





Risk Management Manual Program

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Approved by: <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <small>DocuSigned by:</small>  <small>A336B06F41DE407...</small> </div> Vice-President, Administration  President and Vice-Chancellor	Date of Most Recent Approval: September 2020
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Responsible Executive: Vice-President, Administration	Enquiries: Environmental and Occupational Health Support Services (EOHSS) ehss@mcmaster.ca
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1 PURPOSE

- 1.1 The Laser Safety Program is to ensure and maintain the safe use of lasers;
- protect users from harmful laser radiation;
 - protect laser equipment while using, servicing and maintaining;
 - implement controls to protect the environment from hazardous energy sources while operating laser and laser systems; and
 - ensure compliance with the Occupational Health and Safety Act and the American National Standard for Safe Use of Lasers (ANSI Z136.1-2014).

2 SCOPE

- 2.1 All members of the McMaster community using or working in areas where lasers are in use.

3 RELATED DOCUMENTS

- 3.1 Environmental Protection Act R.S.O., Amended to 408/19
 3.2 Occupational Health and Safety Act R.S.O. 1990

- 3.3 ANSI Z136.1-2014 Safe Use of Lasers
- 3.4 Z 136.5 Safe Use of Lasers in Educational Institutions (2009)
- 3.5 RMM #102 Occupational Health and Safety Act
- 3.6 RMM #103 Environmental Protection Act
- 3.7 RMM #111 Contracting Work Safety-Due Diligence Program
- 3.8 RMM #300 Safety Orientation and Training Program
- 3.9 RMM #301 Standard Operating Procedures (SOP) Program
- 3.10 RMM #306 Lockout/Tag-out Program
- 3.11 RMM #309 Laboratory Safety Program
- 3.12 RMM #310 Eye Protection Program
- 3.13 RMM #320 Personal Protective Equipment Program
- 3.14 RMM #325 Process and Equipment Purchases and/or Modifications Program
- 3.15 RMM #600 Biosafety Program
- 3.16 RMM #700 Radiation Safety Program
- 3.17 RMM #1000 Reporting & Investigating Injury/Incident/Occupational Disease Program
- 3.18 RMM #1202 Spills to the Environment – Emergency Response & Reporting Program

4 DEFINITIONS

- 4.1 **Authorized Individual** – persons trained and authorized to use or work with laser/laser system. Includes a pre-qualified contractor for installation/modification.
- 4.2 **Aversion Response** – closure of the eyelid, eye movement, papillary constriction, or movement of the head to avoid an exposure to a noxious or bright light stimulant, that is to limit the exposure of a specific retinal area to 0.25 seconds or less.
- 4.3 **Class 1, 1M, 2, 2M, 3R, 3B, 4** – classification system defined by ANSI to identify the potential safety hazard rating of a laser.
- 4.4 **Collateral Radiation** – any electromagnetic radiation, except laser radiation, emitted by a laser or laser system which is physically necessary for its operation.
- 4.5 **Collecting Optics** – lenses or optical instruments having magnification and thereby producing an increase in energy or power density. Such devices may include telescopes, binoculars, microscopes, or loupes.
- 4.6 **Continuous Wave** – the output of a laser which is operated in a continuous rather than a pulse mode, a continuous output for a period >.25 seconds (CW laser).

- 4.7 **Embedded Laser** – an enclosed laser that has a higher classification than the laser system in which it is incorporated, where the system’s lower classification is appropriate due to the engineering features limiting accessible emission.
- 4.8 **Employer** – a person who employs one or more workers or contracts for the services of one or more workers and includes a contractor or subcontractor who performs work or supplies services, and a contractor or subcontractor who undertakes with the owner, constructor, contractor or subcontractor, to perform work or supply services.
- 4.9 **Laser** – a device, which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to low energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.
- 4.10 **Laser Hazards** – exposure to laser radiation can produce eye and skin damage. The extent of the damage depends on the wavelength and intensity of the radiation, and on the duration of exposure. Powerful lasers may also present fire and chemical hazards. Other hazards include electrical, explosion and collateral radiation.
- 4.11 **Laser Safety Officer** – the designated health & safety specialist within EOHSS who has the authority and knowledge to evaluate laser hazards, monitor and enforce the control of laser hazards.
- 4.12 **Laser Supervisor** – responsible for the Class 3B and Class 4 laser/laser system and laser workers. Is an authorized laser user specifically trained and shall be permitted to conduct modifications or changes to the laser system with PI authorization.
- 4.13 **Laser System** – assembly of electrical, mechanical and optical components, which includes one or more lasers.
- 4.14 **Laser Worker** – someone who is trained and operates or works in proximity to Class 3B or Class 4 laser/laser system.
- 4.15 **Maximum Permissible Exposure (MPE)** – the level of laser radiation to which an individual may be exposed without hazardous effect or adverse biological changes to the eye or skin.
- 4.16 **Nominal Hazard Zone (NHZ)** – describes the space within which the level of the direct, reflected, or scattered radiation during operation exceeds the applicable Maximum Permissible Exposure. Exposure levels beyond the boundary of the NHZ are below the applicable MPE level.

