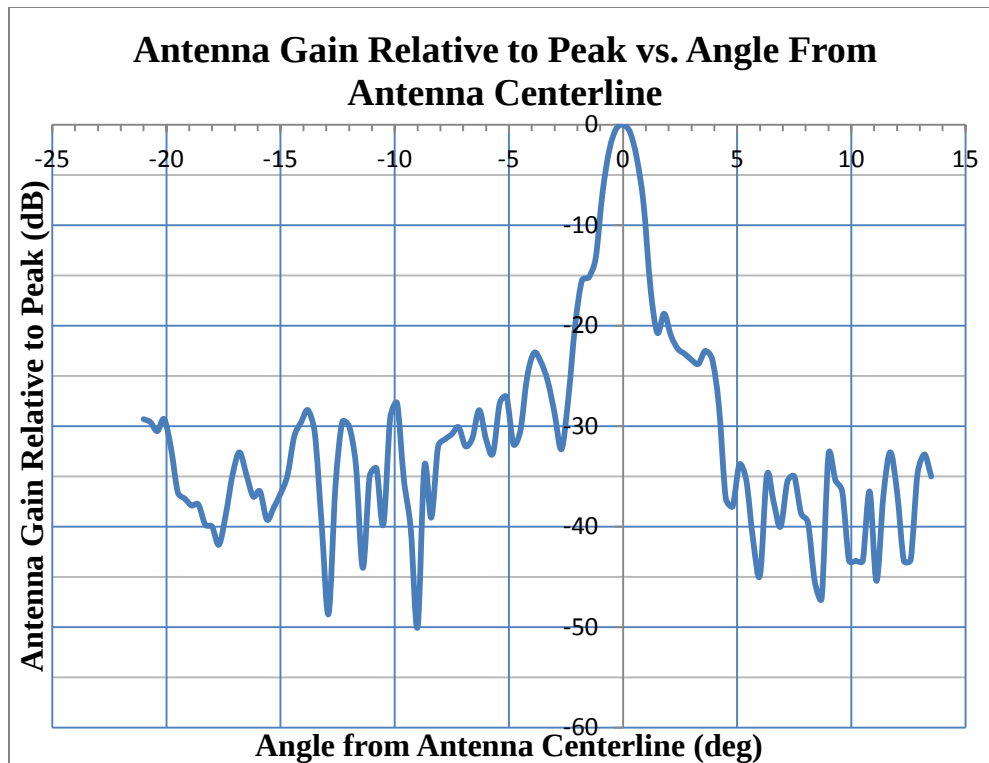


Figure A2-1. 4-Foot Antenna Model

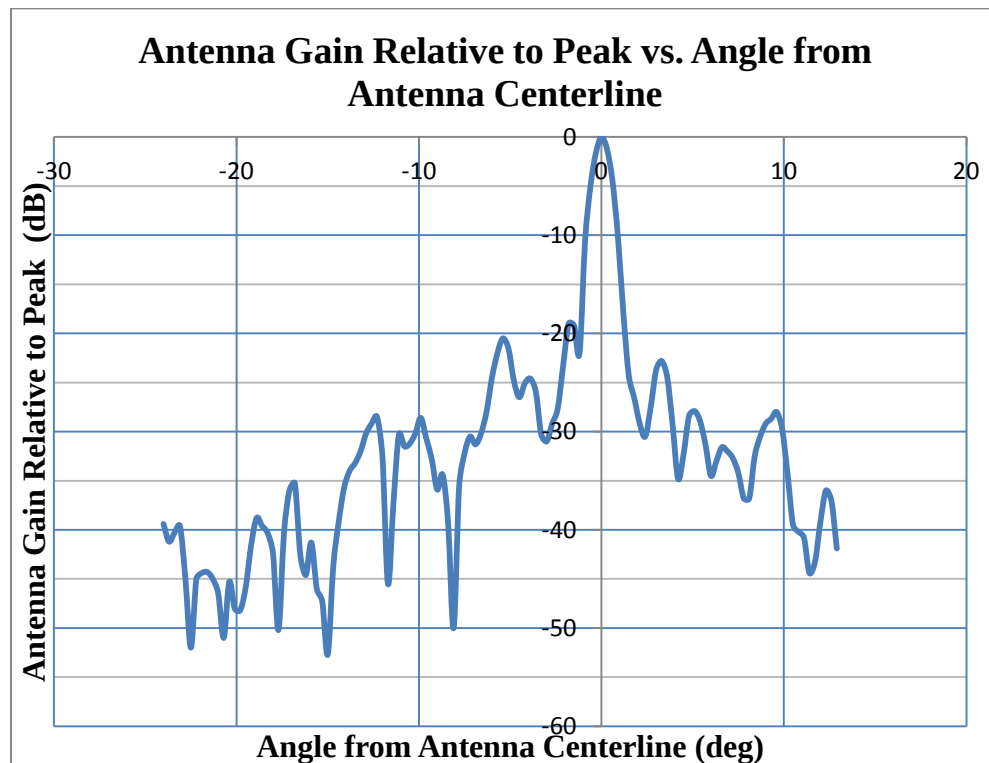


Figure A2-2. 6-Foot Antenna Model

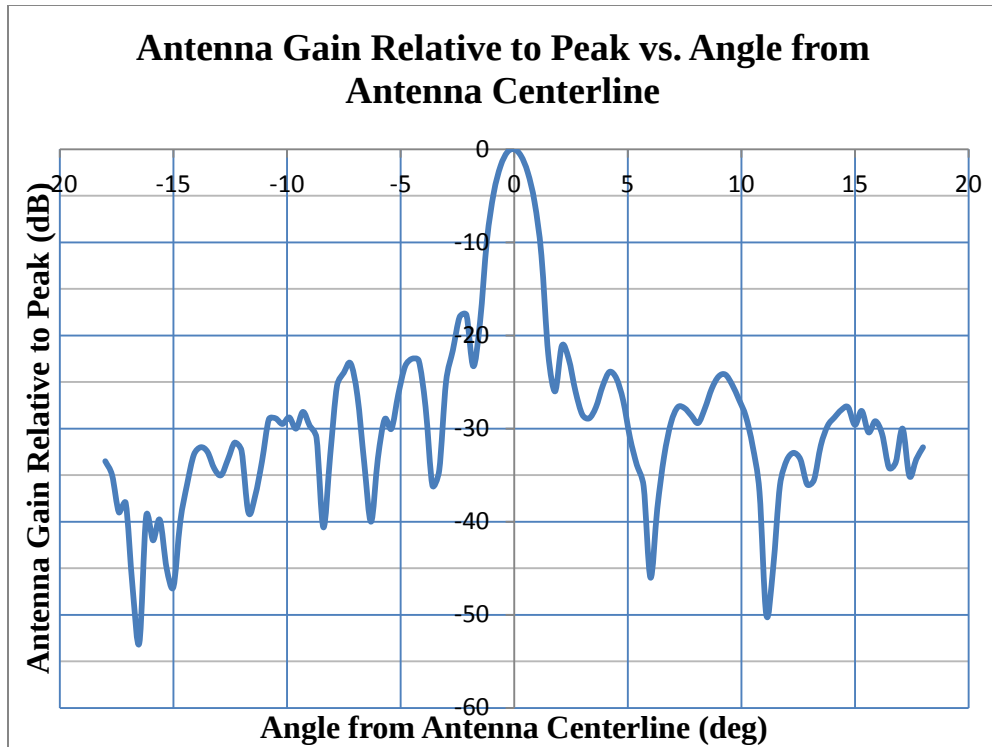


Figure A2-3. 8-Foot Antenna Model

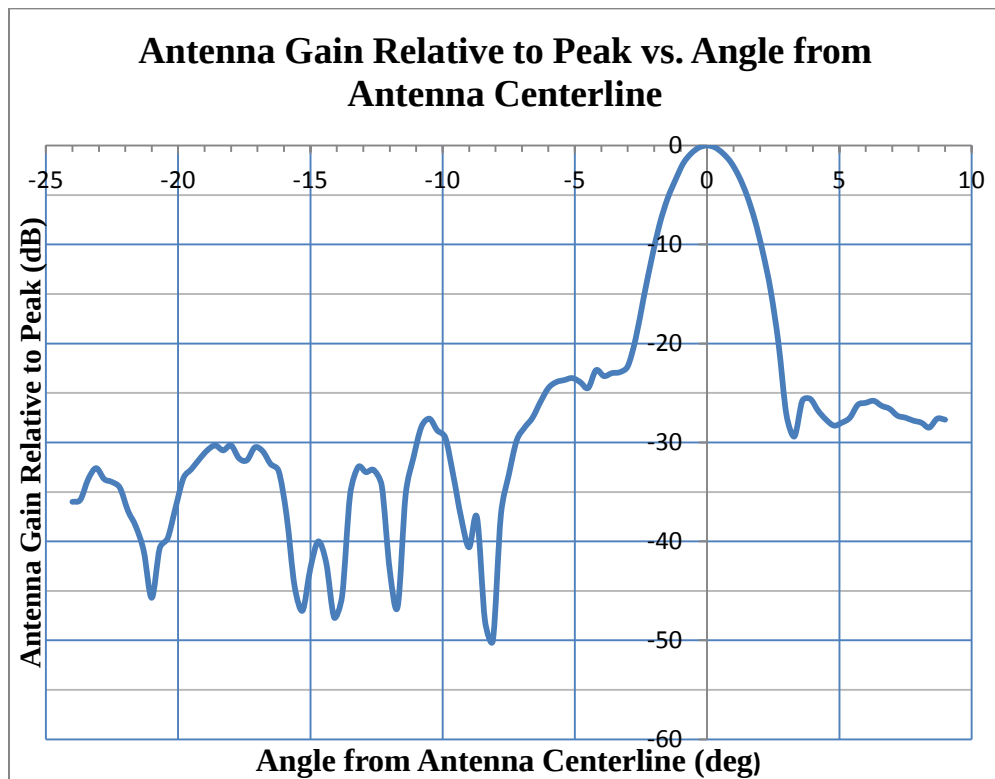


Figure A2-4. 10-Foot Antenna Model

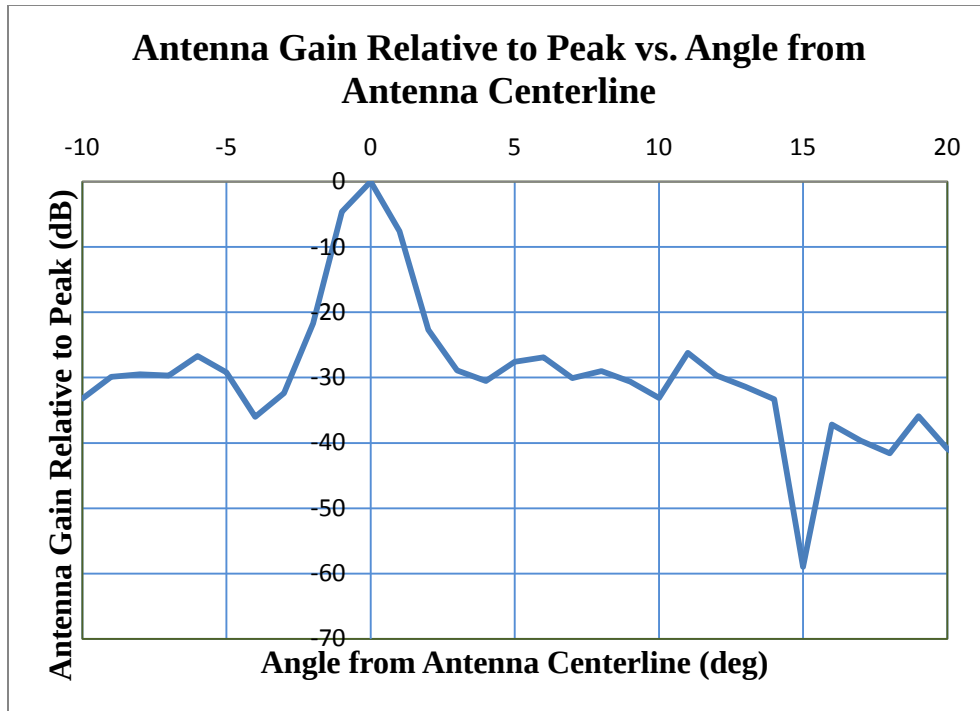


Figure A2-5. 15-Foot Antenna Model

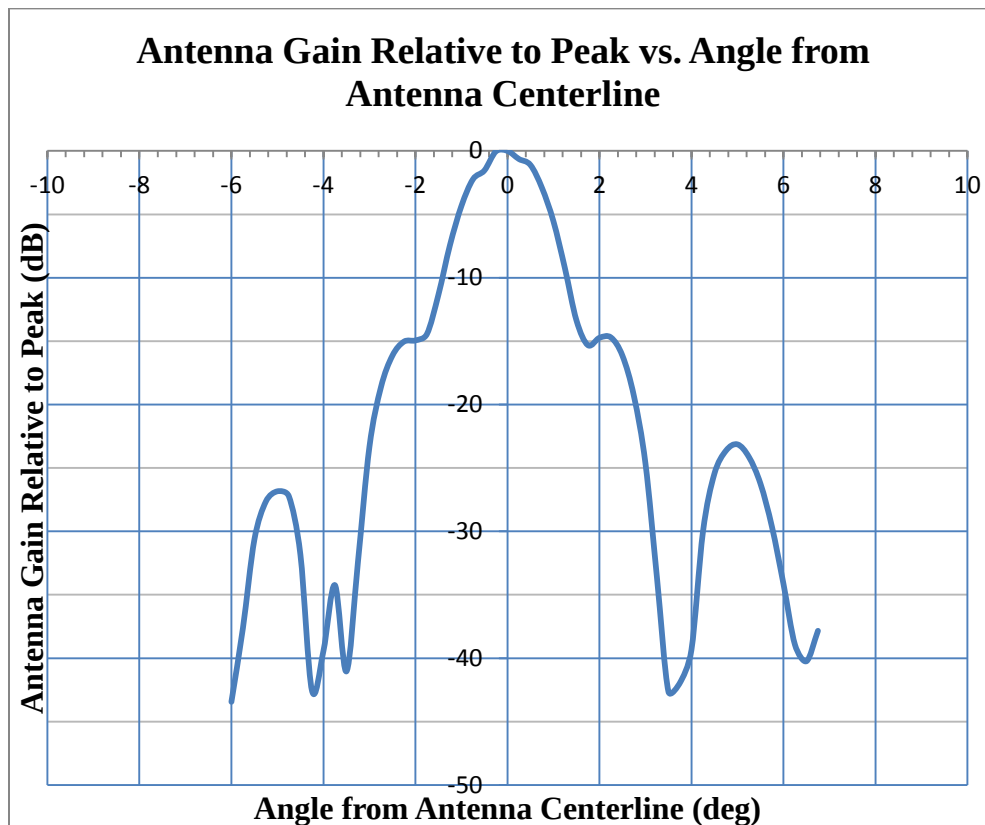


Figure A2-6. 28-Foot Antenna Model

Attachment 3
Calibration Certificates for Narda Equipment

**US Army Primary
Standards Laboratory
Electromagnetic Standards Laboratory
AMSAM-TMD-SM
Redstone Arsenal, AL 35898-5000**

Report of Calibration

for

Radiation Monitor

Narda NBM-520, S/N A-0063

with

Isotropic Probe

Narda EF-5092, S/N 01003

Submitted By

FNSY00



