

## THE STATE OF MUSEUM LIGHTING IN RUSSIA<sup>1</sup>

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### ABSTRACT

The article contains the results of analysis of answers of 90 museums of the Russian Federation to questions regarding lighting of these museums as well as the results of inspection and measurement of lighting parameters (average exhibit illuminance, correlated colour temperature, colour rendering index, and luminance distribution) conducted in 7 museums and 1 conservation centre. It is found that museum lighting in the Russian Federation generally complies with the applicable requirements and recommendations and requires fundamental changes only in few cases. Many museums already use light emitting diodes (LEDs) as light sources and are ready to cross over to LED lighting completely. In the meantime, museums (primarily small ones) consider lack of regulations in the sphere of museum lighting one of the major problems.

**Keywords:** museum lighting in Russia, illuminance, correlated colour temperature, general colour rendering index, museum lighting standards

### 1. INTRODUCTION

In early 2018, the Ministry of Culture of the Russian Federation initiated the study aiming at development of up-to-date museum lighting requirements which museum employees may adhere to in their work [1]. One of the research directions of this

study was to obtain a complete picture of the current state of museum lighting based on the results of polling and selective monitoring of lighting parameters in a number of museums of Moscow and Saint Petersburg.

### 2. POLLING RESULTS

In order to obtain a complete picture of the actual state of museum lighting in the Russian Federation, S.I. Vavilov VNISI, in cooperation with the Ministry of Culture of the Russian Federation, the State Hermitage, the State Tretyakov Gallery, and the State Conservation Research Institute (GosNIIR) developed a questionnaire, which was distributed among 168 museums of the Russian Federation of different levels, from state to regional.

The questionnaire contained 13 questions regarding different aspects of lighting of museum exhibits answered by 90 out of 168 museums (54 %), which allowed us to form the following picture of the state of museum lighting in the Russian Federation.

#### Question 1: General museum information

Most museums have no light engineers in employment and their duties are primarily performed by electricians not educated in the sphere of light engineering and even they are employed only by 53 % of the museums, which answered the questions.

#### Question 2: Exhibits

In some museums, collections are categorised by regions and peoples, and exhibits are not divided in terms of light stability in storage premises and exhi-

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<sup>1</sup> Based on the report at the 29th CIE Quadrennial Session, June 14–22, 2019, Washington DC, USA.

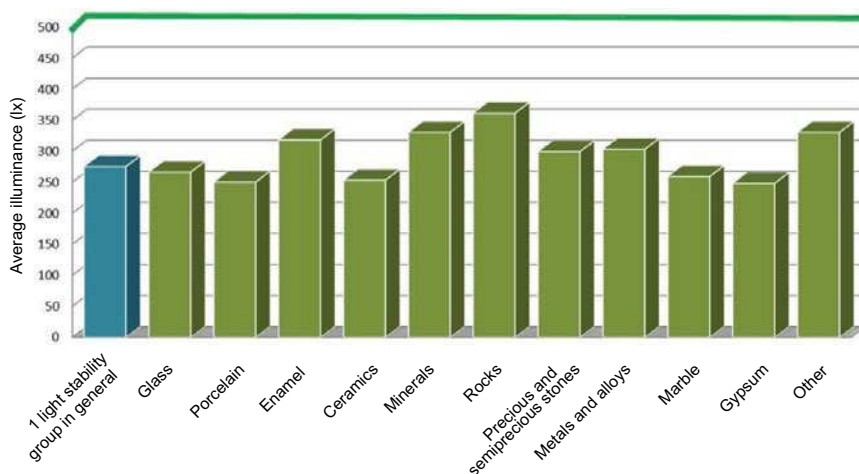


Fig. 1. Illuminance values for materials of the 1st light stability group averaged over all responding museums (according to the CIE recommendations [4], for the group 1 materials, illuminance levels are not limited, and green line stands for maximum acceptable value of illuminance according to Russian recommendations (500 lx) [2, 3])

bition halls, so in all premises where the exhibits are located, the integrated storage mode is maintained. This gives rise for the problem of correct maintenance of lighting mode for exhibits stored on the basis of the thematic and chronological principle.

