TFSR-06-07

(= Revision of TFSR-05-04)

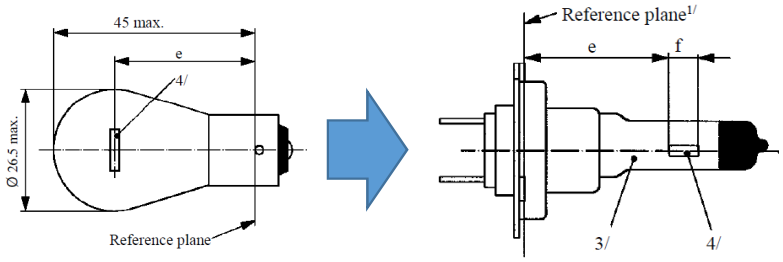
Equivalence Criteria for LED Substitute Light Sources

Extension to light source categories having no use restrictions

= Light sources used in Road Illumination Devices

Walter Schlager

21-May-2019



Additional / modified criteria

80th GRE adopted …
- GRE/2018/39 *(R128)*
- GRE/2018/40 *(R.E.5, PY21W/LED)*

… based on:
- GRE-80-02 *(Equivalence Criteria)*

LED Substitutes for Headlighting, TFSR-06-04
- Specific intensity distribution
- Specific homogeneity of LEA
- Contrast
- … *e.g. H11/LED*

LED light sources for Headlighting, GRE/2017/20
- Specific intensity distribution
- Specific homogeneity of LEA
- Contrast
- … *e.g. L1/6*

78th GRE adopted …
- GRE/2017/20 *(R128)*
- GRE/2017/16 *(R.E.5, L1/6)*

… based on:
- GRE-77-04 *(Guideline Criteria)*

LED Substitutes for Signaling, GRE-80-02
- Test voltage
- Luminous flux
- …
- Intensity distribution
- Homogeneity of LEA
- …
- Spectral content
- Thermal behavior
- … *e.g. PY21W/LED*

Substitutes for use in LSD only

- Test voltage
- Luminous flux
- …
- Intensity distribution
- Homogeneity of LEA
- …
- Spectral content
- Thermal behavior
- …

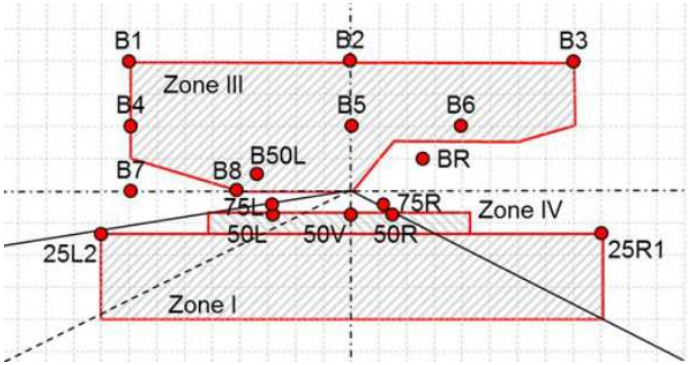
e.g. H11/LED

Substitutes for use in RID devices

* with minor amendment, see GRE-80 report, Annex III

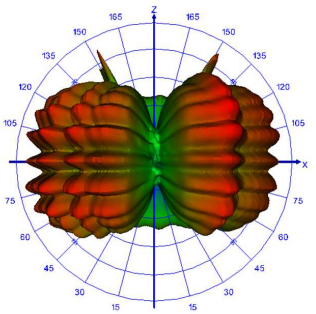
Main difference …

- Road illumination functions must realize beams with cut-off and with areas of limited glare

