LASERS

INTRODUCTION

Laser systems can present electrical, chemical, and non-ionizing radiation hazards. Radiation hazards are classified on a scale of 1 (safe) to 4 (dangerous), as shown in the table below. Most precautions apply to Class 3a, 3b, and 4 lasers; therefore, the use and procurement of these lasers is discouraged where lasers of a lower classification can be used.

Electrical hazards are associated with the high voltage power supplies used in many laser systems. In particular, hazard Class 4 lasers often use large power supplies which carry an appreciable risk of electrocution, especially in maintenance and adjustment procedures. Chemical hazards can be associated with halogen and dye lasers, as well as with radiation decomposition.

This chapter describes procedures for assessing and controlling the hazards associated with the use of lasers and laser systems. The normal use of commercial products containing Class 1, 2, 3a, and 3b lasers, that preclude personnel exposure through use of failsafe interlocks (e.g., laser printers), is exempt from the requirements of this chapter. This exemption does not apply when interlocks may be defeated for purpose of maintenance, service, or modification of the products. In addition, this chapter does not apply to optical fiber communication systems. Refer instead to ANSI Z136.2 - American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources... Though not exempt, visible wavelength Class 2 and 3a laser bar code readers and laser pointers require only minimal controls (see especially control #5. *Precautions for public displays*).

ACCESSIBLE LASER RADIATION CLASSIFICATION AND PRIMARY PRECAUTIONS

HAZARD CLASS	DESCRIPTION OF HAZARD	PRIMARY PRECAUTION
1	Radiation cannot cause injury in exposures =30,000 s	None
2	Visible wavelength radiation which requires >0.25 s to cause retinal injury	Do not stare into beam
3a[1]	Visible wavelength radiation which can cause retinal eye injury in exposures >0.25 s because of large beam diameter	Do not stare into beam or view directly with optical instruments
3a[1]	Visible wavelength radiation can cause eye injuries in exposures <0.25 s OR UV/IR radiation can cause injury in exposures <30,000 s	Avoid direct eye exposure
3b[2]	Radiation can cause eye injuries in exposures <0.25 s	Avoid direct exposure to beam

[1]Class 3a visible wavelength lasers have outputs 1-5x that of the maximum associated Class 2 output. Class 3a UV/IR lasers have outputs 1-5x that of the maximum associated Class 1 output.

4	Diffuse reflection of radiation can cause eye injury in exposures <0.25 s OR Radiation can cause skin injury OR Radiation can cause material damage/fire	Avoid eye or skin exposure to direct or scattered radiation

[2]Class 3b visible wavelength lasers have outputs >5x that of the maximum associated Class 2 output. Class 3b UV/IR lasers have outputs >5x that of the maximum associated Class 1 output.

APPLICABLE STANDARDS

ANSI Z136.1 - American National Standard for the Safe Use of Lasers
ACGIH Threshold Limit Values - Lasers

DEFINITIONS

Accessible laser radiation - laser radiation to which the eye or skin may be exposed during normal usage. The accessible laser radiation is often less than the maximum potential laser output due to enclosure, reduction in use factor, use of filters, beam splitting, etc.

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.

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

Maintenance - performance of adjustments or procedures on a laser or laser system specified by the manufacturer which are performed to ensure the intended performance of the product.

MPE (Maximum Permissible Exposure) - the level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. It is a complex function of wavelength, exposure duration, modulation, and target organ.

NHZ (Nominal Hazard Zone) - the space within which the level of direct, reflected, or scattered radiation during operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the applicable MPE level.

Public - people who have not had appropriate laser training and/or eye exam and whose access to an NHZ is not controlled by the qualified laser operator.

Qualified Laser Operator - an individual who has received laser safety training and a laser eye exam and is knowledgeable in the operational and hazard control parameters of the laser under his control.

Service - performance of adjustments or procedures on a laser or laser system described in the manufacturer's service instructions which may affect any aspect of the performance of the product.

