биомедицинских системах. – 2018. – Т. 7, № 2. – С. 433-436.

7. Рустамов И.М., Рустамов М.И., Аскаров П.А. Оптимальные методы хирургического лечения свежих повреждений магистральных желчных протоков. // Проблемы биологии и медицины. 2020, № 4,1 (121). Стр 165-170.

8. Bohl J.L. Indications and Options for Surgery in Ulcerative Colitis [Text] / J.L. Bohl, K. Sobba // Surg. Clin. North Am. – 2015. – Dec., Vol. 95(6). – P. 12111– 12132. doi: 10.1016/j.suc.2015.07.003.

PROBLEMS OF HYGIENIC REGULATION OF LASER RADIATION FOR POPULATION IN RUSSIAN FEDERATION. REVIEW

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Abstract

Hygienic studies have shown that the laser radiation of projectors can exceed Maximum Allowable Levels (MAL). Exposure to laser radiation levels not exceeding MAL induced unpleasant sensations in the eyes, temporary color perception disturbances, temporary blindness, headache in show participants. Specificity of laser radiation and the peculiarities of its regulation do not allow it to fit into the framework of exclusively numerical values that are established in the current regulatory document, therefore it is necessary to create a separate document on laser radiation that would contain, in addition to the MAL, requirements for laser safety. The determination of the Maximum Allowable Levels assumes the absence of hidden and temporarily compensated changes, however, MAL standards were initially calculated based on the damaging effect of laser radiation and did not take into account short-term changes. It is proposed to revise the MAL standards for population based on the reversible effects of radiation, such as temporary blinding.

Keywords: laser radiation; population.

Introduction

Laser radiation is the youngest occupational factor, but not the safest one. Rapid development of current laser technologies and their implementation into various areas of science and engineering allowed lasers to be widely used in the everyday life, as well as in the field of culture, fine arts and show industry. And if 40 years ago only narrow groups of scientists, researchers and design engineers, and assembly workers were exposed to radiation effect, nowadays almost everybody can be subjected to occupational and non-occupational exposure to laser radiation.

Eyes and skin are human body target organs of laser radiation. Biological effect of laser radiation is manifested by local thermal disturbances, most often as burns. General effect is characterized by non-specific action on central nervous, cardiovascular and hematopoietic systems. Attributing the revealed changes to radiation exposure might be a challenge even for experienced experts due to lack of specificity of general manifestations.

In this regard, problem of substantiating maximum allowable levels of laser radiation for population, ensuring safety of laser equipment usage in everyday life and throughout concerts and theatrical and entertainment events is of particular relevance.

The objective of the study is an analytical review on the issue of laser safety

Review of available scientific literature sources, as well as regulatory documents in the field of laser safety, search and selection of sources was carried out using open databases PubMed and RINC.

Unlike laser installations intended for industrial use where one can find almost the entire spectral radiation range, in everyday life equipment due to specifics of application, visible radiation range is preferred.

In direct contact with the eye a laser beam with a wavelength in visible range of spectrum passes freely through optical media of the eye and reaches the retina [1]. Retinal pigment epithelium contains melano-protein granules which absorb most part of visible radiation entering the eye.

High-intensity laser radiation is known to damage all retinal layers: burns, hemorrhages in the retina and adjacent tissues occur. Later a scar is formed over the burn resulting in persistent visual acuity decrease [2].

Hygienists have been dealing with laser safety problem since the 1970-s, and in 1972 first established maximum allowable levels have been already grounded. Based on these developments, two regulatory documents were issued, i.e.: "Sanitary Regulations and Standards for Laser Design and Operation" in 1981(SanPiN №2392-81)[1] and in 1991 (SNiP №5804-91)[2].

Subsequent Sanitary Regulations and Standards of 2016 (SanPiN 2.2.4.3359-16 "Sanitary and Epidemiological Requirements to Physical Factors at Workplaces") [3] and 2021 (SanPiN1.2.3685-21 "Hygienic

[1] SanPiN №2392-81 "Sanitary Regulations and Standards for Laser Design and Operation".

