Chapter 50

Non-ionizing Radiation

Chapter Outline

1	Overview		2
	1.1	Hazards/Impacts	2
2	Scope		3
	2.1	Exemptions	3
3	Standards		3
4	Definitions		4
5	Requirements		5
	5.1	General	5
	5.1.1	Hazard Determination	5
	5.1.2	Radio Frequency Safety Program Development	6
	5.1.3	Operation	8
	5.1.4	Servicing, Maintenance, and Repair	8
	5.1.5	Recordkeeping	8
	5.1.6	Personnel	9
	5.1.7	Roles and Responsibilities	9
	5.2	Procedures and Specific Requirements	11
	5.2.1	Radio Frequency Exposure Limits	11
	5.2.2	Radio Frequency Equipment Lockout Procedure	11
	5.3	Training	12
6	Exhibits		12
7	References		12
8	Implementation		13
9	Ownership		13

1 Overview

SLAC conducts research and development programs that involve sources of radio frequency (RF) non-ionizing electromagnetic radiation (NIR). (In this chapter *RF* will refer to frequencies in the range from 3 kilohertz (kHz) to 300 gigahertz (GHz)). Devices that may produce RF radiation include high-power amplifiers such as klystrons, high-energy electron and positron beams traveling through beam chambers, telecommunications equipment, and induction heaters and ultrasonic cleaners.

With the exception of some telecommunication equipment, the high-power RF systems in use at SLAC are designed to deliver the RF fields they generate to accelerating structures via waveguides or coaxial cables. When functioning properly, these systems emit no hazardous levels of NIR. Other devices at SLAC, such as modulators, produce large electromagnetic transients in the RF spectrum, but the energy they emit is well below the threshold at which it would become a hazard.

Central to meeting the safety goals and requirements of this chapter is the development of a *radio frequency safety program (RFSP)* for each installation that has the potential to exceed the *action level* determined by the adopted Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-2005).[1] The RFSP must be approved by the Non-ionizing Radiation Safety Committee (NIRSC)[2] and the RFSP becomes the vehicle to ensure that hazard mitigation and communication are achieved. This chapter provides guidance for developing such a program.

This chapter is a general interpretation of relevant laws and standard and does not address all conceivable situations. Contact the NIRSC for any specific situations and for exceptions to the requirements found in this document.

1.1 Hazards/Impacts

The potential hazards associated with exposure to RF fields are electro-stimulation of nerves in the frequency range of 3 kHz to 5 megahertz (MHz) and thermal heating of body tissues in the frequency range of 100 kHz to 300 GHz.

1 Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-2005)

See the SLAC Library for available standards (http://www-group.slac.stanford.edu/library/CommunityPages.asp). This IEEE standard is available online from a SLAC login (http://ieeexplore.ieee.org/iel5/10830/34126/01626482.pdf?tp=&isnumber=34126&arnumber=1626482)

2 "Non-Ionizing Radiation Safety Committee - Charter", https://www-internal.slac.stanford.edu/esh/committees/nrsc/charter.htm

2 Scope

This chapter establishes requirements for controlling the exposure of both SLAC personnel and the public to non-ionizing electromagnetic radiation and fields in the RF portion of the spectrum (3 kHz to 300 GHz). These requirements apply to all SLAC personnel, subcontractors, visiting scientists, users, and any other persons who conduct operations in which they may be exposed to such energy sources.

This chapter covers only the RF portion of the NIR spectrum. For NIR safety concerning lasers, see Chapter 10, "Laser Safety".[3] For other NIR safety issues consult the SLAC Environment, Safety, and Health Division.[4]

2.1 Exemptions

All systems with RF sources are subject to NIRSC review, except for such consumer items as microwave ovens and cell phones, which are regulated under federal RF emissions standards.

3 Standards

This program has adopted the following standards.

- Title 29, *Code of Federal Regulations*, , "Labor", Part 1910, "Occupational Safety and Health Standards"
  - Section 97, "Non-ionizing Radiation" (29 CFR 1910.97)[5]
  - Section 1020, "Access to Employee Exposure and Medical Records" (29 CFR 1910.1020)[6]
- Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-2005)[7]
- IEEE Standard C95.7-2005, "IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz", (IEEE Std C95.7-2005), including Annex A[8]

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3 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 10, "Laser Safety", http://www-group.slac.stanford.edu/esh/hazardous_activities/laser/policies.htm

4 Resource List for Environment, Safety and Health, http://www-group.slac.stanford.edu/esh/about_esh/resource.pdf

5 http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9745

6 http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10027

7 For link to IEEE Std C95.1-2005, see note 1

8 See the SLAC Library for available standards (http://www-group.slac.stanford.edu/library/CommunityPages.asp). This IEEE standard is available online from a SLAC login (http://ieeexplore.ieee.org/iel5/10721/33840/01611107.pdf?tp=&isnumber=33840&arnumber=1611107).

- American Conference of Governmental Industrial Hygienists (ACGIH), "Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs)", (ACGIH TLVs and BEIs – most recent edition)[9]

4 Definitions

Action level.[10] The values of the electric and magnetic field strength, the incident power density, contact and induced current, and contact voltages above which steps should be initiated to protect against exposures that exceed the upper tier, specifically, implementation of an RF safety program.

Controlled RF environment.[11] An area where the occupancy and activity of those within is subject to control and accountability as established by an RF safety program for the purpose of protection from RF exposure hazards. (Note that industry standard terminology for this definition is just *controlled environment*, but we use *controlled RF environment* to distinguish from an environment which is controlled with respect to other hazards, such as ionizing radiation.)

Duty factor. The fraction of time a transmitter or source is emitting radio frequency or microwave energy, usually expressed as the ratio of the time on to the sum of the time on and off during the averaging time. For continuous emitters, the duty factor is equal to 1. The duty factor is multiplied by the field measurement to obtain a time-averaged exposure.

Maximum permissible exposure (MPE) limit. An exposure limit or guideline for RF energy exposure published by a recognized consensus standards organization, such as the IEEE

Non-ionizing radiation (NIR).[12] All radiation and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 electron volts (eV), wavelengths greater than 100 nanometers (nm), and frequencies lower than $3x10^{15}$ hertz (Hz)

Radio frequency (RF).[13] A frequency that is useful for radio transmission. For purposes of this chapter, the frequency range of interest is 3 kHz to 300 GHz.

Radio frequency safety program (RFSP).[14] An organized system of policies, procedures, practices and plans designed to protect against hazards associated with RF fields, contact voltage, and contact and induced currents. RFSPs must be documented in writing.

