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EXPLANATORY NOTE

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ABSTRACT

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Pages 51; Figures 20; tables 13; drawings __; sources 16; Annex 0.

Diploma thesis of the bachelor was performed on the basis of the task on the topic: «The project development of the lighting and power supply system of the football stadium gaming zone».

The purpose of the work is to develop a project of lighting system for a gaming zone of a football stadium of the II category.

On the basis of lighting and electrical calculations, a project of the lighting system of the gaming zone of the stadium «Kolos», which is located in the the city of Zboriv, Ternopil region.

Keywords: ILLUMINANCE, SPOTLIGHT, LED, UNIFORM LIGHTING, WORKING CURRENT, CURRENT MOMENT.

CONTENT

INTRODUCTION

One of the ways to develop and promote sports is the construction of new or reconstruction of existing sports facilities and structures. An important task is to create opportunities for competitions or training both in light and in the dark. Therefore, lighting of any sports facility can increase the time of its operation, and thus increase interest in a particular sport.

Designing lighting for sports facilities is one of the most difficult and responsible tasks. The complexity is due to the lack of universality in decision-making, as each facility differs in purpose for sports, the size of sports grounds, the necessary lighting characteristics that must be provided.

Football stadiums are one of the most popular sports facilities. This is due to the possibility of holding not only football matches, but also competitions in other sports (such as athletics, field hockey, rugby) and cultural events (meetings, concerts). Therefore, the design of lighting systems for football stadiums is an important task.

Currently, the greatest attention is paid to stadiums where international and national competitions are held. Requirements for lighting of such buildings are quite high, due to the need to create conditions for television broadcasts. However, it is necessary to illuminate training grounds and stadiums where regional competitions can be held, and the requirements for lighting systems of such sports facilities are significantly lower, due to the lack of need to provide conditions for television broadcasts. In this paper, a lighting project was developed for one of these football stadiums.

1 ANALYTICAL SECTION

1.1 Requirements for lighting systems of football stadiums

The main purpose of lighting football stadiums, as well as any other sports facilities is to create and provide the necessary visibility conditions for [1, 2]:

1) players, coaches and referees, ie those who take direct participation in the process of competitions or training;

2) spectators who are directly at the stadium, ie it is necessary to create such conditions of visibility that would provide the possibility of observation even at the most distant distances between them and athletes;

3) film, photo and television operators, ie providing conditions for obtaining high quality images.

When designing sports facilities use the requirements for lighting parameters given in documents [3 - 5], but these documents do not provide clear information on regulatory requirements that characterize lighting systems. In particular, ДБН В.2.2-13 - 2003 [3] specifies only the lighting requirements for sports facilities, which can be televised sports events. In addition, it is indicated that for outdoor areas where physical education and health classes are held, the minimum value of horizontal illumination should be 150 lux. More specifically, the lighting requirements for football stadium lighting systems are specified in the European standard DIN EN 12193. Light and lighting - Sports lighting [6]. According to this standard, the lighting requirements for football stadiums are determined by the levels of sporting events that may be held there (Table 1.1).

Requirements for lighting of open football stadiums without the possibility of television broadcasts in accordance with the standard [6], as well as their comparison with the requirements of other regulations are given in Table 1.2. As can be seen from Table 1.2, the requirements for the lighting of football and its uniformity, given in different regulations, stadiums can differ significantly. In some literature, in particular in [1] it is recommended to use the standard [6] in the design.

Table 1.1 – Levels of sports competitions, given in the standard DIN EN 12193. Light and lighting – Sports lighting

The level of competition	Type of competition	The purpose of the sports facility
I	Competitions of the highest category	Carrying out competitions of national and international levels in large sports facilities (number of seats in the stands – not less than 800)
II	Intermediate level competitions	Carrying out of competitions in large and average sports complexes
III	School sports and leisure	Carrying out of non-professional competitions, school sports and leisure

Table 1.2 – Requirements for lighting of open football stadiums without the possibility of telecasts in accordance with the standard [6], as well as their comparison with the requirements of other regulations

Class of game or sports facility	Normative document							
	BCH-1-73 Minimal illuminance, lx		EN12193 Average illuminance, lx		IES Rec. Pract. RP-2000 Average illuminance, lx		CIE Average illuminance, lx	
	Horizontal/ratio of minimal to maximal illuminance	Vertical	Horizontal/ratio of minimal to maximal illuminance	Vertical	Horizontal/ratio of maximal to minimal illuminance	Vertical	Horizontal/ratio of maximal to minimal illuminance	Vertical
Training	50/ 1/3	30	75/ 0,5	-	500/ 4/1	-	100/3/1	-
Competitions with the number of spectators from 1500 to 10000	100/ 1/3	50	-	-	1000/ 3/1	-	500/ 3/1	-

Continuation of table 1.2

Class of game or sports facility	Normative document							
	BCH-1-73 Minimal illuminance, lx		EN12193 Average illuminance, lx		IES Rec. Pract. RP-2000 Average illuminance, lx		CIE Average illuminance, lx	
	Horizontal/ratio of minimal to maximal illuminance	Vertical	Horizontal/ratio of minimal to maximal illuminance	Vertical	Horizontal/ratio of maximal to minimal illuminance	Vertical	Horizontal/ratio of maximal to minimal illuminance	Vertical
Competitions with the number of spectators from 10000 to 25000	200/ 1/3	75	200/ 0,5	-	1500/ 2,5/1	-	750/3/1	-
Competitions with the number of spectators from 25000	400/ 1/3	100	500/ 0,7	-	1000/ 3/1	-	500/ 3/1	-

For stadiums that are able to broadcast, the regulatory requirements for lighting are presented in Table 1.3 [1, 6, 7].

Table 1.3 – Lighting requirements for stadiums with the possibility of broadcasting competitions

Class of game or sports facility	Average horizontal illuminance, lx	Uniformity of lighting	Index GR	Correlated color temperature, K	Color rendering index
I	500	0,7	≥50	>4000	80
II	200	0,6		>4000	65
III	75	0,6		>2000	20

1.2 Analysis of lighting systems for football stadiums

Thanks to simpler and less expensive operation, floodlights are used to illuminate sports facilities, including stadiums. In addition, the use of floodlights is also explained by the impossibility of placing supports with lighting fixtures in the lighting area [2]. Most football stadiums are illuminated with [1,8]:

- systems with four masts;
- systems with six / eight masts;
- linear systems.

The most common stadium lighting system is a four-mast system (Figure 1.1).

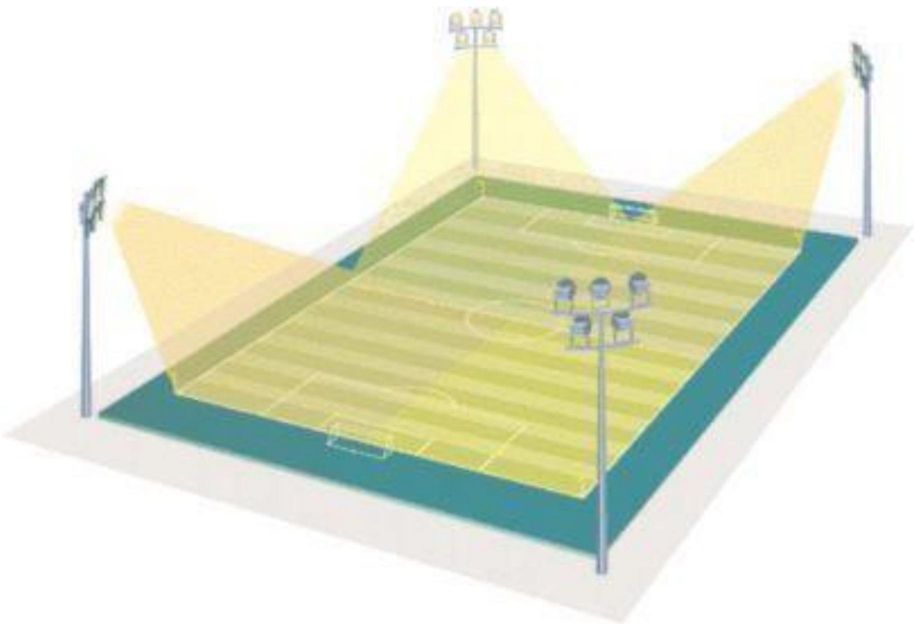


Figure 1.1 – Four-mast football stadium lighting system

With such a lighting system, the floodlights are placed on four masts of sufficiently high height, which are located behind the front line of the field. The purpose of this arrangement of the mast is to provide conditions for the goalkeeper to see the ball, not its silhouette. Spotlights placed on each mast, go to the whole field. This allows you to create both the necessary levels of horizontal illumination and high levels of vertical illumination in the plane that passes through the longitudinal axis of the football field. In addition, this location and direction allows you to achieve the required uniformity of light distribution. In the presence of spectator stands, the masts are placed behind the stands or mounted in their upper part, which minimizes the glare of players and referees. The advantage of such lighting systems is the relatively lower cost, which can be explained by the low number of masts. The disadvantage of such a system is the presence of shadow-creating properties, ie when using this system, a "cross of shadows" is created, which moves behind each participant of the match. In addition, this system is currently practically not used in the construction of new large stadiums, due to the need to increase the number of floodlights, their capacity, and hence increase the capital and operating costs of the lighting installation. For such cases, as well as for lighting training fields, a system of six / eight masts is used (Figure 1.2).