- 4.17 **Optical Density (OD)** – logarithm to the base 10 of the reciprocal of the transmittance. The OD (attenuation) at a specific wavelength shall be specified for laser protective eyewear.
- 4.18 **Principal Investigator (PI)** – an individual who has charge of a laser laboratory and or principal authority for Class 3B or Class 4 laser/laser system. May delegate responsibilities to a Laser Supervisor.
- 4.19 **Pulsed Laser** – a laser which delivers its energy in the form of a single pulse or a train of pulses. In this standard, the duration of a pulse is < 0.25 seconds.
- 4.20 **Laser Standard Operating Procedures (SOPs)** – a written procedure that defines the standard way in which a laser or laser system will be operated.

5 ACRONYMS

- **CJHSC** – Central Joint Health and Safety Committee
- **EOHSS** – Environmental and Occupational Health Support Services
- **FHS S O** – Faculty of Health Sciences Safety Office
- **JHSC** – Joint Health and Safety Committee
- **LASER** – Light Amplification by Stimulated Emission of Radiation
- **LGAC** – Laser Generated Air Contaminants
- **LSO** – Laser Safety Officer
- **MOECP** – Ministry of the Environment, Conservation & Parks
- **MOLTSD** – Ministry of Labour, Training & Skills Development
- **OHSA** – Occupational Health and Safety Act
- **SOP** – Standard Operating Procedure

6 RESPONSIBILITIES

6.1 Role of Senior Managers (Directors/Deans/Chairs/Department Managers):

Senior Managers shall:

- Provide the resources and direction necessary to support and maintain the Laser Safety Program.

6.2 Role of Principal Investigator:

Principal Investigator shall:

- Ensure the registration of Class 3B and Class 4 lasers/laser systems with EOHSS using [this form](#);
- Ensure all Class 3B and Class 4 laser supervisors/workers under the authority of the principal Investigator are identified (Appendix C);

- Ensure inspections are conducted on the laser/laser systems, identifying unsafe conditions and correcting in a timely manner; (Appendix A);
- Ensure that the Laser Supervisor/worker participate in Laser Safety training and site specific training, including standard operating procedures, alignment and service procedures, operating manuals, laboratory directives and protocols and applicable programs, to ensure the safe operation of the specific Class 3B and or Class 4 laser/laser systems that he/she will operate; (Appendix C);
- Ensure standard operating procedures are provided including alignment/maintenance procedures for all Class 3B and Class 4 laser/laser systems to ensure each laser is used ONLY under conditions and in locations which meet the requirements of the SOP(s);
- Ensure that Class 3B and Class 4 laser/laser systems are stored securely and safely when not in use;
- Ensure that spectators are properly informed of and protected from potential laser hazards;
- Support laser supervisors/workers participation in the University's medical surveillance program if they decide to participate;
- Report known or suspected injuries, incidents and hazardous situations immediately to the laser supervisor. An injury/incident report form must be completed and provided to EOHSS/FHSSO. Laser related emergency must be reported immediately to McMaster Security; and
- Laser supervisors shall investigate, determine the source and implement corrective measures for all laser related incidents.

6.3 Role of Laser Supervisor:

The Laser Supervisor shall:

- Identify all Class 3B and Class 4 laser workers under the authority of the principal investigator (Appendix C);
- Develop standard operating procedures, alignment/maintenance and other procedures connected with Class 3B and Class 4 laser operation under the approval of the principal investigator;
- Ensure laser workers complete Laser Safety training and site specific training, including standard operating procedures, alignment and service procedures, operating manuals, laboratory directives and protocols and applicable programs prior to working with active systems, to ensure the safe operation of the specific Class 3B and or Class 4 laser/laser system he/she will be operating (Appendix C);
- Ensure administrative and engineering controls are practiced;
- Issue and enforce the use of personal protective equipment when required;
- Inspect laser/laser systems, report to the Principal Investigator unsafe conditions and implement corrective measures; (Appendix A);

- Laser/laser systems used ONLY under conditions and in locations which meet the requirements of the SOP(s);
- Ensure that modifications or new laser/laser systems have Principal Investigator approval and notice to LSO. Ensure classification is consistent with ANSI Z136.1-2014;
- Class 3B and Class 4 laser/laser systems are stored securely and safely when not in use;
- Support laser workers participation in the University's medical surveillance program, if the worker decides to participate;
- Report known or suspected injuries, incidents, and hazardous situations to, Principal Investigator, LSO/EOHSS and your area safety office immediately. Investigate to determine the source and implement corrective measures; and
- Report laser related emergencies immediately to McMaster Security.

