

RADIATION HAZARD REPORTS

INTRODUCTION

The FCC adopted new guidelines and procedures in 1996 for evaluating environmental effects of radio frequency (RF) emissions. In order to provide assistance in determining whether proposed or existing transmitting facilities comply with the new guidelines, the FCC Office of Engineering and Technology revised OET Bulletin 65. The revised version updates limits for Maximum Permissible Exposure (MPE) in terms of electric and magnetic field strength and power density for transmitters operating at frequencies between 300 kHz and 100 GHz. This bulletin was adopted by the FCC in their General Docket No. 97-303 on August 25, 1997. In order to comply with the requirements of the Report and Order, calculations to determine the power flux densities in the far field, near field, and reflector regions of the earth station antenna have been made and are contained in this study.

The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and the status of the individuals who are subject to exposure. The earth station transmitting equipment and antenna are located in an area not accessible to the general public. Entry is restricted to employees who have been made fully aware of the potential for human exposure and can exercise control over their exposure. Therefore occupational / controlled exposure maximum power density limits are used in this study.

The FCC Office of Engineering and Technology suggests a method for calculating the maximum values of the power densities emanating from an aperture antenna in OET bulletin 65. This method is used to determine the power densities associated with the satellite antenna.

The Ku-Band Very Small Aperture Terminal (VSAT) will be equipped with an amplifier having a maximum output of 4 watts. The transmitter will feed a 1.06 meter antenna and is directly attached to the feed horn. The following calculations will be based on a maximum output power at the antenna flange of 4 watts:

Antenna Surface. The maximum power density directly in front of the antenna may be expressed as:

$$S_{surface} = \frac{4P}{A}$$

Where: $S_{surface}$ = maximum power density at the antenna surface
 P = power fed to the antenna
 A = physical area of the aperture antenna

Using the parameters for this antenna:

$$S_{surface} = 4 (4 \text{ Watts}) / \pi (1.06 \text{ meters} / 2)^2$$

$$S_{surface} = 16 \text{ Watts} / 0.88 \text{ m}^2$$

$$S_{surface} = 18.18 \text{ Watts} / \text{m}^2$$

$$S_{surface} = 1.8 \text{ mW} / \text{cm}^2$$

Near- Field Region. In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

where: R_{nf} = extent of near field

D = maximum diameter

λ = wavelength

Using the parameters for this antenna:

$$\lambda = 0.02 \text{ meters @ } 14500 \text{ MHz}$$

$$R_{nf} = (1.06 \text{ meters})^2 / 4(0.02 \text{ meters})$$

$$R_{nf} = 1.12 / .08 \text{ meters}$$

$$R_{nf} = 14.0 \text{ meters}$$

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

where: S_{nf} = maximum near field power density

η = aperture efficiency

P = power fed to the antenna

D = antenna diameter

Using the parameters for this antenna:

$$\begin{aligned}\eta &= .64 \\ P &= 4 \text{ Watts} \\ S_{nf} &= 16 (.64) (4 \text{ Watts}) / \pi (1.06 \text{ meters})^2 \\ S_{nf} &= 40.9 \text{ Watts} / 3.53 \text{ meter}^2 \\ S_{nf} &= 11.58 \text{ Watts} / \text{meter}^2 \\ S_{nf} &= 1.2 \text{ mW} / \text{cm}^2\end{aligned}$$

Far Field Region. For purposes of evaluating RF exposure, the distance to the beginning of the far field region can be approximated by the following equation:

$$R_{ff} = \frac{0.6D^2}{\lambda}$$

where: R_{ff} = distance to the beginning of far field
 D = diameter of antenna
 λ = wavelength

Using the parameters for this antenna:

$$\begin{aligned}R_{ff} &= 0.6 (1.06 \text{ meters})^2 / .02 \text{ meters} \\ R_{ff} &= 34 \text{ meters}\end{aligned}$$

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The power density in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where: S_{ff} = power density (on axis)
 P = power fed to antenna
 G = power gain of the antenna in the direction of interest
 R = distance to the point of interest

Using the parameters for this antenna:

$$S_{ff} = 4\text{Watts (40.8 dBi)} / 4 (\pi) (34)^2$$

$$S_{ff} = 48090 / 14526$$

$$S_{ff} = 3.31 \text{ Watts / meter}^2$$

$$S_{ff} = 0.3 \text{ mW / cm}^2$$

Main Reflector - Feed horn Region

The RF energy radiated from the feed system is confined to a conical shape whose vertex is located at the feed and extends outward to the main reflector surface. The power density at any point in this region is expressed by the equation:

$$S_{feed} = P/A$$

Where :

A = Cross section area of the conical region in meter²

P = Radiated transmitted power in watts

At the feed the power density is:

$$S_{feed} = P/A = 4 / \pi (0.10/2)^2 = 509 \text{ Watts/meter}^2$$

$$S_{feed} = 51 \text{ mW/cm}^2$$

Conclusion

The results of the above calculations are summarized in the following table and in Figure 1.

