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# LASER SYSTEMS SAFETY CLASSIFICATION ACCORDING TO HEALTH HAZARD LEVEL

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*The importance of work safety in laser and optoelectronic technology professional activity is discussed in the paper. The principles defined are considered when forming the professional competence of the field, as working with laser technology is connected with exposure to complex hazardous and harmful factors, the number and intensity of which depends on laser emission. Hence, ensuring safety is essential and failure to comply with working conditions requirements could result in injuries or fatalities.*

*Key words: safety recuirements, laser safety classes, biological hazards, non-beam laser hazards.*

*кандидат педагогічних наук, Дембіцька С. В., Краснощока А. К. Класифікація безпеки лазерних систем за ступенем загрози здоров'ю / Вінницький національний технічний університет, Україна, Вінниця.*

*В статті висвітлено важливість охорони праці в професійній діяльності спеціаліста з лазерної та оптоелектронної техніки. Визначені принципи, які необхідно враховувати під час формування професійної компетентності майбутніх фахівців в галузі, тому що при роботі із лазерною технікою працівник піддається впливу комплексу небезпечних і шкідливих факторів, кількість і інтенсивність яких залежать від лазерного випромінювання. Відповідно, у професії оптотехніка є надзвичайно важливим забезпечення безпеки праці, оскільки недотримання нормативних вимог щодо умов праці можуть спричинити травмування або летальні випадки .*

*Ключеві слова: класи лазерної безпеки, біологічні загрози, безпроменеві лазерні загрози.*

*кандидат педагогических наук, Дембицкая С.В., Краснощека А.К .. Классификация безопасности лазерных систем по степени угрозы здоровью. / Винницкий наиональний технический университет, Украина, Винница.*

*В статье освещены важность охраны труда в профессиональной деятельности специалиста по лазерной и оптоэлектронной технику. Определены принципы, которые необходимо учитывать при формировании профессиональной компетентности будущих специалистов в данной области, так как при работе с лазерной техникой работник подвергается воздействию опасных и вредных факторов, количество и интенсивность которых зависят от лазерного излучения. Соответственно, в профессии оптотехника чрезвычайно важным является обеспечение безопасности труда, поскольку несоблюдение нормативных требований по условиям труда могут привести к травмированию или летальным случаям.*

*Ключевые слова: классы лазерной безопасности, биологические угрозы, безлучевые лазерные угрозы.*

**Introduction.** Nowadays laser technique is acquiring more and more significance. Hence, the problem of labor safety and protection are critical in optoelectronic professionals` heath and life.

The issues of labor safety and protection are highlighted in the works of such scholars as G. Hohitashvili, O. Hornostai, E. Zhelibo, V. Lapin, J. Sagaiduck, A. Tereverko, A. Tretyakov et al., that consider low level of safety culture in Ukrainian society result in unacceptably high rate of injuries and occupational diseases.

Exploring regional aspects of safety management, AI Amosha, AF Novikov, V. Krot emphasize low coordination of regional and sectoral safety management system of public administration, low labor and production discipline [1, p.12-13].

The aim of current research is to demonstrate that the main causes of injuries in the workplace are lack of the appropriate industrial safety level and low production discipline, which indicates the need for creating safety culture at the stage of professional training.

The term LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Light can be produced by atomic processes which generate laser light. A laser consists of an optical cavity, a pumping system, and an appropriate lasing medium.

The main components of a laser are:

- Lasing medium (solid state, gas, liquid-dye, semiconductor-diode, or free electron lasers-FELs)
- Pump Source (Excitation via an electrical source, lamps, lasers, etc.)
- Optical Cavity
- Output Coupler

The optical cavity contains the media to be excited with mirrors to redirect the produced photons back along the same general path.

The pumping system uses photons from another source as a xenon gas flash tube (optical pumping) to transfer energy to the media, electrical discharge within the pure gas or gas mixture media (collision pumping), or relies upon the binding energy released in chemical reactions to raise the media to the metastable or lasing state.

