The illuminance in industrial environments

1. Introduction

The visibility of everything that surrounds us is essential to better understand the nature’s gifts. A proper lighting, whether natural or artificial, means that the objects are more highly valued and perceived.

The lighting requirements are different: highlight items, see actions of primary importance (eg. Operating rooms), the protection of people in areas at greatest risk of fire and explosion, proper illumination of roads etc. etc.

Cortem Group, focused on everything concerning lighting suitable for installation in areas with danger of explosion, has designed a series of products for Zones 1-21 and 2-22, suitable for installation and operation in potentially explosive atmospheres such as refineries, mining and Off-Shore drilling platforms, drilling and extraction FPSO ships, chemical and petrochemical plants, grain depots, paint booths, biogas plants and in all industrial areas where there may be such a risk.

2. Levels of illuminance

The UNI EN 12464-1: 2011 "Lighting of workplaces" standard defines the essential parameters for a proper illumination such as:

- Value of average illuminance that ensures visual comfort, considering the natural physiological deterioration of the light in the years of operation (Em).
- Glare harassing that prevents a correct view and that must be measured using the CIE of the unified glare (UGR).
- Yield of color, which refers to the apparent color of the light emitted and defined by the correlated color temperature (Color rendering index Ra).

3. Choosing the type of illuminance

Considering the illuminance specifications required, the most appropriate choice is made considering if:

- the areas to be illuminated are placed outside of buildings, such as handrails on access stairs and landings, instrumentation above or below the tube bundles of the process, operating machines such as pumps, compressors, heat exchangers, resistors etc… The correct choice will be the "Punctual" type (point to point);
- the areas to be illuminated are placed inside buildings closed or partially closed, for example salt compressors, generators etc. The correct choice will be the "Distributed" type, with possible incrementing of "Punctual" lighting for those areas of the building covered with large volumes of machinery and, therefore, not easily accessible by a "Distributed" illumination.
- the areas to be illuminated are parts of the plant that require a level of illumination "targeted" to the object to be illuminated, such as instruments field which require a reading during the processing stages or tanks which require a vision of the level of product. The right choice will still be the type "Punctual".

- The areas to be illuminated are of primary importance for the protection of people and things. The illuminance need serves to make reliable and safe the evacuation of the plants in case of emergency, such as:
  
a. *Emergency lighting*, designed to operate when the normal supply fails.

b. *Security lighting*, as part of emergency lighting, but it is intended to provide for the safety of the people during the evacuation of an area or of people attempting to complete a potentially dangerous operation, before leaving the zone.

c. *Backup lighting*, always as part of emergency lighting, allowing continuing the normal activities without substantial changes.

d. *Lighting of high risk areas*, even as part of emergency lighting, designed to ensure the safety of the people involved in processes or potentially dangerous situations and to allow appropriate shutdown procedures for the safety of the operator.

For all the types set out above, the designer has to speak to the process responsible, in order to perform an accurate analysis of the risk and, subsequently, proceed to the sizing of the emergency lighting system, in accordance to the UNI EN 12464-1:2011.

4. Type of area to be illuminated

For the drafting of a lighting calculation, you can use specific free software packages available on the market such as "Litestar of Soc. Oxytech", "Dialux Soc. DIAL" etc. etc., by analyzing the required needs and considering the dimensional parameters such as:

- Type of the area to be illuminated
- Average illuminance guaranteed
- Value in % of lamps decline
- Type and color of the walls, ceiling and floor, resulting, according to the UNI EN 12464-1:2011, the reflection factor of these types
- Field of view of all the visual elements, such as the size of the structures and contrast
- Distance between the light source and the floor or the work surface
- Distance between the light source and the illuminated point
- Light intensity emitted by the source in the direction of the point to be illuminated.
5. Comparison between traditional lighting fixtures and new LED technology of Cortem

To reduce the environmental impact resulting from the use of energy-inefficient solutions, the European Union member States have adopted, since the year 2005, the progressive ban of less efficient lighting products.

Currently on the plants with risk of explosion are installed lighting fixtures with lamps of different types such as filament lamps (incandescent), fluorescent and discharge lamps, mercury vapor, high pressure sodium, metal halide lamps that do not meet the mandatory requirements of this Directive.

The EuP Directive 2005/32/EC, implemented in Italy in 2007 and later repealed and replaced by the EuP Directive 2009/125/EC, implemented in Italy on 16.2.2011 with DL No. 15 and the Regulation (EC) No. 244/2009, the instrument that regulates the time steps for the transition from the old to the new lighting system (as indicated by the EuP Directive 2005/32/EC), identify the steps of banning as from Tables 1 and 2 below.

