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INDUSTRIAL PLANTS II

Chapter seven (part 3): Lighting plants

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

CAMPUS OF PORDENONE

UNIVERSITY OF TRIESTE

Criteria for choosing the lighting plant

In choosing a new plant of lighting industrial must take into account these factors:

- height of suspension of the sources;
- characteristics of the power lines;
- annual operating hours of the equipment;
- cost of electricity;
- cost of the plant;
- cost of maintenance;
- need of partialize the zones to be illuminated.

The use of light sources more efficiently, with greater luminous flux emitted at constant electrical power consumption, and repainting of the rooms allows to increase the illuminance in industrial environments without changing the distribution networks.

Lighting systems

Criteria for choosing the lighting plant

In the design phase of a lighting plant should take account of the following parameters:

a) lighting requirements, with particular reference to the level of illuminance suitable for a visual task, the luminance ratio, the index allowable glare, the directionality of the light, the color rendering and the color of the light;
b) constraints to the planimetric arrangement, the possible need for two levels of illumination, the color of the walls, ceiling and floor, the reflective elements (floors, desks, etc.). and environmental conditions;
c) operating conditions, with particular reference to the annual hours of operation of the plant, the cost of electricity for lighting and to the cost of periodic maintenance.

Methods for calculation of the illuminance

A correct project of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

- geometric characteristics of the environment analyzed;
- reflection coefficients of the various surfaces delimiting the environment;
- type of lamp, or rather of the lighting body, chosen;
- average illuminance level set.

The goal is to define the number and the distribution of the lighting fixtures needed to get on the floor the working illuminance level established, creating satisfactory conditions for viewing.

Methods for calculation of the illuminance

To design an artificial lighting system is first necessary to define the illuminance on the working plane (or on decking plane).

The calculation methods most used are:

1) method of the point for point (or punctual)
2) method of the total flux.

The choice of one or the other system depends:

- from the available data;
- by the number and position of light sources;
- by the presence of shielding or reflective surfaces.

In general:

- the first method is adopted for outdoor areas;
- the second method for closed environments.

The use of the computer allows, therefore, to easily use the first method for closed environments.

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

a) punctual method

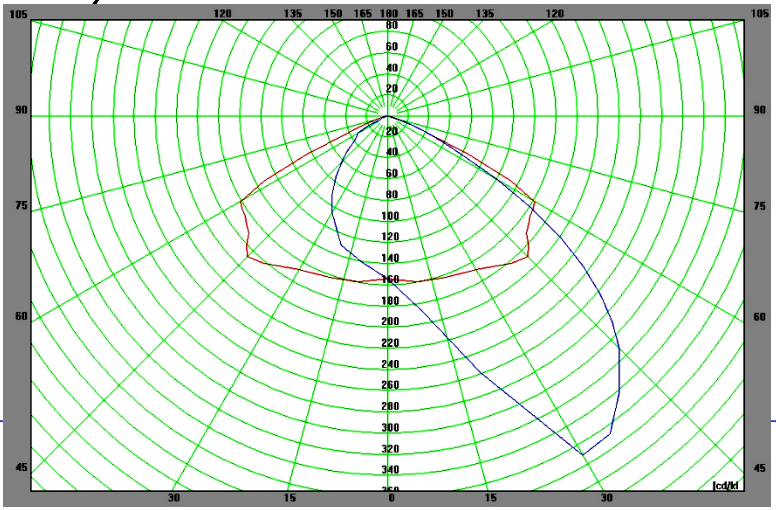
It is fundamental in the case of outdoor lighting or surfaces of reduced dimensions; it employs formulas relating to the calculation of the illumination at a point due to point sources, linear or equivalent, and is used as occurs in the calculation of interior lighting.

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

a) punctual method

This calculation method is used to determine the illuminance that you will have on a given area, known the number and characteristics of the light sources installed. The calculation, repeated for a number of points is sufficiently high, allows to construct diagrams of illumination (photometric curves)



