RF Exposure

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

§2.1091 Radio frequency radiation exposure evaluation: mobile devices

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

RSS-102 Requirement: Devices that have a radiating element normally operating at separation distances greater than 20 cm between the user and the device shall undergo an RF exposure evaluation.

RF exposure evaluation shall be made in accordance with the latest version of IEEE C95.3.

For the purpose of this standard, Industry Canada has adopted the SAR and RF field strength limits established in Health Canada's RF exposure guideline, Safety Code 6.

Test Results: Equipment complies with this Section.

Test Engineer(s): Len Knight

Test Date(s): 09/27/13

FCC - Limits for Maximum Permissible Exposure (MPE)

Requirements: FCC Guidelines for evaluating exposure to RF Emissions, from the FCC OET Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
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
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
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
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

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

IC – RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	$280/f$	$2.19/f$	-	6
10-30	28	$2.19/f$	-	6
30-300	28	0.073	2*	6
300-1500	$1.585f^{0.5}$	$0.0042f^{0.5}$	$f / 150$	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000 / f^{1.2}$
150000-300000	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000 / f^{1.2}$

Note: f is frequency in MHz.
* Power density limit is applicable at frequencies greater than 100 MHz.

IC - RF Field Strength Limits for Controlled Devices (Controlled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Averaging Time (minutes)
0.003-1	600	4.9	-	6
1-10	$600/f$	$4.9/f$	-	6
10-30	60	$4.9/f$	-	6
30-300	60	0.163	10*	6
300-1500	$3.54f^{0.5}$	$0.0094f^{0.5}$	$f / 30$	6
1500-15000	137	0.364	50	6
15000-150000	137	0.364	50	$616000 / f^{1.2}$
150000-300000	$0.354f^{0.5}$	$9.4 \times 10^{-4} f^{0.5}$	$3.33 \times 10^{-5} f$	$616000 / f^{1.2}$

Note: f is frequency in MHz.
* Power density limit is applicable at frequencies greater than 100 MHz.

Procedures: Prior to radiated testing, the radio was connected to a power meter in order to see if any channel was significantly stronger than the rest for each band. For the purposes of testing, the channel with the highest power from each band was used.

Test Procedures:

1. The test setup was as described in the EUT Configuration section of this test report. The TETRA signal generator was on the outside of the chamber while the antenna was on the inside.
2. The antenna under test was mounted to a 30x30cm ground plane and placed on an 80cm test table.
3. The EUT was set to transmit continuously at the selected frequency and modulation at maximum RF power. The distance between the field intensity probe and the EUT's antenna was 20 cm since the calculated distance for uncontrolled environments was $R < 20$ cm.
4. Field intensity measurements were taken at different heights of the probe from the ground (0.1 to 2 meters) in 10cm increments, while rotating versus azimuth (from 0° to 360°).
5. Each maximized peak field intensity measurement was recorded.
6. Raw field strength was corrected with the field intensity probe correction factors.
7. The corrected field strength in V/m was converted to power density using the formula:
   $S = E^2 / Z_o$ where $Z_o = 120\ \pi \approx 377\ \Omega$
8. Average values of power density were calculated for the imaginary whole human body (0.1–2.0 m), for the lower part of the body (0.1–0.9 m) and for the upper part of the body (1.0–2.0 m). The results of calculations are shown in the following tables.

Calculation for Part 90 TI D-LMR 409-430 MHz

highest conducted power = 33.06 *dBm* (429.9875 MHz), therefore, **Limit for Controlled Exposure: 1.43 mW/cm^2**

EUT maximum antenna gain = 8 *dBi*.

Equation from page 18 of OET 65, Edition 97-01

$S = PG / 4\pi R^2$ or $R = \sqrt{PG / 4\pi S}$

where, S = Power Density
P = Power Input to antenna (2023.02 mW)
G = Antenna Gain (6.31 numeric)
D.C. = Duty Cycle (25%)
R = 25 cm

$S = (D.C.)(P)(G) / 4\pi R^2$
$S = (0.25)(2023.02)(6.31) / 4\pi 625$
$S = 0.4$ mW/cm^2

Calculation for RSS-119 TETRA 409-430 MHz

highest conducted power = 35.48 *dBm* (409.09375 MHz), therefore, **Limit for Controlled Exposure: 1.36 mW/cm^2**

EUT maximum antenna gain = 8 *dBi*.

