UNIVERSITY OF KANSAS

LAWRENCE CAMPUS

LABORATORY SAFETY MANUAL

PART V

LASER SAFETY PLAN

Revised November 2000

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1) Introduction to the Laser Safety Plan

1.1) Elements of the KU Laser Safety Plan

The KU Laser Safety Plan consists of the following components:

1.1.1) The requirements, conditions and procedures of the "University's Safety and Health Manual" apply to all university personnel, students and visitors and are, therefore, part of the Laser Safety Plan. See the Kansas University (Lawrence) Safety Plan.

1.1.2) The requirements, conditions and procedures of Part I: General Laboratory Safety Plan marked with an asterisk or by LS apply to all laboratory users/occupants in laboratories with non-exempt lasers and are, therefore, part of the Laser Safety Plan.

1.1.3) The requirements, conditions, and procedures of this part (Part V) apply to all laboratory users/occupants in laboratories with non-exempt lasers . For Laser Safety Levels III and IV (see Glossary) additional requirements, conditions, and procedures based upon the characteristics of the laser system may be necessary for the use of such lasers. See Section 3.9.3 of this Part.

1.1.4) This Part V in conjunction with the items specified in 1.1.1, 1.1.2, and 1.1.3, above, make up the University's Laser Safety Plan.

1.2) Laser Safety Considerations

Lasers emit intense coherent electromagnetic radiation that is potentially dangerous to the eye and skin. The laser operator must also comply with safety requirements that address electrical, fire and chemical hazards associated with the operation of the laser. The KU laser safety plan is designed to provide for the safety of all laboratory users/occupants and visitors. It is based on the latest edition of the American National Standards Institute, Inc. (ANSI) Z136.1, "American National Standard for the Safe Use of Lasers," which is the generally accepted safety standard for laser use.

Part V is intended to provide specific requirements and guidelines based on ANSI Z136.1 to provide for the safety of laser operators and other individuals likely to be exposed to laser hazards. In practice, the hazard classification of a laser is first determined, and then the appropriate controls are applied taking into account the laser environment and the potential for excessive exposure of laboratory users/occupants and visitors. Training and medical surveillance requirements are also included.

Note: When chemical hazards are associated with laser use, the Chemical Safety Plan (Part II) of the Laboratory Safety Plan is automatically applicable and Authorized Users shall be trained in both components.

Part V-Chapter 8 contains a glossary of terms that are common in laser usage and applications.

1.3) Organization of Part V

1.3.1) Laser Safety-specific operating procedures and/or emphasized universal safety standard operating procedures are addressed in Part V-Chapter 2.

1.3.2) Laser Safety-specific aspects of hazard communication and control are addressed in Part V-Chapter 3.

1.3.3) How to obtain authorization for use of lasers at Laser Safety Levels III and IV is described in Part V-Chapter 3 section 3.9.

1.3.4.) Laser Safety-specific information and training requirements are outlined in Part V-Chapter 4.

1.3.5) Medical factors that may need to be considered for Laser Safety are listed in Part V-Chapter 5.

1.3.6) Disposal of laser-associated hazardous wastes and/or transfer of laser ownership are addressed in Part V-Chapter 6.

1.3.7) Laser Safety-specific recordkeeping is addressed in Part V-Chapter 7.

1.3.8) Appendices for the various chapters in this Laser Safety Plan are provided in Part V-Chapter 8.

1.4) Summary of KU Laser Safety Plan Requirements

Requirement	Laser Classes (defined in Part V 3.9)				
Manufacturer's Warning label 1	2	3a	3b	4	
Warning sign	2	3a	3b	4	
Registered with LS Office		2	3a	3b	4
Laser Safety Training			3a	3b	4
Laser Safety Operating Procedures				3b*	4
Medical Surveillance				3b*	4

(*if invisible to the eye, and if cw laser, visible beams > 15 mW power)

2) Standard Operating Procedures (SOPs) and Practices for Laboratories Using Non-exempt Lasers

2.1) General Principles for Working Safely with Laboratory Non-exempt Lasers

All authorized users and authorized laboratory supervisors using non-exempt lasers shall:

2.1.1) Avoid laser exposures in excess of limits established in ANSI Z136.1

2.1.2) Avoid underestimation of laser-related risks.

2.1.3) Comply with the requirements of this KU Laser Safety Plan.

2.2) Review of Universal Standard Operating Procedures for Non-Exempt Lasers

Note: This section provides references ~~back~~ to the Universal Standard Operating Procedures in Laboratories with Hazardous Materials/Radiation Generating Equipment provided in Part I, as applicable, for achieving Laser Safety. References to Part I are given.

All individuals, authorized users, and authorized laboratory supervisors using non-exempt lasers shall:

2.2.1) Responsibilities under Standard Operating Procedures

2.2.1.1) Fulfill their responsibilities as identified under Standard Operating Procedures in Part I: Section 2.1, specifically Sections 2.1.1 through 2.1.4.

2.2.2) Procurement of non-exempt lasers

2.2.2.1) Procure non-exempt lasers in accordance with the procedures given in Part I: Section 2.2 marked with an asterisk.

2.2.3) General Lab Safety Practices and Conduct with non-exempt lasers

2.2.3.1) Comply with and enforce the access restrictions applicable to visitors, non-laboratory personnel, and/or non-laboratory authorized occupants in rooms with non-exempt lasers as identified in Part I: Section 2.5.1.

