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CHAPTER 7.5 NON-IONIZING RADIATION PROTECTION

7.5.1. Applicability of this chapter

7.5.1.1 You are required to follow this chapter if you operate or supervise anyone who operates devices producing non-ionizing radiation. Non-ionizing radiation includes any of the following from the electromagnetic radiation spectrum:

- a. Laser radiation.
- b. Radiofrequency (RF) and microwave radiation.
- c. Radar.
- d. Ultraviolet (UV) radiation.
- e. Infrared (IR) radiation.
- f. Visible light and high-intensity lighting (HIL).

7.5.2. Hazards of non-ionizing radiation

Non-ionizing radiation is classified as a physical agent and can be harmful because it produces thermal and other effects with the potential to damage cells in the body. RF and microwave devices may cause these effects through electric and magnetic fields and induced currents. For more information on hazards from non-ionizing radiation, contact the JSC Radiation Safety Office.

7.5.3. Requirements for working with lasers

7.5.3.1 Operators of lasers or laser systems shall:

- a. Contact Radiological Health at x36726 or Email jsc-dl-occ-health@mail.nasa.gov for a laser hazard evaluation before purchasing, using, or modifying any laser, laser system, or equipment containing an embedded laser at JSC, Sonny Carter Training Facility (SCTF), or Ellington Field (EF). Submit a JSC Form 44B for Class 3B, or 4 laser systems. The JSC Laser Safety Officer (LSO) or designee will determine any documentation, approvals, engineering and administrative controls, personal protective equipment (PPE) and additional safety requirements and training necessary for the safe use of the laser or laser system.

NOTE: At WSTF, contact the LSO working for S&MA-WSTF before purchasing, using, or modifying a laser or a laser system.

- b. Follow these requirements:
 - (1) LIA/ANSI Z136.1.
 - (2) LIA/ANSI Z136.6.
 - (3) 21 CFR 1040.10, "Laser products."
 - (4) 21 CFR 1040.11, "Specific purposes of laser products."
 - (5) NPR 1800.1, Chapter 4.
- c. Never operate a laser unless certified to do so by the LSO.
- d. Know the hazards and hazard controls of each laser operated.

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- e. Before using any laser or laser system outdoors, contact JSC Radiological Health at x36726 or Email jsc-dl-occ-health@mail.nasa.gov for a laser hazard evaluation. LIA/ANSI Z136.6 provides guidance for safely using potentially hazardous lasers and laser systems (0.18 μm to 1 mm outdoors environment. Beams directed into airspace may require coordination with the Federal Aviation Administration (FAA) and possibly the U.S. Space Command Laser Clearinghouse.
- f. Tell all visitors in the area what the laser hazards are and what safety requirements they need to follow. Visitors shall also:
 - (1) Be under the direct supervision of at least one certified operator.
 - (2) Wear required protective equipment.

7.5.3.2 Training required for laser operations

- a. The JSC LSO determines what, if any, training and experience requirements are commensurate with the laser hazards at each facility. The JSC LSO designates all Area Laser Safety Officers (ALSOs) and certifies all laser operators (LOs). Training Categories are:
 - (1) **Laser operator.** The training and experience required for a certified LO may include, but is not limited to, the laser training topics as seen in LIA/ANSI Z136.1, “Safe Use of Lasers,” Appendix D6.2 (1). LOs are required to have initial training and refresher training every 2 years thereafter. The LO and the JSC LSO shall document the training and maintain records. The JSC LSO will issue a card to each laser operator certified.
 - (2) **Area laser safety officer.** The training and experience required for an ALSO may include, but is not limited to, the laser training topics in LIA/ANSI Z136.1, “Safe Use of Lasers,” Appendix D6.2 (1) and (2). ALSOs are required to have an initial 40 hours of classroom training and refresher training every 2 years thereafter. The ALSO and the JSC LSO shall document the training and maintain records.
 - (3) **Peripheral personnel (janitors, security, firefighters, waste handlers, etc.).** The ALSO and the LO are responsible for initial awareness-level laser safety training of peripheral personnel in their area such that they understand the laser hazards associated with their work area and are able to take appropriate actions to prevent unnecessary exposure.
- b. In addition to the above training categories and topics, certification, as described in Chapter 5.8, is required to operate a laser.

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7.5.3.3 Laser pointers

7.5.3.3.1 Laser pointers meeting all of these criteria are exempt from the requirements of this chapter:

- a. Do not exceed a maximum power level of 5 mW.
- b. Emit in the visible portion of the spectrum (0.4 to 0.7 μm).
- c. Have a beam diameter of less than 7 mm.
- d. Have a label indicating it is a Class 2 or Class 3a/IIIa/3R laser.
- e. Used only as a pointer.

