Exposure of humans to RF fields

As per FCC KDB 447498 D04 and Section 2.1091 radio frequency transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels.

Calculations have been made using both the Occupational (Controlled Exposure) and General Population (Uncontrolled Exposure) limits that are defined in Section 1.1310.

FCC 1.1310 Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	$*900/f^2$	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	$*180/f^2$	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

Minimum safe distances have been calculated below.

- Occupational / Controlled exposure is (f/300) mW/cm^2

- General Population / Uncontrolled exposure is (f/1500) mW/cm^2

As this radio can operate over the range of 406.0 to 470.0 MHz the lowest frequency of operation which will give the worst case result, would be 406.0 MHz.

The power density (Power density = $E^2/3770$ mW/cm^2) at 406.0 MHz comes out to be as follows:

- For Occupational / Controlled exposure: 1.35 mW/cm^2

- General Population / Uncontrolled exposure: 0.27 mW/cm^2

The rated maximum transmitter power = 50 W (+47 dBm).

A worst case scenario duty cycle of 100% has been used for the calculations.

As per the client, the antenna(s) used for this transmitter must be fixed-mounted on outdoor permanent structures.

Typical antenna used in the calculation for maximum permissible exposure is a 1 dipole antenna which is bi-directional with typical gain of 3.6 dBi.

$$Gain_{(num)} = 10^{(Gain_{(dBi)}/10)}$$

Numeric gain calculated using formula above gives a value of 2.3 which is used in calculations.

The minimum distance from the antenna at which the MPE is met is calculated from the following

Field strength in V/m (FS), Transmit power in watts (P), Transmit antenna gain (G), Transmitter duty cycle (DC), Separation distance in metres (D)
The calculation is as follows:

FS = (√ (30 * P * G * DC)) / D Therefore D = (√ (30 * P * G * DC)) / FS

Alternative formula that can be applied as per OET Bulletin 65 is:

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

Where:
S = power density (in appropriate units, e.g. mW/cm2)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the centre of radiation of the antenna (appropriate units, e.g., cm)

For Controlled Environment
Power Density = 1.35 mW/cm^2 = E^2/3770

E= √ 1.35*3770

E = 71.3 V/m
D = (√ (30 * 50 * 2.3 * 1)) / 71.3
D = 0.82 m

For Uncontrolled Environment
Power Density = 0.270 mW/cm^2 = E^2/3770

E= √ 0.270*3770

E = 31.9 V/m
D = (√ (30 * 50* 2.3 * 1)) / 31.9
D = 1.84 m

Result: Complies if a safe distance of at least (D) calculated above is applied to this device.