[2] SNiP №5804-91 "Sanitary Regulations and Standards for Laser Design and Operation".

[3] SanPiN 2.2.4.3359-16 "Sanitary and Epidemiological Requirements to Physical Factors at Workplaces ».

Standards and Requirements for Ensuring Environmental Safety and and/or Harmlessness for Humans") [4] just copy the Tables for calculating Maximum Allowable Levels, developed earlier.

Currently, there are two approaches to laser radiation regulating. First approach is based on damaging effect of laser radiation on target organs, i.e.: eyes, skin (direct collimated radiation). Minimum eye retina disturbance in the form of a whitish focus determined ophthalmologically, was taken as a threshold damage. The second approach is based on functional change in a body system or an organ which is most vulnerable to exposure (scattered or reflected radiation).

According to the current SanPiN1.2.3685-21, Maximum Allowable Levels of laser radiation are calculated depending on exposure duration and operation mode of laser equipment: single or chronic exposure and continuous or impulse mode of laser radiation installation.

Radiation source parameters also play a certain role in regulating Maximum Allowable Levels of laser radiation:

- collimated (parallel beam) or non-collimated (scattered) radiation;
- spot or area source**.**

The greatest attention in domestic regulation in the field of laser safety was paid to the assessment of the factor at the workplace, and Maximum Allowable Levels of laser radiation outside the workplace area were established only for usage of laser installations at cultural an entertainment events and in educational institutions.

Item 3.11 of SNiP № 5804-91 stated that when using lasers in theatrical and entertainment events and for demonstrations in educational institutions Maximum Allowable Levels for all participants are set in accordance with chronic radiation exposure, i.e., respective limit values for single exposure are 10 times decreased.

It follows from item 8.4.2.11 of SanPiN 2.2.4.3359-16 that safe application of laser devices in construction, at laser displays in educational institutions, theatrical and entertainment events, and outdoors, including communication facilities, must be agreed with Rospotrebnadzor authorities, and be provided with organizational and engineering measures, including preliminary development of laser layout and laser beam trajectory, under strict control over compliance with these SanPiN.

No approval is required if 1-st danger class lasers are used. Application of 3B-4 class laser devices is allowed only in communication facilities and for a screen projection. Presence of objects along laser beam path is prohibited.

In current SanPiN 1.2.3685-21 only standards in the form of Maximum Allowable Level tables, separately at workplaces and in living quarters and public buildings and in residential areas are presented.

It should be mentioned that Maximum Allowable Levels per se have not changed since 1991. Maximum Allowable Level is a maximum value of factors, which doesn't cause changes, including latent and temporarily compensated ones.

The weakest manifestation of damaging effect of laser radiation in visible spectrum range is blinding caused by bright light flash. This effect is a temporary one and is manifested as "a blind spot" occurring in visual field. Subsequent recovery of light sensitivity results from interaction of photochemical and neurophysiological mechanisms, having different duration and evidence degree. Initial recovery stage (first 3-5 min.) is characterized by rhodopsin regeneration delay, pronounced neurodynamic disturbances in the retina, and evident phase processes in central structures. Nervous adjustment of retinal structures plays a certain role in it [3]. Though the "blinding effect" is temporary, but it doesn't make it insignificant. There is some evidence, that it is this effect, which is responsible for the so-called "laser terrorism".

Laser projector is the most illustrative and suitable laser radiation source for population exposure study. Laser projector use for producing visual support of concert performances and cultural events is widespread abroad, as well as in Russia.

Unlike laser pointers and barcode readers, which are common in everyday life, direct laser radiation produced by projectors can cause exposure of numerous people who can't control the direction of laser beam on their own, which can result in accidental penetration of collimated radiation into the eye. Safety assessment of laser projector use is an issue of concern among a lot of experts around the world [4-6].

Hygienic studies conducted have shown that projectors generating radiation in three colour ranges of visible spectrum (red, blue and green) can be dangerous after both, a single and a repeated exposure to the eyes, i.e. laser radiation levels can exceed existing Maximum Allowable Levels[7]. These findings are also consistent with foreign study data, which describe cases of retinal damage during laser shows [8-9].