**Question 3: Applied light sources**

For general lighting of exhibition halls, depositories and restoration workshops, museums use primarily fluorescent lamps (FL), compact fluorescent lamps (CFL) and warm white light-emitting diodes (LED) with correlated colour temperature ( $T_{cc}$ ) of (2700–3200) K, and for accent lighting of exhibits, tungsten halogen lamps (THL), FL, white LED ( $T_{cc}$  equal to (3200–4200) K) and CFL are used. In museum depositories, mostly white ( $T_{cc}$  are in range (3200–4200) K) FL are used for general lighting and LED, CFL, or FL are used for accent lighting (Table 1, 2). In the case of quantitative indicators of introduction of LED lighting in museum practice, to a varying degree, LED light sources are already applied for general and accent lighting by 77 % and 61 % of polled museums respectively. The same

holds for restoration workshops and depositories. At the same time, there are almost no exhibition premises without natural lighting, which is dangerous for works of art with poor light stability. As regards adjustment of light-engineering characteristics of accent and general lighting, it is essentially limited by adjustment of luminous flux values of light sources, i.e. varying of light source power and approximately 32 % of museums cannot afford even this. Just several museums use individual controls at bodies of lighting devices, *Bluetooth* adjustment, etc.

**Question 4: Maintained illuminance level of artificial lighting**

The respondents provided the data on the maintained levels of exhibit illuminance in accordance with the classification of exhibit light stability adopted in the Russian Federation [2, 3] which consists of three groups:

- Group 1 (low-sensitive (high light stability), which approximately corresponds to group I in accordance with CIE157:2004 [4]);

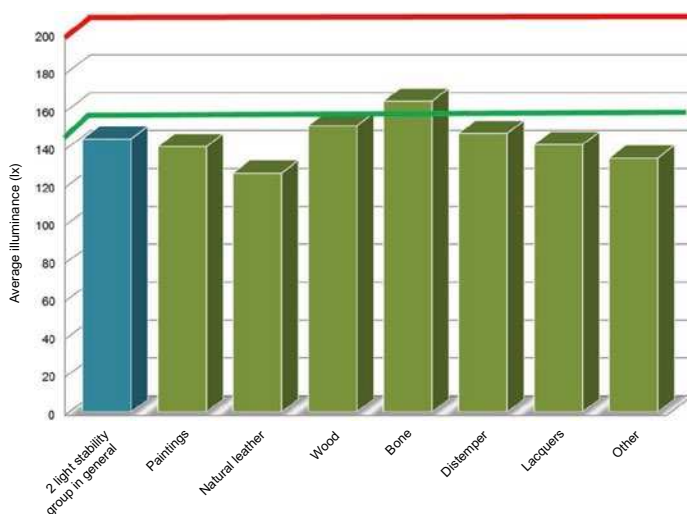


Fig. 2. Illuminance values for materials of the 2nd light stability group averaged over all responding museums (red line stands for the maximum acceptable illuminance value (200 lx) in accordance with the CIE recommendations [3] for materials of this group, green line stands for maximum acceptable value of illuminance according to Russian recommendations (150 lx) [2, 3])

**Table 1. Types of Light Sources Used by the Museums for General Lighting, % of the Number of Responding Museums**

Type of light source	Type of premises		
	Exhibit halls	Museum repositories	Restoration workshops
Daylighting	46	31	37
IL	18	14	10
THL	23	3	3
FL	54	56	43
CFL	49	30	18
LED	77	42	32
MHL	8	3	3

**Table 2. Types of Light Sources Used by the Museums for Accent Lighting, % of the Number of Responding Museums**

Type of light source	Type of premises		
	Exhibit halls	Museum repositories	Restoration workshops
IL	2	2	7
THL	33	3	7
FL	18	3	12
CFL	18	1	17
LED	61	6	14
MHL	9	0	2