Equation from page 18 of OET 65, Edition 97-01

$S = PG / 4\pi R^2$ or $R = \sqrt{PG / 4\pi S}$

where, S = Power Density
P = Power Input to antenna (3531.8 mW)
G = Antenna Gain (6.31 numeric)
D.C. = Duty Cycle (25%)
R = 25 cm

$S = (D.C.)(P)(G) / 4\pi R^2$
$S = (0.25)(3531.8)(6.31) / 4\pi 625$
$S = 0.71$ mW/cm^2

Calculation for Part 22 TI D-LMR 454 - 460 MHz

highest conducted power = 33.04 *dBm* (454.05 MHz), therefore, **Limit for Controlled Exposure: 1.51 mW/cm^2**

EUT maximum antenna gain = 8 *dBi*.

Equation from page 18 of OET 65, Edition 97-01

$S = PG / 4\pi R^2$ or $R = \sqrt{PG / 4\pi S}$

where, S = Power Density
P = Power Input to antenna (2013.7 mW)
G = Antenna Gain (6.31 numeric)
D.C. = Duty Cycle (25%)
R = 25 cm

$S = (D.C.)(P)(G) / 4\pi R^2$
$S = (0.25)(2013.72)(6.31) / 4\pi 625$
$S = 0.4$ mW/cm^2

Calculation for Part 90 TI D-LMR 450 - 470 MHz

highest conducted power = 33.07 *dBm* (465 MHz), therefore, **Limit for Controlled Exposure: 1.5 mW/cm^2**

EUT maximum antenna gain = 8 *dBi*.

Equation from page 18 of OET 65, Edition 97-01

$S = PG / 4\pi R^2$ or $R = \sqrt{PG / 4\pi S}$

where, S = Power Density
P = Power Input to antenna (2027.6 mW)
G = Antenna Gain (6.31 numeric)
D.C. = Duty Cycle (25%)
R = 25 cm

$S = (D.C.)(P)(G) / 4\pi R^2$
$S = (0.25)(2027.6)(6.31) / 4\pi 625$
$S = 0.407$ mW/cm^2

Calculation for Part 90 TETRA 450 - 470 MHz

highest conducted power = 35.28 *dBm* (470 MHz), therefore, **Limit for Uncontrolled Exposure: 1.57 mW/cm^2**

EUT maximum antenna gain = 8 *dBi*.

Equation from page 18 of OET 65, Edition 97-01

$S = PG / 4\pi R^2$ or $R = \sqrt{PG / 4\pi S}$

where, S = Power Density
P = Power Input to antenna (3372.873 mW)
G = Antenna Gain (6.31 numeric)
D.C. = Duty Cycle (25%)

$S = (D.C.)(P)(G) / 4\pi R^2$
$S = (0.25)(3372.873)(6.31) / 4\pi 625$
$S = 0.68$ mW/cm^2

20 cm			
Probe height (cm)	**Raw V/m**	**Corrected V/m**	**PD mW/cm2**
10	2.63	1.9462	0.001005
20	2.52	1.8648	0.000922
30	3.32	2.4568	0.001601
40	4.81	3.5594	0.003361
50	6.89	5.0986	0.006895
60	8.55	6.327	0.010618
70	11	8.14	0.017575
80	19.71	14.5854	0.056428
90	20.84	15.4216	0.063084
100	19.41	14.3634	0.054723
110	18.03	13.3422	0.047219
120	12.71	9.4054	0.023465
130	9.06	6.7044	0.011923
140	6.69	4.9506	0.006501
150	5.03	3.7222	0.003675
160	4.05	2.997	0.002382
170	3.01	2.2274	0.001316
180	2.26	1.6724	0.000742
190	1.77	1.3098	0.000455
200	1.52	1.1248	0.000336