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9 See the SLAC Library for available standards (http://www-group.slac.stanford.edu/library/CommunityPages.asp). For a list of ACGIH publications, see the American Conference of Industrial Hygienists "ACGIH Online Products Center", http://www.acgih.org/Products/. A hard copy of the 2006 edition is available; see http://www.slac.stanford.edu/spires/find/books/www?key=344010.

10 Definition per IEEE Std C95.1-2005, see note 1

11 Definition per IEEE Std C95.1-2005, see note 1

12 Definition per "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), International Commission on Non-Ionizing Radiation Protection". *Health Physics* 74 (4): 494-522; 1998, http://icnirp.de/documents/emfgdl.pdf

13 Definition per IEEE Std C95.1-2005, see note 1

5 Requirements

5.1 General

All RF sources and all significant reconfigurations of existing sources are subject to review by the Non-ionizing Radiation Safety Committee (NIRSC). A review is initiated by contacting the NIRSC to determine if a hazard analysis is required. If the hazard analysis shows that potential RF radiation may exceed *action levels*, the equipment owner must develop a facility-specific radio frequency safety program (RFSP).

The RFSP is reviewed by the NIRSC and approved once all safety measures and requirements are documented, reviewed by experts, and communicated. Implementing an effective RFSP ensures that *controlled RF environments* are identified and that the *maximum permissible exposure* (MPE) limits are not exceeded either in normal operation, or in the event of a credible accident or failure. RFSPs for existing equipment are reviewed periodically.

5.1.1 Hazard Determination

5.1.1.1 Review Requirement

NIRSC review is required if the equipment belongs to of one of the following types:

- Permanently installed RF gear capable of radiating over 1 Watt (W) at frequencies between 3 kilohertz (kHz) and 300 gigahertz (GHz). Such installations include klystrons and RF waveguide systems.
- Satellite and permanently installed communications transmitters (not receivers)
- Industrial induction heaters and large-scale ultrasonic cleaners may need to be reviewed. Contact the NIRSC for details.

NIRSC review can also be required by one or more of the following:

- Discussion of a project at a Safety Overview Committee (SOC) meeting, where the project may be referred to the NIRSC for review
- Recognition of a hazard by line management
- Results of a non-ionizing radiation survey that was conducted by a qualified person, such as an ES&H industrial hygienist or a NIRSC member

5.1.1.2 Preliminary Hazard Analysis

A preliminary hazard analysis is key in determining if a facility-specific RFSP is required. If the hazard analysis demonstrates that the equipment poses no hazard, the NIRSC may approve the equipment for the described use at this stage. For equipment that may pose a hazard, the NIRSC will set RFSP requirements.

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14 Definition per IEEE Std C95.1-2005, see note 1

5.1.2 Radio Frequency Safety Program Development

The equipment owner of RF-generating installations must ensure that all equipment is reviewed by the NIRSC for its potential to exceed the *action levels* indicated in IEEE Std C95.1-2005.[15]

An RFSP includes detailed consideration of items detailed in sections 5.1.2.1 through 5.1.2.5.

5.1.2.1 Equipment Description

A complete description of RF-generating equipment includes

- Equipment location(s)
- Intended use
- Output characteristics, including
  - Frequency
  - Peak power
  - Average power
  - Modulation characteristics
  - Duty factor

5.1.2.2 Hazard Analysis

The hazard analysis must evaluate the potential hazards associated with the RF source(s), both in normal operation and in the event of a credible accident or failure. Supporting materials must be submitted to the NIRSC along with the analysis. (For RF MPEs and action levels, see Non-ionizing Radiation: Selected Radio Frequency Exposure Limits for thresholds that most commonly apply at SLAC,[16] or see the IEEE Std C95.1-2005 for all thresholds.[17])

5.1.2.3 Hazard Controls

The hazards control section must include a description of engineering, work practice, and administrative controls.

Engineering Controls

Insofar as possible, engineering controls such as confinement of the RF fields, shielding, and interlocks should be 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.

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15 For link to IEEE Std C95.1-2005, see note 1

16 Non-ionizing Radiation: Selected Radio Frequency Exposure Limits (SLAC-I-730-0A05S-001), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirReqExpLimits.pdf

17 For link to IEEE Std C95.1-2005, see note 1

For example, high-power systems that generate hazardous levels of RF energy should ideally 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.

Administrative Controls for Controlled RF Environments

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

- **Equipment Lockout Procedure (ELP).** An ELP specific to the RF source(s) must be developed so that the equipment can be serviced safely. For guidelines, see Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines.[18] Any additional work practice procedures that will ensure worker safety should be developed as necessary or as required by the NIRSC.
- **Warning signs.** Signs must be placed to warn personnel of potential RF hazards, both in the controlled RF area and on equipment elements. Contact the NIRSC for assistance in determining appropriate signage.
- **Access limitation.** Program managers and facility managers must ensure that, where required by the RFSP, the operational supervisor controls access to controlled RF environments.

5.1.2.4 Hazard Awareness Training and Documentation of Training Requirements

The RFSP must include all requirements for RF awareness training, such as a description of on-the-job training specific to the equipment or installation. For additional guidance, see IEEE Std C95.7-2005, Annex A.[19]

5.1.2.5 Procedures and Monitoring Requirements

The RFSP must address

- Configuring the system and bringing it online
- Ensuring that the interlocks are operational
- Monitoring the system to detect RF radiation. The RF monitoring procedure should specify the survey method and how and where results must be documented.
- Installing and using safeguards to protect against credible accidents or failures

5.1.2.6 Radio Frequency Safety Program Approval and Periodic Review

Once an RFSP has been reviewed and approved by the NIRSC, the area, equipment, or installation will become a *controlled RF environment* subject to the provisions of the approved RFSP.

All RFSPs are subject to periodic NIRSC review; the frequency of the review will be determined by the NIRSC.

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18 Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines (SLAC-I-730-0A05T-001), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideELP.pdf

19 For link to IEEE Std C95.7-2005, Annex A, see note 8

5.1.3 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 NIRSC.
- All engineering, work practice, and administrative controls, as described in the RFSP, must be in place.