Spectators - people who have not had appropriate laser training and/or eye exams, but whose access to an NHZ is controlled by the qualified laser operator.

SPECIAL RESPONSIBILITIES

The LSO provides technical guidance on laser safety, reviews and approves purchase requisitions for non-exempt laser systems, maintains a sitewide database of laser systems, classifies the radiation hazard of laser systems, provides training in laser safety, provides laser radiation hazard warning signs, determines appropriate protective laser eyewear, and reviews and approves written operating procedures. The LSO shall assure that every laser system is inspected and that associated findings are communicated to the division/section ES&H Group and the division/section head. The LSO may be contacted by calling the ES&H Section, Ext. 4646.

Division/Section ES&H groups maintain inventories of lasers used/stored by personnel within their organization and assist the LSO in conducting laser hazard evaluations.

Qualified laser operators are responsible for managing laser systems in accordance with this chapter. In particular, these individuals must assure that lasers under their control are inventoried, classified, and labeled; are operated in accordance with requirements and, where applicable, laser users receive training and eye exams.

The cost of laser eye examinations to users is back-charged to their home institutions.

PROCEDURES

1. Employees/Users

   The table on the next page is intended for use by employees and users and shall be followed to assure compliance with the DOE prescribed standards for lasers.

2. Subcontractors[3]

   a. Specific laser safety requirements should be considered for inclusion in any request for subcontractor activities which may involve exposure to laser radiation. The Service Subcontractor ES&H Specification Checklist can be used to specify laser safety requirements and the Work Permit can be used to notify key personnel that an activity involving lasers will take place[4]. Preconstruction meetings can be used as a forum to clarify requirements and initiate collection of laser information.

   b. Subcontractors shall notify the Lab Project Leader (usually the Task Manager) of their intent to use laser systems during the course of their activities at Fermilab so that a hazard evaluation may be conducted.

   c. Most lasers used in construction applications present a minimal hazard. In such instances the only requirements are registration of the laser (for Class 2 or

[3]Fermilab's subcontractor ES&H program is described in Chapter 7010 of this Manual.
[4]The Service Subcontractor ES&H Specification Checklist is to be included in Chapter 7010 of this Manual, while the Work Permit can be found in Chapter 2020.

greater) and use of common-sense precautions such as do not stare into the beam, do not leave an functioning laser unattended, or turn off the laser as soon as work is finished.

3. The prescribed standard serves as the technical supplement to this chapter. Copies are available from the ES&H Section.

CONTROLS FOR LASER SYSTEMS	HAZARD CLASS OF ACCESSIBLE LASER RADIATION				
	1	**2**	**3a**	**3b**	**4**
1. Classify/Inventory/Label		X	X	X	X
2. LSO approval to operate			R	X	X
3. Precautions for maintenance, repair or modification	X	X	X	X	X
4. Primary Beam Precautions		X	X	X	X
5. Precautions for public displays		X	X	X	X
6. Training for laser workers		R	R	X	X
7. Eye exam for laser workers				X	X
8. Beam precautions			X	X	X
9. Warning signs			R	X	X
10. Area directly supervised by qualified laser operator				X	X
11. Precautions for spectators				R	X
12. Lock up laser when not in use				R	X
13. Protective eyewear				R	X
14. Startup warning				R	X
15. Standard operating procedures				R	X
16. Locks/Interlocks				X	X
17. Remote interlock connector				R	X

X - Mandatory
R - Recommended
- Exempt unless the laser system is modified to cause the hazard class to exceed 1

KEY TO CONTROLS FOR LASER SYSTEMS

1. Inventory/Classify/Label

Prior to operation, all lasers and laser systems shall be inventoried, classified as to the laser radiation hazard and labeled with the following sticker (other laser stickers are discussed in the technical appendix to this chapter):

NOTICE THIS DEVICE HAS A LASER RADIATION HAZARD CLASS OF *(system class as used)* ASSESSED ON *(date)* BY *(name)* X4646 ES&H SECTION	**Starburst symbol** *(laser seq #)*

The laser sequence number is an internal Fermilab identifier for the laser or laser system and should be used in all communications relevant to the device. It is assigned by the LSO.

