851>Cal/OSHA Implementation Plan: Non-ionizing Radiation

This form is for documenting changes to a program and the program's supporting resources (ESH Manual chapter or similar program description, training courses, databases, and so on) resulting from the adoption of the model Revolutionary Working Group (RWG) contract (see below) and the associated DOE variance from 10 CFR 851, "Worker Safety and Health Program". The purpose is to ensure consistent, concise descriptions of the resulting changes. The form is to be completed by the program manager and sent to the DOE as a cover sheet with the revised documents. The general process is as follows:

1. Program manager completes form
2. Changes to program resources made and reviewed following normal revision processes
3. DOE sent draft form and revisions
4. Changes to program resources published
5. DOE sent final form and revisions

1 Introduction

The RWG model contract and 10 CFR 851 variance are intended to simplify and improve the implementation of worker safety and health requirements by tailoring the laws, regulations, and standards that apply while achieving a level of protection equivalent to the requirements of 10 CFR 851. This mostly entails replacing federal Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910 and 1926) with Cal/OSHA regulations (8 CCR) as external requirements to be complied with but may also involve other laws and regulations and either different versions of industry standards than those cited in 10 CFR 851 or entirely different standards. (One purpose of this form is to capture the specific changes in external requirements for each program.) (For more information on this effort, see the variance application in 851>Cal/OSHA resources.)

2 Plan

Field Number	Field Name	Field
1.	Program name	Non-ionizing Radiation
2.	Program manager	McDaniel, Mike
3.	LBNL counterpart	? (SME list) (LBNL Phonebook)
4.	Program documents	*The following is a list of existing program documents, to be reviewed by the program manager to determine which will need to be revised to reflect 851>Cal/OSHA changes.* ▪ ESH Manual Chapter 50: Non-ionizing Radiation ▪ Non-ionizing Radiation: Quick Start Summary ▪ Non-ionizing Radiation: Radio Frequency Source Review, Operation, and Maintenance Requirements ▪ Non-ionizing Radiation: Radio Frequency Source Review Procedure ▪ Non-ionizing Radiation: Selected Radio Frequency Exposure Limits ▪ Non-ionizing Radiation: Radio Frequency Equipment-specific Lockout Procedure Requirements
5.	Training courses	*The following is a list of existing training courses, to be reviewed by the program manager to*

Field Number	Field Name	Field
		determine which will need to be revised to reflect 851>Cal/OSHA changes. *Course materials are available for review.* ▪ ESH Course 251, Safety Awareness for R&D (ESH Course 251)
6.	Other program resources	*The following is a list of existing program resources, to be reviewed by the program manager to determine which will need to be revised to reflect 851>Cal/OSHA changes.* ▪ Non-ionizing Radiation Safety Program Site (SharePoint)
7.	Current external requirements	*The following is a list of current external requirements for this program, as identified in the program documents above.* ▪ Title 29, Code of Federal Regulations, "Labor", Subtitle B, "Regulations Relating to Labor (Continued)", Chapter 17, "Occupational Safety and Health Administration, Department of Labor", Part 1910, "Occupational Safety and Health Standards", Subpart G, "Occupational Health and Environmental Control", Section 97, "Non-ionizing Radiation" (29 CFR 1910.97) ▪ American Conference of Governmental Industrial Hygienists (ACGIH). Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) (ACGIH TLVs and BEIs) ▪ 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) ▪ Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1a-2010, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. Amendment 1: Specifies Ceiling Limits for Induced and Contact Current, Clarifies Distinctions between Localized Exposure and Spatial Peak Power Density" (IEEE Std C95.1a-2010) *The following is a list of current external reference/guidance documents.* ▪ Institute of Electrical and Electronics Engineers (IEEE) Standard C95.7-2014, "IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz" (IEEE Std C95.7-2014) ▪ 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
8.	Proposed external requirements	*List all the external requirements that will apply to this program. To determine, start by looking up existing external requirements in 851>Cal/OSHA resources (variance, gap analysis, and contract) and finding replacements (for example a specific section in 29 CFR 1910 to a specific section in 8 CCR or a current version of an industry standard).Where Cal/OSHA requirements are less stringent than those of 10 CFR 851, check with Jeremy Sawyer on which to use.* ***Enter "no changes" if none.*** ▪ Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1, "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz" (IEEE Std C95.1)
9.	Proposed substantive changes	*Describe (list) the substantive changes to be made in the program, based on the new external requirements.* ***Enter "no changes" if none.*** Revise to reflect tables and nomenclature changes between the previous C95.1 versions and C95.1 (2019)]
10.	Additional proposed substantive	*Describe (list) the substantive changes to be made in the program, in addition to those based on the new external requirements. For example, those due to stakeholder input, other reviews and*

