LENS Radiation Safety Manual

Approval

Organization	Title	Name	Signature	Date
ISAT - LENS	Radiation Safety Officer	Greg Crouch		7-22-15

Revision History (most recent first)

Revision	Effective Date	Purpose of Release	Author(s)

CONTACT INFORMATION

In order to request radiation safety assistance or service during normal hours contact:

Radiation Safety Officer …….…… **855-3230**

Assistant Radiation Safety Officer …… **856-2712**

ISAT Hall Front Office (to page staff) …… **855-9365**

In the event of an accident that involves serious personal injury or fire, immediately call:

911

TABLE OF CONTENTS

1.0 UNIVERSITY POLICY 5

2.0 REGULATORY REQUIREMENTS 5

3.0 ADMINISTRATIVE ORGANIZATION 5

3.1 Radiation Safety Program 5
3.2 Radiation Safety Officer 6
3.3 Assistant Radiation Safety Officer 6
3.4 CEEM Safety Committee 6

4.0 RESTRICTED AREAS 6

5.0 AUTHORIZATION FOR ACCESS 6

6.0 EMPLOYEE RIGHTS 7

7.0 TRAINING REQUIREMENTS 7

8.0 PERSONNEL DOSE LIMITS 8

8.1 Occupational Dose Limits 8
8.2 ALARA Goals 9
8.3 Dose Limits for an Embryo/Fetus 9
8.4 Dose Limits for Members of the Public 9

9.0 PERSONNEL MONITORING 9

9.1 Personnel Dosimeters 9
9.2 Bioassays 10
9.3 Personnel Exposure Records 10

10.0 RADIATION SURVEYS 10

10.1 Survey Meter Operational Check 10
10.2 Radiation Survey Records 11

11.0 STANDARD OPERATING PROCEDURES ……. 11

11.1 Prior to Working in a LENS Vault or Experimental Area ……..……. 11
11.2 Initial Entrance in a LENS Vault ……..……. 11
11.3 Working in a LENS Vault ……..……..… 12
11.4 Procedure for Clearing a LENS Vault ……..……..… 12
11.5 Bypassing a Radiation Safety Interlock or Displacing Shielding…..……..…… 13
11.6 Surveying Parts for Activation ……..……..……. 13
11.7 Handling Radioactive Parts ……... 13
11.8 Machining Radioactive Parts ……... 14
11.9 Use of Radioactive Sources (< 10 microCi)……..... 14
11.10 Use of Radioactive Sources (>= 10 microCi)…… 14

1.0 UNIVERSITY POLICY

It is the policy of Indiana University to support the use of particle accelerators for purposes of research and teaching. At the same time, the university is committed to ensuring the safety of its students, employees, and visitors and to complying with all regulatory requirements that impact its facilities and operations. For this reason, the administration expects employees, external users, students, and staff at the Low Energy Neutron Source (LENS) to promote positive attitudes regarding safety, to incorporate safety into their work practices, and to cooperate fully in the implementation of the LENS Radiation Safety Program.

2.0 REGULATORY REQUIREMENTS

The use of particle accelerators in the State of Indiana is controlled under Title 410, Article 5 of the Indiana Administrative Code. Enforcement of these regulations is the responsibility of the Indiana State Department of Health (ISDH).

Most radioactive materials in use at Indiana University (including radioactive sources used in LENS) are controlled under Title 10 of the Code of Federal Regulations. Compliance with these regulations is enforced through the licensing and inspection activities of the U.S. Nuclear Regulatory Commission (NRC). Requirements for use of NRC licensed radioactive sources at LENS are detailed in section 11.10 of this manual.

3.0 ADMINISTRATIVE ORGANIZATION

In fulfillment of its commitment to personnel safety and regulatory compliance, Indiana University has established specific administrative entities with responsibilities for developing and implementing a comprehensive Radiation Safety Program for ensuring the safe the use of radioactive materials and machine-produced radiation (including particle accelerators).

3.1 Radiation Safety Program

At Indiana University - Bloomington, the Radiation Safety Program has been established to ensure that: (1) any hazards associated with the use of radioactive materials, x-ray devices, or particles accelerators are minimized; and that (2) all uses of these materials and devices are in compliance with applicable regulatory requirements.