Class 1 lasers and laser systems are exempt from this requirement, unless they are modified or used in a way which causes the hazard class to exceed 1. The normal use of commercial products containing Class 2, 3a, and 3b lasers, that preclude personnel exposure through use of interlocked enclosures (e.g., laser printers), is exempt from the requirements of this chapter. This exemption does not apply when interlocks may be defeated for the purpose of maintenance, service, or modification of the products.

The LSO reviews and approves purchase orders for non-exempt laser systems. In addition, the LSO and the controlling division/section ES&H group shall be notified regarding the procurement, external or internal transfer, change in use location, change in performance, or any change in the hazard of a laser or laser system. Notification of procurement shall be accomplished via submission of a LASER REGISTRATION form (see technical appendix). Please fill out this form as completely as possible. Subsequent notifications can take place by other means (i.e., phone, E-mail, or note). The LSO shall maintain a sitewide database of laser systems[5]. In addition, the LSO shall assure that laser radiation hazard classification and labeling is conducted.

2. LSO Approval to Operate

Class 3b and Class 4 lasers and laser systems shall not be operated without the prior approval of the LSO. Class 3a lasers and laser systems should not be operated without the prior approval of the LSO. At the discretion of the LSO, initial approval to operate Class 3b and Class 3a lasers and laser systems may be done verbally.

The LSO shall assure that a hazard analysis is conducted for all Class 3b and Class 4 lasers and laser systems which includes determination of the NHZ, minimum required control measures, and the adequacy of enclosures which are intended to reduce the hazard class of the laser or laser system. In determining the NHZ, laser transmission systems which employ optical cables are considered enclosed systems with optical cable forming part of the enclosure. These analyses shall serve as the basis for the formal approval to operate.

3. Precautions for Maintenance, Repair or Modification[6]

These procedures may expose persons to increased radiation, electrical hazards, or chemical hazards. Most lasers employ hazardous levels of electrical energy and some use hazardous chemicals (especially corrosive gases and suspected carcinogens). These hazards should be discussed with your division/section ES&H group and/or the LSO prior to the operation.

[5]The need to also submit laser inventory information to the State of Illinois is under evaluation at this time.
[6]Fermilab's programs related to non-laser hazards are described elsewhere in this Manual. In particular, electrical safety programs are described in Chapters 5040-5046 and 5120 of this Manual.

4. Primary Beam Precautions

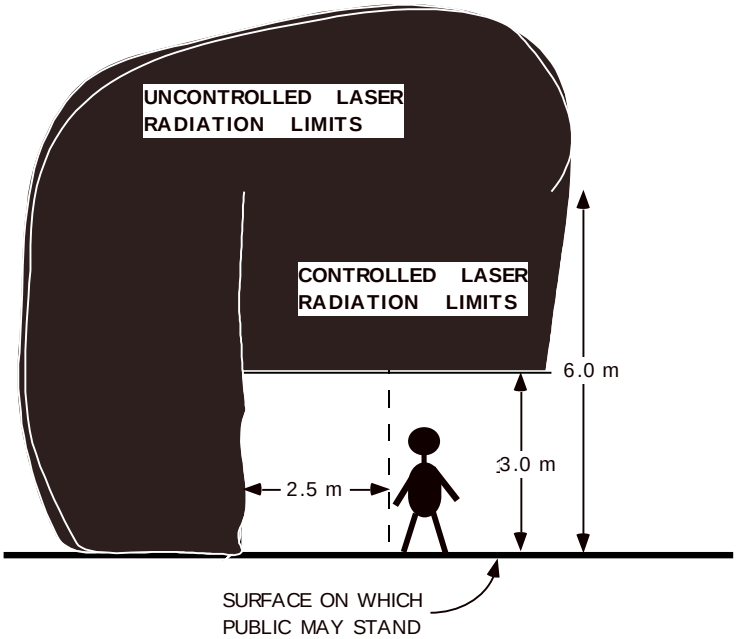
These are the basic precautions which shall be followed to prevent injury.