2.2.3.2) Comply with and enforce the access restrictions applicable to individuals who are authorized occupants in rooms with non-exempt lasers as identified in Part I: Section 2.5.2.

2.2.3.3) Follow the general lab safety practices identified in Part I: Section 2.5.3. (marked with an asterisk or super-script L) when working with non-exempt lasers.

2.2.4) Specialized Safe Laboratory Practices

2.2.4.1) Adhere to each of the specialized safe laboratory practices when working with non-exempt lasers, as applicable. These are identified in Part I: Section 2.6 (marked with an asterisk or superscript L).

2.2.5) Hazard-Specific Safety Procedures

2.2.5.1) Follow hazard-specific safety procedures as identified in Part I: Section 2.7.11.

2.2.5.2) Follow laser-specific safety procedures as identified in this Part V, Section 2.5 below.

2.2.6) Laboratory Specific Standard Operating Procedures

2.2.6.1) Develop and implement laboratory-specific Standard Operating Procedures in accordance with Part I: Section 2.8.

2.2.7) Emergency Procedures

2.2.7.1) Adhere to the general emergency procedures identified in Part I: Section 2.9, specifically Sections 2.9.1 through 2.9.6.

2.3) Hazardous Material (HM) Receipt and Distribution

All individuals, authorized laboratory supervisors, and authorized users shall:

2.3.1) Follow the requirements of Part I, II, III or IV, as applicable, if a laser installation requires the introduction of hazardous materials into the laser laboratory.

2.4) Hazardous Materials Storage

All individuals, authorized laboratory supervisors, and authorized users shall:

2.4.1) Follow the requirements of Part I, II, III or IV, as applicable, if a laser installation requires the introduction of hazardous materials into the laser laboratory.

2.5) Laser Safety - Standard Procedures

2.5.1) General Standard Operating Procedures

Authorized Users and Authorized Occupants shall:

2.5.1.1) Avoid staring into a laser beam (class 2 or higher) or pointing such a beam toward an individual. Avoid looking at the pump source.

2.5.1.2) Wear approved laser eyewear specified for the type and class of laser beam as required whenever the laser is in operation (or follow safety procedures providing equivalent protection as specified in written laboratory-specific standard operating procedures. See section 3.6.1.3.)

Note: Personnel should be especially cautious around lasers with invisible light frequencies.

Authorized Users shall:

2.5.1.3) Not operate lasers at eye level unless specific permission has been granted by the Laser Safety Officer.

2.5.1.4) Warn all individuals present, verify that all required safety measures are satisfied, and certify that all personnel are cleared from the path of the beam before energizing the beam.

2.5.1.5) Not leave an active laser unattended unless it is part of an approved and controlled environment designed for unattended operation.

2.5.1.6) Exercise extreme care in all procedures that might result in inadvertent reflections of the laser beam. (All procedures with such a potential must have been evaluated for safety by the Authorized Laboratory Supervisor and provided in writing together with appropriate training.).

Note: This includes good housekeeping with special emphasis on verifying that no device, tool or other reflective materials are left in the path of the beam.

2.5.1.7) Not wear bright, reflective jewelry or other reflective objects.

2.5.1.8) Use enclosed beams and/or with appropriate beam stops whenever it is feasible to do so.

2.5.1.9) Keep occupancy as low as possible consistent with the required work when open laser beams are in operation and verify that all occupants present are either Authorized Occupants or Authorized Users.

2.5.1.10) Not remove the protective housings of the laser system.

2.5.1.11) Secure the laser against unauthorized use based upon approved written laboratory-specific standard operating procedures when the laser is not in operation or under the control of an Authorized User.

2.5.1.12) Not over ride or by-pass laser safety system interlocks unless specific permission is granted by the Laser Safety Officer.

2.5.1.13) Report all accidents or suspected eye injuries to the Laser Safety Officer.

2.5.2) Restricted or controlled access to Laboratory during operations with accessible laser beams

The Authorized Laboratory Supervisor shall:

2.5.2.1) Evaluate the need for restrictions on access to the laboratory during critical laser operations within the laboratory. This evaluation should include the need for interlocked entrances and/or annunciators and flashing "beam on" lights (See Section 3.4.2, Section 8.5,and ANSI standards)

2.5.2.2) Instruct the Authorized Users and Authorized Occupants concerning the nature of those restrictions, including the instructions in the laboratory specific Standard Operating Procedures.

Note: This includes an evaluation of the need to inform visitors, authorized occupants, and even authorized users of special risk factors.

2.5.2.3) Implement all access restrictions specifically required by any applicable Laboratory-Specific Safety Plan.

Authorized Users and Authorized Occupants shall:

2.5.2.4) Follow the instructions given by the Authorized Laboratory Supervisor concerning access restrictions.

2.5.3) Location of Non-exempt Lasers and Associated Warning Devices:

The Authorized Users shall:

2.5.3.1) Not move lasers to a new location unless the appropriate hazard evaluation has been performed by the Authorized Laboratory Supervisor and/or Laser Safety Officer, as applicable.

2.5.3.2) Maintain warning signs, interlocks and alarms in accordance with the requirements specified in Section 3.4.2 of this Part.

2.5.3.3) Not by-pass required interlocks unless written procedures for by-passing an interlock have been approved by the Authorized Laboratory Supervisor/Laser Safety Officer and the user has been specifically trained in the procedure.

All occupants of a laser laboratory shall:

2.5.3.4) Follow the safety precautions and/or restrictions specified by any sign, annunciator, or warning light.