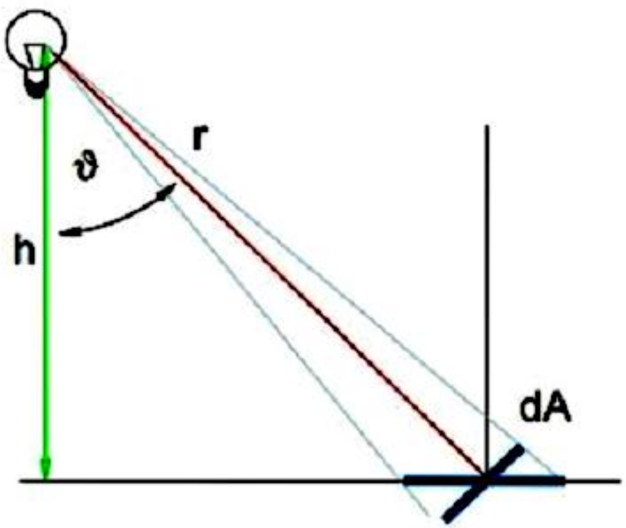
Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

a) punctual method

In the case where there is a source to a fixed height h, which emits a luminous flux toward the ground, can be defined:

$$h = r \cdot \cos \vartheta$$



with:

h = distance of the source from the floor or from the work surface (m);

r = distance of the point illuminated by source (m).

<u>Methods for calculation of the illuminance</u>

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

a) punctual method

The direct illuminance produced by a point source on a surface refers to the plane perpendicular to the radius E_n (lux) is defined by the relation:

$$E_n = \frac{I}{r^2}$$

having indicated with I the intensity of light emitted by the source in the direction of the point(cd).

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

a) punctual method

If the illuminated surface is horizontal, then the relationship becomes:

$$E_o = \frac{I \cdot \cos\vartheta}{r^2} = \frac{I \cdot \cos^3\vartheta}{h^2}$$

In the case in which more light sources that contribute to illuminate the same point, it must be separately calculate the illumination produced at that point by each light source and then carry out the sum of the individual illuminance. The values are then divided by the factor of maintenance provided in relation to the maintenance cycle considered

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

b) method of the total flux

Allows a rapid calculation of the total flow necessary on a work plan to ensure a certain illuminance, but the premise is regular in shape and the luminous centers are arranged in a uniform manner.

This method takes into account various factors, such as the size of the venue, the characteristics of the device and the color of the walls, ceiling and floor, and is based on a number of factors which must be chosen with care to get the satisfactory results. The result has to be corrected, as in the punctual method, with the maintenance factor.

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

b) method of the total flux

Established an average illuminance E_m requested and provided in the design stage on the working plane of the surface or on the lattice of calculation A, the luminous flux that reaches the work plane ϕ is equal to:

$$\Phi = E_m \cdot A$$

that is related to the total flux emitted by the lamps ϕ_T è is detectable by the relation:

$$\Phi_T = \frac{E_m \cdot A}{u \cdot m}$$

where:

m = maintenance coefficient (< 1, usually 0.8), which depends on the cleanliness of the device and the depreciation of the lamp. This coefficient is determined experimentally;

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

b) method of the total flux

The total flux emitted by the lamps ϕ_T is detectable by the relation:

$$\Phi_T = \frac{E_m \cdot A}{u \cdot m}$$

where:

u = utilization coefficient (<1), which depends of the type of device, the geometry of the environment and the reflection coefficients. It is defined by the ratio between the total flux incident on the illuminated plane, which usually coincides with the work plane, and the total flux emitted by the lamps installed in the environment; it depends on the shape of the room and, in particular, by its height, the efficiency and the type of luminaire and the reflection coefficient of the ceiling, walls and floor.

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

b) method of the total flux

To define the coefficient is necessary to know the so-called index of local K, which is given by:

$$K = \frac{a \cdot b}{h \cdot (a + b)}$$

where:

a = width of the room;

b = length of the room;

h = height of the light sources with respect to the working plane.

It is noted that the coefficient of utilization increases with the amplitude of the local and decreases with increasing height of installation. This coefficient is determined experimentally.

Methods for calculation of the illuminance

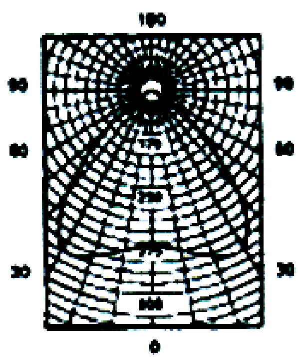
Un impianto di illuminazione deve essere progettato sulle base delle:

b) method of the total flux

The figure gives curves phonometric, yields, the coefficients of utilization and the maximum spacing for some types of appliances and lamps used in industrial environments.

NB: the values of u refer to buildings in average conditions of cleaning characterized by reflection coefficients equal to: ceiling: 50%, walls 50% and floor: 10%

Diffusing reflector with lamp at sodium vapor A.P.