Functional state of visual analyzer and questionnaire studies of 20-23 year-old people after exposure to laser show radiation with intensities under Maximum Allowable Level (Fig.1-4) were carried out.

[4] SanPiN1.2.3685-21 "Hygienic Standards and Requirements for Ensuring Environmental Safety and and/or Harmlessness for Humans".

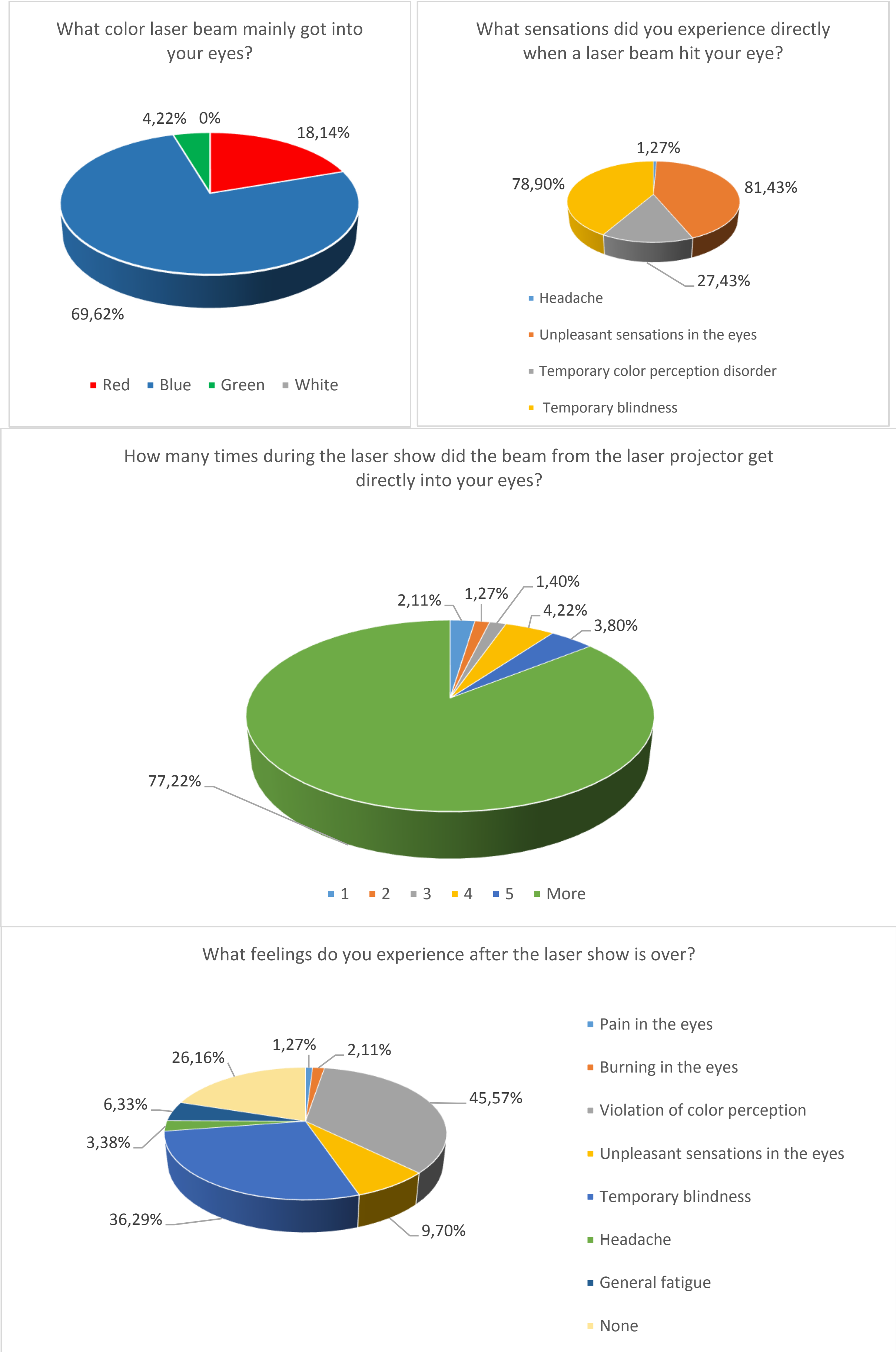

Fig. 1-4 The results of the survey of visitors to the laser show

Laser ray penetration caused eye discomfort, temporary colour perception disturbances, temporary blinding and a headache in show participants. It has been shown that laser radiation effect of red, green and blue spectrum ranges, and irradiances used in laser shows in doses under Maximum Allowable Level results in short-term changes of visual function, as regards light and colour sensitivity [10-11]. Occurrence of such functional changes in visual organ exposed to laser radiation levels under Maximum Allowable Level shows that current laser radiation standards for population need to be revised, taking into account temporary effects.

Conclusion

Specificity of laser radiation and peculiarities of its regulation do not allow it to be placed within the framework of exclusively numerical values, which are stated in the current standard, therefore, it is necessary to develop a separate document on laser radiation, which in addition to Maximum Allowable Levels, would include laser safety requirements to ensure laser safety.

Necessity of revision of Maximum Allowable Level standards for population is caused by revealing reversible radiation effects, such as temporary blinding, using up-to-date methods. Introduction of MAL, developed with consideration for temporary blindness, will allow to minimize negative changes in visual organs among persons occupationally unrelated to laser radiation effects, and to improve hygienic assessment quality of laser radiation.

References