7.5.4. Radio Frequency (RF) Radiation Safety

7.5.4.1 Users and organizations working with RF/microwave radiation devices shall:

- a. Contact Radio Frequency Radiological Health at x36726 or Email jsc-dl-occ-health@mail.nasa.gov for a radiation hazard evaluation before purchasing, bringing on site, using or modifying any RF radiation-producing devices. The JSC RSO or designee will determine any documentation, approvals, additional safety requirements and training necessary for purchase, use or modification of these sources.
- b. Unless specifically exempted or not required by the JSC RSO, complete JSC Form 44A Radio Frequency/Microwave Hazard Evaluation Data and JSC Form 1023 Nonionizing Radiation Training & Experience Summary, for any RF or microwave radiation device operating at frequencies between 3 kHz and 300 GHz. WSTF users are authorized to use the JSC Form JF44A, Form JF1023, or an approved JSC Radiation Safety Committee.
- c. Ensure accountability for their sources and coordinate this effort with the JSC RSO, or designated representative.
- d. Include reasonable controls directed toward reducing exposure. Such controls include engineering and administrative controls as well as the use of personal protective equipment, placement of appropriate RF safety signage, designation of restricted access areas, RF safety awareness training, and the use of personal RF monitors.
- e. Maintain the beam height of RF and microwave transmitters at a level that does not intercept occupied facilities or structures, or personnel within the identified hazard distance.
- f. Follow IEEE Standard C95.1 for limits on maximum permissible exposure and induced and contact RF currents.
- g. Follow the ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for limits on lower frequency electromagnetic fields and static magnetic fields.
- h. Make sure the operation of industrial, scientific, medical, and other equipment generating RF energy doesn't interfere with authorized radio, radio-navigation, and telecommunication systems.
- i. Treat equipment generating RF energy between 30 Hz and 30,000 MHz as a cause of interference unless the equipment has power line filters, shielding, bonding, or grounding.

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- j. Never look into waveguide horns, antennas, or open waveguides when any microwave equipment is on.
- k. Never wear metal jewelry or eyeglasses near electronic equipment radiating RF energy, even if the level is below the established safe value. Jewelry or eyeglasses may act as a conductor and cause a shock or burn.

7.5.4.2 Training required for RF/microwave radiation devices

Workers who have occupational duties requiring exposure at IEEE C95.1 defined levels shall have training to include the hazards of exposure; safe work practices; concepts of "time-averaged exposure;" and the methods to reduce, eliminate, or mitigate the hazards.

7.5.4.3 Exempted Item Categories

- a. The following general categories of radio frequency/microwave radiation devices are exempted from the requirements of this chapter:
 - (1) Devices for voice communication with transmitter power of 7 watts or less and an antenna gain of unity (walkie-talkies, car phones, cellular phones), at frequencies between 100 kHz and 450 MHz.
 - (2) Speed monitoring devices (radar guns).
 - (3) Automotive radar detectors.
 - (4) Microwave ovens designed for home use.
 - (5) RF/microwave radiation devices designed for and operated in a completely enclosed configuration where no open-air transmission is possible.
 - (6) RF/microwave radiation devices designed to operate in a hard-lined, closed loop configuration where no open air transmission is possible.
 - (7) Devices or systems which have been shown incapable of emitting radiation levels greater than one half (50%) of current applicable maximum permissible exposures levels by documented worst case analysis.
- b. Exemptions are valid for the general categories of equipment, instruments, and systems identified immediately above provided:
 - (1) The individual item is maintained in its original design configuration and used for its originally intended use over the useful life of the item.
 - (2) The design and manufacture of the item is in accordance with the specifications of the Federal Performance Standard for Electronic Products (Title 21, CFR, Part 1010).
 - (3) The item is operated in accordance with the manufacturer's recommended operating procedures.
 - (4) Maintenance, service, or repair activities which could expose personnel to accessible levels of radiation equal to or greater than the levels described or implied in IEEE C95.1 shall be performed only by appropriately authorized and qualified personnel.