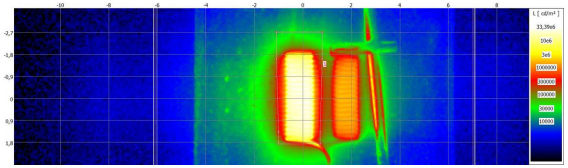


➢More specific equivalence criteria with respect to …

✓"where does the light go to" *(far-field behavior)*



✓"where does the light precisely come from" *(near-field behavior)*

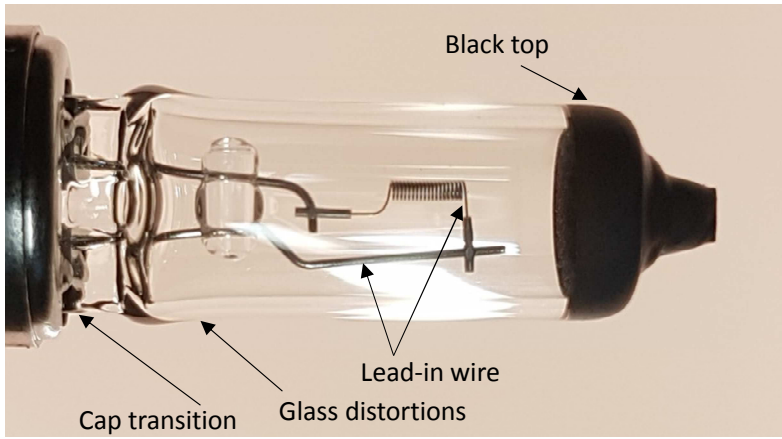


#1: Intensity distribution (“far field”)

- Target: Emulate physical behavior of the emission of a coiled filament

➢Specify light emission !

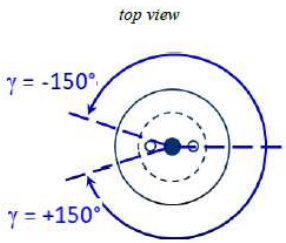
- predominantly including directions of undistorted glass envelope
- generally excluding:
  - transition region of the cap
  - proximity of the filament axis
  - area of strong glass distortions *(e.g. tips)*
  - shading region due to internal elements *(e.g. lead-in wires, second filament, shield)*
  - black top region

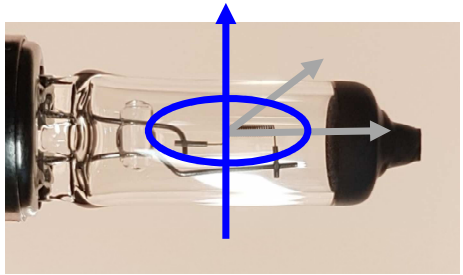


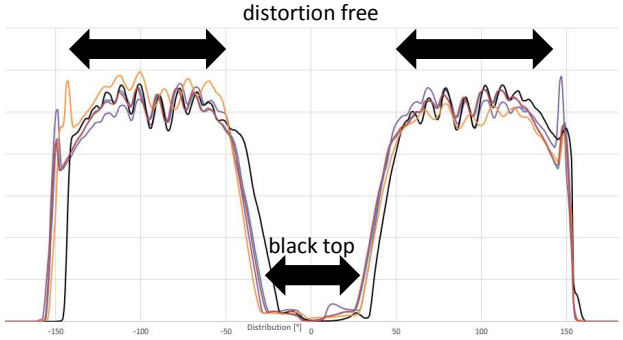
#1: Intensity distribution (“far field”)

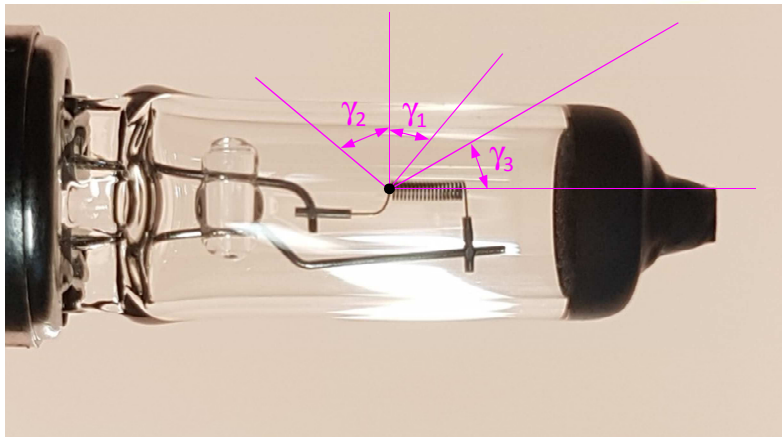
Proposal:

- Check in three C-γ planes covering the distortion free area (γ_1, γ_2)
- Limit to [80] … [130] cd/1000 lm *(variation due to glass bulb and coil structure)*
- In case of Black-top: upper limit of [10] cd/1000 lm (γ_3)
- Lead-in wire: no specification within [+/- 30°] shading area





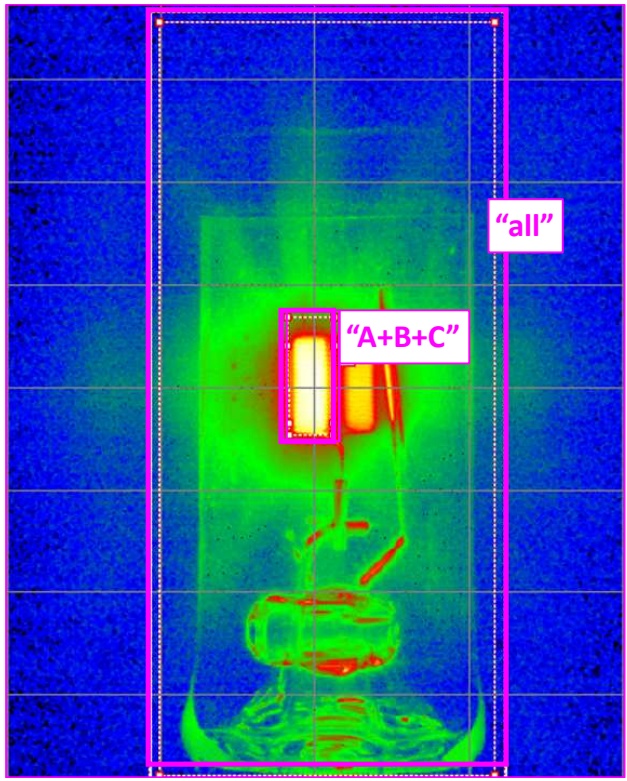




From R37 sheet
From measurements

#2: Direct Flux Ratio (DFR)

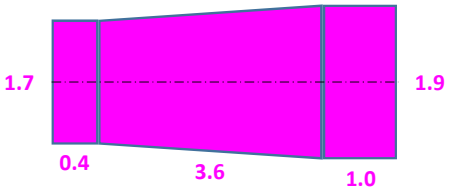
- Translate “indirect” light emission of a filament light source into an upper limit requirement for the Substitute light source
  - “ghost image” of filament
  - Reflections from lead-in wire and glass construction
  - Scattering from glass bulb
- Specify minimum “Direct-Flux-Ratio” (DFR)
  - Luminous flux emitted from whole box (A+B+C)
  - Relative to luminous flux emitted from whole bulb (“all”)
  - $DFR = \frac{A+B+C}{"all"} > [90\%]$



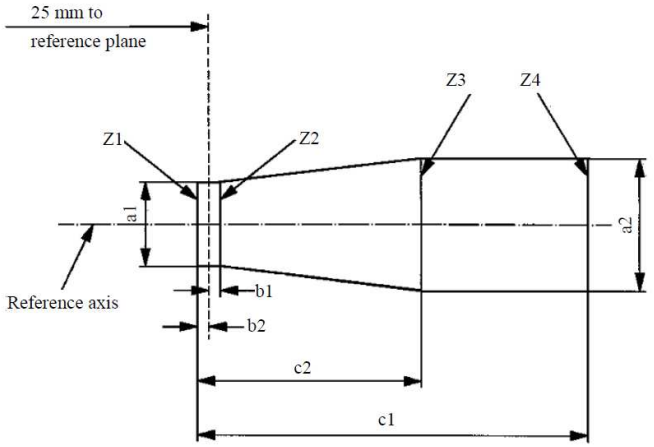
From R37 sheet
From measurements

#3: Size / position of light-emitting-area

- Different situations exist:
  - Single filament in axial direction (mainly trapezoidal box definition)
  - Single filament in transversal direction (butterfly box definition)
  - Double filaments without shield/baffle
  - Double filaments with shield baffle
- Proposal in case of single filament in axial direction
  - Same box shape, same box dimensions
  - Three viewing directions *(excluding view from lead-in wire)*