**Table 1: Phases of the ban on inefficient fluorescent lighting**

<table>
<thead>
<tr>
<th>Typology of lamps</th>
<th>2010</th>
<th>2012</th>
<th>2015</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>T8 and T5 * (* except for fluorescent lamps mini ≤ a 13W and lamp&gt; 80W).</td>
<td>Elimination of all fluorescent lamps with halophosphate inefficient (poor value lm / W and poor color rendering) or staining 33–640 and 54–765</td>
<td>Elimination of all fluorescent lamps with halophosphate inefficient (poor value lm / W and poor color rendering) or staining 33–640 and 54–765</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent T12</td>
<td>Use still allowed</td>
<td></td>
<td>Use still allowed</td>
<td></td>
</tr>
<tr>
<td>Lighting fixtures with conventional power electromagnetic (Cu–Fe) and reactors with low dispersion</td>
<td></td>
<td></td>
<td></td>
<td>Elimination of luminaires for fluorescent lamps with power class B1, B2 and electronic A3</td>
</tr>
<tr>
<td></td>
<td>No power limit but the determining factor is the luminous flux (lumens)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The products can no longer be placed on the market by producers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The EuP Directive, implemented by the Regulation (EC) No. 245/2009 (Appendix [70]), published in the Official Journal of the European Union on 24 March 2009, states, in particular, the Eco design requirements for fluorescent lamps without integrated ballast and discharge lamps. Regulation (EC) No. 245/2009, valid for lighting in the tertiary sector, has led to the prohibition of placing on the market for less efficient gas discharge lamps used in the public and industrial fields. The urgent need to get more and more efficient energy saving, among other legislative obligations as set out by the Kyoto Protocol and the European Directives, decides to impose an efficient lighting for all applications where it’s necessary to illuminate, public sector or industry.

It’s therefore evident that, from 2017, lamps that do not have the requirements of this Directive may not be put into circulation and installed.

Cortem Group, based on the provisions of the regulations, has long included in its product range a new series of lighting fixtures with LED technology that fully complies with all statutory and regulatory requirements.

In order to better understand the importance of this sea change, which aim to improve factors such as the efficiency, the lifespan, the absence of UV emissions, vibration resistance, instant restrike, the absence of light pollution, we give you the following examples of the savings resulting from the installation of new lighting fixtures with LED technology, comparing with traditional discharge lighting fixtures still in production.

First example
Area of 40x30m, lighting fixtures positioned at 5m, maintenance coefficient 0.8, average illuminance level required 300lux.

Table 2 Phases of the ban on lighting fixtures with inefficient discharge lamp

<table>
<thead>
<tr>
<th>Typology of lamps</th>
<th>Entry into force of the ban, starting from the month of April of the year</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure sodium lamps (introduced for all high-pressure sodium lamps, the minimum values of Lamp Lumen Maintenance Factor Lamp Survival Factor)</td>
<td>2010: Use still allowed, 2012: Elimination of high pressure sodium lamps with poor value for lumens / watt (low energy efficiency)</td>
</tr>
<tr>
<td>High pressure sodium lamps with integrated igniter</td>
<td>2012: Use still allowed, 2015: Elimination of high pressure sodium lamps with integrated igniter and poor value for lumens / watt (low energy efficiency)</td>
</tr>
<tr>
<td>Metal halide lamps (introduced for all metal halide, minimum values of Lamp Lumen Maintenance Factor Lamp Survival Factor)</td>
<td>2015: Elimination of metal halide lamps with Ra ≤ 80 that do not meet the minimum requirements for energy efficiency, 2017: Elimination of metal halide lamps with Ra ≤ 80 that do not meet the minimum requirements for energy efficiency</td>
</tr>
<tr>
<td>Mercury vapor lamps</td>
<td>2017: Elimination of all mercury vapor lamps</td>
</tr>
</tbody>
</table>

No power limit but the determining factor is the luminous flux (lumens)

The products can no longer be placed on the market by producers
**Case A:** traditional metal halide lamps 400W nominal, luminous flux 15,132 lm, color temperature 5,900K (Cortem Group series EWA50100IM6).

**Case B:** LED lamps 186W nominal, luminous flux 16,994 lm, color temperature 5,700K (new lighting fixture Cortem Group EWL-100 LED).

