

the organization requiring access, such as a service organization. However, there shall be a designated LSO for all circumstances of operations of a laser or laser system above Class 2. Specific minimum duties of the LSO are detailed in 1.3.2 .

(2) Education of authorized personnel (LSOs, operators, service personnel and others) in the assessment and control of laser hazards. This may be accomplished through training programs.

(3) Application of adequate protective measures for the control of laser hazards as required in Section 4 .

(4) Incident investigation, including reporting of alleged accidents, and preparation of action plans for the future prevention of accidents following a known or suspected incident. (See reference [7] in D7 for Federal reporting requirements.)

(5) Provide an appropriate medical surveillance program in accordance with Section 6 .

A guide for the organization of a laser safety program is outlined in Appendix D.

5.2 Education. The management shall provide training to the LSO on the potential hazards (including bioeffects), control measures, applicable standards, medical surveillance (if applicable) and other pertinent information pertaining to laser safety or provide to the LSO adequate consultive services. The training shall be commensurate to at least the highest class of laser under the jurisdiction of the LSO. Safety training program(s) shall be provided to the users of Class 3b or Class 4 lasers and laser systems, and should be provided to the users of Class 2 and Class 3a lasers and laser systems. Users shall include operators, technicians, engineers, maintenance and service personnel, etc., working with or around lasers. The training shall ensure that the users are knowledgeable of the potential hazards and the control measures for laser equipment they may have occasion to use. The need to train users of Class 2 lasers is not so much a need to instruct on the safe use of the laser, but rather to educate against the misuse of the laser. Curiosity and lack of knowledge can lead to increased risks of misuse of Class 2 lasers.

Where applicable, training shall include electrical safety and cardiopulmonary resuscitation (CPR).

A guide for the organization of a training program is outlined in D6.

5.3 Implementation. The management shall provide adequate supervision, personnel training, facilities, equipment and supplies to control potential hazards of laser and laser systems.

6. Medical Surveillance

6.1 General. The rationale for medical surveillance requirements for personnel working in a laser environment and specific information of value to examining or attending physicians are included in Appendix E. Medical surveillance requirements have been limited to those that are clearly indicated, based on known risks of particular kinds of laser radiation. Medical surveillance is not required for personnel using Class 1, Class 2, Class 2a or Class 3a lasers and laser systems as defined in 3.3.3.2, and shall be required for Class 3b and Class 4 lasers and laser systems. Some employers may wish to provide their employees with additional examinations for medical-legal reasons, to conform with established principles of what constitutes a thorough ophthalmologic or dermatologic examination, or as part of a planned epidemiologic study. Further information is provided in Appendix E.

6.2 Personnel Categories. Each employee's category shall be determined by the LSO in charge of the installation involved. The individuals who should be under laser medical surveillance are defined in 6.2.1 and 6.2.2 .

6.2.1 Incidental Personnel. Incidental personnel are those whose work makes it possible (but unlikely) that they will be exposed to laser energy sufficient to damage their eyes or skin, e.g., custodial, military personnel on maneuvers, clerical, and supervisory personnel not working directly with laser devices.

6.2.2 Laser Personnel. Laser personnel are those who work routinely in laser environments. These individuals are ordinarily fully protected by engineering controls or administrative procedures, or both.

6.3 General Procedures

6.3.1 Incidental personnel shall have an eye examination for visual acuity (see Appendix E for further details).

6.3.2 Laser personnel shall be subject to the following baseline eye examination:

Ocular history (E2.2.1). If the ocular history shows no problems and visual acuity (E2.2.2) is found to be 20/20 (6/6 in each eye for far, and Jaeger 1+ for near) with corrections (whether worn or not), and Amsler Grid Test (E2.2.3) and Color Vision (E2.2.4) responses are normal, no further examination is required. Laser workers with medical conditions noted in E2.2.1 should be evaluated carefully with respect to the potential for chronic exposure to laser radiation. Any deviations from acceptable performance will require an identification of the underlying pathology either by a fundoscopic examination (E2.2.5), or other tests as determined appropriate by the responsible medical or optometric examiner.

