RF Exposure Technical Brief

This Technical Brief calculates the minimum separation distance from an antenna, connected to the subject base station, such that the power density values listed in RSS-102, Radio Frequency (RF) Exposure Compliance of Radiocommunications Apparatus (All Frequency Bands) Table 4.2 and Table 4.4 are not exceeded. The analysis is for a typical installation using a structure mounted antenna.

Within the frequency range that the subject equipment operates, 406.1 MHz – 435 MHz the permitted exposure limit is frequency dependent. Table 1 lists the maximum permitted exposure limits by environment type for the subject equipment at the lowest frequency. The lowest operating frequency, 406.1 MHz, is selected because the power density calculations per RSS-102, Table 4.2 and Table 4.4 result in a lower exposure level than for the highest operating frequency, 430 MHz. The maximum permitted exposure limit for uncontrolled environments is a power density of 2.71 W/m^2 and the maximum permitted exposure limit for controlled environments is 13.5 W/m^2.

Table 1 - Maximum Permissible Exposure Limits

	Uncontrolled Environment	Controlled Environment
Frequency	406.1-430 MHz	406.1-430 MHz
Limit	2.71 W/m^2	13.5 W/m^2

Example Calculations for GTR8000, UHF Range 1 Transmitter:

The example configuration is a single frequency site, with minimal RF network losses, set to zero for this example, between the transmitter output connector and the antenna input connector. The antenna has an omni directional pattern in the horizontal plane and a 29 degree beamwidth in the vertical plane. The largest dimension of the antenna is in the vertical plane. For the operating band of the equipment commonly available mid to low gain base station antennas have typical gains of 3 dBd or greater. A low gain antenna was selected to realize a short physical antenna length which results in a higher power density over the analyzed surface area. This configuration results in a conservative separation distance (i.e. a larger distance).

Table 2 - Transmitter Configuration

Frequency	406.1 - 430 MHz
Base Station Output Power	110 W
RF Network Loss	0 dB
Antenna Type RFS BMR6-O-B1	3 dBd / 5.1 dBi (Omni)
Antenna length	1.25 m

For the subject antenna the cylindrical model power density and the far field power density crosses over at 2.04 meters. Therefore the cylindrical power density calculation method will be used for the controlled environment and the far field calculation method will be used for the uncontrolled environment.

Controlled Environment Cylindrical Method

Using Equation 1 the spatially averaged plane-wave equivalent power densities parallel to the antenna in the vertical plane may be estimated by dividing the net input power to the antenna by the surface area of an imaginary cylinder at a distance *R* from the antenna, with the height of the cylinder equal to the length of the antenna[1].

$$S = \frac{Pnet}{2\pi Rh} \quad (1)$$

Where:

S = power density, W/m^2

Pnet = net input power to the antenna, W

R = radial distance from the antenna, m

h = height of the antenna, m

The minimum separation distance can be found by solving Equation 1 for *R* and setting *S* to the maximum power density for the environment per Table 1.

$$R = \frac{Pnet}{2\pi hS} = \frac{110}{2\pi \times 1.25 \times 13.5} = 1.03 \text{ m} \quad (2)$$

Uncontrolled environment:

Using Equation 3 the spatially averaged plane-wave equivalent power densities in the far field may be estimated.

$$S = \frac{PnetG}{4\pi R^2} \quad (3)$$

Solving equation 3 for R yields the separation distance for the far field case.

$$R = SQRT\left(\frac{PnetG}{4\pi S}\right) = SQRT\left(\frac{110x3.27}{4\pi \times 2.71}\right) = 3.25 \text{ m} \quad (4)$$

For the example site configuration the minimum separation distance for a controlled environment is 1.03 m and the minimum separation distance for the uncontrolled environment is 3.25 m.

[1] Federal Communications Commission Office of Engineering & Technology, OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, page 32, Tell's cylindrical model.