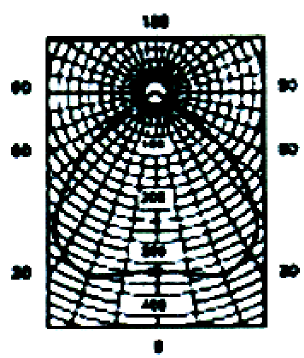


250 W

Yield (with cover glass): 66%

Relationship of distance between the reflectors and mounting height: ≤1.6

Maximum angle of intensity: 25°



400 W

Yield (with cover glass): 64%

Relationship of distance between the reflectors and mounting height: ≤1.7

Maximum angle of intensity: 20°

utilization coefficient u		
K	250 W	400W
0,60	0,49	0,43
0,80	0,56	0,51
1,00	0,62	0,57
1,25	0,66	0,62
1,50	0,69	0,66
2,00	0,74	0,70
2,50	0,76	0,73
3,00	0,78	0,76
4,00	0,80	0,77
5,00	0,81	0,78

Methods for calculation of the illuminance

Un impianto di illuminazione deve essere progettato sulle base delle:

b) method of the total flux

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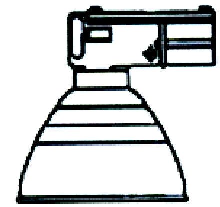
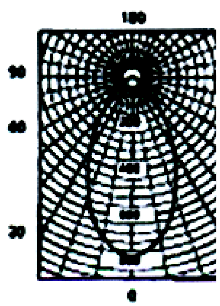


Diffusing reflector with lamp at sodium vapor A.P.

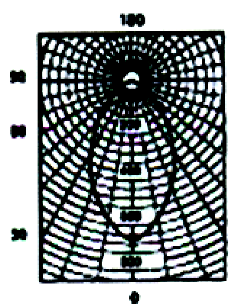


250 W

Yield (with cover glass): 76%

Relationship of distance between the reflectors and mounting height: ≤1.0

Maximum angle of intensity: 0°



400 W

Yield (with cover glass): 74%

Relationship of distance between the reflectors and mounting height: ≤1.0

Maximum angle of intensity: 0°

Utilization coefficient u

K	250 W	400W
0,60	0,54	0,51
0,80	0,60	0,58
1,00	0,66	0,64
1,25	0,70	0,69
1,50	0,73	0,72
2,00	0,78	0,77
2,50	0,81	0,80
3,00	0,83	0,82
4,00	0,85	0,84
5,00	0,86	0,85

Methods for calculation of the illuminance

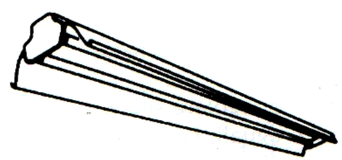
Un impianto di illuminazione deve essere progettato sulle base delle:

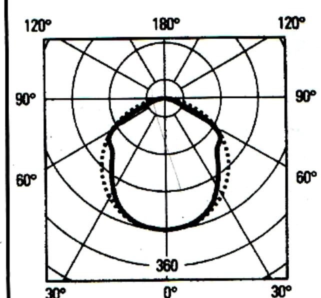
b) method of the total flux

The figure gives curves phonometric, yields, the coefficients of utilization and the maximum spacing for some types of appliances and lamps used in industrial environments.

NB: the values of u refer to buildings in average conditions of cleaning characterized by reflection coefficients equal to: ceiling: 50%, walls 50% and floor: 10%

Reflector at two fluorescent tubes





2x35 W

Yield (with cover glass): 76%

Relationship of distance between the reflectors and mounting height: ≤1.6

Maximum angle of intensity: 0°

Utilization coefficient u	
K	2/36 W
0,60	34
0,80	41
1,00	48
1,25	52
1,50	56
2,00	61
2,50	65
3,00	68
4,00	70
5,00	72

Changes to the table: Values 2 * 36 W - the values of the two columns should be understood divided by 100