All work must be performed in compliance with the approved RFSP. If there is an actual or suspected RF overexposure, line management must ensure that the accident is handled in accordance with Chapter 28, "Incident Investigation". [20]

5.1.4 Servicing, Maintenance, and Repair

Any system under an RFSP must be locked out and tagged out according to requirements specific to the procedure developed for the RFSP. For general guidelines, see Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines.[21]

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

5.1.5 Recordkeeping

5.1.5.1 Equipment Owners

Equipment owners must keep on file

- A current inventory of potential RF hazards
- The current RFSP for their RF-generating equipment, and associated documents required by the RFSP
- Requests for operational variance and subsequent approvals

5.1.5.2 Facility Managers

Facility managers must keep on file

- An area hazard analysis (AHA) that includes potential RF hazards[22]

5.1.5.3 NIRSC

The NIRSC must keep on file

- A copy of approved RFSPs
- A compilation of available inventories of potential RF hazards at SLAC

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20 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 28, "Incident Investigation", http://www-group.slac.stanford.edu/esh/general/incident/policies.htm

21 Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines (SLAC-I-730-0A05T-001), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideELP.pdf

22 "Area Hazard Analysis", http://www-group.slac.stanford.edu/esh/general/hazanalysis/aha.htm

5.1.6 Personnel

5.1.6.1 Qualifications

Line management must ensure that persons working in controlled RF environments have completed required on-the-job training and that only qualified persons conduct surveys to measure non-ionizing radiation.

5.1.6.2 Medical

SLAC workers, users, subcontractors, and visitors who wear a medical electronic implant such as a cardiac pacemaker, or who have ferromagnetic implants are strongly encouraged to obtain medical clearance from their treating physician (who has knowledge of the implanted device) before working at or visiting SLAC. For details from the IEEE standard, see Non-ionizing Radiation: Medical Information Guideline.[23]

5.1.7 Roles and Responsibilities

5.1.7.1 Laboratory Director

The laboratory director

- Has responsibility, accountability, and authority for all SLAC facilities and processes and is ultimately responsible for developing an RF protection plan for all of SLAC for controlling the exposure of SLAC personnel and the public to RF electromagnetic fields with frequencies from 3 kHz to 300 GHz associated with the work conducted in those facilities and processes.
- Establishes the appropriate authorities of program and facility managers to ensure that this document is effectively implemented

5.1.7.2 Non-ionizing Radiation Safety Committee

The Non-ionizing Radiation Safety Committee (NIRSC) will

- Review in a timely manner RFSPs for new facilities, requests for operational variance in existing facilities, and, where appropriate, issue a formal approval when potential hazards are shown to be sufficiently controlled and the proposed activity conforms to SLAC ES&H policy and requirements
- Assist project and facility managers in evaluating and containing RF hazards. These tasks include
  - Recommending appropriate engineering controls and hazard mitigation to keep RF radiation below the maximum permissible exposure limit
  - Providing guidance on appropriate interlocks and RF measurement equipment
- Review plans and recommend, as needed, engineering and administrative controls that line managers and facility managers must implement prior to facility operation
- Assist project managers, line managers, and facility managers in evaluating RF areas and sources
- Assist line managers and facility managers in training qualified personnel to measure RF radiation
- Compile available inventories of potential RF hazards and controlled RF environments at SLAC

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23 Non-ionizing Radiation: Medical Information Guideline (SLAC-I-730-0A05T-002), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideMedical.pdf

- When requested, provide training assistance, information, and advice about RF radiation, fields, and hazards
- Recommend SLAC policies and procedures concerning RF hazards
- Review accelerator facility procedures
- Review ES&H training programs
- Update this chapter as needed

5.1.7.3 NIR Program Manager

The NIR program manager will

- Coordinate updates of this chapter
- Attend NIRSC meetings
- Conduct non-ionizing radiation surveys as required

5.1.7.4 Equipment Owner

The equipment owner will

- Act as an agent of the laboratory director to ensure that this chapter is effectively implemented within his or her area(s) of responsibility
- Ensure development of a written, facility-specific RFSP for his or her facility or activity
- Submit an RFSP to the NIRSC detailing the methods used to ensure these levels of exposure for new installations or changes to existing installations
- Provide to the NIRSC an accurate hazard analysis and supporting information to ensure that exposures to RF radiation do not exceed applicable levels specified in IEEE Std C95.1-2005.[24]
- Notify the NIRSC in a timely manner of any new source or change in existing sources with respect to frequency of operation, source power, or configuration that could change the exposure potential
- Obtain a statement of approval from the NIRSC if any requirements in the approved RFSP cannot be met

5.1.7.5 Project Manager

The project manager will

- Minimize exposure to RF sources through implementing engineering, work-practice, and administrative controls as specified in the RFSP
- Ensure that calibrated equipment is used to measure RF radiation levels to determine compliance to the RFSP
- Inform building or area managers when work is to be performed on an RF system that requires system re-certifications (such as when a waveguide is to be opened)
- Verify that administrative locks are placed on equipment before major work is begun and throughout the duration of this work

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24 For link to IEEE Std C95.1-2005, see note 1

- Call upon the NIRSC as needed for appropriate training resources

5.1.7.6 Facility Manager

The facility manager will

- Maintain a current inventory of potential RF hazards in his or her facility and provide a copy to the NIRSC
- Update the area hazard analysis (AHA) form(s) to include any change in RF hazards
- Ensure general worker safety around potential RF sources, including confirming that personnel are protected from potential RF hazards when major work is performed on RF systems
- Verify that project managers perform their required periodic RF safety checks as specified in the RFSP
- Ensure that a system is returned to a safe condition upon completion of major work

5.1.7.7 Supervisors and Managers

- Know and understand the potential RF hazards in the areas in which they and their personnel work
- Document required job-specific training, and maintain copies of job hazard analysis and mitigation forms (JHAMs)[25] and work procedures ensuring that appropriate RF potential hazards and corresponding training are included for RF workers
- Ensure their workers are properly trained if they are required to work on systems in a controlled RF environment

5.1.7.8 Personnel (SLAC employees, subcontractors, scientists, users, students, and visitors)

- Follow procedures specified in the RFSP and other applicable requirements for working in areas with the potential for hazardous RF radiation and fields
- Observe requirements in their job hazard analysis and mitigation (JHAM) form and the area hazard analysis (AHA)
- Cooperate with the NIR program manager to ensure that valid and representative sampling data are collected

5.2 Procedures and Specific Requirements

5.2.1 Radio Frequency Exposure Limits

RF exposure limits adopted by SLAC are detailed in the IEEE Std C95.1-2005.[26]

5.2.2 Radio Frequency Equipment Lockout Procedure

Guidelines for developing an RF equipment lockout procedure (ELP) are in Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines.[27]

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25 "Job Hazard Analysis", http://www-group.slac.stanford.edu/esh/general/hazanalysis/jham.htm

26 For link to IEEE Std C95.1-2005, see note 1

5.3 Training

Personnel who are likely to work in or enter a controlled RF area must be made aware of potential RF hazards before entering the area. Personnel who routinely work in or enter a controlled RF environment must be provided with on-the-job training covering non-ionizing radiation hazards as detailed in the RF safety program (RFSP). Line management is responsible for ensuring that this training is provided and may call upon the NIRSC for appropriate training resources.