Class 2	Do not stare into beam.
Class 3a	Do not stare into beam or view directly with optical instruments.
Class 3b	Avoid direct exposure to beam.
Class 4	Avoid eye or skin exposure to direct or scattered radiation.

5. Precautions for Public Displays

Members of the public shall not be exposed to laser radiation exceeding hazard Class 1. Further, the distances between radiations exceeding hazard Class 1 and members of the public shall be at least as great as the values tabulated below (see also figure).

Minimum distance from >Class 1 radiation	Display under direct control of experienced/trained laser operator	Display not under direct control of experienced/trained laser operator
Vertical distance from surface on which member of public may stand	3.0 m	6.0 m
Horizontal distance from surface on which member of public may stand	2.5 m	2.5 m



In the special case of visible wavelength (0.4-0.7 μm) Class 2 and 3a lasers and laser systems, public exposure can often be adequately controlled by simply not directing the beam toward others or toward reflective surfaces. Most bar code scanners and some pointers are Class 2 systems which can be safely used in public areas as long as operators do not point the beam at people. However, use of Class 3a pointers should be avoided since the NHZ[7] typically extends 10-30 m from the laser and it is difficult to control the direction in which such devices are aimed.

[7]The Nominal Hazard Zone is defined here by an irradiance of 2.5 mW/cm^2: the visible wavelength 0.25 s "blink reflex" limit.

6. Training for Laser Workers

Training shall be provided for operators, maintenance or service personnel for Class 3b or Class 4 lasers or laser systems. Training should be provided for operators, maintenance or service personnel for Class 2 and Class 3a lasers or laser systems. The level of training shall address anticipated hazards and necessary precautions, shall be commensurate with the level of potential hazard, and shall be completed at least once prior to potential exposure. Laser safety training is provided by the LSO on request. Call the ES&H Section at Ext. 4646 to schedule training.

7. Eye Exam for Laser Workers

Persons whose work with laser systems may involve exposure to hazard Class 3b or Class 4 radiations shall obtain a laser eye exam prior to potential exposure, after any suspected ocular injury from laser exposure, and upon termination of work at Fermilab. Laser eye exams are conducted off-site at local eye clinics and are scheduled by the Medical Department. The Medical Department pays for the exams of Lab employees, while those for users are back-charged to their home institutions. Call the Medical Department at Ext. 3232 to schedule a laser eye exam. Allow several weeks lead time for an appointment.

8. Beam Precautions

The following precautions should be taken to prevent inadvertent beam exposure to laser radiations exceeding hazard Class 2.

a) *Terminate the Beam* - this is especially important in outdoor applications or in rooms with windows. Hazard Class 4 radiations may require special "beam dumps" which are designed to safely absorb and dissipate the beam.

b) *Control Reflections* - specular reflections shall be controlled for hazard Class 3b and 4 radiations and should be controlled for hazard Class 3a radiations. In addition, diffuse reflections; including those from dust, snow, rain, etc.; should be considered for hazard Class 4 radiations.

c) *Attenuate Beam* - attenuation of the beam to radiation hazard Class 1 shall be provided for all viewing optics and windows. Use the minimum laser output needed for the task.

d) *Control External Focusing for Hazard Class 3a Radiations* - such focusing can cause the hazard Class to increase to 3b.

e) *Avoid use at Eye Height*.

f) *Extra Caution for Invisible Radiations* - infrared and ultraviolet radiations exceeding hazard Class 1 should be completely enclosed since it is easy to be inadvertently exposed to these invisible radiations.

