



Radio Frequency (RF) Exposure Evaluation

**For the
Reutech Mining
Movement and Surveying Radar**

FCC ID: YSD-5840-GR-1000

WLL JOB# 13134 Rev 1
August 28, 2013
Revised May 15, 2014

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Testing Certificate AT-1448

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Abstract

This report has been prepared on behalf of Reutech Mining, to document the findings of the maximum permissible exposure evaluation on the Movement and Surveying Radar. The purpose of this evaluation is to establish a minimum safe distance as per the RF exposure requirements as defined in in the following documents:

- ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300GHz): 1998
- Australia ARPNSA RP3: RADIATION PROTECTION STANDARD: Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz: 2002
- Industry Canada RSS-102 Issue 4: Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) 2010
- FCC CFR47 Part 1.1310 Radiofrequency radiation exposure limits.: 2012

Reference Documents:

- OET65: Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.

The Evaluation was performed by Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Washington Laboratories, Ltd. has been accepted as an EMC Conformity Assessment Body (CAB) under the United States/European Union Memorandum of Agreement. Washington Laboratories, Ltd. is accredited by ACLASS under Testing Certificate AT-1448.

Revision History	Reason	Date
Rev 0	Initial Release	August 28, 2013
Rev 1	Removed References to MSR 060 and corrected typographical error in Table 6	September 10, 2013
Rev 2	Changed Mala to Reutech	May 15, 2014

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1 Introduction

This report has been prepared on behalf of Reutech Mining. to show compliance with the RF exposure requirements as defined in the following standards and to provide minimum safe RF distances for Humans:

- ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300GHz): 1998
- Australia ARPNSA RP3: RADIATION PROTECTION STANDARD: Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz: 2002
- Industry Canada RSS-102 Issue 4: Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) 2010
- FCC CFR47 Part 1.1310 Radiofrequency radiation exposure limits.: 2010

Testing supporting this evaluation was performed at Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Washington Laboratories, Ltd. has been accepted as an EMC Conformity Assessment Body (CAB) under the United States/European Union Memorandum of Agreement. Washington Laboratories, Ltd. is accredited with ACLASS under Testing Certificate AT-1448.

2 Product Evaluated

This evaluation is for the Reutech Mining. Movement and Surveying Radar with the following antennas:

- Reutech 1.2m Circular Dish Antenna

3 Limits

The standards listed in section 1 group RF exposure limits into two general categories, Occupational/Controlled Exposure and General Population/Uncontrolled Exposure. This test report shall document the results using the General Population/ Uncontrolled Exposure limits as this is the most stringent. The following tables are excerpts from the standards showing the required exposure limits.

Table 1: ICNIRP Exposure Limits for Uncontrolled Exposure

Frequency range	E-field strength (V m ⁻¹)	H-field strength (A m ⁻¹)	B-field (μT)	Equivalent plane wave power density S _{eq} (W m ⁻²)
up to 1 Hz	—	3.2 × 10 ⁴	4 × 10 ⁴	—
1–8 Hz	10,000	3.2 × 10 ⁴ /f ²	4 × 10 ⁴ /f ²	—
8–25 Hz	10,000	4,000/f	5,000/f	—
0.025–0.8 kHz	250/f	4/f	5/f	—
0.8–3 kHz	250/f	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	0.73/f	0.92/f	—
1–10 MHz	87/f ^{1/2}	0.73/f	0.92/f	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	1.375f ^{1/2}	0.0037f ^{1/2}	0.0046f ^{1/2}	f/200
2–300 GHz	61	0.16	0.20	10

Table 2: ARPNSA RP3 Exposure Limits

Exposure category	Frequency range	E-field strength (V/m rms)	H-field strength (A/m rms)	Equivalent plane wave power flux density S _{eq} (W/m ²)
Occupational	100 kHz – 1 MHz	614	1.63 / f	—
	1 MHz – 10 MHz	614 / f	1.63 / f	1000 / f ² (see note 5)
	10 MHz – 400 MHz	61.4	0.163	10 (see note 5)
	400 MHz – 2 GHz	3.07 × f ^{0.5}	0.00814 × f ^{0.5}	f / 40
	2 GHz – 300 GHz	137	0.364	50
General public	100 kHz – 150 kHz	86.8	4.86	—
	150 kHz – 1 MHz	86.8	0.729 / f	—
	1 MHz – 10 MHz	86.8 / f ^{0.5}	0.729 / f	—
	10 MHz – 400 MHz	27.4	0.0729	2 (see note 6)
	400 MHz – 2 GHz	1.37 × f ^{0.5}	0.00364 × f ^{0.5}	f / 200
	2 GHz – 300 GHz	61.4	0.163	10

NOTES:

1 **f** is the frequency in MHz.

