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Item 5 of the provisional agenda
Regulations Nos. 37 (Filament lamps), 99 (Gas discharge light sources), 128 (Light emitting diodes light sources) and the Consolidated Resolution on the common specification of light source categories

Proposal for Supplement 7 to the original version of Regulation No. 128 (Light emitting diodes light sources)

Submitted by the expert from the International Automotive Lighting and Light Signalling Expert Group (GTB)*

The text reproduced below was prepared by the expert from GTB to introduce requirements and test specifications to light emitting diode (LED) forward lighting light sources. The modifications to the existing text of the Regulation are marked in bold for new or strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2016–2017 (ECE/TRANS/254, para. 159 and ECE/TRANS/2016/28/Add.1, cluster 3.1), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

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I. Proposal

Insert a new paragraph 2.1.2.4., to read:

"**2.1.2.4. Thermal grade."**

Paragraph 2.2.2.3., amend to read:

"2.2.2.3. Five samples ~~of each colour which has been applied for~~;"

Insert a new paragraph 2.3.1.5., to read:

"2.3.1.5. The designation of the thermal grade, if specified in the relevant data sheet of Annex 1."

Paragraph 2.4.6., amend to read:

"2.4.6. The marks and inscriptions specified in paragraphs 2.3.1. and 2.4.~~3~~**4**. shall be clearly legible and be indelible."

Paragraph 3.2.3., amend to read:

*"*3.2.3. LED light sources shall exhibit no scores or spots on their optical surfaces which might impair their efficiency and their optical performance. **This shall be verified when commencing approval testing and when required in the respective paragraphs in this Regulation."**

Paragraph 3.7.2., amend to read:

*"*3.7.2. The colour of the light emitted shall be measured by the method specified in Annex 4. ~~Each~~ **The** measured **integral** value **of the chromaticity coordinates** shall lie within the required ~~tolerance~~ **chromaticity** area."

Insert a new paragraph 3.7.2.1., to read:

*"***3.7.2.1. Moreover, in the case of LED light sources emitting white light and for use in forward lighting devices, the colour shall be measured in the same directions as where the luminous intensity distribution is specified in the relevant data sheet, but only where the specified minimum luminous intensity is exceeding 50 cd/klm. Each measured value of the chromaticity coordinates shall lie within a tolerance area of 0.025 units in the x direction and 0.050 units in the y direction, containing the measured integral value. The measured value in the direction of maximum luminous intensity and all measured values for a standard (étalon) LED light source shall also lie within the required chromaticity area for white light."**

Insert a new paragraph 3.10., to read:

"**3.10. Thermal grade**

In case one or more thermal grades are specified in the relevant data sheet of Annex 1, the following requirements shall apply:

3.10.1. When measured according to the conditions specified in Annex 4, paragraph 5:

(a) The luminous flux values at elevated temperatures shall be within the limits given in the relevant data sheet of Annex 1; and

(b) The colour variation shall not exceed 0.010.

3.10.2. **After completion of the measurement procedure as prescribed in paragraph 3.10.1., the LED light source shall be continuously operated during 1000 h at the relevant test voltage(s) and**

(a) **In case of an integrated heatsink at an ambient temperature corresponding to the thermal grade chosen for type approval;**

(b) **In case of a specified T_b-point at a T_b-value corresponding to the thermal grade corresponding to the thermal grade chosen for type approval.**

3.10.3. **After completion of the procedure as prescribed in paragraph 3.10.2., when measured according to the conditions specified in Annex 4, paragraph 5:**

a) **The luminous flux values at elevated temperatures shall not deviate by more than ± 10 per cent from the corresponding values of the individual sample measured according to paragraph 3.10.1.; and**

b) **The colour variation shall not deviate from the corresponding values of the individual sample measured according to paragraph 3.10.1. by more than ± 0.010.**

3.10.4. **After completion of the measurement procedure as prescribed by paragraph 3.10.3., the requirements in 3.2.3. shall be verified again."**

Insert a new paragraph 3.11., to read:

"**3.11.** **LED light sources without general restrictions**

3.11.1. **Light emitting area characteristics**

The size and position of the nominal emitter box as well as the side(s) of the light emitting area capable to generate the cut-off are specified in the relevant data sheet of Annex 1.

