ECO design regulations
2nd draft, a summary review.

7th September 2018
Adam Bennette
Version 4

Following the publication of the 2nd Draft Regulation by the Commission. Adam Bennette has provided his interpretations summarising what the Exemptions could technically mean. Please be clear that this is not a definite outcome, it is an interpretation to aid understanding. There has been comment that some of the lamps are still being debated.

EXEMPTIONS

Introduction
Basically there are seven types of exemption that affect our industries:

- Lamp base list
- Absolute brightness
- Point-source brightness
- Beam angle
- Color mixing ability
- Exempted due to use in other exempted industries
- R7 linear lamps with high output.

Definitions and scope
Mantra: this regulation applies to light sources alone and not to luminaires.

A light source is carefully defined, although room remains for interpretations.

Simplistically a light source is the moral equivalent of a lamp. In some cases this is too simplistic and the regulation definitions must be carefully analyzed to decide where the light source stops and the luminaire begins.

The regulation is NOT retrospective. All products, whether luminaires or light sources, already in the market (including on the shelves of distributors) remain legal to sell up to and to use beyond the enactment date of the regulation, currently set at September 2021.
The lamp voltage is not relevant, the regulation applies to any light source connected to the mains whether or not via a voltage convertor or driver.

Battery powered lights including mains rechargeable types are exempt.

The EU’s own text uses the following definition in one place. We should adopt this and make sure to specify it every time we talk about 'our industries':

Scene lighting use in film studios, TV-studios, and photographic-studios, or for stage-lighting use in theatres, discos and during concerts or other entertainment events.

The lamp base list

The exemption is given by the type of base, which is defined primarily by the pin spacing.

Any tungsten lamp type sitting on top of an exempted base is exempted regardless of its characteristics such as voltage, power, brightness, colour temp, service life and so on.

These base types are exempted:

- G9.5
- GX9.5
- GY9.5
- GZ9.5
- G9.5 HPL
- G16D
- GX16 (PAR)
- GX16D (PAR)
- G22
- P28S
- P40S
- PGJX50
- G38
- QXL
- GX38Q
- GX38Q

Cross reference, base type to model ref:

For information, this list does not appear like this in the draft regulation, only the base types are mentioned.

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</table>

**Absolute brightness**

All light sources of more than 82,000 lumens output are exempt.

In practice this equates to around 3.5kW tungsten and 1kW discharge. So, for example, a 5kW tungsten lamp and a 1.2kW HMI are both exempted by this means, and of course all higher powers.
Point-source brightness
Light sources with a radiance or surface brightness of more than 500 lumens per mm2 are exempted. This is relatively easily determined. The regulation contains diagrams of source types and how to measure the light emitting surface area.

In practice this exempts all short-arc discharge sources and many if not all medium output discharge lamps such as 575W MSR, however for a particular lamp you should make the calculation to check.

Beam angle
Any lamp or light source producing a beam of 10 degrees angle or less is exempt.

In practice this will exempt some narrow-angle MR16, pinspots, possibly some types of AR111 and Aircraft landing lights.

Note: this exemption is for a naked lamp that cannot be further dismantled, such as a Pre-aligned reflector lamp.

Color mixing ability
This exemption is curiously devised: Instead of providing a simple exemption for professional colour changing luminaires, as requested, the EU have devised a definition of what a ‘color tuneable’ light source is.

If the source can produce particular shades and purities of the three primaries, red, green and blue then it is wholly exempted, regardless of any other colours it may be able to produce.

The definitions for blue and red are conventional and easily met by all common color-mixing lights. The definition of green is highly restricted, apparently deliberately so as to exclude lime from the exemption and may give rise to problems with a few designs, notably those that use Red, Lime & Blue recipes.

Note that again it is the light source that is regulated. A white light source with colored filters or dichroics mounted separately cannot enjoy this exemption.

Variable white light sources, e.g. ‘fade to warm’ or ‘cool/warm’ are not considered to be ‘color tuneable’ and are not exempted.

Exempted due to use in other exempted industries
Light sources, lamps, used for these purposes are exempt:

Military, Road vehicles, Aircraft, Railway vehicles, Marine equipment, Medical devices

R7 linear lamps with high output.
R7-type linear double-capped lamps, with two caps of 7mm diameter, above 2700 lumens output are exempted. This corresponds to a power of around 200W or less.