Considering the required value of average illuminance equal to 300lux, it is found that, in the case A will be necessary 42 lighting fixtures of 400W nominal (tot. 16,8kW), to obtain a value of average illuminance (Lm) equal to 310 lux, while, in case B, will be necessary the same amount of lighting fixtures but with absorption of 186W nominal (tot. 7,812kW), to obtain a value of average illuminance (Lm) equal to 312 lux. As you can well note, the energy committed to the case A is superior to the case B of 215%, thus resulting in a saving more than half of the energy normally engaged to illuminate an area of equal size with conventional lamps.

*Second example*

Area of 40x30m, lighting fixtures positioned at 5m, maintenance coefficient 0.8, average illuminance level required 300lux.

**Case C:** traditional metal halide lamps 250W nominal luminous flux 13,053 lm, color temperature 5,900K (lighting fixture series EWAT5080IM5).

**Case D:** LED lamps 86W nominal, luminous flux 8,111 lm, color temperature 5,700K (new LED lighting fixture series EVL-80).

Considering the required value of average illuminance equal to 300lux, it is found that, in the case C will be necessary to install 88 lighting fixtures 250W nominal (tot. 22,0kW), to obtain a value of average illuminance (Lm) equal to 314 lux, while, in the case D, will be necessary to install the same amount of lighting fixtures but with absorption of 86W nominal (tot. 7,568kW), to obtain a value of average illuminance (Lm) equal to 305 lux. As you can clearly see, the energy involved in the case C is higher than the case D of 290%, thus saving more than almost three-quarters of the energy normally committed to illuminate an area of equal size with traditional lamps.

Naturally LED lamps are more expensive, but the return on investment is included in a period economically acceptable given that their greater efficiency, longer life and better reliability.

Just say that the replacement of all lamps at low efficiency used worldwide for lighting systems would allow a saving of over 390 Mtoe (million tonnes of oil equivalent), or about 100 billion euro, and every year could be avoided the production of about 780milioni tons of carbon dioxide.

Based on this technological renewal, Europe would save 28 billion euro and Italy would avoid a charge of about 102 million Euros, this considering only the energy used for public lighting.
6. Consequences of light pollution

Light pollution is an alteration of light levels naturally present in the environment at night. This alteration, higher or lower depending on the location, causes damage of different nature: environmental, cultural and economic.

The main cultural damage is due to the disappearance of the night sky in more polluted Countries, starry sky that was always an inspiration to religion, philosophy, science and culture in general. Among the sciences most damaged by the disappearance of the starry sky there is astronomy, both amateur and professional; a sky too bright, in fact, limits severely the efficiency of optical telescopes that must increasingly be placed away from this form of pollution.

The economic damage is mainly due to the waste of electricity used to illuminate areas that should not be unnecessarily lit, like the sky, the facades of private buildings, meadows and fields to the side of the roads or in the middle of roundabouts. Also for this reason, one of the issues driving the fight against light pollution is energy saving.

The legislative definition most used qualifies it as "any direct irradiation of light outside of the areas in which it is functionally dedicated and in particular towards the sky."

A national law does not regulate the discipline of light pollution in Italy, at current date, even though it has been repeatedly submitted to parliament but has never come to a classroom discussion.

The individual regions have enacted regulatory texts on the subject, while the UNI 10819 discipline this matter where there is no more restrictive standard.

Depending on the technical regulations referred to, the texts can be classified into:

- Provisions based on the UNI 10819: no provisions prior to the year 2000 and the current from the Valle d’Aosta, from Basilicata and Piemonte.
- Provisions based on more stringent specifications of the UNI 10819: promulgated in final form or modified between 1997 and 2005 from Tuscany, Lazio and Campania.
- Provisions based on the criterion "zero upward light": refer to the contents of the Lombardy Regional Law 17/2000, as amended. They are based on the criterion for which, except for a few very specific exceptions, no luminaire can send light above the horizon. They were enacted from Lombardy, Emilia-Romagna, Friuli Venezia Giulia, Umbria, Marche, Abruzzo, Puglia, Sardinia, Liguria, Veneto and the Autonomous Province of Trento. All provisions subsequent to 2005 are based on these foundations. The Veneto region, the first region which issued a law to fight light pollution, has adapted its legislation in summer 2009, making it much more effective.

We conclude this technical article saying that the environment is respected taking care of it and this care must be sought in every possible action to improve the living conditions of the environment and to avoid any waste of energy, but to get that respect, it should support a greater outlay at the beginning of this action but knowing that, in the long run, it will give positive results for all mankind.