RF RADIATION EXPOSURE

RF Safety Rules

Based on ET Docket No. 93-62.

- **http://www.fcc.gov/oet/rfsafety**

All Details are in OET Bulletin 65

- **http://www.fcc.gov/oet/info/documents/bulletins/#65**

Parabolic Antennas

Near-Field or Fresnel Region:

The radiation is substantially confined within a cylindrical pattern having the same diameter as the antenna. This region may be considered to extend out from the antenna to a distance of R_{nf} as defined on the following slide.*

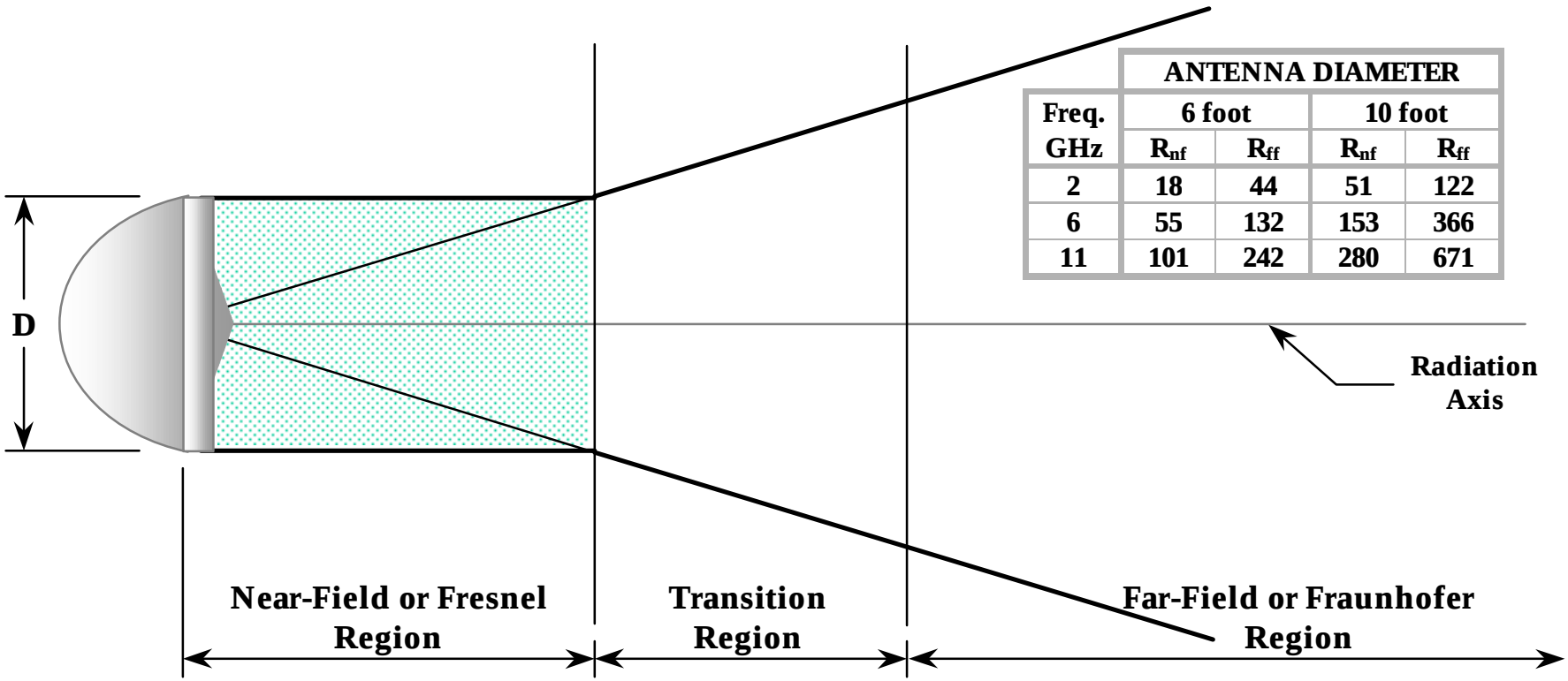
Transition Region:

Since the distance to the far-field region is two to three times the length of the near-field region, there is a transition region between the two.* Within the transition region the power density decreases inversely with distance.

Far-Field or Fraunhofer Region:

At a substantial distance from an antenna, the power density begins to decrease in proportion to the inverse square of the distance from the antenna. This occurs at a distance from a parabolic antenna where the difference in path length between a ray on the axis of the beam, and a ray from the edge of the antenna to a given point on the beam axis, is less than 1/16 of a wavelength. This region begins at a distance designated as R_{ff} as defined on the following slide.

Antenna Near & Far Fields



Freq. GHz	ANTENNA DIAMETER			
	6 foot		10 foot	
	R_{nf}	R_{ff}	R_{nf}	R_{ff}
2	18	44	51	122
6	55	132	153	366
11	101	242	280	671

R_{nf} = Distance from the antenna to Near-Field boundary (ft).
R_{ff} = Distance from the antenna to Far-Field boundary (ft).
D = Diameter of antenna (ft).
? = Wavelength (ft). F = Frequency (GHz).