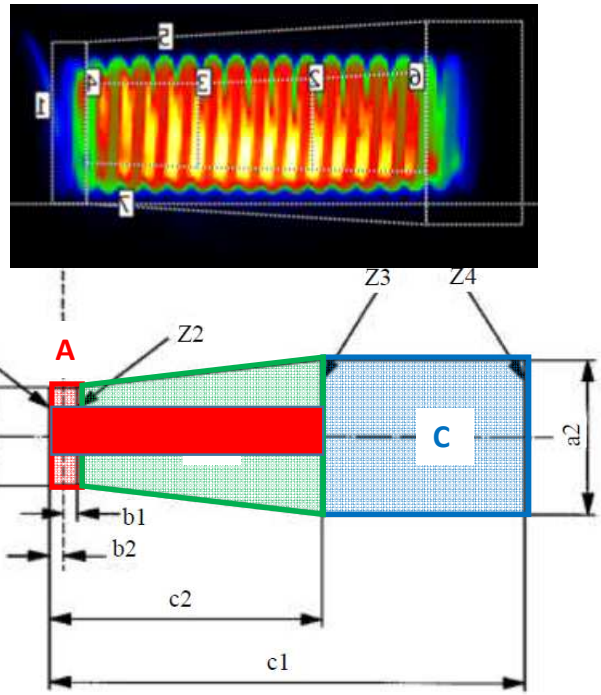
Example of H11
(d=1.4mm)



From R37 sheet
From measurements

#4: homogeneity of LEA (“near field”)

- Translate extreme position and dimension of filament case into homogeneity requirements of LED case
- Specify accordingly minimum and maximum limits for the different parts of the LEA
  - Maximum for part A: max. > $\frac{A}{A+B+C} = \frac{b1+b2}{c2}$
  - Minimum for part B: min. < $\frac{B}{A+B+C} = \frac{c2-b1-b2}{c1}$
  - Maximum for part C: max. > $\frac{C}{A+B+C} = \frac{c1-c2}{c1-b1-b2}$
  - Three viewing directions *(excluding view from lead-in wire)*



A: contains left end turn of filament
B: is covered by filament horizontally
C: contains right end turn of filament

From R37 sheet
From measurements

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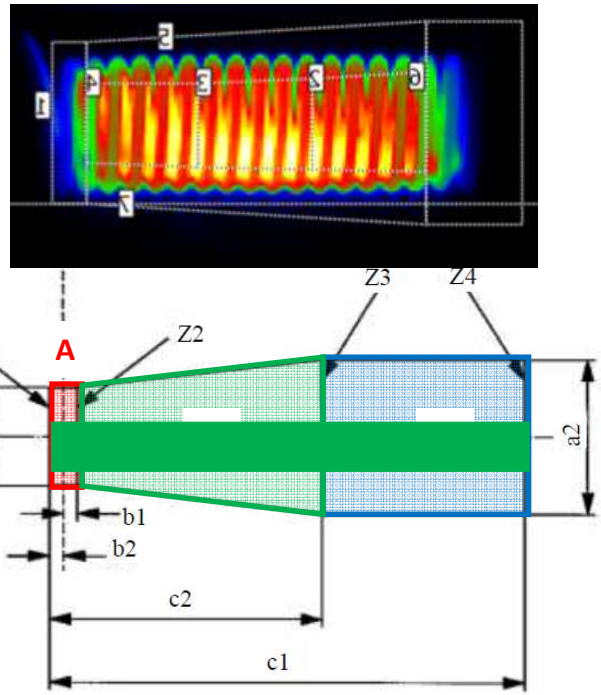
  - Maximum for part C: max. > $\frac{C}{A+B+C} = \frac{c1-c2}{c1-b1-b2}$
  - Three viewing directions *(excluding view from lead-in wire)*