Methods for calculation of the illuminance

A correct design of artificial lighting must take into account the intended use and the visual tasks to be performed within the room, and should be designed on the basis of:

b) method of the total flux

The number of lighting devicesprovided N is defined by the ratio of the total flow required ϕ_T and that emitted from a single lighting fixture to be installed ϕ_L:

$$N = \frac{\Phi_T}{\Phi_L} = \frac{E_m \cdot A}{\Phi_L \cdot u \cdot m}$$

Lighting systems

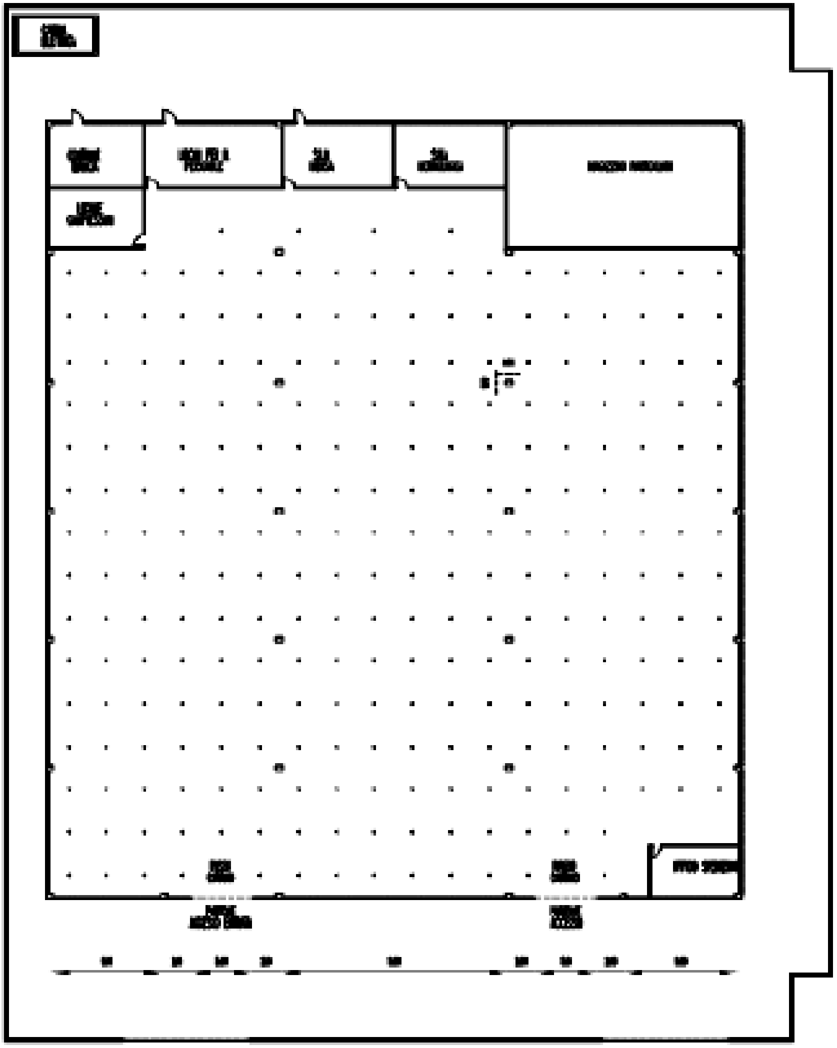
<u>Methods for calculation of the illuminance</u>

<u>Example of lighting calculation of a workshop with the method of the total flux</u>

Consider the example of a company that performs precision machining third parties.

It has a workshop of size 50 x 70 m, with the lighting equipment installed at a height of 18 m with respect to the working plane.

The devices are the type scattering with vapor lamp, high pressure sodium (AP) 400 W, luminous flu Φ_L 47,000 lm and optical efficiency of 64%.



Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

The reflection coefficients are: ceiling 50%, walls 50% and floor 10%, while the conditions of cleaning are scarce. The average lighting system is expected to 700 lux.

It first calculates the index of local k using the formula:

$$K = \frac{a \cdot b}{h \cdot (a + b)}$$

where:

a = 50 m, b = 70 m, h = 18 m and then:

$$K = \frac{50 \cdot 70}{18 \cdot (50 + 70)} = 1,62$$

Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

To find the total number of devices necessary to N, then the formula:

$$N = \frac{E \cdot A}{\theta_L \cdot u \cdot m}$$

being:

E = average illuminance expected = 700 lux;

A = area of the room (50 x 70) = 3500 m^2 ;

θ_L = initial flux emitted by a lighting devices= 47000 lm;

u = utilization coefficient = 0,65 (indicated by the table in front of the value of the local K = 1,62);

m = maintenance factor = 0,75 (seen in the table of the same name previously considered).

Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

Then:

$$N = \frac{700 \cdot 3500}{47000 \cdot 0{,}65 \cdot 0{,}75} = 107 \ \ apparecchi$$

Assuming subdivide the property (surface 3500 m ^ 2) in 35 "mesh" rectangular of (15 x 6.7 m) 100.5 m^2 each, the number of devices that will illuminate each mesh will be equal to :

$$\frac{107}{35} = 3{,}05$$

It takes the value 3.

Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

Therefore:

- the number of luminaires final N' to be taken in each grid is:

  105 (35 mesh x 3 devices for mesh)

- the illumination of the work plan and final E' will remain 700 lux forecast at regime

Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

As mentioned, the design of lighting systems may be performed by specific calculation programs on a PC.

The electric power input from the electric lighting that will power the lamps will be:

P = number of devices definitive N’ · nominal power of a lamp = 105 · 400 = 42 kW

At this value you will have to add the lost power relative to accessories for the ignition ("power") detectable by the catalogs of the Builders and reputable for lamps considered, at 30 W each; then to 42 kW will have to add another 3.15:

$$105 \cdot 30 = 3150 \text{ W} = 3{,}15 \text{ kW}$$

Methods for calculation of the illuminance

Example of lighting calculation of a workshop with the method of the total flux

In total, the electric power consumed overall by the electrical lighting will be equal to:

$$42 + 3,15 = 45,15 \text{ kW}$$

Worth noting, for completeness, since the power factor of such lamps is of the order of 0,30÷0,45, will necessary to re-phase the plant, through the distributed compensation of each lamp, up to the value of 0.95.

Lighting systems

Installation of lighting devices

The objectives to be asked for the installation of the lighting fixtures are:

- rational and smooth installation of the lamps;
- ease of access for maintenance;
- non-interference with other engineering communications and structures;
- possible enhancement or reduction - in the future - the lighting level.

Installation of lighting devices

The lighting devices can be installed:

a) at ceiling or at flush chain

The solution adopted in the sheds at low flat roof, halls high with any type of coverage and those served by overhead cranes;

b) below that level or lowered

The solution is often adopted in workshops with heights under chain of 6-8 m, with networks of overhead pipes, overhead conveyors and lofts.

Installation of lighting devices

The lighting devices can be installed:

a) at ceiling or at flush chain

The installation of lighting devices as high as possible is usually less expensive, because you can take distributions with a few light spots of high intensity; the height does not affect much on the performance of the system if the dimensions of the room are large enough.

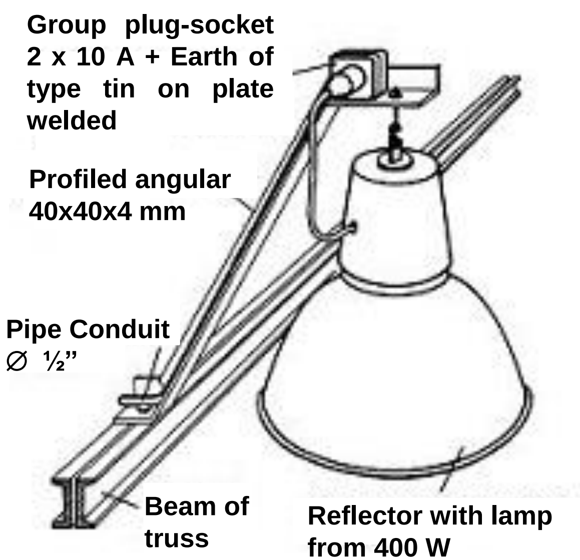
It seeks to achieve a regular arrangement situating devices and distances roughly equal, with values of the ratio distance / height generally next to one and you take armor to concentrated flow.

