

Press Kit

Lighting systems using light-emitting diodes: health issues to be considered

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Lighting systems using light-emitting diodes (LEDs): health issues to be considered

Today, the French Agency for Food, Environmental and Occupational Health & Safety (ANSES)¹ is publishing its expert appraisal on the health issues surrounding lighting systems using LEDs; such a study has never been carried out before. Because of their low electricity consumption and high efficiency, lighting systems using LEDs are at the forefront of technology in terms of energy performance and are well-fitted to play a role in energy-saving policy. The market for these systems is growing rapidly. However, risks have been identified concerning the use of certain LED lamps, raising potential health concerns for the general population and professionals.

The principal characteristic of diodes sold for lighting purposes is the high proportion of blue in the white light emitted and their very high luminance (“brightness”). The issues of most concern identified by the Agency concern the eye due to the toxic effect of blue light and the risk of glare.

The blue light necessary to obtain white LEDs causes toxic stress to the retina. Children are particularly sensitive to this risk, as their crystalline lens is still developing and is unable to filter the light efficiently.

These new lighting systems can produce “intensities of light” up to 1000 times higher than traditional lighting systems, thus creating a risk of glare. The strongly directed light they produce, as well as the quality of the light emitted, can also cause visual discomfort.

As part of its expert appraisal, ANSES carried out various pioneering studies to evaluate the risks of these new lighting systems, on the basis of the European photobiological safety standard². Some of these products fall into higher Risk Groups than certain traditional lighting systems which are still available to the general public.

In this context, ANSES recommends that only LEDs belonging to Risk Groups similar to those of traditional lighting systems be accessible to the general public, with higher-risk lighting systems being reserved for professional use under conditions in which it is possible to guarantee the safety of workers.

Furthermore, ANSES emphasises the need to reduce the perceived luminous intensity, in order to mitigate the risk of glare.

The agency also recommends avoiding the use of light sources with a strong blue component in places frequented by children.

Lastly, ANSES has made various recommendations concerning consumer information, modifications to and implementation of the standards in force and the need for further knowledge of health issues surrounding artificial lighting.

¹ Since 1 July 2010, ANSES has assumed all the missions that were previously the responsibility of the French Food Safety Agency (AFSSA) and the French Agency for Environmental and Occupational Health Safety (AFSSET).

² NF EN 62471. This standard applies to lamps and devices using lamps. It recommends exposure limits for radiation from these light sources. It considers all of the photobiological hazards that may affect the eye (thermal and photochemical hazards) and defines 4 risk groups: risk group 0 (no risk), risk group 1 (low risk), risk group 2 (moderate risk), risk group 3 (high risk).

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1- ANSES recommendations

- **Adapt the regulatory framework and applicable standards**

Considering the health risks related to the blue light emitted by certain lighting systems using LEDs, the risk of significant glare caused by such systems and the marketing of LED-based products for light therapy, comfort or well-being, the agency recommends that:

- only LEDs falling into risk groups similar to those of traditional lighting systems be available to the general public, and that the highest risk lighting systems be reserved for professional use under conditions in which it is possible to guarantee the safety of workers.
- manufacturers and integrators of lighting systems using LEDs be encouraged to:
 - design lighting systems in which beams of light emitted by LEDs cannot be seen directly, to avoid glare. In particular, ANSES recommends the use of optical devices to reduce the intensity of light perceived directly or by reflection and to make the sources of LED light more diffuse;
 - take account of the progressive wear of layers of phosphor in white LEDs, which in time could lead to devices being moved from one photobiological risk group to a higher one
- the safety and compliance of devices for light therapy, comfort or well-being be assessed and their use regulated.

Considering that the standards in force for designing LED-based lighting installations are not always applied by professionals (electricians, lighting technicians and designers) and that the photobiological safety standard seems unsuited to lighting systems using LEDs, ANSES recommends:

- obliging professionals designing lighting systems using LEDs to apply all standards concerning the quality of lighting³
- adapting the standard entitled “Photobiological safety of lamps and lamp systems” to cover lighting systems using LEDs so as to make it easier for manufacturers to take them into account and remove any ambiguity concerning the way in which they should apply to LED systems.