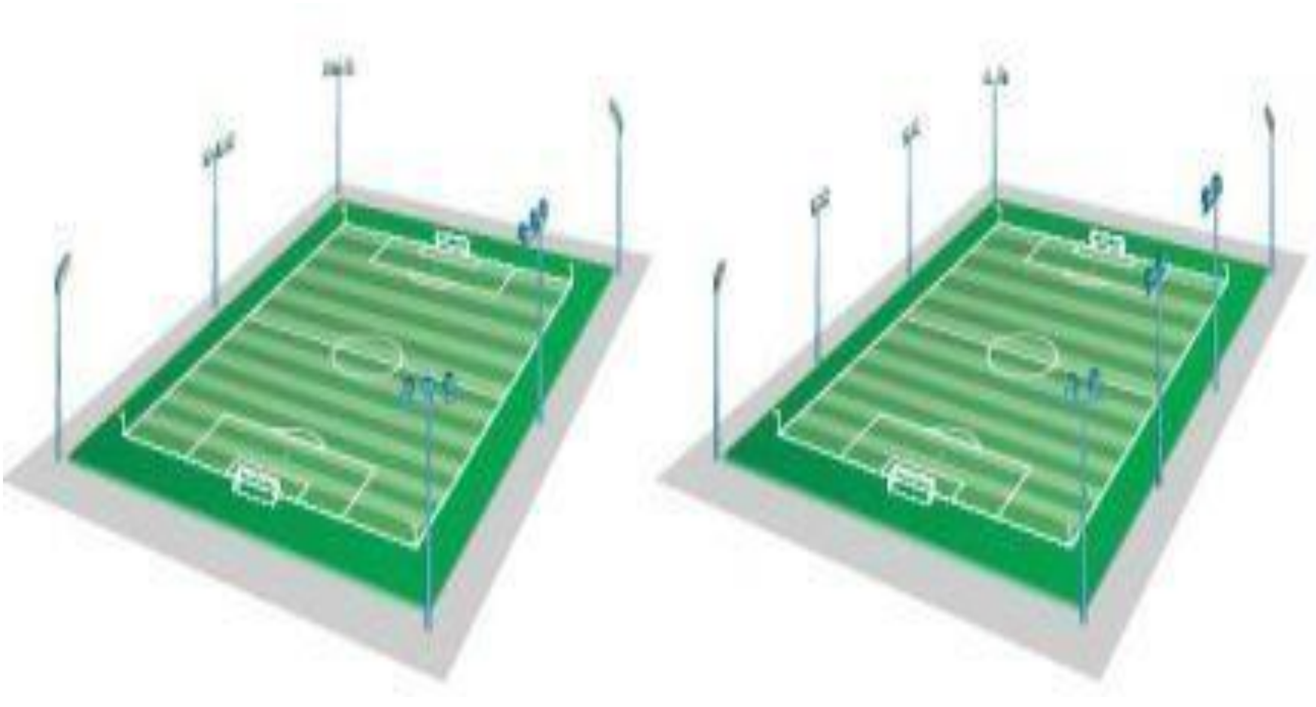


Figure 1.2 – Lighting system with six / eight masts

The use of more masts softens the shadows from the players. In addition, in this system, the spotlights are directed to the nearest 2/3 or 1/2 of the playing field, which can significantly increase the uniformity, as well as cylindrical illumination. The disadvantage of this system, compared to four-masted, is the increased level of glare due to the use of more blinding light sources. If there are visors in the stadium that cover a large part of the stands, a linear lighting system is used (Figure 1.3), in which lighting fixtures are installed in one or more rows of solid or broken lines on the stands on both sides of the football field. K. Another condition for its use is a sufficient height of the visor.

Figure 1.3 – Linear lighting system of a football stadium

The advantages of a linear lighting system are the highest uniformity, compared to mast systems, as well as the complete removal of shadows from players and the creation of volume. The disadvantage is the increased blinding effect on the participants of the match due to the large length of searchlight batteries, which are capable of occupy a significant part of the field of view in any position of the players on the football field.

1.3 Setting the task of qualifying work

The subject of design in the qualification work is the stadium, which is located in the city of Zboriv, Ternopil region. This stadium hosts trainings, as well as home meetings of the amateur football club "Kolos". Therefore, the aim of this work is to develop a lighting system for this stadium, which would provide regulatory requirements for lighting of stadiums of this level.

2 PROJECT DESIGNING SECTION

2.1 Characteristics of the design object and the choice of standardized lighting characteristics

The object of design is stadium (Figure 2.1), located in the city of Zboriv, Ternopil region. The stadium is designed both for the training process and for home matches of the amateur football club "Whirlwind", which plays in regional football competitions.

Figure 2.1 – Location of the stadium on the map of city of Zboriv

The characteristics of the football field of the stadium are as follows:

1. length – 100 m;
2. width – 65 m;
3. the distance from the side line of the football field to the inner edge asphalt

treadmills – 1 m;

4. treadmill width – 2.5 m

For further design we use the requirements given in the standard [6]. As competitions of regional level take place on the object of design, it belongs to sports facilities of the II level. For such football stadiums, the lighting requirements to be met are as follows:

- average illumination in the horizontal plane – 200 lux;

- uniformity of illumination, which is determined by the ratio of the minimum illumination to the maximum – 0.6;

2.2 Choosing a lighting system

To illuminate the stadium, choose a four-mast lighting system, following the following requirements [1, 8]:

- the angle between the perpendicular lowered to the longitudinal axis of the field or its continuation from any light fixture, and the horizontal plane must be at least 27º (Figure 2.2);

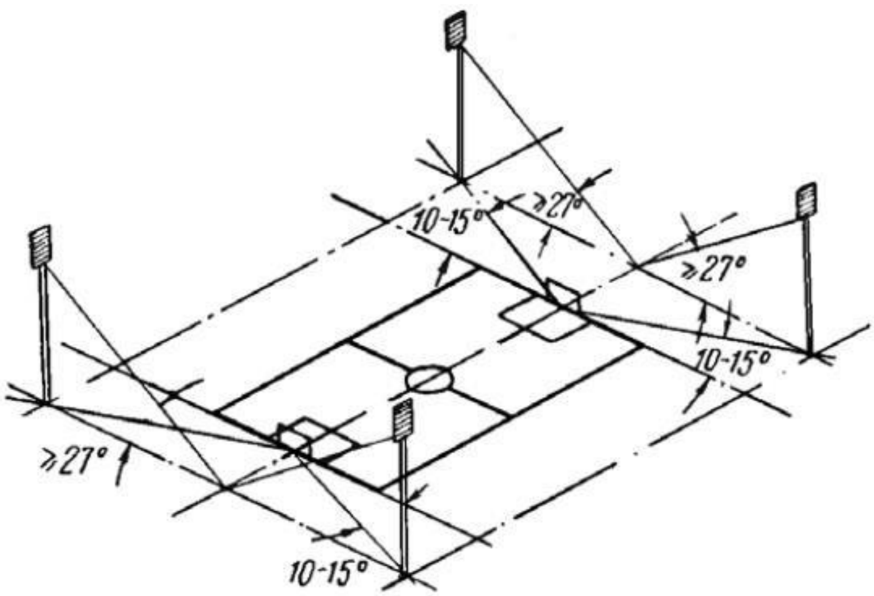


Figure 2.2 – Requirements for the location of masts in a four-mast system lighting

- a line that is behind the front line and connects the points placement of the bases of the mast, should be at a distance from the front line, it is sufficient that the angle between the direction from the base of the mast to the center of the gate and the front line of the field was 10 - 15°;

- the minimum angle between the lines connecting the bases of the mast with the middle of the side line is 5º.

We place the supports of light devices at a distance of 8.5 m from the side line of the football field and at a distance of 7.5 m from the front line of the field. The angle α between the lines connecting the bases of the mast with the middle of the side line can be calculated by the formula:

$$\alpha = arctg\frac{\Delta a}{\frac{B}{2} + \Delta b}, \tag{2.1}$$

where $\Delta a = 7{,}5\,\text{m}$ – the distance between the front line and the bases of the masts;

$B = 65\,\text{m}$ – width of the football field;

$\Delta b = 8{,}5\,\text{m}$ – the distance between the side line and the bases of the mast.

Substituting numerical values for Δa, B, Δb in the formula (2.1), we obtain

$$\alpha = arctg\frac{7{,}5}{\frac{65}{2} + 8{,}5} = 10{,}4°,$$

which is permissible because the angle-should be in the range of 10 to 15º.

Angle β between the lines that are connecting the bases of the masts with the middle of the sidelines are calculated by the formula:

$$\beta = arctg\frac{\Delta b}{\frac{A}{2} + \Delta a}, \tag{2.2}$$

where $A = 100\,\text{m}$ – length of the football field;

Substituting numerical values for Δa, A, Δb in the formula (2.2), we obtain

$$\beta = arctg\frac{8,5}{\frac{100}{2}+7,5} = 8,4°,$$

which is acceptable because the minimum value of the angle should be 5°.

For such arrangement of supports the minimum height $H_{\min}$ installation lighting fixtures is:

$$H_{\min} = \frac{B}{2}\cdot tg27°. \qquad (2.3)$$

Substituting values $B = 65$ m in the formula (2.3), we obtain:

$$H_{\min} = \frac{65}{2}\cdot tg27° = 16,5 \text{ m}.$$

With this in mind, place light fixtures on masts 24 m high (Figure 2.3).

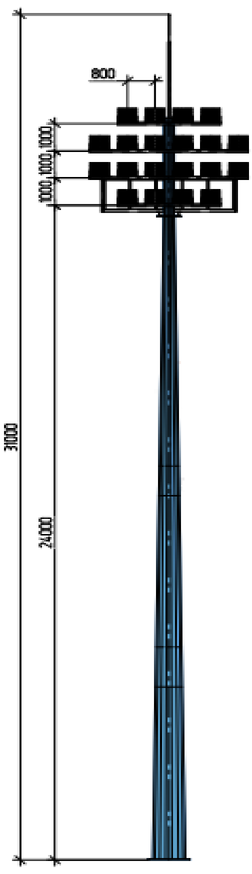


Figure 2.3 – Mast for lighting the football stadium

2.3 Selection of light sources and lighting devices

When choosing light sources, the following characteristics must be taken into account:

1) lighting - luminous flux, radiation spectrum, correlated color temperature, color rendering index;

2) electric - supply voltage, power consumption;

3) energy and economic - light output, service life, cost.

According to the principle of operation, all light sources, which currently generate 98-99% of the total luminous flux, can be divided into three types: thermal (incandescent and quartz-halogen incandescent), gas-discharge (fluorescent, metal halide, sodium, mercury and others).) and semiconductor light sources (LEDs).