Essential services and activities of the Radiation Safety Program include:

- Regulatory affairs, licensing, project review
- Personnel training
- Facility safety audits and radiation surveys
- Personnel monitoring
- Radioactive waste management
- Calibration and maintenance of radiation survey meters
- Leak testing of sealed radioactive sources

3.2 Radiation Safety Officer

The Radiation Safety Officer (RSO) directs the development and implementation of integrated programs for radiological safety and regulatory compliance associated with the use of radioactive materials and radiation-producing devices on the Bloomington Campus. The RSO establishes and communicates the policies and requirements for the safe use of radioactive materials and radiation-producing devices and ensures that safety and regulatory requirements are met during the course of such activities. The RSO has the authority to immediately terminate any operation at LENS that violates established procedures or poses an unacceptable risk to health and safety.

3.3 Assistant Radiation Safety Officer

The Assistant Radiation Safety Officer (ARSO) is responsible for the day-to-day implementation of the Radiation Safety Program at LENS. The ARSO reports directly to the RSO and works with the RSO and the CEEM Safety Committee to establish policies and procedures for the radiological safety at LENS.

3.4 CEEM Safety Committee

The Director of the Center for the Exploration of Energy and Matter (CEEM) has appointed a Safety Committee that advises on all safety issues within LENS. Membership of this committee includes the RSO and the Assistant RSO.

4.0 RESTRICTED AREAS

In accordance with 410 IAC 5-1-2, a “restricted area” is any “area, access to which is controlled for the purpose of protecting individuals from exposure to radiation.” To qualify as an “unrestricted area”, there can be no circumstances under which an individual could receive a dose from external sources in excess of 2 mrem (20 microSv) in any one hour (410 IAC 5-4-6).

At LENS, entrances to restricted areas are controlled by locked doors and posted with a “Caution – Radiation” and/or a “Caution – Radioactive Materials Area” sign. Access to these areas must be approved by the RSO.

5.0 AUTHORIZATION FOR ACCESS

Access and work within the LENS vault or other restricted areas must be specifically authorized by the RSO. The requirements for such authorization (and any limitations or conditions) are determined based on training and work practices. A list of individuals approved for access is kept in the CEEM Radiation Safety Database.

6.0 EMPLOYEE RIGHTS

In accordance with 410 IAC 5-10-3, individuals who work in or frequent any portion of a "restricted area" at LENS have the right to:

1. Be instructed in the potential health hazards associated with exposure to ionizing radiation and in the appropriate safety precautions for minimizing exposure.

2. Report to the RSO any condition that they believe is a violation of state, federal, or university regulations or could cause unnecessary radiation exposure (this is a responsibility as well as a right).

3. Be instructed in the appropriate response to warnings or unusual events that may involve exposure to ionizing radiation.

4. Request an annual summary of their radiation exposure (if they have been monitored with a dosimeter).

7.0 TRAINING REQUIREMENTS

In accordance with 410 IAC 5-10-3, individuals who work in, or frequent, any portion of a restricted area within LENS shall be provided with sufficient training to enable them to conduct their work safely. The training for such individuals (who are defined here as "radiation workers") must include information on the potential hazards associated with ionizing radiation; the means by which these hazards can be minimized; standard operating procedures for working within LENS, employee rights and responsibilities, and emergency procedures.

In order to meet the regulatory requirements for training, all students, staff, and visitors who plan to use the LENS facility must first accomplish the following:

1. Complete the online *Radiation Safety Training Module*.

2. Read the *LENS Radiation Safety Manual*.

3. Complete a LENS facility Orientation by the LENS Operations Manager (which includes a review of the interlock/access control systems, associated keys, and status lights for the LENS vaults and experimental areas).

4. Obtain training from the Principal Investigator on the specific procedures for completion of the required tasks

5. Complete an onsite review of applicable "Radiation Safety Procedures" with the Assistant Radiation Safety Officer.

8.0 PERSONNEL DOSE LIMITS

A primary goal of LENS Radiation Safety Program is to ensure that all personnel doses are maintained below regulatory limits and "as low as is reasonably achievable" (ALARA).