Field Number	Field Name	Field		
	changes	*audits, operating experience.* ***Enter "no changes" if none.*** [Add text]		
11.	Affected program documents	*List program documents affected by the changes above.* ***Enter "no changes" if none.*** ▪ [All program documents]		
12.	Affected training courses	*List training courses affected by the changes above.* ***Enter "no changes" if none.*** ▪ [List, can copy from above]		
13.	Other affected program resources	*List other program resources affected by the changes above.* ***Enter "no changes" if none.*** ▪ [List, can copy from above]		
14.	Comments/Questions/Issues	*Add any comments or questions regarding applicable requirements or changes.* [Add text]		
15.	Status	☒ Initial draft (proposed changes)	☒ Draft (for DOE review)	☒ Final (published changes)
16.	Date completed	5/12/2020	7/17/2020	7/21/2020

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 50: Non-ionizing Radiation

Quick Start Summary

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URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/nirQuickstart.pdf

1 Who needs to know about these requirements

The requirements of the Non-ionizing Radiation program apply to workers, supervisors, equipment owners, area and building managers, and the non-ionizing radiation program manager; and the Occupational Health Center.

2 Why

SLAC research and development involve sources of *radio frequency (RF) non-ionizing electromagnetic radiation (NIR)*. This includes klystrons and waveguide systems; communications transmitters; and induction heaters and ultrasonic cleaners. Most RF systems at SLAC are designed to not emit hazardous levels of NIR when operating normally. There are, however, cases in which RF systems at SLAC could emit hazardous levels of NIR. The hazards associated with exposure are electro-stimulation of nerves and thermal heating of body tissues. Also, even normally non-hazardous RF fields may interfere with electric medical devices.

3 What do I need to know

All new RF sources and all significant reconfigurations of existing sources must be reviewed and approved by the program manager. Review begins with a preliminary hazard analysis prepared by the equipment owner. 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. 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)*. The RFSP is reviewed by the program manager and approved once all safety measures and requirements are documented and reviewed.

4 When

These requirements take effect 21 July 2020.

5 Where do I find more information

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

- Chapter 50, “Non-ionizing Radiation”

Or contact the program manager.

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 50

Non-ionizing Radiation

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URL: https://www-group.slac.stanford.edu/esh/eshmanual/pdfs/ESHch50.pdf

1 Purpose

The purpose of this program is to ensure personnel are not exposed to hazardous levels of non-ionizing radiation. It covers 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. It applies to workers, supervisors, equipment owners, area and building managers, and the non-ionizing radiation program manager; and the Occupational Health Center.

1.1 IEEE C95.1 Standard

This program is based on, and complies with, the Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1, "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 kHz to 300 GHz" (IEEE Std C95.1). That standard defines radio frequency (RF) as "a frequency that is useful for radio transmission, generally considered frequencies between approximately 3 kHz and 300 GHz" but covers frequencies starting at 0 kHz. The scope of this SLAC program is limited to the RF band.

The IEEE standard groups exposure levels into two tiers: upper tier for *restricted* (or *controlled*) *environments*, and lower tier for the general public in unrestricted (or uncontrolled) environments. Each tier has an upper limit. Exposure levels above the lower tier upper limit require the initiation of a RF safety program, to ensure the upper limit of the upper tier is not exceeded. (Exposures beyond this limit are known to have adverse health effects.)

The standard uses the term *exposure reference level (ERL)* to refer to exposure levels generally and *safety program initiation level* to refer to the upper limit of the lower tier. These terms replace the deprecated terms *maximum permissible exposure (MPE)* and *action level*, respectively.

2 Roles and Responsibilities

Functional roles and general responsibilities for each are listed below. More detailed responsibilities and when they apply are provided in the procedures and requirements.

The roles may be performed by one or more individuals and one individual may play more than one role, depending on the structure of the organizations involved. Responsibilities may be delegated.