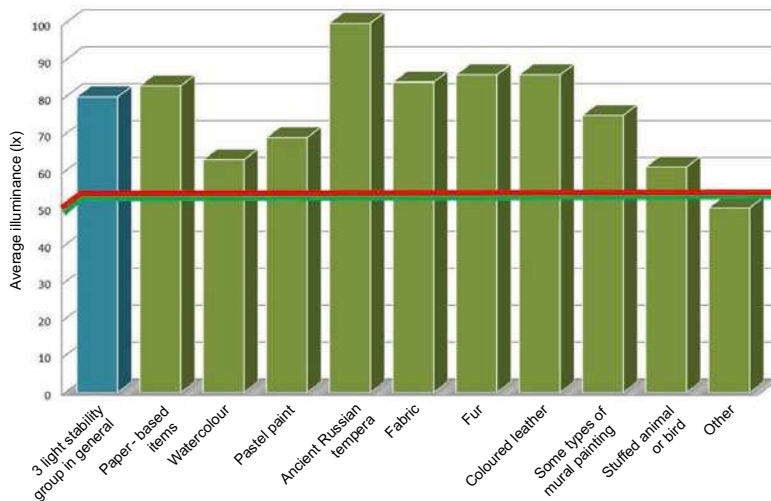


Fig. 3. Illuminance values for materials of the 3rd light stability group averaged over all responding museums (red line stands for the maximum acceptable illuminance value (50 lx) in accordance with the CIE recommendations [4] for materials of this group, green line stands for maximum acceptable value of illuminance according to Russian recommendations (also 50 lx) [2, 3])

– Group 2 (medium-sensitive (medium light stability), which approximately corresponds to group II in accordance with CIE157:2004 [4]);

– Group 3 (hypersensitive (low light stability), which approximately corresponds to group III in accordance with CIE157:2004 [4]).

In the context of this classification, it follows from the museums’ answers that, for exhibits of light-stability groups 1 and 2, the recommendations regarding maximum acceptable illuminance levels

applicable currently in Russia are complied with in most cases whereas the international requirements which are less strict in the case of the 2nd materials group are complied with almost in all cases. As regards exhibits of the 3rd light-stability group, just one half of the museums comply with the requirements (Tables 3–5, Figs. 1–3).

**Questions 5 and 6: Exhibition hall background (walls) tonality and background illuminance (as compared to exhibit illuminance)**

**Table 3. Number of Museums Maintaining the Specified Value of Illuminance (% of General Number of the Museums Answering the Relevant Questions) and Average Value of Illuminance (lx) For Materials of the Light Stability Group Number 1**

Illuminance, lx*	0–100	100–200	200–300	300–400	400–500	> 500
Group 1 in general: Number of museums,%	19	27	21	9	23	1

\* Illuminance averaged over all exhibits of group 1 is 275 lx.

**Table 4. Number of Museums Maintaining the Specified Value of Illuminance (% of General Number of the Museums Answering the Relevant Questions) and Average Value of Illuminance (lx) for Materials of the Light Stability Group Number 2**

Illuminance, lx*	0–100	100–150	150–200	200–300	>300	0–150**	0–200***
Group 2 in general: Number of museums,%	32	40	24	4	–	72	96

\* Illuminance averaged over all exhibits of group 2 is 144 lx.

\*\* Acceptable illuminance as per the recommendations applicable in Russia (<150 lx) [2, 3].

\*\*\* Applicable illuminance as per international recommendations (<200 lx) [4].

There are medium, light and dark background tonalities encountered in the museums, but medium or light and, to the less extent, dark background tonalities are preferred by the museums (Table 6). As regards preferences of the relation between illuminance of background and exhibits, background illuminance is primarily equal or less than exhibit illuminance and museums consider background with illuminance less than or approximately equal to illuminance of exhibits preferable (Table 7).

**Question 7: What methods of daylight illuminance regulation and protection are used in the museum?**

Museums use most of existing methods including curtains, louvres and protective glazing.