6.4 **Role of Laser Workers:**

Laser Workers shall:

- Participate in the Laser Safety training and site-specific training including standard operating procedures, alignment and service procedures, operating manuals, laboratory directives and protocols and applicable programs;(Appendix C);
- Work as directed by the Laser Supervisor in compliance with the Occupational Health & Safety Act and the Laser Safety Program;
- Use personal protective equipment when required;
- Report malfunctions or unsafe conditions immediately to the Laser Supervisor and Principal Investigator;
- Operate Class 3B and Class 4 laser/laser systems ONLY under the conditions authorized by the Laser Supervisor/Principal Investigator;
- Store laser/laser systems are stored securely and safely when not in use;
- Review the University's medical surveillance program;
- An incident, injury or hazardous situation shall be reported immediately to the Laser Supervisor, Principal Investigator, LSO and/or EOHSS/FHSSO); and
- Report laser related emergencies immediately to McMaster Security.

6.5 **Role of Contractor:**

Contractors shall:

- Comply with Laser Safety Program RMM #703, Contracting Work Safety Program/Due Diligence RMM #111, and Occupational Health & Safety Act and regulations, environmental legislation, and modifications or new installations shall be in accordance with the McMaster University Building and Design Standards.

6.6 **Role of Laser Safety Officer:**

The Laser Safety Officer shall:

- Maintain a laser inventory for all Class 3B and Class 4 lasers.
 - principal investigator
 - supervisor and worker names
 - telephone number
 - location
 - classification
 - type (CO₂, Nd:YAG etc.)
 - number of lasers
- Confirm classifications, consistent with ANSI Z136.1-2014;
- Conduct inspections on a random basis (Appendix A);
- Consult in the safe operation of lasers, evaluations and controls;
- Audits of laser laboratories, functionality of laser safety features and controls (Appendix B);
- Maintain a list of completed training (Appendix C);
- Ensure adequate education and training is available;
- Accompany regulatory agency inspectors and ensure corrective action implemented; and
- Respond to known or suspected accidents, investigate, ensure analysis of the cause and corrective measures are adequate.

6.7 **Role of EOHSS**

EOHSS shall:

- Review and provide comment on completed inspections, inventory and training database;
- Audit the Laser Safety Program effectiveness on an on-going basis;
- Attend with the regulator agency inspector on site visits to inspect; and
- Review the Laser Safety Program (RMM #703) on a scheduled basis.

6.8 **Role of Central H & S Committee:**

CJHSC shall:

- Review the Laser Safety Program RMM #703 on a scheduled basis; and
- Review and comment on JHSC minutes related to the Laser Safety Program in areas relevant to lasers or laser systems.

6.9 Role of JHSC

JHSCs shall:

- Review inspections and recommend remedial action on deficiencies (Appendix A); and
- Review the Laser Safety Program (RMM #703) and the impact on laser or laser systems in the committee's jurisdiction.

6.10 Role of LSO Committee

The LSO Committee shall:

- Be comprised of the LSO designate from EOHSS, and five representatives (worker and management) from within the University community with laser technology and expertise;
- Establish and maintain adequate policies and practices for the evaluation and control of laser hazards, including the recommendation of appropriate training programs; and
- Maintaining an awareness of all applicable new or revised laser safety standards.

7 PROCEDURAL GUIDELINES:

ANSI Z136.1-2014 adopted by the Ontario Ministry of Labour for the safe use of lasers is applied in the Laser Safety Program #RMM 703.

Inventory be maintained on Class 3B and Class 4 laser/laser systems, verifying classification consistent with ANSI Z136.1-2014.

Inventory be maintained on completed training.

Inspection of Class 3B and Class 4 laser/laser systems performed annually.

Medical surveillance records kept on file with McMaster University's Occupational Health Nurse.

Laser protective eyewear is to be available and worn by all within the Nominal Hazard Zone (NHZ) of Class 3B and Class 4 lasers where exposures above the Maximum Permissible Exposure (MPE) can occur. The greater the OD (optical density) the greater the attenuation (less light will reach the eye). Eyewear shall be clearly labeled (optical density and the wavelength for which protection is afforded) and inspected for damage periodically and prior to use.

For Class 3B and/or Class 4 laser/laser system operating in the ultraviolet, skin protection shall be utilized if chronic (repeated) exposures are anticipated at or near the applicable MPE for skin. If engineering controls are not entirely feasible, then

skin covers and/or sun screen creams are recommended. Most gloves will provide some protection against radiation. Tightly woven fabrics and opaque gloves provide the best protection. A laboratory coat can provide protection for the arms.

Applicable signage and labeling as prescribed in ANSI Z136.1.

Requirement for engineering and administrative procedural controls (Appendix D/E).

Program Audit may consist of but is not limited to the following: inspections completed, review of training records, review of medical surveillance records and review of records versus inspections to confirm that the registration process is working effectively and review JHSC minutes to verify inspections received.

Education and Training

Authorized individuals required to work or use class 3B or class 4 laser/laser systems shall be trained in laser safety guidelines and site specific training, including standard operating procedures, alignment and service procedures, operating manuals, laboratory directives and protocols and applicable programs. Training inventory maintained.

Refresher training is required every three years.

Use and care of personal protective equipment (i.e. eye protection, protective clothing) specific training shall be provided.

