

UNIVERSITY OF KANSAS - LAWRENCE CAMPUS

LABORATORY SAFETY MANUAL

PART V - LASER SAFETY PLAN

Section 3) Laser Hazard Communication & Control

This chapter provides guidance on meeting the hazard communication and hazard control requirements of Chapter 3 of Part I and further detailed procedures for laboratories working with non-exempt lasers. This chapter should be used together with Chapter 3 of Part I.

3.1) General Laser Hazard Control

The Authorized Laboratory Supervisor or Authorized User shall:

3.1.1) Utilize and comply with the general hazard control methods specified in Part I: Chapter 3-Section 3.1 (marked with an asterisk) for addressing laser radiation hazards in their lab.

3.1.2) Not conduct any laser-related activities in a lab that has not been properly designed for such activities, nor where appropriate and functional engineering controls are missing, nor where required personal protective equipment and/or safety equipment are not available.

3.2) Non-Exempt Laser Hazard Control Responsibilities

3.2.1) The general hazard control responsibilities specified in Part I: Chapter 3-Section 3.2 are applicable for addressing Laser Safety.

3.3) Lab Hazard Registration

The Authorized Laboratory Supervisor (ALS) shall:

3.3.1) For each lab under his/her jurisdiction, perform an assessment to identify laser hazards present in their lab in accordance with Part I: Chapter 3-Section 3.3.

3.3.2) Complete the LHR form and submit it to EHS according to the procedures identified in Part I: Chapter 3-Section 3.3. The form can be found on the EHS website.

3.3.2.1) Attach a copy of the laboratory's laser inventory list to the LHR form.

(Note: This information will be used by Laser Safety Office to determine the laboratory's Laser Safety hazard level (I, II, III or IV), to fulfill emergency response information needs, and to prepare laboratory entrance postings.)

3.3.3) Update the LHR information whenever conditions change significantly and as required under Part I: Chapter 3-Section 3.3 and Section 3.8 and obtain an approved amendment for such changes in the Laboratory-Specific Safety Plan for the specific laser system, if needed.

3.3.4) Appropriately train and/or inform all Authorized Users, Authorized Occupants and Visitors with respect to the hazards identified on this form.

3.4) Communication of Laser Hazards in the Laboratory

3.4.1) Inventory of Hazardous Non-exempt lasers (Use with Part I-3.4.1)

The Authorized Laboratory Supervisor shall:

3.4.1.1) Establish and maintain an up-to-date inventory of all non-exempt lasers being used in the laboratory.

a) Include the following information in the inventory for each laser:

- * Identity of Laser - (Type and class of laser)
- * Laser's Manufacturer
- * Location Information - (Building, Department, and Room)

b) Not operate unless it has been added to the inventory, the appropriate EHS Laser Safety Authorization, if required, has been obtained, and all Authorized Users and Authorized Occupants have been appropriately trained and informed with respect to the new laser.

3.4.1.2) Keep the inventory list readily available to any person entering the laboratory should they request to see it. (Repeat of Part I-3.4.1.3).

3.4.1.3) Submit a copy of the laser inventory list to EHS Laser Safety Officer in accordance with the requirements of 3.4.1.1 above for required registration with the state.

3.4.2) Laser Hazard Warning Labels, Signs, Annunciators and/or Warning Lights

The Authorized Laboratory Supervisor shall:

3.4.2.1) Provide and maintain laser warning signs/labels that meet the standards of ANSI Z136.1. An example is in Part V appendices.

Notes on specific requirements:

Class 1 lasers: Do not require a sign but manufacturer's labels must be maintained.

Class 2 and 3a lasers: The word CAUTION shall be used.

Class 3b and Class 4 lasers: The word DANGER shall be used.

a) Position 1: Precautionary instructions and protective actions, such as the following examples, shall be printed at Position 1.

Class 2: Laser Radiation - Do Not Stare Into Beam. Do Not Direct the Beam Towards the Eye of Individuals.