**Question 8: Applied lighting control devices**

Illuminance monitoring is conducted primarily by means of illuminance meters and, unfortunately, only 34 % of the monitored museums are equipped with them. Irradiance meters, colorimeters, and spectroradiometers are possessed only by 4 %, 3 % and 2 % of museums respectively and only one museum is equipped by a central lighting monitoring system. With that, it is noted that non-availability of necessary calibrated devices is caused by underfunding.

**Question 9: What regulatory and/or recommendation documents do you use for arrangement of lighting in your museum? Please assess their practical utility for your work on a 1–10 scale**

Analysis of answers to this question showed that museums primarily are keeping using the guideline

issued by GosNIIR in 1995 [5] (38 % of museums) and already void Order of the Ministry of Culture of the Russian Federation dated on December 8, 2009 [6] (33 % of museums). On a scale of 1–10, practical utility of these documents was assessed as 9.3 and 8.3 respectively.

**Question 10: Do the existing requirements to maximum acceptable illuminance levels provide adequate perception and preservation of exhibits in your opinion?**

This question was designed to find out whether the museums consider that the existing requirements to maximum acceptable illuminance levels provide adequate perception and preservation of exhibits in exhibition halls, restoration workshops and depositories. As it follows from the data presented in Fig. 4–6, the most of the polled museums consider that the existing requirements to maximum acceptable illuminance levels provide adequate perception and preservation of exhibits in exhibition halls, restoration workshops, and depositories. However, about a half of the respondents were either undecided-

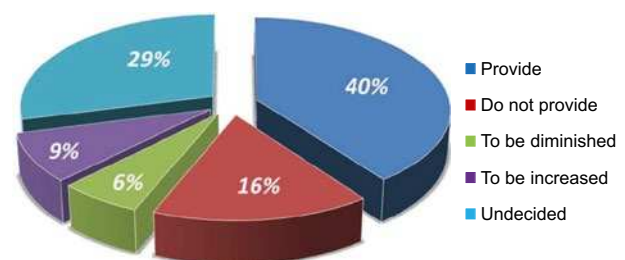


Fig. 4. Museum answers to question 10 of the questionnaire (adequacy of lighting requirements) as regards exhibition halls

**Table 5. Number of Museums Maintaining the Specified Value of Illuminance (% of General Number of the Museums Answering the Relevant Questions) and Average Value of Illuminance (lx) for Materials of the Light Stability Group Number 1**

Illuminance, lx*	0–50**	50–75	75–100	100–150	150–200	>200
Group 3 in general: Number of museums,%	51	16	16	9	6	2

\* Illuminance averaged over all exhibits of group 1 is 80 lx.

\*\* Acceptable illuminance as per the recommendations applicable in Russia and the international recommendations (<50 lx) [2–4].

**Table 6. Preferred Tonality of Background (% of the Total Number of Museums (90) Answered Question 6 of the Questionnaire)**

	Very light	Light	Medium	Dark	Very dark
Current	7	33	38	19	3
Preferable*	2	22	28	11	2

\* 35 % of the museums were undecided

**Table 7. Preferred Relation between Background Illumination and Exhibit Illumination (% of the Total Number of Museums (90) Answered Question 7 of the Questionnaire)**

	Much less	Less	Roughly the same	Higher	Much higher
Current*	5	25	27	–	–
Preferable**	6	18	13	1	–

\* 43 % of the museums were undecided to name the current relation

\*\* 62 % of the museums were undecided to name the preferred relation

ed or gave negative answers, which suggests that it is necessary to make amendments to the applicable requirements.