6 Exhibits

- Non-ionizing Radiation Safety Committee Charter[28]
- Non-ionizing Radiation: Implementation Plan (SLAC-I-730-0A05M-001)[29]
- Non-ionizing Radiation: Selected Radio Frequency Exposure Limits (SLAC-I-730-0A05S-001)[30]
- Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines (SLAC-I-730-0A05T-001)[31]
- Non-ionizing Radiation: Medical Information Guideline (SLAC-I-730-0A05T-002)[32]

7 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)[33]

- Chapter 1, "General Policy and Responsibilities"[34]
- Chapter 2, "Work Authorization"[35]
- Chapter 10, "Laser Safety"[36]
- Chapter 28, "Incident Investigation"[37]

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27 Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines (SLAC-I-730-0A05T-001), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideELP.pdf

28 https://www-internal.slac.stanford.edu/esh/committees/nrsc/charter.htm

29 http://www-group.slac.stanford.edu/esh/eshmanual/references/nirPlanImplement.pdf

30 http://www-group.slac.stanford.edu/esh/eshmanual/references/nirReqExpLimits.pdf

31 http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideELP.pdf

32 http://www-group.slac.stanford.edu/esh/eshmanual/references/nirGuideMedical.pdf

33 http://www-group.slac.stanford.edu/esh/eshmanual/

34 http://www-group.slac.stanford.edu/esh/general/general_policy/policies.htm

35 http://www-group.slac.stanford.edu/esh/general/work_authorization/policies.htm

36 http://www-group.slac.stanford.edu/esh/hazardous_activities/laser/policies.htm

Other SLAC documents

- *SLAC Lock and Tag Program for the Control of Hazardous Energy* (SLAC-I-730-0A10Z-001)[38]

Other

- "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), International Commission on Non-Ionizing Radiation Protection". *Health Physics* 74 (4): 494-522; 1998[39]

8 Implementation

The requirements of this chapter will be implemented according to Non-ionizing Radiation: Implementation Plan.[40]

9 Ownership

Department: Chemical and General Safety

Program: Non-ionizing Radiation

Owner: Program Manager

37 http://www-group.slac.stanford.edu/esh/general/incident/policies.htm

38 http://www-group.slac.stanford.edu/esh/hazardous_activities/lockout_tagout/locktag.pdf

39 http://icnirp.de/documents/emfgdl.pdf

40 Non-ionizing Radiation: Implementation Plan (SLAC-I-730-0A05M-001), http://www-group.slac.stanford.edu/esh/eshmanual/references/nirPlanImplement.pdf

Non-ionizing Radiation: Implementation Plan

Department: Chemical and General Safety
Program: Non-ionizing Radiation
Owner: Program Manager
Authority: ES&H Manual, Chapter 50, Non-ionizing Radiation[1]

The requirements of Chapter 50, "Non-ionizing Radiation", will be phased in according to the following schedule.

Section Number	Section Title	Requirement Note	Status	Effective Date	Schedule Note
5	Requirements				
5.1	General				
5.1.1	Hazard Determination		Existing	Immediate	
5.1.1.1	Review Requirement		Existing	Immediate	
5.1.1.2	Preliminary Hazard Analysis		Existing	Immediate	
5.1.2	Radio Frequency Safety Program Development		Existing	Immediate	
5.1.2.1	Equipment Description		Existing	Immediate	
5.1.2.2	Hazard Analysis		Existing	Immediate	
5.1.2.3	Hazard Controls		Existing	Immediate	
5.1.2.4	Hazard Awareness Training and Documentation of Training Requirements	The NIRSC will determine training requirements and standards (forthcoming).	New	10/08	
5.1.2.5	Procedures and Monitoring Requirements		Existing	Immediate	
5.1.2.6	Radio Frequency Safety Program Approval and Periodic Review		Existing	Immediate	
5.1.3	Operation		Existing	Immediate	
5.1.4	Servicing, Maintenance, and Repair		Existing	Immediate	

1 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 50, "Non-ionizing Radiation", http://www-group.slac.stanford.edu/esh/hazardous_substances/nir/policies.htm

Section Number	Section Title	Requirement Note	Status	Effective Date	Schedule Note
5.1.5	Recordkeeping		In progress	Immediate	Expected completion date: 12/08
5.1.5.1	Equipment Owners		In progress	Immediate	Expected completion date: 12/08
5.1.5.2	Facility Managers		In progress	Immediate	Expected completion date: 10/08
5.1.5.3	Non-ionizing Radiation Safety Committee		In progress	Immediate	Expected completion date: 12/08
5.1.6	Personnel		Existing	Immediate	
5.1.6.1	Qualifications		Existing	Immediate	
5.1.6.2	Medical		Existing	Immediate	
5.1.7	Roles and Responsibilities				
5.1.7.1	Laboratory Director		Existing	Immediate	
5.1.7.2	NIR Program Manager	This title is new, but this role continues to be performed by a CGS industrial hygienist.	Existing	Immediate	
5.1.7.3	Equipment Owner		Existing	Immediate	
5.1.7.4	Project Manager	This role may also be referred to as program manager in some directorates.	Existing	Immediate	
5.1.7.5	Facility Manager		Existing	10/08	Facility managers must update any affected area hazard analysis (AHA) by the next scheduled update or 10/08, whichever comes first.
5.1.7.6	Non-ionizing Radiation Safety Committee	See requirement note for 5.1.2.4 for recommended training.	Existing	Immediate	See schedule note for Section 5.1.5.3 for recordkeeping schedule.
5.1.7.7	Supervisors and Managers		New	04/09	This date refers to the documentation of the training requirements and revision of job hazard analysis and mitigation (JHAM) forms and work procedures.
5.1.7.8	Personnel (SLAC employees, subcontractors, scientists, users, students, and visitors)		Existing	Immediate	

Section Number	Section Title	Requirement Note	Status	Effective Date	Schedule Note
5.2	Procedures and Specific Requirements				
5.2.1	Radio Frequency Exposure Limits		Existing	Immediate	
5.2.2	Radio Frequency Equipment Lockout Procedure		Existing	Immediate	
5.3	Training		Existing	Immediate	Until training requirements and standards are determined by the NIRSC, line management must ensure that on-the-job training is provided as required by the RF Safety Program (RFSP) for each controlled RF environment.