8.1 Occupational Dose Limits

Current dose limits for occupational radiation exposure have been established at levels which, in light of present knowledge, should: (1) prevent all acute radiation effects (e.g., erythema, epilation); and (2) limit the risks of late effects such as cancer or genetic damage to very low, "acceptable" levels. Occupational dose limits are found in 410 IAC 5-4-2 and 10 CFR 20.1201. Because the federal dose limits are, in general, more restrictive than state limits and because NRC licensed sources may be utilized in LENS, the federal dose limits are observed for LENS personnel.

Dose related terms and limits found in 10 CFR 20 include:

Deep-dose equivalent (DDE) - the dose-equivalent resulting from an external whole-body exposure, as determined at a tissue depth of 1 cm.

Shallow-dose equivalent (SDE) - the dose-equivalent resulting from an external exposure of the skin or an extremity, as determined at a tissue depth of 0.007 cm and averaged over an area of 1 square cm.

Eye dose equivalent (EDE) - The dose-equivalent resulting from an external exposure of the lens of the eye, as determined at a tissue depth of 0.3 cm.

Committed dose equivalent (CDE) - the dose-equivalent to a given organ or tissue that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

Committed effective dose equivalent (CEDE) - the sum of the products of the risk based weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Total effective dose equivalent (TEDE) - the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Table 1. Dose Equivalent Limits for Occupational Exposures

	Annual
Whole body (TEDE)	5 rem (50 mSv)
Skin and extremities (SDE)	50 rem (500 mSv)
Individual organ or tissue (DDE + CDE)	50 rem (500 mSv)
Eye (EDE)	15 rem (150 mSv)

8.2 ALARA Goals

10 CFR 20.1101 requires that radiation safety programs incorporate sufficient radiation safety control measures to ensure that occupational doses and dose to members of the public are maintained "**A**s **L**ow **A**s **R**easonably **A**chievable" (ALARA). The ALARA goals for LENS radiation workers are as follows:

Whole body (TEDE): 2 mrem/day 20 microSv/day Extremities (SDE): 20 mrem/day 200 microSv/day

Each individual radiation worker must manage his/her dose to stay within these goals. A radiation safety employee must be consulted in advance for any work that may result in doses that exceed the ALARA goals.

8.3 Dose Limits for an Embryo/Fetus

In accordance with 10 CFR 20.1208, the human embryo or fetus may receive a dose of no more than 0.5 rem (5 mSv). This is accomplished by limiting the total effective dose equivalent of a "declared" pregnant worker to 0.5 rem (5 mSv) over the course of her pregnancy. However, for this lower limit to be in effect, the worker must voluntarily declare her pregnancy in writing to the RSO. The Nuclear Regulatory Commission has published Regulatory Guide 8.13 that details potential health risks of prenatal exposure and suggests precautions and options for the pregnant worker. Copies of Regulatory Guide 8.13 may be obtained from the RSO.

8.4 Dose Limits for Members of the Public

In accordance with 10 CFR 20.1301, the total effective dose equivalent to any member of the general public from operational activities at LENS must be limited to 0.1 rem (1 mSv) per year. In addition, operation of LENS may not produce, under any circumstances, a dose of more than 2 mrem (20 microSv) in an hour within any unrestricted area.

9.0 PERSONNEL MONITORING

Various devices and methods exist for assessing an individual's dose from exposure to ionizing radiation. These devices and methods are not substitutes for sound radiation safety practice and are utilized only when warranted by the particular work activities of the individual.

9.1 Personnel Dosimeters

Federal regulations (10 CFR 20.1502) require that any individual who is likely to receive, from external sources, more than 10 percent of an applicable annual dose limit be monitored for radiation exposure. Devices or materials used to assess an individual's cumulative dose from external sources are collectively called "dosimeters."

In order for a dosimeter to provide an accurate indication of an individual's exposure, it must be used and stored properly. For assessing whole body doses, the dosimeter should be worn on the most dose intensive part of the whole body (as defined by 10 CFR 29.1003). Ring badges should be worn beneath gloves with the sensitive surface on the palm side of the hand. When not in use, dosimeters must be stored away from radiation sources and under conditions of relatively stable temperature and humidity. Anyone receiving a dosimeter for use in LENS should leave their dosimeter in the dosimeter rack, at their personal desk, or at the front office desk. Dosimeters must be returned promptly at the end of the visit or at the end of the assigned monitoring period (quarterly for IU staff and students).