2.1 Worker

- Follows procedures specified in the *radio frequency safety program (RFSP)* and work procedures applicable to areas with the potential for hazardous RF radiation and fields
- Observes requirements in the area hazard analysis (AHA)
- Completes required training
- Cooperates with the program manager to ensure that valid and representative sampling data are collected
- Is encouraged to seek guidance on potential hazards from his or her supervisor, the non-ionizing radiation program manager, or the Occupational Health Center if using an electronic medical device, such as such as a cardiac pacemaker, defibrillator, or drug delivery system
- Follows 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, in the event of a known or suspected RF over-exposure or of interference with an electronic medical device

2.2 Supervisor

- Knows and understands the potential RF hazards in the areas in his or her work area
- Documents required job-specific training and work procedures, ensuring that potential RF hazards, controls, and training are included
- Provides information regarding RF hazards to the Human Resources Development and Services Division via a job requirement and exposure checklist (JREC) before workers are being reassigned or newly hired into a work area with RF sources
- Ensures his or her workers are properly trained if they are required to work on systems in a controlled RF environment
- Ensures workers understand and follow all applicable requirements

2.3 Equipment Owner

- Ensures requirements of this program are effectively implemented within his or her area(s) of responsibility
- Submits to the program manager a preliminary hazard analysis and supporting information comparing potential RF radiation exposures to applicable levels
- Submits to the program manager an RFSP, when required, detailing the methods used to ensure these levels of exposure for new installations or changes to existing installations
- Minimizes exposure to RF sources by implementing engineering, work practice, and administrative controls as specified in the RFSP
- Obtains a variance from the program manager if any requirements in the approved RFSP cannot be met
- Notifies the program manager 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 and revises hazard analysis and RFSP if necessary

- Ensures that a system is returned to a safe condition upon completion of major work
- Informs area or building 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)
- Ensures control of hazardous energy requirements are met, including implementation of equipment-specific lockout procedures (ELP) required by the RFSP
- Ensures that calibrated equipment is used to measure RF radiation levels to determine compliance to the RFSP

2.4 Area / Building Manager

- Maintains a current inventory of potential RF hazards in his or her facility and provides to the program manager
- Updates the area hazard analysis (AHA) to include any change in RF hazards
- Ensures 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
- Verifies that equipment owners perform their required periodic RF safety checks as specified in the RFSP
- Performs a cross-check with the equipment owner that a system has been returned to a safe condition upon completion of major work before re-energizing system

2.5 Occupational Health Center

- Provides guidance to workers on potential hazards of RF radiation and interference with electric medical devices, if requested
- Conducts an exam and arranges for further exams if needed, in the event of a known or suspected RF over-exposure

2.6 Non-ionizing Radiation Program Manager

- Approves preliminary hazard analyses and RFSPs for new facilities and requests for operational variance in existing facilities
- Convenes as needed an ad hoc committee to assist in review and approval of hazard analyses, RFSPs, and variances
- Compiles available inventories of potential RF hazards and restricted environments at SLAC
- Conducts non-ionizing radiation surveys as required

3 Procedures, Processes, and Requirements

These documents list the core requirements for this program and describe how to implement them:

- Non-ionizing Radiation: Radio Frequency Source Review, Operation, and Maintenance Requirements (SLAC-I-730-0A05S-013). Describes requirements for 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

- Non-ionizing Radiation: Radio Frequency Source Review Procedure (SLAC-I-730-0A05C-002). Describes process for reviewing new and modified permanently installed sources of non-ionizing radiation capable of radiating over 1 Watt (W) at radio frequencies
- Non-ionizing Radiation: Selected Radio Frequency Exposure Limits (SLAC-I-730-0A05S-001). Presents a subset of data most applicable to potential radio frequency (RF) hazards at SLAC, reproduced from IEEE Std C95.1. The data are to be used by equipment owners and the non-ionizing radiation program manager when preparing preliminary hazard analyses and radio frequency safety programs (RFSPs).
- Non-ionizing Radiation: Radio Frequency Equipment-specific Lockout Procedure Requirements (SLAC-I-730-0A05S-014). Describes requirements for development and implementation of equipment-specific lockout procedures for radio frequency sources

These documents provide useful guidance; their use is not mandatory:

- None

4 Training

4.1 Worker

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 RFSP.

Personnel who construct, maintain, or install research and development equipment that contains hazards such as RF sources must in addition complete this course:

- ESH Course 251, Electrical and General Safety Awareness for R&D (ESH Course 251)

5 Definitions

action level. See *safety program initiation level*

controlled environment. See *restricted area*

duty factor. The fraction of time a transmitter or source is emitting RF 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.

equipment owner. A person or organization exercising direct control over and having line responsibility for the operation of a machine, system, or component. For RF sources in production equipment that is required for the operation of an accelerator at SLAC (such as klystrons, waveguides, and structures for LCLS and FACET, and similar equipment), the equipment owner is the division director of the accelerator group that is responsible for accelerator operations. For equipment used for individual experiments or tests that are

part of research not needed for the production machines, including development of cavity structures, new klystrons, the owner is the person responsible for planning and carrying out the experiment.