ANSES considers that it is necessary to:

- give precise instructions in the standard for the measurement and evaluation of LED systems
- publish a guide for applying this standard, especially for LED systems
- determine the risk group for the worst case of observation (at a distance of 200 mm from the system) that will thus constitute the most unfavourable risk group
- adapt the standard to cover children and people with either no lenses or artificial crystalline lenses (aphakic or pseudophakic), taking into account the phototoxicity curve of the relevant type of light published by the ICNIRP⁴

³ French standard NF X 35-103 (*‘Ergonomie : Principes d’ergonomie visuelle applicables à l’éclairage des lieux de travail’* – Ergonomics: Principles of visual ergonomics applicable to lighting in the workplace), and European standards NF EN 12464-1 (*‘Lighting of workplaces – Part 1: indoor workplaces’*), NF EN 12464-2 (*‘Lighting of workplaces – Part 2: outdoor workplaces’*), the series of standards NF EN 13201 (*‘Street Lighting’*) and NF EN 12193 (*‘Sports Lighting’*).

⁴ International Commission on Non-Ionizing Radiation Protection

- consider proposing sub-groups for each risk group that would allow the risk to be assessed more precisely as a function of exposure time;
 - in the case of risk groups greater than 0, evaluate safe distances (distance at which observation corresponds to Risk Group 0) and for these to be indicated explicitly on products intended for consumers (the case of devices for the general public) or for professionals responsible for installing lighting systems.
- photobiological safety requirements be included in all safety standards concerning LEDs⁵.

- **Use, information and traceability**

ANSES recommends that consumer information about health risks related to the use of LED lighting systems be made available immediately while waiting for an appropriate regulatory framework to be implemented.

Considering the proven risk resulting from acute exposure to blue light and the uncertainty surrounding the effects of chronic exposure at low doses, as well as the fact that certain populations are sensitive to light in general⁶, ANSES recommends:

- that the use of light sources emitting bright cold light (light with a strong blue component) be avoided in places frequented by children (maternity wards, nurseries, schools, play areas, etc.) or in the objects they use (toys, electronic display panels, game consoles and joysticks, night lights, etc.);
- that patients taking medicines that increase sensitivity to light be informed about the risks related to exposure to light with a strong blue component.

Considering that there are populations of workers that are likely to be exposed to bright LED lighting systems, ANSES recommends that appropriate means of protection⁷ be developed for workers particularly exposed to LED lighting systems.

Considering the lack of information available to the public concerning the LED lighting systems on the market, ANSES recommends:

- ensuring that manufacturers and integrators of LEDs carry out quality controls and qualify their products with regard to the different Risk Groups
- setting up a clear, easy to understand labelling system for consumers, particularly concerning the technical characteristics of the lighting and any potential health and safety issues
- making it mandatory to indicate the photobiological safety Risk Group, assessed at a distance of 200 mm, on the packaging of LED products. For light sources falling under Risk Group 1, it would be necessary to indicate the safety distance beyond which the classification returns to Risk Group 0.

⁵ Especially the series of French standards NF EN 60598 ('Luminaires' and NF EN 62031: ('LED modules for general lighting. Safety specifications'); IEC standard 62560 ('Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications'); the draft IEC standard 62663-1 ('Non-ballasted single-capped LED lamps for general lighting – safety requirements').

⁶ Children, aphakic and pseudophakic persons, patients suffering from certain eye and skin diseases, patients consuming substances increasing sensitivity to light, etc.

⁷ Such as safety goggles specifically to protect against exposure to LEDs

- making it mandatory to indicate the photobiological safety Risk Group for all types of lighting.

- **Studies and research to be undertaken**

Concerning the lack of data about exposure of the general and working population to artificial light, ANSES recommends:

- enriching the available documentation on exposure of the population to artificial light in both occupational and general environments
- defining an index suitable for evaluating the intensity of glare produced by an LED source. This is because the Unified Glaring Rate used for the other types of lighting is unsuitable for LEDs, which are sources of low-angle light.