At lighting of sports objects by the State building norms [3] the use of discharge lamps is recommended. Since fluorescent lamps have lighting characteristics, they are not recommended for liginhsttinagbility outdoor buildings and outdoor lighting. For other types of discharge lamps, the best energy characteristics are sodium lamps (Table 2.1), the principle of which is to use the resonant radiation of sodium D-lines. There are two types of sodium lamps: high (SLHP) and low pressure (SLLP) [1, 9].

Table 2.1 – Characteristics of sodium lamps

Characteristic	SLLP	SLHP
Maximum power, W.	180	1000
Correlated color temperature, K	2300 … 4900	2300 … 2900
Color rendering index	40 … 60	40 … 60
Light output, lm/W.	200	150
Service life, thousand hours	9 … 12	12 … 28
Burning time, minutes	5 … 7	

The disadvantages of sodium lamps are:

- low color rendering index;

- prolonged burning;

High pressure mercury arc lamps are now widely used in both indoor and outdoor lighting systems. The main characteristics of arc mercury lamps are presented in table 2.2.

Table 2.2 – Characteristics of mercury arc lamps

Power, W	80 … 2000
Correlated color temperature, K	3000 … 6000
Color rendering index	40 … 70
Light output, lm/W.	30 … 60
Service life, thousand hours	10 … 12
Burning time, minutes	7

The disadvantages of arc mercury lamps are:

- low color rendering, due to the predominance of spectral the composition of the radiation of the blue-green part;
- possibility of use in networks with alternating current;
- high level of light flux pulsations;
- significant reduction of luminous flux at the end of service life.

Structurally, metal halide lamps are similar to arc mercury lamps, and they differ in the additional introduction into the burner of special additives (sodium, waist, indium, etc.). As a result, the light output of the lamp (74 - 108 lm/W) is significantly increased and a high color rendering index is provided. The characteristics of metal halide lamps are given in table 2.3. The level of pulsations of light flux in metal halide lamps is significantly lower than in arc mercury lamps, and the service life is from 8 to 15 thousand hours.

The disadvantages of metal halide lamps are as follows:

- the dependence of the lighting parameters of the lamp on its position during operation (has a horizontal position);
- high cost;

- require a sufficiently long time to ignite and re-ignition;
- decrease in luminous flux during service life reaches 40%;
- the presence, as in all bit light sources, contains mercury requires special disposal methods.

Table 2.3 – Characteristics of metal halide lamps

Power, W	70 … 20000
Correlated color temperature, K	3000 … 6500
Color rendering index	65 … 92
Light output, lm/W.	74 … 108
Service life, thousand hours	8 … 15
Burning time, minutes	10

Until recently, semiconductor light sources were used only in indication and signaling systems. However, currently, LEDs are used in light fixtures of low, medium and high power. The main characteristics of semiconductor light sources are given in table 2.4.

Table 2.4 – Characteristics of semiconductor light sources

Correlated color temperature, K	2700 … 6500
Color rendering index	70 … 95
Light output, lm/W.	150 … 250
Service life, thousand hours	50 … 100
Burning time, minutes	-

The main disadvantage of semiconductor light sources is the need for efficient heat dissipation, which leads to an increase in the overall size of light devices based on light-emitting diodes, as well as their mass.

The advantages of semiconductor light sources are as follows:

high energy efficiency;

high mechanical strength (no glass bulb);

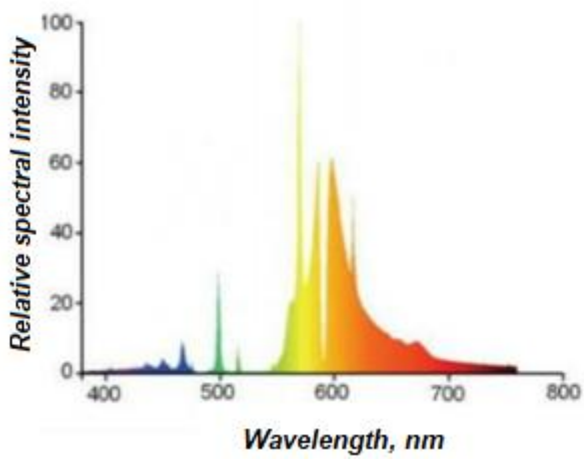
long service life;

no influence of the number of inclusions on the service life;

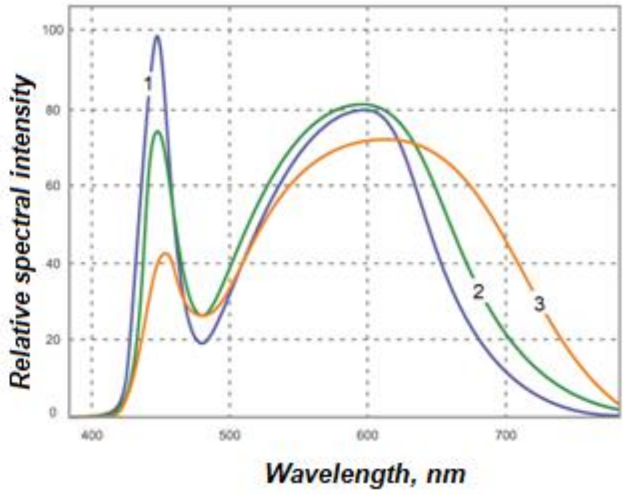
continuous spectrum radiation (Figure 2.4);

the ability to turn on immediately at full cost;

environmental friendliness (absence of mercury component).



a)



b)

Figure 2.4 – Spectral composition of radiation of sodium lamp (a) and LEDs (b) cold white (1), neutral white (2) and warm white (3) glow colors

Based on the above characteristics, as well as advantages and disadvantages, to illuminate the stadium as a light source, we will choose to use semiconductor light sources.

According to regulatory requirements correlated color temperature of light sources in lighting installations of sports facilities should is 4000 K, and the color rendering index for stadium lighting systems without television broadcasting must be at least 65. To illuminate the football field of the stadium, we will choose light devices of the floodlight type DSU05U (model A-max) (Figure 2.5), manufactured by VATRA Corporation (Ukraine) [10].

The purpose of this spotlight is to illuminate sports complexes infrastructure, squares and other open spaces, territories of construction, transport and agricultural facilities, quarries, as well as production, agricultural and storage facilities. Features of this spotlight:

- degree of dust protection – IP 67;
- operating voltage range – 120… 375 V;
- presence of anti-vibration fastening;
- smooth inclusion of light diodes allows to prolong their term services;
- the presence of a reversing circuit for each LED protection that allows to continue the searchlight in normal mode.

Figure 2.5 – Image of the searchlight DSU05U (model A-max)

Technical characteristics of the DSU05U floodlight (model A-max) are given in table 2.5.

Table 2.5 – Technical characteristics of the searchlight DSU05U (model Amax)

Power, W.	150 … 1400
Luminous flux, lm	20250 … 189000
Light output, lm/W.	135
Correlated color temperature ,K	4000
Active power factor	0.95
Operating temperature range	-40 … +60 ºC

2.4 Selection of components of the electric lighting network

The Rules for the Installation of Electrical Installations [11] state that a voltage of not more than 220 V AC or DC is usually used to power general lighting fixtures. According to the reliability of power supply, all power receivers are divided into categories:

electric receivers, interruption in the power supply of which is impossible or can be allowed only for the time of automatic inclusion of the reserve – I category;

electric receivers for which an interruption in the power supply is allowed only for the time required to turn on backup power by regular personnel (up to 1 hour) – Category II;

electric receivers, interruption in the power supply of which is allowed for a while, required for repair or replacement of damaged equipment (not more than 1 day, 24 hours) – III category.

It is the category of electric receivers that determines the reliability of their power supply circuit. According to [12], the reliability of the power supply system lighting of the stadium, as an object with the number of simultaneous stay of people up to 800, belongs to the III category of power supply. Electricity consumers of this category can be supplied from one transformer substation. Moreover, all types of load can be supplied by independent lines both from the low voltage bus of the transformer substation and from the entrance to the house.

The plan of stadium lighting networks is presented in Figure 2.6. The floodlights will be powered by four group lines from the control panel, which is located in the administrative building of the stadium, to the lighting poles. On each lighting pole we will install a cabinet to control the lighting from the spotlights, which are located on this pole.

Laying of cables of group lines from a control panel to control cabinets of searchlights is carried out underground, and from control cabinets to light devices - in the middle of a support.

Figure 2.6 – Plan of stadium lighting networks

In accordance with the Rules [11], it is recommended to power outdoor lighting systems with the TN-C earthing system, in which the main earthing bus is a grounded neutral, to which all exposed parts, as well as housings and metal parts of light fixtures are connected by additional neutral wires. which are able to conduct electric current (Figure 2.7) [1, 13].

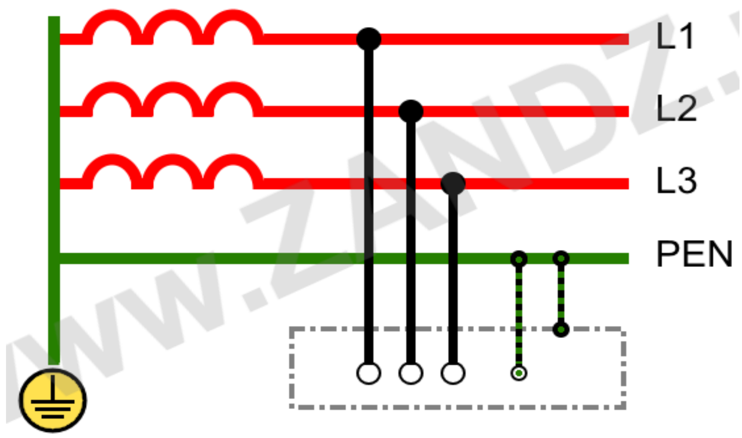


Figure 2.7 – Schematic of the grounding system type TN-C

As cables for underground laying we will choose a copper armored four core cable like ВббШв, and for laying inside a support - the ВВГнг cable.The lengths and brands of group line cables from the control panel to the control cabinets are given in Table 2.6.