9. Warning Signs

An area which contains an operating Class 3b or Class 4 laser or laser system shall be posted with the appropriate sign as indicated in the attached figures. The NHZ shall be demarcated as a laser hazard area. An area which contains an operating Class 3a laser or laser system should be posted with the appropriate sign as indicated in the attached figures. The signs shall be posted in a fashion which best serves to warn onlookers.

Laser warning signs should only be posted when a laser radiation hazard actually exists. The practice of long-term posting for operations with infrequent laser use is discouraged: personnel soon believe the hazard is normally absent and ignore the warning. Laser signs and labels should be designed in accordance with guidance provided in the technical appendix to this chapter. They are available from the LSO.

10. Area Directly Supervised by a Qualified Laser Operator

A qualified laser operator shall directly control all locations where accessible laser radiations are hazard Class 3b or 4. This individual shall be responsible for assuring that all pertinent safety precautions are followed while the system is under his control.

11. Precautions for Spectators

Spectators shall not enter regions where accessible laser radiations are hazard Class 4 and should not enter those where accessible laser radiations are hazard Class 3b except by permission of the qualified laser operator. The operator shall assure that spectators are aware of pertinent hazards and controls and that appropriate precautions have been taken. The operator shall be responsible for the safety of spectators.

12. Lock up Laser When Not in Use

Laser systems having accessible laser radiations of hazard Class 4 shall not be operable and those having accessible laser radiations of hazard Class 3b should not be operable by unauthorized persons. This should be accomplished by a key-locking system.

13. Protective Eyewear

Appropriate protective eyewear shall be worn by all persons whose work with lasers may involve exposure to hazard Class 4 radiations and should be worn by all persons whose work with lasers may expose them to hazard Class 3b radiations. The optical density of the eyewear at the hazardous laser radiation wavelength shall be sufficient to limit the exposure to the MPE over the maximum anticipated exposure duration. The optical density of the eyewear, D_λ, is given by the following expression:

$$D_l = \log_{10}\left(\frac{H_p}{MPE}\right),$$

where H_p is the potential eye exposure. Contact the LSO for information on how to obtain appropriate laser safety eyewear.

The wavelength and optical density of the eyewear shall be marked on the eyewear to avoid improper application. The transmission of the eyewear over the visible portion of the spectrum should be sufficient to prevent accidents and allow efficient escape in emergencies (e.g., can exit signs be seen?). In addition, protective eyewear should be periodically inspected for integrity, especially following exposure to hazard Class 4 radiations.

14. Startup Warning

An audible or visual warning device shall be used with hazard Class 4 systems and should be used with hazard Class 3b systems to alert persons that they will be at risk of potential exposure to hazardous laser radiations. A verbal warning or "countdown" fulfills this requirement.

15. Written Operating Procedures

Written standard operating, maintenance and service procedures (SOPs) should be prepared and approved by the LSO for Class 3b lasers or laser systems. Written SOPs shall be prepared and approved by the LSO for Class 4 lasers or laser systems. Preparation of SOPs is the responsibility of the division/section operating the laser or laser system. They shall be maintained with the laser equipment for reference by the operator, and maintenance or service personnel.

16. Locks/Interlocks

Where an enclosure is used to prevent unexpected access to hazard Class 3b or Class 4 radiations, access points shall be locked or interlocked to inactivate the radiation reaching that location. In addition, these access points shall be labeled with the appropriate sign, except in the case of failsafe interlocks.

17. Remote Interlock Connector

A Class 3b laser or laser system should be provided with a remote interlock connector. A Class 4 laser or laser system shall be provided with a remote interlock connector. The interlock connector facilitates electrical connections as may be required for a Class 4 controlled area. When the terminals of the connector are open circuited, the accessible radiation shall not exceed the appropriate MPE levels.

