GRE TF/SR discussion on LED replacement light sources

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March 7, 2023

Bonn, Germany

Content

(1) Starting point and reference
   - What has been discussed in GRE so far?

(2) Potential ways forward
   - UN approval process
   - National approval process

(3) Technical background – Photometrical tutorial

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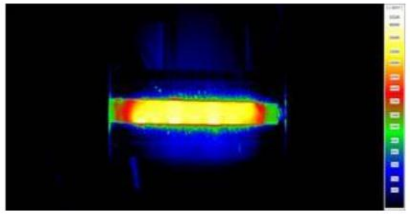
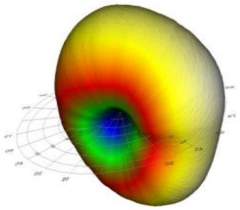
What has been discussed in GRE87 so far? Slide copied from GRE-87-02

UN R37 approval
full photometric equivalence according to guideline (GRE-83-15)

<u>Example 1</u>: Signalling light source C5W (low power)



Near field: filament-like



Far field: filament-like

- PRO‘s
  - complete set of light source specifications based on “full equivalence” to incandescent technology
    - Possible for 5W types with today LED technology
    - Possible for 10W and 20W types in near / mid future
  - Leads to same photometric performance in the application
  - No need for testing in the luminaire (i.e. no need for positive list)
- CON‘s
  - none

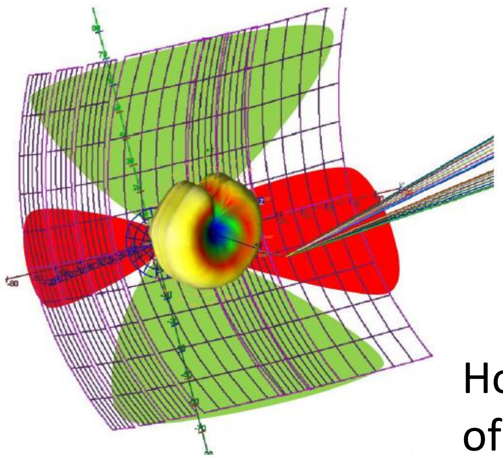
Full equivalence achievable – maintain as-is

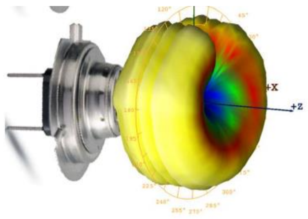
What has been discussed in GRE87 so far? Slide copied from GRE-87-02

UN R37 approval
full photometric equivalence according to guideline (GRE-83-15)

UNECE

Example 2: Road illumination light source H7 (high flux)

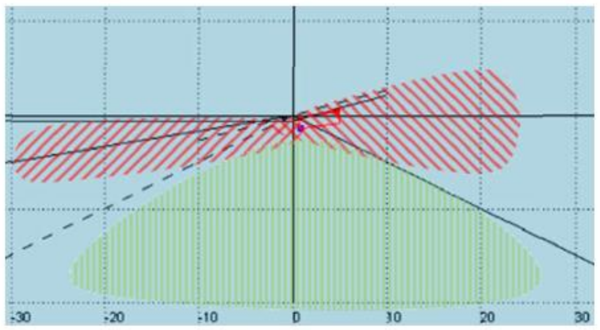




Far field: filament-like

Homogeneous illumination of whole reflector (green and red segments)

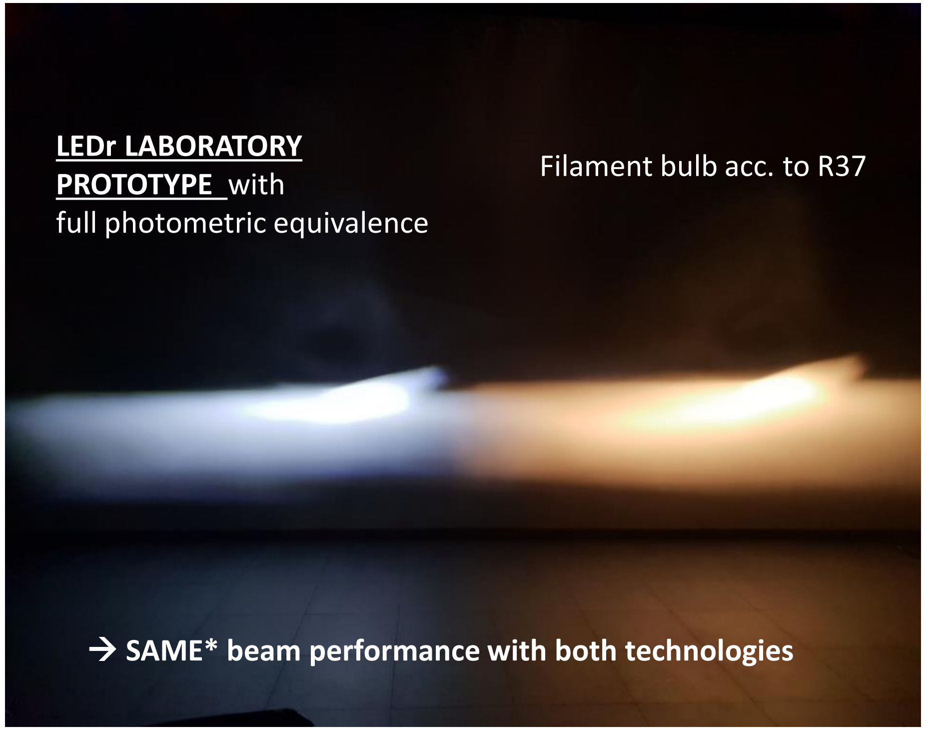
from reflector segment to light on the road



- PRO's
  - complete set of light source specifications based on "full equivalence" to incandescent technology
    - But not technically feasible today for high flux categories
  - It would …
    - lead to same beam performance
    - mean no headlamp testing, no positive list needed
- CON's
  - Full equivalence (= emulation of filament) would not improve the beam performance, i.e. advantages of LED technology not utilised

full-equivalence solutions not feasible for high flux categories with today's LED technology

Technology neutral full equivalence



** Besides the color temperature*

CON's

Full equivalence (= emulation of filament) does show the same beam performance, i.e. advantages of LED technology not utilised

- Same photometric values
- Only change of colour temperature

Excerpt from GRE-87 report

- Section 15 (copied and emphasis added):

The expert from IEC analysed the approval process of LED replacement light sources according to UN Regulation No. 37 (GRE-87-02), based on the full photometric equivalence according to the guidelines (GRE-83-15). According to him, full-equivalence solutions were not feasible for high flux categories with the today's LED technology. As a consequence, some countries were issuing national approvals deviating from the full photometric equivalence, based on extensive testing (in headlamps and vehicles) for limited light source specifications and resulting in a positive list for particular vehicle models. ***GRE stressed the advantages of harmonization at the United Nations level*** and noted that ***several contracting parties were in favour of cautious re-evaluation of the equivalence criteria*** for LED replacement light sources. ***GRE invited IEC to start this work as a new activity of the Task Force on Substitutes and Retrofits (TF SR) in cooperation with those contracting parties***.

- Target of discussion in this Task Force:
  - Create foundation for a converging discussion to achieve LEDr unification in all UNECE countries

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Potential ways forward for high power LEDr (in R37 / RE5)

1 – "intelligent equivalence" on light source level
(also called "EQ+")

- Detailed light source specification via emission in two directions
- Making full use of LED technology benefits
- Several deviations from "full photometric equivalence"
  - Keeping LEA and contrast requirements (in 2 viewing directions only)
  - Modified far-field emission requirements
- Valid in all headlamps / vehicles
- No need to consider mis-use
- Not used in any country so far

2 – "application-level equivalence"
(also called "positive list approach")

- Very limited requirements on light source level
- Making full use of LED technology benefits
- Confirmation of UN compliant photometry in the application by measurement
- Valid in tested vehicles / headlamps *
- Already accepted by several contracting parties (via national type approval)
  - Germany, and some countries accepting:
    - Austria
    - Czech Republic
    - Croatia
    - Slovenija
  - France
  - South Korea

* Mis-use can be addressed via "special measures" to prevent glare , to be discussed further

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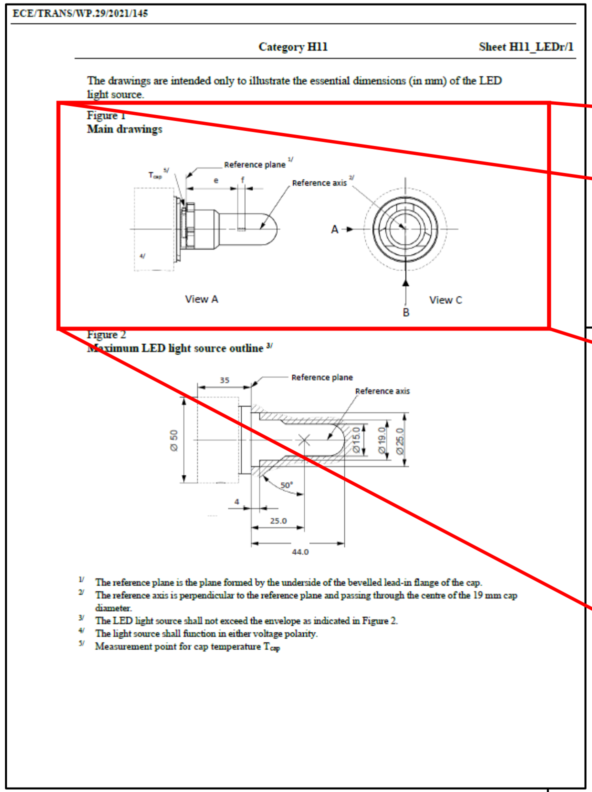
Potential ways forward “intelligent equivalence”

Starting Point: enforced specifications given by full photometric equivalence

Sheet H11 LEDr/1 and/2 remain unchanged !