Occupational/Controlled Environment 20 cm	EBM 0dB Flex Whip 380-430 MHz
Part of the Body/Averaging Points	Averaged Power Density
Whole Body (0.1 m to 2.0 m)	0.01571
Lower Body (0.1 m to 0.9 m)	0.01794
Upper Body (1.0 m to 2.0 m)	0.01389

Table 1. MPE Measurement, 416.01875 MHz, 20 kHz

20 cm			
Probe height (cm)	**Raw V/m**	**Corrected V/m**	**PD mW/cm2**
10	3.72	2.604	0.0017986
20	5.12	3.584	0.0034072
30	7.18	5.026	0.0067004
40	9.73	6.811	0.012305
50	12.24	8.568	0.0194723
60	15.8	11.06	0.0324466
70	22.39	15.673	0.0651573
80	36.73	25.711	0.1753463
90	32.06	22.442	0.1335924
100	27.7	19.39	0.0997273
110	20.81	14.567	0.0562858
120	15.13	10.591	0.0297531
130	11.12	7.784	0.0160718
140	8.62	6.034	0.0096576
150	7.06	4.942	0.0064783
160	6.63	4.641	0.0057132
170	5.15	3.605	0.0034472
180	4.03	2.821	0.0021109
190	3.24	2.268	0.0013644
200	2.69	1.883	0.0009405

Occupational/Controlled Environment 20 cm	EBM BASE 0dB Flx 430 - 472.5 MHz
Part of the Body/Averaging Points	Averaged Power Density
Whole Body (0.1 m to 2.0 m)	0.03409
Lower Body (0.1 m to 0.9 m)	0.05003
Upper Body (1.0 m to 2.0 m)	0.02105

Table 2. MPE Measurement, 459.950 MHz, 20 kHz

20 cm			
Probe height (cm)	**Raw V/m**	**Corrected V/m**	**PD mW/cm2**
10	3.71	2.597	0.001789
20	4.88	3.416	0.0030952
30	6.71	4.697	0.0058519
40	9.12	6.384	0.0108105
50	11.61	8.127	0.0175194
60	14.16	9.912	0.0260604
70	18.88	13.216	0.0463296
80	34.42	24.094	0.1539843
90	34.81	24.367	0.1574936
100	31.24	21.868	0.126846
110	25.96	18.172	0.0875919
120	19.59	13.713	0.0498797
130	14.05	9.835	0.0256571
140	11.05	7.735	0.0158701
150	8.52	5.964	0.0094348
160	6.65	4.655	0.0057478
170	5.27	3.689	0.0036097
180	4.41	3.087	0.0025277
190	3.65	2.555	0.0017316
200	2.94	2.058	0.0011234