Ref.: "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency EM Fields" OET Bulletin 65, Edition 97-01, August 1997. FCC Office of Engineering and Technology

Power Density for Parabolic Antennas

- Power density calculations for the Near-Field Region of a Parabolic Antenna.
  - The magnitude of the on-axis power density varies with location within the near-field. However, the maximum value of the near-field power density can be calculated by the following equation:

$$W_{nf} = \frac{4 \cdot P}{A} = \frac{16 \cdot P}{\pi \cdot D^2}$$

Where: W_{nf} = **Maximum power density in the Near-Field Region in mW / cm²**
η = **Apeture efficiency, typically 50-60% for commercially available antennas**
P = Average transmitter power in mW
D = Antenna diameter in cm
A = Area of antenna aperture ($\pi D^2/4$) in cm²

Power Density for Parabolic Antennas (Cont.)

- Power density calculations for the Transition Region of a Parabolic Antenna.
  - Within the transition region, the magnitude of the on-axis power density decreases inversely with distance from the antenna. Therefore the power density within this region can be calculated the following equation:

$$W_t = W_{nf} R_{nf} / R$$

Where: W_t = **Power density in the transition region in** mW / cm^2

W_{nf} = **Maximum power density in the Near - Field Region in** mW / cm^2

R_{nf} = **Distance from the antenna to Near - Field boundary in feet**

R = **Distance to point of interest in feet**

Power Density for Parabolic Antennas (Cont.)

- Power density calculations for the Far-Field Region of a Parabolic Antenna.
  - The power density in the far-field region decreases inversely as the square of the distance from the antenna surface. Within this region the power density can be estimated by the following equation:

$$W_{ff} = \frac{PG}{4\pi R^2}$$

Where: W_{ff} = **Maximum power density on axis in the Far - Field Region in mW / cm^2**

P = Average power fed to the antenna in mW

G = Gain of antenna in the direction of interest relative to an isotropic radiator

R = Distance to the point of interest in cm

Maximum Permissible Exposure

FCC Office of Engineering & Technology Bulletin 65 Edition 97-01 (August 1997) Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

	Maximum Permissible Exposure (MPE) (mW/cm^2)	
Frequency Range (MHz)	**Occupational/ Controlled Exposure***	**General Population/ Uncontrolled Exposure****
30 - 300	1.0	0.2
300 - 1500	f / 300	f / 1500
1500 - 100,000	**5.0**	**1.0**

f = Frequency in MHz

*** Controlled Environments - A location where individuals are aware of radiation exposure. (Averaging time 6 min.)**

**** Uncontrolled Environments - Individuals have no knowledge or control over their exposure. (Averaging time 30 min.)**

FIXED WIRELESS

Power Density Calculation

Exemple:

- Antenna Diameter = 8 ft
- Aperture efficiency = 55%
- Operating frequency = 5.8 GHz
- MW transmitter output = +30 dBm (1Watt)
- Transmission line loss = 0.2 dB (worst case)

Power @ antenna input port = 30 dBm - 0.2 dB = 29.8 dBm

$P_{mw} = 10^{P_{dbm/10}} = 10^{2.98} = 954.99$ mW

D = 8 ft x m/3.2808 x 100cm/m = 243.84 cm

$A = \pi D^2/4 = \pi \times (243.84)^2/4 = 46699.297$ cm^2

W = Power density in Near - Field Region of example system.

$W = 4\pi P / A = 4 \times .55 \times 954.99$ mW / 46699.297 cm^2 = 0.04498 mW/cm^2

- Bulletin-65 Maximum allowable power density for 11.2 GHz is 1.0 mW/cm^2 , or <u>22.2 times greater</u> than calculated maximum power density.

Power Density Calculation

Example:

- Antenna Diameter = 2ft
- Aperture efficiency = 62% (for G=29.3dbi)
- Operating frequency = 5.8 GHz
- MW transmitter output = +30 dBm (1Watt)
- Transmission line loss = 0.2 dB (worst case)

Power @ antenna input port = 30 dBm - 0.2 dB = 29.8 dBm

$P_{mw} = 10^{P_{dbm/10}} = 10^{2.98} = 954.99$ mW

D = 2 ft x m/3.2808 x 100cm/m = 60.96 cm

$A = \pi D^2/4 = \pi \times (60.96)^2/4 = 2918.635$ cm^2

W = Power density in Near - Field Region of example system.

$W = 4\pi P / A = 4 \times .62 \times 954.99$ mW / 2918.63 cm^2 = 0.81146 mW/cm^2

- Bulletin-65 Maximum allowable power density for 5.8 GHz is 1.0 mW/cm^2 .

Power Density Calculations (Cont.)

Near-Field Power Density Calculations for 2, 6, & 11 GHz MW Radios with High Power PA's

Operating Frequency (GHz)	Power into Antenna-Feeder Losses (dBm)	Antenna Diameter (feet)	Near-Field Power Density (mW/cm^2)	Max Permissible Exposure (MPE) (mW/cm^2)*
1.96	+30-1.5 = +28.5	6	0.05928	1.00
5.8	+30-0.2 = +29.8	2	0.81146	1.00
5.8	+30-0.2 = +29.8	8	0.04498	1.00
6.2	+33-1.8 = +31.2	10	0.03975	1.00
11.2	+34-4.6 = +29.4	6	0.07295	1.00
11.2	+34-4.6 = +29.4	10	0.02626	1.00

* Maximum Permissible Exposure for Uncontrolled Environment from FCC OET Bulletin 65, Edition 97-01; Aug. 97.