6.4 Frequency of Medical Examinations. For both incidental and laser personnel, required examinations shall be performed prior to participation in laser work. Following any suspected laser injury, the pertinent required examinations will be repeated, in addition to whatever other examinations may be desired by the attending physician. Periodic examinations are not required.

7. Non-Beam Hazards

7.1 General. In addition to direct hazards to the eyes and skin associated with exposure to the laser beam, it is also important to address other hazards associated with the use of lasers, *i.e.*, non-beam hazards. The non-beam hazards, in some cases, can be life threatening, *e.g.*, electrocution. As a result, the special considerations discussed in this section require use of control measures different from those discussed in Section 4. Because of the diversity of these potential hazards, the LSO may employ safety and/or industrial hygiene personnel to effect the hazard evaluations for special considerations. Appendix F provides additional background material on safety and industrial hygiene to aid in the control of these hazards.

NOTE: References useful in evaluating non-beam hazards covered in 7.1 through 7.12 may be found in Appendix F.

7.2 Electrical Hazards. The use of lasers or laser systems can present an electric shock hazard. This may occur from contact with exposed utility power utilization, device control, and power supply conductors operating at potentials of 50 volts and above. These exposures can occur during laser set-up or installation, maintenance and service,, where equipment

protective covers are often removed to allow access to active components as required for those activities. Those exposed can be equipment installers, users, technicians, and uninformed members of the public, such as passers by.

The effect upon those who accidentally come into contact with energized conductors at or above 50 volts can range from a minor "tingle", to startle reaction, to serious personal injury, or death. Because the pathways of current are all pervasive, such as ground, it is not possible to characterize all the parameters in any situation to predict the occurrence or outcome of an electric shock accident. Electric shock is a very serious opportunistic hazard, and deaths associated with laser systems have occurred.

Protection against accidental contact with energized conductors by means of a barrier system is the primary methodology to prevent electric shock accidents with laser equipment. Hazard warnings and safety instructions extend the safety system to embody exposures caused by conditions of use, maintenance, and service, and provide protection against the hazards of possible equipment misuse. The utilization of recognized independent testing organizations who verify the efficacy of equipment safety systems with respect to the requirements of consensus safety standards, is important for the protection of the equipment user.

Additional electrical safety requirements are imposed upon laser devices, systems, and those who work with them, by the United States Department of Labor, Occupational Safety and Health Administration (OSHA), the National Electrical Code (NFPA 70), and related state and local laws and regulations. These requirements govern equipment connection to the electrical utilization system, electrical protection parameters, and specific safety training. These requirements must be observed with all laser installations. The following potential problems have frequently been identified during laser facility audits.

- (1) Uncovered electrical terminals
- (2) Improperly insulated electrical terminals
- (3) Hidden "power-up" warning lights
- (4) Lack of personnel trained in current cardiopulmonary resuscitation practices, or lack of refresher training (see 5.2)
- (5) "Buddy system" not being practiced during maintenance and service

Appendix E

Medical Surveillance

E1. Purpose of Medical Surveillance

The basic reasons for performing medical surveillance of personnel working in a laser environment are the same as for other potential health hazards. Medical surveillance examinations may include assessment of physical fitness to safely perform assigned duties, biological monitoring of exposure to a specific agent, and early detection of biologic damage or effect.

Physical fitness assessments are used to determine whether an employee would be at increased or unusual risk in a particular environment. For workers using laser devices, the need for this type of assessment is most likely to be determined by factors other than laser radiation per se. Specific information on medical surveillance requirements that might exist because of other potential exposures, such as toxic gases, noise, ionizing radiation, etc, are outside the scope of this appendix.

Direct biological monitoring of laser radiation is impossible, and practical indirect monitoring through the use of personal dosimeters is not available.

Early detection of biologic change or damage presupposes that chronic or subacute effects may result from exposure to a particular agent at levels below that required to produce acute injury. Active intervention must then be possible to arrest further biological damage or to allow recovery from biological effects. Although chronic injury from laser radiation in the ultraviolet, near ultraviolet, blue portion of the visible, and near infrared regions appears to be theoretically possible, risks to workers using laser devices are primarily from accidental acute injuries. Based on risks involved with current uses of laser devices, medical surveillance requirements that should be incorporated into a formal standard appear to be minimal.

