

# **IEEE 1902.1 RuBee Electromagnetic Radiation Hazards to Personal, Fuel and other Flammable Material (HERF)**

## **RuBee Provides HERF-complaint, Wireless Visibility with a Zero Safe Separation Distance**

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## 1. Introduction

The RuBee protocol uses a full duplex 131 KHz data carrier with phase and amplitude modulated data communications. Due to the long wavelength, very little, if any, energy is dissipated at these low frequencies in the form of an electric field (**E**), and most radiated energy (99.99%) is in the form of a magnetic field (**H**). The RuBee tags, typically, require a minimum signal of 0.1 mGauss to a maximum of about 3 mGauss for reliable communication and transmit about 30-50 mGauss. The strongest field in direct contact with a typical RuBee loop antenna, with the strongest test antenna (a Ranger Antenna) is 600 mGauss and within one meter drops to about 20 mGauss. To help provide some context for these values, the earth's magnetic field is 300-600 mGauss, a typical anti-theft system (EAS) seen in retail stores is 3,000 mGauss, and metal detectors seen in airports are 3,000 to 20,000 mGauss.

The same base station and Ranger Antenna emit maximum **E** power at a setting on the base station of Power 7, of 40 nano-watts ( $40 \times 10^{-9}$  Watts). To provide some context for these values, RFID systems are 1-4 Watts, a typical cell phone is 0.25-1 Watt, WiFi Zigbee and Bluetooth are 0.1-1 Watt and RuBee is 0.0000000040 Watts. At Power 7 a RuBee base station and standard antenna meets US Federal Communications Commission Part B (see reference 11). RuBee has no EMC or EMI issues with electronic equipment or known international licensing issues (see reference 2,4,5 and 6).

Explosives Fuel and Humans all share the same heating risks when exposed to RF energy (see reference 10). Explosives, Fuel and Flammables can all be heated and accidentally ignited by **E** fields. Exposure to **E** fields can also lead to heat related risks of cataracts, tissue damage and other medical problems again because of its ability heat liquids and human tissue similar to a microwave oven. However, magnetic **H** fields do not have the ability to heat, cause tissue damage or accidentally ignite flammables. Magnetic Resonance Imaging (MRI) has been in use for three decades. MRI uses very strong (1-2 Tesla) magnetic fields about 1.5 million times Power 7 on a RuBee base stations. In three decades and 400 million scans no one has ever reported any MRI tissue damage or heating.

The **E** fields produced by RuBee base stations and antennas are so small they are difficult measure and they pose no hazard to explosives, fuels, flammables or humans. The Safe Separation Distance or SSD, for an antenna and base station is the distance from an antenna to flammable substance and is typically given in meters or feet. In 2011 the US Department of Energy (DoE) published a report based on a one year Sandia Lab study, stating that RuBee has a zero Safe Separation Distance on explosives and on nuclear weapons (see reference 7). We provide detailed results below with additional RF and EMI tests and references in this document. A summary table providing Safe Separation Distance from any RuBee antenna connected to a base station set to Power 7 to any explosive, fuel, flammable or human with reference standard tests is shown below.

Safety Test	RuBee Power	Safe Separation Distance (SSD)	Standard
Fuel	7	.024"	NAVSEA 3565 16-1-529
Explosives	7	.0062"	NAVSEA 385-64, DoE
Humans	7	0"	IEEE C95.1, FDA

## 2. HERF SSD Intrinsic Safety

Electromagnetic Radiation Hazards to Personal, Fuel and other Flammable Material or HERF specifies the Safe Separation Distance (SSD) for any RF emitting device from fuel and flammable liquids. RuBee at power 7 effectively has a zero SSD for fuels based on NAVSEA OP 3565/NAVAIR 16-1-529 Volume 1 Technical Manual, for fuel and other flammable materials (see reference 11). The primary reference from that document is shown in table below.