Table 2.6 – Lengths of power cables about

Mast number	Cable length, m	Cable brand	Number of veins
1	144	ВббШв	4
2	60		4
3	60		4
4	119		4

Control of switching on and off of the lighting installation is carried out on the basis of use of the scheme with the electromagnetic starter (figure 2.8). The principle of operation of this scheme is as follows. Input circuit breaker 1 is on. The voltage from the main input is fed to the electrical circuit, which is in the next position. That is, the voltage from phase C is applied to the contact of the "START" button (4), and passes through the normally closed contacts of the "STOP" button (5). It will not be possible to turn on the whole circuit while the "START" button is open

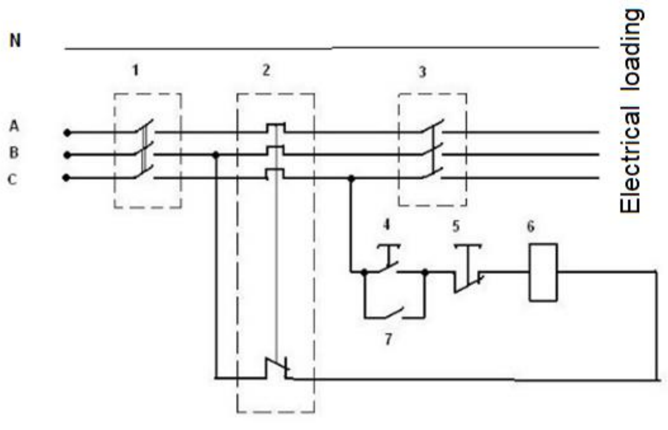


Figure 2.8 – Scheme of control of floodlights on one mast with using a magnetic starter

In the event of a short circuit, the circuit breaker 1 is triggered, as a result, the entire circuit is de-energized. When the current consumption is exceeded, the thermal relay 2 is triggered, which de-energizes the contactor winding and the load is switched off. To switch off the load in manual mode, the "STOP" button is used, when pressed, the power supply circuit of the magnetic starter coil is interrupted.

3 CALLCULATION AND RESEARCH SECTION

3.1 Initial data for lighting calculation of lighting football stadium systems

When carrying out lighting calculation, the following is taken into account:

placement of lighting devices relative to the surfaces to be illuminated;

normalized values of lighting parameters;

lighting and photometric characteristics of lamps;

stock ratio.

The previous section described the main characteristics of the floodlight type DSU05U model A-max. For further lighting calculation, we use two types of such floodlights with a power of 900 W and a luminous flux of 121,500 lm, namely: 4 floodlights DSU05U-800-511 (A-max) with a scattering angle of 30º (Figure 3.1), 24 floodlights DSU05U-800-411 A-max) with a scattering angle of 15º (Figure 3.2) [14].

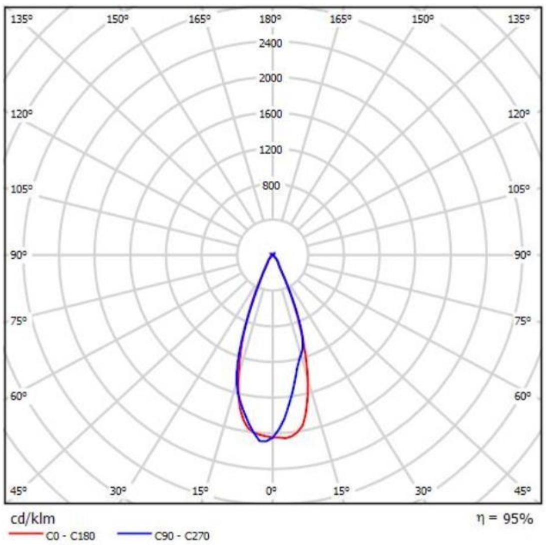


Figure 3.1 – Curve of light intensity of the searchlight DSU05U-800-511 (A-max)

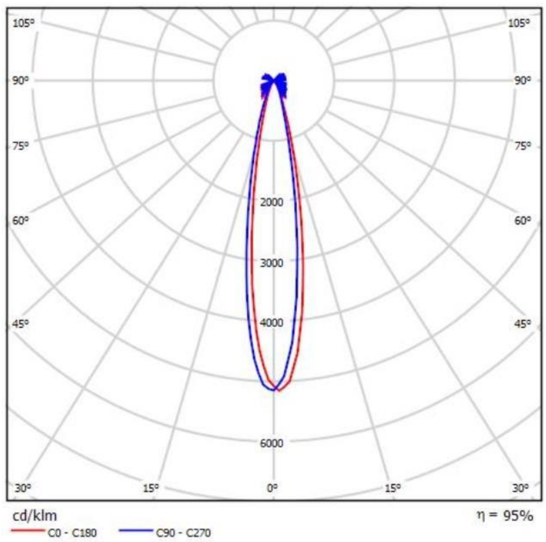


Figure 3.2 – Curve of light of a searchlight DSU05U-800-411 (A-max)

We will place the spotlights in accordance with Figure 3.3, and for the point with zero coordinates we will choose the center of the football field. The distance between the searchlight masts along the longer side of the football field is 115 m, and along the shorter – 82 m. The coordinates of the searchlights on the plan of the football stadium are given in table 3.1.

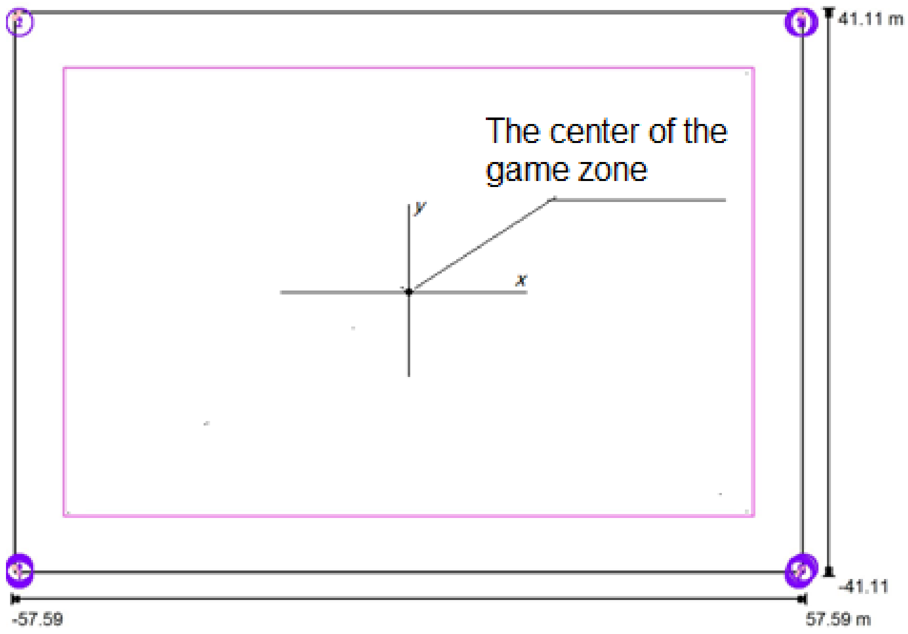


Figure 3.3 – Layout of spotlights on the plan of the football stadium

When calculating the lighting, it should be taken into account that the normalized illumination should be provided at the end of the service life of the floodlights or before the next cleaning. Therefore, we take into account the stock ratio, which is equal to the ratio of luminous fluxes at the beginning and end of the service life of floodlights. In accordance with [6] the stock ratio is 1.25.

Table 3.1 - Coordinates of spotlights on the scheme of the football stadium

№ floodlight on the plan	Spotlight type	*x*, m	*y*, m	*z*, m
1	DSU05U-800-511 (A-max)	-56.886	-40.094	24.000
2	DSU05U-800-511 (A-max)	56.886	-40.094	24.000
3	DSU05U-800-511 (A-max)	-56.886	40.094	24.000
4	DSU05U-800-511 (A-max)	56.886	40.094	24.000

Continuation of table 3.1

№ floodlight on the plan	Spotlight type	*x*, m	*y*, m	*z*, m
5	DSU05U-800-411 (A-max)	-56.691	-40.687	25.000
6	DSU05U-800-411 (A-max)	56.691	-40.687	25.000
7	DSU05U-800-411 (A-max)	-56.691	40.687	25.000
8	DSU05U-800-411 (A-max)	56.691	40.687	25.000
9	DSU05U-800-411 (A-max)	-56.891	-40.195	25.000
10	DSU05U-800-411 (A-max)	56.891	-40.195	25.000
11	DSU05U-800-411 (A-max)	-56.891	40.195	25.000
12	DSU05U-800-411 (A-max)	56.891	40.195	25.000
13	DSU05U-800-411 (A-max)	-56.600	-40.881	24.000
14	DSU05U-800-411 (A-max)	56.600	-40.881	24.000
15	DSU05U-800-411 (A-max)	-56.600	40.881	24.000
16	DSU05U-800-411 (A-max)	56.600	40.881	24.000
17	DSU05U-800-411 (A-max)	-57.355	-39.900	24.000
18	DSU05U-800-411 (A-max)	57.355	-39.900	24.000
19	DSU05U-800-411 (A-max)	-57.355	39.900	24.000
20	DSU05U-800-411 (A-max)	57.355	39.900	24.000
21	DSU05U-800-411 (A-max)	-57.237	-39.900	25.000
22	DSU05U-800-411 (A-max)	57.237	-39.900	25.000
23	DSU05U-800-411 (A-max)	-57.237	39.900	25.000
24	DSU05U-800-411 (A-max)	57.237	39.900	25.000
25	DSU05U-800-411 (A-max)	-56.733	-40.463	24.000
26	DSU05U-800-411 (A-max)	56.733	-40.463	24.000
27	DSU05U-800-411 (A-max)	-56.733	40.463	24.000
28	DSU05U-800-411 (A-max)	56.733	40.463	24.000

3.2 Lighting calculations of lighting system of football stadium

Lighting calculation searchlight lighting it is possible perform using two methods:

- by the method of light flux utilization;

- point method.

