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Non-Ionizing Radiation Safety

Effective: September 2000

Vice-President, Finance and Administration

Applicable Legislation:

Occupational Health and Safety Act (OHSA), Sections 25(2)h, 27(2)c

Relevant Standards:

Safety Code 6, *Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz*. **Radiation** Protection Bureau, Health Canada, 1999.

International Commission on Non-Ionizing **Radiation** Protection. *Guidelines on Limits of Exposure to Static Magnetic Fields*. Health Physics, 66:100-106, 1994.

International Commission on Non-Ionizing **Radiation** Protection. *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields*. Health Physics, 58:113-122, 1990.

International Commission on Non-Ionizing **Radiation** Protection. *Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields up to 300 GHz.* Health Physics, 74:494-522, 1998.

International Commission on Non-Ionizing **Radiation** Protection. *Guidelines on Limits of Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 100 kHz* to 300 GHz. Health Physics, 54:115-123, 1988.

International Commission on Non-Ionizing **Radiation** Protection. *Interim Guidelines on Limits of Human Exposure to Airborne Ultrasound, (20 kHz to 100 kHz).* Health Physics, 46:969-974, 1984.

International Commission on Non-Ionizing **Radiation** Protection. *Guidelines on Limits of Exposure to Broad-Band Incoherent Optical* **Radiation** (0.38 to 3 Fm). Health Physics, 73:539-554, 1997.

American Conference of Governmental Industrial Hygienists. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, 1999.* ACGIH, Cincinnati, OH.

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Intent:	To summarize University requirements regarding the safe management and use of non-ionizing radiation sources, and to ensure health protection, workplace safety, and regulatory compliance.	
Definitions:		
antenna	a transmitter or receiver of electromagnetic rad	liation.
electric field	a vector field E measured in volts per metre (V	//m).
EMF	refers to electric, magnetic fields, and electrom	agnetic fields.
exposure metric	a single number which summarizes an electric a exposure.	and/or magnetic field
extremely low frequency (ELF)	non-ionizing electromagnetic radiation ; descri electromagnetic spectrum from 3Hz to 300 Hz.	bes the
frequency	the number of sinusoidal cycles completed by e in one second; expressed in hertz (Hz).	electromagnetic waves
magnetic field	refers to the H field measured in Tesla (T) or to measured in ampere per metre (A/m); both field essentially interchangeable in studies concernin	the B field d quantities are ng health effects.
microwave radiation (MW)	non-ionizing electromagnetic radiation ; descri electromagnetic spectrum from 300 MHz to 30	bes the 0 GHz.
non-ionizing	radiation or fields that have insufficient energy molecules; typically, photon energies are less the	y to ionize water han 12.4 eV;

radiation	describes the electromagnetic spectrum from sub-ELF (1 Hz) to the visible (3 x 10 15 Hz).
power density	the power of the radiation arriving at a surface divided by the cross- sectional area of the surface; time average energy flow; measured in watt per metre 2 (W/m ²).
power frequency	the frequency at which AC electricity is generated, 60 Hz in North America.
radio frequency radiation (RF)	non-ionizing electromagnetic radiation characterized by long wavelength, low frequency, and low photon energy; describes the electromagnetic spectrum from 3 kHz to 300 GHz.

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	specific absorption rate (SAR)	the mass-normalized rate of energy absorption or RF of fundamental quantity of the exposure criteria for the s from about 3 MHz to 6 GHz; measured in watt per kil (W/kg).	lose rate; the pectral region ogram	
	wavelength	the distance between two successive points of a period direction of propagation, at which the oscillation has t	lic wave in the he same phase.	
	Requirements of the Occupational Health and Safety Act, Sections 25(2)h, 27(2)c			
	25.(2)h	An employer shall take every precaution reasonable in circumstances for the protection of a worker.	n the	
	27.(2)c	A supervisor shall take every precaution reasonable in circumstances for the protection of a worker.	<i>i the</i>	

Policy:

- 1. Occupational exposures to non-ionizing **radiation** shall be kept as low as reasonably achievable (ALARA).
- 2. Technical protective measures such as engineered controls shall be applied to the

source of the non-ionizing radiation.

- 3. Operational protective measures such as administrative controls, including source use authorization, shall be implemented as appropriate for the emitter.
- 4. Controlled, restricted or forbidden areas near emitters shall be delineated, posted, and secured.
- 5. Source-specific safety instructions shall be developed and implemented.
- 6. Potentially exposed personnel shall be provided training about the safe use of an emitter or safe work procedures near an emitter, and shall be informed about any appropriate health protection precautions.
- 7. Personnel involved with non-ionizing **radiation** sources or emitters shall contact Environmental Health and Safety to identify appropriate limits for occupational exposures and to discuss controls and protective measures.

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 Guidelines:
 Guidelines:
 The Non-Ionizing Spectrum

 Non-ionizing radiations (NIR) encompass the long wavelength (> 100 nm), low photon energy (< 12.4 eV) portion of the electromagnetic spectrum, from 1 Hz to 3 x 10</td>
 ¹⁵ Hz.

 Except for the narrow visible region, NIR is unperceived by any of the human senses unless its intensity is so great that it is felt as heat. The ability of non-ionizing radiation to penetrate the human body, the sites of absorption, and the subsequent health hazards are very much wavelength (frequency) dependant.
 ¹⁵ Hz.

