

1. Keywords

FPS 16
FPS 3
FPS 33
MICROWAVE 0801
MICROWAVE HAZARD
MICROWAVE OVEN 0801
MRFCS
OCC HLTH PROG EVAL
OCC HLTH SER PER
RADAR SITE
RADIATION PROTECTION 0808
RF EQUIP
SOPS

2. Start Date: FY 85 Quarter 1
End Date: FY 85 Quarter 4

3. HQ Division: 42 - LASER MICROWAVE DIVISION

4. Phase:

5. Program NO: 24

6. Survey Type: NZ - RFR/ULTRASOUND EQUIPMENT DEVELOPMENT STUDY

7. INSTALLATION OR SOURCE OF INFORMATION (CITY & STATE OR COUNTY ARE ESSENTIAL)

XM - TEST & EVALUATION COMMAND

8. Authors:

9. ARLOC/Activity: 04289 006 - USA ELECTRONIC PG

Location: FORT HUACHUCA

State: AZ

10. Project Control Number: 42-0702-85

11. Title: RADN HAZ RF/MICROWAVE AN/FPS-16 RADAR

12. DSA: 66



**UNITED STATES ARMY
ENVIRONMENTAL HYGIENE
AGENCY**

ABERDEEN PROVING GROUND, MD 21010-5422

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NONIONIZING RADIATION PROTECTION STUDY NO. 24-42-0702-85
AN/FPS-16 RADAR SITES
US ARMY ELECTRONIC PROVING GROUND
FORT HUACHUCA, ARIZONIA
29 OCTOBER-2 NOVEMBER, 1984

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command; Jul 85. Requests for this document must be
referred to Commander, US Army Electronic Proving Ground,
Fort Huachuca, Arizona 85613-7110.



DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

Mr. Hicks/fmb/AUTOVON
584-3353

HSHB-RL

19 JUL 1985

SUBJECT: Nonionizing Radiation Protection Study No. 24-42-0702-85,
AN/FPS-16 Radar Sites, US Army Electronic Proving Ground,
Fort Huachuca, Arizona, 29 October-2 November 1984

Commander
US Army Materiel Command
ATTN: AMCSG
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

EXECUTIVE SUMMARY

The purpose, essential findings, and major recommendations of the enclosed report follow:

a. Purpose. To evaluate the potential radiation hazards associated with the use of radio frequency (RF), and microwave sources at the AN/FPS-16 radar sites managed by the US Army Electronic Proving Ground and to make recommendations to prevent needless exposure of personnel to such potentially hazardous radiation.

b. Essential Findings. There were several RF and microwave sources at two sites, Mt. Oatman and Mt Lemmon, that were surveyed. Among these, the AN/FPS-16, AN/FPS-3, and AN/FPS-33 radars were able to produce power density levels that are subject to radiation protection control. Two communications systems at Mt. Oatman were also evaluated. One of these, the microwave line-of-sight system is able to produce power density levels that are subject to control, but in the maintenance mode only. The programs that were in place to control these potentially hazardous sources were providing adequate protection for personnel.

c. Major Recommendations. Recommendations have been made to document the radiation protection control procedures at both of the locations and to provide formal instruction to the personnel in the application of the program. A recommendation was also included to request a study of new or reactivated systems at Mt. Oatman.

FOR THE COMMANDER:

Encl

for *Arthur B. Webb* LTC, MS
JOSEPH T. WHITLAW, JR
Colonel, MS
Director, Radiation and
Environmental Sciences

CF:



DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO
ATTENTION OF

HSHB-RL

NONIONIZING RADIATION PROTECTION STUDY NO. 24-42-0702-85
AN/FPS-16 RADAR SITES
USA ARMY ELECTRONIC PROVING GROUND
FORT HUACHUCA, ARIZONA
29 OCTOBER-2 NOVEMBER, 1984

1. AUTHORITY. Letter, HQ AMC, AMCSG-S, 1 Oct 84, subject: USAEHA Mission Services, FY 85.
2. REFERENCES.
 - a. AR 40-5, 1 June 1985, Preventive Medicine.
 - b. AR 40-583, 1 May 1981, Control of Potential Hazards to Health from Microwave and Radio Frequency Radiation.
 - c. AR 385-30, 15 September 1983, Safety Color Code Markings and Signs.
 - d. TB MED 523, 15 July 1980, Control of Hazards to Health from Microwave and Radio Frequency Radiation and Ultrasound.
3. PURPOSE. To evaluate the potential radiation hazards associated with the use of radio frequency (RF) and microwave sources at the AN/FPS-16 radar sites managed by the US Army Electronic Proving Ground (USAEPG) and to make recommendations to prevent needless exposure of personnel to such potentially hazardous radiation.
4. GENERAL.
 - a. Background and Briefings. This study was requested by the USAEPG Safety Office during the triennial survey of Fort Huachuca. The two radar sites, Mt. Lemmon and Mt. Oatman, had not been surveyed since major system modifications had been implemented. The study was scheduled as part of USAEHA Mission Services for FY 85. Mr. L. Raney, Safety Director for USAEPG coordinated the study and accompanied the survey officers. CPT J. Vanderstar and Mr. C. Hicks conducted the study for USAEHA and briefed Mr. Raney on the findings and tentative recommendations.

b. Instrumentation.