Concerning studies and research on the health issues surrounding lighting systems using LEDs, ANSES recommends:

- developing clinical research to define exposure limit values for blue light and, for this purpose, paying particular attention to the accumulative medium and long-term effects of exposure to blue light by means of prospective and retrospective studies of populations undergoing light therapy with the use of blue LEDs
- undertaking research for improved characterisation of the effects of artificial light and in particular light emitted by LED systems on biological rhythms. ANSES therefore recommends:
 - further studies for improved characterisation of the spectrum of action of the mechanisms by which light regulates the human biological clock
 - quantifying the consequences of exposure to cold artificial lights on circadian rhythms and pupil contraction
 - in general, studying the health effects of light pollution (and any links with possible maladjustment of the biological clock) and systematic installation of LED lighting systems
- studying the triggering or aggravation of photo-dermatoses caused by LED lighting
- organising measurement campaigns to characterise the electromagnetic fields generated by LED lighting systems.

Concerning studies and research to be carried out on LED technology to mitigate potential health risks, ANSES recommends:

- encouraging research for the development of new emissive materials coupled with optimised luminophores, to obtain high quality white light, with the highest possible luminous efficacy
- developing research into the design of lighting units adapted to LEDs with a view to reducing the luminance, by applying optical solutions
- studying the mechanisms that cause the degradation of the layers of phosphor in white LEDs thus potentially leading to an increase in the amount of blue light emitted

2- LEDs and health: what are the risks?

The risks identified by ANSES as causing the most concern, both because of the seriousness of the corresponding dangers and because of the probability of their occurring due to the increasingly widespread use of LEDs for lighting purposes, are related to the photochemical effects of blue light on the eye and the glare phenomenon. These are long-term risks, resulting from:

- the spectral imbalance in LEDs (high proportion of blue light in white LEDs)
- the very high luminance of LEDs⁸ (high density of brightness per surface unit emitted by these very small sources)

Risks related to blue light

Photochemical risk is associated with blue light. The risk level depends on the accumulated dose of blue light to which the person has been exposed, which is generally the result of low intensity exposure repeated over long periods. Evidence from human observation and experimental studies on cell cultures and various animal species has converged to demonstrate the particular toxicity of shortwave (blue) light for the retina. Blue light is therefore recognised as being harmful and dangerous for the retina, as a result of cellular oxidative stress.

Three populations have been identified as either particularly sensitive to the risk or particularly exposed to blue light:

- **children** (because of the transparency of their crystalline lens) and both aphakics (with no crystalline lens) and pseudophakics (with artificial crystalline lenses) who consequently either cannot or can only slightly filter short wavelengths (particularly blue light);
- **populations which are already light-sensitive:** patients suffering from certain eye diseases (e.g. ARMD) and skin conditions, patients consuming substances that increase sensitivity to light, etc. for whom blue light can be an aggravating factor for their condition;
- **populations particularly exposed to LEDs** (certain categories of workers: those installing lighting systems, theatre and film industry professionals, etc.) who are subjected to high-intensity lighting, and are therefore likely to be exposed to large quantities of blue light.

Risk related to glare

In indoor lighting, it is generally agreed that luminance higher than 10,000 cd/m² causes visual discomfort whatever the position of the lighting unit in the field of vision. Because the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source can be 1000 times higher than the discomfort level. The level of direct radiation from this type of source can therefore easily exceed the level of visual discomfort, far more than is the case with "traditional" lighting.

According to the existing scientific literature, other risks related to the use of LED lighting systems have been raised and are dealt with more extensively in the Report and the Opinion published by the Agency. However, knowledge of risks is still partial and requires further study. ANSES has made a series of recommendations to overcome this lack of data.

⁸ Luminance is the unit used to quantify the light emitted by a non-point source, per surface unit, in other words, the light density. It is expressed in candela per square metre. Candela (cd) is the unit used to quantify light intensity, in other words the brilliance of a light source as perceived by the human eye. A normal candle emits approximately 1 cd.

At the European level, a working group has been set up by the SCENIHR⁹ whose mission is to evaluate the health issues surrounding artificial lighting in the widest sense, including LEDs.

3- Regulatory framework and applicable standards: room for improvement

The Directive relative to general product safety¹⁰ applies to all products classified in sectors not covered by specific legislation. The “EC” label, which is mandatory on all electrical devices sold in Europe, is a ‘self-declaration’, indicating that the manufacturer considers that the product complies with all the EU conditions for use of the label.