Medical Surveillance

Medical surveillance is recommended by ANSI for laser workers using Class 3B and or Class 4. Eye examination may be arranged by the individual with an optometrist or ophthalmologist and copy of results forwarded to the University's Occupational Health Nurse for appropriate maintenance, storage and to preserve privacy and confidentiality of employee health information. These records are kept in strict confidence and separate from the employee's personnel, and Return to Work files.

As per baseline examination protocol recommended by ANSI, the following eye examinations are recommended for laser workers: visual acuity, macular function and color vision. Cost is the responsibility of the department.

Base line eye examination is conducted only once and would be required following any suspected laser injury.

Appendices

- Appendix A Laser Inspection Form
- Appendix B Laser Audit Form
- Appendix C Laser Worker Checklist

- Appendix D Engineering Controls
- Appendix E Administrative Controls
- Appendix F Classification of Laser/Laser System
- Appendix G ANSI Signage

Appendix A

LASER INSPECTION FORM

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Class 3B and Class 4 Lasers/Laser Systems

INSPECTOR _____ DATE OF INSPECTION _____ LOCATION /RM _____

DEPT _____ NAME OF PRINCIPAL INVESTIGATOR _____ EXT _____

NAME OF LAB CONTACT _____ EXT _____

LASER TYPE _____ CLASS _____ MODEL # _____ SERIAL # _____

PRODUCTION CLASS _____ OTHER INFORMATION _____

LASER POSTING, LABELING AND ROOM SECURITY MEASURES: Y (yes) N (no) NR (not required)

Entrances properly posted Y N Comments: _____

Room security adequate Y N Comments: _____

Windows/doorways/open portals in room covered Y N NR Comments: _____

Entryway interlock system Y N NR Comments: _____

Interlock functioning Y N NR Comments: _____

A door, blocking barrier, curtain, etc. at entryway Y N NR Comments: _____

Laser status indicator outside room Y N NR Comments: _____

Laser class label in place Y N Comments: _____

Laser hazard label in place Y N Comments: _____

LASER UNIT SAFETY CONTROL MEASURES: Y (yes) N (no) NR (not required)

Protective housing in place Y N Comments: _____

Interlock on housing Y N Comments: _____

Beam shutter present: Y N NR Comments: _____

Key control Y N NR Comments: _____

Laser activation warning system (with emission delay) in place Y N NR Comments: _____

Remote interlock connector (emergency shutoff) available Y NNR Comments: _____

ENGINEERING SAFETY CONTROL MEASURES: (Y (yes) N (no) NR (not required)

Laser secured to table Y N Comments: _____

Laser optics secured to prevent stray beams Y N Comments: _____

Exposed beam path at normal eye level Y N NR Comments: _____

Enclosed beam path: Y N Comments: _____

Limited open beam path Y N Comments: _____

Totally open beam path Y N Comments: _____

Beam barriers in place Y N NR Comments: _____

Beam stops in place Y N NR Comments: _____

Beam intensity reduced through filtration Y N NA Comments: _____

Remote viewing of beam Y N Comments: _____

Reflective materials kept out of beam path Y N Comments: _____

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Laser user checking for stray beams Y N Comments: _____

Physical evidence of stray beams Y N Comments: _____

ADMINISTRATIVE AND PROCEDURAL SAFETY CONTROL MEASURES:

Standard Operating Procedures (SOPs) are available Y N Comments: _____

Alignment procedures are available Y N Comments: _____

Laser operated by authorized and trained person Y N Comments: _____

Excessive power/radiant energy accessible for required application Y N Comments: _____

Appropriate action taken for spectator control Y N NR Comments: _____

All supervisors/workers have met the laser safety training requirements Y N Comments: _____

Has homebuilt/modified laser/laser system been classified Y N Comments: _____

Proper laser eye protection available Y N NR Comments:

Proper skin protection available Y N NR Comments: _____

OTHER SAFETY MEASURES:

All Class 3B/4 lasers/laser systems under the jurisdiction of the PI have been registered Y N Comments: _____

NON BEAM HAZARDS:

Toxic laser media in use Y N Comments:

Hazardous laser media stored properly Y N Comments:

Cryogenics in use Y N Comments:

Compressed gas in use Y N Comments:

Gas Cylinders properly restrained Y N Comments: _____

Fume hood for dye mixing Y N Comments: _____

Laser Generated Air Contaminant (LGAC) production Y N Comments: _____

High voltage power hazard Y N Comments: _____

Other electrical hazards Y N Comments: _____

Collateral and plasma radiation hazard Y N Comments: _____

Fire hazard Y N Comments: _____

Explosion hazard Y N Comments:

Mechanical hazard Y N Comments:

Noise/vibration hazard Y N Comments:

Proper disposal of chemical waste Y N Comments:

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Additional Comments:

Legend: Y – yes N – no NA – not applicable NR – not required

Summary of Action Required:

Acceptable safety practices

Improved safety measure(s) required – minor issue(s) to be addressed

Improved safety measure(s) required – major issue(s) to be addressed

Unacceptable safety practice(s) – requires action by: _____ completion date _____