2.5.4) Disposal of laser associated hazardous materials and/or transfer of laser ownership.

Authorized Users and Authorized Laboratory Supervisors shall:

2.5.4.1) Comply with the requirements identified in Part V: Chapter 6 .

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/Safety Authorization Application (LHRSAA)

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 LHRSAA form and submit it to EHS according to the procedures identified in Part I: Chapter 3-Section 3.3. The form can be found in Part I: Chapter 8.

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

3.3.5) A copy of the appropriate LHRSAA form is available in Part I: Chapter 8.

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 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 Laser Safety Office 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-Chapter 8.

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. (See Chapter 8)

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 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 Laser Safety Office and consultation with 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:Chapter3-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. See chart in chapter 8, Section 8.6.

Additional notes of guidance:

The basic system shall satisfy all applicable electrical codes and the evaluations of the 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 Chapter 8.

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 Laser Safety Officer and shall be appropriately justified. See Standard Operating Procedures--section 2.5.1 above.

The 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 Chapter 8.

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 Safety Authorizations for Level III and IV Laser Systems

3.9.1) Introduction

The assignment of laser classes to particular 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. The University Health and Safety Manual has adequate guidelines for such use.

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 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 LHRSAA 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 LHRSAA 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 intrabeam 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 LHRSAA 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 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 LHRSAA 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 LHRSAA 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 Chapter 8.

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 so as 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 Laser Safety Office so that a proper hazard classification based on ANSI standards can be made on the laser. Construction of lasers at KU shall take into account the requirements given in Chapter 8.

Authorized Laboratory Supervisors shall:

d) Submit the LHRSAA 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 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 LHRSAA 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 Chapter 8.

Note: In the event that the Laser Safety Subcommittee is unavailable to review the procedures, the procedures may be reviewed and approved temporarily by the Laser Safety Officer and/or Chair/designated member of the Laser Safety Subcommittee. See section 3.9.3. See Chapter 8 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, Appendix 8.3.

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 Laser Safety Officer will perform an inspection to verify that all conditions have been met. After that verification, the 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 Chapter 8 for an outline for Standard Operating Procedures to be included in the proposed Laser Specific-Safety Plan.

c) The 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.

4) Laser Safety-Specific Information & Training

Federal and State regulations, as well as "prudent practice," require the University to provide all faculty, staff, students, and visitors with information concerning the laser hazards present in their University environments, and sufficient training to enable them to perform their tasks safely and protect themselves from potential laser exposure.

4.1) Review of Universal (Part I) Information & Training Requirements

Note: This section provides references back to the universal laboratory safety information and training requirements provided in Part I-Chapter 4, as applicable for achieving Laser Safety. References to Part I are given.

All individuals, authorized users, and authorized laboratory supervisors using non-exempt lasers shall:

4.1.1) Responsibilities

4.1.1.1) Fulfill their responsibilities for universal laboratory safety information and training as identified in Part I-Chapter 4: Section 4.1 as applicable.

Note: For example, if the laser system and its use involves hazardous chemicals then Part I-4.2.1 is applicable in addition to Part I-4.2.4.

4.1.2) Required Information

4.1.2.1) Be familiar with and make the required information specified in Part I-Chapter 4: Section 4.2 (specifically 4.2.1 through 4.2.4) available as applicable.

4.1.3) Required Training

4.1.3.1) Comply with the required training specified in Part I-Chapter 4 (specifically Sections 4.3 through 4.5) as applicable.

4.1.4) Frequency of Information & Training

4.1.4.1) Comply with the information and training frequency requirements specified in Part I-Chapter 4: Section 4.6.

4.1.5) Documentation of Information & Training

4.1.5.1) Comply with the information and training documentation requirements specified in Part I-Chapter 4: Section 4.7.

4.2) Laser Safety-Specific Information

Authorized Laboratory Supervisors shall:

4.2.1) General Laser Safety Information

4.2.1.1) Inform all users of non-exempt lasers in their labs with the information required under Part I-Chapter 4: Section 4.2.4.

4.2.2) Specific Laser Safety Information

4.2.2.1) Show the LHRSAA form for their lab to all authorized laser users and authorized occupants and ask them to be familiar with it. See Part V-: Section 3.2 for details.

4.2.2.2) Review the inventory of non-exempt lasers present in the lab with all users and occupants. See Part V-: Section 3.3.1 for details.

4.2.2.3) Inform all users and occupants of the location of a copy of ANSI 136.1. (See Part V-: Section 3.3.2.) A copy will be readily available in the Laser Safety Office of the Department of Environmental Health and Safety.

4.2.2.4) Inform all users and occupants about warning signs, indicators and/or annunciators and the appropriate response to them.

4.3) Laser Safety-Specific Training

Authorized Laboratory Supervisors shall:

4.3.1) General Laser Safety Training

4.3.1.1) Provide all users of non-exempt lasers in their lab with access to initial lab safety training specified in Part I-Chapter 4: Section 4.5.6. Training for users shall cover the content of Part V and its references to other sections of the Laboratory Safety Manual. Users will be instructed to become proficient with this general lab safety information and will be required to pass a lab safety evaluation, that will be available online at www.ehs.ukans.edu.

4.3.1.2) Provide all users of non-exempt lasers in their lab with access to information on all of the "Standard Operating Procedures and Practices for Laboratories Using Non-exempt Lasers" found in Part V-Chapter 2: Sections 2.1 through 2.5 with special emphasis on section 2.5. Users will be instructed to become proficient with this safety information and will be required to pass a lab safety evaluation, that will be available on-line at www.ehs.ukans.edu.