WP.29/2021/145



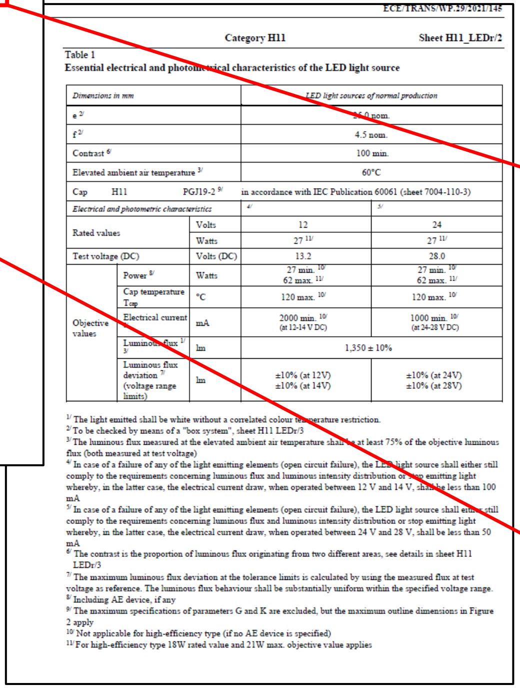
Category H11 **Sheet H11_LEDr/1**

The drawings are intended only to illustrate the essential dimensions (in mm) of the LED light source.

Figure 1
Main drawings

Figure 2
Maximum LED light source outline [3/]

[1/] The reference plane is the plane formed by the underside of the bevelled lead-in flange of the cap.
[2/] The reference axis is perpendicular to the reference plane and passing through the centre of the 19 mm cap diameter.
[3/] The LED light source shall not exceed the envelope as indicated in Figure 2.
[4/] The light source shall function in either voltage polarity.
[5/] Measurement point for cap temperature T_{cap}

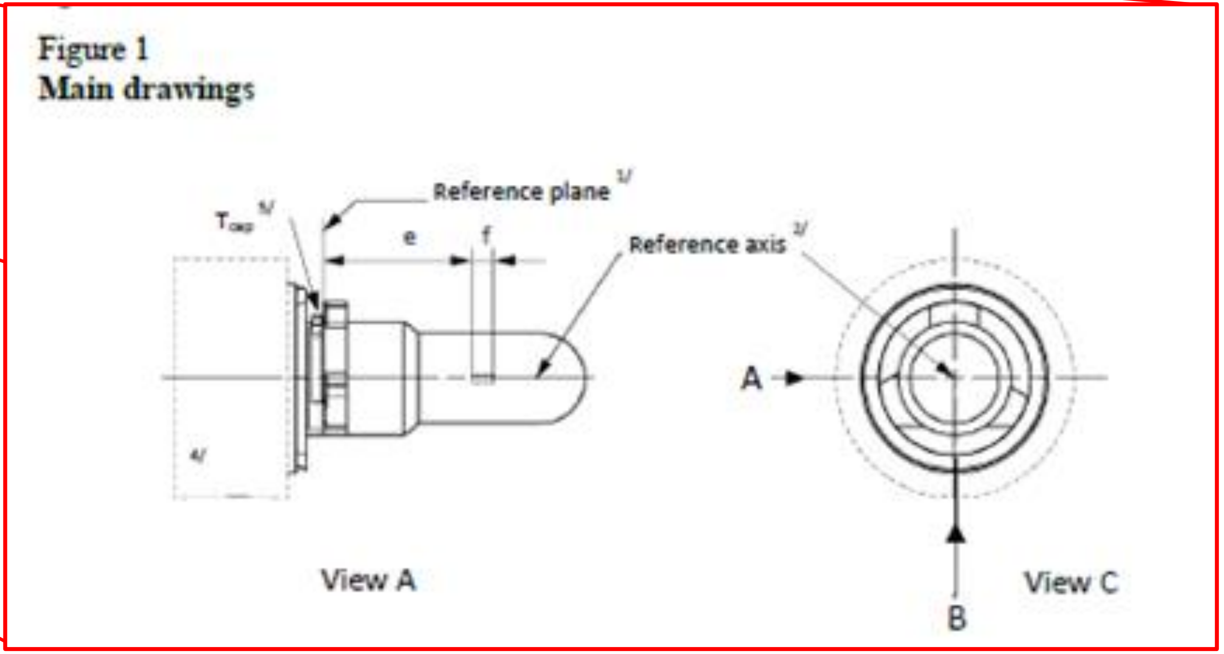


Category H11 **Sheet H11_LEDr/2**

Table 1
Essential electrical and photometrical characteristics of the LED light source

Dimensions in mm			*LED light sources of normal production*	
e [2/]			25.0 nom.	
f [2/]			4.5 nom.	
Contrast [6/]			100 min.	
Elevated ambient air temperature [3/]			60°C	
Cap H11		PGJ19-2 [9/]	in accordance with IEC Publication 60061 (sheet 7004-110-3)	
Electrical and photometric characteristics			[4/]	[5/]
Rated values		Volts	12	24
		Watts	27 [11/]	27 [11/]
Test voltage (DC)		Volts (DC)	13.2	28.0
Objective values	Power [8/]	Watts	27 min. [10/] 62 max. [11/]	27 min. [10/] 62 max. [11/]
	Cap temperature T_{cap}	°C	120 max. [10/]	120 max. [10/]
	Electrical current	mA	2000 min. [10/] (at 12-14 V DC)	1000 min. [10/] (at 24-28 V DC)
	Luminous flux [1/] [3/]	lm	1,350 ± 10%	
	Luminous flux deviation [7/] (voltage range limits)	lm	±10% (at 12V) ±10% (at 14V)	±10% (at 24V) ±10% (at 28V)

[1/] The light emitted shall be white without a correlated colour temperature restriction.
[2/] To be checked by means of a "box system", sheet H11 LEDr/3
[3/] The luminous flux measured at the elevated ambient air temperature shall be at least 75% of the objective luminous flux (both measured at test voltage)
[4/] In case of a failure of any of the light emitting elements (open circuit failure), the LED light source shall either still comply to the requirements concerning luminous flux and luminous intensity distribution or stop emitting light whereby, in the latter case, the electrical current draw, when operated between 12 V and 14 V, shall be less than 100 mA
[5/] In case of a failure of any of the light emitting elements (open circuit failure), the LED light source shall either still comply to the requirements concerning luminous flux and luminous intensity distribution or stop emitting light whereby, in the latter case, the electrical current draw, when operated between 24 V and 28 V, shall be less than 50 mA
[6/] The contrast is the proportion of luminous flux originating from two different areas, see details in sheet H11 LEDr/3
[7/] The maximum luminous flux deviation at the tolerance limits is calculated by using the measured flux at test voltage as reference. The luminous flux behaviour shall be substantially uniform within the specified voltage range.
[8/] Including AE device, if any
[9/] The maximum specifications of parameters G and K are excluded, but the maximum outline dimensions in Figure 2 apply
[10/] Not applicable for high-efficiency type (if no AE device is specified)
[11/] For high-efficiency type 18W rated value and 21W max. objective value applies



Starting Point: enforced specifications given by full photometric equivalence

Potential ways forward "intelligent equivalence"

Sheet H11 LEDr/3 changes

WP.29/2021/145 → Sheet H11_LEDr/3

KEEP all essential characteristics (Table 1) unchanged, especially the box and contrast requirement to avoid glare !

These correspond to the primary (main) directions of emission "A" and "– A"

REMOVE the box requirements in the secondary (third) direction "B"

In order to maintain relationship between meridional "A" and "–A" emission directions INSERT one new parameter: the spacing parameter "z" describing the "thickness"

ECE/TRANS/WP.29/2021/145

Category H11 **Sheet H11_LEDr/3**

Screen projection requirements

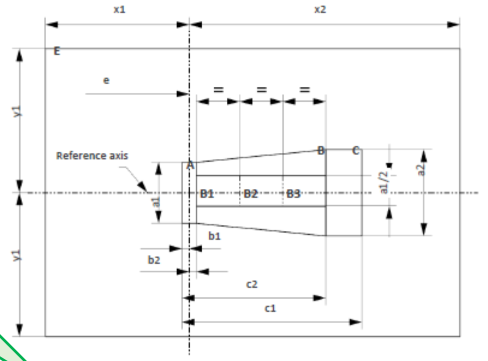
The following test is intended to define the requirements for the apparent light emitting area of the LED light source and to determine whether the light emitting area is correctly positioned relative to the reference axis and reference plane in order to check compliance with the requirements.