- (1) Narda Model 8300, Broadband Isotropic Radiation Monitor.
- (2) Raham Model 12, Radiation Hazard Meter with Extension probe.
- (3) Narda Model 8200, Radiation Survey Meter.
- (4) Victoreen Model 440RF/C, X-Ray Survey Meter.

5. FINDINGS AND DISCUSSION.

a. General. The USAEPG is responsible for several radar systems located at two remote sites, Mt. Lemmon and Mt. Oatman. The principal radars are the AN/FPS-16(V) Capri at Mt. Lemmon and the AN/FPS-16(V) Vanguard at Mt. Oatman. There were two other radars at Mt. Oatman: the AN/FPS-33 Acquisition Radar and the AN/FPS-6 Height Finder Radar. Neither of these last systems was operational or scheduled to be operational as part of current planning. The FPS-6 was reportedly to be dismantled in the near future. There were also two communications systems at Mt. Oatman which were checked as part of this study. Additionally, the three microwave ovens used at the sites were surveyed. Both sites were operated by contract personnel who were very knowledgeable of the systems, the potential hazards, and the radiation protection programs (RPP's) which were providing radiation protection control.

b. System Description. The AN/FPS-16 radar is designed for passive (skin) or active (beacon) target tracking. The transmitter operates at 5.4 to 5.8 GHz with a fixed peak power output of 1.0 MW. There are two selections of pulse repetition frequency (PRF): 160 or 640 pulses per second. There are also 3 pulse width (PW) selections: 0.25, 0.5, or 1.0 μ sec. Up to 3 PW's of five each 0.25 μ sec pulses may be repeated during each pulse repetition period; however, the duty cycle (PRF x PW x pulse/period) is automatically limited to 0.001. At this maximum duty cycle, the average transmitter power will be 1000 W. Typical average power levels reportedly used were 640 W or less. The voltages used in the transmitter (klystron, pulse modulator tubes, etc.) were as high as 35 KV, and ionizing radiation warning signs were posted on the appropriate cabinet doors. The AN/FPS-16 antenna is a 5 m diameter casse-grain-fed parabola using a 4-horn monopulse feed for tracking. The antenna can track through 360^o in azimuth and -10 to +90^o in elevation. The nominal gain of the antenna at 5.8 GHz is 47 dB. The hazard analysis of the system based on 47 dB gain and 1000 W transmitter power is presented in Table 1. The 640 and 160 W hazard analyses are also included in Table 1.

TABLE 1. AN/FPS-16 RADIATION HAZARD ANALYSIS

Parameter	Power*	Power Density versus Range
<u>Main Beam</u>	1000 W	27 mW/cm ² maximum, to a range of 120 m; decreasing to 10 mW/cm ² at 200 m.
	640 W	17 mW/cm ² maximum, to a range of 120 m; decreasing to 10 mW/cm ² at 160 m.
	160 W	4.3 mW/cm ² maximum, not subject to control in the main beam.
<u>Open Waveguide</u>	1000 W	200 W/cm ² , decreasing to 10 mW/cm ² at a range of 2 m.
	640 W	128 W/cm ² , decreasing to 10 mW/cm ² at a range of 1.5 m.
	160 W	32 W/cm ² , decreasing to 10 mW/cm ² at a range of 0.7 m.

*This power is assumed to be available at the feed horn of the parabola, which represents the most conservative analysis.

c. Mount Lemmon.

(1) Installation. The AN/FPS-16(V) Capri was the only USAEPG radar located at Mt. Lemmon. The radar was a permanently emplaced version of the AN/FPS-16 mounted on an enclosed tower under a permanent geodesic radome. The antenna boresight axis was sufficiently high above the co-located buildings, systems, and potentially occupied raised terrain features to preclude irradiation of personnel who might be present. The receiver/transmitter work area was located at least one floor below the antenna platform and would not be exposed to the radar main beam. A warning light was located at the base of the antenna approach ladder with a warning sign that ladder access when the blue light was flashing. A red-blue light code was used, with the red indicating a potential "standby" hazard, and the blue indicating an actual radiating condition. A "man-on-antenna" sign was posted on the transmitter control console whenever personnel were at the antenna.