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7.5.5. Non-Laser Optical Radiation Safety (Ultraviolet (UV) Radiation, Infrared Radiation (IR), and High Intensity Light (HIL) Safety

7.5.5.1 Definitions and hazards:

- a. Pulsed or continuous-wave systems capable of producing light of wavelengths from 2100 nanometers (nm) to 400 nm are sources of UV radiation.
- b. Pulsed or continuous-wave systems capable of producing light of wavelengths from 760 nm to 3000 nm are sources of IR radiation.
- c. HIL is high intensity visible light, which falls into wavelengths of 380 nm to 780 nm. HIL sources include compact arc lamps, tungsten-halogen lamps, electronic flash lamps, and other sources of high irradiance. Many HIL sources may also produce UV along with visible and infrared radiation.
- d. Non-coherent optical sources such as ultraviolet (UV), visible and infrared (IR) light are capable of causing injury to both the skin and the eyes.
- e. A “hazardous” UV, IR, or HIL producing device with the potential for emissions above the Threshold Limit Values shown in the ACGIH TLV reference booklet.

7.5.5.2 Requirements for working safely with UV, IR, and HIL sources:

- a. For all sources of potentially hazardous UV, IR, and HIL, the custodian of the device shall request an evaluation from the RSO or designee of the proposed source and its use. The request should describe the UV, IR, or HIL source and its planned use adequately enough to show it can be used in a safe manner.
- b. The custodian is responsible for the safe use of all UV, IR, and HIL emitters under his or her control.
- c. The RSO or designee shall review and evaluate custodian requests to determine if there is a potential for hazardous radiation from the device. This evaluation shall be based on the limits established by the ACGIH.
- d. If the RSO's or designee's review identifies a potential for personnel exposure above the ACGIH limits, the custodian of the device shall prepare a safety plan containing the procedures used to minimize personnel exposure. The safety plan shall list all trained personnel who will be operating the device.

7.5.5.3 Exposure Control – If an evaluation of UV/IR/HIL source determines there is a potential for exposure above the ACGIH limits, use the following measures to reduce unnecessary exposures:

- a. Where feasible, UV/IR/HIL devices should be located to minimize exposures in areas adjacent to and within the NASA installations.
- b. All hazardous areas within the NASA installations should be conspicuously posted with appropriate warning signs.
- c. Evaluation of each anticipated operating condition shall include consideration and development of procedures for insuring proper placing of warning signs for that operation.
- d. Typical control measures are provision of enclosures and shielding around the source to

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prevent exposure, use of protective clothing to prevent skin exposure and use eye protection to prevent eye exposure. The type and amount of protection depends on the frequency, nature, and intensity of light.

7.5.5.4 Work Practices for Ultraviolet (UV) Radiation Exposures

- a. Worker exposure to UV energy from 100 nm to 400 nm shall be controlled by adherence to the standard ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices and this section, as applicable. Compliance with the standard, based on measurement data or emission data, or adherence to the work practice procedures will protect against injury from UV energy.
- b. Exposure to UV energy can be controlled by enclosures, shields, protective clothing, skin creams, gloves, goggles, and/or face shields. Employees shall be protected from eye or skin exposure to UV radiation depending on the sources below:
 - (1) Sunlight – Susceptible persons working outside in strong sunlight should be protected. Protective clothing, such as long-sleeved shirts, trousers or skirt, and face and neck protection will normally be adequate. A broad-brimmed hat can afford face and neck protection, as well as a billed-hat or cap or neck shield (if the neck is not protected by hair). Hard hats may have bills or face shields to protect the face and may have neck shields. Alternatively, barrier creams and goggles or spectacles can achieve face and eye protection.
 - (2) Low-intensity UV sources – Examples of low-intensity UV sources are low-pressure mercury-vapor lamps, sunlamps, and black-light lamps. Glass or plastic (1/8-inch thickness or greater) spectacles, goggles, or shields provide adequate eye protection. Lightweight clothing can protect skin, as well as skin creams containing benzophenones or p-aminobenzoic acid, or barrier creams containing titanium dioxide or zinc oxide.
 - (3) High-intensity UV sources – Examples of high-intensity UV sources are high-pressure mercury vapor lamps, high-pressure xenon arcs, xenon-mercury arcs, carbon arcs, plasma torches and welding areas. Having high-intensity UV generating devices located in a separate room, alcove, or low-traffic area of a lab is ideal. To avoid exposure to other personnel, avoid placing high-intensity UV generating devices in the vicinity of desk areas or other equipment. The use of light-tight cabinets and enclosures is the preferred means of preventing exposure. Where it is not practicable to fully enclose the high-intensity UV source, use screens, shields, and barriers. Some solar simulator enclosures come with interlocks; alternatively, interlock devices can be installed. Interlocks should not be tampered with and should be replaced or repaired when defective
- c. For eye protection, employees shall wear goggles, face shields or masks. The ACGIH guide should be referenced for shade (transmission density) required for this eye protection.
- d. Skin shall also be protected. Clothing of densely woven flannelette, poplin or synthetic fabric will give sufficient protection. Face shields can protect facial skin or shades specified in ANSI AWS Z49.1 or by barrier cream containing titanium dioxide or zinc oxide. Because many synthetic clothing fibers can melt or catch fire and thereby cause severe thermal burns, clothing of synthetic fibers should be flame-resistant if operations involve great heat, sparks, or flame.
- e. Welders' helpers and others working nearby may also require protection. Shielding such as the welder's booth, guard against accidental exposure of other people. Reflection from lamp-housings,