Non-ionizing Radiation: Selected Radio Frequency Exposure Limits

Department: Chemical and General Safety
Program: Non-ionizing Radiation
Owner: Program Manager
Authority: ES&H Manual, Chapter 50, Non-ionizing Radiation[1]

This exhibit reproduces a subset of data most applicable to potential radio frequency (RF) hazards at SLAC. The reproduced data is from the Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-2005).[2]

All RF installations at SLAC must comply with all of the *maximum permissible exposure (MPE) limits* given in IEEE Std C95.1-2005, not just the data presented here. The reader is encouraged to consult the standard, especially Section 4, "Recommendations", to verify that the equipment in question satisfies these MPE limits. Contact the Non-ionizing Radiation Safety Committee (NIRSC) for any specific questions regarding the data presented here or in IEEE Std C95.1-2005.[3]

Symbols, Units, and Acronyms

A	ampere
E	electric field strength vector, measured in V/m
E	electric field strength amplitude, measured in V/m
f	frequency, measured in Hz
GHz	gigahertz
H	magnetic field strength vector, measured in A/m
H	magnetic field strength amplitude, measured in A/m
Hz	hertz, cycles per second

1 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 50, "Non-ionizing Radiation", http://www-group.slac.stanford.edu/esh/hazardous_substances/nir/policies.htm

2 Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-2005)

See the SLAC Library for available standards (http://www-group.slac.stanford.edu/library/CommunityPages.asp). This IEEE standard is available online from a SLAC login (http://ieeexplore.ieee.org/iel5/10830/34126/01626482.pdf?tp=&isnumber=34126&arnumber=1626482)

3 "Non-Ionizing Radiation Safety Committee - Charter", https://www-internal.slac.stanford.edu/esh/committees/nrsc/charter.htm

kg	kilogram
kHz	kilohertz
J	joule
m	meter
MHz	megahertz
MPE	maximum permissible exposure
NIRSC	Non-ionizing Radiation Safety Committee
RF	radio frequency
RFSP	RF safety program
RMS	root mean square
S	equivalent power density vector in mW/cm^2
SAR	specific absorption rate
T	tesla
V	volt
W	watt
WBA	whole body average

Definitions

Note *The definitions below for far and near fields apply to simple sources of RF and microwave radiation (such as antennas or radar dishes) and are provided as a general guideline. These definitions may not be accurate for complex or irregularly shaped sources such as arbitrary radiation from broken or improperly connected waveguide flanges. Separate measurements of both the electric and magnetic fields should be made until it is certain that one is well outside the near field before relying on a single probe. A single probe is used only when the electric and magnetic fields are proportional, that is, the ratio of the two remains constant through space.*

Action level.[4] The values of the electric and magnetic field strength, the incident power density, contact and induced current, and contact voltages above which steps should be initiated to protect against exposures that exceed the upper tier, specifically, implementation of an RF safety program

Averaging time.[5] The appropriate time period over which exposure is averaged for purposes of determining compliance with a maximum permissible exposure (MPE) limit or reference level

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4 Definition per IEEE Std C95.1-2005, see note 2

5 Definition per IEEE Std C95.1-2005, see note 2

Basic restrictions (BR).[6] Exposure restrictions that are based on established adverse health effects that incorporate appropriate safety factors and are expressed in terms of the in situ electric field (3 kHz to 5 MHz), specific absorption rate (100 kHz to 3 GHz), or incident power density (3 GHz to 300 GHz)

Controlled RF environment.[7] An area where the occupancy and activity of those within is subject to control and accountability as established by an RF safety program for the purpose of protection from RF exposure hazards. (Note that industry standard terminology for this definition is just *controlled environment*, but we use *controlled RF environment* to distinguish from an environment which is controlled with respect to other hazards, such as ionizing radiation.)

Duty factor. The fraction of time a transmitter or source is emitting radiofrequency or microwave energy, usually expressed as the ratio of the time on to the sum of the time on and off during the averaging time. For continuous emitters, the duty factor is equal to 1. The duty factor is multiplied by the field measurement to obtain a time-averaged exposure.

Electric field strength. The electric field strength, **E**, is a vector quantity that represents the force, **F**, on a positive test charge, q, at a point divided by the charge ($\mathbf{E} = \mathbf{F}/q$). Electric field strength is expressed in terms of a voltage gradient with units of volts per meter (V/m).

Electromagnetic (EM) energy. The total energy stored in the electric and magnetic fields in a given volume. If this electromagnetic energy is absorbed by a body, the energy will raise the body temperature, whether or not the energy is confined in space or radiated. For radiated fields, electromagnetic energy consists of an electric field and a magnetic field oscillating in unison.

Electromagnetic (EM) radiation. The transmission of energy through space in wave form, which can be characterized in terms of a wavelength and a frequency

Induced body current. Currents induced in an individual during exposure to radio frequency electromagnetic fields

Magnetic field strength. The force with which a magnetic field acts on an element of current situated at a particular point. Magnetic fields can be referred to in terms of two vector quantities: magnetic flux density, **B**, or the magnetic field strength, **H**. The literature pertaining to extremely-low-frequency (ELF) radiation typically uses magnetic flux density, and the RF community uses magnetic field strength. The International System of Units (SI) unit for flux density is the tesla (T). Another commonly used unit for flux density is milligauss (mG), where 1 µT = 10 mG. In contrast, the RF community expresses field strength in terms of amperes per meter (A/m). Field strength and flux density in vacuum are related by the following equation: 1 A/m = 12.57 mG.

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6 Definition per IEEE Std C95.1-2005, see note 2

7 Definition per IEEE Std C95.1-2005, see note 2

Maximum permissible exposure (MPE) limit. An exposure limit or guideline for RF energy exposure published by a recognized consensus standards organization, such as the IEEE

Non-ionizing radiation (NIR).[8] Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 eV, wavelengths greater than 100 nm, and frequencies lower than 3×10^{15} Hz

Plane wave power density. Although most RF exposure standards are written in terms of **E** and **H** fields, it is sometimes convenient to express field strength in terms of the equivalent plane wave power density, **S**, in watts per square meter (W/m^2).

Power density. Power per unit area normal to the direction of propagation, usually expressed in terms of watts per square meter (W/m^2) or milliwatts per square centimeter (mW/cm^2) (The conversion between the two units is 10 W/m^2 = 1 mW/cm^2.)

Pulse-modulated field. An electromagnetic field produced by the amplitude modulation of a continuous-wave radio frequency or microwave carrier signal at a known repetition rate with a controlled duty factor

Radio frequency (RF).[9] A frequency that is useful for radio transmission. For purposes of this chapter, the frequency range of interest is 3 kHz to 300 GHz.