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TECHNICAL APPENDIX TO LASERS

Fermilab

LASER REGISTRATION FORM

Your Name _____ Date _____

Fermilab Contact Person _____

Laser Owner: [ ] Fermilab, Division/Section _____

[ ] Other, Name _____

Expected Dates of Operation: Start _____ Stop _____

Intended Use(s) of Laser _____

Intended Use Location(s) of Laser _____

LASER SPECIFICATIONS

Manufacturer _____ Model _____

Serial Number _____ FNAL Number _____

Lasing Medium _____

Manufacturer's hazard classification: [ ]1 [ ]2 [ ]3a [ ]3b [ ]4

Wavelength (λ) _____ [ ]nm [ ]µm [ ]mm Specify all wavelengths or range.

Emergent beam characteristics

Diameter (a) _____ [ ]mm [ ]cm If not circular, specify dimensions.

Divergence (ϕ) _____ [ ]mrad [ ]^o

For continuous wave (CW) lasers only

Radiant power (Φ) _____ [ ]nW [ ]µW [ ]mW [ ]W [ ]kW

Irradiance (E) _____ [ ]µW/cm^2 [ ]mW/cm^2 [ ]W/cm^2 [ ]kW/cm^2
[ ]µW/mm^2 [ ]mW/mm^2 [ ]W/mm^2

For pulse wave (PW) lasers only

Radiant energy/pulse (H) _____ [ ]µJ/cm^2 [ ]mJ/cm^2 [ ]J/cm^2 [ ]kJ/cm^2
[ ]µJ/mm^2 [ ]mJ/mm^2 [ ]J/mm^2

Single pulse duration (t) _____ [ ]ps [ ]ns [ ]µs [ ]ms [ ]s

Pulse repetition frequency (F) _____ [ ]mHz [ ]Hz [ ]kHz [ ]MHz

For rotating beam lasers only

Rotation rate (S) _____ [ ]rpm [ ]rps

Min eye-axis distance (r_{min}) _____ [ ]cm [ ]in [ ]ft [ ]m

Copies to: LSO @ MS119, Your Division/Section ES&H Office, Fermilab Contact Person

LASER WARNING SIGNS AND LABELS

The table below summarizes the content required on warning signs and labels for lasers and laser systems at Fermilab. A version of the "primary message" should appear on a laser label as well as warning signs. In nearly all cases, this label will be provided by the manufacturer. Signs are required for Class 3b and Class 4 lasers and laser systems and are recommended for Class 3a lasers and laser systems. All listed labels are required. Laser radiation hazard warning signs and labels are available from the LSO.

Hazard Class	Primary message signs and labels	Other labels
1	None	a. Fermilab classification/inventory
2	**CAUTION** LASER RADIATION DO NOT STARE INTO BEAM *(other precautionary instructions which may apply)* *(laser specifications)* CLASS 2	a. Fermilab classification/inventory
3a visible =MPE	**CAUTION** LASER RADIATION DO NOT STARE INTO BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS *(other precautionary instructions which may apply)* *(laser specifications)* CLASS 3A	a. Fermilab classification/inventory
3a visible >MPE	**DANGER** LASER RADIATION AVOID DIRECT EYE EXPOSURE *(other precautionary instructions which may apply)* *(laser specifications)* CLASS 3A	a. Fermilab classification/inventory
3a UV/IR	**CAUTION**[8] INVISIBLE LASER RADIATION AVOID DIRECT EYE EXPOSURE (other precautionary instructions which may apply) (laser specifications) CLASS 3A	a. Fermilab classification/inventory
3b	**DANGER** [9]LASER RADIATION AVOID DIRECT EXPOSURE LASER TRAINING AND EYE EXAM REQUIRED *(other precautionary instructions which may apply)* *(laser specifications)* CLASS 3B	a. Fermilab classification/inventory b. Use in laser controlled area... c. This device contains...(enclosed) d. ..radiation when disconnected (fibers)

[8]The signal word DANGER is used in cases where the MPE for irradiance is exceeded.
[9]The word INVISIBLE precedes the word LASER for UV or IR radiations.

