Chapter 50: Non-ionizing Radiation

Radio Frequency Source Review, Operation, and Maintenance Requirements

1 Purpose

The purpose of these requirements is to ensure personnel are not exposed to hazardous levels of non-ionizing radiation. They cover review, operation, and maintenance of new and modified permanently installed sources of non-ionizing radiation capable of radiating over 1 Watt (W) at radio frequencies (RF), defined as from 3 kilohertz (kHz) to 300 gigahertz (GHz). This includes klystrons and waveguide systems; communications transmitters [not receivers]; and induction heaters and ultrasonic cleaners. Consumer items such as microwave ovens and cell phones are exempted. They apply to workers, supervisors, equipment owners, area and building managers, and the non-ionizing radiation program manager; and the Occupational Health Center.

2 Requirements

2.1 Review

Review by the non-ionizing radiation program manager is required for all new RF sources and all significant reconfigurations of existing sources, with respect to frequency of operation, source power, or configuration that could change the exposure potential. Review may also be triggered by recognition of a hazard by line management or by the results of a non-ionizing radiation survey conducted by a qualified person, such as an industrial hygienist.

A review is initiated by contacting the program manager to determine if a preliminary hazard analysis is required.

- If the hazard analysis demonstrates that the equipment poses no hazard (that is, will not generate levels of radiation exceeding safety program initiation levels), the program manager may approve the equipment for the described use at this stage. (See Non-ionizing Radiation: Selected Radio Frequency Exposure Limits for safety program initiation levels and exposure reference levels (ERLs).)

- If the hazard analysis shows that RF radiation may exceed safety program initiation levels, the equipment owner must develop a facility-specific radio frequency safety program (RFSP). (See Section 2.2 for required RFSP elements.)

The RFSP is reviewed by the program manager and approved once all safety measures and requirements are documented and reviewed. Implementation of the RFSP establishes an effective restricted environment and ensures that the ERLs are not exceeded, either in normal operation or in the event of a credible accident.
2.2 Radio Frequency Safety Program Requirements

A radio frequency safety program (RFSP) must include the following items.

2.2.1 Equipment

A complete description of the RF-generating equipment, covering
- Equipment location(s)
- Intended use
- Output characteristics, including
  - Frequency
  - Peak power
  - Average power
  - Modulation characteristics
  - Duty factor

2.2.2 Hazard Analysis

The hazard analysis evaluating the potential hazards associated with the RF source(s), both in normal operation and in the event of a credible accident or failure.

2.2.3 Hazard Controls

A hazards control section including a description of engineering and administrative controls.

2.2.3.1 Engineering Controls

Engineering controls such as confinement of the RF fields, shielding, and interlocks are the preferred means of hazard control. These are the most effective in attaining the goal of eliminating hazardous levels of uncontained RF energy in occupied areas.

For example, high-power systems that generate hazardous levels of RF energy should be equipped with redundant interlocks that shut the equipment off if the integrity of any of the elements or connections is damaged. All interlocks should be managed so that they are recertified periodically.

2.2.3.2 Administrative Controls

Administrative controls rely heavily on hazard communication and minimizing access. The following should be incorporated into the RFSP as appropriate.

- Equipment-specific lockout procedure (ELP). An ELP specific to the RF source(s) must be developed so that the equipment can be serviced safely (see Non-ionizing Radiation: Radio Frequency Source Review Procedure).
2.3 Operation

Before an RF source is energized the following conditions must be met:

- The approved RFSP must be on file with the equipment owner and the program manager.
- All engineering and administrative controls, as described in the RFSP, must be in place and communicated to workers. Persons working in controlled RF environment must have completed the on-the-job training required by the RFSP.

All work must be performed in compliance with the approved RFSP.

2.4 Service, Maintenance, and Repair

Any system under an RFSP must be locked out and tagged out according to requirements specific to the ELP developed for the RFSP (see Section 2.2.3.2).

If a repair involves the engineering controls required by the RFSP, the system must be recertified according to specifications in the RFSP.

2.5 Over-exposure Incident Response

In the event of a known or suspected RF over-exposure or of interference with an electronic medical device, personnel must follow SLAC’s incident response procedures, which include seeking appropriate medical assistance and notifying supervisors, the non-ionizing radiation program manager, and the Occupational Health Center.
Symptoms such as pain, reddening of the skin, unusually elevated body temperature, or any other evidence of tissue burning, are possible indications of overexposure to RF energy.

In the absence of definitive physical evidence, information about the incident will be used to determine whether an actual over-exposure took place. Technical information will be gathered for evaluation by a knowledgeable person (such as the program manager and the project manager), including location, frequency, source power levels, source description, and exposure duration.

In some cases, reconstruction of the exposure may prove effective in determining exposure levels during the incident. The exposure reconstruction may include RF field measurements and must be carried out under the guidance of the program manager.

Following an assessment of exposure and medical evaluation, where applicable, details of the incident will be documented in the records of the RFSP and in those of other required procedures.

### 2.6 Electronic Medical Devices

Some electronic medical devices, such as cardiac pacemakers, defibrillators, and drug delivery systems, can exhibit improper operation when subjected to strong RF fields. It is important to note that devices that are used external to the body can be substantially more susceptible to interference and that interference may occur at RF field strengths that are substantially less than human maximum exposure limits.

Personnel who use electronic medical devices and may need access to areas near RF sources are encouraged to seek guidance on potential hazards from their supervisor, the non-ionizing radiation program manager, or the Occupational Health Center. This is best done as a fitness-for-duty health assessment as part of a job safety analysis.

Consultation with the individual’s medical provider may also be recommended or needed. Additionally, useful information concerning possible RF interference issues may also be available from the RF source manufacturer or the medical device manufacturer.

### 3 Forms

The following are forms required by these requirements:

- None

### 4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

Equipment owners must keep on file

- A current inventory of potential RF hazards
- An approved preliminary hazard analysis for his or her RF-generating equipment
- The current RFSP for RF-generating equipment, and associated documents required by the RFSP, including ELPs
Requests for operational variance and subsequent approvals
Records of over-exposure incidents

Area and building managers must keep on file
- An area hazard analysis (AHA) that includes potential RF hazards

The non-ionizing radiation program manager must keep on file
- A copy of approved preliminary hazard analyses and RFSPs
- A compilation of available inventories of potential RF hazards at SLAC

5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)
- Chapter 50, “Non-ionizing Radiation”
  - Non-ionizing Radiation: Radio Frequency Source Review Procedure (SLAC-I-730-0A05C-002)
  - Non-ionizing Radiation: Selected Radio Frequency Exposure Limits (SLAC-I-730-0A05S-001)
  - Non-ionizing Radiation: Radio Frequency Equipment-specific Lockout Procedure Requirements (SLAC-I-730-0A05S-014)

Other SLAC Documents
- None

Other Documents
- Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1, “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz” (IEEE Std C95.1)
- Institute of Electrical and Electronics Engineers (IEEE) Standard C95.7, “IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz” (IEEE Std C95.7)