Class 3: Laser Radiation - Avoid Direct Exposure to Beam.

Class 4: Laser Radiation - Avoid Eye or Skin Exposure to Direct or Scattered Radiation.

Additional precautionary instructions and protective actions that may be required at Position 1 are: "Invisible Laser Radiation," "Knock Before Entering," "Do Not Enter When Light Is On," "Restricted Area," etc.

b) Position 2: Laser information is printed at Position 2. This includes the type of laser (Ruby, HeNe, etc.) or the emitted wavelength, pulse duration (if appropriate), and the maximum output.

c) Position 3: The Class of the laser is printed at Position 3.

3.4.2.2) Display and maintain all warning signs and labels conspicuously in locations where they best will serve to warn individuals of potential safety hazards. Normally, warning signs are posted at entryways (e.g., on doors) to laser-controlled areas. Warning labels are affixed to the lasers in a conspicuous location.

3.4.2.3) Remove laser warning signs if the laser has been removed from the room or area.

3.4.2.4) Provide and maintain safety interlocks, annunciators and/or warning lights as specified by ANSI Z136.1 or equivalent safety warnings and protection.

Note: Regulations require that areas where certain compounds or laser hazards are present be identified by warning signs, tags, etc. Contact Laser Safety Office for assistance in identifying appropriate signs.

The Authorized User shall:

3.4.2.5) Post the appropriate hazard warning signs before initiating any operation or activity inside the lab that may present a laser hazard.

3.4.3) Laboratory Entrance Posting

The Authorized Laboratory Supervisor shall:

3.4.3.1) Assist EHS Laser Safety Office in establishing the appropriate laboratory entrance posting(s) that identifies the laser hazards present in the lab. This will be done in accordance with the procedures identified in Part I: Section 3.4.6.

a) This will consist of submission of the completed Hazard Registration form and the laser inventory list to the EHS Laser Safety Officer and consultation with EHS Laser Safety Officer to determine laser hazard levels.

3.4.3.2) Maintain readily visible laboratory entrance postings with up-to-date laser hazard warning information.

3.4.3.3) Post Appropriate Access Restrictions.

Guidance Note: Access restrictions are to be evaluated by the Authorized Laboratory Supervisor for any Laser Safety Level I or II Laboratories. Access might be restricted only during certain specifically identified procedures within the laboratory. In this case, temporary signs may need to be used that forbid entrance during those times. In other cases, access might be restricted just as it is for Levels III and IV.

3.4.3.4) Post requirements for any required medical status: exclusion of or special protection for persons with special susceptibilities--might include allergy sensitivities, etc.

3.5) Engineering Controls for Laser Safety

The Authorized Laboratory Supervisor and Authorized Users shall:

3.5.1) Utilize and comply with the generic engineering control measures specified in Part I: Chapter 3-Section 3.5 when working with non-exempt lasers. This includes:

3.5.1.1) Process Modifications (Part I: Section 3.5.1)

3.5.1.2) Physical Isolation/Containment (Part I: Section 3.5.2)

The Authorized Laboratory Supervisor shall:

3.5.2) Verify that all applicable engineered safety standards of ANSI Z136.1 (or equivalent level of safety) for the type and kind of laser involved are incorporated in the system and fully functional before the laser is placed in use.

Additional notes of guidance:

The basic system shall satisfy all applicable electrical codes and the evaluations of the EHS Laser Safety Officer that are documented in the Laser Standard Operating Procedures. They provide acceptable methods of compliance with the electrical requirements of ANSI Standard Z136.1. Examples include:

Fail-safe Control Systems
 Barriers and Safety Interlocks
 Safety interlocks for Transmission Lines
 Remote-control Interlocks
 Laser Activation Warning Systems and Annunciators
 Grounding Methods
 Temporary By-passing of Safety Interlocks
 Safety Watch and CPR certified personnel

Although the arrangements and power levels of lasers used at KU may not result in the potential hazards listed below, the safety review shall verify that such non-beam hazards are not relevant before a laser is placed in use and shall address protection against any hazards of the following types if they exist by incorporating the appropriate engineered controls and/or Standard Operating Procedures.