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From R37 sheet
From measurements

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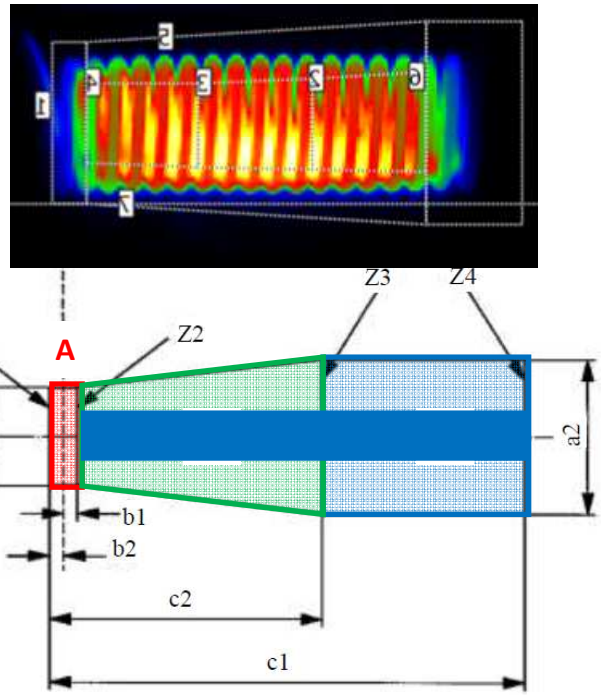
  - Three viewing directions *(excluding view from lead-in wire)*



A: contains left end turn of filament
B: is covered by filament horizontally
C: contains right end turn of filament

From R37 sheet
From measurements

#4: homogeneity of LEA (“near field”)

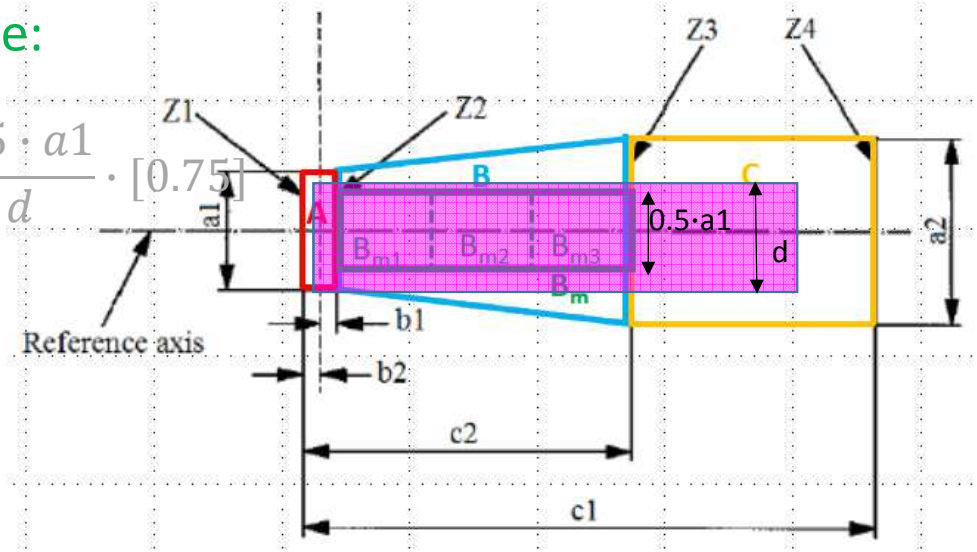
- Simulate in the core part (B) a filament in more detail:
  - Apply a central part B_m: $\frac{B_m}{B} = \frac{0.5 \cdot a1}{d}$
  - Divide it in three horizontal parts B_{m1}, B_{m2}, B_{m3}