The position of the light emitting area is checked by a box system defined in Figure 4 when operated at test voltage, which shows the projections when viewing from B (see sheet H11 LEDr/1, Figure 1) and from A and –A (see sheet H11 LEDr/1, Figure 1), i.e. along the C-planes C_0, C_{90} and C_{270} (as defined in Figure 6).

The proportion of the total luminous flux emitted into these viewing directions from the area(s) as defined in Figure 4:

- Total box area: (A+B+C) / E shall be not less than 90%
- Area A: A / (A+B+C) shall be not more than 10%
- Areas B_1, B_2 and B_3: B_1/B, B_2/B, B_3/B shall each be not less than 15%
- Area B: B / (A+B+C) shall be not less than 72 %
- Area C: C / (A+B+C) shall be not more than 22%

Figure 4
Box definition of the light emitting area (dimensions given in Table 2)



The contrast is checked by a box system defined in Figure 5 when operated at test voltage, which shows the projections when viewing from A and –A (see sheet H11 LEDr/1, Figure 1), i.e. along the C-planes C_{90} and C_{270} (as defined in Figure 6).

The contrast is the proportion of the total luminous flux values emitted into these viewing directions from the corresponding areas (A+B+C) and D. The value of the contrast (A+B+C) / D shall be within the limits given in Table 1 (see Figure 5 for the definition of the area D).

Potential ways forward “intelligent equivalence”

Re-distribute the light …we can give room for good illumination

Sheet H11 LEDr/4 and/5 remain unchanged !

WP.29/2021/145

Category H11 **Sheet H11_LEDr/4**

Figure 5
Box definition of the area D (dimensions given in Table 2)

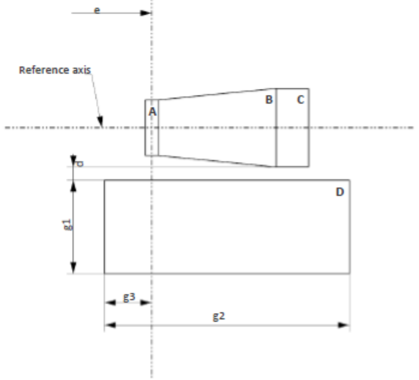


Table 2
Dimensions of the box definitions in Figure 4 and Figure 5

All views (as specified above)	*Dimensions in mm*	*All views (as specified above)*	*Dimensions in mm*
a1	1.7	x1	25
a2	1.9	x2	19
b1	0.2	y1	12.5
b2	0.2	g1	2.85
c1	5.0	g2	7.5
c2	4.0	g3	1.45
d	0.4		

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Category H11 **Sheet H11_LEDr/5**

Normalized luminous intensity distribution

The following test is intended to determine the normalized luminous intensity distribution of the light source in the C-planes as described in Figure 6 when operated at test voltage. The intersection of the reference axis and the plane parallel to the reference plane at distance e = 25.0 mm is used as the coordinate system origin.

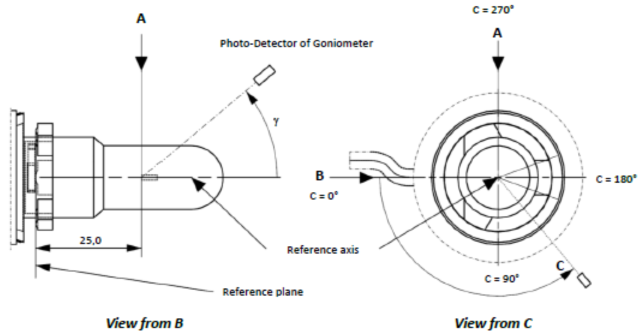
The light source is mounted on a flat plate with the corresponding holder features. The plate is fixed to the goniometer table by a bracket, so that the reference axis of the light source lines up with one of the rotating axis of the goniometer. The corresponding measurement set-up is described in Figure 6.

Luminous intensity data is recorded with a standard photo-goniometer. The measurement distance should be chosen appropriately in order to make sure that the detector is located in the far field of the light distribution.

The measurements shall be performed in C-planes for which the line of intersection coincides with the reference axis of the light source. The test points for each plane and polar angles γ are specified in Table 3.

The measured luminous intensity values, normalised to the measured luminous flux of the individual light source under test, shall be converted to normalised luminous intensity values of a 1000 lm light source. These data shall comply with the limits as defined in Table 3.

Figure 6
Setup to measure the luminous intensity distribution and the definition of C-Planes and angle γ



C-planes: see CIE publication 70-1987, "The measurement of absolute intensity distributions".

Potential ways forward "intelligent equivalence"

<u>Re-distribute the light</u> …we can give room for good illumination

<u>Sheet H11 LEDr/4 and/5 remain unchanged !</u>

WP.29/2021/145 → Sheet H11_LEDr/6

ALLOW more light in the main emission directions ("A" and "–A") and remove intensity requirement for direction "B"

(i.e.: *amend Table 3 – Part 2*)

This means making full use of LED technology benefits

ECE/TRANS/WP.29/2021/145

Category H11 **Sheet H11_LEDr/6**

Table 3 – Part 1
Test point values of normalized intensity (Black top area)

	LED light source of normal production	
	Minimum intensity (cd/klm)	*Maximum intensity (cd/klm)*
γ	C_0, C_{90}, C_{180}, C_{270}	C_0, C_{90}, C_{180}, C_{270}
0°	n/a	10
10°	n/a	10
20°	n/a	10
30°	n/a	10

The light pattern as described in Table 3 – part 1 shall be substantially uniform, i.e. in between two adjacent grid points the relative luminous intensity requirement is calculated by linear interpolation using the two adjacent grid points. In case of doubt this may be checked in addition to verification of the grid points given in Table 3 – part 1.

Note: The angular range in Table 3 – Part 1 is equivalent to the black top of its counterpart H11 filament light source specified by γ_3 in sheet H11/3.

Table 3 – Part 2
Test point values of normalized intensity (Distortion free area)

	LED light source of normal production	
	Minimum intensity (cd/klm)	*Maximum intensity (cd/klm)*
	C_0, C_{90}, C_{270}	C_0, C_{90}, C_{270}
50°	80	130
60°	80	130
70°	80	130
80°	80	130
90°	80	130
100°	80	130
110°	80	130
120°	80	130
130°	80	130
140°	80	130

The light pattern as described in Table 3 – part 2 (excluding the section between C_{90} and C_{270}) shall be substantially uniform, i.e. in between two adjacent grid points the relative luminous intensity requirement is calculated by linear interpolation using the two adjacent grid points. In case of doubt this may be checked in addition to verification of the grid points given in Table 3 – part 2.

Note: The angular range in Table 3 – Part 2 is equivalent to the distortion free area of its counterpart H11 filament light source specified by γ_2 and γ_1 in sheet H11/3.

Potential ways forward "intelligent equivalence"

Re-distribution of light will focus on main emission of light

WP.29/2021/145 → Sheet H11_LEDr/7

Consequently, LESS light needs to be required in the sagittal emission directions ("B").

(i.e.: *amend Table 3 – Part 3*)

This does not compromise safety as the corresponding light of a filament emission profile is not used in safety-critical parts of the beam (this corresponds to foreground light, quite close to the car, where usually there is an abundance of light)

This is a <u>minor</u> editorial change:
A bit less light in the one direction,
A bit more in the other.

ECE/TRANS/WP.29/2021/145

Category H11 **Sheet H11_LEDr/7**

Table 3 – Part 3
Test point values of normalized intensity (Shading area of the lead-in wire of the counterpart filament light source)

	LED light source of normal production	
	Minimum intensity (cd/klm)	*Maximum intensity (cd/klm)*
C-plane	$\gamma = 90°$	$\gamma = 90°$
C_0	80	130
C_{30}	80	130
C_{60}	80	130
C_{90}	80	130
C_{120}	80	130
C_{150}	80	130
	n/a	n/a
	80	130
C_{240}	80	130
C_{270}	80	130
C_{300}	80	130
C_{330}	80	130
C_{360} (= C_0)	80	130

The light pattern as described in Table 3 – part 3 (excluding the section between C_{150} and C_{210}) shall be substantially uniform, i.e. in between two adjacent grid points the relative luminous intensity requirement is calculated by linear interpolation using the two adjacent grid points. In case of doubt this may be checked in addition to verification of the grid points given in Table 3 – part 3.

Note: Due to the shading area created by the lead-in wire of its counterpart H11 filament light source (opposite to the metal-free zone; see Figure 4 on sheet H11/2) there is no requirement in the C_{180}-plane."