a) Atmospheric Contamination

1. Vaporized target material: Materials may include carbon monoxide, ozone, lead, mercury, and other metals.
2. Gases from flowing gas lasers or byproducts of laser reactions such as fluorine, chlorine, hydrogen-cyanide, and many others.
3. Gases or vapors from cryogenic coolants.

b) Chemicals - Chemicals, including dyes and solvents, from certain dye lasers have been shown to be carcinogenic, toxic, or otherwise hazardous.

c) Cryogenic Coolants - Cryogenic liquids, such as liquid nitrogen or hydrogen, may cause burns.

d) Electrical Hazards - The potential for electrical shock is present in most laser systems. Pulsed lasers utilize capacitor banks for energy storage and cw lasers generally have high voltage DC or RF electrical power supplies.

- e) Explosive Hazards - The potential exists for explosions at capacitor banks or optical pump systems during the operation of some high-power lasers. Explosive reactions of chemical laser reactants or other gases used within the laser laboratory could cause damage to equipment or injury to personnel.
- f) Jewelry - The use of jewelry (watches, rings, etc.) is often an overlooked source of exposure to a beam reflected by a mirror-like surface.
- g) Ultraviolet Radiation - Either direct or reflected beams from flash lamps and cw laser discharge tubes may cause eye injury. Usually, ultraviolet radiation is a problem only when quartz tubing or windows are used.
- h) Visible Radiation (non-laser) - High luminance radiation emitted from unshielded pump lamps may cause eye injury.
- i) X-rays - Potentially hazardous X-rays may be generated from high voltage (over 15 kV) power supply tubes.

Note: If a laser is to be built or modified at KU, also see the Design Criteria in Appendices.

3.6) Personal Protective Equipment for Laser Safety

The Authorized Laboratory Supervisor and Authorized Users shall:

3.6.1) Adhere to the personal protective equipment control measures specified in Part I: Chapter 3-Section 3.6 when working with non-exempt lasers. This includes:

3.6.1.1) General PPE Measures (Part I: Section 3.6.1)

3.6.1.2) Head Protection (Part I: Section 3.6.2)

Normally not needed for protection against laser beams at KU but might be necessary if lasers with sufficient power to produce burns are introduced.

3.6.1.3) Eye & Face Protection Measures (Part I: Section 3.6.3)

Normally, all personnel who work in areas where there is radiation from Class 3b or Class 4 lasers shall wear laser eyewear approved for the type of beam and class of the laser if the potential exists for exposure in excess of the MPE. Exceptions may be approved if wearing protective eyewear produces a greater safety hazard than when it is not worn. Exceptions shall be noted in written procedures or otherwise be approved by the EHS Laser Safety Officer and shall be appropriately justified. See Standard Operating Procedures--section 2.5.1 above.

The EHS Laser Safety Officer shall review and approve protective eyewear to assure that is appropriate for the use for which it is intended. The eyewear to be used will depend on the wavelength(s) and intensity of the accessible radiation.

Note: Engineering controls such as enclosed beam paths and enclosures are preferable to using filter goggles and spectacles for eye protection. However, safety goggles and spectacles are often an effective safety measure when engineering controls are not possible. It should be noted that the user must be careful that the filter material and side shields can withstand the maximum irradiance encountered in the laser environment for at least 3 seconds, and the filter is of the required optical density. Goggles may be damaged by lasers and lose their protective power.

3.6.1.4) Hand & Body Protection Measures (Part I: Section 3.6.4) -- Normally not needed for protection against laser beams at KU but might be necessary if lasers with sufficient power to produce burns are introduced.

3.6.1.5) Foot Protection Measures (Part I: Section 3.6.5) -- usually not needed for protection against laser beams but may be necessary if other foot hazards are present in the lab.

3.6.1.6) Hearing Protection Measures (Part I: Section 3.6.6) --usually not needed for protection against laser beams but may be necessary if other noise hazards are present in the lab.