Copy kept on file by Laser Supervisor, Principal Investigator LSO/EOHSS and JHSC

Appendix B

LASER AUDIT FORM (Page 1 of 3)

Auditors Name: _____ Date of Audit: _____

Location of Laser System (Bldg. & Room #): _____

Principal Investigator: _____ Laser Supervisor: _____

LASER SYSTEM INFORMATION:

Laser Type: _____ Laser Classification: _____ Laser Make: _____

Laser Model: _____ Laser Serial #: _____

Wavelength: _____ nm Output (max/used): _____ W or J (circle one)

Beam Diameter at Aperture: _____ mm Beam Divergence: _____ mrad

Pulse duration: _____ sec Pulse Frequency: _____ Hz

Laser is Q-Switched/Mode locked: Y or N (circle one)

Laser is: active or inactive (circle one)

LASER POSTING, LABELING AND SECURITY MEASURES:

Entrances properly posted: Y N Comments: _____

Room security adequate: Y N Comments: _____

Door interlock system: Y N N/A Comments: _____

Laser status indicator outside room: Y N N/A Comments: _____

Laser class label in place: Y N Comments: _____

Laser hazard label in place: Y N Comments: _____

Laser aperture label in place: Y N Comments: _____

LASER UNIT SAFETY CONTROLS:

Protective housing in place: Y N Comments: _____

Interlock on housing: Y N N/A Comments: _____

Interlock on housing functioning: Y N Comments: _____

Beam shutter present: Y N Comments: _____

Beam shutter functioning: Y N Comments: _____

Key operation: Y N Comments: _____

Laser activation indicator on console: Y N Comments: _____

Beam power meter: Y N Comments: _____

LASER AUDIT FORM (Page 2 of 3)

Emergency shutoff available: Y N Comments: _____

ENGINEERING SAFETY CONTROLS:

Laser secured to table: Y N Comments: _____

Laser optics secured to prevent stray beams: Y N Comments: _____

Laser at eye level: Y N Comments: _____

Beam is enclosed: Y N Comments: _____

Beam barriers in place: Y N Comments: _____

Beam stops in place: Y N Comments: _____

Remote viewing of beam: Y N Comments: _____

Beam condensed or enlarged: Y N Comments: _____

Beam focused: Y N Comments: _____

Beam intensity reduced through filtration: Y N Comments: _____

Fiber optics used: Y N Comments: _____

Windows in room covered: Y N N/A Comments: _____

Reflective materials kept out of beam path: Y N Comments: _____

Beam management documented: Y N Comments: _____

Physical evidence of stray beams: Y N Comments: _____

Class 4 diffuse reflection hazard: Y N N/A Comments: _____

ADMINISTRATIVE SAFETY CONTROLS:

Authorization up to date: Y N Comments: _____

Authorization posted: Y N Comments: _____

SOP up to date: Y N Comments: _____

SOP posted: Y N Comments: _____

Emergency contact list posted: Y N Comments: _____

Laser safety guidelines posted: Y N Comments: _____

Laser operating manual available: Y N Comments: _____

OTHER LASER SAFETY MEASURES:

Proper laser eye protection available: Y N N/A Comments: _____

Proper skin protection available: Y N N/A Comments: _____

All users have meet training requirements: Y N Comments: _____

LASER AUDIT FORM (Page 2 of 3)

NON BEAM HAZARDS:

Toxic laser media in use: Y N Comments: _____

Fume hood for dye mixing: Y N Comments: _____

Cryogens in use: Y N Comments: _____

Compressed gasses in use: Y N Comments: _____

High voltage power hazard: Y N Comments: _____

Optical tables properly grounded: Y N Comments: _____

Collateral radiation hazard: Y N Comments: _____

Explosion hazard: Y N Comments: _____

Fire hazard: Y N Comments: _____

LGAC production: Y N Comments: _____

Copy on file by Laser Supervisor, Principal Investigator , LSO/EOHSS and JHSC

Appendix C

Laser Worker Checklist

Department: _____ Building: _____ Room Number: _____

Laser Type: _____ Max Power: _____ Class: _____ Wavelength: _____

NAME	DATE OF SITE SPECIFIC TRAINING COMPLETED	DATE OF LASER SAFETY GUIDELINES (EOHSS) COMPLETED	MEDICAL SURVEILLANCE YES or NO

Name of Principal Investigator: _____

Name of Laser Supervisor

Site Specific includes reviewing:

- standard operating procedures
- alignment and service procedures
- available operating manual(s)
- laboratory directives and protocols
- applicable RMM Programs (i.e. Lab Safety, PPE, LOTO, Radiation Safety, BioSafety, Eye Protection, Hazardous Materials Spill Response, Environmental Protection, etc.)

Appendix D

Engineering Controls

Protective Housing is a physical barrier preventing laser radiation in excess of the MPE from exiting the laser. Normally, this protective housing is provided.

