Non-Ionizing Radiation

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Non-Ionizing radiation is energy in the Electromagnetic Spectrum that does not strip electrons from atoms and molecules. This Loss Prevention Data Guide is an overview of Non-ionizing radiation in the radio frequency (RF) spectrum.

- Radiation energy comes from a source and travels through a material or through space in the form of waves or particles as in light, heat and sound.
- Electromagnetic "radiation" is a wave of electric and magnetic energy moving together (i.e. radiating) through space. Examples include ultra-violet, visible light, infrared, microwaves, radio/television and electrical power lines.
- Radiofrequency (RF) energy is described in terms of the electric and/or magnetic field strength at a given location and is characterized by wavelength and frequency. The RF portion of the Electromagnetic Spectrum where electromagnetic waves have frequencies is in the ranges from about 3 kilohertz (kHz) to 300 gigahertz (GHz).
- The two basic sources of RF Energy are:
    1. Telecommunications, such as radio and television broadcasting, cellular telephones, pagers, cordless telephones, two way radios, amateur radio, microwave point-to-point radio links, satellite communications and personal communications services.
    2. Non-communications, such as microwave ovens and radar are other sources. Industries use RF devices for plastic molding, gluing, sealing objects and food processing. Medical uses include diathermy-heating tissue below the surface.

Public and industrial interest in the long-term biological/health effects from exposures to non-ionizing radiation is considerable. Results from low-level RF energy epidemiologic studies have been inconsistent and mechanisms, particularly at the cellular level, are poorly understood. In addressing critical non-ionizing radiation questions, investigators have conducted research in various fields and some areas, like those involving the use of cellular phones and the potential risk of brain cancer incidence have become media and legal issues.

Health effects from high exposure levels of non-ionizing radiation arise from heat generation in body tissue. Worldwide, scientists are conducting research looking into other potential health effects, many of which are ongoing. In spite of this, less is known about non-ionizing radiation than about ionizing radiation. Most of the health effects that have been observed occur at much higher levels than those to which most people are exposed.

A biological effect is a safety hazard when it "causes detectable impairment of the health of the individual or his/her offspring." Biological effects are caused from heating internal organs/tissues by RF energy, thermal effects. The extent of

heating depends on radiation frequency, duration of exposure and efficiency of heat dissipation. Human tissue damage can occur from exposure to high levels of RF energy. Excessive RF exposure is serious because affected internal organs have no nerves to warn of the exposure.

Two body areas particularly vulnerable are the eyes and testes. There can be an increase in temperature where an individual feels sick. Other RF body symptoms may include listlessness and/or confusion, dizziness/vertigo, headache, blurred vision, a bad taste or nausea. Burns to the body from touching highly energized sources are also possible. Contact with a high power, low frequency emitter or contact with nearby metal objects can cause "contact induced current" burns to the skin or internal body parts.

The FCC authorizes and licenses all devices, transmitters and facilities generating RF radiation. FCC policies ensure that RF transmitters do not expose the public or workers to harmful levels of RF radiation according to the Maximum Permissible Exposure (MPE) law adopted in 1996. Any environmental assessment must consider human exposure to RF radiation. Guidelines for compliance and whether a company must comply with FCC are found in FCC OET Bulletin 65. The National Environmental Policy Act (NEPA) of 1969 requires all Federal Agencies to evaluate the effects of their actions on the quality of the human environment, including RF radiation exposure.

Regulatory compliance responsibility primarily rests with the employer or property owner or the company controlling access to an RF source. There may be dual responsibility when a building owner leases rooftop space for RF transmitting antennas. The building owner controls access to the roof and the antenna owner/employer must advise of any RF exposure.

The MPE law establishes safety standards both for employees (controlled area) and the general population (uncontrolled area). The difference in acceptable levels is based on the premise that employees are aware of their exposure and have the knowledge and means to control exposure effectively verses the greater potential for continuous exposure on the part of the public. Exposure is expressed in terms of electric and magnetic field strength and power density for RF transmitters operating at frequencies from 300 kHz to 100 GHz.

For safety purposes, RF transmitters require regular site MPE evaluation/ environmental assessments. A third party expert should be consulted for regulatory compliance.

- If the RF exposure is below MPE Law, no further action is needed. You must retain written record and evaluate periodically or when there are changes.
- If the RF exposure exceeds MPE Law controlled/uncontrolled, you must conduct Environmental Assessment with site measurements. Following that, RF exposure must be reduced below MPE Law and or a written safety plan must be prepared, secure access must be provided, along with required signs, employee training and periodic monitoring. RF ground level sites should be enclosed with a 6' high fence and have a locked access gate with required signage. Other safety items: lockout/tag out, personal alarm, administrative controls and personal protective clothing.