3.6.1.7) Respiratory Protection Measures (Part I: Section 3.6.7) -- Might be needed under some circumstances--See a) under 3.5.2 above.

3.7) Safety Equipment for Laser Safety

The Authorized Laboratory Supervisor and Authorized Users shall:

3.7.1) Adhere to the safety equipment control measures specified in Part I: Chapter 3-Section 3.7 when working with non-exempt lasers. This includes:

3.7.1.1) Safety Shields/Containment (Part I: Section 3.7.1)

Note: A laser installation shall be evaluated for the need for "beam stops", shields, safety interlocked beam enclosures and/or interlocked doors, and "beam annunciators" according to ANSI recommendations. If ANSI recommendations for the type and class of laser are not followed, very clear specifications for equivalent protection must be provided.

If needed, windows to hallways and other outside areas shall be appropriately provided with shades or covers.

Conditions that have a reasonable potential for specular reflections shall be minimized to the degree possible consistent with the required use.

See Part I, sections 3.7.2 - 3.7.7 for controls that may be needed that are not specific to the hazards of the laser beam itself.

See also section 3.5.2, and the Guidance on Control Measures in Appendices.

3.8) Laboratory Inspections/ Reviews for Laser Safety

3.8.1) Laboratory Inspections/Reviews shall be conducted as specified in Part I: Chapter 3-Section 3.8.1.

3.8.2) Deficiencies, Violations and Corrective Actions shall be handled in accordance with Part I: Chapter 3-Section 3.8.3.

3.9) Prior Hazard Registration of Laser Systems and EHS Safety Authorizations for Level III and IV Laser Systems

3.9.1) Introduction

The assignment of laser classes to hazard levels used with the KU Laboratory Safety Plan is based on the premise that the level of scrutiny and care that needs to be introduced in the establishment of controls and procedures that will adequately protect against accidental injury of eyes (and, in some cases, skin) needs to become greater as the potential for such injury increases.

3.9.2) Laser Safety Levels

The following Laser Safety Levels have been established to identify the severity of laser hazards present in the lab and to facilitate the prior registration, and/or the process for obtaining EHS Safety Authorizations, if required.

3.9.2.1) Laser Safety Level: Exempt

a) Class 1 denotes exempt lasers or laser systems that cannot, under normal operating conditions, produce a hazard. Equipment such as laser printers that completely enclose the laser and laser beam are normally specified as Class 1.

b) Class 1 lasers must be labeled (manufacturer's label) but are exempt from other requirements.

Note: Class 1 lasers that are used as designed and on which no maintenance is performed by KU personnel that would expose any laser beam that has been enclosed by the manufacturer are exempt from the Laser Safety Plan.

c) All embedded lasers that require onsite maintenance or services with interlocks by-passed are subject to the KU Laser Safety Plan. Otherwise, all embedded lasers are exempt from the KU Laser Safety Plan.

3.9.2.2) Laser Safety Level: Level I Laser Hazards

a) Class 2 lasers as defined in ANSI Z136.1 are assigned to the Level I hazard category on the KU campus and are subject to this Laser Safety Plan.

Note: Class 2 denotes low power visible-radiation lasers or laser systems. Visible cw HeNe lasers above Class 1, but not exceeding 1 mW radiant power, are common examples of this class. Because of the normal human aversion responses, these lasers normally do not present a hazard, but may present some potential for hazard if viewed directly for extended periods of time (like many conventional light sources).

b) Class 2 lasers must be labeled and registered with the EHS Laser Safety Officer but are exempt from other requirements. The warning label or sign shall caution users to avoid staring into the beam or directing the beam toward the eye of individuals and shall be placed on or near the laser in a conspicuous location. (HeNe lasers used as pointers in the auditorium or classroom at KU are restricted to be no higher than Class 2.)