Potential ways forward "application-level equivalence"

Potential ways forward for high power LEDr (in R37 / RE5)

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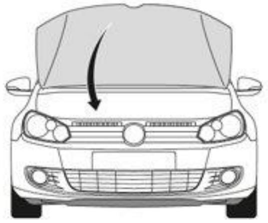
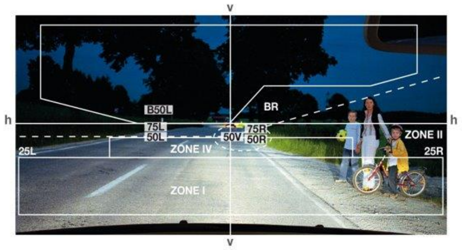
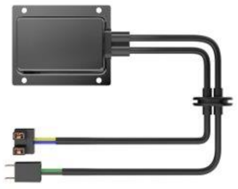
Potential ways forward “application-level equivalence”

Vehicle Specific Approval
National Approval Process in Germany and France

Steps of testing by external test house			Steps for approval		
1. **Light source** photometry and geometry check & Mechanical vehicle installation check	2. **Headlamp** photometry check (e.g. ECE R112) in left & right luminaire	3. **Electrical in-vehicle** installation check & definition of additional electronics, if needed	4. Submission of expert report to approval body by external test house	5. Verification and approval by approval body	Street legal product for the tested and approved car list (positive list)







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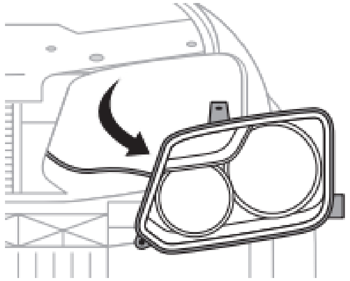
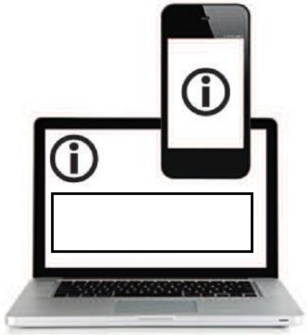
Vehicle Specific Approval – what does it mean for the consumer?

Step BEFORE lamp & Acc. purchase		**Step AFTER lamp & Acc. purchase**			
1. Check vehicle compatibility	**2.** Identify approval numbers	**3.** Download approval	**4.** Print approval and carry along	**5.** Attach sticker in the engine compartment (optional)	Criteria for street approval fulfilled





The E-number of the headlamp is the guiding number!

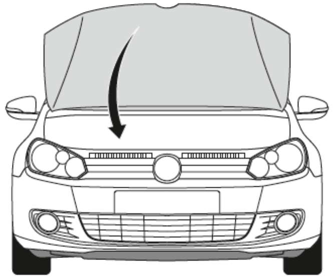
Kraftfahrt-Bundesamt
DE-24932 Flensburg

ALLGEMEINE BAUARTGENEHMIGUNG (ABG)

nach § 22a der Straßenverkehrs-Zulassungs-Ordnung (StVZO) in der Fassung vom 18.05.2017 (BGBl. I S. 1282) in Verbindung mit der Verordnung über die Prüfung und Genehmigung der Bauart von Fahrzeugteilen sowie deren Kennzeichnung (FzTV) in der Fassung vom 12.08.1998 (BGBl. I S. 2142)

Nummer der ABG: K 1821

Gerät: Austauschlichtquelle H7-LED



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Some further details on vehicle coverage by „positive list“

Status Quo Germany

<u>List of vehicles already tested</u>

<u>Example:</u> Page 23 of vehicle list for ***ams OSRAM H7-LED***

Similar lists exit for other light sources covered by „postive list“ from ams OSRAM (H4-LED) and Lumileds (H7-LED and H4-LED)

Prüfbericht Nr. / *Test report No.*: 20-00014-CM-GBM-12
Hersteller / *Manufacturer:* OSRAM GmbH, D-80807 München
Typ / *Type:* H7-LED

TÜV SÜD Auto Service

A N L A G E 1/12V
E N C L O S U R E 1/12V

Verwendungsbereich / *Application range*

§22a K 1821*12

Lfd. Nr. Fahr-zeug / *No. of vehicle*	Scheinwerfer-Genehmigung Nr. / *Headlamp approval no.*	Variante Austausch Lichtquelle / *Variant replacement light sources*	Auflagen / Hinweise / *Require-ments / Remarks*	Verbaut in folgenden Fahrzeugen / *Installed in the following vehicles:* Hersteller / *Manufacturer*	Fahrzeugtyp (Genehmigungsnr.) / *Vehicle type (no. of homologation)*	Handelsbezeichnung (EU-Fahrzeugklasse) / *Trade name (EU vehicle class)*	Abblendlicht (A) / Fernlicht (F); [FK]*) / *passing-beam (A) / driving-beam (F); [FK]*)*
128)	E1 2538	100	1)	RENAULT (F)	Z (e2*2001/116*0373* ..)	Megane (M1)	A
156)	E1 3674	100	1)6)		Z (e2*2001/116*0373*..)	Megane (M1)	A / F [17,5]
75)	E9 16479	100	1)	SEAT (E)	KJ (e9*2007/46*3134*..)	Ibiza (M1) / Arona (M1)	A
149)	E1 2853	1IF ww. / *or* 1IG	2)		7N (e1*2007/46*0402*..)	Alhambra (M1)	A
150)					7N (e1*2007/46*0435*..)	Alhambra (N1)	
165)	E9 14198	100	1)		FP (e9*2007/46*6394*..)	Ateca (M1)	A / F
13)	E1 3340	100 10B ww. / *or* 10G	1) 2)	SKODA (CZ)	5E (e11*2007/46*0243*..)	Octavia (M1)	A
102)	E1 4337	100	1)5)		5E (e11*2007/46*0243*..)	Octavia (M1)	A
103)					5E (e11*2007/46*0244*..)	Octavia (N1)	
143)					5E (e8*2007/46*0318* ..)	Octavia (M1)	
142)	E8 7375	1B0	1)		3T (e8*2007/46*0317* ..)	SUPERB (M1)	A
201)	**E8 8081**	**1B0**	**1)6)**		**AA (e13*2007/46*1169*..)**	**Citigo (M1)**	**A / F [20]**

TÜV SÜD Auto Service GmbH, Westendstraße 199, D-80686 München

Content

(1) Starting point and reference
  - What has been discussed in GRE so far?

(2) Potential ways forward
  - UN approval process
  - National approval process

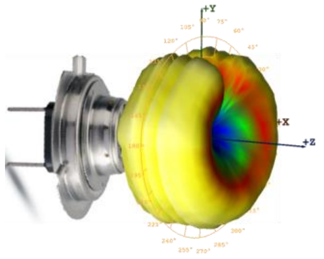
(3) Technical background - Photometrical tutorial

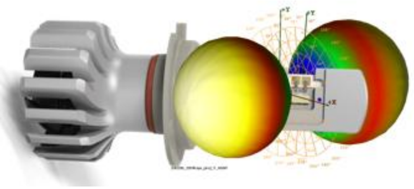
Currently regulated category and nationally approved products Existing H11-LEDr in R.E 5 and H7_LED with ABG

Key elements discriminating the light source specification

far field -> normalized intensity distribution

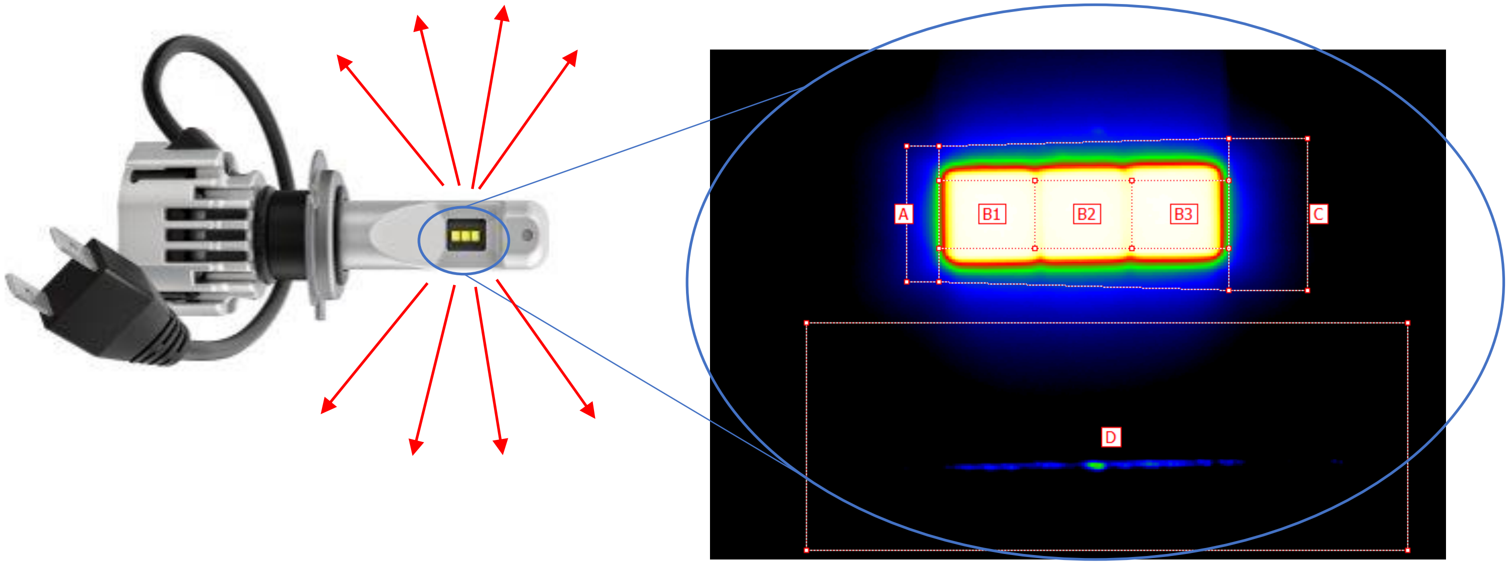
In which direction is the light emitted?





near field -> box and contrast requirements

Where does the light come from?