1. Kulikov AN, Vlasenko AN, Mal'tsev DS, Kovalenko AV, Kovalenko IYu. Clinical cases of eye damage caused by laser pointer. Vestnik Rossiyskoy Voenno-meditsinskoy akademii. 2019, 3 (67): 103-106. (In Russ.)

2. Zheltov GI. Standards for laser safety: origins, level, perspectives. Photonics Russia. 2017; (1):10-35.

3. Preobrazhensky P.V., Shostak V.I., Balashevich L.I. Light damage to the eyes. L.; 1986. (In Russ.)

4. Higlett, Michael & O'Hagan, John. Assessing audience exposure at laser shows. International Laser Safety Conference. 2011: 231-237. DOI: 10.2351/1.5056754.

5. Frigerio, Francesco and L. Biazzi. Maximum Permissible Exposure in the Laser Display Shows. 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe) (2018): 1-7.

6. Patrick Murphy and Greg Makhov. Scanning audiences at laser shows: Theory and practice. ILSC 2009, (2009): 334-343. https://doi.org/10.2351/1.5056708

7. Mal′kova N.Yu. Assessment of the risk of adverse effects of laser radiation on the organ of vision during cultural events // Meditsina truda i promyshlennaya ekologiya.2018; 5:54–57. (In Russ.)

8. Boosten K, Van Ginderdeuren R, Spileers W, Stalmans I, Wirix M, Van Calster J, Stalmans P. Laser-induced retinal injury following a recreational laser show: two case reports and a clinicopathological study. Bull Soc Belge Ophtalmol. 2011; (317):11-6.

9. Jeon, Sohee & Lee, Won. Inner retinal damage after exposure to green diode laser during a laser show. Clinical ophthalmology (Auckland, N.Z.). 2014; (8): 2467-70. DOI: 10.2147/OPTH.S68254.

10. Mal′kova N.Yu., Ushkova I.N., Romanenko E.I. The effect of laser radiation from projectors on the organ of vision // Meditsina truda i promyshlennaya ekologiya. 2014; 9: 37-40. (In Russ.)

11. Mal′kova N.Yu., Petrova M.D. On the issue of revision of the hygienic standard of laser radiation for the population // Trudy mezhdunarodnoy molodezhnoy nauchnoy konferentsii «Ekologicheskiye problemy prirodo- i nedropol′zovaniya» Tom XIX/ pod red. V.V. Kurilenko – SPb.: SPbGU; 2019: 229-232. (In Russ.)