Authorized Laboratory Supervisors shall:

c) Provide the LHR Form and Laser Inventory to EHS.

d) Provide the required documented training and approve all laser users. This can be accomplished by meeting the laser safety-specific information and training requirements in Part V: Chapter 4-Section 4.2 and 4.3.

3.9.2.3) Laser Safety Level: Level II Laser Hazards

a) All class 3a lasers (as defined in ANSI 136.1) are assigned to KU hazard Level II and are subject to the KU Laser Safety Plan.

Note: Class 3a denotes lasers or laser systems that normally would not produce a hazard if viewed for only momentary periods with the unaided eye. They may present a hazard if viewed using collecting optics. Visible cw HeNe lasers above 1 milliwatt (mW), but not exceeding 5 mW radiant power, are common examples of this class.

b) Class 3a lasers shall be operated in a location where access to the beam can be controlled. The potential for viewing of the direct or specularly reflected beam shall be minimized. The operator of the laser shall inform personnel entering the area of the presence of the laser beam and the precautions they need to follow.

Authorized Laboratory Supervisors shall:

- c) Provide the LHR Form and Laser Inventory to EHS.
- d) Provide the required documented training and approve all laser users. This can be accomplished by meeting the laser safety-specific information and training requirements in Part V: Chapter 4-Section 4.2 and 4.3.

3.9.2.4) Laser Safety Level: Level III Laser Hazards

- a) All class 3b lasers as defined in ANSI 136.1 are assigned to KU hazard Level III and are subject to the KU Laser Safety Plan.

Note: Class 3b denotes lasers or laser systems that can produce a hazard if viewed directly. This includes intra-beam viewing or specular reflections. Except for the higher power Class 3b lasers, this class laser will not produce hazardous diffuse reflections. Visible cw HeNe lasers above 5 mW, but not exceeding 500 mW radiant power, are examples of this class.

- b) Class 3b lasers shall be used in areas where entry by unauthorized individuals can be controlled. Entry into the area of individuals untrained in laser safety may be permitted by the laser operator if they are instructed as to safety requirements and are provided with protective eyewear, if required.

Authorized Laboratory Supervisors shall:

- c) Submit the LHR form and Laser Inventory to EHS.
- d) Provide the required documented training and approve all laser users. This can be accomplished by meeting the laser safety-specific information and training requirements in Part V: Chapter 4-Section 4.2 and 4.3.
- e) Provide the EHS Laser Safety Officer with a copy of the laboratory-specific standard operating procedures for the laser(s) and a description of the location of the laser and all engineered safety controls applicable to the laser(s) as part of the proposed Laboratory-Specific Safety Plan. The procedure of Part I: section 3.9 is to be followed in obtaining EHS Safety Authorization that is required before the laser is energized.

Note: The submission of the LHR form constitutes an application for permission to operate the laser. The procedures specified in Part I: section 3.9 are initiated upon receipt of the LHR form. Upon receiving authorization from the EHS Laser Safety Officer/Laser Safety Subcommittee, the laser may be put into use subject to the conditions specified in the approved submitted procedures and controls specified in the approved Laboratory-Specific Safety Plan. If changes are to be made in those procedures or controls that might impact protection against potential hazardous exposure to laser beams, those changes shall be submitted to the EHS Laser Safety Officer for approval. See section 3.9.3 below and Appendices.

3.9.2.5) Laser Safety Level: Level IV Laser Hazards

a) Class 3b lasers (as defined in ANSI 136.1) with invisible beams or with visible beams at power levels equal to or greater than 15 mW and all class 4 lasers are assigned to KU hazard Level IV and are subject to the KU Laser Safety Plan.

Class 3b lasers are described under section 3.9.2.3 above.

Class 4 denotes lasers or laser systems that can produce a hazard not only from direct or specular reflections, but also from a diffuse reflection. In addition, such lasers may produce fire and skin hazards. Examples are visible, near IR, UV, or IR lasers that emit accessible radiant power in excess of 500 mV.