exposure reference level (ERL).[1] The maximum exposure level relative to ambient electric and/or magnetic field strength or power density, induced and/or contact current, or contact voltage. ERLs provide an adequate margin of safety against established adverse health effects. Also referred to as *maximum permissible exposure (MPE)*. See also *safety program initiation level*

maximum permissible exposure (MPE). See *exposure reference level (ERL)*

non-ionizing radiation (NIR).[2] 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).[3] A frequency that is useful for radio transmission, generally considered frequencies between approximately 3 kHz and 300 GHz

radio frequency safety program (RFSP).[4] 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

restricted environment.[5] 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. Also referred to as *controlled environment*

safety program initiation level.[6] The lower tier *exposure reference level (ERL)* above which a safety program must be implemented. Also referred to as *action level.*

6 References

6.1 External Requirements

The following are the external requirements that apply to this program:

1 Per IEEE Std C95.1

2 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

3 Definition per IEEE Std C95.1

4 Definition per IEEE Std C95.1

5 Definition per IEEE Std C95.1

6 Definition per IEEE Std C95.1

- Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1, "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 kHz to 300 GHz" (IEEE Std C95.1)

6.2 Related Documents

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

- Chapter 10, "Laser Safety"
- Chapter 51, "Control of Hazardous Energy"

Other SLAC Documents

- None

Other Documents

- "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
- 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)

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 50: Non-ionizing Radiation

Radio Frequency Source Review, Operation, and Maintenance Requirements

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URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/confinedReqPost.pdf

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

or failure. (See Non-ionizing Radiation: Radio Frequency Source Review Procedure for details on the review process.)

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

Equipment-specific Lockout Procedure Requirements). Any additional work practice procedures that will ensure worker safety should be developed as necessary or as required by the non-ionizing radiation program manager.

- **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 program manager for assistance in determining appropriate signage.
- **Access limitation.** Project managers and area/building managers must ensure that, where required by the RFSP, the operational supervisor controls access to controlled RF environments.
- **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, Annex A.
- **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

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)

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 50: Non-ionizing Radiation

Radio Frequency Source Review Procedure

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URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/nirProcedReview.pdf

1 Purpose

The purpose of this procedure is to protect workers from exposure to *non-ionizing electromagnetic radiation (NIR)* and fields in the *radio frequency (RF)* portion of the spectrum defined as from 3 kilohertz (kHz) to 300 gigahertz (GHz). It applies to the review of new and modified permanently installed sources of non-ionizing radiation capable of radiating over 1 Watt (W) at radio frequencies. 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. It applies to equipment owners and the non-ionizing radiation program manager.

2 Procedure

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. (See Non-ionizing Radiation: Radio Frequency Source Review, Operation, and Maintenance Requirements.)

2.1 Review

Step	Person	Action
1.	Equipment owner	Contacts the non-ionizing radiation program manager
2.	Equipment owner	Performs a preliminary hazard analysis of the RF source. The preliminary hazard analysis must review the amount of RF energy that could be generated by the source in both normal operating mode and during credible failures of engineered and other controls. The resulting calculated RF energy levels are then compared to the *safety program initiation levels*. (See Non-ionizing Radiation: Selected Radio Frequency Exposure Limits for safety program initiation levels and the *exposure reference levels (ERLs)* upon which they are based.) ▪ If the hazard analysis demonstrates that the equipment poses no hazard (that is, will not generate levels of radiation exceeding safety program initiation levels), submits the analysis and supporting materials to the non-ionizing radiation program manager for approval (goes to Step 3) ▪ If the hazard analysis shows that RF radiation may exceed safety program initiation levels, develops a facility-specific *radio frequency safety program (RFSP)* (goes to Step 4)

Step	Person	Action
3.	Non-ionizing radiation program manager	Approves the source for the described use. The program manager's signature on a cover letter affixed to the submitted preliminary hazard analysis documents the approval. *Note: if the preliminary hazard analysis cannot definitively demonstrate that the source poses no hazard, because of the complexity of the system, because it closely approaches the action level, or for other reasons, then a more detailed risk analysis will be required and incorporated into the RFSP.*
4.	Equipment owner	Develops an RFSP The required RFSP must include the elements listed in Non-ionizing Radiation: Radio Frequency Source Review, Operation, and Maintenance Requirements.
5.	Equipment owner	Submits the analysis, supporting materials, and RFSP to the program manager
6.	Non-ionizing radiation program manager	Reviews the RFSP. The program manager may invite other experts to participate in the review. Approves the RFSP once all safety measures are documented and reviewed. The program manager's signature on a cover letter affixed to the submitted RFSP documents the approval.
7.	Equipment owner and non-ionizing radiation program manager	Maintain separate copies of preliminary hazard analyses, cover letters, and approved RFSPs

3 Forms

The following forms are required by this procedure:

- None

4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- The non-ionizing radiation program manager and the equipment owner will each maintain copies of preliminary hazard analyses, cover letters, and approved RFSPs.