**NAVSEA OP 3565/NAVAIR 16-1-529  
VOLUME 1 SIXTH REVISION**

The following equation may be used to calculate the separation distance required to achieve a power density equivalent to that existing 50 feet from an antenna radiating 250 watts (equivalent to 0.009 mW/cm<sup>2</sup> or 0.09 W/m<sup>2</sup>).

$$D = \sqrt{\frac{PG}{4\pi PD}} = \frac{\sqrt{PG}}{1.06}$$

where:

- D = distance (meters),
- P = peak transmitter power (watts),
- G = antenna gain ratio =  $(10^{\frac{\text{antenna gain (in dBi)}}{10}})$ ,
- $\pi$  = numeric value of 3.14159 (pi),
- PD = desired power density (in W/m<sup>2</sup>) = 0.09 W/m<sup>2</sup>.

**Example**

Calculate how far an antenna for the AN/URC-131 transmitter (2-30 MHz) must be from the fueling area to ensure that the power density in the fueling area does not exceed 0.09 W/m<sup>2</sup>. A greater separation distance will provide an increased margin of safety.

- P = 1,000 watts
- Antenna Gain = 2.1 dBi
- antenna gain ratio =  $(10^{\frac{2.1}{10}}) = (10^{0.21}) = 1.62$

$$D = \frac{\sqrt{1,000(1.62)}}{1.06}$$

$$D = \frac{\sqrt{1620}}{1.06}$$

$$D = \frac{40.25}{1.06} = 37.9 \text{ meters} \times 3.28 = 124.5 \text{ feet}$$

FIGURE 6-4. HERF Safe Separation Distance Calculation for MOGAS/AVGAS  
(Communication Systems Below 225 MHz)

When calculated with formula shown in 3565, RuBee Power 7 emissions where  $P = 40 \times 10^{-9}$  Watts,  $G = 1.0$  the SSD or  $D$  is equal to .024 inches or 0.63mm. The SDD is greater than the insulation on the antenna so HERF SSD is effectively zero, and pose no HERF risk.

### 3. Explosives SSD Intrinsic Safety

The US Department of Army Manual 385-64 specifies the Safe Separation Distance (SSD) formula for any RF emitting device from passive explosives. The primary reference from that document is shown in table below.

Department of the Army  
Pamphlet 385-64

UN-SHIELDED MUNITIONS		SHIELDED MUNITIONS	
UP TO 2.3 KHz	$D = 0.093\sqrt{PG}$	UP TO 73 KHz	$D = 0.093\sqrt{PG}$
2.3 KHz to 450 KHz	$D = 39.7F\sqrt{PG}$	73 KHz to 450 KHz	$D = 1.26F\sqrt{PG}$
450 KHz to 400 MHz	$D = 18\sqrt{PG}$	450 KHz to 400 MHz	$D = 0.6\sqrt{PG}$
400 MHz to 75,000 MHz	$D = \frac{7137}{F}\sqrt{PG}$	400 MHz to 2,400 MHz	$D = \frac{226}{F}\sqrt{PG}$
ABOVE 75,000MHz	$D = 0.093\sqrt{PG}$	ABOVE 2,400 MHz	$D = 0.093\sqrt{PG}$

Safety

# Ammunition and Explosives Safety Standards

Notes:

- 1 Variables:
- 2 D=Safe separation distance to transmitter in feet.
- 3 P=Output power to transmitter in Watts.
- 4 G=Numerical gain of transmitter antenna.
- 5 F=Frequency in MHz.

When calculated for 2.3Khz to 450 KHz with RuBee Power 7 RF emissions where  $P = 40 \times 10^{-9}$  Watts,  $G = 1.0$ ,  $F$  is 0.131 Mhz the SSD or  $D$  is equal to .0062 inches or 0.157mm. The SDD is greater than the insulation on the antenna so Explosive SSD is effectively zero, and pose no Explosive risk. This is consistent with the independent US Department of Energy study that also concluded RuBee has a zero SSD for Explosives (see reference 7).