Laser Use Without Protective Housing, in some applications of research and development, the operation of lasers or laser systems without a protective housing may become necessary. In such cases controls are instituted appropriate to the class of maximum accessible emission to ensure safe operations, these controls may include, but are not limited to:

- Access restriction
- Eye protection
- Area controls
- Barriers, shrouds, beam stops, etc.
- Administrative and procedural controls
- Education and training

Interlocks On Protective Housing, is activated when the protective housing is opened during operation and maintenance. The interlock prevents exposure to laser radiation above the MPE.

The protective housing interlock shall not be defeated or overridden during operation unless the provisions of “**Laser Use Without Protective Housing**” (above) have been fully implemented.

Service Access Panels are part of the protective housing, which are intended to be removed by service personnel only and permit direct access to laser radiation. They must either:

- (a) be interlocked (fail-safe interlock not required), or
- (b) require a tool for removal and shall have an appropriate warning label.

Key control shall be provided on all Class 4 lasers with a master switch which is operated by a removable key or coded access (such as a computer code).

Viewing Portals and Display Screens included as an integral part of a laser shall incorporate a suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation at the viewing position at or below the applicable MPE for all conditions of operations and maintenance.

Collecting Optics, all optical instruments intended for viewing a laser or laser system must be equipped with suitable means (e.g. filters, attenuators, or interlocks) to preclude the transmission of laser light in excess of the MPE under all conditions of operation and maintenance.

Totally Unenclosed Beam Path – where the entire beam path is unenclosed, a laser hazard analysis must be performed to establish the NHZ if not furnished by the manufacturer.

Limited Open Beam Path – where the beam path is confined by design to significantly limit the degree of accessibility of the open beam, a hazard analysis be conducted to establish the NHZ.

Enclosed Beam Path – when the protective housing requirements are temporarily relaxed, such as during service, temporary area control and or administrative and procedural controls must be implemented.

Remote Interlock Connector – deactivates the laser or reduces the accessible radiation to levels at or below the applicable MPE (i.e. ‘panic button’).

Beam Stop or Attenuator – Class 4 laser/laser system must be provided with a permanently attached beam stop or attenuator capable of preventing the emission of laser light in excess of the MPE when the beam is not required.

Laser Activation Warning System – an activation warning system required on Class 4 laser/laser systems, could be an audible system e.g. an alarm, or a warning light (visible through protective eyewear), or a verbal ‘countdown’ command during activation or start up of the laser.

Emission Delay – a warning system, which provides sufficient time prior to emission of laser radiation to allow appropriate action be taken to avoid exposure to the laser radiation.

Equipment Labels – commercial laser requires labeling. Homemade laser, (except Class 1) must have a label (with laser sunburst symbol) affixed to a conspicuous place on the laser housing or control panel.

Area Posting Signs – an area which contains a Class 3B or class 4 laser/laser system shall be posted with appropriate signage. Also a notice sign shall be posted outside a temporary laser controlled area.

Indoor Laser Controlled Area – the following items are required for the various types of laser control areas:

Class 3B Laser Controlled Area

Posted with the appropriate warning sign(s)

Operated by trained and authorized person

Under the direct supervision of a laser supervisor

Located so that access to the area by spectators is limited

Have any potentially hazardous beam terminated in a beam stop of an appropriate material

Within the controlled area provide eye protection if there is any possibility of viewing the direct or reflected beams

Where possible, have the laser secured such that the beam path is above or below eye level of a person in any standing or seated position

Have all windows, doorways, open portals, etc. from an indoor facility be either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the appropriate ocular MPE

Ensure appropriate steps are available to prevent unauthorized use

Class 4 Laser Controlled Area

ALL OF THE ABOVE IN CLASS 3B – **in addition** the following:

Person(s) entering a class 4 controlled area shall be trained, provided with appropriate protective equipment and follow all applicable administrative and procedural controls.

Fire exits and entryway shall be designed to allow both rapid egress by laser person(s) at all times and admittance to the laser controlled area under emergency conditions.

For emergency conditions, appropriate means shall be available (e.g. 'Panic Button') for deactivating the laser/laser system or reducing the output to the appropriate MPE levels.

Ensure controls are in place to prevent unexpected and unauthorized entry into the laser controlled area. These controls may be non-defeatable, defeatable or procedural as defined by the PI/LSO.

Non-Defeatable (non override) Area or Entryway Safety Controls – may be safety latches, entryway or area interlocks (e.g. electrical switches, or pressure sensitive floors mats, or infrared detectors) used to deactivate the laser or reduce the output to safe levels when the door is open **OR**

Defeatable Area or Entryway Safety Controls – defeatable safety latches, entryway or area interlocks may be used if non-defeatable controls limit the intended use of the laser when operation without interruption is necessary, for example, during long term testing. These safety controls maybe overridden to allow access if it is clearly evident that there is no laser hazard at the point of entry. Authorized person requiring entry must be trained and provided with adequate personal protective equipment **OR**

Procedural Area or Entryway Safety Controls – where door interlocks are not feasible or are inappropriate, the following procedural controls apply:

- (a) Authorized person may be adequately trained and provided with adequate personal protective equipment upon entry, and
- (b) a door, blocking barrier, screen, curtains, etc. must be used to block or attenuate the laser beam at the entryway to assure the laser radiation outside the area does not exceed the MPE, no one receives exposure above the MPE immediately upon entry, and
- (c) in this case there shall be a warning light or sound at the entryway indicating that the laser is energized and operating.