Note: Any user who can demonstrate prior proficiency for the required laser training may be certified by the Laser Safety Officer.

4.3.2) Specific Laser Safety Information

4.3.2.1) Train all prospective authorized laser users about the hazards that are specific to the type and class of laser to be used.

4.3.2.2) Train all users of non-exempt lasers in their lab on the Hazard Communication Procedures found in Part V-Chapter 3: Sections 3.1 through 3.3.

4.3.2.3) Train all users of non-exempt lasers and authorized occupants in their lab in the correct use of any required personal protective equipment, such as special laser safety goggles, and the quality assurance checks that need to be performed to verify continued effectiveness.

4.3.2.4) Train all users of non-exempt lasers in their lab on all requirements imposed upon the lab by an applicable Laser Safety Registration and Use Approval. (Refer to Part V: Chapter 3-Section 3.9.)

4.3.2.5) Train all users of non-exempt lasers in their lab concerning any medical surveillance requirements based upon Part V-Chapter 5.

4.3.2.6) Train all users of non-exempt lasers in their lab on any laboratory-specific Laser Safety procedures that have been implemented by the laboratory supervisor that are above and beyond those identified in Part V of this manual.

Note: For Level III and Level IV, this is accomplished by fulfilling 4.4.2.4 above, but 4.4.2.4 does not address lab-specific procedures for Level I and Level II.

4.4) Laser Safety - Information & Training Frequency

Laser Safety Officer shall:

4.4.1) Provide the authorized laboratory supervisor of non-exempt lasers with updated information and training documents for laboratory users at yearly intervals, as specified in Part I-Chapter 4: Section 4.6. Typically, this will consist of very short reading materials and documentation by which the user can indicate he or she has read them.

4.5) Laser Safety-Information & Training Documentation

Authorized Laboratory Supervisor shall:

4.5.1) Document the training of all laser -users in their lab accordance with the procedures specified in Part I-Chapter 4: Section 4.7.

5) Medical Factors to Consider in Laser Safety

5.1) Introduction

This chapter identifies a number of factors (not necessarily complete) that may need to be considered in the establishment of laboratory-specific safety requirements and/or procedures when non-exempt lasers are being used. This chapter should be used together with Chapter 5 of Part I on exposure assessment and medical surveillance.

5.2) Medical Factors in Evaluating Access Restriction

The Authorized Laboratory Supervisor shall:

5.2.1) Inform users that some individuals may have special sensitivity (for example, allergies) to products created by the laser beam or chemicals that must be used in the operation of the laser. In such cases, Part II-section 5.2.1 applies.

5.3) Medical Care

5.3.1) Emergency Response to Exposure to Hazardous Non-exempt Lasers

The Authorized Laboratory Supervisor shall:

5.3.1.1) Add laboratory-specific procedures to the general emergency procedures described in I-2.9 and I-5.3 that address any actions that need to be taken very quickly in order to reduce the magnitude of the medical consequences of the emergency if an evaluation indicates the need. The responding and attending medical services personnel need to know the type and level of exposure the person might have experienced.

Note: There may be no action other than obtaining medical assistance as soon as possible but the possibility that there are actions that could be taken needs to be explored.

5.3.2) Effects of Acute Exposure above MPE levels

5.3.2.1) Evaluate and address actions that should be taken if an individual receives a laser beam exposure that is potentially greater than the MPE.

5.4) Laser Use Requiring Mandatory Medical Surveillance

5.4.1) Medical Surveillance for Level IV Laser Hazards

The Authorized Laboratory Supervisor shall:

5.4.1.1) Inform authorized resident users of their responsibility for medical surveillance with Watkins Student Health Center as described in 5.4.2 below. The costs of such surveillance shall be covered by the University.

Authorized resident users potentially exposed to laser beams assigned to Level IV shall:

5.4.1.2) Participate in the medical surveillance program arranged for them by the authorized laboratory supervisor.

5.4.2) Nature of the Medical Surveillance Program

a) The purpose of laser medical surveillance is twofold. The first purpose is to establish a baseline of ocular conditions before exposure to laser radiation.

b) The second purpose is to detect and document, as early as possible, ocular damage in the event of a suspected exposure incident. Both purposes serve to assess the effectiveness of control measures and to promptly institute appropriate therapeutic measures.

Note: Laser medical surveillance includes a preliminary baseline eye exam. Additional eye exams may be required in the event of exposure or suspected exposure to laser radiation above the MPE. An eye exam also is required upon termination of laser work or upon termination of employment at KU. Other routine laser eye exams are not required.

6) Safe Disposal of Hazardous Laser-Associated Waste and Transfer of Laser Ownership

6.1) Introduction

There may be laboratories with lasers that do not use other hazardous materials. The authorized laboratory supervisors of such laser laboratories are, however, responsible for any hazardous materials produced by laser beams or used in the laser system itself.

Because laser systems that are potentially operable must remain under the responsibility of an authorized laser supervisor, laser systems cannot be permitted to be abandoned or discarded as junk.

6.2) Disposal and Transfers of Lasers and Associated Materials

6.2.1) Disposal of Laser-Associated Hazardous Waste

Authorized Laboratory Supervisors and Authorized Users shall:

6.2.1.1) Follow the procedures specified in Chapter 6 of Parts I, II, III and IV as applicable for any hazardous material waste generated from laser activities.