(2) Radiation Measurements. Measurements were made with the system on and radiating. The antenna was too high to permit meaningful main beam measurements; however, feed, spillover, and leakage measurements were made at the antenna, and leakage and x-radiation measurements were made at the transmitter. The results are summarized in Table 2. The transmitter was operated at about 640 W, average power, with the antenna depressed to -3° in elevation.

TABLE 2. AN/FPS-16 MEASUREMENTS, MOUNT LEMMON

Source	Measured Results
Feed-Radome	50 mW/cm ² at the feed radome edge increasing to greater than 150 mW/cm ² at the radome center surface.
Antenna Surface	0.2 mW/cm ² at reflector edge increasing to about 10 mW/cm ² at 1.5 m in from the reflector edge and 20 mW/cm ² at the reflector center.
Leakage	No levels in excess of instrument detection threshold (0.01 mW/cm ²) at any waveguide surfaces, flanges, etc.
X-Radiation	No levels in excess of the instrument detection threshold (0.05 mR/hr), cabinet doors open.

d. Mt Oatman. There were three separate system sites at Mt. Oatman using RF or microwave sources. These were West Mountain with the AN/FPS-16 and AN/FPS-33 radars; Knob Hill with the 10 W and 100 W line-of-sight (LOS) UHF Terminals; and East Mountain with the AN/FPS-16 radar. Only the FPS-16 radar and the LOS radio sets were evaluated. If either of the other radars is activated in the present site configuration, this Agency is able to provide radiation protection control assistance based on this current study (see paragraph 8, this report).

(1) AN/FPS-16(V) Vanguard (East Mountain). This is a transportable version of the AN/FPS-16 radar consisting of a transmitter/receiver van and a separate trailerized antenna. Rigid waveguide is used to connect the transmitter to the antenna. The antenna was emplaced in a knoll which placed the main beam above the transmitter van, even with the elevation axis at 0°. In the direction away from the van, the main beam could irradiate personnel standing on the ground. A flashing light was automatically turned on when the radar was transmitting, and personnel were very cautious about moving around the site when the radar was on. A closed-circuit TV camera was mounted on the antenna. This provided the operator with constant visual surveillance in the direction of radiation. Radiation measurements were made with the system at 640-W average power. The results are presented in Table 3.

(2) AN/FPS-6, AN/FPS-33 Radars (West Mountain). The AN/FPS-6 radar was reportedly being dismantled. The installation was such that the fixed AN/FPS-33 shelter was inside the radiation control range of the AN/FPS-6; however, the primary target line for the AN/FPS-16 did not lie across the AN/FPS-33 shelter and would not have posed a threat to personnel working with

the FPS-33. The AN/FPS-33 was not operational at this time, but could be made so in the future. The fixed installation of the FPS-33 would keep the 360° azimuth-scanning main beam well above any potentially occupied local terrain features. The only expected radiation hazards associated with the system would be waveguide leakage, x-radiation levels from the transmitted tubes that operated at greater than 10 kV, and maintenance procedures involving work on the antenna or open waveguide. An acceptable SOP would prohibit working either on the antenna or waveguide with the transmitter turned on. Leakage measurements should be made around all waveguide components, and x-radiation levels should be tested at any high voltage transmitter components if the system is reactivated.

TABLE 3. AN/FPS-16 MEASUREMENTS, MT OATMAN.

Source	Measured Results
Reflector Surface	8-10 mW/cm ² at 1.5 m in from the reflector edge. 0.2 mW/cm ² at reflector edge.
Subreflector	10-12 mW/cm ² at subreflector edge (spillover).
Main Beam	3 mW/cm ² peaks at 5 m, 15 m, and 30 m ranges. 5 mW/cm ² peaks at the 3 to 5-m range, off axis.
Leakage	No detectable leakage from waveguide components.
X-radiation	No detectable level, cabinet doors open.

(3) Communications Systems. There are two LOS radio sets used at Mt. Oatman. One is a 400-MHz, 100 W system, Motorola Model MR-46, using large diameter coax transmission line to the antenna. The antenna is mounted on a pole, well above ground level. The other LOS radio set is a Terracom microwave system, operating at 8 GHz and 10 W and using a bendable elliptical waveguide. The antenna for the Terracom is a 2.5-m diameter reflector mounted on a pole outside the building, well above ground. Either of these radio sets is able to produce power density levels in excess of allowable limits. The 400 MHz system will produce 10 mW/cm² to a few centimeters away from the antenna. The microwave system will produce 10 mW/cm² within a few centimeters of open or broken waveguide. The antenna for the 400-MHz system is well out of reach of personnel. The elliptical guide of the microwave set is not prone to damage and is not expected to leak within a reasonable lifetime. These systems should be listed on the installation inventory of potentially hazardous sources, and personnel should be instructed in the potential hazards.

e. Microwave Ovens. There was one microwave oven at Mt. Lemmon and two at Mt. Oatman. These were being surveyed by the USAEPG Safety Office personnel during routine visits to the sites. The ovens were checked during this survey and found to be in acceptable condition. The results are summarized in Table 4.