Note: Class 4 lasers shall be operated by authorized operators in areas dedicated to their use. Fail-safe interlocks shall be used to prevent unexpected entry into the controlled area, and access shall be limited by the laser operator to persons who have been instructed as to safety procedures and who are wearing proper laser protection eyewear (if required by written procedures) when the laser is capable of emission. Authorized operators are responsible to provide information and safety protection to untrained personnel who may enter the laser-controlled area as visitors.

b) For pulsed systems, interlocks shall be designed to prevent firing of the laser, by dumping the stored energy into a dummy load. For continuous wave lasers, the interlocks shall turn off the power supply or interrupt the beam by means of shutters.

c) The existence of homemade lasers shall be made known to the EHS Laser Safety Officer so that a proper hazard classification based on ANSI standards can be made on the laser. Construction of lasers at KU shall adhere to the requirements given in Appendices.

Authorized Laboratory Supervisors shall:

d) Submit the LHR form and Laser Inventory to EHS.

e) Provide the required documented training and approve all laser users. This can be accomplished by meeting the laser safety-specific information and training requirements in Part V: Chapter 4 - Section 4.2 and 4.3.

f) Provide the EHS Laser Safety Officer with a copy of the laboratory-specific standard operating procedures for the laser(s) and a description of the location of the laser(s) and all engineered safety controls applicable to the laser(s) as part of the proposed Laboratory-Specific Safety Plan. The procedure of Part I: Section 3.9 is to be followed in obtaining EHS Safety Authorization that is required before the laser is energized.

Note: The submission of the LHR form constitutes an application for permission to operate the laser. The procedures specified in Part I: Section 3.9 are initiated upon receipt of the Hazard Registration form. Upon receiving authorization from the Laser Safety Officer/Laser Safety Subcommittee, the laser may be put into use subject to the conditions specified in the approved submitted procedures and controls specified in the approved Laboratory- Specific Safety Plan. If changes are to be made in those procedures or controls that might impact protection against potential hazardous exposure to laser beams, those changes shall be submitted to the Laser Safety Officer for approval. See section 3.9.3 below and Appendices.

Note: If the Laser Safety Subcommittee is unavailable to review the procedures, the procedures may be reviewed and approved temporarily by the EHS Laser Safety Officer and/or Chair/designated member of the Laser Safety Subcommittee. See section 3.9.3. See Appendices for guidance in establishing laboratory-specific Standard Operating Procedures to be included in the proposed Laboratory-Specific Safety Plan.

g) Arrange for the medical surveillance requirements of Part V: Chapter 5.

3.9.3) Process for Obtaining the Required EHS Safety Authorizations for Level III or IV Laser Hazard Classifications

See Section 3.9.3 of Part I or follow the procedures specified in this part and Appendices.

a) Section 3.9.3 describes how a Laboratory-Specific Safety Plan is to be developed including how the appropriate approvals may be obtained for the proposed Laboratory-Specific Safety Plan. After the Laboratory-Specific Safety Plan (or more appropriately Laser-Specific Safety Plan) has been approved, the EHS Laser Safety Officer will perform an inspection to verify that all conditions have been met. After that verification, the EHS Laser Safety Officer will provide a written safety authorization that will permit the Laboratory Supervisor to begin use of the Laser System.

b) In preparing the proposed Laser Specific Safety Plan, the Laboratory Supervisor should evaluate what engineered safety controls are needed, the safest location and placement of the laser system in the laboratory, what, if any, facility safety features need to be included, and the types of personal protective equipment required for the safe use of the system. This evaluation, as a minimum, shall address the generic requirements listed in section 3.5 through 3.6. Based upon the proposed safety features of the system, Standard Operating Procedures shall be written that specify how the laser system will be safely used. See Appendices for an outline for Standard Operating Procedures to be included in the proposed Laser Specific-Safety Plan.

c) The EHS Laser Safety Officer/Laser Safety subcommittee will review the proposed plan and verify that safety equivalent to that specified by ANSI Z136.1 and the KU Laser Safety Plan will be met if the conditions of the Laser-Specific Safety Plan are satisfied.