According to the utilization factor method, the number of spotlights *N*, required to provide normalized illumination *E*, can be calculated for formula [15]:

$$N = \frac{E \cdot A \cdot K}{\Phi \cdot \eta \cdot U \cdot z}, \qquad (3.1)$$

where A – the area of the object that is illuminated;

K – stock ratio;

Φ – luminous flux of light sources in the searchlight;

η – efficiency of the searchlight;

U – luminous flux utilization factor;

z – coefficient of uneven lighting.

In accordance with the point method, the calculation of floodlight is performed on the basis of the use of curves of light forces of floodlights, which can be set graphically or analytically and the illuminance of the calculated point created by a searchlight with a curve of light intensity $I(\beta_B, \beta_\Gamma)$ and may be calculated by the formula [16]:

$$E_A = \frac{I_{\beta_B \beta_\Gamma} \cdot \cos^3 \alpha}{h_C^{\;2}}, \qquad (3.1)$$

де α – the angle between the vector normal to the illuminated surface at the calculation point and direction of force $I(\beta_B, \beta_\Gamma)$.

The light intensity $I(\beta_B, \beta_\Gamma)$ is determined based on the values of the angles β_B

and $\beta_{Г}$ (Figure 3.4):

$$\beta_B = \pm\left(arctg\frac{a}{h_c} - arctg\frac{a_0}{h_c}\right),\ \ \beta_Г = arctg\left(\frac{b\cdot\cos\alpha_1}{h_c}\right). \qquad (3.2)$$

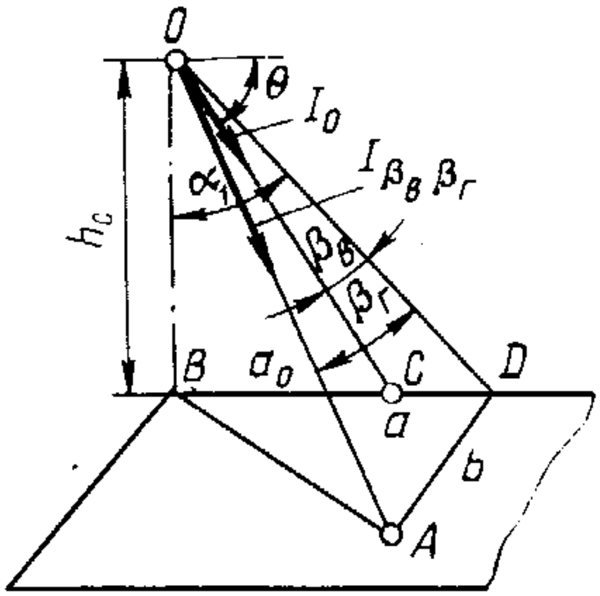


Figure 3.4 – Geometric scheme of lighting calculation of illuminance from searchlight

The use of formulas (3.1) and (3.2) for lighting calculation is somewhat difficult. The reasons for this are:

- lack of data on the luminous flux utilization factor for lighting installations with LED floodlights;

- the possibility of significant errors in determining the intensity of light in the direction of the calculation point.

In this regard, we use specialized software for modeling and lighting calculation of lighting systems, namely the DIALux package.

Entering in this package a set of output data, namely the plan of the football stadium, the coordinates of the location of lighting fixtures, photometric files of lighting fixtures (ies files with the extension. Ies or .ldt), as well as the coefficient of operation, which is numerically equal to the inverse of 0,8, we obtain the results of the calculation, is presented in Table 3.2.

Table 3.2 – The results of lighting calculation of the lighting system of the football stadium

Average illuminance, lx	224
Minimal illuminance, lx	182
Maximal illuminance, lx	248
The ratio of minimal to average illuminance	0.82
The ratio of minimal to maximal illuminance	0.74

The deviation of the average illumination from the normalized one, which is regulated by the standard [6], is:

$$\frac{224-200}{200}\cdot 100\% = 12\,\%,$$

that is permissible. In addition, the deviation of the minimum illumination from the value of 200 lx, regulated by BCH-1-73 does not exceed 10%, and therefore meets the requirements set out in this document.

Figures 3.5 and 3.6 show, respectively, the lines of uniform illumination and visualization of the distribution of illumination on the surface of the football field.

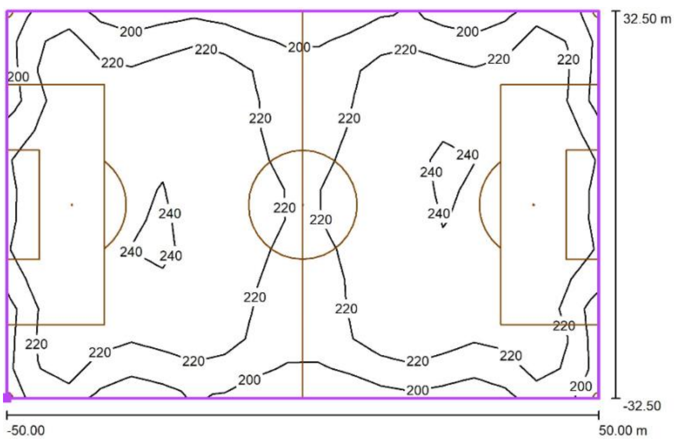


Figure 3.5 – Lines of uniform illumination of the surface of the football field of the stadium

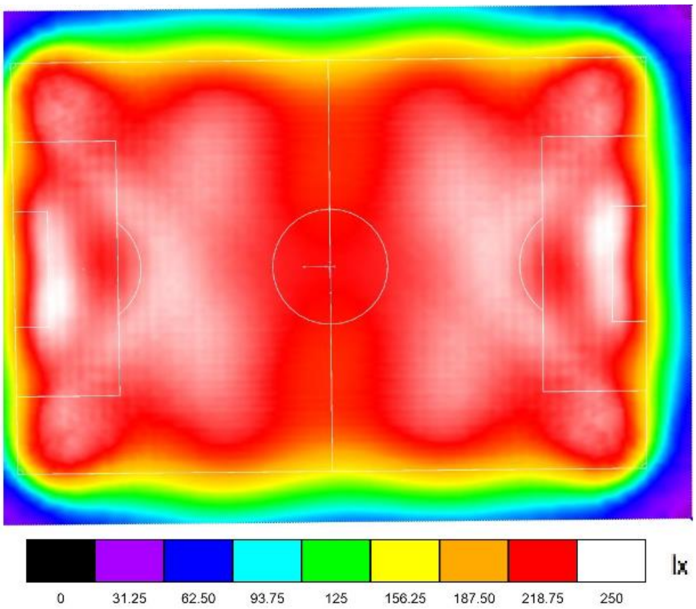


Figure 3.6 – Visualization of light distribution on the surface of the football field stadium

As can be seen from Figures 3.5, 3.6 and Table 3.2, such a lighting system meets the requirements of [6] for uneven lighting, and the ratio of minimum to maximum illumination is 0.74, while for category II stadiums this value should be at least 0 , 7. The maximum value of the light gradient between two adjacent points is 14% (Figure 3.7), while for football stadiums where no telecasts are provided, this value should not exceed 55% [2].

199	226	212	194	197	206	206	197	186	182	189	201	210	206	195	194	213	228	202
211	237	227	217	219	228	230	222	212	207	210	221	227	225	217	217	229	236	212
199	234	228	225	227	236	235	225	216	211	214	223	232	234	228	225	231	236	202
203	227	235	232	233	238	235	226	216	211	215	224	236	239	235	234	236	232	209
223	233	233	240	238	238	234	226	217	214	217	227	236	241	240	241	235	242	227
225	241	226	235	242	237	231	225	220	218	220	226	233	241	243	236	230	248	227
222	244	223	231	243	239	231	225	221	220	221	225	231	239	243	231	223	244	222
227	248	230	236	243	241	233	226	220	218	220	225	231	237	242	235	226	241	225
227	242	235	241	240	241	236	227	217	214	217	226	234	238	238	240	233	233	223
209	232	236	234	235	239	236	224	215	211	216	226	235	238	233	232	235	227	203
202	236	231	225	228	234	232	223	214	211	216	225	235	236	227	225	228	234	199
212	236	229	217	217	225	227	221	210	207	212	222	230	228	219	217	227	237	211
202	228	213	194	195	206	210	201	189	182	186	197	206	206	197	194	212	226	199

32.50 m
-32.50
-50.00
50.00 m

Figure 3.7 – The value of the illumination of the football field in the calculation checkpoints

Such values of illuminance, as well as uniformity of distribution can be achieved by directing the spotlights in the same way as shown in Figure 3.8.

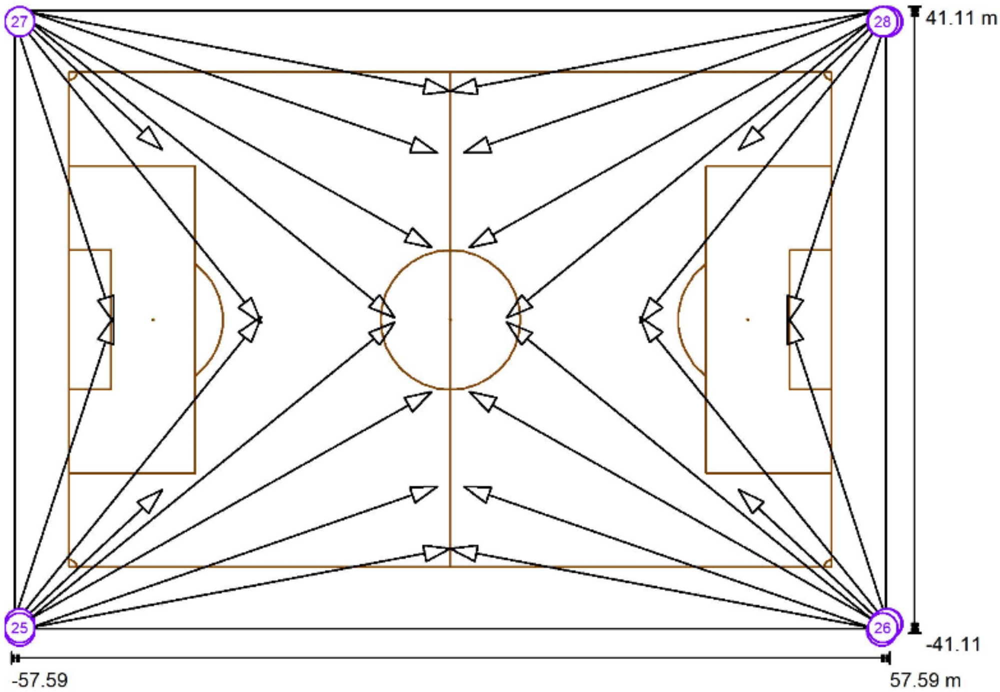


Figure 3.8 – Directions of illumination of floodlights of the lighting system stadium

Table 3.3 shows the coordinates of the lighting points, ie the points to which the maximum light forces of the spotlights are directed, as well as the angles of their inclination relative to the coordinate axes.