TABLE 4. MICROWAVE OVEN INVENTORY/SURVEY

Location	Manufacturer/Model/Serial No.	Condition/Leakage
Mt. Lemmon	GE, JET910Y3, SN GG904526M	Good, NDL*
Mt. Oatman	Sharp, R7704A, SN 138027	Good, 0.3 mW/cm ² max
Mt. Oatman	Litton, 7005, NSN	Good, NDL

*NDL: No detectable leakage above instrument 0.1 mW/cm² threshold.

6. CONCLUSIONS. There were potentially hazardous radiation levels associated with the RF and microwave sources located at Mt. Lemmon and Mt. Oatman. The RPP at each site was providing fully adequate radiation protection control. Implementation of the following recommendations will assure that the RPP's meet all applicable requirements of AR 40-5 and AR 40-583.

7. RECOMMENDATIONS.

a. Mt. Lemmon and Mt. Oatman Sites.

(1) Document the radiation protection control procedures at all radar sites in a published SOP (AR 40-583, paragraph 6f). Note: These SOP's should be conspicuously posted in the work place.


(2) Instruct all personnel in the application of the SOP (AR 40-583, paragraph 6f).

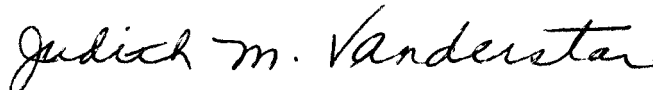
b. Mt. Oatman.

(1) Request a study of all new or reactivated RF or microwave sources at this site (AR 40-583, paragraph 6e).

(2) Assure that the inventory of potentially hazardous sources is current and includes the operational status of such sources (AR 40-5, paragraph 9-9a).

8. TECHNICAL ASSISTANCE. Requests for services should be directed through appropriate command channels of the requesting activity to Commander, US Army Environmental Hygiene Agency, ATTN: HSHB-RL, Aberdeen Proving Ground, MD 21010-5422, with an information copy furnished the Commander, US Army Health Services Command, ATTN: HSCL-P, Fort Sam Houston, TX 78234-6000.


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DEPARTMENT OF THE ARMY
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AMCSG-R

9 December 1985

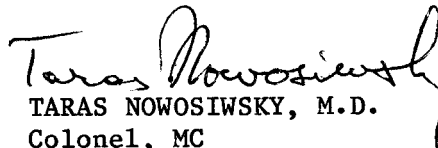
SUBJECT: Nonionizing Radiation Protection Study No. 24-42-0702-85, AN/FPS-16
Radar Sites, U.S. Army Electronic Proving Ground, Fort Huachuca,
Arizona, 29 October - 2 November 1984

Commander
U.S. Army Environmental Hygiene Agency
ATTN: HSHB-RL
Aberdeen Proving Ground, MD 21010-5422

Actions taken based upon subject report recommendations have been reviewed by
this office and are forwarded for information.

FOR THE COMMANDER:

Encl


TARAS NOWOSIWSKY, M.D.
Colonel, MC
Command Surgeon

CF:
AMCSF-P

AMSTE-ST-S (HSHB-RL/19 Jul 85) 4th End PALMATEER/cjwh/AV 298-2270/5147
SUBJECT: Nonionizing Radiation Protection Study No. 24-42-0702-85, AN/FPS-16
Radar Sites, U.S. Army Electronic Proving Ground, Fort Huachuca,
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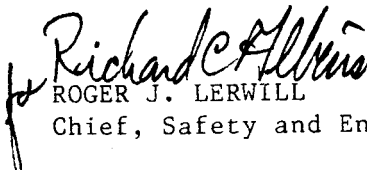
Cdr, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, MD 21005-5055

2 DEC 1985
TO: Commander, U.S. Army Materiel Command, ATTN: AMCSG-R, 5001 Eisenhower Avenue,
Alexandria, VA 22333-0001

1. This headquarters has reviewed the response to subject report and considers it appropriate.
2. The response was delayed because the contractor was late providing a copy of the SOP to USAEPG.
3. Attention is directed to para 2a, 3d endorsement. A copy of the SOP has not been provided as enclosure 1 as stated.
4. TECOM - Providing Leaders the Decisive Edge.

FOR THE COMMANDER:

Encl


ROGER J. LERWILL
Chief, Safety and Environmental Office