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walls, ceilings and other possible reflective surfaces should be kept to a minimum by coating such surfaces with a pigment-based paint of low UV reflectance. Where such shielding and non-reflective surfaces are not used, welders' helpers and others near the welding operation should wear protective clothing, skin creams, gloves, goggles and/or face shields.

7.5.5.5 Training required for using UV, IR, and HIL

- a. Individuals shall be properly trained before operating hazardous UV, IR, and HIL.
- b. Each employee who may be exposed to hazardous UV, IR, or HIL shall be apprised of all hazards, relevant symptoms, and precautions concerning exposure. This hazards appraisal shall include:
 - (1) Information on the proper eye protection, skin protection, and protective clothing to be used.
 - (2) Instruction on how to recognize the symptoms of eye and skin damage due to UV radiation.
 - (3) Instruction on how to recognize the symptoms of eye damage due to IR and HIL radiation.
 - (4) Special caution to be exercised in situations where employees are exposed to toxic agents and/or other stressful physical agents which may be present in addition to, and simultaneously with, UV radiation.
 - (5) Information on possible long-term effects of sun exposure and of the desirability of preventing these effects by the use of PPE or sunscreens for highly susceptible (i.e., light skinned, easily sunburned) employees who regularly work out-of-doors and are exposed to sunlight.

7.5.6. Emergency actions for non-ionizing radiation mishaps

If a mishap involving non-ionizing radiation occurs, follow the emergency procedures in Chapter 3.8, "Emergency Preparedness," and the emergency procedures for the facility. For laser mishaps, contact the LSO as soon as possible to help investigate the mishap. For mishaps involving other non-ionizing radiation, contact the RSO as soon as possible to help investigate the mishap.

7.5.7. For more information on non-ionizing radiation protection

- a. 21 CFR 1000 – 21 CFR 1040, "Food and Drug Administration Rules and Regulations"
- b. 29 CFR 1910.97, "Non-ionizing Radiation"
- c. IEEE C95.1 Standard, "IEEE Standard for Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"
- d. NPR 1800.1, NASA Occupational Health Program Procedures, Chapter 4
- e. *Manual of Regulations and Procedures for Federal Radio Frequency Management*, U.S. Department of Commerce," National Telecommunications and Information Administration, Washington, D. C., January 2008 Edition/September 2009 Revision

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f. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (TLVs® and BEIs®)*, American Conference of Governmental Industrial Hygienists, latest edition

7.5.8. Responsibilities

- a. As a supervisor, you are responsible for:
 - (1) Making sure employees follow the requirements of this chapter.
 - (2) Providing training to employees in their non-ionizing radiation tasks and procedures.
- b. The JSC RSO is responsible for:
 - (1) Implementing JSC’s non-ionizing radiation protection program.
 - (2) Supervising the Radiation Safety Office.
 - (3) Answering to the JSC Radiation Safety Committee.
- c. The LSO shall fulfill the responsibilities in chapter 4 of NPR 1800.1.
- d. The Director of Human Health and Performance is responsible for:
 - (1) Making sure the non-ionizing radiation protection program is developed and carried out.
 - (2) Establishing an RSC.
- e. The Radiation Safety Committee is responsible for:
 - (1) Coordinating the requirements for controlling non-ionizing radiation among the various agencies that regulate radiation.
 - (2) Approving all uses of non-ionizing radiation on site.
- f. The Radiation Safety Office is responsible for:
 - (1) Reviewing procedures.
 - (2) Monitoring operations.
 - (3) Educating personnel in radiation protection and in the safe handling of non-ionizing radiation-producing equipment.
 - (4) Making sure all operations meet established exposure criteria.

7.5.9. Safety and health records for non-ionizing radiation protection

Center-level –Occupational Health shall keep records on radiation exposure.

NOTE: See Appendix F, Attachment 1.1A for details on records required by this chapter.