Table 3.3 – Coordinates of lighting points, as well as the angles of the spotlights relative to the coordinate axes.

№ floodlight on the plan	Angles of rotation of searchlights relative to the coordinate axes			Coordinates of the lighting point		
	x	*y*	*z*	*x*, м	*y*, м	*z*, m
1	47.4	0.0	-47.0	-37.800	-22.300	0.000
2	47.4	0.0	47.0	37.800	-22.300	0.000
3	47.4	0.0	-133.0	-37.800	22.300	0.000
4	47.4	0.0	133.0	37.800	22.300	0.000
5	65.6	0.0	-79.3	0.000	-30.019	0.000
6	65.6	0.0	79.3	0.000	-30.019	0.000
7	65.6	0.0	-100.7	0.000	30.019	0.000
8	65.6	0.0	100.7	0.000	30.019	0.000

Continuation of Table 3.3

№ floodlight on the plan	Angles of rotation of searchlights relative to the coordinate axes			Coordinates of the lighting point		
	x	*y*	*z*	*x*, м	*y*, м	*z*, m
9	67.2	0.0	-60.5	-2.500	-9.453	0.000
10	67.2	0.0	60.5	2.500	-9.453	0.000
11	67.2	0.0	-119.5	-2.500	9.453	0.000
12	67.2	0.0	119.5	2.500	9.453	0.000
13	66.6	0.0	-70.9	-1.700	-21.878	0.000
14	66.6	0.0	70.9	1.700	-21.878	0.000
15	66.6	0.0	-109.1	-1.700	21.878	0.000
16	66.6	0.0	109.1	1.700	21.878	0.000
17	59.5	0.0	-18.1	-44.185	0.402	0.000
18	59.5	0.0	18.1	44.185	0.402	0.000
19	59.5	0.0	-161.9	-44.185	-0.402	0.000
20	59.5	0.0	161.9	44.185	-0.402	0.000
21	63.2	0.0	-38.8	-24.797	0.400	0.000
22	63.2	0.0	38.8	24.797	0.400	0.000
23	63.2	0.0	-141.2	-24.797	-0.400	0.000
24	63.2	0.0	141.2	24.797	-0.400	0.000
25	68.3	0.0	-50.9	-7.337	-0.300	0.000
26	68.3	0.0	50.9	7.337	-0.300	0.000
27	68.3	0.0	-129.1	-7.337	0.300	0.000
28	68.3	0.0	129.1	7.337	0.300	0.000

3.3 Electrical calculation of electric lighting network stadium lighting systems with a minimum of conductive material

The choice of the cross-sectional area of the wires of the electric lighting network of the stadium is performed based on the results of the calculation of the minimum conductive material.

According to this method,*S*cross sections of wires electric lighting networks are calculated based on the use of the formula [1, 15]:

$$S = \frac{M_G}{c \cdot \Delta U}, \tag{3.3}$$

where M_G – the given moment of electric loading;

c – coefficient that depends on the network system, material and voltage and can take the following values [15]:

for a three-phase electric network with a zero wire at a voltage of 380/220 V – 72;

for two-phase electric lighting network with a neutral wire at a voltage of 380/220 V – 32;

for two-wire lighting network at a voltage of 220 V – 12;

ΔU – allowable voltage loss as a percentage of nominal $\Delta U = 2,5\,\%$ [1].

The scheme for calculating the electric lighting network is shown in Figure 3.9.

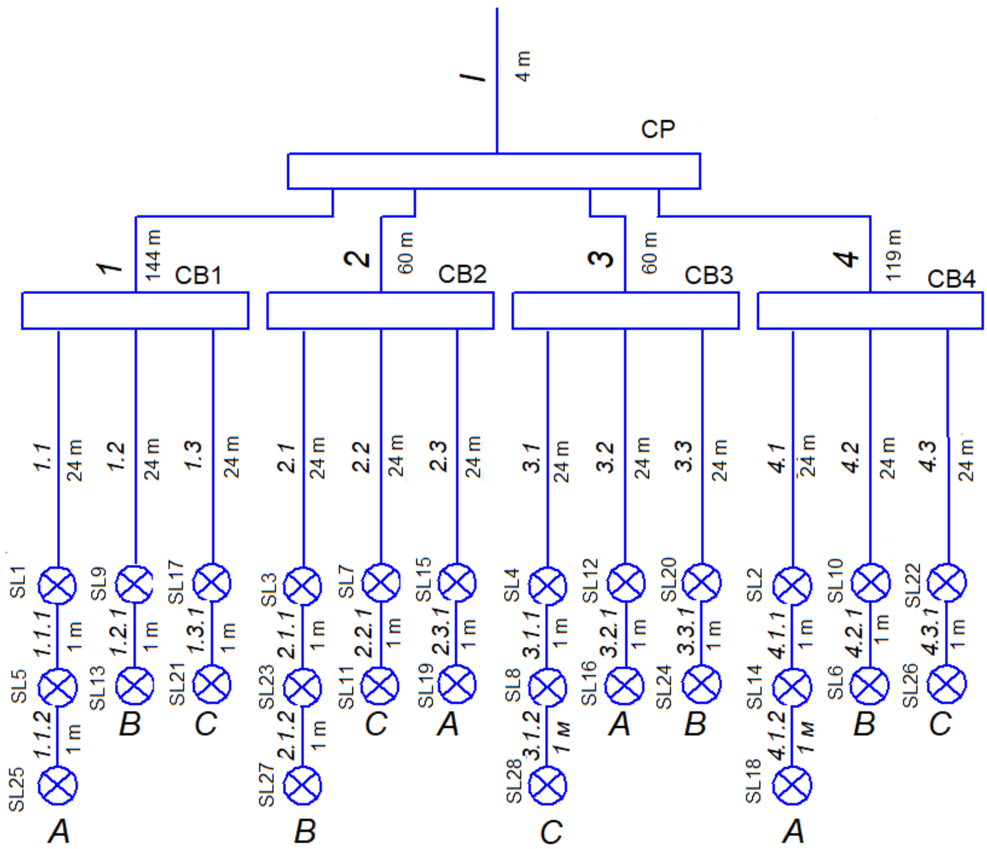


Figure 3.9 – Scheme for calculating the electric lighting network

The given moment M_G of electrical load of a specific area electric lighting network can be calculated by the formula:

$$M_G = \sum M + \alpha \cdot \sum m, \tag{3.4}$$

where $\sum M$ – the sum of specific moments and all subsequent in the direction of power sections in which the number of wires is equal to the number of wires of a particular section;

$\sum m$ – the sum of the moments of electrical loads of the areas, the power supply of which is carried out through a specific section of the electric lighting network, and the number of wires in these areas is different than the number of wires in a particular area;

α – the conversion factor of the moments, which is1.83 for the system three-phase line with zero wire - single-phase line is 1.83, 1.37 for the system three-phase line with zero wire - two-phase line with zero wire, for the system two-phase line with zero wire - single-phase line.

For sections of the electrical network 1.1.2, 2.1.2, 3.1.2 4.1.2, 1.2.1, 1.3.1, 2.2.1, 2.3.1, 3.2.1, 3.3.1, 4.2.1, 4.3.1 moments of electrical load are:

$$M_{1.1.2} = 1 \cdot 0.8 = 0.8 \text{ kW} \cdot \text{m.}$$

For sections 1.1.1, 2.1.1, 3.1.1, 4.1.1 of the electric lighting network moments of electric load are:

$$M_{1.1.1} = 1 \cdot 2 \cdot 0.8 = 1.6 \text{ kW} \cdot \text{m.}$$

For sections 1.1, 2.1, 3.1, 4.1 of the electric lighting network, the moments of electric load are:

$$M_{1.1} = 24 \cdot 3 \cdot 0.8 = 57.6 \text{ kW} \cdot \text{m.}$$

For sections 1.2, 1.3, 2.2, 2.3, 3.2, 3.3, 4.2, 4.3 of the electric lighting network moments of electric are:

$$M_{1.2} = 24 \cdot 2 \cdot 0.8 = 38.4 \text{ kW} \cdot \text{m.}$$

Moments of electrical loads of sections 1, 2, 3 and 4 are:

$$M_1 = 144 \cdot 7 \cdot 0.8 = 806.4 \text{ kW} \cdot \text{m},$$
$$M_2 = M_3 = 60 \cdot 7 \cdot 0.8 = 366.0 \text{ kW} \cdot \text{m},$$
$$M_4 = 119 \cdot 7 \cdot 0.8 = 666{,}4 \text{ kW} \cdot \text{m}.$$

The moment of the mail plot:

$$M_I = 4 \cdot 28 \cdot 0.8 = 59.6 \text{ kW} \cdot \text{m}.$$

The given moments of sections 1.1.1, 2.1.1, 3.1.1, 4.1.1:

$$M_{G1.1.1} = 1 \cdot 2 \cdot 0.8 + 1 \cdot 0.8 = 2.4 \text{ kW} \cdot \text{m}.$$

For sections 1.2, 1.3, 2.2, 2.3, 3.2, 3.3, 4.2, 4.3 electric lighting network moments of electrical load are:

$$M_{G1.2} = 24 \cdot 2 \cdot 0.8 + 1 \cdot 0.8 = 39.2 \text{ kW} \cdot \text{m}.$$