Calibration of this device was performed under ambient conditions of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and nominal 50 percent relative humidity. The temperature of the device was maintained constant to within 1.0°C during the calibration. The calibration frequency was accurate to $\pm 0.1\%$. The probe was immersed in an electromagnetic field with a nominal power density of 50 percent of the full-scale meter range indicated.

This device was calibrated using technique number MSL-7. Calibrations below 1 GHz were performed in a transverse electromagnetic (TEM) cell. The power density at the probe was calculated using the calibrated electrical characteristics of the cell and the measured net power transmitted into the cell.

At frequencies of 1 GHz and above the probe was immersed in an electromagnetic field established in an anechoic chamber facility using standard gain horns. The power density at the probe was calculated using the measured net transmitted power, the distance from the horn, and the horn gain corrected for distance. The probe was mounted on a multi-axis positioner, with the probe element centered on the horn boresight axis and the probe handle oriented parallel to the horn boresight axis.

The total estimated measurement uncertainty in Calibration Factor at the time of calibration is plus or minus 2.0 dB and represents an approximate 95% ($k \approx 2$) confidence level. The user should be aware that over the recommended calibration interval the reported calibration factors could change significantly within the stated uncertainty, depending on how well the probe is protected from rough usage. The user should be aware that there are many factors that may cause the item to drift out of calibration before the recommended interval has expired.

All values provided herein are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request. This calibration is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation (A2LA Cert. No. 1256.01). The quality system of the US Primary Standards Laboratory is registered to ISO 9001:2008. This report may not be reproduced except in full without the permission of the Electromagnetic Standards Laboratory.

It should be noted that when the probe is hand-held, additional measurement errors are possible due to perturbations of the field by the probe cable and/or the operator. These errors can usually be held to 0.5 dB or less by holding the probe close to the transmitting source, as far as possible away from the operator.

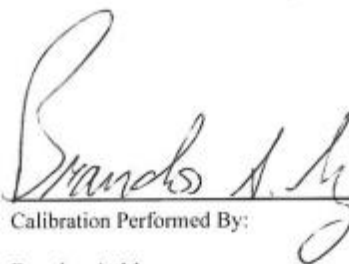
The probe **CALIBRATION FACTOR** is a correction to be applied to the meter indication to obtain the true power density. Calibration Factor is calculated as the true power density divided by the peaked meter indication. Multiply the meter indication by the Calibration Factor to obtain the true power density.

