

# RF/MW QUICK REFERENCE SHEET

This document was developed by the AIHA NIR Committee. The intent is to provide general information to practicing Industrial Hygienists on NIR topics and to determine next steps for assessing and controlling NIR hazards. For additional, detailed information please refer to the reference section.

**Characteristics** – Electromagnetic energy in the region between 30 kHz and 300 GHz, with wavelengths between 100 kilometers and 1 mm (Microwave radiation is a subset of RF), characterized by both frequency and wavelength; also known as radiofrequency radiation (RFR).

## **Units of Measure:**

Electric Field Strength	V/m, V <sup>2</sup> /m <sup>2</sup>	E
Magnetic Field Strength	A/m; A <sup>2</sup> /m <sup>2</sup>	H
Power Density	W/m <sup>2</sup> ; mW/cm <sup>2</sup>	S, PD
Specific Absorption Rate	W/kg	SAR

**Significant Sources:** (note: sources are not limited to those listed) Intentional radiators (i.e. with antennas): Navigation, time signals, AM, FM, and TV broadcasting, communications satellites, satellite television, RFID, weather radio, radio astronomy, mobile phones, wireless LAN, Bluetooth, GPS, microwave ovens and two way radios (land mobile, marine mobile, amateur radio, CB radio, radar. Unintentional radiators (leakage fields): examples are microwave heating units (e.g., ovens), dielectric heaters, medical diathermy, and induction heaters.

**Exposure Guidelines:** The guidelines from the ACGIH are given in the table at the end of the document for 6 minute averaging times.

**Biological effects:** Adverse effects in this wavelength and frequency region are thermal (heating of body tissues) plus RF shocks and burns. Reversible behavior disruption, a thermal effect, is the biological basis for the exposure limits. Non-thermal effects have been proposed and are under study. IARC classifies RFR as a category 2B carcinogen (possible human carcinogen) based primarily on epidemiology studies of brain cancer (glioma) in cell phone users. Biological effects are related to the specific absorption rate (SAR) measured in watts per kilogram (W/kg) in tissue in the frequency range between 100 kHz and 3 GHz, according to the IEEE. The SAR for a given sized subject (animal or human) varies dramatically with the frequency of the incident radiation and there is a resonant frequency band where absorption is greatest for each biological object. Thus the exposure guidelines will vary by frequency. The exposure guides from the ACGIH and IEEE reflect the electric and magnetic field strengths that will maintain the SAR below harmful levels. The resonance region (~30 to 300 MHz) is where the length of the human body is close to the half-wavelength. Absorption of electromagnetic energy is optimized in the resonance region. Induced and contact currents: An RF field can produce alternating electric potentials on ungrounded conducting objects. A person touching such an object will be subjected to an RF current flowing to ground. This is called contact current. The body can also be that (conducting) object in which a current is induced by the field. This is known as an induced body current. These effects are seen at low RF frequencies.

**Exposure Assessment -** Potential exposure may be calculated, measured or both. Information can be collected to allow numerical modeling exposure around antennas before measurement surveys are performed. Leakage sources have to be measured which may involve spatial averaging and time averaging data, per requirements of

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the exposure guidelines. Near field exposures (typically, frequencies less than 300 MHz) may require measurement of both E Field and H fields. Surveys may involve sources emitting over a broad spectral region. Hence, most evaluations utilize broadband instruments. Contact and induced current measurements may be necessary at frequencies less than 110MHz.

**Exposure Controls** - Engineering controls include shielding and using interlocks as applicable; filtering, and waveguides below cutoff. RF protective clothing may be used in antenna farms, and nonconductive gloves or shoes may be used to help control contact currents or induced currents, at  $f < 110\text{MHz}$ . Administrative controls include RF safety training, increasing distance, controlling exposure time, restricting access, and using warning signs. A comprehensive RF safety program is recommended for workplaces with exposures above the safety guidelines.

**Other:** Conductive body implants or eyewear with conductive frames can localize exposures. RFR may affect medical electronic devices and can activate explosive devices or create hazards from ignition of flammable materials.

**Radiofrequency and Microwave TLVs Electromagnetic Fields (f=frequency in MHz)**

Frequency	Power Density, S (W/m <sup>2</sup> )	Electric Field Strength E (V/m)	Magnetic Field Strength H (A/m)
30 kHz-100 kHz		1842	163
100 kHz-1 MHz		1842	16.3/f
1 MHz-30 MHz		1842/f	16.3/f
30 MHz-100 MHz		61.4	16.3/f
100 MHz-300 MHz	10	61.4	0.163
300 MHz-3 GHz	f/30		
3 GHz-30 GHz	100		
30 GHz-300 GHz	100		

## References and websites for further information

American Conference of Governmental Industrial Hygienists (ACGIH): Radiofrequency and Microwave Radiation TLV Documentation (2010)

IEEE Standard C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3kHz to 300 GHz <http://standards.ieee.org/findstds/standard/C95.1-2005.html> IEEE Standard C95.7, IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz

Baan R, et al. on behalf of the WHO International Agency for Research on Cancer Monograph Working Group. 2011. Carcinogenicity of radiofrequency electromagnetic fields. Lancet Oncology 12: 624-626.

R.Timothy Hitchcock Radio-frequency and Microwave Radiation, Third Edition, AIHA Nonionizing Radiation Committee, AIHA, 2004

<http://www.osha.gov/SLTC/radiofrequencyradiation/> OSHA's site has a wealth of information on exposures to NIR

<http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08511.html>-The Canadian standard  
<http://transition.fcc.gov/oet/rfsafety/> The FCC RF Safety website