 The NIR part of the electromagnetic spectrum is divided into four approximate regions:
 The NIR part of the electromagnetic spectrum is divided into four approximate regions:

static electric and magnetic fields, 0 Hz;
extremely low frequency (ELF) fields, >0 Hz to 300 Hz;

- radiofrequency (RF) and microwave (MW) radiation, 300 Hz to 300 GHz;
- optical radiations: infrared (IR) visible ultraviolet (UV) 100 - 400 nanometres (nm)

(Ionizing radiations, with wavelengths less than 100 nm, constitute the high photon energy portion of the electromagnetic spectrum.)

Radiation Sources and Exposures

Occupational exposures to **NIR** can arise from numerous man-made sources. Ultraviolet **radiation** (UVR) from mercury and zenon-arc lamps is used for sterilizing equipment and air. Corneal injuries and potential damage to the **skin** can arise from excessive exposures. Sources of intense incoherent visible light (incandescent, gas discharge, and high intensity discharge lamps, welding arcs, etc.), are too bright for unprotected eyes, and certain wavelengths may damage **skin**. Natural aversions to bright light and thermal pain help to alert us to take precautions. Exposure to infrared **radiation** can arise from industrial, domestic, and natural heat sources. The body's biological warning system is generally efficient, but thermal protective clothing and special eye protection are necessary for certain occupations (e.g. in the glass and steel industries). The use of lasers (coherent **radiation**) in research and industry is expanding and presents potential risks for eye and **skin** exposures when engineered protection and personal precautions are not adequate.

Uses of microwave (MW) and radiofrequency (RF) **radiation** for heating, television and radio broadcasting, satellite communication facilities, mobile transmitters, radar, and research and development may present activity-specific occupational hazards which are usually evaluated as near field (i.e. within one wavelength), single source exposure situations. Athermal biological effects are associated with induction currents in irradiated tissues that may or may not manifest as detectable impairments. Prolonged thermal stress is known to cause hematologic and immunologic change. Shocks and burns are acute

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effects that may be possible in higher frequency fields. Safety measures involve engineered controls (e.g. interlocking, switching, filtering, grounding), isolating or shielding the source, wearing RF-protective clothing, and using administrative controls such as warning signs, zoning, restricting access, and limiting exposure time. Ultrasound has widespread uses in industry (20-50 kHz) and medicine (1-15 MHz), though personal non-medical exposures are usually accidental or incidental to purpose.

Potential adverse consequences, if any, might arise from the thermal and mechanical bioeffects of ultrasound. Exposures to ELF occur primarily due to the generation, transmission and uses of electrical energy. ELF electromagnetic fields are known to cause biological (enzymatic) effects, but the implications for human health have yet to be elucidated. Occupational exposures to static magnetic fields (e.g. related to uses of magnetic resonance imaging or magnetic levitation) are associated with no known

irreversible health effects.

Biological Effects and Protection Standards

The nature, extent, and physiological importance of biological effects from **NIR** exposures will depend on many factors such as the energy of the incident **radiation** (which determines the **penetration depth**), the power density of the field or beam, source emission characteristics, duration of exposure, environmental conditions, and the spacial orientation and biological characteristics of the irradiated tissues (molecular composition, blood flow, pigmentation, functional importance, etc.). In the lower frequency range (300 Hz to 1 MHz), induction currents may interfere with the functioning of the central nervous system. In the intermediate frequency range (100 kHz to 10 GHz), the absorption of electromagnetic energy generates heat. At the upper frequency range of 10 GHz to 300 GHz, heating of superficial tissues is possible. It is generally recognized that, except for optical **radiation**, there is scant data on the quantitative relationships between exposures to different types of **NIR** and pathological responses in humans.

The health protection standards for **NIR** from different authorities apply in general to characteristic parameters of the **radiation** field at the point in space where the individual can be or is exposed. They are based on biophysical models and on laboratory and field observations of the biological effects of electric and magnetic fields. The standards are *limits* for field parameters (e.g. to limit current density, SAR, and power density) which are designed to protect workers from potentially adverse effects of electromagnetic **radiation** and to permit the general use of **NIR** under safe conditions, though there is no precise boundary between risk and no risk Equipment standards for the design, construction and performance of **NIR** devices used for industrial, scientific, medical, and home applications also protect workers and the public from unacceptable exposures. Occupational exposure situations must be evaluated individually for risks and benefits. Normally, only a very small number of people would ever be occupationally exposed to levels comparable to the exposure limits.

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Contact Environmental Health and Safety to obtain general advice about source controls and exposure management, and for details about health protection limits for the various types of non-ionizing radiations encountered in University workplaces.

References

Internet sites offer further information about non-ionizing radiation and non-ionizing

radiation protection:

Radiation Protection Bureau, Health Canada (Safety Code 6): http://www.hc-sc.gc.ca/.

World Health Organization (WHO), International Commission on Non-Ionizing Radiation Protection: www.who.int/peh-emf/ www.who.int/peh-emf/

www.who.int/peh-emf/related sites.htm

United Kingdom, National Radiological Protection Board: http://www.nrpb.org.uk/.

United States, Federal Communications Commission (FCC) RF Safety Program: www.fcc.gov/oet/rfsafety.

United States, National Institute of Environmental Health Sciences, EMF Research and Public Information Dissemination (RAPID) Program: www.niehs.nih.gov/emfrapid/home.htm.

Ultraviolet **Radiation** Exposure, Measurement and Protection: **www.ntp.org/uk/prodUV 87.html**

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