**Question 11: What would you like to change in lighting of your museum?**

This question implied feedback by the museums regarding possible changes of lighting. As a result, it turned out that:

- 40 % museums would like to replace conventional artificial light sources for general and accent lighting in exhibition halls with LEDs. Linear LED light sources with individually selected chromaticity and high luminous efficacy are also required;

- 11 % of the responding museums would like to remove natural lighting in exhibition halls;
- 30 % of the museums would like to replace artificial light sources for general lighting of depositories with LED;
- 18 % of the museums would like to replace artificial light sources for accent lighting of depositories with LED;
- About 4 % of the responding museums would like to remove natural lighting in depositories;
- 26 % of the museums would like to replace artificial light sources for general lighting of restoration workshops with LED;

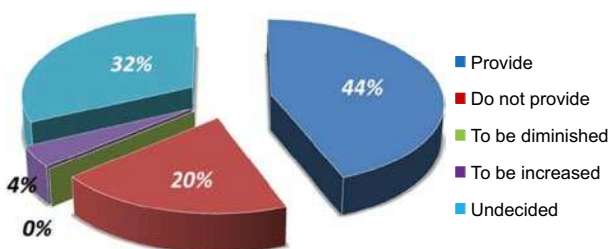


Fig. 5. Museum answers to question 10 of the questionnaire (adequacy of lighting requirements) as regards museum depositories

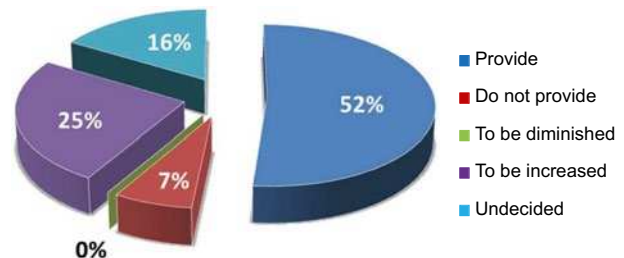


Fig. 6. Museum answers to question 10 of the questionnaire (adequacy of lighting requirements) as regards restoration workshops





Fig. 7. Lighting of the halls of the State Hermitage (a), the State Tretyakov Gallery (b), the State Museum of History (c), and the Alexander Shilov Gallery (d)

- 19 % of the museums would like to replace artificial light sources for accent lighting of restoration workshops with LED;

- About 1 % of the responding museums would like to remove natural lighting in restoration workshops.

**Question 12: Assess necessity of development of the following regulatory documents for monitoring and provision of preservation conditions for displayed and stored exhibits**

It follows from the answers to this question, that the museum community is interested in development of a number of documents containing general requirements to museum lighting standardisation. These are:

- Standard, Museum lighting. General requirements;
- Standard, Museum lighting. Light and engineering characteristics measurement methods;
- Museum light sources and lighting devices selection recommendations.

**Question 13: Your wishes as to standardisation of museum exhibits lighting**

The next suggestions follow from the answers on this question:

- Start formulating standards or recommendations for standardisation of museum lighting with a uniform system of measurement of light and engineering (photometric) characteristics and criteria of selection of necessary cutting-edge equipment;

- Conduct experimental studies to obtain objective data for justification of exhibit illuminance standards;

- Standardise not only illuminance, but also annual luminous exposure for different materials;

- Organise a lighting standardisation workshop for heads of conservation.

### 3. MEASUREMENT RESULTS

In order to clarify the picture of the current state of museum lighting in the Russian Federation, we inspected lighting systems and measured their characteristics in the State Hermitage, the State Museum of History, the Museum of the 1812 French Invasion, the State Tretyakov Gallery, the Pushkin State Museum of Fine Arts, the Alexander Shilov Gallery as well in the Church of St. Nicholas in Tolmachi, which is the museum church and house church being a part of the Tretyakov Gallery and in the Academician I.E. Grabar All-Russian Art Restoration Research Centre<sup>2</sup>. In the course of this work, the following parameters were measured:

- Illuminance on exhibit surfaces and in halls including semi-cylindrical illuminance;
- Correlated colour temperature;
- General colour rendering index of the used light sources;
- Luminance distribution over a viewer's field of view.

Measurements of the listed parameters were performed by means of, respectively, Ekosfera illuminance meter by EcoLight, Russia,

<sup>2</sup> Preliminary results of these studies were published in [7]. – authors' note.