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, Operation, and Maintenance Requirements (SLAC-I-730-0A05S-013)
  - Non-ionizing Radiation: Selected Radio Frequency Exposure Limits (SLAC-I-730-0A05S-001)

Chapter 50: Non-ionizing Radiation

Selected Radio Frequency Exposure Limits

Product ID: 94 | Revision ID: 2262 | Date published: 21 July 2020 | Date effective: 21 July 2020
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/nirReqExpLimits.pdf

1 Purpose

This document presents a subset of data most applicable to potential *radio frequency (RF)* hazards at SLAC, reproduced from the Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1, "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 kHz to 300 GHz" (IEEE Std C95.1). (That standard defines radio frequency as "a frequency that is useful for radio transmission, generally considered frequencies between approximately 3 kHz and 300 GHz" but covers frequencies starting at 0 kHz. The scope of this SLAC program is limited to the RF band.) The data are to be used by equipment owners and the non-ionizing radiation program manager when preparing preliminary hazard analyses and *radio frequency safety programs (RFSPs).*

2 Requirements

RF installations at SLAC must comply with the exposure levels given in IEEE Std C95.1. These levels are grouped in two tiers: upper tier for *restricted environments* and lower tier for the general public in uncontrolled environments.

The upper limit of the lower tier levels are *safety program initiation levels*: potential exposures at or above these levels require preparation of an RFSP (see Section 2.4). Once the RFSP is approved, a restricted environment is established in which exposures must not exceed the upper tier levels (see Section 2.3).

Note *The standard uses the term* exposure reference level (ERL) *to refer to exposure levels generally and* safety program initiation level *to refer to the upper limit of the lower tier. These terms replace the deprecated terms* maximum permissible exposure (MPE) *and* action level*, respectively.*

Note *Equipment owners are encouraged to consult the standards to verify that the equipment in question satisfies these limits. Contact the non-ionizing radiation program manager for any specific questions regarding the data presented here or in the standards.*

2.1 Symbols, Units, and Acronyms

A ampere

BR basic restriction

E electric field strength vector, measured in V/m

E	electric field strength amplitude, measured in V/m
f	frequency, measured in Hz
EM	electromagnetic
ERL	exposure reference level
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
kg	kilogram
kHz	kilohertz
J	joule
m	meter
MHz	megahertz
MPE	maximum permissible exposure
NIR	non-ionizing radiation
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

2.2 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. See *safety program initiation level*

averaging time.[1] The appropriate time period over which exposure is averaged for purposes of determining compliance with a maximum permissible exposure (MPE) limit or reference level

basic restriction (BR).[2] Exposure restriction based on established adverse health effects that incorporates appropriate safety factors and is 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 environment. See *restricted area*

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 (**E** = **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.

exposure reference level (ERL).[3] The maximum exposure level relative to ambient electric and/or magnetic field strength or power density, induced and/or contact current, or contact voltage. ERLs provide an adequate margin of safety against established adverse health effects. Also referred to as *maximum permissible exposure (MPE)*. See also *safety program initiation level*

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,

1 Definition per IEEE Std C95.1

2 Definition per IEEE Std C95.1

3 Per IEEE Std C95.1

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.

maximum permissible exposure (MPE). See *exposure reference level (ERL)*

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.)

power density, plane wave. 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)

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

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

radiation, non-ionizing (NIR).[4] 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 $3x10^{15}$ Hz

radio frequency (RF).[5] A frequency that is useful for radio transmission, generally considered frequencies between approximately 3 kHz and 300 GHz

safety program initiation level.[6] The lower tier *exposure reference level (ERL)* above which a safety program must be implemented. Also referred to as *action level.*

2.3 Exposure Reference Levels

Note *The following tables and graphs are reproduced from and numbered the same as in Section 4.3.2 of IEEE Std C95.1. Note although the standard and tables and graphs below cover the range from 0 kHz to 300 GHz, the scope of this SLAC program is limited to the RF band, approximately 3 kHz and 300 GHz.*

4 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

5 Definition per IEEE Std C95.1

6 Definition per IEEE Std C95.1

Table 8 ERLs for Whole-body Exposure of Persons Permitted in Restricted Environments (100 kHz to 300 GHz)

Frequency range (MHz)	Electric field strength (E)[a,b,c] (V/m)	Magnetic field strength (H)[a,b,c] (A/m)	Power density (S)[a,b,c] (W/m^2)		Averaging time (min)
			S_E	S_H	
0.1 to 1.0	1842	16.3 / f_M	9000	100 000 / f_M^2	30
1.0 to 30	1842 / f_M	16.3 / f_M	9000 / f_M^2	100 000 / f_M^2	30
30 to 100	61.4	16.3 / f_M	10	100 000 / f_M^2	30
100 to 400	61.4	0.163	10		30
400 to 2000	—	—	f_M / 40		30
2000 to 300 000	—	—	50		30
NOTE—S_E and S_H are plane-wave-equivalent power density values, based on electric or magnetic field strength respectively, and are commonly used as a convenient comparison with ERLs at higher frequencies and are sometimes displayed on commonly used instruments.					