Installation of lighting devices

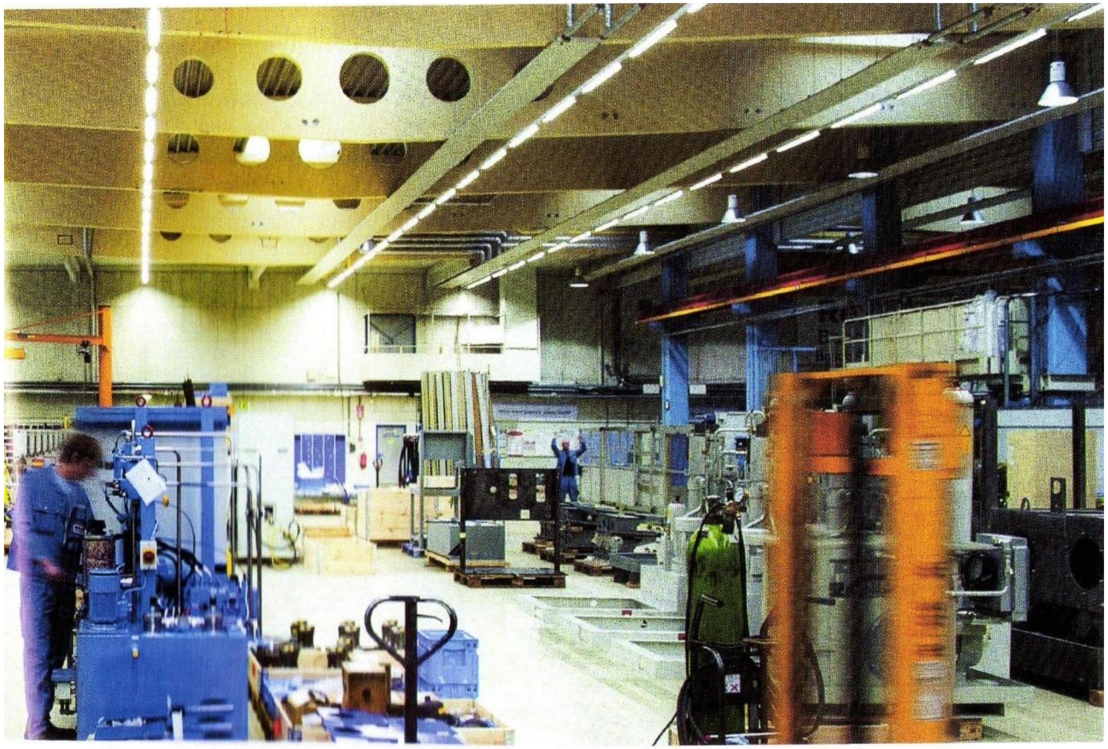
The lighting devices can be installed:

a) at ceiling or flush chain

The devices are suspended to the structures of the cover, just below the rafters or on the sides of these when you have to avoid interference with overhead cranes or other transportation overhead.