Note: All individuals who handle such materials are not authorized users until they have been trained at the level required under Part II for that material.

6.2.2) Transfer of Laser Ownership

Authorized Laboratory Supervisors shall not:

6.2.2.1) Transfer responsibility for a non-exempt laser unless prior approval has been obtained from the Laser Safety Officer.

Note 1: As indicated above, this includes discarding the laser in trash or abandoning it.

Note 2: Temporary transfer of responsibility to the Laser Safety Officer is an option that may be arranged.

The Laser Safety Officer or EHS staff shall:

6.2.2.2) Verify that a laser system has been so disabled that potential use of the system has been destroyed and that any associated hazardous waste has been properly processed prior to approving the placement of such a system in the trash. The laser shall then be removed from the university inventory.

6.2.2.3) Accept responsibility for a laser system if a proposed transfer of the laser is to another employee who is not an authorized user and shall transfer that responsibility when the perspective owner has been certified as an authorized laboratory supervisor.

6.2.2.4) Approve the transfer of the unit to a non-university owner if appropriate and remove the laser from the university inventory or to an authorized laboratory supervisor who has the appropriate approval, and change the inventory information.

6.2.2.5) Document the actions that have been taken and place these in the records.

7) Laser Safety-Specific Record-Keeping

7.1) Auditable Records

7.1.1) Establish and maintain auditable records in accordance with the requirements of Part I: Chapter 7-Section 7.1.

7.2) Identification and Dating of Records

7.2.1) Identify and date records in accordance with the requirements of Part I: Chapter 7-Section 7.2.

7.3) Retention of Records

7.3.1) Retain records in accordance with the requirements of Part I: Chapter 7- Section 7.3.

7.4) LSO Records

7.4.1) LSO shall establish and maintain the appropriate records in accordance with the requirements of Part I: Chapter 7-Section 7.4.

8) Laser Safety-Appendices

Appendix 8.1
Glossary of Terms Used in Laser Methodology

Authorized (Laser) Laboratory Supervisor. The authorized laser user who assumes responsibility for the control and safe use of a laser or laser system.

Authorized (Laser) User. An individual who has met all applicable laser safety training, and approval requirements for operating a laser or laser system.

Authorized Resident (Laser) User. An individual who has met all applicable laser safety training, and approval requirements for operating a laser or laser system and who is a user of the laser facility on a regular basis for a period of at least three months.

Aversion response. Movement of the eyelid or the head to avoid an exposure to a noxious stimulant or bright light. It can occur within 0.25 s, including the blink reflex time.

Continuous wave (cw). The output of a laser which is operated in a continuous rather than a pulsed mode. For purposes of safety evaluation, a laser operating with a continuous output for a period > 0.25 s is regarded as a cw laser.

Controlled area. An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from laser radiation and related hazards.

Diffuse reflection. Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

Embedded Laser. An enclosed laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the systems lower classification is appropriate due to the engineering features limiting accessible emission.

Energy (Q). The capacity for doing work. Energy content is commonly used to characterize the output from pulsed lasers and is generally expressed in joules (J).

Exempt Laser. Class 1 lasers which are used as designed and on which no maintenance is performed that would expose any laser beam which has been enclosed by the manufacturer are exempt from the Laser Safety Plan. These lasers are covered by guidelines in the University Health and Safety Manual.

Failsafe interlock. An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

Infrared radiation. Electromagnetic radiation with wavelengths which lie within the range 0.7 m to 1 mm.

Intrabeam viewing. The viewing condition whereby the eye is exposed to all or part of a laser beam.

Irradiance (E) (at a point of a surface). Quotient of the radiant flux incident on an element of the surface containing the point at which irradiance is measured, by the area of that element. Unit: watt per cm2.

Laser. A device which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

Laser Operator. See Authorized Laser User.

Laser Safety Officer (LSO). One who has the authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System. An assembly of electrical, mechanical, and optical components which includes one or more lasers.

Maximum Permissible Exposure (MPE). The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. MPE is expressed in terms of either radiant exposure (joules/cm2) or irradiance (watts/cm2). The criteria for MPE are detailed in Section 8 of ANSI Z136.1.

Nominal Hazard Zone (NHZ). The nominal hazard zone describes the space within which the level of the direct, reflected or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

Non-Exempt Lasers. All lasers *except* for Class 1 lasers which are used as designed and on which no maintenance is performed that would expose any laser beam which has been enclosed by the manufacturer.

Optical Density (D_1). Logarithm to the base ten of the reciprocal of the transmittance: $D_1 = -\log T$, where T is the transmittance.

Power. The rate at which energy is emitted, transferred, or received. Unit: watts (joules per second). Also called radiant power.

prf. Abbreviation for pulse repetition frequency. (See repetitively pulsed laser.)

Pulsed laser. A laser which delivers its energy in the form of a single pulse or a train of pulses. The duration of a pulse is regarded to be < 0.25 s.

Q-Switched Laser. A laser that emits short (~30 ns), high-power pulses by means of a Q-switch.

Radiant Exposure (H). Surface density of the radiant energy received. Unit: joules per cm2.

Radiant Flux ( ). Power emitted, transferred, or received in the form of radiation. Unit: joule (J).

Repetitively Pulsed Laser. A laser with multiple pulses of radiant energy occurring in sequence with a prf > 1 Hz.

Specular Reflection. A mirror-like reflection.

Transmittance. (T) The ratio of total transmitted radiant power to total incident radiant power.