The values of the following characteristics shall be determined by using the method described in Annex 9:

(a) **Luminance contrast;**

(b) **Size and position of zone 1a and zone 1b;**

(c) **Surface ratio $R_{0.1}$ and $R_{0.7}$**

(d) **Value of maximum deviation ΔL.**

3.11.2. **Luminance contrast of the light emitting area**

3.11.2.1. **The value(s) of luminance contrast of the light emitting area shall be within the limits given on the relevant data sheet of Annex 1.**

3.11.2.2. **In case in the relevant data sheet only one side of the light emitting area is specified as to generate the cut-off, zone 1b shall have a position closer to the corresponding side of zone 1a than to the opposite side.**

3.11.3. **Luminance uniformity of the light emitting area**

3.11.3.1. **The area of zone 1a (light emitting area) shall be within the nominal emitter box as specified in the relevant data sheet of Annex 1, and the size of the light emitting area shall be within the limits given on the relevant data sheet of Annex 1.**

3.11.3.2. The value of $R_{0.1}$ shall be within the limits given on the relevant data sheet of Annex 1.

3.11.3.3. The value of $R_{0.7}$ shall be within the limits given on the relevant data sheet of Annex 1.

3.11.3.4. The deviation of the luminance ΔL shall not exceed ± 20 per cent."

Annex 2, Communication Sheet, Item 9; amend to read:

"9. Concise description: .....

Category of LED light source: .....

Rated voltage: .....

Colour(s) of the light emitted: White/amber/red [2]

Thermal grade"

10. Position of the approval mark: ....."

Annex 4,

Introductory part, amend to read:

"**LED** light sources of all categories with integrated heatsink shall be measured at ambient temperature of (23 ± 2) °C in still air. For these measurements, the minimum free **air** space as defined in the data sheets shall be maintained.

LED light sources of all categories with definition of a temperature T_b shall be measured by stabilising the T_b-point at the specific temperature defined on the category data sheet.

In case one or more thermal grades are specified in the relevant data sheet of Annex 1 additional measurements shall be carried out at elevated temperatures, related to the thermal grade chosen for type approval, according to the method described in paragraph 5 of this annex."

Paragraph 2.1., amend to read:

"2.1. The luminous intensity measurements shall be started ~~after~~

a) **In case of an integrated heatsink after** 30 minutes of ~~stabilization time~~ **operation** or

b) **In case of a T_b point is specified in the relevant data sheet after s**tabilisation of **the** temperature **at this** T_b **point** ~~at the value given in the relevant data sheet~~."

Paragraph 2.3., amend to read:

"2.3 Normalized luminous intensity of a test sample is calculated by dividing the luminous intensity distribution as measured under paragraph 2.1. **and 2.2.** of this annex by the luminous flux as determined ~~after 30 minutes~~ under paragraph 1.2. of this annex."

Paragraph 2.4., amend to read:

"2.4. Cumulative luminous flux of a test sample is calculated according to CIE publication 84-1989, section 4.3 by integrating the luminous intensity **values as measured under 2.1 and 2.2** within a cone enclosing a solid angle."

Insert a new paragraph 5., to read:

"**5. Photometric measurements in case one or more thermal grades are specified**

5.1. Temperature and temperature range

5.1.1. Photometric measurements as specified in paragraphs 5.3., 5.4. and 5.5. shall be carried out at elevated temperatures T in steps not larger than 25°C, while the LED light source is continuously operated.

5.1.1.1. In case of LED light sources of a category with integrated heatsink the temperature range is defined by the ambient temperature of (23 ± 2) °C elevated up to and including the temperature specified by the thermal grade, whereas the minimum free air space as defined in the relevant data sheet shall be maintained and a period of 30 minutes of operation shall be awaited after each increase of the ambient temperature.

5.1.1.2. In case of LED light sources of a category, for which a temperature T_b is specified, the temperature range is defined by the temperature T_b specified in the relevant data sheet elevated up to and including the temperature specified by the thermal grade, whereas the temperature at the T_b-point is stabilised before each measurement.

5.2. Voltage

Measurements shall be carried out at relevant test voltage.