Thereby, the lamps used in Blondes, Redheads, Space lights, Soft lights and Cyc lights in our industries are exempted.
REQUIREMENTS

Anything not exempted must comply with the following basic requirements.

These are the big-ticket items that will challenge our industries:

- Standby Power and Network Standby Power
- Luminous efficiency when applied to very high output LED arrays

Standby Power

Standby power and network standby power are two definitions of the same basic limit:

- The light source must consume less than 0.5W when no light is being emitted.

This requirement is both difficult to meet and difficult to correctly interpret and apply to a product. The 0.5W is intended to be the part due to the operation of the light source alone with all other ‘things’ turned off, disabled or disconnected.

In practice complete separation of the electrical functional sections is often not possible, and particularly where a single power supply feeds various sub-systems including the light source driver in a complex luminaire, e.g. a moving light.

The regulation text appears to take this into account with unsatisfactory loose language: “...power consumption shall be minimized ...”.

Of course, large luminaires cannot comply with 0.5W Standby – there may be motors holding position – but it is not the luminaire that must comply.

In theory a surveillance authority would demand to remove the light source and driver and verify the Standby Power.

Luminous efficiency

The minimum efficiency allowed is around 75-90lm/W. It is not a single precise value and must be calculated according to:

\[ P_{onmax} = C \times (L + \Phi_{use} / (F \times \eta)) \times R \]

Where:

- \( P_{onmax} \) = Maximum allowed wall power consumption.
- \( C \) = Light source correction factor
  
  \[ C = Table\ 2(type) + Table\ 2Bonus(type) \]
  
  For mains directional sources (DLS), \( C = 1.23 \)

- \( L \) = End loss factor:
  
  \[ L = Table\ 1(type) \]
For LED directional light source, \( L = 2 \)

\[
\Phi_{\text{use}} = \text{Useful luminous flux (in lumens)}
\]

\[
\Phi_{\text{use}} = \text{Declared useful luminous flux (manufacturer's measurement and declaration)}
\]

The light source flux, total lumens

\[
F = \text{Efficacy factor}
\]

\[
\begin{align*}
\text{Non-directional, } F &= 1.0 \\
\text{Directional, 120 degree cone, } F &= 0.85 \\
\text{Directional, 90 degree cone, } F &= 0.56
\end{align*}
\]

\[
\eta = \text{Threshold efficacy}
\]

\[
\eta = \text{Table1(type)}
\]

for LED sources \( \eta = 120 \)

\[
R = \text{CRI factor:}
\]

\[
R = (CRI + 80)/160
\]

For CRI = 80, \( R = 1 \)

Tables are found in Annex II

Example LED light source:

- 10,000 lumens,
- CRI=90
- Directional 120 degrees

\[
P_{\text{on max}} = 1.23 \times \left( \frac{2 + 10,000}{0.85 \times 120} \right) \times \left( \frac{90 + 80}{160} \right) \sim 128W
\]

\[
\frac{Lm}{W} = \frac{10,000}{128} \sim 78Lm/W
\]

The limit given is achievable now for low power white sources. Some modern commercial and household lamps and LED light sources achieve nearly double the minimum efficiency.

However, as power is increased, and power density is also increased, the achievable efficiencies diminish. Typically at maximum allowed dissipation LED dies produce 80% of the stated efficiency at their optimal operating point. In the example the 78Lm/W becomes 63Lm/W. Another way to look at it is this: Very high power sources consume 25% more power, relatively to a source running at low power, for a given lumen efficiency.

Large area arrays rated at hundreds of watts and higher do not currently get at all close to the required minimum efficiency.
Labelling
New labelling will be needed on all products

Technical documentation
New technical documentation will be needed for all products

Light source removability
Light sources should be removable if at all possible. This does not need to mean by the end user. If the manufacturer can remove the light source for measurement it must be measured. If the source cannot be removed without causing damage then the smallest demountable part which emits light must be measured, and if that includes any optics will in most cases result in a miserable fail for efficiency.

SURVEILLANCE

Spare a thought for the surveillance authorities armed with their integrating spheres and spectrometers. Dashing from place to place on their unicorns to open up our equipment and find it lacking.

Fittingly, for the standby power measurement the light source must be ‘cut off from the breast’ of the luminaire without a ‘drop of blood’ of the rest of the body being included.

Thus would have argued Portia... (Merchant of Venice Act IV, Scene 1).

Adam Bennette
London, 7th September 2018