Ultraviolet Radiation. Electromagnetic radiation with wavelengths smaller than those of visible radiation; for the purpose of this section on laser safety, 0.2 to 0.4 m.

Visible Radiation (Light). Electromagnetic radiation which can be detected by the human eye. This term is commonly used to describe wavelengths which lie in the range 0.4 to
0.7 m.

Wavelength (l). The distance between two successive points on a periodic wave which have the same phase.

Appendix 8.2
Summary of KU Laser Safety Plan Requirements

Requirement	Laser Class				
Manufacturers Warning label	1	2	3a	3b	4
Warning sign		2	3a	3b	4
Registered with LSO		2	3a	3b	4
Laser Safety Training			3a	3b	4
Laser Safety Operating Procedures				3b*	4
Medical Surveillance			3b*	4	

(*if invisible to the eye, and if cw laser, visible beams > 15 mW power)

Exempt Lasers

Class 1 lasers which are used as designed and on which no maintenance is performed by KU personnel/students/visitors that would expose any laser beam which has been enclosed by the manufacturer are **exempt (thus exempt lasers)** from the Laser Safety Plan. The University Health and Safety Manual has adequate guidelines for such use.

Embedded Lasers

Embedded lasers are enclosed lasers with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the systems lower classification is appropriate due to the engineering features limiting accessible emission. All embedded lasers that require onsite maintenance or services with interlocks bypassed are subject to the KU Laser Safety Plan. Otherwise, all embedded lasers are exempt from the KU Laser Safety Plan.

Appendix 8.3

Procedures for Obtaining Authorization for Level III and IV Operations

The prospective Authorized Laboratory Supervisor is encouraged to discuss plans with the Laser Safety Office very early in the planning stages.

The Laboratory Supervisor shall complete and submit an updated Lab Hazard Registration Safety Authorization Application (LHRSAA) form to EHS, 140 Burt Hall, whenever plans for a change in the type and/or level of activities at Level III or IV are being made. Upon receipt of the LHRSAA form, EHS shall provide the Laser Registration and Laser-Specific Safety Plan to the Laboratory Supervisor. This form provides instructions concerning the types of safety information (engineered controls, facilities, SOP's) that need to be addressed.

The Laboratory Supervisor shall complete and submit one copy of the proposed Laser-Specific Safety Plan to the LSO for Level III lasers and six copies for Level IV lasers. Only the Laser Safety Officer needs to review Level III Safety Plans. Both the LSO and the Laser Safety Subcommittee review the Safety Plan for Level IV lasers.

The LSO/Laser Safety Subcommittee shall review the proposed Laser-Specific Safety Plan for adequacy in safety at the level of activities requested. This evaluation will be based upon the proposed safety facilities/equipment and appropriate standard operating procedures taking into account any applicable federal, state and local regulations and the requirements of this Manual.

If deficiencies in the proposed Laser-Specific Safety Plan (s) are identified by the LSO or Laser Safety Subcommittee, the Laboratory Supervisor shall plan appropriate changes which will then be resubmitted by the Laboratory Supervisor for approval.

Upon approval of the proposed Safety Plan, EHS shall notify the Laboratory Supervisor of that approval. Upon receiving approval, the Laboratory Supervisor shall prepare the laboratory to meet all conditions specified in the approved plan and then request an inspection by EHS. Laser procurement and installation shall be accomplished in collaboration with the LSO and shall not be energized until the LSO issues the Safety Authorization described in 3.9.3.8 below. No individual may use Level III/IV lasers until they have satisfactorily documented all required training. This includes the Laboratory Supervisor and all other potential users. The Laboratory Supervisor is urged to address these issues in consultation with EHS as soon as plans for a Level III or IV laboratory are anticipated.

When all the conditions of the approved LSSP(s) have been met as verified by EHS, a written Safety Authorization shall be issued to the Laboratory Supervisor which references all documents associated with the approved Laser Specific Safety Plan.

Upon receiving the Safety Authorization from EHS, the Laboratory Supervisor may initiate use of the materials/equipment under the conditions of the applicable Laser Specific Safety Plan and this Manual.

LASER REGISTRATION
and
LASER-SPECIFIC SAFETY PLAN

Instructions

Class 2, Class 3a and 3b, and Class 4 laser systems and all embedded lasers (a laser with a higher class than the laser system) must be registered with the Laser Safety Office. In addition, approval for procurement and installation of Class 3b and 4 lasers must be coordinated with the Laser Safety Office/Committee prior to obtaining the laser system. Engineering controls will be evaluated to verify that special safety features for the facility meet current requirements. Information that is not known at the time of registration may be completed at a later date.

Please submit only the "Registration" (Part A) for embedded laser systems and for Class 2 and Class 3a lasers systems. Please submit the "Registration and Laser-Specific Safety Plan" (Part A and Part B) for Class 3b and Class 4 laser systems.

Registration - Part A

1. Name of Laboratory Supervisor: _____

Principle Operator (if appropriate): _____

2. Department: _____

3. Campus address: _____

4. Phone #: _____ E-mail:_____

5. Location of unit (building and room): _____

6. Laser
a) Type: _____ b) Laser Class: _____
c) Laser System Class:_____
d) Manufacturer/(homemade): _____
e) Model: _____ f) Serial #: _____
g) Beam Wavelength (nm): _____ h) Beam at Aperture (mm):_____
i) Power (maximum/used): _____
j) Continuous/Pulsed: _____

7. The Standard Operating Procedures serve as the written laboratory specific standard operating procedures for embedded laser systems, and for Class 2 and Class 3a lasers systems. Any additional restrictions for this specific system - operating, access, security, or special health/medical susceptibilities - should be included with the registration and submitted to the Laser Safety Office.