The given moments sections 1.1, 2.1, 3.1, 4.1:

$$M_{G1.1} = 24 \cdot 3 \cdot 0.8 + 2 \cdot 1 \cdot 0.8 + 1 \cdot 0.8 = 60.0 \text{ kW} \cdot \text{m}.$$

The given moments of sections 1, 2, 3 and 4 can be calculated by the formula:

$$\begin{aligned} M_{G1} &= M_1 + 1.83 \cdot \left(M_{G1.1} + M_{G1.2} + M_{G1.3}\right), \\ M_{G2} &= M_2 + 1{,}83 \cdot \left(M_{G2.1} + M_{G3.2} + M_{G3.3}\right), \\ M_{G3} &= M_3 + 1{,}83 \cdot \left(M_{G3.1} + M_{G3.2} + M_{G3.3}\right), \\ M_{G4} &= M_4 + 1{,}83 \cdot \left(M_{G4.1} + M_{G4.2} + M_{G4.3}\right). \end{aligned} \quad (3.5)$$

Substituting the numerical values of the moments in the formula (3.5), we obtain:

$$M_{G1} = 806.4 + 1.83 \cdot \left(60.0 + 39.2 + 39.2\right) = 1059.67 \text{ kW} \cdot \text{m},$$

$$M_{G2}=M_{G3}=366.0+1.83\cdot(60.0+39.2+39.2)=619.27\text{ kW}\cdot\text{m},$$

$$M_{G4}=666.4+1.83\cdot(60.0+39.2+39.2)=919.67\text{ кВт}\cdot\text{м}.$$

`The given moment of section I is calculated by the formula:

$$M_{GI}=M_{I}+M_{G1}+M_{G2}+M_{G3}+M_{G4}. \tag{3.6}$$

Substituting values M_I, $M_{П1}$, $M_{П2}$, $M_{П3}$ та $M_{П4}$ in formula 3.6, we obtain:

$$M_{GI}=59.6+1059.67+619.27+619.27+919.67=3277.48\text{ kW}\cdot\text{m}.$$

Substituting in formula (3.3) the value for M_{GI} with $c=72$

$$S_I=\frac{3277.48}{72\cdot 2.5}=18.21\text{ mm}^2.$$

From table 1.3.6 of the Rules [11] we choose wires with the nearest larger cross-sectional area $S_I=25\text{ mm}^2$. The actual voltage loss in section I is

$$\Delta U_I=\frac{59,6}{72\cdot 25}=0,033\ \%.$$

For sections of electric lighting network 1, 2, 3, 4, which are supplied through section I, the allowable level of voltage ΔU_1 will be:

$$\Delta U_1=2.5-0.033=2.467\ \%.$$

Substituting the numerical values of the reduced moments of sections 1, 2, 3, 4 in the formula (3.3), as well as the values for ΔU_1 and $c=72$, we obtain:

$$S_1=\frac{1059.67}{72\cdot 2.467}=5.97\text{ mm}^2,$$

$$S_2 = S_3 = \frac{619.27}{72 \cdot 2.467} = 3,49 \text{ mm}^2,$$

$$S_4 = \frac{919.67}{72 \cdot 2.467} = 5.18 \text{ mm}^2,$$

From table 1.3.6 [11] we accept: $S_1 = S_4 = 6 \text{ мм}^2$, $S_2 = S_3 = 4 \text{ мм}^2$. The real voltage drops on sections 1, 2, 3, 4:

$$\Delta U_1 = \frac{806.4}{72 \cdot 6} = 1.867\ \%,$$

$$\Delta U_2 = \Delta U_3 = \frac{366.0}{72 \cdot 4} = 1.271\ \%,$$

$$\Delta U_4 = \frac{666,4}{72 \cdot 6} = 1.543\ \%.$$

Permissible voltage drops in the following areas:

$$\Delta U_{1.1} = 2.467 - 1.867 = 0.600\ \%,$$

$$\Delta U_{2.1} = \Delta U_{3.1} = 2.467 - 1.271 = 1.196\ \%,$$

$$\Delta U_{4.1} = 2.467 - 1.543 = 0.924\ \%.$$

Cross-sectional areas of cables of sections fed through section 1:

$$S_{1.1} = \frac{60,0}{12 \cdot 0.600} = 8.33 \text{ mm}^2,$$

$$S_{1.2} = S_{1.3} = \frac{39.2}{12 \cdot 0.600} = 5,44 \text{ mm}^2.$$

We accept that $S_{1.1} = 10 \text{ mm}^2$, $S_{1.2} = S_{1.3} = 6 \text{ mm}^2$.

Real voltage drops

$$\Delta U_{1.1} = \frac{57.6}{12 \cdot 10} = 0.480\ \%,$$

$$\Delta U_{1.2} = \Delta U_{1.3} = \frac{38.4}{12 \cdot 6} = 0.533\,\%.$$

Permissible voltage drops in sections 1.1.1, 1.2.1, 1.3.1

$$\Delta U_{1.1.1} = 0.600 - 0.480 = 0.120\,\%,$$

$$\Delta U_{1.2.1} = \Delta U_{1.3.1} = 0.600 - 0.533 = 0.067\,\%.$$

Cross-sectional areas of these sections

$$S_{1.1.1} = \frac{2.4}{12 \cdot 0.120} = 1.66\ \text{mm}^2,$$

$$S_{1.2.1} = S_{1.3.1} = \frac{0.8}{12 \cdot 0.067} = 1.00\ \text{mm}^2.$$

We accept that $S_{1.1.1} = 2.5\ \text{mm}^2$, $S_{1.2.1} = S_{1.3.1} = 1.5\ \text{mm}^2$. Real voltage drop on the section 1.1.1

$$\Delta U_{1.1.1} = \frac{1.6}{12 \cdot 2.5} = 0.050\,\%.$$

Permissible voltage loss on the site 1.1.2

$$\Delta U_{1.1.2} = 0.120 - 0.050 = 0.070\,\%,$$

and the estimated cross-section of the cable cores

$$S_{1.1.2} = \frac{0.8}{12 \cdot 0.070} = 0.952\ \text{mm}^2.$$

We accept $S_{1.1.2} = 1{,}5\ \text{мм}^2$. Real voltage losses in section 1.1.2:

$$\Delta U_{1.1.2} = \frac{0.8}{12 \cdot 1.5} = 0.044\,\%.$$

Total voltage losses from section 1.1.2 to section I:

$$\Delta U = 0.044 + 0.050 + 0.480 + 1.867 + 0.033 = 2.474\,\%.$$

Similarly, we calculate the cross section of the wires for other areas. The results of the calculation are presented in table 3.4.

Table 3.4 – The results of the calculation of sections of the electric lighting network at least the conductive material

Section	Admissible loss voltage, %	Cross-section area, mm^2		Real voltage loss, %
		Calculated value	Table value	
2.1, 3.1	1.196	4.18	6.0	0.800
2.1.1, 3.1.1	0.396	0.51	1.5	0.089
2.1.2, 3.1.2	0.307	0.22	1.5	0.044
2.2, 2.3, 3.2, 3.3	1.196	2.73	4.0	0.800
2.2.1, 2.3.1, 3.2.1, 3.3.1	0.396	0.17	1.5	0.044
4.1	0.924	5.41	6.0	0.800
4.1.1	0.124	1.61	2.5	0.053
4.1.2	0.071	0.94	1.5	0.044
4.2, 4.3	0.924	3.54	4.0	0.800
4.2.1, 4.3.1	0.124	0.54	1.5	0.044

Total voltage losses from sections 2.1.2 and 3.1.2 to section I:

$$\Delta U = 0.044 + 0.089 + 0.800 + 1.271 + 0.033 = 2.237\ \%,$$

and sections 4.1.2 to section I:

$$\Delta U = 0.044 + 0.053 + 0.800 + 1.543 + 0.033 = 2.473\ \%.$$

3.4 Electrical calculation of electric lighting network stadium lighting systems according to the load current

The calculation of the electric lighting network on the load current is performed using the following formulas [16]:

for three-phase electrical network

$$I_c = \frac{P_c \cdot 10^3}{\sqrt{3} \cdot U_l \cdot \cos\varphi}, \qquad (3.7)$$

for two-wire electrical network:

$$I_c = \frac{P_c \cdot 10^3}{U_p \cdot \cos\varphi}, \quad (3.8)$$

where P_c – calculated power;

$U_l = 380\text{ V}$ – linear voltage;

$\cos\varphi = 0.95$ – power factor.

$U_p = 220\text{ V}$ – phase voltage.

Substituting values $P_c = 22.4\,\text{kW}$ for section I in formula (3.7), we obtain:

$$I_c = \frac{22.4 \cdot 10^3}{\sqrt{3} \cdot 380 \cdot 0.95} = 35.82\text{ A}.$$

From table 1.3.6 [11] for a given current value we choose for three-phase cables laid in the ground, choose $S_I = 2{,}5\,\text{mm}^2$. According to the received values based on the calculation of the load current and the minimum of the conductive material stop your choice on a larger cross section, and therefore on $S_I = 25\,\text{mm}^2$. Similarly, calculate the value of operating currents and determine cross-sectional areas and for the following sections. The results of the calculation are presented in table 3.4.

According to the calculated values of operating currents, we will choose protection devices [17]:

- for the section of the electric lighting network I – BA-2017 / D 3p 40A;
- for sections 1, 2, 3, 4 – BA-2017 / C 3p 10A;
- for sections 1.1, 2.1, 3.1, 4.1 – BA-2017 1p 16A;
- for sections 1.2, 1.3, 2.2, 2.3, 3.2, 3.3, 4.2, 4.3 – VA-2017 1p 10A.

We use ПМЛ-1100 magnetic starters to control the on and off of floodlights on masts.