The laser medium can be a solid (state), gas, dye (in liquid), or semiconductor [2-3].Lasers and laser systems are assigned one of four broad Classes (I to IV) depending on the potential for causing biological damage. The biological basis of the hazard classes are summarized in Table 1 [3].

There are different classification schemes (e.g. international and American ones), using classes such as 1 to 4 but with somewhat different definitions. Particularly important standards are:

- the IEC 60825-1 international laser safety standard of the International Electrotechnical Commission (IEC) ;
- those based on the US user standard ANSI Z-136 (with various variations Z-136.X, in particular the Z-136.1, revised in 2007) ;

Table 1

International laser safety classes

| Safety class | Simplified description |
|---|---|
| 1 | The accessible laser radiation is not dangerous under reasonable conditions of use. |
| 1M | The accessible laser radiation is not hazardous, provided that no optical instruments are used, which may e.g. focus the radiation. |
| 2 | The accessible laser radiation is limited to the visible spectral range (400–700 nm) and to 1 mW accessible power. Due to the blink reflex, it is not dangerous for the eye in the case of limited exposure (up to 0.25 s). |
| 2M | Same as class 2, but with the additional restriction that no optical instruments may be used. The power may be higher than 1 mW, but the beam diameter in accessible areas is large enough to limit the intensity to levels which are safe for short-time exposure. |
| 3R | The accessible radiation may be dangerous for the eye, but can have at most 5 times the permissible optical power of class 2 (for visible radiation) or class 1 (for other wavelengths). |
| 3B | The accessible radiation may be dangerous for the eye, and under special conditions also for the skin. Diffuse radiation (as e.g. scattered from the some diffuse target) should normally be harmless. Up to 500 mW is permitted in the visible spectral region. |
| 4 | The accessible radiation is very dangerous for the eye and for the skin. Even light from diffuse reflections may be hazardous for the eye. The radiation may cause fire or explosions. |

The IEC standard has been fully adopted by the European standardization organization as EN 60825-1. Note that these standards cover much more than only defining safety classes; they also determine the measures to be taken in order to work safely with laser products in such classes. Generally, it is the duty of the manufacturer of a laser product to classify the product and to equip it accordingly with warning labels. However, the classification may change when a laser product is modified by a user, and the user is then responsible for reclassification. The primary concern in laser safety is the possibility of eye injury. A secondary one is damage to the skin. Biological effects of laser light may depend on a number of factors including the wavelength of the light, its power, whether it possesses a continuous wave nature or is pulsed, or whether it is the result of a direct exposure of laser light rather than a diffuse reflection.