Date: _____ Signed: _____

Laser-Specific Safety Plan for Class 3b and Class 4 Lasers - Part B

8. Provide the following information on experimental design:

a) Is the beam exposed or enclosed? (circle one.)

b) A diagram of the room with the location of the laser. Identify the laser control area and the nominal hazard zone.

c) A brief description of the proposed use of the laser system. Include sufficient detail to permit Committee evaluation of the adequacy of engineering controls.

9. Provide the following special considerations, if applicable:

a) Procedures for alignment, maintenance, and/or service, including procedures for bypass of safety interlocks.

b) Description of planned equipment modifications/updates to the system.

10. Identify and evaluate the hazards as described below:

__ electrical (shock)	**__ target area**	**__ chemical (dyes, gas, solvents)**
__ absorbing media	**__ atmospheric contaminants**	**__ beam path**
__ fire protection	**__ severity of potential accidents**	**__ noise/explosive/cryogenic**

11. Specify the personnel protective equipment that will be used.

12. Use the following check list to identify additional controls that might be needed for the laser system.

Access controls
- **__ door interlocks**
- **__ signs**
- **__ signals**

Beam Controls
- **__ key-lock**
- **__ enclosures**
- **__ shutters**
- **__ stops**

Electrical Controls
- **__ light on powersupply**
- **__ HV signs**

Eye Protection
- **__ type of eyewear**
- **__ optical density requirements for beam**

Room Design
- **__ ventilation**
- **__ reflective surfaces**
- **__ windows/viewing area limited**
- **__ water/electrical supply**
- **__ potential fire hazards**
- **__ security**

13. Note:

a) Certification for training must be documented to operate or maintain the laser system. A current list of trained individuals will be kept on the appropriate form.

b) Any actual or suspected exposure must be reported immediately to the Laser Safety Officer and followed by appropriate medical surveillance.

c) The posting requirements will be met in cooperation with the Laser Safety Officer.

d) No unit may be transferred to another individual or destroyed without prior consultation with the Laser Safety Officer.

e) A log should be used to document the actual time that the equipment is being used.

Date:_____Signed: _____

Appendix 8.4
Standard Operating Procedures for Laser Systems

1. One should never look directly into any laser beam, and the beam should never be pointed at an individual.

2. Approved eyewear should be worn as specified for the type/class of laser whenever it is in operation.

3. Lasers should not be operated at eye level.

4. Only authorized users shall operate the laser system.

5. All individuals present should be warned when the beam is operating, and all required safety measures shall be satisfied.

6. An active laser should not be left unattended unless it is part of an approved and controlled environment and designed for such an operation.

7. Extreme care should be exercised in all procedures which might result in inadvertent reflections of the laser beam. Individuals should not wear bright, reflective jewelry or other objects.

8. Beam stops (diffuse/non-reflective), collimators, and barriers should be used whenever feasible to do so.

9. The lowest possible beam power should be used for alignments.

10. Occupancy should be kept as low as possible, and all occupants should be authorized users/occupants.

11. The protective housings of the laser system should not be removed.

12. The laser should be secured against unauthorized use.

13. The Laser Safety Officer should be informed of any new, modified, relocated, disposal or transfer of a laser system.

14. Laser safety system interlocks should never be by-passed or over-ridden.

15. All accidents or suspected eye injuries should be reported to the Laser Safety Officer.

Appendix 8.5
Outline for Written Laser Safety Operating Procedures

All Authorized Users and Occupants shall be informed of applicable hazards and trained in the applicable laboratory-specific operating procedures and shall follow them as specified in section 4.3.2.4. Of course, they shall also be trained in the content of Part V and its references.

The following outline is to be followed in preparing written laser safe operating procedures . A written procedure is to include all lasers in a laser system, including alignment of lasers. This LSOP must be reviewed for adequacy yearly and is done via a simple e-mail from the Laser Safety Officer to the Laboratory Supervisor. Usually this will require no more than a simple response that there have been no changes in the laboratory.

I. INTRODUCTION

1. Location of laser or laser system (site, building, room).
2. Diagram of areal layout (attachment).
3. Description of (each) laser, including classification, laser medium, and beam characteristics (divergence, aperture diameter, pulse length, repetition rate, and maximum output, as applicable).
4. Purpose/application of beam(s).

II. HAZARDS

1. Identification of the hazards (beams, electrical, chemical, etc./).
2. Analysis of hazards (target area, absorbing media, beam path, severity of potential accidents, etc.).

III. CONTROLS

1. Access controls (door interlocks, signs, signals).
2. Beam controls (key-lock, enclosures, shutters, stops).
3. Electrical controls (light on power supply, HV signs).
4. Eye protection (medical surveillance requirements, type of eyewear, optical density required for beam).
5. Other.

IV. OPERATING PROCEDURES

1. Initial preparation of laboratory environment for normal operation (key position, warning lights on, interlock activated, identification personnel).
2. Personnel protection requirements (eyewear, protective barriers).
3. Target area.
4. Countdown procedures.
5. Shutdown procedures.
6. Special procedures (alignment, safety tests, interlock bypass, emergency, etc.).

V. TRAINING

1. Laser Safety Orientation Requirements.
2. Laser-specific safety training requirements.
3. Training maintenance and repair personnel.