5.3. Measurement direction of luminous intensity and colour coordinates

All the values of luminous intensity and the colour coordinates in the temperature range as specified by paragraph 5.1. may be measured in one and the same direction. This direction shall be such that the luminous intensity is exceeding 20 cd for all measurements.

5.4. Luminous flux values at elevated temperatures

The values of the luminous flux at elevated temperatures T in the range as specified by paragraph 5.1. may be calculated by correcting the value of the luminous flux as measured according to paragraph 1.2. of this annex, by the ratio of the luminous intensity values as described in paragraph 5.3. and the luminous intensity value measured at:

(a) 23°C, in case of an integrated heatsink;

(b) T_b, in case a temperature T_b is defined.

5.5. Colour variation

The colour variation is the maximum deviation of all colour points (given by the chromaticity coordinates x, y) at elevated temperatures T in the range as specified by paragraph 5.1., from the colour point (x_0, y_0) at:

(a) 23°C, in case of an integrated heatsink:

$$\max\{\sqrt{[(x(T)-x_0(23°C))^2 + (y(T)-y_0(23°C))^2]}\};$$

(b) T_b, in case a temperature value T_b is defined:

$$\max\{\sqrt{[(x(T)-x_0(T_b))^2 + (y(T)-y_0(T_b))^2]}\}.$$ "

Insert a new Annex 9, to read:

“Annex 9

Method for the measurement of luminance contrast and luminance uniformity of the light emitting area

1. **The luminance measurement equipment shall be capable to distinguish clearly whether the luminance contrast of the light emitting area is above or below the required level for the LED light source under test.**

Further, this equipment shall have a resolution of 20 µm or smaller in an area that is larger than the light emitting area of the LED light source under test. In case this equipment has a resolution of less than 10 µm, adjacent luminance measurement values shall be arithmetically averaged so as to represent a luminance value of an area of between 10 µm and 20 µm.

2. **The luminance measurements of an area shall be done in an equidistant grid in both directions.**

3. **Zone 1a and zone 1b shall be determined from luminance measurements of an area which consists of the nominal emitter box as specified in the relevant data sheet of Annex 1 and enlarged to all sides by 10 per cent of the corresponding box dimension (see figure 1). The value L_{98} is the 98^{th} percentile of all values of these luminance measurements.**

3.1. **Zone 1a (light emitting area) shall be the smallest circumferential rectangle having the same orientation as the nominal emitter box and containing all luminance measurements with a value of 10 per cent or more of the value L_{98}. The value L_1 shall be the arithmetic average of the values of all luminance measurements in zone 1a (see figure 2). The value of $R_{0.1}$ shall be the surface ratio of zone 1a where the luminance value is exceeding 10 per cent of the value L_1. The value of $R_{0.7}$ shall be the surface ratio of zone 1a where the luminance value is exceeding 70 per cent of the value L_1.**

3.2. **Zone 1b shall be the smallest circumferential rectangle having the same orientation as the nominal emitter box and containing all luminance measurements with a value of 70 per cent or more of the value L_{98}.**

4. **Zone 2 shall have in both directions 1,5 times the size of the nominal emitter box as specified in the relevant data sheet of Annex 1 and it shall be positioned symmetrically to the nominal emitter box at a distance of d_0=0.2 mm to zone 1a, unless otherwise specified on the data sheet (see figure 3). The value L_2 shall be the arithmetic average of 1 per cent of all measured luminance values in zone 2 which represent the highest values.**

In case in the relevant data sheet more than one side of zone 1a (light emitting area) is specified as to generate the cut-off, for each of these sides a value L_2 shall be determined as described above.

5. **The luminance contrast value(s) shall be the ratio of the luminance value L_1 of zone 1a and the luminance value L_2 of zone(s) 2.**

6. **In case the nominal emitter box as specified in the relevant data sheet of Annex 1 is subdivided in n areas (e.g. n = 1 x 4), the same subdivision shall also apply to zone 1a.**

6.1. **For each of the n areas the value $L_{1,i}$ (i = 1, …, n) shall be the arithmetic average of the values of all luminance measurements in the corresponding area.**