Where LED lighting is concerned, EC labelling testifies that the product complies with the following essential European Directives: “Low voltage”¹¹, “Electromagnetic compatibility”¹² and “Ecodesign” (for Energy-using Products)¹³, with particular attention to product safety, their energy consumption, their emissions (noise, vibrations, radiation, electromagnetic fields), whether they can be recovered for recycling, etc.

Products that satisfy these requirements comply with specific standards, known as harmonised standards, published in the Official Journal of the European Union. Regarding LED lighting, the safety requirements that have been declared mandatory for EC labelling are described in the standards covering electrotechnical aspects of hardware safety, electromagnetic compatibility and personal exposure to optical¹⁴ and electromagnetic¹⁵ radiation.

Furthermore, the Government Decree 2010-750 of 2 July 2010, integrating directive 2006/25/EC into French law, lays down the measures to be applied to ensure that workers are protected against the risks of exposure to artificial optical radiation.

The need to adjust the standards framework

In the context of its work on the health effects of lighting systems using light-emitting diodes, ANSES examined the current standards framework and how it could be adapted to the specific features of LEDs. It found in particular that the photobiological safety standard¹⁶ seems ill-adapted to lighting systems using LEDs and furthermore that:

- the exposure limit values used to define the Risk Groups are not appropriate for repeated exposure to blue light as they were calculated for exposure of one 8-hour day and do not take into account the possibility of exposure over an entire lifetime;
- it contains ambiguities concerning the measurement protocols for attributing Risk Groups: the same LED could be assigned to different Risk Groups if considered individually or if part of an integrated lighting system, as the evaluation distance required by the standard could be different;

⁹ Scientific Committee on Emerging and Newly Identified Health Risks

¹⁰ Directive 2001/95/EC

¹¹ Directive 2006/95/EC

¹² Directive 2004/108/EC

¹³ Directive 2005/32/EC

¹⁴ NF EN 62471 standard concerning photobiological safety of lamps

¹⁵ NF EN 62311 standard concerning electromagnetic fields

¹⁶ NF EN 62471 standard

- it does not take into account the sensitivity of certain specific populations (children, aphakics, pseudophakics, etc.).

In its Report, the Agency therefore makes a series of recommendations for adapting the regulatory framework and applicable standards to take into account identified health risks and the specific features of LEDs.

4- The LED report: how did ANSES proceed?

ANSES studied the health issues arising from lighting systems using LEDs as the result of a request made on its own initiative. The expert appraisal was entrusted to the Expert Committee on “Physical agents, new technologies and development areas”, which, after a public call for applications, set up a working group including experts in ophthalmology, dermatology, lighting and the physics of optical radiation. This Report was therefore compiled by a group of experts with complementary experience and knowledge. It was carried out in compliance with the French Standard NF X 50-110 “Quality in Expert Appraisal Activities” in order to comply with the following points: competence, independence and transparency, while at the same time ensuring traceability. Such a study has never been carried out before.

The experts in this working group considered five main themes:

- a review of the current situation regarding lighting;
- a presentation of the technology behind LEDs;
- an analysis of the way light interacts with biological systems (the eyes and skin);
- a summary of the standards currently applicable to LEDs;
- an analysis of the potential health issues surrounding LEDs when used for lighting purposes.

To produce its appraisal, the working group carried out a broad review of the international scientific literature to be found in international, English-language, peer-reviewed journals, in addition to interviews with French and international scientific experts and representatives of the French Association of Lighting Professionals (*Association Française de l’Eclairage – AFE*). At the group’s request, the French Environment and Energy Management Agency (ADEME) submitted a written contribution on the French and European market for lighting systems and the recycling of lamps.

Members of the working group

Chairperson

- Mrs Francine BEHAR-COHEN – Director of Research at the National Institute for Health and Medical Research (INSERM), Physiopathology of eye diseases: innovative therapies

Members

- Mrs Annick BARLIER-SALSI – National Research and Safety Institute (INRS), specialist on optical radiation in the workplace
- Mr Jean-Pierre CESARINI – Anatomico-pathologist (past Director of the laboratory for research into tumours of human skin, A. de Rothschild Foundation and INSERM) – Ultra-violet radiation. Member of the “Physical agents, new technologies and development areas” CES
- Mr Olivier ENOUF – Engineer responsible for compliance tests of laser devices and LED products, National testing Laboratory (LNE)
- Mr Michel GARCIA – Engineer in the Lighting, Electricity and Electromagnetism (3E) Unit at the French scientific and technical centre for building (CSTB)