8 Definition per "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), International Commission on Non-Ionizing Radiation Protection." *Health Physics* 74 (4): 494-522; 1998, http://icnirp.de/documents/emfgdl.pdf

9 Definition per IEEE Std C95.1-2005, see note 2

Maximum Permissible Exposure Limits

Note The following tables and graphs are numbered the same as the originals in Section 4 of IEEE Std C95.1-2005.

Table 8 Maximum Permissible Exposures for Controlled RF Environments

Frequency range (MHz)	RMS electric field strength (E)[a] (V/m)	RMS magnetic field strength (H)[a] (A/m)	RMS power density (S) E-field, H-field (W/m^2)	Averaging time $\|E\|^2$, $\|H\|^2$, or S (min)
0.1-1.0	1842	$16.3/f_M$	$(9000, 100000/f_M^2)$[b]	6
1.0-30	$1842/f_M$	$16.3/f_M$	$(9000/f_M^2, 100000/f_M^2)$[b]	6
30-100	61.4	$16.3/f_M$	$(10, 100000/f_M^2)$[b]	6
100-300	61.4	0.163	10	6
300-3000	-	-	$f_M/30$	6
3000-30000	-	-	100	$19.63/f_G^{1.079}$
30000-300000	-	-	100	$2.524/f_G^{0.476}$

Note—f_M is the frequency in MHz, f_G is the frequency in GHz

[a] For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the MPEs in the Table. For non-uniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area), or a smaller area depending on the frequency (see “Notes to Tables below), are compared with the MPEs in the table.

[b] These plane-wave equivalent power density values are commonly used as a convenient comparison with MPEs at higher frequencies and are displayed on some instruments in use.

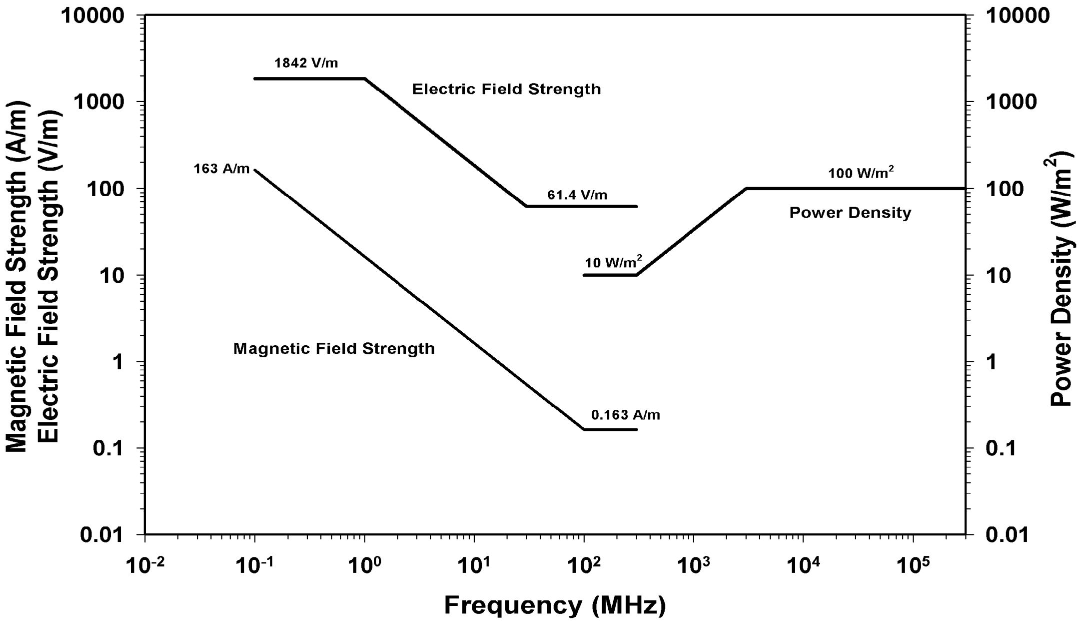

Figure 3 Graphic Representation of the MPEs in Table 8 (exposures in controlled environments)

Action Levels

The *action level* values in Table 9 indicate that an RF safety program (RFSP) plan must be initiated and submitted for review to the NIRSC. Once the RFSP is approved, a *controlled RF environment* is established in which exposures must not exceed the limits shown in Table 8.

Table 9 Action Level (Maximum Permissible Exposures for the General Public When No RFSP Exists)

Frequency range (MHz)	RMS electric field strength (E)[a] (V/m)	RMS magnetic field strength (H)[a] (A/m)	RMS power density (S) E-field, H-field (W/m²)	Averaging time $\|E\|^2$, $\|H\|^2$, or S (min)	
0.1-1.34	614	$16.3/f_M$	$(1000, 100000/f_M^2)$[c]	6	6
1.34-3	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100000/f_M^2)$	$f_M^2/0.3$	6
3-30	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100000/f_M^2)$	30	6
30-100	27.5	$158.3/f_M^{1.668}$	$(2, 9400000/f_M^{3.336})$	30	$0.0636f_M^{1.337}$
100-400	27.5	0.0729	2	30	30
400-2000	-	-	$f_M/200$	30	
2000-5000	-	-	10	30	
5000-30000	-	-	10	$150/f_G$	
30000-100000	-	-	10	$25.24/f_G^{0.476}$	
100000-300000	-	-	$(90f_G-7000)/200$	$5048/[(9f_G-700)f_G^{0.476}]$	

Note: f_M is the frequency in MHz, f_G is the frequency in GHz

[a] For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the MPEs in the Table. For non-uniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area), or a smaller area depending on the frequency (see Notes to Tables, below), are compared with the MPEs in the table.

[b] The left column is the averaging time for $|E|^2$, the right column is the averaging time for $|H|^2$. For frequencies greater than 400 MHz, the averaging time is for power density S.

[c] These plane-wave equivalent power density values are commonly used as a convenient comparison with MPEs at higher frequencies and are displayed on some instruments in use.

