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# 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**

Prepared for:

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ACLASS ACCREDITED TESTING

**Testing Certificate AT-1448**

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Prepared by:

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Compliance Engineer

Reviewed by:

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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 ($\mu T$) | Equivalent plane wave power density $S_{eq}$ ($W\ m^{-2}$) |
|---|---|---|---|---|
| up to 1 Hz | — | $3.2 \times 10^4$ | $4 \times 10^4$ | — |
| 1–8 Hz | 10,000 | $3.2 \times 10^4/f^2$ | $4 \times 10^4/f^2$ | — |
| 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 | $3.07 \times f^{0.5}$ | $0.00814 \times f^{0.5}$ | $f/40$ |
| | 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 | $1.37 \times f^{0.5}$ | $0.00364 \times f^{0.5}$ | $f/200$ |
| | 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 | $0.158\ f^{0.5}$ | $4.21 \times 10^{-4}\ f^{0.5}$ | $6.67 \times 10^{-5}\ f$ | $616000/f^{1.2}$ |

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

**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 $W/m^2$ (1 $mW/cm^2$) 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 | $S_{surface} = 4P/A$ |
| Near-Field | $R_{nf} = D^2/4\lambda$ | $S_{nf} = 16\eta P/\pi D^2$ |
| Transition | $R_{nf} \leq R_t \leq R_{ff}$ | $S_t = S_{nf} R_{nf}/R$ |
| Far-Field | $R_{ff} = 0.6D^2/\lambda$ | $S_{ff} = PG/4\pi R^2$ |

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
$\lambda$ = wavelengths in m
$\eta$= 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$^{o}$ |
| **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

 