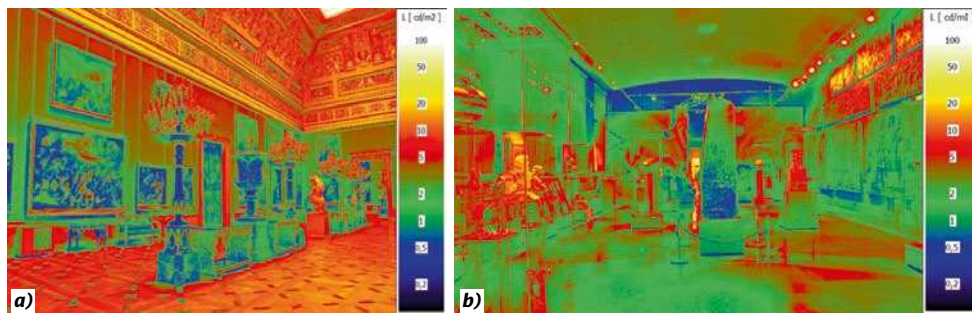


Fig. 8. Pseudo-colour luminance distribution in halls of the State Hermitage (a) and the Pushkin State Museum of Fine Arts (b)

and *LMT Pocket Lux 2* illuminance meter by *LMT*, Germany, *UPRtek MK350S* spectrophotometer by *United Power Research Technology Corporation*, Taiwan, and *LMK mobile advanced* luminance meter by *LMK*, Germany. At the initial stage, apart from measurement of photometric parameters, heating of works of art under effect of incident radiation, i.e. temperature distribution over picture surface was measured by means of *Testo 882* thermal camera by *Testo*, Germany, as well as the level of UV radiation, which was measured by means of *TKA-AVS* UV radiometer by *TKA*, Russia. At later stages, these measurements were not made due to negligible difference between temperature on picture surfaces and ambient temperature, and negligible, as compared to maximum allowed values [8], level of UV radiation reached by protective film on windows, and correct selection of artificial light sources.

The museums in which the survey was carried out differ significantly in the interiors for exhibiting the works of art (mainly paintings and graphics) and, accordingly, in their lighting systems. For in-

stance, while the Hermitage is a complex of palace premises with remarkable architecture and decorations and is, therefore, a work of art in itself, a most valuable exhibit requiring quality interior lighting, the Tretyakov gallery, the Museum of History, and the Alexander Shilov Gallery are designed for demonstration of paintings and graphics and natural lighting is substantially limited or non-available there (Fig. 7).

As a result of the study, it was found that majority of lighting devices in the museums is based on tungsten halogen lamps and linear and compact fluorescent lamps following. At the same time, there is a trend of transition to LED-based luminaires. For instance, in the Hermitage, the leader in advancement of lighting systems, such devices are already installed over 15,000 (25 %) lighting points.

The measurement results showed that values of average illuminance on museum exhibits do not exceed recommended levels in the most museums and general luminance distribution is arranged rather well (Fig. 8). At the same time, in the Tretyakov Gallery, illuminance of certain areas of some pic-



Fig. 9. Lighting of the iconostasis of the Church of St. Nicholas in Tolmachi: Photograph (a) and pseudo-colour luminance distribution (b)





Fig. 10. Preservation specialist worktable lighting (a) and general lighting of restoration premises (b) of the Academician I.E. Grabar All-Russian Art Restoration Research Centre

tures is exceeded due to non-uniformity of lighting, whereas some pictures are insufficiently lighted in the Hermitage and the Museum of History. In the French Invasion Museum, where only LEDs are used for lighting, local areas with exceeding lighting of exhibits were found as well as cases of significant, up to thirty-fold, luminance variations. In the Pushkin Museum of Fine Arts, lighting of exhibits fully complies with the requirements although the level of illuminance was intentionally set higher in some cases for better perception of pictures by viewers.

It is worth noting that diversity of museum collections often makes lighting arrangement more difficult. For instance, in hall No. 223 of the Hermitage, there are two cases with different levels of lighting standing in front of each other one of which contains glass and bronze exhibits (with low light sensitivity) and the other one contains laceworks (hypersensitive exhibits with standard illuminance not exceeding 50 lx).