Table 3: 210 RSS-102 Exposure Limits for General Population

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	1.585 f ^{0.5}	0.0042 f ^{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	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000/f ^{1.2}

Note: f is frequency in MHz.

* Power density limit is applicable at frequencies greater than 100 MHz.

Table 4: FCC CFR47 Pt1.1310 Exposure Limits for General Population

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

3.1 Summary of Limits

The system being evaluated operates between 9.2 GHz and 10.0 GHz. The above exposure limits shown in tables Table 1 through Table 4 all have a power density limit 10 W/m² (1 mW/cm²) for this frequency range. This power density will determine the minimum safe distance allowed for this system.

4 Test Parameters

4.1 Test Method

Testing was performed using the Prediction Modeling Methods specified in OET65 for devices with aperture antennas. This method designates four exposure regions determined by wavelength and antenna parameters. These calculations are shown in Table 5.

Table 5: Distance vs. Power Density Formulas –OET65

Region	Distance of Region	Maximum Power Density of Region
Antenna Surface	No formula- Directly in front of antenna	$S_{\text{surface}} = 4P/A$
Near-Field	$R_{\text{nf}} = D^2/4\lambda$	$S_{\text{nf}} = 16\eta P/\pi D^2$
Transition	$R_{\text{nf}} \leq R_t \leq R_{\text{ff}}$	$S_t = S_{\text{nf}} R_{\text{nf}}/R$
Far-Field	$R_{\text{ff}} = 0.6D^2/\lambda$	$S_{\text{ff}} = PG/4\pi R^2$

where:

S_{surface} = maximum power density at the antenna surface in W/m^2

S_{nf} = maximum near-field power density in W/m^2

S_t = power density in the transition region in W/m^2

S_{ff} = power density (on axis) in W/m^2

R_{nf} = extent of near-field in m

R_{ff} = distance to beginning of near field in m

R = distance in m

P = power fed to the antenna feed horn in W

A = physical (geometrical) area of the aperture antenna in m^2

D = maximum dimension of antenna (diameter if circular) in m

G = power gain factor (linear units) in the direction of interest relative to an isotropic radiator

λ = wavelengths in m

η = aperture efficiency (typically 0.5-0.75 for circular apertures)

Aperture efficiency can be estimated with the following equation:

$$\eta = (G\lambda^2/4\pi)/(\pi D^2/4)$$

4.2 Radio Parameters

Table 6 below summarizes the criteria and RF characteristics used to evaluate the Movement and Surveying Radar not including the antenna systems

Table 6: Device Summary of the Movement and Surveying Radar

Model Evaluated:	Movement and Surveying Radar
Exposure Category:	General Population/ Uncontrolled
Power Output (dBm):	9.08dBm (0.00809W)
Modulation:	FMCW
Frequency Range:	9.2 GHz-10.0GHz

4.3 Antenna Parameters

This report covers the following antenna systems:
 Reutech 1.2m Circular Dish Antenna

The pertinent antenna parameters are covered in the following table:

Table 7: Antenna Parameters

Model Evaluated:	Reutech 1.2m Circular Dish Antenna
Antenna Gain (on AXIS)	38dB
Antenna Diameter	1.232m
Minimum elevation angle	-45°
Minimum installation Height	1.44m
Polarization	Circular
Frequency Range	9.2-10.00GHz
Wavelength at Center Frequency	0.03125m

5 Test Results

5.1 Movement and Surveying Radar with Reutech 1.2m Circular Dish Antenna

The calculations are based on 38dBi gain with a 9.08dBm input.

The estimated aperture efficiency for this system based on the following equation from OET65 equals:

$$\eta = (G\lambda^2/4\pi)/(\pi D^2/4) = 0.4481$$

Table 8: Distance vs. Power Density Formulas for 74cm Antenna

Region	Distance of Region (m)	Power Density of Region (W/m ²)	Power Flux Density Limit (W/m ²)
Antenna Surface	0	0.0272	10
Near-Field	0 - 11.64	0.0122	10
Transition	11.64 – 27.94	0.0122 – 0.0052	10
Far-Field	> 27.94	.0052	10

5.1.1 Test Summary

The main on axis beam complied in all 4 regions (surface, near-field, transition, & far-field).

In addition, no elevation angle or antenna height properties were utilized as the zero degree on-axis levels were compliant with the RF exposure limits.

5.1.2 Restrictions for operation

None