- Mr Christophe MARTINSONS – Head of the Lighting, Electricity and Electromagnetism (3E) Unit at the French scientific and technical centre for building (CSTB)
- Mr Serge PICAUD – Director of Research, Vision Institute, INSERM, Processing visual information in the retina, pharmacology and pathologies
- Mrs Françoise VIENOT – Professor at the Natural History Museum, Manager of the “Vision, light and appearance” Team at the Centre for research into the conservation of collections (CRCC)
- Mr Georges ZISSIS – Deputy-Director of the Plasma and Energy Conversion Laboratory, LaPlaCE, University of Toulouse 3

5- Lighting and LEDs: an overview

In France, lighting accounts for 10% of total energy consumption, or 350 kW/h per year and per household. In application of the European Eco-design Directive¹⁷, the European Commission plans a progressive ban on the sale of the most high-energy lamps. Compact fluorescent or “low-energy” lamps or other sources of energy-saving lighting such as light-emitting diodes, seem destined to replace them eventually. The French Environment and Energy Management Agency (ADEME) published an Opinion concerning the latter (LEDs) in February 2010¹⁸.

To avoid confusion:

- **A lumen (lm)** is the unit used to quantify a luminous flux.
- **A lux (lx)** is the unit used to express the illumination, in other words the luminous flux hitting a surface.
- **A candela (cd)** is the unit used to quantify the intensity of light, in other words the intensity of a light source perceived by the human eye. A normal candle emits approximately 1 cd.

Light-emitting diodes are light sources that are currently undergoing rapid technological and financial development. They have been used for several years in electronics as weak, monochromatic light sources for indicator or warning lights and are now commonly used as normal light sources in various lighting systems: traffic lights, portable lighting, vehicle lights and domestic room lighting, for example.

History of LEDs

The first visible spectrum LED was created in 1962 and emitted only very low intensity light. The blue diode was invented in the 1990s, followed by improvements to the white diode that made it possible to use it in new and important applications (mainly for lighting and for television and computer screens). The first white LEDs appeared on the market gradually, particularly for domestic lighting, and have now become increasingly powerful.

Where do LEDs stand in relation to other types of lighting?

Because of their low electricity consumption and high efficiency, these lighting systems are at the forefront of technology in terms of energy performance and are well-fitted to play a role in energy-saving policy.

Compared to the other types of lighting systems, LEDs offer greater energy efficiency. As an example, some LEDs have an efficiency as high as 100 to 150 lm/W¹⁹ whereas incandescent lamps achieve only 10 to 15 lm/W, halogen lamps 15 to 30 lm/W, and compact fluorescent lamps in the region of 50 to 100 lm/W. As for their lifecycles, current LEDs are estimated to last 50 times longer than incandescent lamps and 3 to 5 times longer than compact fluorescent lamps.

LED technology has certain disadvantages, however; the quality of the light they emit (temperature and colour rendering index) is not always equivalent to that of other systems.

¹⁷ Directive 2005/32/EC, also known as “EuP” (Energy using Products), aims to improve the energy efficiency of certain consumer goods. This Directive was transposed into national law by the Member States of the European Union in 2007 with a schedule to bring it into force between 2008 and 2010.

¹⁸ Opinion of ADEME “Lighting using light-emitting diodes (LEDs)”, *L'éclairage à diodes électroluminescentes (LED)* – available from www.ademe.fr (in French)

¹⁹ Lumens per Watt is the unit for expressing the efficacy of lighting. The lumen is the unit used to quantify luminous flux.

6- Where are LEDs found?

As a result of their low energy consumption, the market for LEDs is expanding rapidly. They are used in a growing number of sectors for a wide range of applications, including the following examples:

- **Signposting:** traffic lights, city lighting, road and traffic safety (automobile lights), warning lights etc.
- **Lighting at home and in the workplace:** torches and head lamps, lighting units, spotlights, decorative lighting (spotlights, arrays, decorative strings of electrical lights, etc.), lighting for operating theatres and dentists' chairs, etc.
- **Medical or beauty applications:** lamps for light-therapy applications, for medical or beauty treatment.