

Analysis of Non-Ionizing Radiation for a UHF Yagi Antenna Earth Station System

This report analyzes the non-ionizing radiation levels for a UHF Yagi antenna earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology's General RF Exposure Guidance, 447498 D01 v05r02. The radiation safety limits used in the analysis are in conformance with Title 47 Chapter I, Subchapter A, Part 1, Subpart I, Section 1.1310. Section 1.1310 specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
0.3 - 1.34	100
1.34 - 30	$180/(\text{Frequency}(\text{MHz}))^2$
30-300	0.2
300-1500	$\text{Frequency}(\text{MHz})/1500$
1500-100,000	1

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
0.3-3.0	100
3.0-30	$900/\text{Frequency}(\text{MHz})^2$
30-300	1
300-1500	$\text{Frequency}(\text{MHz})/300$
1500-100,000	5

For UHF, the following values are calculated:

- Uncontrolled Exposure (MPE) - .269 mw/cm²
- Controlled Exposure (MPE) – 1.34 mw/cm²

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Frequency	F	Input	403	MHz
Wavelength	λ	300/F	0.74	m
Transmit Power	P	Input	6.3	W
Antenna Gain (dBi)	G _{es}	Input	16.2	dBi

The following website was used to calculate distances

[RF Exposure Calculator - Lake Washington Ham Club](#)

This site was recommended by ARRL to calculate exposure distances.

Transmission Duty Cycles are part of the calculations and a worst case cycle is used. Current calculations indicate the actual duty cycle is:

- 4 Contacts for a max of 9 minutes 30 seconds over a 24 hour period. This results in 38 minutes of transmission over 24 hours.

The RF Exposure Calculator determines Transmission duty cycles using minutes transmitted and minutes received with the cycle repeating. The following was used to calculate the RF exposure

- 1 minute of transmission at 100% duty cycle followed by 30 minutes of receive operation. This results in 48 minutes of transmission over 24 hours.

Calculations were done with and without ground reflections. Yagi antennas are highly directed antennas so ground reflections are very small and the calculations without ground reflections are more applicable. The calculations with ground reflections are included as worst case.

Exposure Limits

For transmission at 403 MHz, the following limits are calculated:

- Uncontrolled exposure – 0.2687 mw/cm²
- Controlled Exposure – 1.3433 mw/cm²

5. Summary of Calculations

Table 4 shows the results of the calculations made using the parameters given above. The keepout zone is the same for uncontrolled and controlled environments.

Table 4. Summary of Keep Out zones for antenna

Beam Angle	Keepout zone		Hazard Assessment
	feet		
Main Beam	feet	2.72	Satisfies FCC MPE by using signage
15 degrees from main beam	Feet	1.93	Satisfies FCC MPE
20 dehees from man beam	Feet	0.83	Satisfies FCC MPE

The antenna will be mounted on a 10 foot mast on the roof of a building and will not be pointed any lower than 0 degrees elevation. The antenna/mast will be located on the roof 3 feet from any other structures on the roof.

8. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have not been exceeded with the use of appropriate warning signs regarding RF radiation. The applicant proposes to comply with the Maximum Permissible Exposure (MPE) limits of 0.27 mW/cm^2 for the Uncontrolled Areas, and the MPE limits of 1.34 mW/cm^2 for the Controlled Areas.

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The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing.

Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.