Other arguments in favor of performing extensive medical surveillance have been based on the fear that repeated accidents might occur and the workers would not report minimal acute injuries. The limited number of laser injuries that have been reported in the past 20 years and the excellent safety records with laser devices do not provide support to this argument.

E2. Medical Examinations

E2.1 Rationale for Examinations

E2.1.1 Preassignment Medical Examinations. Except for examination following suspected injury, these are the only examinations required by this standard. One purpose is to establish a baseline against which damage (primarily ocular) can be measured in the event of an accidental injury. A second purpose is to identify certain workers who might be at special risk from chronic exposure to selected continuous-wave lasers. For incidental workers (e.g., custodial, military personnel on maneuvers, clerical and supervisory personnel not working directly with lasers) only visual acuity measurement is required. For laser workers' medical histories, visual acuity measurement, and selected examination protocols are required. The wavelength of laser radiation is the determinant of which specific protocols are required (see E2.2). Examinations should be performed by, or under the supervision of, an ophthalmologist or optometrist or other qualified physician. Certain of the examination protocols may be performed by other qualified practitioners or technicians under the supervision of a physician. Although chronic skin damage from laser radiation has not been reported, and indeed seems unlikely, this area has not been adequately studied. Limited skin examinations are suggested to serve as a baseline until future epidemiologic studies indicates whether they are needed or not.

E2.1.2 Periodic Medical Examinations. Periodic examinations are not required by this standard. At present no chronic health problems have been linked to working with lasers. Also, most uses of lasers do not result in chronic exposure of employees even to low levels of radiation. A large number of these examinations have been performed in the past, and no indication of any detectable biologic change was noted. Employers may wish to offer their employees periodic eye examinations or other medical examinations as a health benefit; however, there does not appear to be any valid reason to require such examinations as part of a medical surveillance program.

E2.1.3 Termination Medical Examinations. The primary purpose of termination examinations is for the legal protection of the employer against unwarranted claims for damage that might occur after an employee leaves a particular job. The decision on whether to offer or require such examinations is left to individual employers.

E2.2 Examination Protocols

E2.2.1 Ocular History. The past eye history and family history are reviewed. Any current complaints concerned with the eyes are noted. Inquiry should be made into the general health status with a special emphasis upon systemic diseases which might produce ocular problems in regard to the performance cited in Section 6.1. The current refraction prescription and the date of the most recent examination should be recorded.

Certain medical conditions may cause the laser worker to be at an increased risk for chronic exposure. Use of photosensitizing medications, such as phenothiazines and psoralens, lower the threshold for biological effects in the skin, cornea, lens and retina of experimental animals exposed to ultraviolet and near ultraviolet radiation. (See Table E1 for a representative list of photosensitizing agents.) Aphakic individuals would be subject to additional retinal exposure from blue light and near ultraviolet and ultraviolet radiation. Unless chronic viewing of these wavelengths is required, there should be no reason to deny employment to these individuals.

E2.2.2 Visual Acuity. Visual acuity for far and near vision should be measured with some standardized and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance, and Jaeger 1+ for near, a more extensive examination is indicated as defined in 6.3.

E2.2.3 Macular Function. An Amsler grid or similar pattern is used to test macular function for distortions and scotomas. The test should be administered in a fashion to minimize malingering and false negatives. If any distortions or missing portions of the grid pattern are present, the test is not normal.

E2.2.4 Color Vision Color vision discrimination can be documented by Ishihara or similar color vision tests.

E2.2.5 Examination of the Ocular Fundus with an Ophthalmoscope This portion of the examination is to be administered to individuals whose ocular function in any of Sections E.2.2.1 through E.2.2.4 is not normal. The points to be covered are: the presence or absence of opacities in the media; the sharpness of outline of the optic disc; the color of the optic disc; the depth of the physiological cup, if present; the ratio of the size of the retinal veins to that of the retinal arteries; the presence or absence of a well-defined macula and the presence or absence of a foveal reflex; and any retinal pathology that can be seen with an ophthalmoscope (hyper-pigmentation, depigmentation, retinal degeneration, exudate, as well as any induced pathology associated with changes in macular function). Even small deviations from normal should be described and carefully localized. Dilation of the pupil is required.