9.2 Bioassays

Assessing internal irradiation from intakes of radioactive material via ingestion, inhalation, or dermal puncture or absorption is accomplished through use of various procedures collectively termed “bioassays”. For most water soluble radioactive materials, the bioassay consists of analyzing the amount of radioactivity in urine. Given the limited amounts of “unsealed” radioactive material produced or used at LENS, the need for a bioassay is unlikely but would be determined by the RSO based upon the particular exposure circumstances.

9.3 Personnel Exposure Records

The results of all personnel monitoring performed for individuals at LENS are maintained by the RSO. Each individual's exposure records are available to him or her upon request. An individual is notified immediately by the RSO should his/her reported dose exceed 10 percent of an applicable regulatory limit.

10.0 RADIATION SURVEYS

Continuous characterization of changing radiation levels within LENS is essential to maintaining personnel doses ALARA. Each individual approved to work within LENS must be competent in conducting and interpreting such radiation surveys. A variety of portable radiation safety meters are available for LENS users. Each is calibrated on an annual basis and sourced checked to within +/- 10% of the initial calibrated reading once per week or as necessary.

10.1 Survey Meter Operational Check

The objective of a survey meter operational check is to assure that the meter is functioning properly. Users are required to check meters with the following four steps. Any meter that fails any one of these tests must be taken out of service until it can be successfully repaired and calibrated.

1. Perform an integrity check by examining the meter to ensure that it has not suffered any visible or other readily apparent damage (electrical short in detector cable).

2. Check the calibration date on the sticker on the side of the meter (the date must be within the past year).

3. Perform a battery test. If the battery is low, take the meter out of service until the batteries are replaced.

4. Perform a radiation source check utilizing the source near the vault entrance.

10.2 Radiation Survey Records

In accordance with 410 IAC 5-9-10 (h), records of all radiation surveys performed at LENS are maintained for inspection by ISDH, the NRC, or other regulatory agency. Such records are retained for a period of at least 3 years.

11.0 STANDARD OPERATING PROCEDURES

An important component of any safety program is the development of standard procedures for conducting various potentially hazardous operations in order to ensure that such hazards are minimized. This section contains various "Standard Operating Procedures" developed to fully incorporate radiation safety considerations into routine LENS activities and to thereby ensure that any occupational exposures are ALARA.

11.1 Prior to Working in a LENS Vault or Experimental Area

1. Obtain and wear your assigned dosimeter(s). Depending on the type of work, both a whole body and ring dosimeter may be required.

2. Obtain and check the function of an appropriate survey meter (users will be instructed on the proper meter use during the onsite procedure review with the Assistant Radiation Safety Officer).

11.2 Initial Entrance into LENS Vault

1. Remove the vault key from the LENS interlock panel in the LENS electronics control cabinet.

2. The vault may be entered once the red light (beam enabled) changes to green (beam disabled). Once the door is open, the top lights go from yellow (room clear) to green (room unclear).

3. Open the vault door with the key and leave the key in the door. If another vault door needs to be opened, get the key and open that vault door and leave the key in the final door that is opened. The key may be taken by the LENS Operations Manager if a particular vault needs to be secured.

4. Upon initial entry into a TMR vault or the accelerator vault, conduct a radiation survey of the general areas around the beam line or TMR. Mark any elevated dose rates (greater than 0.1 mR/hr on the map outside the vault). A general area survey will be made after each beam run. This survey will be for general use for all qualified people entering the vault.

11.3 Working in a LENS Vault

1. Check the map outside the vault for general area dose rates. If you are dismantling the TMR, surveys should be made for each shield layer taken off. Survey the area in which you will be working. If you are taking samples out of the TMR1, survey the area near the opening and the part. If you are working with a group of users/workers, communicate the dose rates for the area in which you are working.

2. While working in the vault, maintain radiation dose ALARA (less than or equal to 2 mrem per day, whole body, 20 mrem per day, extremities) through efficient management of time, maximizing distance from radioactive areas, and installing shielding around highly radioactive parts or areas.