The OSHA action level criteria use the MPE Law for uncontrolled exposure levels. Employees should be trained in RF safety, provided with applicable personal protective equipment, lock out training provided, and provided with a personal monitoring device. OSHA recognizes RF as a physical hazard for

general industry, telecommunications and construction industries. But OSHA standards are incomplete. Safety violations are often cited under the General Duty Clause, "employers shall provide work which is free from recognized hazards that are causing or likely to cause death or serious physical harm." Other agencies like the Federal Aviation Administration (FAA) or U.S. Food and Drug Administration (FDA) may also become involved if there are RF violations.

Required Signage for an RF Site

- **FCC Registration Number** is printed on white background with black lettering and numbers.
- **Notice** is blue with black lettering and posted at the entry point to a location that may exceed the uncontrolled exposure limit and/or the OSHA action limit.
- **Caution** is yellow with black lettering in areas where RF emissions exceed the uncontrolled exposure limit and/or the OSHA action limit. Employees in this area should have RF safety training.
- **Warning** is red with black lettering in areas where RF emissions exceed controlled exposure limit. Employees entering the area should have RF safety training.
- **Contact or Induced current** is red with black lettering in areas where the potential for contact/induced current or electrical burns exists. Employees entering the area should have RF safety training and follow lockout procedures.

Useful Definitions

Categorically excluded from the requirement for routine evaluation when the RF source is low-powered, intermittent, or inaccessible.

Controlled RF exposure is the maximum RF exposure levels for those persons who are fully aware of their exposure potential and can exercise control of their exposure. This applies to employees working in the RF exposure.

Electromagnetic radiation (EMR) are waves of electric and magnetic energy radiating through space and can be characterized by a wavelength and a frequency. The wavelength is the distance covered by one complete electromagnetic wave cycle. The frequency is the number of electromagnetic waves passing a given point in one second.

- **Hertz (Hz)** is the unit for expressing frequency.
  (a) One hertz equals one cycle per second.
  (b) One kilohertz (kHz) = one thousand hertz.
  (c) One megahertz (MHz) = one million hertz.
  (d) One gigahertz (GHz) = on billion hertz.

Environmental Assessment (EA) determines if the RF radiation will have a significant impact on the environment and evaluate exposure hazards.

Far-field refers to more than several wavelengths distance from a typical RF source and where the electric and magnetic components of the electromagnetic wave are in a right angle relationships or orthogonal.

Maximum Permissible Exposure (MPE) is the FCC standard for human exposure to RF radiation.

Near-field refers to close proximity to an RF source where the electric and magnetic components of the electromagnetic wave are in an undefined state, not an orthogonal relationship.

Radiofrequency radiation (RF) relates to electromagnetic waves with frequencies in the range of about 3 kilohertz to 300 gigahertz. RF field can be described in terms of the electric and/or magnetic field strength at that location.

- **Radiation** is the propagation of energy through space in the form of waves or particles.
- **Volts per meter (V/m)** used to measure field strength of the electric field.
- **Amperes per meter (A/m)** is used to express the strength of the magnetic field.
- **Power density** expressed in terms of milliwatts per square centimeter (mW/cm2). Used when point of measurement is more than several wavelengths distance from the RF source, referred as "far-field."

Specific-absorption rate (SAR) measures the rate of energy that is absorbed, or dissipated in tissue mass and is usually expressed in watts per kilogram (W/g) or milliwatts per kilogram (mW/kg). SAR is at maximum, whole-body RF absorption, in the "far-field" for an average adult when the frequency of RF radiation is between about 80 and 100 MHz. The most restrictive limits on exposure, MPE, are in this frequency range.

Uncontrolled RF exposure is the maximum RF exposure levels for those persons that are not fully aware of their exposure potential and cannot exercise control of their exposure. This applies to the public and workers with no RF training.

References

American National Standards Institute (ANSI), www.ansi.org
Environmental Protection Agency (EPA)
Federal Aviation Association (FAA)
Federal Communication Commission (FCC), www.fcc.gov/oet/rfsafety
Office of Engineering and Technology (OET)
Institute of Electrical and Electronics Engineers (IEEE), www.ieee.org
National Council on Radiation Protection and Measurements (NCRP), www.ncrp.com
National Environmental Policy Act (NEPA)
Occupational Safety and Health Administration (OSHA), www.osha.gov
U.S. Food and Drug Administration