#### 4. IEC-60079 International Explosive Standard

IEC 60079 (14) specifies the general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres. The standard atmospheric conditions (relating to the explosion characteristics of the atmosphere) under which it may be assumed that electrical equipment can be operated are:

- temperature  $-20\text{ }^{\circ}\text{C}$  to  $+60\text{ }^{\circ}\text{C}$ ;
- pressure 80 kPa (0,8 bar) to 110 kPa (1,1 bar); and
- air with normal oxygen content, typically 21 % v/v.

This standard and other standards supplementing this standard specify additional test requirements for equipment operating outside the standard temperature range, but further additional consideration and additional testing may be required for equipment operating outside the standard atmospheric pressure range and standard oxygen content, particularly with respect to types of protection that depend on quenching of a flame such as ‘flameproof enclosure “d”’ (IEC 60079-1) or limitation of energy, ‘intrinsic safety “i”’ (IEC 60079-11).

**Table 5 – Radio-frequency energy thresholds**

Equipment for	Threshold energy $Z_{th}$ $\mu\text{J}$
Group I	1 500
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1 500

Table 5 from the IEC-60079 is shown above. The Standard specifies that category IIC is the highest risk explosive environment, with pure Hydrogen. The IIC RF energy limit is  $50\text{e-}6$  Joules. RuBee produces  $40\text{e-}9$  watts of RF and each packet is 120 msec. That represents  $4.8\text{e-}9$  Joules or about 10,000 times below the IEC-60079 most hazardous condition limit.

## 5. Human Safety

Providing the RuBee antennas and base stations are installed and certified by Visible Assets, Inc., they produce about 600 mGauss maximum magnetic power and  $40 \times 10^{-9}$  radiated watts (40 nano-watts). These values are many orders of magnitude below IEEE C95.1 human safety power limits for 131Khz, and are considered human safe by all OSHA standards for human exposure of RF. These systems have no known untoward effects on pacemakers or ICD's. (see references 2 and 6). RuBee has been approved by the FDA for safe use in operating rooms (see reference 1). Detailed white papers are available summarizing all RuBee and RF Human safety issues (see reference. 12 1nd 13).

## 6. Conclusion

Both outside independent tests, data review and calculations based on universal standards (see reference 1, 7, 8,10) show that RuBee base stations and tags produce insufficient **E** field to pose any HERF risk and have a zero Safe Separation Distance near Fuels, Explosives Flammables and Humans.

## 7. About Visible Assets, Inc. and RuBee

Visible Assets, Inc. (**Visible**®) sells integrated asset visibility and security networks based on a unique wireless technology known as RuBee®. The RuBee protocol became an IEEE standard in 2009 (IEEE 1902.1). RuBee is similar to WiFi, except it has been specifically designed for asset visibility and asset security, not high-speed data communication. RuBee uses magnetic waves, not radio frequency (RF) waves. This means it is not affected by water and signals can be enhanced on steel. RuBee is the only wireless technology ever to be approved for use in secure areas, and on Nuclear Weapons by the US Department of Energy. RuBee provides Three-Layer Security and asset visibility even in harsh environments. RuBee visibility networks and products (Armory 20/20, Asset 20/20) are installed in some of the most secure sites within the US and Mid-East, where RF wireless systems are banned (e.g. WiFi, Bluetooth, ZigBee, and RFID), managing mission critical, secure assets. Visible owns RuBee technology, and has extensive patent protection (36 US issued patents, and 110 US/PCT pending). Visible licenses RuBee for non-security applications. (see [www.rubee.com/VIS](http://www.rubee.com/VIS) for corporate information).