E2.2.6 Skin Examination. Not required for pre-placement examinations of laser workers; however, suggested for employees with history of photosensitivity or working with ultraviolet lasers. Any previous dermatological abnormalities and family history are reviewed. Any current complaints concerned with the skin are noted as well as the history of medication usage, particularly concentrating on those drugs which are potentially photosensitizing.

Further examination should be based on the type of laser radiation, above the appropriate MPE levels, present in the individual's work environment.

E2.2.7 Other Examinations. Further examinations should be done as deemed necessary by the examiner.

E3. Medical Referral Following Suspected or Known Laser Injury

Any employee with a suspected eye injury should be referred to an ophthalmologist. Employees with skin injuries should be seen by a physician.

E4. Records and Record Retention

Complete and accurate records of all medical examinations (including specific test results) should be maintained for all personnel included in the medical surveillance program. Records should be retained for at least 30 years.

E5. Access To Records

The results of medical surveillance examinations should be discussed with the employee.

All non-personally identifiable records of the medical surveillance examinations acquired in Section E.4 of these guidelines should be made available on written request to authorized physicians and medical consultants for epidemiological purposes. The record of individuals will, as is usual, be furnished upon request to their private physician.

E6. Epidemiologic Studies

Past use of lasers has generally been stringently controlled. Actual exposure of laser workers has been minimal or even nonexistent. It is not surprising that acute accidental injury has been rare and that the few reports of repeated eye examinations have not noted any chronic eye changes. For these reasons, the examination requirements of this standard are minimal. However, animal experiments with both laser and narrow-band radiation indicate the potential for chronic damage from both subacute and chronic exposure to radiation at certain wavelengths. Lens opacities have been produced by radiation in the 0.295 to 0.45 μm range and are also theoretically possible from 0.75 to 1.4 μm .

Photochemical retinitis appears to be inducible by exposure to 0.35 to 0.5 μm radiation. If laser systems are developed that require chronic exposure of laser workers to even low levels of radiation at these wavelengths, it is recommended that such workers be included in the long-term epidemiologic studies and have periodic examinations of the appropriate eye structures.

Epidemiologic studies of workers with chronic skin exposure to laser radiation (particularly ultraviolet) are suggested.

E7. References

- Friedman, A. I. The ophthalmic screening of laser workers. *Ann Occup Hyg.* 21: 277-279; 1978.
- Hathaway, J. A., Stern, N., Soles, E. M., Leighton, E. Ocular medical surveillance on microwave and laser workers. *J. Occup Med.* 19: 683-688; 1977.
- Hathaway, J. A. The Needs for Medical Surveillance of Laser and Microwave Workers. Current Concepts in Ergophthalmology. *Societas Ergophthalmologica Internationalis.* Sweden: 139-160; 1978.
- Wolbarsht, M. L., and Landers, M. B. Testing visual capabilities for medical surveillance or to ensure job fitness. *J. Occup Med.* 27: 897-901; 1985.

Table E1
Representative List of Photosensitizing Agents

Agent	Reaction
1 Sulfanamide	Phototoxic Photoallergic
2 Sulfonylurea	Phototoxic
3 Chlorothiazides	Papular and Edematous Eruptions Plaques
4 Phenothiazines	Exaggerates Sunburn Urticaria Gray-Blue Hyperpigmentation
5 Antibiotics, e.g., Tetracycline	Exaggerates Sunburn Phototoxic
6 Griseofulvin	Exaggerates Sunburn Phototoxic Photoallergic
7 Nalidixin Acid	Erythema Bullae
8 Furocoumarins (Psoralen)	Erythema Bullea Hyperpigmentation
9 Estrogens/Progesterones	Melasma Phototoxic
10 Chlordiazepoxide (Librium)	Eczema
11 Triazetyldiphenolisatin (Laxative)	Eczematious Photoallergic Reaction
12 Cyclamates	Phototoxic Photoallergic
13 Porphyrins (Porphyria)	Phototoxic
14 Retin-A (Retinoic Acid)	Exaggerates Sunburn Photoallergic