[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 ERLs in Table 8. For more typical nonuniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the plane-wave-equivalent power densities or the squares of the field strengths, are compared with the ERLs in Table 8. (See notes to Table 7 through Table 11 in 4.3.5.)

[b] f_M is the frequency in MHz.

[c] The E, H, and S values are those rms values unperturbed by the presence of the body.

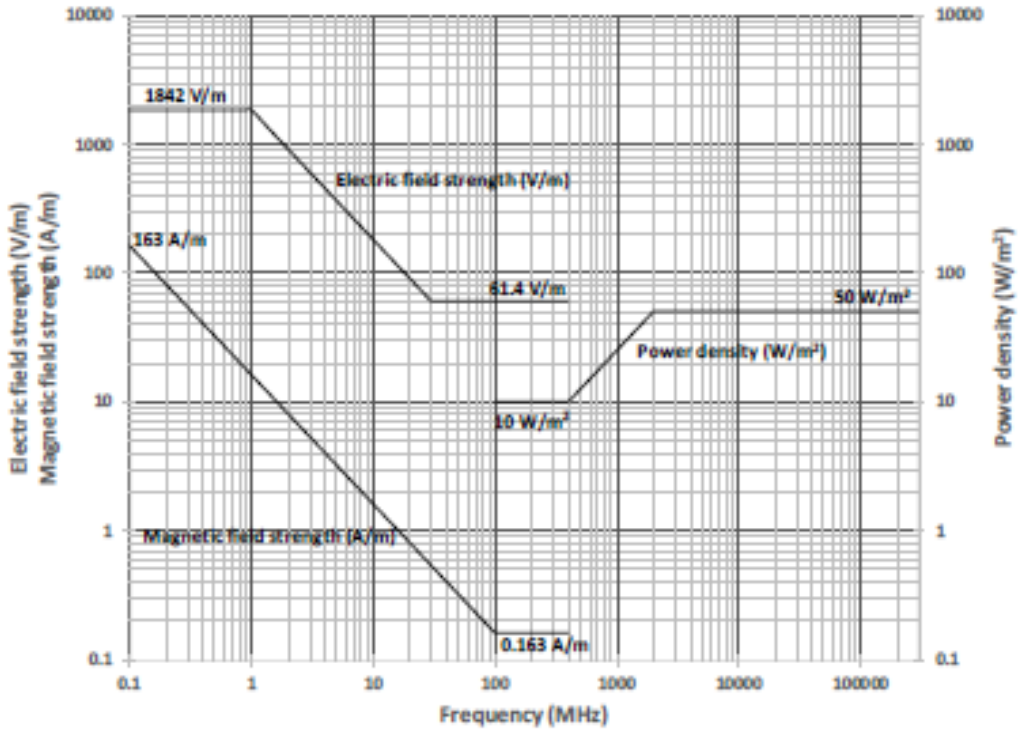

Figure 4 Graphical Representations of the ERLs in Table 8 for Electric and Magnetic Fields and Plane-wave-equivalent Power Density – Persons in Restricted Environments

2.4 Safety Program Initiation Levels

The *safety program initiation level* values in Table 7 indicate that an RF safety program (RFSP) plan must be initiated and submitted for review to the non-ionizing radiation program manager. Once the RFSP is approved, a *restricted environment* is established in which exposures must not exceed the limits shown in Table 8.

Table 7 ERLs for Whole-body Exposure of Persons in Unrestricted Environments (100 kHz to 300 GHz))

Frequency range (MHz)	Electric field strength (E)[a,b,c] (V/m)	Magnetic field strength (H)[a,b,c] (A/m)	Power density (S)[a,b,c] (W/m^2)		Averaging time (min)
			S_E	S_H	
0.1 to 1.34	614	16.3 / f_M	1000	100 000 / f_M^2	30
1.34 to 30	823.8 / f_M	16.3 / f_M	1800 / f_M^2	100 000 / f_M^2	30
30 to 100	27.5	158.3 / $f_M^{1.668}$	2	9 400 000 / $f_M^{3.336}$	30
100 to 400	27.5	0.0729	2		30
400 to 2000	—	—	f_M / 200		30
2000 to 300 000	—	—	10		30

NOTE—S_E and S_H are plane-wave-equivalent power density values, based on electric or magnetic field strength respectively, and are commonly used as a convenient comparison with ERLs at higher frequencies and are sometimes displayed on commonly used instruments.