Installation of lighting devices



Fluorescent lighting and reflectors in a mechanical engineering company

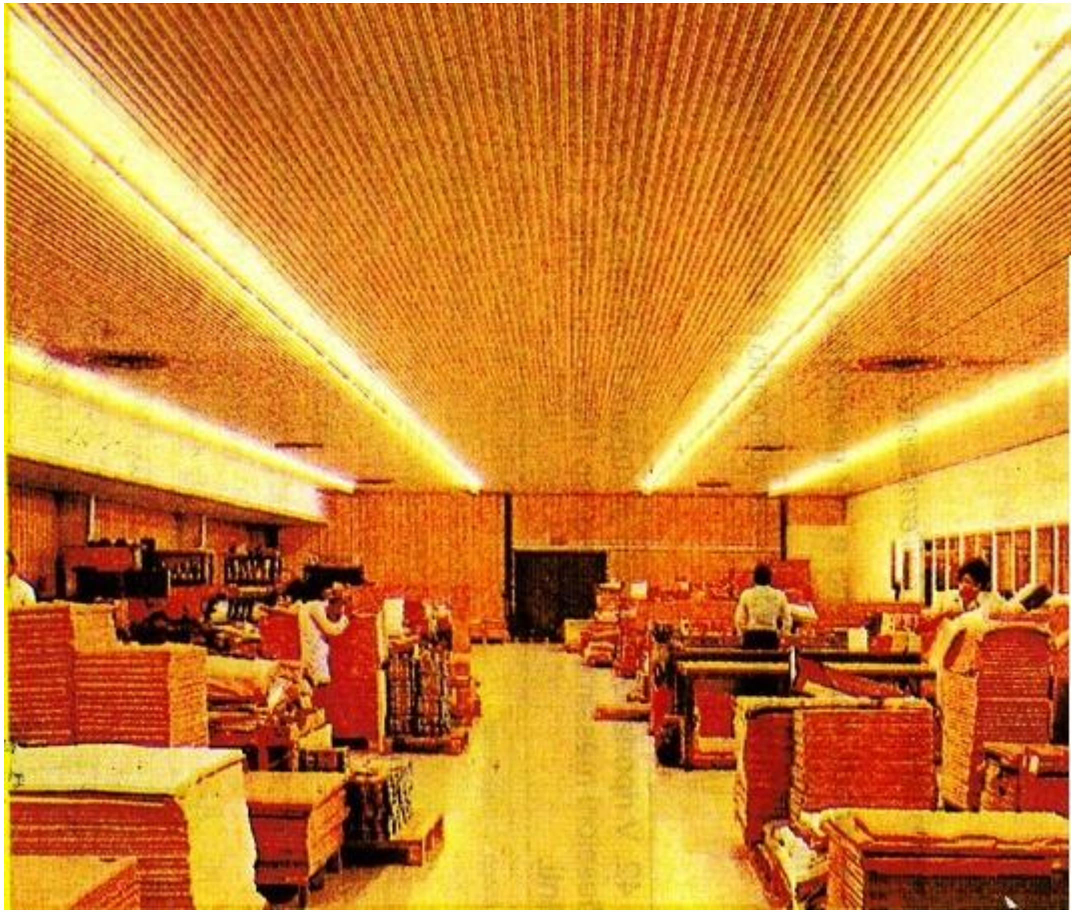
Lighting systems

Installation of lighting devices

Fluorescent lighting at a department of the Danieli of Buttrio

Lighting systems

Installation of lighting devices



Lighting fluorescent tubes in a textile company

Lighting systems

Installation of lighting devices

Lighting fixtures with fluorescent tubes in a shoe factory

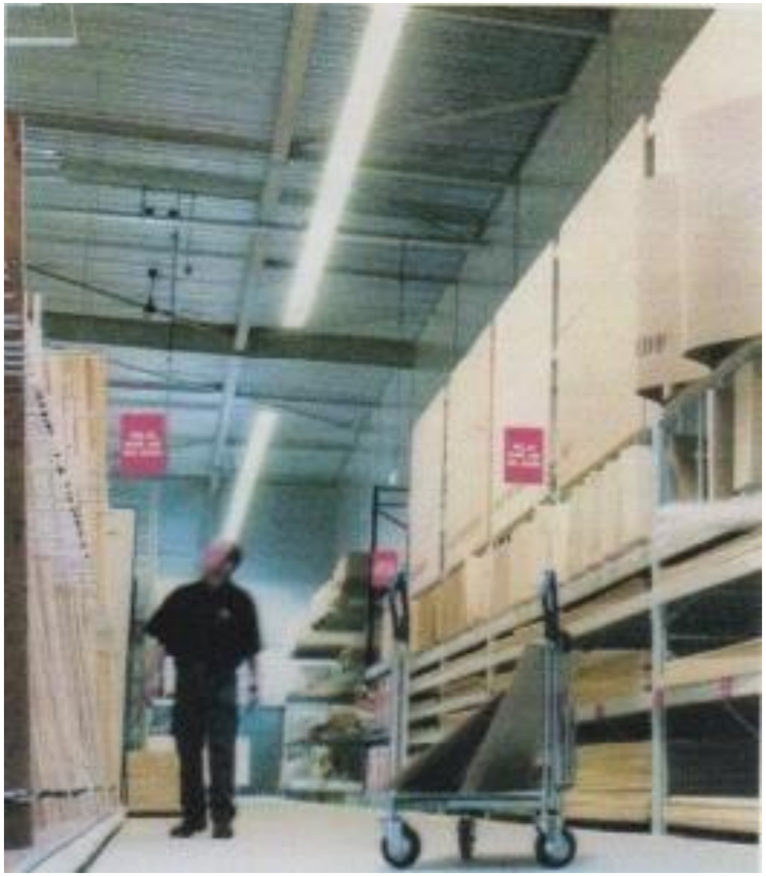
Lighting systems

Installation of lighting devices

Lighting in continuous lines in fluorescent tubes suspended in a company for the production of motor vehicles

Lighting systems

Installation of lighting devices



Lighting lines of lighting fixtures with fluorescent tubes

Installation of lighting devices

Lighting lines of lighting fixtures with fluorescent tubes

Lighting systems

Installation of lighting devices

The lighting devices can be installed:

a) at ceiling or flush chain

The devices are powered with single-phase lines and ground wire inserted inside a protective metal tube attached to the trusses.

Each unit is connected to the line via a plug socket, which facilitates removal during periodic checks. The accessories (reactor, capacitor, ignitor) can be allocated in a container built into or mounted separately to reduce weight to handle during maintenance.