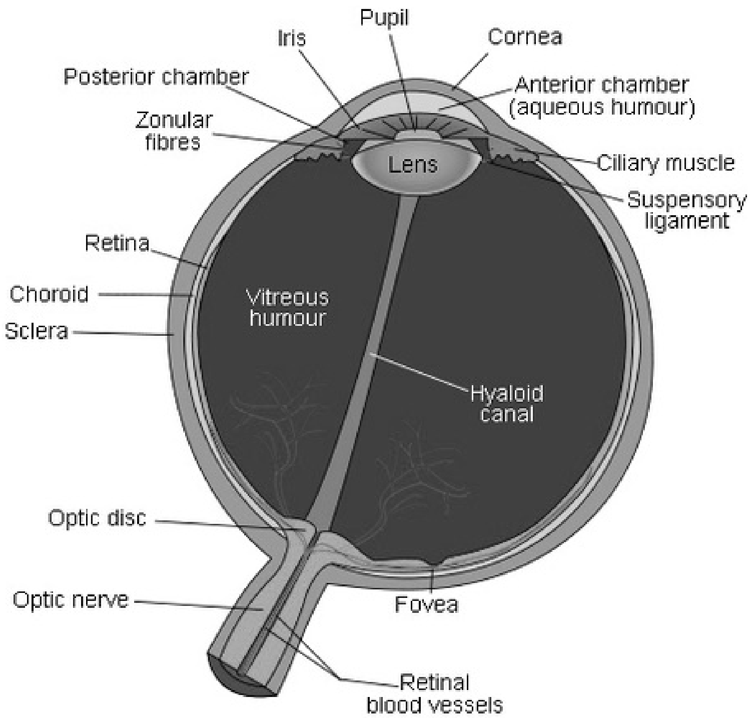


Fig. 1 Eye anatomy

Important components of the eye, such as the cornea, lens, and retina are susceptible to damage by laser light. Light enters through the transparent layers of the cornea and then is focused by the lens onto the retina. The eye in essence intensifies light energy, particularly the visible and the near-infrared wavelengths, in some cases as much as 100,000 times. For example, if there is a 1 mW/cm2 irradiance of light entered the eye, it can be intensified on the retina to an irradiance of 100 W/cm2. The fovea on the retina is a small area (~ 4% of retina) that is responsible for our acute and color vision, so that damage to this portion of the eye can result in a serious loss of sight [4]. Symptoms of exposure: if the eye has been damaged by laser light the first symptoms can be a bright flash of light (if a visible wavelength) followed by watering of the eye, headache, and floaters. Floaters are actually dead cells that have detached from the retina and choroid. If the cornea has been damaged there will be a sensation of grittiness, as if sand were in the eye. In some cases there may be immediate pain at the site of exposure.

The chance for skin exposure from lasers is greater due to the skin's greater surface area compared to the eye. Damage to the skin, however, is considered to be less serious. Different wavelengths of light penetrate to different depths of the skin, the most penetrating being from 700-1200 nm. It is possible to have a painful injury from a severe laser burn, but most skin injuries heal. Usually a sensation of heat to the exposed area will be noticed, preventing most injuries.

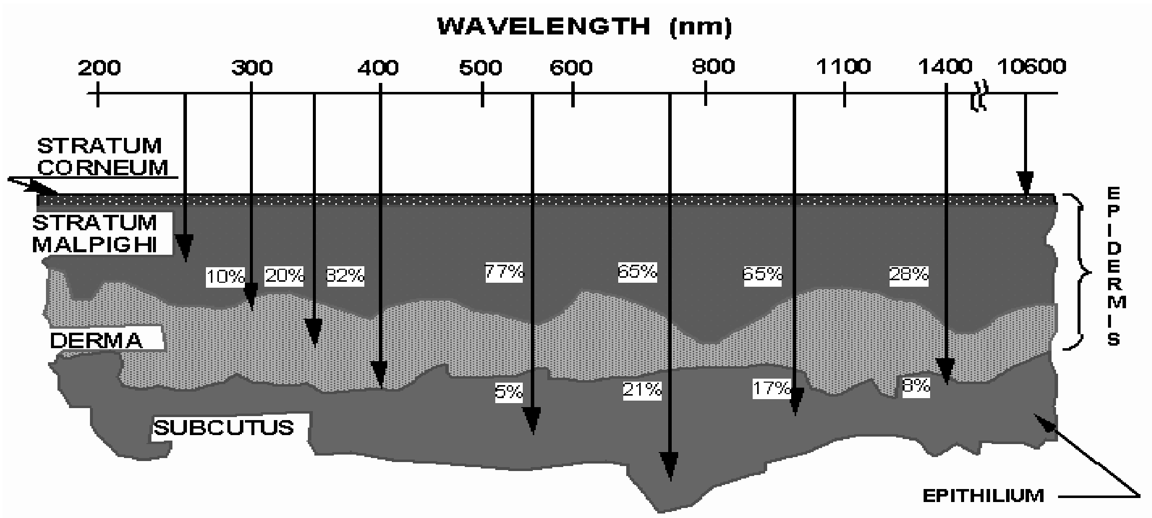


Fig. 2 Laser emission penetration into skin

The exceptions to this are some high-powered lasers in the far-IR range. The UV-B range of lasers can be the most injurious, resulting not only in thermal damage but possibly in carcinogenesis. UV-A can cause hyperpigmentation and erythema. UV-C seems to have the least effect on the skin due to its short wavelength which is absorbed by the epidermis short-pulsed lasers, due to their dominant acoustic effects.Hazards to the eye and skin are summarized below:

Table 2

Hazard Effects at Different Wavelengths

| Wawelenght range | Effect on Eye | Effect on Skin |
|---|---|---|
| Ultraviolet C<br>200 – 280 nm | Photokeratitis | Enthema (sunburn)<br>Skin cancer<br>Accelerated skin aging |
| Ultraviolet B<br>280 – 315 nm | Photokeratitis | Increased pigmentation |
| Ultraviolet A<br>315 – 400 nm | Photochemical<br>Cataract | Pigment darkening<br>Skin burn |
| Visible<br>400-700 nm | Photochemical<br>Thermal retinal<br>Injury | Pigment darkening<br>Skin burn |
| Near-infrared<br>700-1400 nm | Cataract and<br>Retinal burns | Skin burn |
| Mid-infrared<br>1400-3000 nm | Corneal burn | Skin burn |
| Far-infrared<br>3000-100000 nm | Corneal burn | Skin burn |

In some laser operations, particularly in the research laboratory, general safety and health guidelines should be considered .

Explosion Hazards. High-pressure arc lamps and filament lamps or laser welding equipment shall be enclosed in housings which can withstand the maximum pressures resulting from lamp explosion or disintegration. The laser target and elements of the optical train which may shatter during laser operation shall also be enclosed. [5]

Nonbeam Optical Radiation Hazards. This relates to optical beam hazards other than laser beam hazards. Ultraviolet radiation emitted from laser discharge tubes, pumping lamps and laser welding plasmas shall be suitably shielded to reduce exposure to levels below the ANSI Z 136.1 (extended source), and ACGIH TLV's.

Collateral Radiation. Radiation, other than laser radiation, associated with the operation of a laser or laser system, e.g., radio frequency (RF) energy associated with some plasma tubes, x-ray emission associated with the high voltage power supplies used with excimer lasers, shall be maintained below the applicable protection guides. The appropriate protection guide for RF and microwave energy is that given in the American National Standard "Safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 kHz to 100 GHz," ANSI C95.1; the appropriate protection guides for exposure to X-ray emission is found in the Department of Labor Occupational Safety and Health Standards, 29 CFR Part 1910.1096 and the applicable State Codes. Lasers and laser systems which, by design, would be expected to generate appreciable levels of collateral radiation, should be monitored.

Electrical Hazards. The intended application of the laser equipment determines the method of electrical installation and connection to the power supply circuit (for example, conduit versus flexible cord). All equipment shall be installed in accordance with the National Electrical Code and the Occupational Safety and Health Act.

Flammability of Laser Beam Enclosures. Enclosure of Class IV laser beams and terminations of some focused Class IIIB lasers, can result in potential fire hazards if the enclosure materials are exposed to irradiances exceeding 10 W/cm2. Plastic materials are not precluded as an enclosure material, but their use and potential for flammability and toxic fume release following direct exposure should be considered. Flame-resistant materials and commercially available products specifically designed for laser enclosures should also be considered [4-5].

**Conclusion**

Lasers have become a prominent tool in many research areas at Vinnytsia national technical university. If improperly used or controlled, class 3, 4 can produce severe injuries, such as blindness and burns to operators and other personnel, including uninitiated visitors to laboratories, and cause significant damage to property.

Respectively, the issue of labor safety and protection are essentially important for workers' health and life.

Observing industrial safety requirements is indespensible part of working process.

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