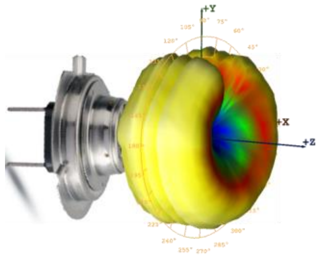


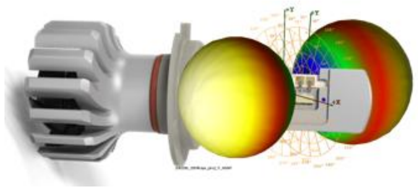
Currently regulated category and nationally approved products existing H11-LEDr in R.E 5 and H7_LED with ABG

Key elements discriminating the light source specification and PROPOSED amendments to H11_LEDr

far field -> normalized intensity distribution

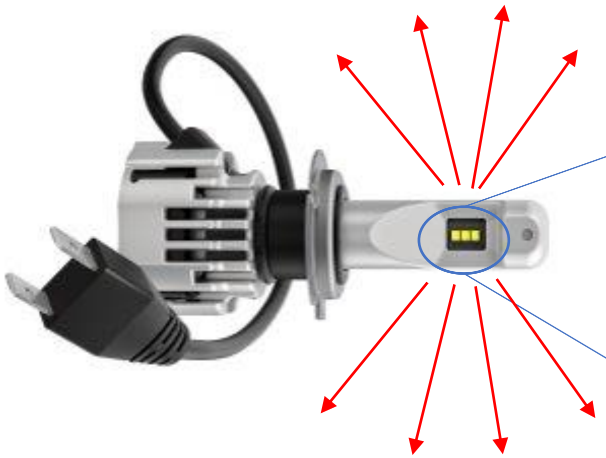
PROPOSAL: allow far-field emission characteristic of two LEDs with Lambertian radiation pattern

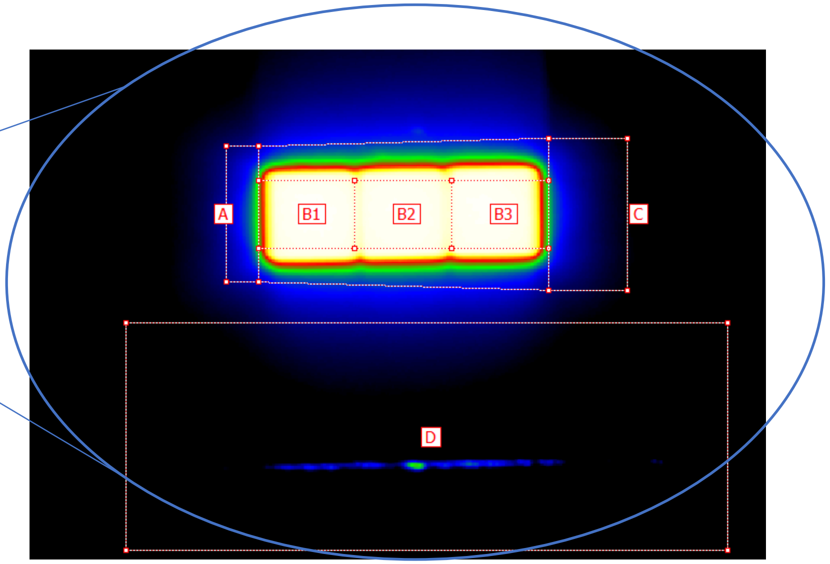




near field -> box and contrast requirements

PROPOSAL: same LEA as “full-equivalent“ But only from view “A” and “-A”



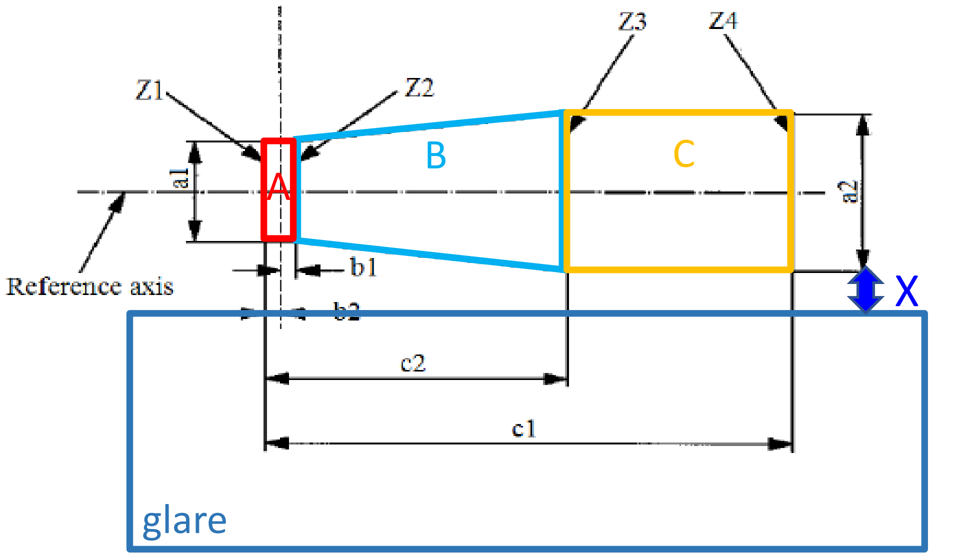


PROPOSAL: add maximum distance between two light emitting surfaces

How to maintain glare control

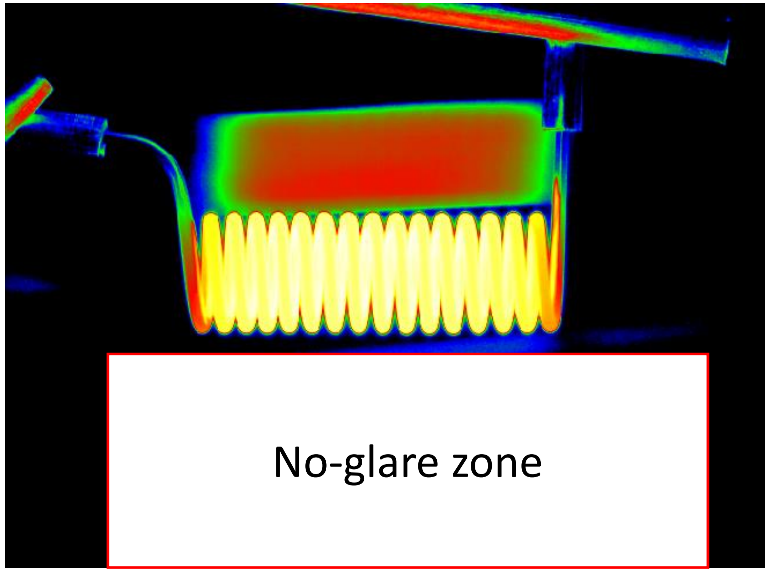
Contrast
ensuring a sharp cut-off (and controlling the glare)

- Already adressed by full equivalance in R37 today
- Maintain in intelligent equivalence approach



Contrast

ensuring a sharp cut-off (and controlling the glare)



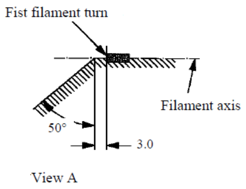
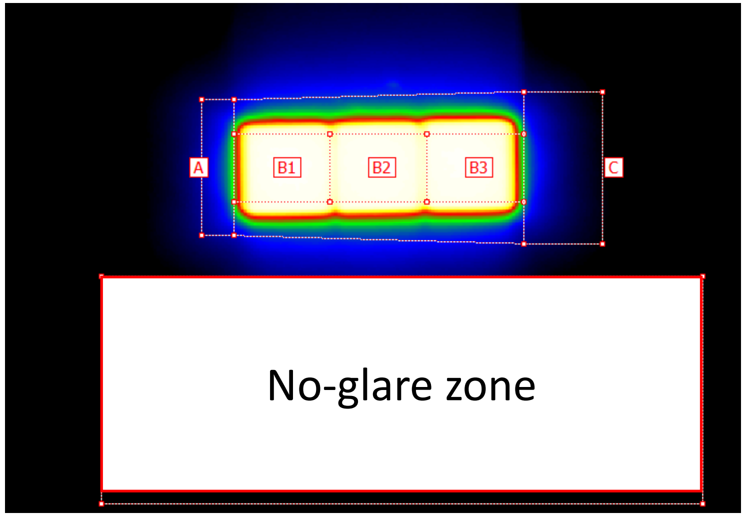