Calibration Report No. PJ131213-0006
Date Calibrated: 17 Dec 2013
Calibration Due: 7 Dec 2015

Page: 1 of 2

AMSAM-TMD-SM
Radiation Monitor/Isotropic Probe
Narda NBM-520/Narda EF-5092
Serial No. A-0063/01003

Calibration Data Table	
All Values Apply to Meter Range: 2(mW/cm) ²	
Frequency (GHz)	Calibration Factor
0.3000	1.054
0.5000	1.490
2.4500	1.185
3.0000	1.341
6.0000	1.098
9.0000	0.915
12.0000	1.302
15.0000	1.496
18.0000	1.583
26.5000	1.284
40.0000	1.203
Standards used during calibration:	
NIST 5cm Antenna #3: Report# 923034, Cal Date 27 Sep 2011	
NIST 5cm Antenna #4: Report# 922683, Cal Date 27 Sep 2011	
NIST 6mm Antenna #2: Report# 936801, Cal Date 17 Jul 2010	
NIST 6mm Antenna #3: Report# 700348, Cal Date 17 Jul 2010	


Calibration Performed By:

Brandon A. May
Electronics Engineer
Electromagnetic Standards Laboratory
DSN: 746-4961 Comm: 256-876-4961
E-mail: brandon.a.may.civ@mail.mil

Calibration Report No. PJ131213-0006
Date Calibrated: 17 Dec 2013
Calibration Due: 7 Dec 2015


Calibration Reviewed By:

David G. Zajac
Electronics Engineer
Electromagnetic Standards Laboratory
DSN: 788-5848 Comm: 256-842-5848
E-mail: david.g.zajac.civ@mail.mil

Page:2 of 2

**US Army Primary
Standards Laboratory
Electromagnetic Standards Laboratory
AMSAM-TMD-SM
Redstone Arsenal, AL 35898-5000**

Report of Calibration

for
Radiation Monitor
Narda NBM-550, S/N B-0858
with
Isotropic Probe
Narda EB-5091, S/N 01032
Submitted By
FNSY00



Calibration of this device was performed under ambient conditions of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and nominal 50 percent relative humidity. The temperature of the device was maintained constant to within 1.0°C during the calibration. The calibration frequency was accurate to $\pm 0.1\%$. The probe was immersed in an electromagnetic field with a nominal power density of 50 percent of the full-scale meter range indicated.

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It should be noted that when the probe is hand-held, additional measurement errors are possible due to perturbations of the field by the probe cable and/or the operator. These errors can usually be held to 0.5 dB or less by holding the probe close to the transmitting source, as far as possible away from the operator.

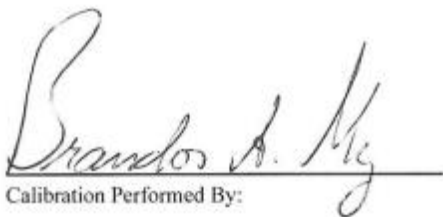
The probe **CALIBRATION FACTOR** is a correction to be applied to the meter indication to obtain the true power density. Calibration Factor is calculated as the true power density divided by the peaked meter indication. Multiply the meter indication by the Calibration Factor to obtain the true power density.

Calibration Report No. PJ131213-0009
Date Calibrated: 17 Dec 2013
Calibration Due: 7 Dec 2015

Page:1 of 2

AMSAM-TMD-SM
Radiation Monitor/Isotropic Probe
Narda NBM-550/Narda EB-5091
Serial No. B-0858/01032

Calibration Data Table	
All Values Apply to Meter Range: 2(mW/cm) ²	
Frequency (GHz)	Calibration Factor
0.0030	0.676
0.0100	0.909
0.0300	1.258
0.0500	0.919
0.1000	0.965
0.2000	1.154
0.3000	1.473
2.4500	1.007
3.0000	1.176
6.0000	0.940
9.0000	1.386
12.0000	1.549
15.0000	1.529
18.0000	1.522
26.5000	1.437
40.0000	1.232
Standards used during calibration:	
NIST 5cm Antenna #3: Report# 923034, Cal Date 27 Sep 2011	
NIST 5cm Antenna #4: Report# 922683, Cal Date 27 Sep 2011	
NIST 6mm Antenna #2: Report# 936801, Cal Date 17 Jul 2010	
NIST 6mm Antenna #3: Report# 700348, Cal Date 17 Jul 2010	



Calibration Performed By:

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Calibration Report No. PJ131213-0009
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Calibration Reviewed By:

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Page:2 of 2