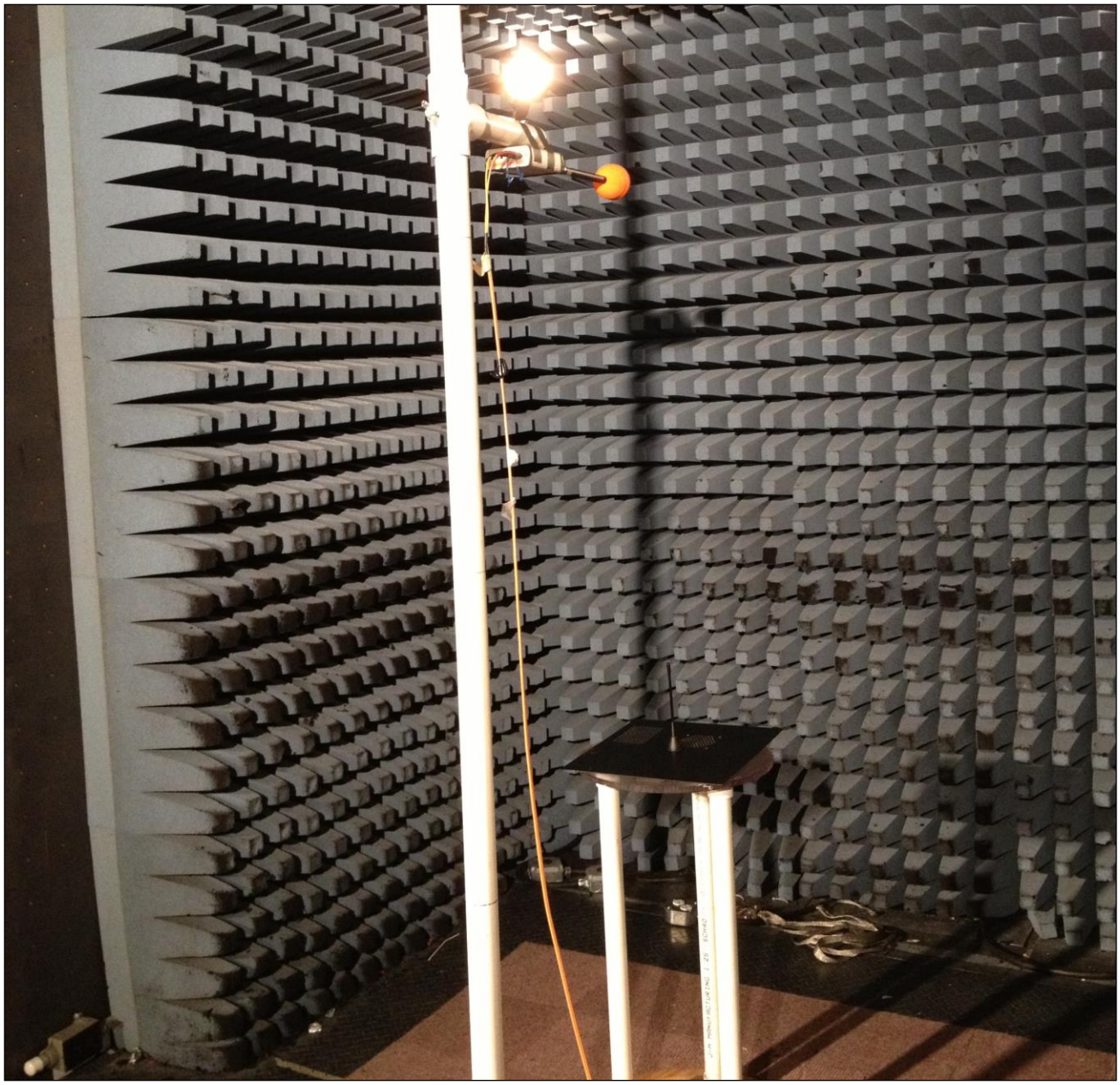
Occupational/Controlled Environment 20 cm	EBM BASE 0dB Flx 430 - 472.5 MHz
Part of the Body/Averaging Points	Averaged Power Density
Whole Body (0.1 m to 2.0 m)	0.03765
Lower Body (0.1 m to 0.9 m)	0.04699
Upper Body (1.0 m to 2.0 m)	0.03000

Table 3. MPE Measurement, 465 MHz, 20 kHz

20 cm			
Probe height (cm)	**Raw V/m**	**Corrected V/m**	**PD mW/cm2**
10	4.03	2.821	0.0021109
20	5.25	3.675	0.0035824
30	7.34	5.138	0.0070024
40	10.14	7.098	0.0133638
50	12.5	8.75	0.0203084
60	15.33	10.731	0.0305449
70	19.83	13.881	0.0511093
80	33.02	23.114	0.1417127
90	37.89	26.523	0.1865967
100	35.08	24.556	0.1599462
110	30.86	21.602	0.1237789
120	22.05	15.435	0.0631934
130	14.97	10.479	0.0291272
140	10.98	7.686	0.0156697
150	8.38	5.866	0.0091273
160	6.61	4.627	0.0056788
170	5.49	3.843	0.0039174
180	2.82	1.974	0.0010336
190	2.43	1.701	0.0007675
200	1.95	1.365	0.0004942

Occupational/Controlled Environment 20 cm	EBM BASE 0dB Flx 430 - 472.5 MHz
Part of the Body/Averaging Points	Averaged Power Density
Whole Body (0.1 m to 2.0 m)	0.04345
Lower Body (0.1 m to 0.9 m)	0.05070
Upper Body (1.0 m to 2.0 m)	0.03752

Table 4. MPE Measurement, 470 MHz, 22 kHz



Photograph 1. RF Exposure, Test Setup