Figure 4 – Metal free zone8/



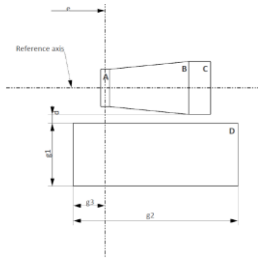


Figure 5: Box definition of the area D (dimensions given in Table 2)

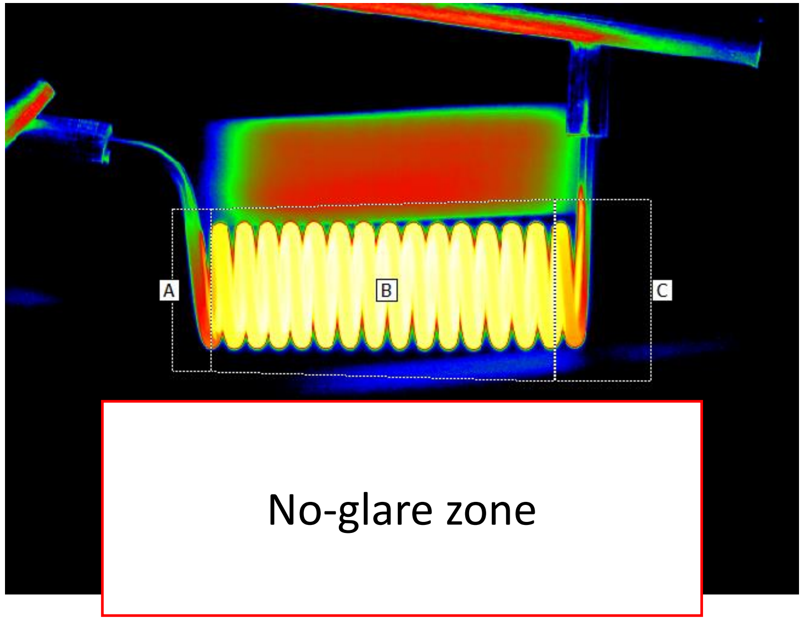
halogen performance

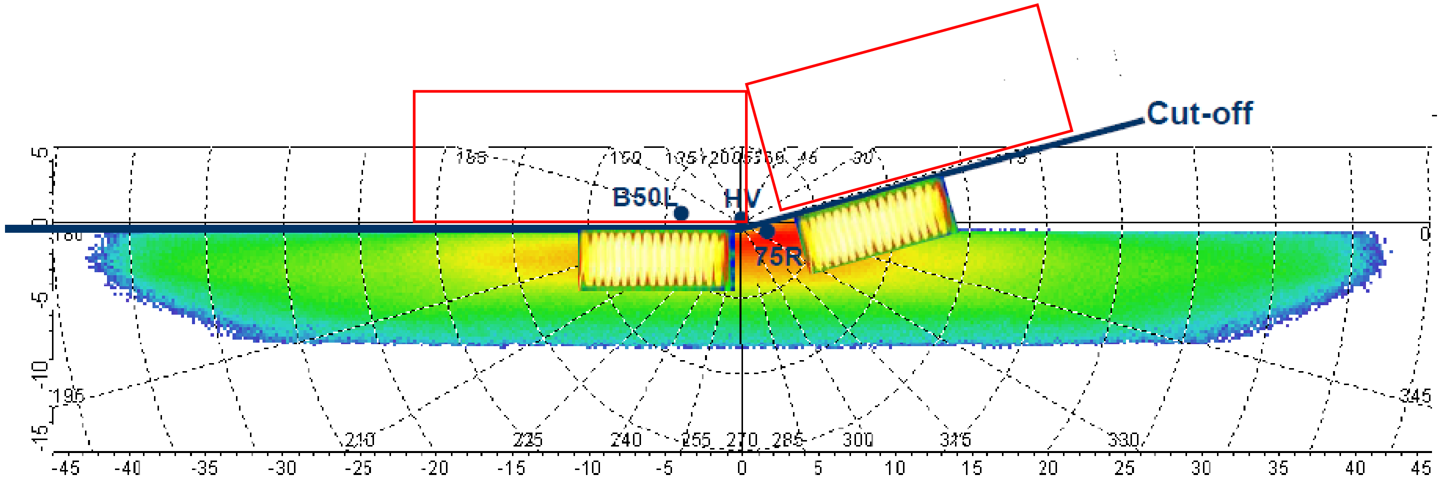
LEDr performance

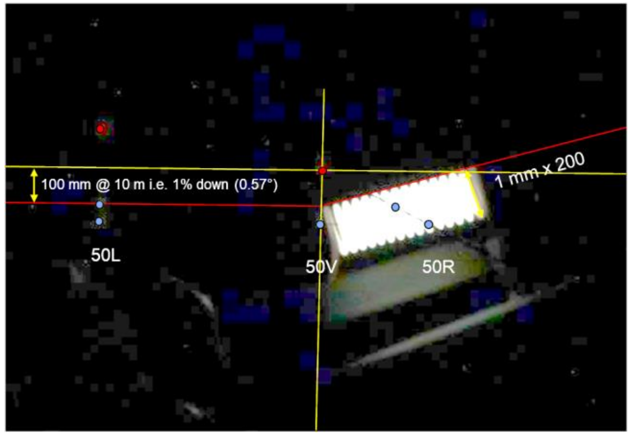
- already part of R37 today (full equivalence)
- Maintain in intelligent equivalence approach

How does glare control work

Halogen and LEDr comparison



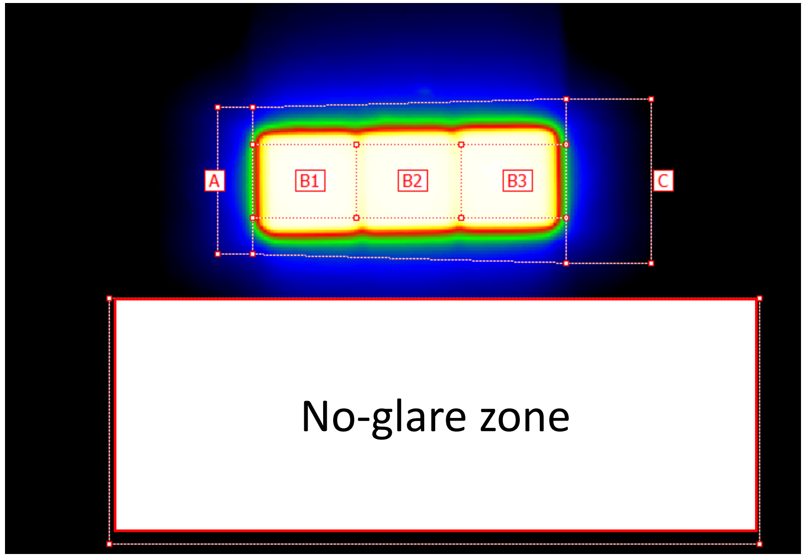


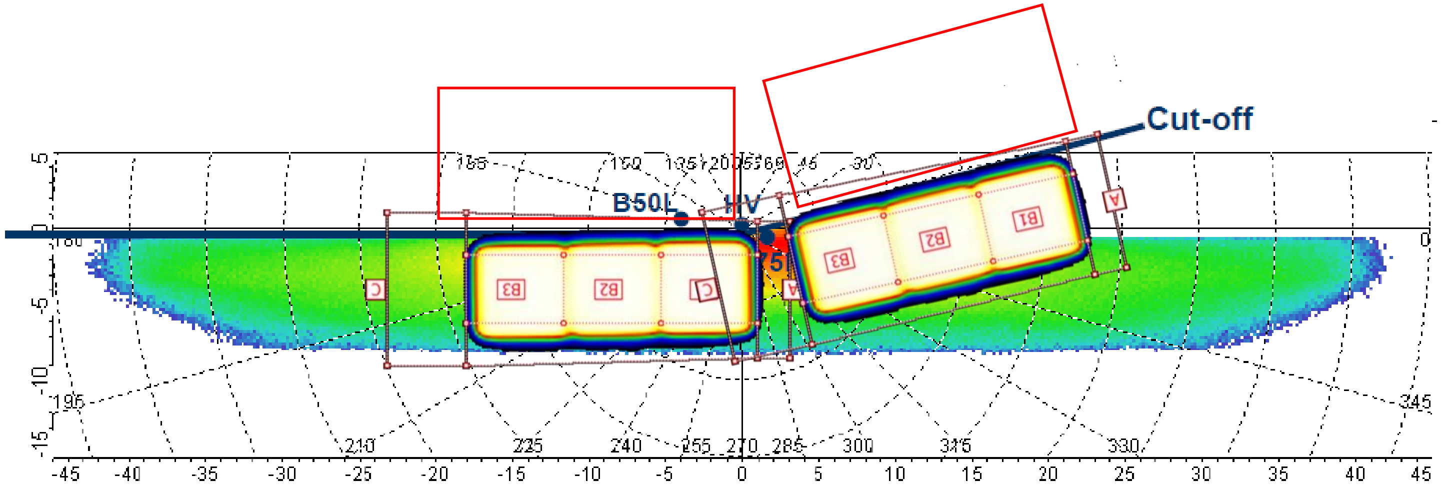


No glare zone:
Realised for filament lamps by a defined geometry
(“metal free zone“ and “out-of-center“ position)