6.2. **The value ΔL shall be the maximum relative deviation of all luminance values $L_{1,i}$ from the luminance value L_1**

$$\Delta L = \text{Max} \{ (L_{1,i} - L_1)/L_1; i = 1, \ldots, n\}$$

Figure 1
Enlargement of the nominal emitter box

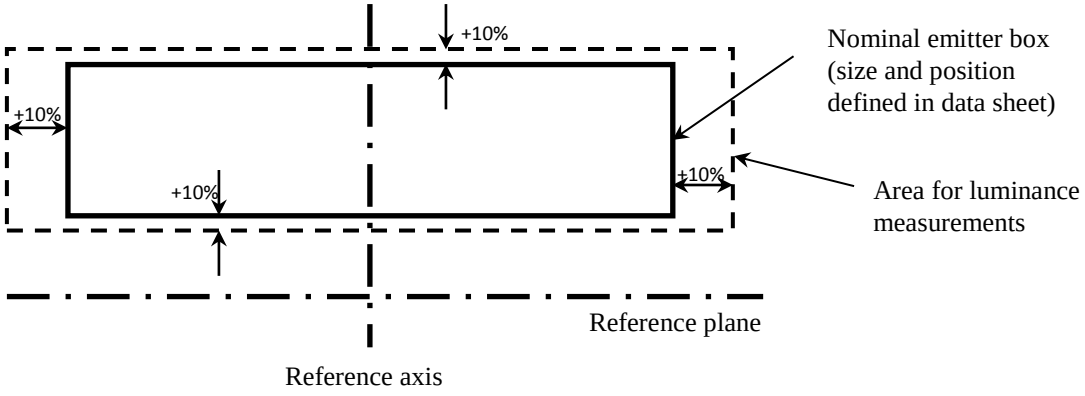


Figure 2
Definition of zones 1a and 1b

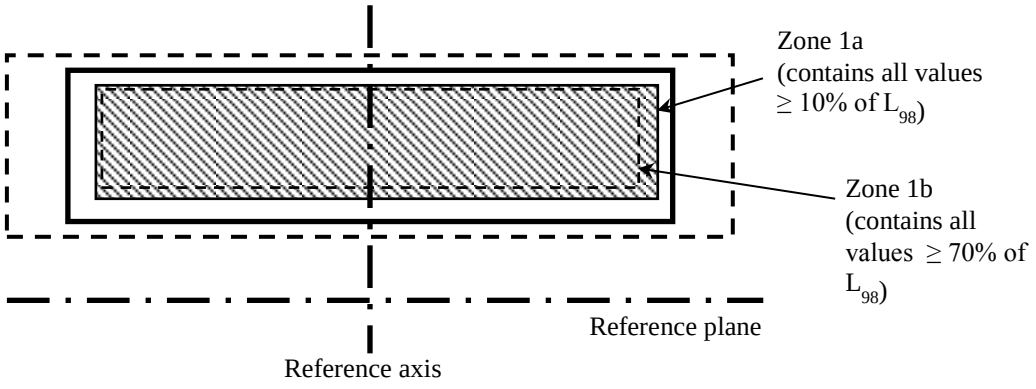
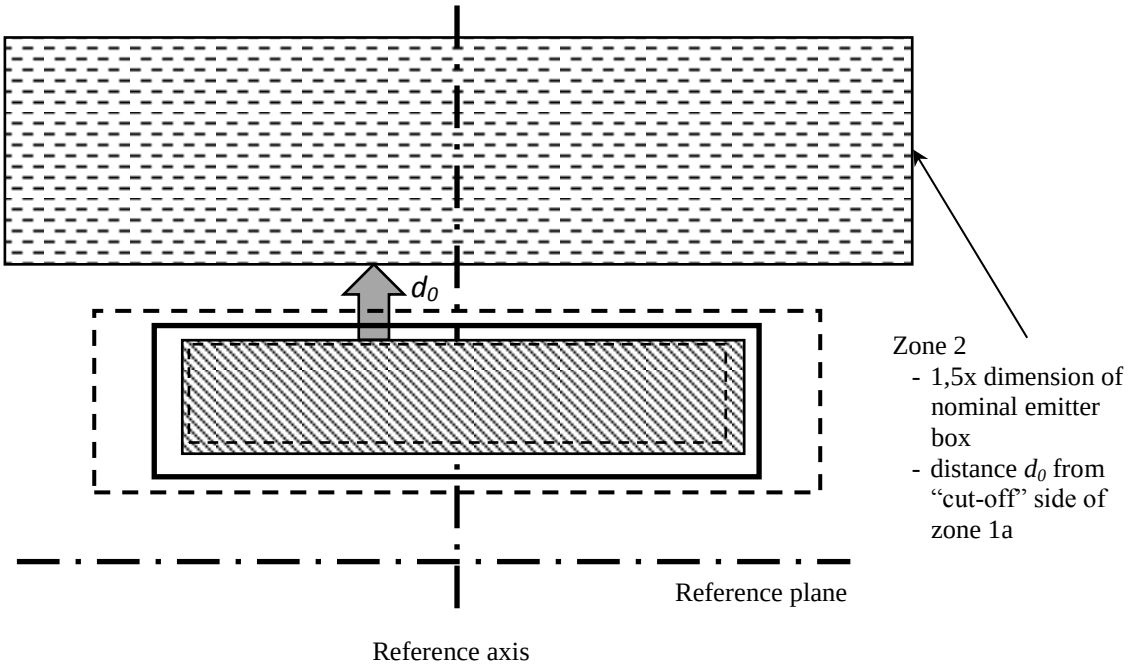