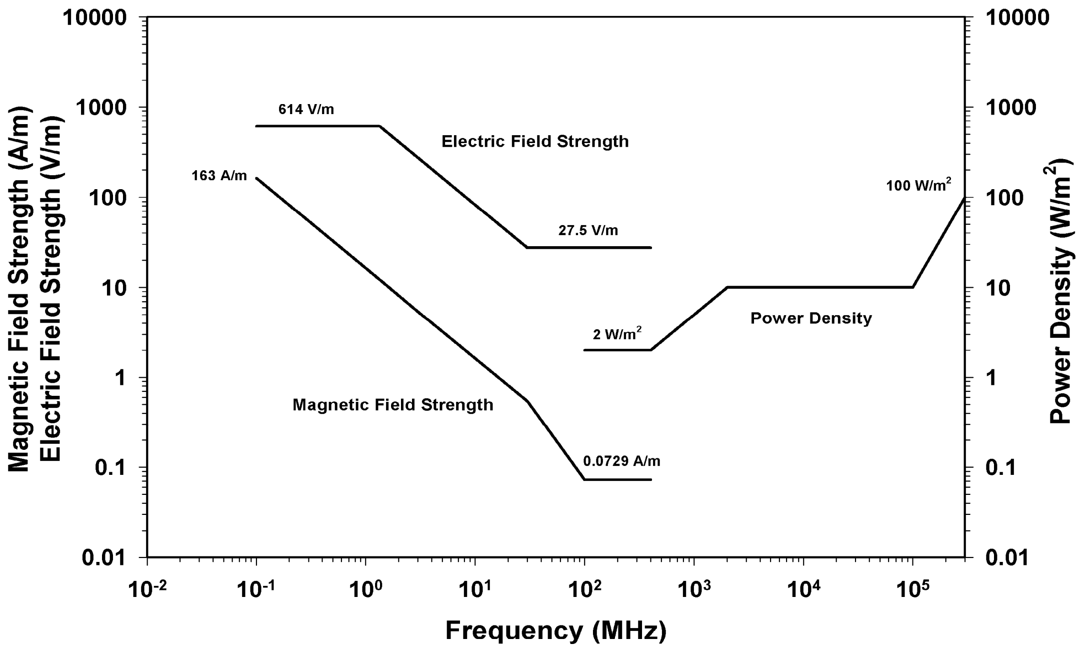

Figure 4 Graphic Representation of the MPEs in Table 9 (lower tier -- action level)

Notes to Tables

a) The MPEs refer to exposure values obtained by spatially averaging the electric and magnetic field strengths, the squares of the electric and magnetic field strengths, or the plane wave equivalent power densities along a line corresponding to the axis of the human body as follows:

Frequencies between 100 kHz and 3 GHz. The MPE for fields between 100 kHz and 3 GHz are derived on the basis of limiting the whole body averaged (WBA) SAR, which is proportional to the spatial average of the incident plane wave equivalent power density (or squares of electric and magnetic field strengths), averaged over the projected area of the body. Therefore, the MPE corresponds to the spatially averaged plane wave equivalent power density or the spatially averaged values of the squares of electric and magnetic field strengths. In practice, a measurement over the length of the body is sufficient for assessing exposures for comparison with the MPE.

Frequencies greater than 3 GHz. For frequencies greater than 3 GHz, the MPE is expressed in terms of the incident power density. To provide a transition in the frequency range 3 GHz to 6 GHz, compliance with this standard may be demonstrated by evaluation of either incident power density or local SAR. From 3

GHz to 30 GHz, the power density is spatially averaged over any contiguous area corresponding to 100 λ^2, where λ is the free space wavelength of the RF field in centimeters. For frequencies exceeding 30 GHz, the power density is spatially averaged over any contiguous area of 0.01 m^2 (100 cm^2), not to exceed a maximum power density of 1000 W/m^2 in any one square centimeter as determined by a calculation or a conventional field measurement.

b) For near-field exposures at frequencies below 300 MHz, the applicable MPE is in terms of rms electric and magnetic field strength, as given in Table 8 and Table 9, columns 2 and 3. For convenience, the MPE may be expressed as equivalent plane-wave power density, given in Table 8 and Table 9, column 4. For frequencies below 30 MHz, both the rms electric and magnetic field strength must be determined; for frequencies between 30 and 300 MHz, either field component will be sufficient provided that the point in question is in the far-field of the source. For frequencies above 300 MHz, either field component may be used, when expressed as equivalent plane wave power density, for determining compliance with the MPEs in Table 8 and Table 9.

c) For mixed or broadband fields at a number of frequencies for which there are different values of the MPE, the fraction of the MPE [in terms of $|\mathbf{E}|^2$, $|\mathbf{H}|^2$, or power density (**S**)] incurred within each frequency interval should be determined and the sum of all such fractions should not exceed unity. See Annex D of IEEE Std C95.1-2005 for an example of how this is accomplished.

d) In a similar manner, for mixed or broadband induced currents at a number of frequencies for which there are different values of the basic restriction, the fraction of the induced current limits (in terms of I^2) incurred within each frequency interval shall be determined, and the sum of all such fractions should not exceed unity.

e) For exposures to pulsed RF fields, in the range of 100 kHz to 300 GHz, the peak (temporal) value of the MPE for the instantaneous peak **E** field is 100 kV/m.

f) For exposures to pulsed RF fields in the range of 100 kHz to 300 GHz, the peak pulse power densities are limited by the use of time averaging and the limit on peak **E** field, with one exception: the total incident energy density during any one-tenth second period within the averaging time shall not exceed one-fifth of the total energy density permitted during the entire averaging time for a continuous field (1/5 of 144 J/kg).

Non-ionizing Radiation: Radio Frequency Equipment Lockout Procedure Guidelines

Department: Chemical and General Safety
Program: Non-ionizing Radiation
Owner: Program Manager
Authority: ES&H Manual, Chapter 50, Non-ionizing Radiation[1]

All equipment that generates radio frequency (RF) non-ionizing electromagnetic radiation (NIR) is subject to review by the Non-ionizing Radiation Safety Committee (NIRSC).[2] If the committee determines that an RF safety program (RFSP) is required, equipment owners must develop an equipment lockout procedure (ELP) for RF-generating equipment that may be repaired or modified. This exhibit provides guidelines for developing an ELP appropriate for containing potential RF hazards.

Note *An ELP to protect against RF hazards differs from a lockout/tagout procedure for electrical hazards due to the potentially larger area that an RF radiation leak could affect.*

ELP Overview

An ELP must

- Require all work to be done in a locked-out zero-power state
- Specify administrative controls and the qualifications of the person initiating them
- Specify inspection requirements and any RF monitoring that must be conducted by system experts prior to removing administrative controls

Minimum Qualifications for the Person in Charge

The engineer responsible for carrying out the ELP or overseeing the team that carries it out must possess sufficient knowledge and competence in these areas:

- Controlling the system configuration
- Securing the RF source
- Inspecting the system following any servicing, maintenance, repair, or modifications that can impact RF safety
- Certifying or recertifying a system, which involves such activities as surveying for RF leakage or knowing how to verify that the system is leak proof by, for instance, checking bolt tightness

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1 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 50, "Non-ionizing Radiation", http://www-group.slac.stanford.edu/esh/hazardous_substances/nir/policies.htm

2 "Non-Ionizing Radiation Safety Committee - Charter", https://www-internal.slac.stanford.edu/esh/committees/nrsc/charter.htm

Equipment Lockout Procedure Requirements

1. **Specify work planning and control documents.**
   All work planning and control must be communicated and understood by team members before work begins. This is required at all times, but it is especially important when work is done by various groups over a longer period; meticulous coordination and adherence to lock out tag out protocol is required to ensure uninterrupted safety.