A lighted warning sign or a flashing light are two examples of methods to appropriately accomplish this requirement. Alternatively, a light assembly may be interfaced with the laser in such a manner that: one light indicates when the

laser is not operational (high voltage off), and a second light indicates when the laser is powered up (high voltage applied – but no laser emission), and a third light (flashing optional) indicates when the laser is operating (emission on).

Temporary Laser Controlled Area – where removal of panels or protective housings, overriding of protective housing interlocks, or entry into the NHZ becomes necessary (such as for service), and the accessible laser radiation exceeds the applicable MPE, a temporary laser controlled area shall be set up. This control area shall provide all safety requirements for all persons, both within and outside the area and shall be posted outside the temporary laser controlled area to warn of the potential hazard.

Engineering Control Measures For The Seven Classes

Engineering Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.3.1)	X	X	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.3.2)	∇	∇	∇	∇	∇	X	X
Service Access Panel (4.3.3)	∇	∇	∇	∇	∇	X	X
Key Control (4.3.4)	—	—	—	—	—	•	X
Viewing Windows, Display Screens and Collecting Optics(4.3.5.1)	Assure viewing limited < MPE						
Collecting Optics (4.3.5.2)							
Fully Open Beam Path (4.3.6.1)	—	—	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	—	—	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled						
Remote Interlock Connector (4.3.7)	—	—	—	—	—	•	X
Beam Stop or Attenuator (4.3.8)	—	—	—	—	—	•	X
Activation Warning Systems (4.3.9.4)	—	—	—	—	—	•	X
Indoor Laser Controlled Area (4.3.10)	—	*	—	*	—	X NHZ	X NHZ
Class 3B Indoor Laser Controlled Area (4.3.10.1)	—	—	—	—	—	X	—
Class 4 Laser Controlled Area (4.3.10.2)	—	—	—	—	—	—	X
Outdoor Control Measures (4.3.11)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Temporary Laser Controlled Area (4.3.12)	∇ MPE	∇ MPE	∇ MPE	∇ MPE	∇ MPE	—	—
Controlled Operation (4.3.13)	—	—	—	—	—	—	•
Equipment Labels (4.3.14 and 4.7)	X	X	X	X	X	X	X
Laser Area Warning Signs and Activation Warnings (4.3.9)	—	—	—	—	•	X NHZ	X NHZ

- LEGEND: X Shall
 • Should
 — No requirement
 ∇ Shall if enclosed Class 3B or Class 4
 MPE Shall if MPE is exceeded
 NHZ Nominal Hazard Zone analysis required
 * May apply with use of optical aids

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Appendix E

ADMINISTRATIVE AND PROCEDURAL CONTROLS

Standard Operating Procedures (SOP's) shall be maintained with the laser equipment and shall always be available as a reference for all laser workers, SOPs may include the laser instruction manual (prepared by the manufacturer) and as appropriate, additional written information to ensure compliance with best work practices and safety. SOPs are required for the following Class 3B and Class 4 laser/laser systems:

- Experimental set up and system alignment
- Routine operation
- Laser maintenance and set-up and
- Non standard/modified laser/laser systems

Output Emission Limitations, if excessive power or radiant energy is accessible during operation or maintenance of, action as required to reduce the levels of accessible power or radiant energy to that which is commensurate with the required application.

Laser Worker Training shall be provided for all laser workers. The level of training shall be commensurate with the level of potential hazard. Recommended topics to be included in an EOHSS Laser Safety Guideline training:

- Laser fundamentals
- Bioeffects of laser radiation on the eye and skin
- Relations of specular and diffuse reflections
- Chemical Agents – laser generated air contaminants, compressed gases, dyes/solvents
- Biological – LGAC laser generated air contaminants, microorganisms, infectious material
- Physical Agents – electrical, collateral & plasma radiation, fire, explosion, mechanical/robotic, noise
- Human Factors – Ergonomics, limited work space, work patterns, laser & laser waste disposal, chillers
- Laser Classifications
- Control measures: protective equipment, signage, LOTO, etc.
- Duties of supervisor/worker

Authorized Person shall be trained and authorized to operate, maintain or service with the approval of the PI/Laser Supervisor or LSO.

Alignment procedures shall be available describing the method, to ensure the primary beam or a specular or diffuse reflection of a beam does not expose the eye to a level above the applicable MPE.

Protective equipment, eye and skin protection and any other device(s) which have been specifically selected for suitable protection against laser radiation may be required when other control measures are inadequate to eliminate potential exposure in exposure in excess of the applicable MPE.

Spectator Control shall not be permitted within a laser controlled area unless:

- Appropriate approval from the PI or Laser Supervisor
- The degree of hazard and avoidance procedure has been explained
- Appropriate protective measures are taken

Laser Optical Fibre Systems, if a disconnection of a connector results in accessible radiation in an uncontrolled area and is above the MPE the Laser Supervisor/PI/LSO shall be consulted.