How does glare control work

Halogen and LEDr comparison



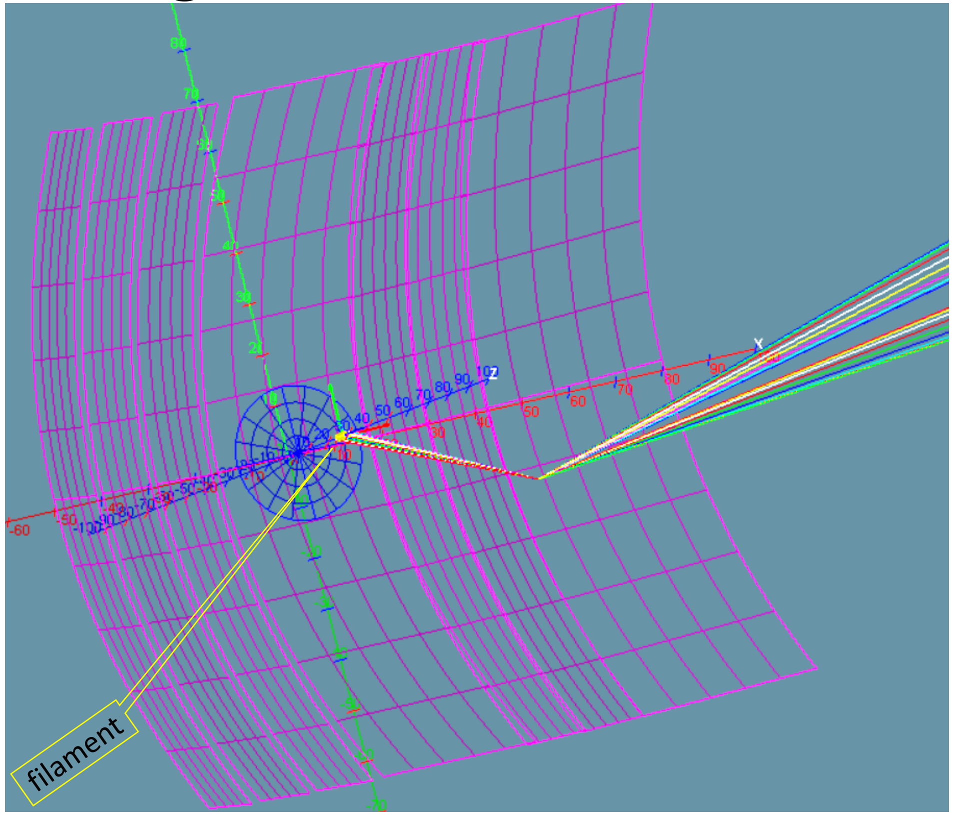


No glare zone:
Realised for LEDr by a constrast requirement (luminance measurement)

- Already adressed by full equivalence in R37 today

Beam shaping in a filament reflector headlamp

- Beam on wall / street created by projecting individual filament images via reflector elements



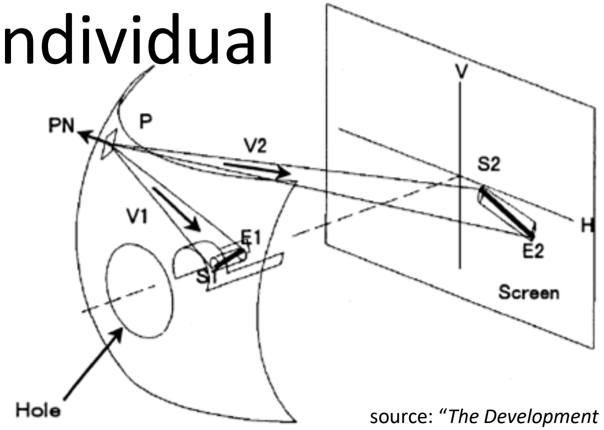
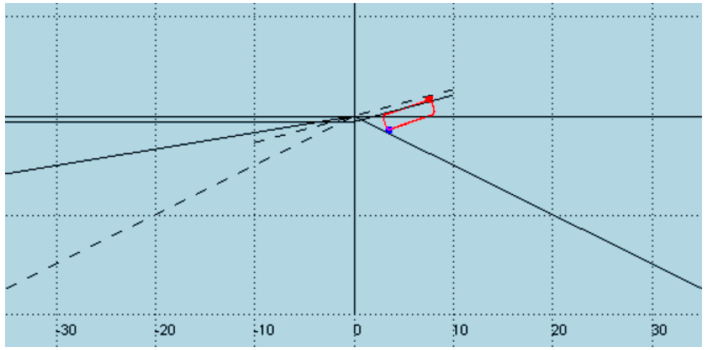


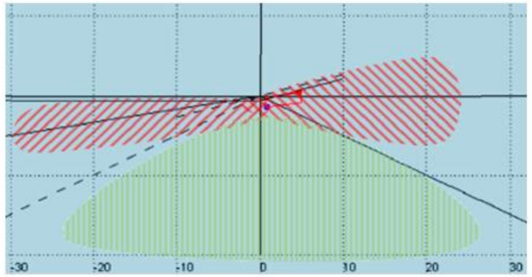
Figure 6. Principle of Simulation

source: *"The Development of the Line-Beam Headlamp"* Stanley Electric, SAE 1999

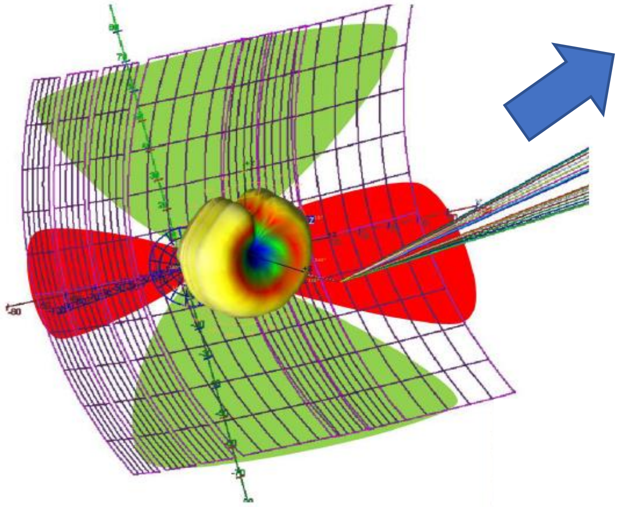
source: LucidShape visualization, B. Spinger