2. **Describe LOTO lock and tag requirements.**
   All persons working on or very near the source of the RF hazard must apply their individual LOTO locks per the SLAC LOTO program.[3]

3. **Identify a zero-hazard verification method.**
   Since testing must often be completed prior to the disassembly of the transmission system, the ELP may need to incorporate alternate methods of verifying a zero-hazard state, such as one or more of the following:
   - A shorting bar is observed to be grounding the beam voltage source for the klystron (as for the Positron Electron Project [PEP] klystrons).
   - The modulator control system is completely de-energized due to the LOTO of the AC power source and it does not turn on when the controls are manipulated.
   - The modulator control system indicates the modulator is off, and manipulating the controls cannot turn the device on.
   - The modulator is quiet, and remains quiet while manipulating the controls.

4. **Specify post-work inspection(s).**
   The engineer must inspect the system to ensure that it is properly assembled and that RF power will be adequately contained when the system is activated per inspection criteria described in the RFSP. Once all inspections are complete, the engineer may remove the administrative lock and tag.

5. **Specify RF survey requirement(s).**
   If the RFSP requires an RF survey, the method and results must be documented as required. (Unless specified otherwise, the experiment log-book is appropriate.) If any RF hazards are identified, the source of the problem must be addressed or the system must be secured until it is safe.

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3 *SLAC Lock and Tag Program for the Control of Hazardous Energy* (SLAC-I-730-0A10Z-001), http://www-group.slac.stanford.edu/esh/hazardous_activities/lockout_tagout/locktag.pdf

Non-ionizing Radiation: Medical Information Guideline

Department: Chemical and General Safety
Program: Non-ionizing Radiation
Owner: Program Manager
Authority: ES&H Manual, Chapter 50, Non-ionizing Radiation[1]

IEEE Standard C95.7 sections 4.5.4 and 4.5.5 provide the following guidance for medical issues related to exposure to non-ionizing radiation (NIR) in the radio frequency (RF) range.[2]

Note *The following information is verbatim from the standard with the exception of replacing generic language with SLAC-specific contact information.*

Medical Devices and Implants

Radio frequency safety programs (RFSPs) should make sure that personnel are informed of the potential RF susceptibility of medical devices, and personnel should be encouraged to discuss the device manufacturer's information with appropriate occupational medical personnel to resolve any questions concerning compatibility with the work environment. Personnel should also be encouraged to inform the NIR program manager or SLAC Medical Department of their reliance on electronic devices so that additional guidance may be provided regarding their potential for RF exposure and the possibility that strong RF fields may interfere with electronic medical devices. This process is best accomplished as part of a job safety analysis that includes a fitness-for-work health assessment.

Note *In addition to the job hazard analysis and mitigation (JHAM) process, the Environment, Safety and Health (ES&H) Chemical and General Safety Department (CGS) NIR program manager or the project manager can provide information on the types and intensity of RF radiation for the treating physician to consider.*

Consultation with the employee's medical advisor is also recommended. Useful information that addresses possible RF interference issues may also be available from the RF source manufacturer.

Some medical devices, such as cardiac pacemakers, defibrillators, and drug delivery systems can exhibit improper operation when subjected to strong RF fields. Devices and systems that are used external to the body can be substantially more susceptible to

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1 *SLAC Environment, Safety, and Health Manual* (SLAC-I-720-0A29Z-001), Chapter 50, "Non-ionizing Radiation", http://www-group.slac.stanford.edu/esh/hazardous_substances/nir/policies.htm

2 Institute of Electrical and Electronics Engineers (IEEE) Standard C95.7-2005, "IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz", (IEEE Std C95.7-2005)

See the SLAC Library for available standards (http://www-group.slac.stanford.edu/library/CommunityPages.asp). This IEEE standard is available online from a SLAC login (http://ieeexplore.ieee.org/iel5/10721/33840/01611107.pdf?tp=&isnumber=33840&arnumber=1611107).

interference. For personnel who use electronic medical devices or systems and may need access to areas near RF sources, a request for an evaluation of the potential interference can be referred to the manufacturer for the manufacturer's own evaluation and guidance on electromagnetic compatibility (EMC). This may require contact with the device manufacturer and/or appropriate regulatory authorities and an evaluation of the RF fields where the subject employee may need access. It is important to note that device interference may occur at RF field strengths that are substantially less than human exposure limits.

Over-exposure Incident Response

Any person suffering harm from an RF over-exposure incident should receive medical treatment. Personnel should be instructed to inform their supervisor and the SLAC Medical Department of suspected and/or actual RF over-exposure or incidents of interference with a medical device, as soon as practicable. Symptoms such as pain, reddening of the skin, unusually elevated body temperature, or any other evidence of tissue burning, are possible indications of overexposure.

Without physical evidence of an over exposure, it can be very difficult to ascertain the severity of the exposure. However, the mere belief such an exposure has occurred can lead to heightened anxiety manifested in actual physiological reactions (such as headaches and nausea). Information about the exposure incident should be used to make an administrative determination of whether an actual over-exposure took place. Technical information should be gathered for evaluation by a knowledgeable person (such as the NIR 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 should be carried out under the guidance of the Non-ionizing Radiation Safety Committee (NIRSC)[3] and the NIR program manager.

Following an assessment of potential exposure and medical evaluation, where applicable, details of the incident should be documented in the records of the RFSP. A formal investigation to ascertain the cause of an over-exposure, and to develop appropriate strategies to reduce the likelihood of subsequent incidents, should be performed whenever the exposure exceeds the limit by a factor of 5 or more. Remedial options that could be considered include

- Improving the awareness of any person(s) who contributed to the occurrence of the over exposure incident through counseling or retraining
- Reviewing the adequacy of local controls implemented at the exposure site
- Reviewing the adequacy of the corporate procedures for the RFSP

3 "Non-Ionizing Radiation Safety Committee - Charter", https://www-internal.slac.stanford.edu/esh/committees/nrsc/charter.htm