Laser Robotic Installations (Class 3B and Class 4), in instances including those created by hardware failure and software errors, the laser beam from robotic delivery systems could lead to scattering. Measurements are often required to confirm the NHZ.

Eye Protection (Class 3B and Class 4), eye protection devices, which are specifically designed for protection against radiation from Class 3B should and Class 4 shall be administratively required and enforced to be worn when engineering or other procedural and administrative controls are inadequate to eliminate the potential exposure in access of the MPE.

Protective Windows (class 3B or Class 4), facility windows (exterior or interior) that are located within the NHZ of a class 3B or Class 4 laser shall be provided with appropriate absorbing filter, scattering filter, blocking barrier, or screen which reduces any transmitted laser radiation to levels below the applicable MPE level.

Protective Barriers and Curtains, a blocking barrier, screen, or curtain (specifically selected to withstand direct and diffusely scattered beams) which block or filter the laser beam at the entryway should be used inside the controlled area to prevent the laser light from exiting the area at levels above the applicable MPE level.

Skin Protection, some lasers, such as excimer lasers operating in the ultraviolet, the use of skin cover (e.g. gloves, lab coats and/or sun screen) are recommended. For wavelengths great than 1.4 μm , large area exposures can cause heat loading – causing skin dryness and lead to heat stress.

Other Protective Equipment, respirators, additional local exhaust ventilation, fire extinguishes, and hearing protection may be required whenever engineering controls cannot provide protection from a harmful ancillary environment.

Warning Signs and Labels, shall confirm the required specifications and be displayed in locations whereby to best serve to warn onlookers.

Service and Repairs, person who requires access to Class 3B or Class 4 lasers shall comply with appropriate control measures.

Modifications and Laser Systems, re-classifying a laser which has been modified is permitted with the consultation of laser supervisor, principal investigator and laser safety officer.

Administrative and Procedural Controls for the Seven Classes

Administrative and Procedural Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures (4.4.1)	—	—	—	—	—	•	X
Output Emission Limitations (4.4.2)	—	—	—	—	LSO Determination		
Education and Training (4.4.3)	—	•	•	•	•	X	X
Authorized Personnel (4.4.4)	—	*	—	*	—	X	X
Alignment Procedures (4.4.5)	∇	∇	∇	∇	∇	X	X
Protective Equipment (4.6)	—	*	—	*	—	•	X
Spectators (4.4.6)	—	*	—	*	—	•	X
Service Personnel (4.4.7)	∇	∇	∇	∇	∇	X	X
Demonstration with General Public (4.5.1)	—	*	X	*	X	X	X
Laser Optical Fiber Transmission Systems (4.5.2)	MPE	MPE	MPE	MPE	MPE	X	X
Laser Robotic Installations (4.5.3)	—	—	—	—	—	X NHZ	X NHZ
Protective Eyewear (4.6.2)	—	—	—	—	—	•	X
Window Protection (4.6.3)	—	—	—	—	—	X	X NHZ
Protective Barriers and Curtains (4.6.4)	—	—	—	—	—	•	•
Skin Protection (4.6.6)	—	—	—	—	—	X	X NHZ
Other Protective Equipment (4.6.7)	Use may be required						
Warning Signs and Labels (4.7) (Design Requirements)	—	—	•	•	•	X NHZ	X NHZ
Service Personnel (4.4.7)	LSO Determination						
Laser System Modifications (4.1.2)	LSO Determination						

LEGEND: X Shall
 • Should
 — No requirement
 ∇ Shall if enclosed Class 3B or Class 4
 MPE Shall if MPE is exceeded
 NHZ Nominal Hazard Zone analysis required
 * May apply with use of optical aids

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Appendix F

Laser/Laser Systems - CLASSIFICATION

A **Class 1** laser is:

- Considered to be incapable of producing damaging radiation levels during operation, and
- Exempt from any control measures or other forms of surveillance.

A **Class 1M** laser is

- Considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam), and
- Exempt from any control measures other than to prevent potentially hazardous optically aided viewing, and is exempt from other forms of surveillance.

A **Class 2** laser:

- Emits in the visible portion of the spectrum (400 to 700 nm), and
- Eye protection is normally afforded by aversion response.

A **Class 2M** laser:

- Emits in the visible portion of the spectra (400 to 700 nm), and
- Eye protection is normally afforded by aversion response for unaided viewing, however, Class 2M is potentially hazardous if viewed with certain optical aids.

A **Class 3** (medium power):

- May be hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard

There are two subclasses:

- A **Class 3R** laser system is potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but the probability of an actual injury is small. This laser will not pose either a fire or diffuse reflection hazard.
- A **Class 3B** laser system may be hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard.

Laser/Laser Systems **Class 4** (high power):

- Is a hazard to the eye or skin from the direct beam, and
- May pose a diffuse reflection or fire hazard,
- May also produce laser generated air contaminants and hazardous plasma radiation

Appendix G

SIGNAGE