The values of correlated colour temperature of artificial lighting in the museums did not exceed (4000–4200) K, whereas the values of general colour rendering index usually exceeded 90.

Only lighting of the Church of St. Nicholas in Tolmachi, premises with high ceilings and not darkened windows without UV radiation protective film, is out of the generally favourable picture. Artificial lighting of interior, some icons and the iconostasis is performed by means of spotlights with 500 W THL and during daytime, in conditions of simultaneous effect of natural and artificial light, the level of lighting of icons is excessive and veiling reflections are formed (Fig. 9). Currently, reconstruction of lighting is being started in the church with transition to LEDs among others.

In the restoration premises of the Academician I.E. Grabar All-Russian Art Restoration Research Centre and the State Hermitage, natural light is widely used for more accurate demonstration of colours and perception of museum exhibits being preserved. For works with items with different levels of light stability, the restoration centre uses different types of lighting devices with different light sources including LEDs, by means of which lighting necessary for precision works and comfortable for conservation specialists is formed (Fig. 10). During works with paintings, illuminance levels do not exceed (300–400) lx.

#### 4. CONCLUSION

The results of the studies demonstrated that museum lighting in the Russian Federation generally complies with the applicable requirements and recommendations and requires fundamental changes only in few cases. Many museums already use light emitting diodes as light sources and are ready to cross over to LED lighting completely. In the meantime, museums (primarily small ones) consider lack of regulations in the sphere of museum lighting as the major problem. In order to solve this problem and simplification of the process of museum transition to LED lighting, VNISI LLC has started developing a series of two standards and two preliminary standards in the sphere of LED museum lighting with financial support of the Rosnano Infrastructure and Educational Programmes Foundation. Moreover, in cooperation with the Ministry of Culture of the Russian Federation, it is planned to conduct studies of the effect of correlated colour temperature and the level of LED lighting on perception of museum exhibits and the effect of chromaticity of



LED lighting on aging of museum exhibits which will allow us to increase the framework for standardisation of museum lighting.

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### REFERENCES

1. Shakhparunyantz, A.G., Rozovsky, E.I., Chernyak, A. Sh., Fedorishchev, P.A. LED in Museums: New Capabilities and Challenges [Svetodiody v muzeyakh: novyye vozmozhnosti i problemy // Svetotekhnika, 2018, Special Issue Light in the Museum, pp. 36–39.
2. Museum Design Recommendations. [Rekomendatsii po proektirovaniyu muzeev]. B.S. Mezentsev TsNIIEP. Moscow: Stroyizdat, 1988.
3. Recommendations for Design of Artificial Lighting in Museums, Galleries and Exhibition Halls Rekomendatsii po proektirovaniyu iskusstvennogo osvashcheniya muzeev, kartinnykh galerei i vystavochnykh zalov.] Moscow: F.B. Yakubovsky VNIPI Tyazhpromelectroproekt, 1992.
4. CIE157:2004 “Control of Damage to Museum Objects by Optical Radiation”.
5. Museum Storage of Art Treasures [Muzeinoye khraneniye khudozhestvennykh tsennostei]. Practical guidelines. Moscow: State Research Institute of Restoration, 1995, 17 p.
6. Order of the Ministry of Culture of the Russian Federation No. 842 of December 8, 2009 “On approval of uniform rules of organization, accounting, preservation and use of museum pieces and museum collections in the museums of the Russian Federation”, cancelled by the Order No. 116 of 11.03.2010.
7. Chernyak Anatoly Sh., Kuznetsova Alyona B., and Bartseva Alexandra A. Measurement of Illumination Parameters of the Halls and Exhibited Items of the State Hermitage and the State Tretyakov Gallery// Light & Engineering Journal, Vol. 27, #4, pp. 66–72.
8. Sergei S. Bayev, Vladimir N. Kuzmin, and Konstantin A. Tomsy Research of Optical Radiation Impact on Materials of Museum Exhibits and Requirements to Measurement Devices// Light & Engineering Journal, Vol. 27, #4, pp. 73–80.



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