VI. RESPONSIBILITIES

1. Supervisory (include emergency contact).
2. Operators and support personnel.

VII. MISCELLANEOUS

1. Rules for visitors during laser operation.
2. Procedures in case of accident.
3. Other (maintenance, adjustment, special precautions, etc.).

Appendix 8.6
Examples of Laser Signs

Authorized Users and Occupants shall follow any instructions placed on laser signs.

Appendix 8.7
ANSI Guidance on Control Measures

Authorized Users and Occupants shall be instructed in the control measures applicable to lasers being used in their laboratories.

Appendix 8.8
Brief Overview of Biological Effects

1) Effects in Skin

Skin damage from laser radiation is not as great a concern as eye damage; such skin injury can be treated similarly to treatment for a thermal burn or wound. Also, for those beams which the power or energy density is high enough to cause skin damage, the beam is usually enclosed, or some type of physical control is provided for laboratory users/occupants.

2) Minimal Effects in Eyes

2.1) Introduction (summary of ANSI Z136.1-1993 Appendix G)

There is no evidence that exposure at levels equal to or below applicable Maximum Permissible Exposures (MPE) cause any damage. MPE's are generally set a factor of 10 below exposure levels known to cause damage of the types described. However, users must remember that exposures inside any Nominal Hazard Zones are above the MPE's. In such zones, even reflected beams from structures in the beam may produce exposures above the MPE's.

The brightness of a laser can exceed all known natural and man-made light sources. The focusing effect of the cornea and lens of the eye can concentrate parallel rays from laser light by a factor of 100,000. Therefore, it is not surprising to discover that the eyes are the most susceptible organ to laser light. Wavelengths in the infrared (IR) and ultraviolet (uv) range can cause corneal damage. Extremely low densities of pulsed lasers can cause retinal damage.

2.2) Corneal damage

A minimal corneal lesion is a small white area involving the epithelium. It appears within 10 minutes after the exposure. Such a lesion will heal within 48 hours without visible scarring.

2.3) Minimal damage from infrared lasers (1.4 - 1000 m)

Excessive infrared exposure causes a loss of transparency or produces a surface irregularity in the cornea based upon experience with CO2 lasers. Extrapolation to other wavelengths should be made with care.

Damage results from absorption of the energy by tears and tissue water in the cornea. The critical temperature for this effect is not much above normal body temperature and appears to be a function of exposure duration.

2.4) Minimal damage from UV lasers (0.18 - 0.4 m)

Excessive exposure in this region "produces photophobia accompanied by surface redness, tearing, conjunctival discharge, and corneal exfoliation and stromal haze" (quoted from ANSI Z136.1-1993). The action is photochemical rather than thermal.

2.5) Minimal retinal damage (0.4 - 1.4 m)

The minimal retinal lesion has been defined as the smallest ophtalmoscopically visible change in the retina which is a small white patch which occurs within 24 hours of the time of exposure. Most serious effects will occur for damage in the central portion of the retina, the macula. (There are no data for long exposures and small spot sizes but such exposures are not likely.)

For wavelengths that are transitional, both types of damage may occur.

Note on continuous wave (cw) vs. pulsed lasers

A cw laser causes eye damage by thermal processes that overheat the absorbing tissue. The steady stream of photons is absorbed by tissue until the temperature rises above that of the eye's cooling method. Eye surgeons use this thermal effect (under controlled conditions) when they "spot weld" detached retinas using argon or ruby lasers.

Pulsed lasers are more hazardous to the eye than cw, especially when the wavelength is in the ocular focus region. Pulsed lasers cause "blast (mechanical) damage" if the pulse duration is low. The pulse durations are so short that little or no thermal conduction occurs during the length of the pulse.

Appendix 8.9
Selected Design Criteria for Constructing Lasers

Ancillary apparatus for lasers shall be designed and constructed in accordance with applicable safety requirements.

A. A fail-safe control system maintains the desired protective function when the system's final control element returns to the safe position upon activation of its initial control device and upon failure of its power source.

B. Fail-safe control systems shall have been successfully analyzed using the Single Failure Criterion of IEEE Standard 379 before completion of the design.

C. Energy barriers, where required in the Laser Safe Operating Procedures (LSOP) and where readily removable, shall have their positions monitored by initial control devices, such as limit, photocell, or proximity switches, which shall be considered part of the personnel-safety interlock system for the laser.

D. Personnel, equipment, and service access-door positions shall be monitored where required in the LSOP by initial control devices having hardwired final control elements arranged to de-energize the power supply for the laser upon unauthorized access attempts.

E. Where transmission-line enclosures are used, plug and receptacle or pin and socket connectors having one end shorted should be run parallel to transmission-line enclosures and across breaks to ensure continuous enclosure while the beam is operating.

F. Remote control of Class 3b or Class 4 beam operation shall be delegated by sequentially-keyed local remote control stations. The sequential keying shall be considered part of the personnel-safety interlock system for the Laser.

G. Visual indicator used in Laser activation warning systems and annunciators shall have self-checking features, such as push-to-test lights, included in the system design.

H. Laser control elements and devices and emission delay periods shall be listed in the LSOP, Part III, together with any exceptions to the applicable safety-related design criteria accepted by the Laser Safety Officer.

I. Where single-point grounding systems are used with Laser power supplies, systems or structures, (troublesome areas), their design criteria shall be documented and approved by Facilities Operations. Covered copper braid or flat copper bar shall be considered for use as grounding conductors in circuits having fast rise-times.