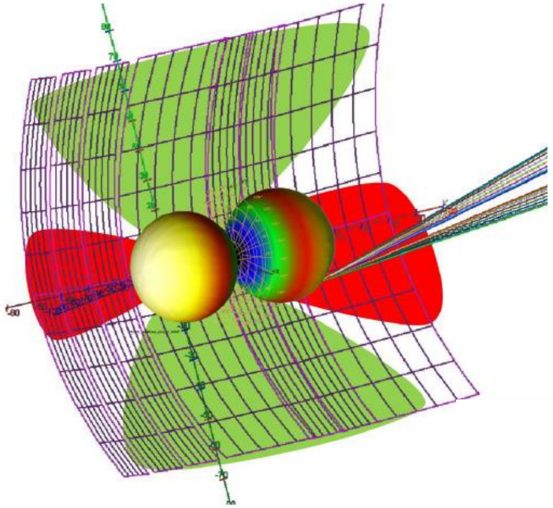


Side-by-side Halogen and Intelligent Equivalent LEDr Beams on 25 m screen



Illuminated reflector segment and corresponding light on the road

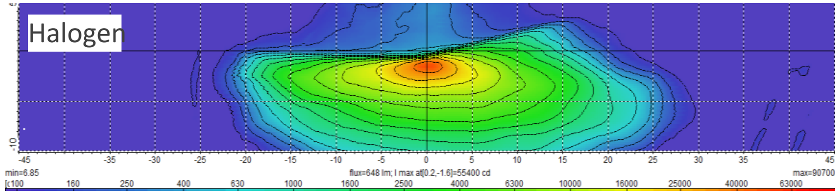


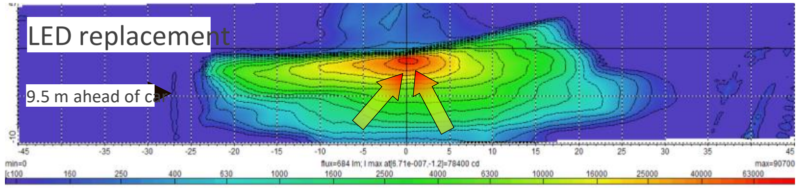


Both light sources 1350 lm

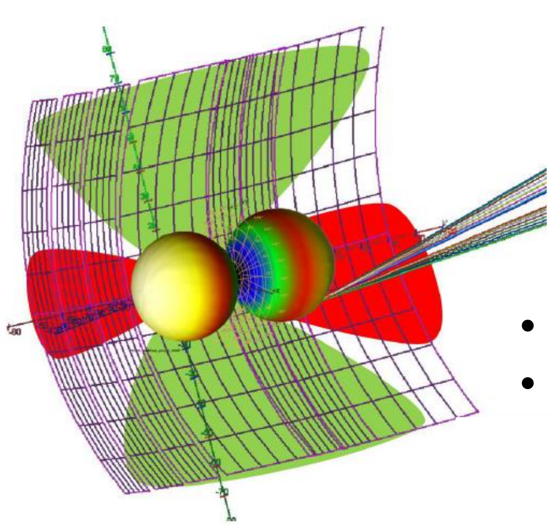
100 cd/klm in red and green direction

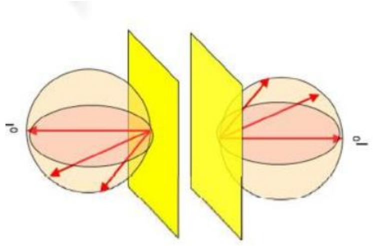
170 cd/klm in “red“ direction
< 80 cd /klm in “green“ direction





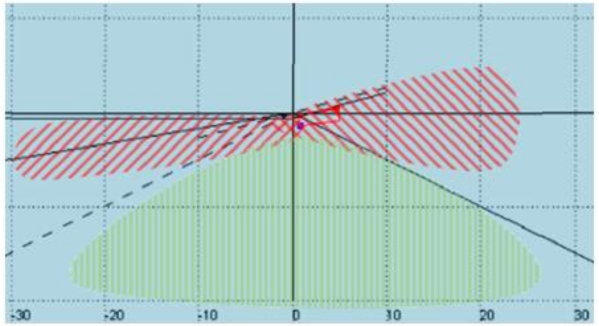
National approvals (Germany, France, Austria ...)
Deviating from full photometric equivalence





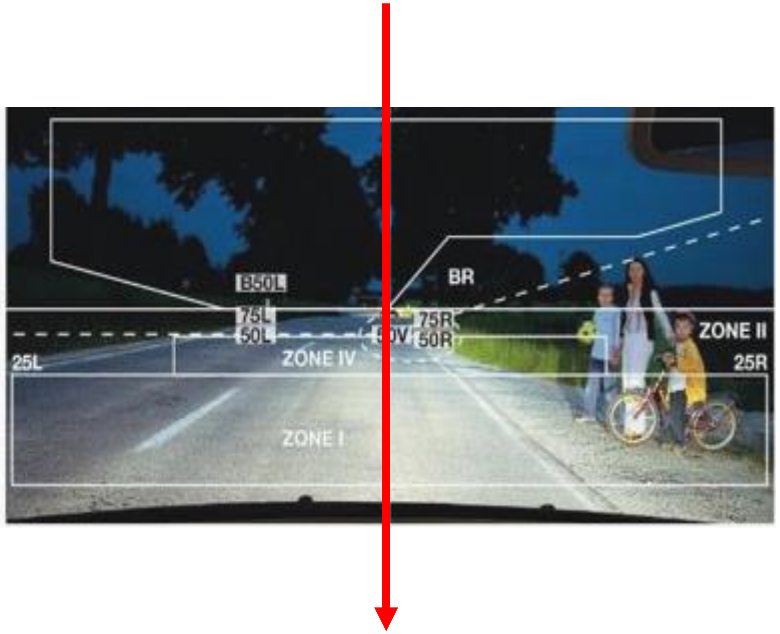
- Less light in green segments
- More light in red segments

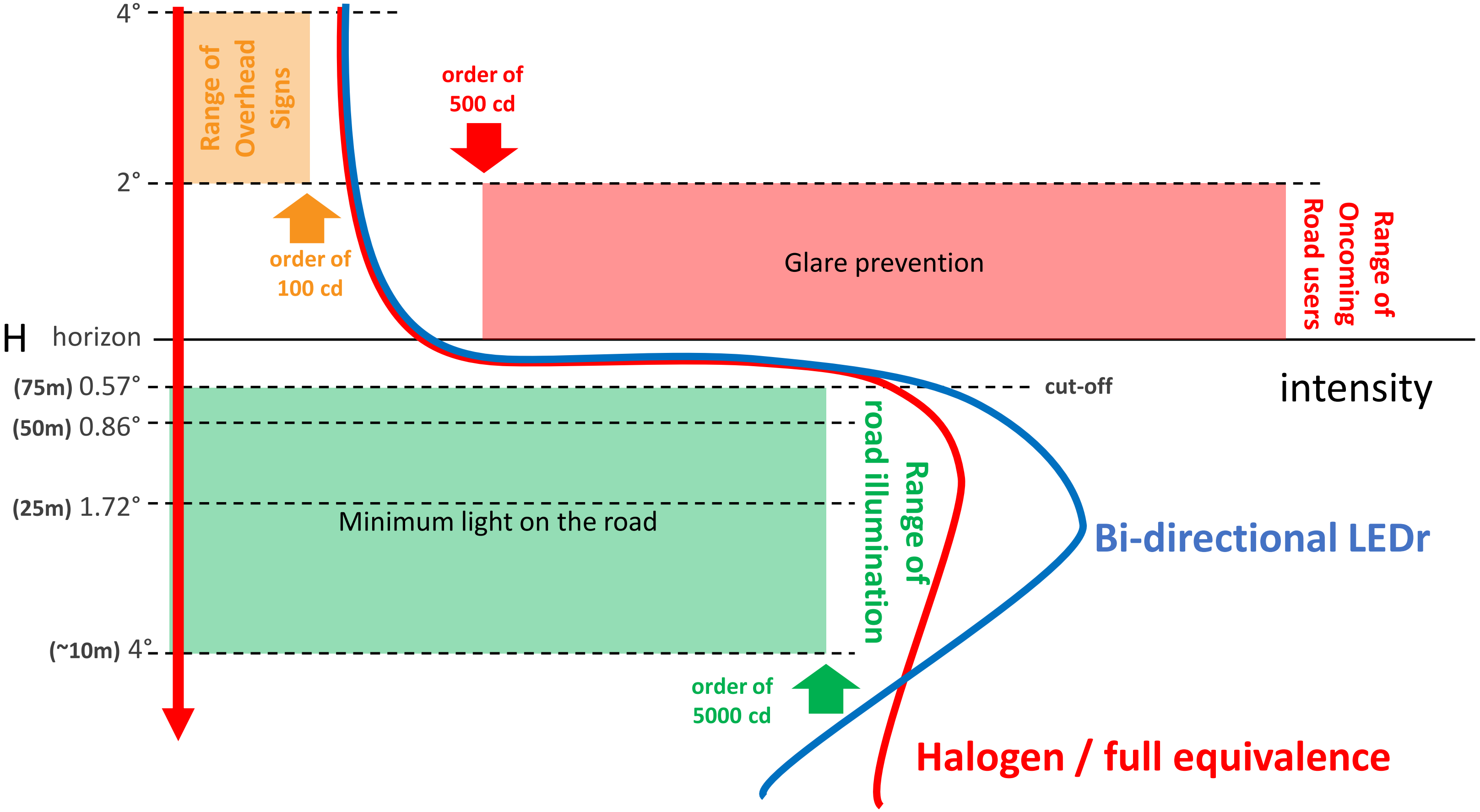
Illuminated reflector segment and corresponding light on the road



- Methodology
  - Extensive testing (in headlamps and vehicles)
  - Limited light source specifications
  - Resulting in positive list
- PRO‘s
  - Enabling legalization of safe LEDr, supporting market surveillance
  - Increased beam performance in many tested headlamps
  - Technically feasible with today LED technology
- CON‘s
  - Incompatible with some headlamps / vehicles
  - Mis-use may lead to non-compliant beams
  - High effort for industry and approval authorities to maintain the positive list
  - Country-specific approval processes, limited mutual recognition
  - Not yet possible in most countries

Summary


B50L
BR
75L
50L
50V
75R
50R
ZONE II
25L
ZONE IV
25R
ZONE I


4°
2°
H-H
horizon
(75m) 0.57°
(50m) 0.86°
(25m) 1.72°
(~10m) 4°
Range of Overhead Signs
order of 100 cd
order of 500 cd
Glare prevention
Range of Oncoming Road users
cut-off
intensity
Minimum light on the road
Range of road illumination
order of 5000 cd
Bi-directional LEDr
Halogen / full equivalence