[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 ERLs in Table 7. For more typical nonuniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the plane-wave-equivalent power densities or the squares of the field strengths, are compared with the ERLs in Table 7. (See notes to Table 7 through Table 11 in 4.3.5.)

[b] f_M is the frequency in MHz.

[c] The E, H, and S values are those rms values unperturbed by the presence of the body.

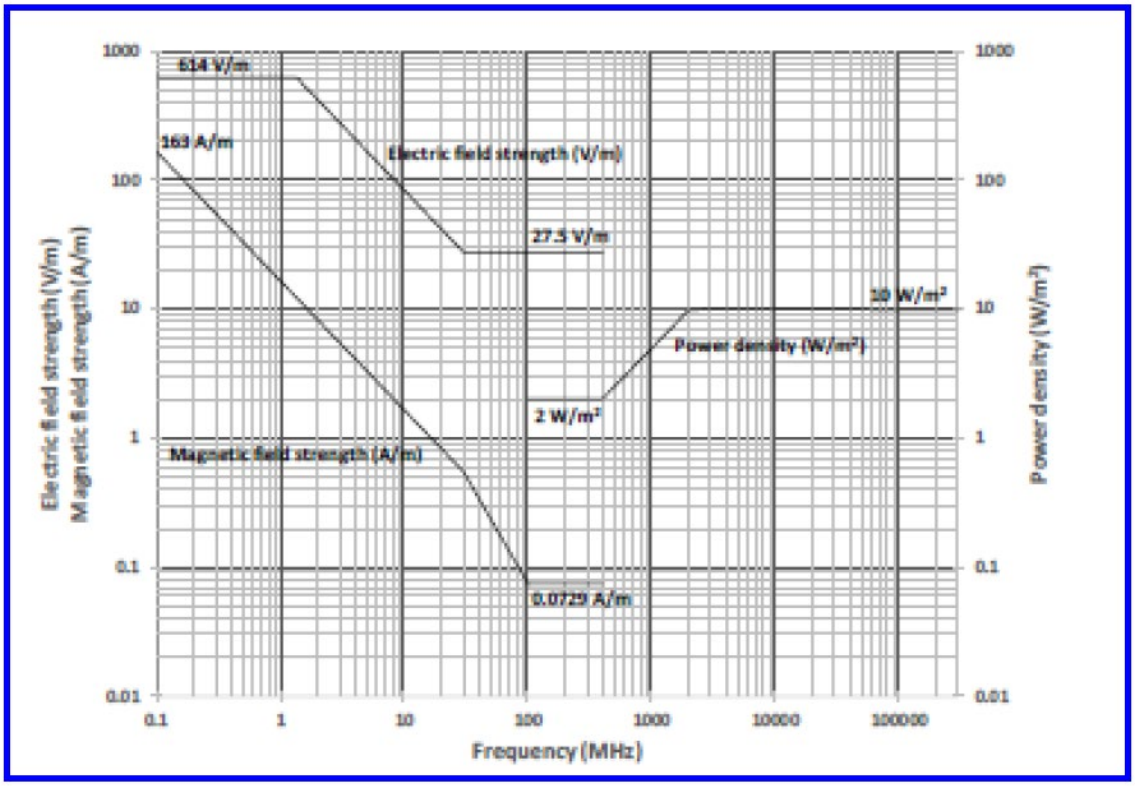

Figure 3 Graphical Representations of the ERLs in Table 7 for Electric and Magnetic Fields and Plane-wave equivalent Power Density—Persons in Unrestricted Environments

2.5 ERLs for Localized Exposures

The C95.1 standard also has allowances for localized (that is, non-whole body) exposures and other special cases that are addressed in its Tables 9, 10, and 11 that are incorporated into this SLAC ESH Manual chapter by reference.

2.6 Notes to IEEE Std. C95.1 Tables 7 through 11

The following notes are excerpted from IEEE Std C95.1, Section 4.3.5.

The following provides explanatory notes for Table 7 through Table 11:

a) The ERLs refer to exposure values obtained by spatially averaging the plane-wave-equivalent power densities, depending on frequency as follows (see Annex D for details):

   1) **Frequencies between 100 kHz and 6 GHz:** The ERLs for fields between 100 kHz and 6 GHz limit the WBA SAR and, therefore, correspond to the spatial average of the incident plane-wave-equivalent power density (or spatial average of the squares of the rms electric field strengths or magnetic field strengths) averaged over the projected area of the body.