## 8. References

1. *FDA Letter of Approval*, July 2006 (<http://www.rubee.com/White-SEC/FDALetter.pdf>)
2. *Electromagnetic Interference (EMI) and Compatibility of an Active 131 KHz Radio Tag (RuBee, IEEE P1902.1) with Pacemakers (PM) and ICDs*. David L. Hayes, MD\*, George Eisinger, Linda Hyberger\*, John K. Stevens, PhD\*\*. Mayo Clinic, Rochester MN\* and Visible Assets, Inc, Stratham NH,\*\*. *Heart Rhythm* 2007; 4:S398 (<http://www.rubee.com/White-SEC/MayoFinal.pdf>)
3. *Visible Assets, Inc. GateGuard Acceptance Test* Monday, August 2, 2010, Version 1-4 (<http://www.rubee.com/White-SEC/GateGuard-AT-010710V1-4.pdf>)
4. *TCG NEBS Compliance Report*, MET Laboratories Baltimore MD, August 2008. (<http://www.rubee.com/White-SEC/EMC-NEB.pdf>)
5. *Sig SAUER Test of P226 Handguns and RuBee GripTags MIL STD 810G*, Packer Engineering, September 2008. (<http://www.rubee.com/White-SEC/SIG-810GV1-1.pdf>)
6. *Electromagnetic Interference from Auto Identification Systems May be Diminished Using IEEE 1902.1, A Low Frequency, Magnetic Field Based Protocol*, in *Healthcare Settings*, Suraj Kapa, MD 1, Timothy Pierce, BIEN, David L. Hayes, MD, David R. Holmes, Jr., MD, Samuel J. Asirvatham, MD 3,4, 1 Department of Medicine, Mayo Clinic, Rochester, MN US 2 Visible Assets, Inc., Division of Cardiovascular Diseases, Department of Medicine, Mayo Clinic, Rochester, MN USA 4 Division of Pediatric Cardiology, Department of Pediatrics and Adolescent Medicine, Mayo Clinic, Rochester, MN USA (<http://www.rubee.com/White-SEC/EMI-OR-MayoV1-4.pdf>)
7. *Advanced Inventory and Materials Management at Pantex*. Leesa L. Duckworth, B&W Pantex LLC Amarillo TX, June 2011. (<http://www.rubee.com/pantex>)
8. *Ammunition and Explosive Safety Standards*, Document 385-64, Headquarters of the Army, May 2011. ([http://www.va-i.com/Vis-SEC/Work/Projects/HERO/Ref/p385\\_64.pdf](http://www.va-i.com/Vis-SEC/Work/Projects/HERO/Ref/p385_64.pdf))
9. *Electromagnetic Environmental Effects Requirements For Systems*, MIL-STD-464C, October 1, 2010, U.S. Department of Defense Interface Standard. (<http://www.va-i.com/Vis-SEC/Work/Projects/HERO/Ref/MIL-STD-464C.pdf>).
10. *Electromagnetic Radiation Hazards to Personal, Fuel and other Flammable Material (Doc NAVSEA OP 3565/NAVAIR 16-1-529 Volume 1* <http://www.va-i.com/Vis-SEC/Work/Projects/HERO/Ref/navsearadiationdanger.pdf>)
11. *RuBee Part 15 FCC Lab Report* <http://www.va-i.com/Corp-SEC/Legal/FCC-PartB/Part15Report.pdf>
12. *The Visible Assets, Inc. RuBee™ IV Visibility Network: Electromagnetic Interference, Electromagnetic Compatibility and Safety Issues*. 2006 Visible Assets White Paper, <http://www.va-i.com/Vis-SEC/Work/Safety/Safety-91306V3-15c.pdf>
13. *Suggested RF-ID EMI EMC and Safety Standards*. 2007 Visible Assets White Paper <file://localhost/http://www.va-i.com/Vis-SEC/Work/Safety:WP-SafeV1-7c copy.pdf>
14. *IEC 60079-0, Edition 6.0 2011-06, Explosive Atmospheres General Equipment Requirements*.