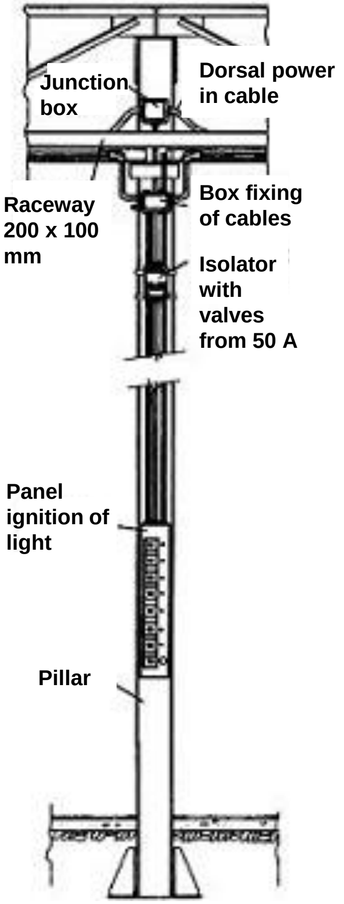
Installation of lighting devices

The lighting devices can be installed:

a) at ceiling or flush chain

The power lines converge on a control panel with automatic circuit breakers.

Each switch controls a single-phase circuit fed some lamps (total load 6-10 A); the circuits are divided into different stages to balance the load and reduce the stroboscopic effect

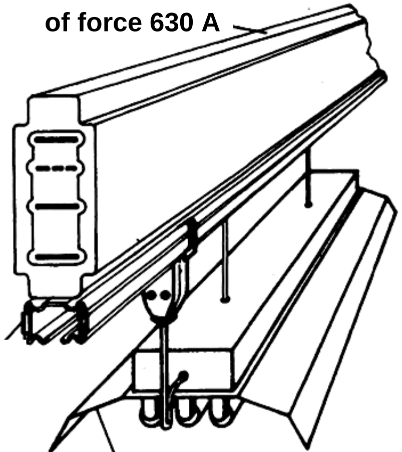


Installation of lighting devices

The lighting devices can be installed:

b) below that level or lowered

The suspension of each reflector through tiges or chains that hanging from the roof is no longer in use. Are routinely adopted structures prefabricated constituents continuous beams; they allow to install the lighting equipment at different distances, in relation to the illuminance to be obtained, and at heights from the working surface of 4-5 m, where possible, provisions are made integrated with the lines armored of distribution of driving force.



Installation of lighting devices

The proportions of the lines and the control scheme are another important element in the design phase of the lighting system.
The lines, which feed the lighting system, must be checked not only for the scope of the permissible current, but also from the point of view of the maximum voltage drop, which must be contained within 3% of the nominal voltage. The luminous flux emitted by the lamps is influenced by the tension.

Installation of lighting devices

In the proportioning of the lines, you accept a voltage drop of 2-2.5% on main lines between the cabin and the electrical control panel and 0.5-1% on extension lines. It is appropriate that the power factor of the load light is made to the contract value of 0.95 on each lighting fixture (phase plug of lighting systems - figure).

Lighting systems

Installation of lighting devices

The wiring diagram more widespread is the one with the dorsal phase and neutral frameworks that feed zone, from which depart phase lines that supply groups of lamps, intercalated with those of other groups in order to reduce the stroboscopic effects. The command can be by local cabinet or centralized.

Lighting systems

Security lighting

In work environments there is much talk of hygiene and safety in the workplace and the lighting is one of the features to be observed. As for security lighting refers to fire regulations. and with UNI and CEI relating to methods of execution.

The most recent to be referred to are:

- Presidential Decree May 30, 1995, n. 419, D.M. March 10, 1998, D.M. 19 August 2002 Decree. April 9, 2008, n. 81 and Decree. August 3, 2009, n. 106;
- UNI 9316 and UNI EN 81;
- CEI 64.8.

Lighting systems

Security lighting

The objectives to be achieved are:

- in case of lack of artificial lighting must avoid danger to persons;
- the evacuation of work areas should be in a safe and well-marked;
- in case of lack of electricity systems must be secured.

Lighting systems

Security lighting

The current legislation indicates the minimum values to be used, but it is good practice increase them for better safety measures to prevent damage to equipment, damage that may impact on the timing of resumption of production activities.

Failure to supply of electric power can sometimes be dangerous or harmful, and for this reason, in some cases, the system of security lighting must be coordinated electrically to the safety system that feeds the machines.

Lighting systems

Security lighting

Normally, we use of autonomous devices with a light source (halogen lamp or fluorescent tube) powered by battery and an electronic device adapted to turn the source in the absence of voltage, ensuring operation for a period from 1 to 3 hours (figure).

Lighting systems

Security lighting

It is also extending the use of uninterruptible power supply (UPS - Uninterruptible Power Supply).

For the legislation to the specific requirements of the light signals of safety within the workplace refers to the Decree. April 9, 2008, n. 81.