3. As another level of shielding is removed, or items close to the beam line or target area are exposed, survey the area in which you are working.

4. Contact a the Radiation Safety Officer if planned activities will likely result in the daily ALARA goal of 2 mrem, (20 microSv) whole body, being exceeded.

5. Do NOT remove any radiation warning tags or tape from items within the vault without permission from a radiation safety staff member.

11.4 Procedure for Clearing a LENS Vault

1. Once work is completed in the vault, visually inspect the experimental setup and/or the beam line to verify that everything is in place and ready to run.

2. Place any part or equipment removed from the vault in a staging area outside of the entrance in preparation for a radiation survey.

3. Clear the room by performing the clearing sequence allocated for that particular vault. Once the initial clearing sequence button is depressed, the yellow strobe will flash and the klaxon horn will sound.

4. Make certain that all individuals leave the vault while performing the clearing sequence. Once the door shuts, the yellow strobe light, and klaxon horn turn off, and the red strobe light starts flashing inside. The box outside the vault turns from green (room unclear) to yellow (room cleared).

5. Take the key from the door and replace it in the panel in the control cabinet.

6. Beam Operation can now proceed.

11.5 Bypassing a Radiation Safety Interlock or Displacing Shielding

1. In accordance with 410 IAC 5-9-9 (e), an intentional bypass of a radiation safety interlock must be:

    a. Authorized in advance by the Radiation Safety Officer (or the LENS Operations Manager).

    b. Recorded in a permanent log and a notice posted at the control console.

    c. Terminated as soon as possible.

2. Alteration of LENS vault shielding must be authorized in advance by the Radiation Safety Officer or the LENS Operations Manager.

11.6 Surveying Parts for Activation

1. Notify a radiation safety staff member of the status and location of the part or equipment to make an official survey of the part or equipment.

2. To make an unofficial survey of a part or piece of equipment, obtain an appropriate survey meter (sodium iodide detector is preferred for measuring CPM).

3. Perform an operational check of the survey meter (this should include, at a minimum, a battery test and response check with a standard source).

4. Move the part and meter to an area with an expected low radiation background.

5. Measure the area's radiation background (with the part at least ten feet away from the meter).

6. Measure radiation levels from the part, holding the meter as close to contact as possible to all accessible surfaces.

11.7 Handling Radioactive Parts

1. Immediately label with a radiation sticker any part or equipment determined to be radioactive (greater than 3 times background levels).

2. Place the radioactive part or equipment in an area designated for storage or repair

3. Notify an ISAT radiation safety staff member of the status and location of the part or equipment.

4. Do NOT remove any activated part or equipment from a storage location (for work, machining, shipping, or disposal) without specific approval from a radiation safety staff member.

11.8 Machining Radioactive Parts

1. Prior to machining any part known (or suspected) to be radioactive, contact an ISAT radiation safety staff member to discuss the operation.

2. Establish the appropriate contamination controls and ventilation (which could include an enclosure and local exhaust as well as a means to collect any shavings produced).

3. Wear appropriate personal protective apparel and equipment (which could include gloves, coveralls, goggles, and respirator).

4. Arrange (with an ISAT radiation safety staff member) for a contamination survey at the end of the procedure and for disposal of any shavings produced.

11.9 Use of Radioactive Sources [< 10 microCi (370 kBq)]

1. To use a small activity (< 10 microcurie) radioactive source, contact a radiation safety staff member (only approved LENS facility users may check out sources).

2. Check-out the source (log book) at the source storage cabinet and accept the source from the radiation safety staff member.

3. Maintain control of the source at all times (secure the source in a lockable storage location when it is not in use).

4. Do NOT transfer the source to anyone without approval from a radiation safety staff member.

5. Upon completion of the use of the source, arrange with the radiation safety staff member to return the source to the storage cabinet.

11.10 Use of Radioactive Sources [>= 10 microCi (370 kBq)]

To use any radioactive source (with activity of 10 microcuries or greater), review the procedures for authorization and use of radioactive material found at the IUB Radiation Safety Website: http://researchcompliance.iu.edu/cs-radsafety.html