Table 3.4 – Results of electrical calculation of the electric lighting network of the stadium

Section	Power, kW	Operating current, A	Cross-section area, mm^2		Cable type/number of cores
			By current load	At a minimum of conductor material	
I	22.4	35.82	2.5	25.0	ВббШв/4
1, 2, 3, 4	5.6	8.96	1.5	Respectively 6.0, 4.0, 4.0, 6.0	ВббШв/4
1.1, 2.1, 3.1, 4.1	2.4	11.48	1.0	Respectively 10.0, 6.0, 6.0, 6.0	ВВГнг/3
1.1.1, 1.2, 1.3	1.6	7.66	1.0	Respectively 2.5, 6.0, 6.0	ВВГнг/3
2.1.1, 2.2, 2.3				Respectively 1.5, 4.0, 4.0	ВВГнг/3
3.1.1, 3.2, 3.3				Respectively 1.5, 4.0, 4.0	ВВГнг/3
4.1.1, 4.2, 4.3				Respectively 2.5, 4.0, 4.0	ВВГнг/3
1.1.2, 1.2.1, 1.3.1, 2.1.2, 2.2.1, 2.3.1, 3.1.2, 3.2.1, 3.3.1, 4.1.2, 4.2.1, 4.3.1,	0.8	3.83	1.0	1.5	ВВГнг/3

4 LABOUR OCCUPATIONAL SAFETY AND SECURITY IN EMERGENCY SITUATIONS

4.1 First aid for a person affected by electric shock

Electric shock occurs when a current of 0.06 A or more passes through the human body. A current of 0.1 A is lethal to humans. The amount of current flowing through a person depends on the resistance of his body. Human resistance to electric current - a variable and depends on many factors, including human fatigue, his mental state. The average value of this resistance is in the range of 20-100 kO. Under particularly unfavorable circumstances, the resistance can drop to 1 kO. In this case, a voltage of 100 V and below will be life-threatening. At low voltage, resistance mainly depends on the condition of the skin. In the CIS, the calculated value of the electrical resistance of the human body is taken to be equal to 1.0 kO. The resistance of the human body depends on the frequency of the current. It becomes the smallest value at current frequencies of 6-15 kHz. The passage of current through the heart is especially dangerous. Much of it passes through the heart in the following ways:

right arm - legs - 6.7%;

left arm - legs - 3.7;

hand - hand - 3.3; foot - foot 0.4% of the total striking current.

Direct current is less dangerous. Yes, we will hardly feel direct current up to 6 mA. At a current of 20 mA there are cramps in the muscles of the forearm.

Alternating current begins to be felt already at 0,8 mA. A current of 15 mA causes contraction of the arm muscles. The risk of DC and AC damage changes with increasing voltage. At voltages up to 220 V alternating current is more dangerous, and at voltages above 500 V - direct current. The greater the current flow, the lower the electrical resistance of the body. If the current is not interrupted quickly, death can occur.

In the case of the passage of current through the victim from hand to foot is essential the material and quality of shoes are important. Electric current can cause severe damage, up to cardiac arrest and respiratory arrest. Therefore, you need to be able to help the victim before the doctor arrives.

First of all, it is necessary to quickly release the victim from the action of electric current, ie to disconnect a current circuit by means of the nearest plug socket, the switch (switch) or by turning of stoppers on a board. If the switch is far from the scene, the wires can be cut or cut (each wire separately) with an ax or other cutting tool with a dry handle of insulating material. If it is impossible to break the circle quickly, it is necessary to pull the victim off the wire or throw the end of the broken wire away from the victim with a dry stick. It must be remembered that the victim himself is a conductor of electric current. Therefore, when releasing the victim from the current, the caregiver must take precautions so as not to be stressed: wear galoshes, rubber gloves or wrap your hands in dry cloth, put an insulating object under your feet - a dry board, rubber mat or, in extreme cases, rolled dry clothes. The victim should be pulled from the wire at the ends of his clothes, exposed parts of the body should not be touched. When releasing the victim from the current, it is recommended to act with one hand. If it is on a ladder, stand or any other device, care must be taken to prevent bumps or fractures from falling. If a person is exposed to a voltage above 1000 V, such precautions are insufficient. It is necessary to turn to specialists who will immediately relieve stress. measures must be taken to prevent blows or fractures in the event of a fall. If a person is exposed to a voltage above 1000 V, such precautions are insufficient. It is necessary to turn to specialists who will immediately relieve stress. measures must be taken to prevent blows or fractures in the event of a fall. If a person is exposed to a voltage above 1000 V, such precautions are insufficient. It is necessary to turn to specialists who will immediately relieve stress.

First aid measures depend on the condition of the victim after discharge from current. To determine this condition it is necessary:

- immediately put the victim on his back;

- unbutton clothing that makes breathing difficult;

- check on the rise of the chest, whether he is breathing; verify

the presence of a pulse (on the radial artery in the wrist or on the carotid artery in the neck);

- check the condition of the pupil (narrow or wide).

A wide stationary pupil indicates a lack of cerebral circulation.

Determination of the victim's condition should be carried out quickly, within 15 - 20 seconds. For this:

a) if the victim is conscious, but was previously unconscious or was under electric shock for a long time, he must ensure complete rest before the arrival of the doctor and further observation for 2-3 hours;

b) in case of impossibility to call a doctor quickly, the victim must be taken to a medical institution immediately;

c) in case of serious condition or lack of consciousness it is necessary to call a doctor (ambulance) to the scene;

d) in no case may the victim be allowed to move: the absence of severe symptoms after defeat does not exclude the possibility of further deterioration of his condition;

e) in the absence of consciousness, but the surviving breath, the victim should be placed comfortably, create a flow of fresh air, sniff ammonia, sprinkle with water, rub and warm the body. If the victim is breathing poorly, very rarely, superficially or, conversely, convulsively, like a dying person, artificial respiration should be performed;

f) in the absence of signs of life (breathing, heartbeat, pulse) can not be considered dead. Death in the first minutes after defeat can only surrender and the victim can come to life with care. The victim is threatened with irreversible death if he is not immediately treated in the form of artificial respiration with simultaneous heart massage. This event must be carried out continuously at the scene before the arrival of the doctor;

g) the victim should be transferred only in cases when the danger continues to threaten the victim or the person providing assistance.

4.2 Economic significance of measures to improve protection conditions labor

The economic importance of labor protection is assessed by the results obtained by changing social indicators through the implementation of measures to improve working conditions: increase productivity; reduction of unproductive costs of time and labor; increase the working time fund; reduction of costs associated with staff turnover due to working conditions, etc.

Increasing the working time and efficiency of equipment use is achieved by reducing downtime during the shift due to deterioration of health due to working conditions and microtrauma. With a complex effect on a person of several harmful production factors, downtime in the workplace can reach 20 ... 40% per shift due to occupational injuries and ill health. The growth of unproductive time, and hence labor, is also due to poor organization of workplaces: without organometric requirements there is a need to perform unnecessary movements and additional physical effort due to awkward position, poor location of equipment controls and poor design of jobs.

As a result of improving working conditions, the psychological climate in the workforce is normalized, work organization is increased, and labor productivity is increased. The increase in the working time fund is achieved by reducing round- the-clock losses on occupational injuries and absenteeism. Harmful working conditions significantly affect not only the occurrence of occupational diseases, but also the occurrence and duration of common diseases.

The effectiveness of measures to improve working conditions and safety is assessed, first of all, by indicators of social efficiency, which include the creation of working conditions that meet sanitary norms and requirements of the rules security.

Improving working conditions and safety leads to a reduction in occupational injuries, general and occupational diseases; to reduce the number of employees working in conditions that do not meet sanitary and hygienic standards; reducing the number of cases of retirement due to disability or occupational disease; reduction of staff turnover due to unsatisfactory working conditions, etc.

The following indicators are used to assess the social effectiveness of measures to improve working conditions and safety:

- reduction of the number of jobs that do not meet the requirements labor safety regulations;
- reduction of the number of employees working in conditions that are not meet sanitary standards;
- increase in the number of machines, mechanisms and production facilities, reduced to the requirements of labor protection standards;
- reduction of the incidence rate;
- reduction of the severity of injuries;
- reduction of the incidence rate of occupational diseases due to unfavorable working conditions;
- reducing the severity of the disease;
- reducing the number of cases of disability retirement due to injury or occupational disease;
- reduction of staff turnover due to unfavorable working conditions.

Assessment of socio-economic effectiveness of measures is carried out at enterprises of all forms of ownership, including the workplace, the site, the shop It can also be determined by industry and the state as a whole.

Indicators of social and socio-economic efficiency are calculated as the ratio of social or socio-economic outcomes to the costs required to implement them. Such indicators characterize the number of conventional units of the total volume of social or socio-economic result per unit cost.

Indexes social and socio-economic efficiency used to determine the actual level of unit costs needed to reduce the number of people working in unsatisfactory conditions, reduce injuries, morbidity, staff turnover in various enterprises and in the economy as a whole.

GENERAL CONCLUSIONS

1. Analysis and comparison of requirements for lighting systems football stadiums, which are put forward to lighting systems and are regulated by both domestic and international regulations.

2. Based on the analysis of football stadium lighting systems for lighting of this design object, it is proposed to use a four-mast lighting system. The minimum distances between the masts and the edges of the football field, as well as the minimum height of the lighting fixtures are calculated.

3. Based on the analysis of the main characteristics of light sources for LED floodlights of the DSU05U type (model A-max) were chosen to illuminate the football field of the stadium. As a result of lighting calculation in the DIALux package it was found that the use of 4 floodlights DSU05U-800-511 (A-max) and 24 floodlights type DSU05U-800-411 (A-max) allows you to create a horizontal average illumination of 224 lux at a normalized value of 200 lux. The coefficient of uniformity of illumination is 0.74 at a normalized value of 0.6. The power of the lighting installation is 22.4 kW.

4. Based on the results of lighting calculation and placement lighting fixtures proposed a plan of electric lighting network, for which the calculation of the minimum conductive material and the load current and the selection of the cross-sectional area of cables. The maximum value of the voltage drop for such an electric lighting network is 2.474%.

5. For this electric lighting network on the basis of calculated values of operating currents the choice of protection devices and switching equipment is made.

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