Region	Power Density	Remarks
Antenna Surface	1.8 mW/cm ²	Safe Level
Main Reflector -Feed horn Region	51 mW/cm ²	Hazardous
Near Field < 14.0 meters	1.2 mW/cm ²	Safe Level
Far Field > 34 meters	0.3 mW/cm ²	Safe Level

Results of this hazard study indicate that the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range is not exceeded in areas directly in front of the antenna, or in the near and far field. The region where this limit may be exceeded will be in the the region between the reflector and the feed horn. This area is not readily accessible to personnel and whenever personnel are required to work on the radiating or reflecting parts of the antenna structure, the transmitter will be turned off. Signs to this effect will be posted at the transmitter site. The antenna will be located in a restricted area and unauthorized personnel are prevented access.

Based on this study of predicted radio frequency levels, it is concluded that operation of this satellite earth station meets OET Bulletin 65 maximum permissible exposure limits and that no harmful effects will occur to station personnel or anyone within proximity of the station.

Therefore, in accordance with 47 CFR § 1.1307 (b) of the Commission's Rules, preparation and submission of an Environmental Assessment (EA) is not required.

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Where: $S_{surface}$ = maximum power density at the antenna surface
 P = power fed to the antenna
 A = physical area of the aperture antenna

Using the parameters for this antenna:

$$S_{surface} = 4 (8 \text{ Watts}) / \pi (1.06\text{meters} / 2)^2$$

$$S_{surface} = 32 \text{ Watts} / 0.88 \text{ m}^2$$

$$S_{surface} = 36.36 \text{ Watts} / \text{m}^2$$

$$S_{surface} = 3.6 \text{ mW} / \text{cm}^2$$

Near- Field Region. In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

where: R_{nf} = extent of near field

D = maximum diameter

λ = wavelength

Using the parameters for this antenna:

$$\lambda = 0.02 \text{ meters @ } 14500 \text{ MHz}$$

$$R_{nf} = (1.06 \text{ meters})^2 / 4(0.02 \text{ meters})$$

$$R_{nf} = 1.12 / .08 \text{ meters}$$

$$R_{nf} = 14.0 \text{ meters}$$

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

where: S_{nf} = maximum near field power density

η = aperture efficiency

P = power fed to the antenna

D = antenna diameter

Using the parameters for this antenna:

$$\begin{aligned}\eta &= .64 \\ P &= 8 \text{ Watts} \\ S_{nf} &= 16 (.64) (8 \text{ Watts}) / \pi (1.06 \text{ meters})^2 \\ S_{nf} &= 80.92 \text{ Watts} / 3.53 \text{ meter}^2 \\ S_{nf} &= 23.21 \text{ Watts} / \text{meter}^2 \\ S_{nf} &= 2.3 \text{ mW} / \text{cm}^2\end{aligned}$$

Far Field Region. For purposes of evaluating RF exposure, the distance to the beginning of the far field region can be approximated by the following equation:

$$R_{ff} = \frac{0.6D^2}{\lambda}$$

where: R_{ff} = distance to the beginning of far field
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Using the parameters for this antenna:

$$\begin{aligned}R_{ff} &= 0.6 (1.06 \text{ meters})^2 / .02 \text{ meters} \\ R_{ff} &= 34 \text{ meters}\end{aligned}$$

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The power density in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where: S_{ff} = power density (on axis)
 P = power fed to antenna
 G = power gain of the antenna in the direction of interest
 R = distance to the point of interest

Using the parameters for this antenna:

$$S_{ff} = 8\text{Watts (40.8 dBi)} / 4 (\pi) (34)^2$$

$$S_{ff} = 96180 / 14526$$

$$S_{ff} = 6.62 \text{ Watts / meter}^2$$

$$S_{ff} = 0.7 \text{ mW / cm}^2$$

Main Reflector - Feed horn Region

The RF energy radiated from the feed system is confined to a conical shape whose vertex is located at the feed and extends outward to the main reflector surface. The power density at any point in this region is expressed by the equation:

$$S_{feed} = P/A$$

Where :

A = Cross section area of the conical region in meter²

P = Radiated transmitted power in watts

At the feed the power density is:

$$S_{feed} = P/A = 8 / \pi (0.10/2)^2 = 1018 \text{ Watts/meter}^2$$

$$S_{feed} = 102 \text{ mW/cm}^2$$

Conclusion

The results of the above calculations are summarized in the following table and in Figure 1.

Region	Power Density	Remarks
Antenna Surface	3.6 mW/cm ²	Safe Level
Main Reflector -Feed horn Region	102 mW/cm ²	Hazardous
Near Field < 14 meters	2.3 mW/cm ²	Safe Level
Far Field > 34 meters	0.7 mW/cm ²	Safe Level

Results of this hazard study indicate that the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range is not exceeded in areas directly in front of the antenna, or in the near and far field. The region where this limit may be exceeded will be in the the region between the reflector and the feed horn. This area is not readily accessible to personnel and whenever personnel are required to work on the radiating or reflecting parts of the antenna structure, the transmitter will be turned off. Signs to this effect will be posted at the transmitter site. The antenna will be located in a restricted area and unauthorized personnel are prevented access.

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