4	**DANGER** [9]LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION LASER TRAINING AND EYE EXAM REQUIRED *(other precautionary instructions which may apply)* *(laser specifications)* CLASS 4	a. Fermilab classification/inventory b. Use in laser controlled area... c. This devise contains... (enclosed) d. ..radiation when disconnected (fibers)

a. Fermilab classification/inventory label

NOTICE THIS DEVICE HAS A LASER RADIATION HAZARD CLASS OF *(system class as used)* ASSESSED ON *(date)* BY *(name)* X4646 ES&H SECTION	**Starburst symbol** *(laser seq #)*

b. Use in laser controlled area... label

NOTICE THIS DEVICE MUST BE USED IN A LASER CONTROLLED AREA BY LASER QUALIFIED OPERATORS. CALL D/S SAFETY OFFICE PRIOR TO CHANGE IN LOCATION OR OPERATION.	**Starburst symbol**

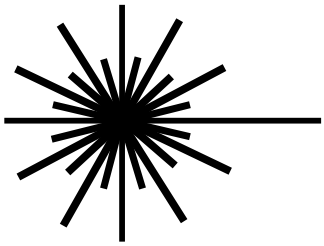
c. This device contains... (enclosed) label This label is used in association with procedure (16.) Locks/Interlocks.

CAUTION THIS DEVICE CONTAINS A CLASS *(3B OR 4)* LASER DO NOT OPEN WITHOUT AUTHORIZATION FROM *(name of designated person)*	**Starburst symbol**

d. ..radiation when disconnected (fibers) label In fibers attached to Class 3b and Class 4 laser or laser sources, the following label or tag is attached where disconnection may result in exposures exceeding the applicable MPE.

CAUTION HAZARDOUS LASER RADIATION WHEN DISCONNECTED DO NOT DISCONNECT WITHOUT AUTHORIZATION FROM *(name of designated person)*	**Starburst symbol**

SAMPLE STARBURST SYMBOL



LASER INSPECTION CHECKLIST

Below is a series of questions which can be used by division/section ES&H personnel and supervisors to assess the adequacy of laser safety programs within their organizations. [NOTE: Not every question applies to every laser Class. See preceding requirements for clarification.]

Question	Class[10]		Yes	No	NA
1. Does the laser/laser system have a classification sticker on it?	All	M			
2. Has the LSO given approval to operate the laser/laser system?	3b-4 3a	M R			
3. Are non-laser radiation hazards adequately addressed (especially electrical and chemical hazards)?	All	M			
4. If used in a "public display," are adequate separations maintained between hazardous laser radiation and the "public?"	2-4	M			
5. Have laser workers received laser safety training?	3b-4 2-3a	M R			
6. Have laser workers received laser eye exams?	3b-4	M			
7. Have appropriate laser warning signs been posted?	3b-4 3a	M R			
8. Is the NHZ under the control of the laser operator?	3b-4	M			
9. Are appropriate precautions provided for "spectators?"	4 3b	M R			
10. Is the laser/laser system locked up when not in use?	4 3b	M R			

[10]"Class" is applicable laser system hazard class. "M" means control is mandatory and "R" means control is recommended.

11. Is appropriate protective eyewear being used?	4 3b	M R			
12. Is a "startup warning" being used?	4 3b	M R			
13. Are interlocks or locks properly employed to prevent unexpected access to laser radiation?	3b-4	M			
14. Are remote interlock connectors provided as necessary?	4 3b	M R			
15. Is the beam terminated (especially outdoors and in rooms with windows)?	3b-4	R			
16. Are potential reflective hazards adequately controlled (specular surfaces or precipitation)?	3b-4 3a	M R			
17. Has the beam intensity been reduced to the minimum necessary to do the job?	All	R			
18. Has "extra care" been used for invisible radiations (IR or UV)?	3a-4	R			