   2) **Frequencies between 6 GHz and 300 GHz:** The ERL is expressed in terms of the incident power density spatially averaged over any square area of 4 cm^2. For exposures from millimeter-wave pulses, the fluence limit is averaged over 1 cm^2 square area of the body surface. The ERLs in Table 11 (see 4.3.3.2) provide guidance on limiting local exposure to RF fields above 6 GHz where the region of interest is the body surface.

b) For near-field exposures at frequencies below 400 MHz, the applicable ERL is in terms of rms electric and magnetic field strength, as given in Table 7 and Table 8 (see 4.3.2), columns 2 and 3. For convenience, the ERL may be expressed as plane-wave-equivalent power density, given in Table 7 and Table 8, column 4. For frequencies below 30 MHz, both the rms electric and the magnetic field strength shall be determined; for frequencies between 30 MHz and 400 MHz, either field component is sufficient provided that the point in question is in the far-field of the source. In the near field of a source, both fields shall be determined and compliant with the ERLs. For determining compliance with the ERLs in Table 7 or Table 8 (see 4.3.2) at the higher frequencies (above 400 MHz), either field component may be used when expressed as plane-wave-equivalent power density.

c) Compliance with the WBA ERL is intended to help ensure that the WBA DRL is not exceeded. However, in spatially nonuniform fields, compliance with the WBA ERL might not ensure compliance with the local DRL. For this reason, Table 9 and Table 10 provide guidance on limiting the magnitude of local ERL, which is intended to help ensure that local DRL is not exceeded.

d) For uncorrelated (in time) fields, for instance, mixed or broadband fields at a number of frequencies for which there are different values of the ERL, the percentage of the ERL [in terms of E^2, H^2, or power density (S)] incurred within each frequency interval shall be determined and the sum of all such percentages shall not exceed 100 %. For frequencies between 100 kHz and 5 MHz the ERLs for electrostimulation and for heating apply independently. In this frequency band the fractional summation for each ERL shall be considered separately. See Annex D for examples of ERL summations for each type of ERL.

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

3 Forms

The following are forms required by these requirements:

- None

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- None

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, Operation, and Maintenance Requirements (SLAC-I-730-0A05S-013)
  - Non-ionizing Radiation: Radio Frequency Source Review Procedure (SLAC-I-730-0A05C-002)

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 Electric, Magnetic, and Electromagnetic Fields, 0 kHz to 300 GHz" (IEEE Std C95.1)

NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 50: Non-ionizing Radiation

Radio Frequency Equipment-specific Lockout Procedure Requirements

Product ID: 676 | Revision ID: 2263 | Date published: 21 July 2020 | Date effective: 21 July 2020
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/nirReqELP.pdf

1 Purpose

The purpose of these requirements is to protect workers servicing, maintaining, and repairing *radio frequency (RF)* sources from hazardous exposure to non-ionizing radiation. They cover development and implementation of equipment-specific lockout procedures. They apply to workers, supervisors, equipment owners, and the non-ionizing radiation program manager.

2 Requirements

An equipment-specific lockout procedure (ELP) for RF-generating equipment is a required element of a *radio frequency safety program (RFSP)* (see Non-ionizing Radiation: Radio Frequency Source Review, Operation, and Maintenance Requirements).

ELPs for RF-generating equipment must meet requirements for ELPs in Control of Hazardous Energy: General Requirements. Additional requirements apply because of the unique hazards of RF energy, such as the larger area that an RF radiation leak could affect.

2.1 ELP Overview

An RF 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 before removing administrative controls

2.2 Minimum Qualifications for Authorized Workers

The authorized worker responsible for carrying out an 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 service, maintenance, repair, or modification that could 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

2.3 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 lock and tag requirements.

   All persons working on or near the source of the RF hazard must apply their individual LOTO locks per Chapter 51, "Control of Hazardous Energy".

3. Identify a zero-hazard verification method.

   Since testing must often be completed before 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.

   – 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 authorized worker 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 worker 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.

3 Forms

The following are forms required by these requirements:

- None

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- Equipment owners are responsible for maintaining ELPs.

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, Operation, and Maintenance Requirements (SLAC-I-730-0A05S-013)
- Chapter 51, "Control of Hazardous Energy"
  - Control of Hazardous Energy: General Requirements (SLAC-I-730-0A10S-004).

Other SLAC Documents

- None

Other Documents

- None