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RADIATION HAZARD STUDY

The purpose of this report is to analyze the non-ionizing radiation levels for a Transportable KU Uplink utilizing an Advent Communications 1.2 meter Antenna. The Office of Science and Technology Bulletin, No. 65, August 1997, specified that the maximum level of non-ionizing radiation that a person may be exposed to over a 0.1 hour (6 minute) period is an average power density equal to $5mW/cm^2$ (five milliwatt per centimeter squared). This report will determine the power flux densities of the earth station in the far field, near field, transition region, the main reflector surface, and between the antenna edge and the ground.

The following parameters were used to calculate the various power flux densities for the earth station:

Antenna Diameter, (D)	= 1.2 meters
Antenna Surface Area, (Sa) = $\pi(D^2)/4$	= 1.13 m^2
Wavelength at 14.25 Ghz, (λ)	= 0.021 meters
Transmit Power at Flange, (P)	= 70 watts
Antenna gain at 14.25GHz (G)	= 43.1 dBi
Antenna Gain, (numeric, (Ges)	= 20417
Antenna Aperture Efficiency, (η)	= 0.65
ANSI Safe Power Density, (Ws)	= $5.0mW/cm^2$

Far Field Calculations

The distance to the beginning of the far field region can be found by the following equation:

Distance to the Far Field Region, (Rf) = $(0.6(D^2))/\lambda$
= 41.1meters

The maximum main beam power density in the far field can be calculated as follows:

Far Field On-axis power density, (Wf) = $((Ges)(P))/((4\pi)(Rf^2))$
= 67.4 W/m^2
= 6.74 mW/cm^2

Near Field Calculations

Power flux density is considered to be at a maximum value throughout the entire length of this region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the extent of the near field region, the power density decreased with distance from the transmitting antenna.

The distance to the end of the near field can be determined by the following equation:

Extent of Near Field, (Rn) = $D^2/(4(\lambda))$ = 17.1 meters

The maximum power density in the near field is determined by:

Near Field On-axis power density, (Wn)
= $(16(\eta)P)/(\pi (D^2))$
= 161 W/m^2
= 16.1 mW/cm^2

Transition Region Calculations

The transition region is located between the near and far field regions. As stated above, the power density begins to decrease with distance in the transition region. While the power density decreases inversely with distance in the transition region, the power density decreases inversely with the square of the distance in the far field region. The maximum power density in the transition region will not exceed that calculated for the near field region. The power density in the near field region, as shown above, will not exceed 16.1 mW/cm^2.

Far Field On-axis Distance to ANSI 5 mW/cm² Calculations - (Dsafe)

Since the power density decreases inversely with the square of the distance in the far field region, the distance to the On-axis Power Density of 5 mW/cm^2 can be calculated from the following:

(Dsafe) = $Rf((Wf/Ws)^{0.5})$
= $41.1x(6.74/5)^{0.5}$ = 47.7 meters

Main Reflector Region Calculations

Transmissions from the feed horn are directed toward the main reflector surface. The power density in the main reflector region can be calculated by the following:

Main Reflector Surface Power Density = 4(P)/Sa
= 247.8 W/m^2
= 24.78 mW/cm^2

Off-axis Evaluation

For off-axis calculations in the near-field and in the transition region, it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20dB) less than the value calculated for the equivalent distance in the main beam.

Near Field On-axis power density,

$Wn = 16.1\ mW/cm^2$

Near Field On-axis power density, 1.8 meters from main beam center

$Wn(off) = 0.01\ Wn$

$= 0.161\ mW/cm^2$

Therefore, the area around and behind the dish at a distance of one dish diameter (1.8 meters) from the center of the main beam will be equal to or less than 16.1 mW/cm^2. For off-axis calculations in the far-field, the calculated main-beam power density of (Wf) can be multiplied by the appropriate relative power density factor obtained from the antenna gain pattern to obtain a more realistic estimate.

The proposed antenna meets or exceeds the performance specifications under part 25.209 of the FCC rules. The off-axis gain of this antenna, therefore, is equal to or greater than 10dBi less than the on-axis gain in any direction of 48 degrees or more removed from the center line of the main beam.

Far Field On-axis power density

$Wf = 6.74\ mW/cm^2$

Far Field Off-axis power density

$Wf(off) = 0.1\ (Wf)$

$= 0.674\ mW/cm^2$

Summary of Expected Radiation Levels

Region	Calculated Maximum Radiation Level (mW/cm^2)	Hazard Assessment
Far Field Region: = 41.1 meters	6.74	Potential Hazard
Near Field Region: = 17.1 meters	16.1	Potential Hazard
Transition Region:	16.1	Potential Hazard
Reflector Surface Region:	24.8	Potential Hazard
Far Field off-axis Region:	0.674	Satisfies ANSI
Near Field off-axis Region:	0.161	Satisfies ANSI
Area around dish equal to dish diameter:	0.161	Satisfies ANSI

Conclusions

Based on the above analysis it is concluded that the ANSI standards of 5 mW/cm^2 or greater would not exist in regions normally occupied by the public or the earth station's operating personnel.

In the area of the Main Reflector, personnel would only enter that area to perform maintenance functions and the transmitter would not be operational at that time, so the ANSI standard of 5 mW/cm^2 would be met.

In the area of the Near Field and Transition Region, since the antenna is mounted at a height of 3 meters above the ground, and will not be pointed in the direction of populated areas, the ANSI standards would again be met. Warning signs are attached to the vehicle to warn individuals of the potential for hazardous radiation.

Because this is a mobile unit and conditions vary from operating site to operating site, procedures have been established for the operational personnel to verify that the antenna is not pointing in the direction of populated areas.

In addition, the transmit power used in these calculations is greater than that which will typically be utilized by the earth station. The higher power level was used for the calculations so that any future upgrades to the RF system would not require license modifications.