Figure 3
Definition of zone 2



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II. Justification

1. The content of Regulation No. 128 is limited to light sources for signalling applications. LED technology has developed to a level that approved light sources for forward lighting applications (front fog, low beam, high beam, adaptive front-lighting systems (AFS)) are now also technically feasible and under development.

2. An extension of Regulation No. 128 to forward lighting needs the introduction of additional requirements in order to cover specific conditions with respect to increasing thermal load (higher lumen packages, higher ambient temperatures) and more challenging beam patterns (sharp cut-off, limited glare).

3. Due to the thermal behaviour of LED technology it is necessary to define a thermal interface for replaceable Regulation No. 128 LED light sources in addition to the electrical, mechanical and optical interfaces known from Regulations Nos. 37 and 99.

4. The concept of "Thermal Grades" is introduced to qualify the appropriate thermal operating environment of replaceable LED light sources. A forward lighting device and hence the mounted LED light source can face different levels of ambient temperature conditions, e.g. from very close to a combustion engine to no combustions engine presence at all.

5. The "Thermal Grade" is a characteristic of Regulation No. 128 LED light sources [for forward lighting] to specify their technical parameters (e.g. luminous flux) up to the temperature limit given by the thermal grade in order to ensure safe replaceability.

6. Approved LED light sources for forward lighting also require the definition of parameters, which are specifically relevant for forward lighting applications, and which therefore need to be specified for the corresponding LED light source categories.

7. The relevant parameters that determine the photometrical properties of the light source for use in forward lighting are specified in Regulation No. 128 as characteristics of the Light Emitting Area:

- The luminance contrast of the light emitting area determines the minimum achievable glare compared to the maximum road illumination in the far field;
- A uniformity parameter ($R_{0.7}$) determines the maximum achievable beam-gradient;
- A uniformity parameter ($R_{0.1}$) is linked to potential inhomogeneity of the beam;
- The relative size of the light-emitting-area of the LED light source is linked to the position accuracy of individual LEDs and impacts the range for re-aiming of the headlamp.

8. A performance-based approach is taken by requiring in Regulation No. 128 that these parameters are quantitatively specified in the relevant data sheets.

9. GTB performed an in-depth technical study of these parameters, specifically for the strictest beam requirement in terms of low glare combined with high road illumination in the far field (a class B passing beam in Regulation No. 112). The requirements for this case are defined in the GTB Guideline document for "Introduction and Evaluation of LED Light Source Categories Intended for Forward Lighting Applications".

10. This proposal consists of:

- A proposal to implement provisions into Regulation No. 128;
- A proposal to introduce a first category L1 into the Group 1 of LED light sources in the Resolution;
- A GTB Guideline document for "Introduction and Evaluation of LED Light Source Categories Intended for Forward Lighting Applications". These guidelines are intended for publication, with the agreement of GRE, on the GRE website under "reference documents", similar to criteria for new filament light sources for head lighting;

11. As is the case for other light sources, additional tests on voluntary basis are described in standards such as from the International Electrotechnical Commission (IEC) or Society of Automotive Engineers (SAE).