    … and specify a minimum for each of those:

$$\frac{B_{m1}}{B} = \frac{B_{m2}}{B} = \frac{B_{m3}}{B} = {}^1\!/_3 \cdot \frac{0.5 \cdot a1}{d} \cdot [0.75]$$

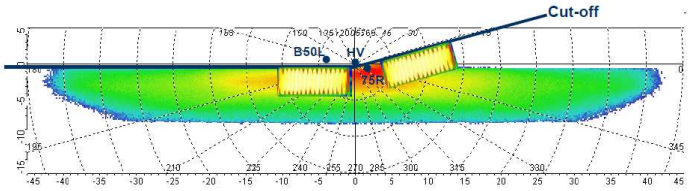
  - Check in three viewing directions

    (excluding direction of lead-in wire position)



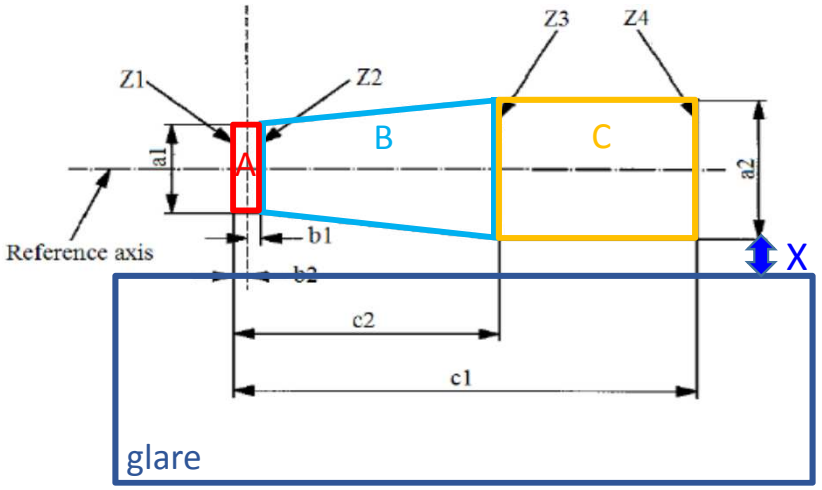
From R37 sheet
From measurements

#5: Contrast



- Translate contrast situation of a filament light source into equivalent contrast criteria
- Specify a minimum value of flux ratio between two areas
  - bright area = box “A+B+C”
  - dark area = “glare”
  - distance X = 0.4mm*
  - Check in two viewing directions *(“glare box” is diametrically opposite of the lead-in wire)*

➢ “A+B+C”/”glare” > [100]**



* derived from the optical magnification of typical Halogen headlamps, where a minimum contrast in the beam must be achieved between 75R and HV

** number confirmed by measurements of H11 filament samples)

„glare“ = rectangle having 1.5 times the width of A+B+C, 1.5 times the height of C, and is located at a distance X from C

From R37 sheet

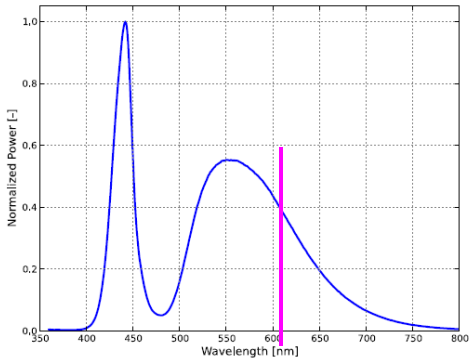
From measurements

#6: CCT resp. spectral content

- Substitute categories for road illumination devices (e.g. H11/LED) will not be used behind red or amber cover lenses
  → no CCT requirement

- All white light sources used for road illumination need to have sufficient red content
  → specify minimum red content *(like for HID and other LED based solutions)*

$$k_{red} = \frac{\int_{\lambda=610nm}^{780nm} E_e(\lambda)V(\lambda)d\lambda}{\int_{\lambda=380nm}^{780nm} E_e(\lambda)V(\lambda)d\lambda} \geq 0,05$$



From UN regulation
From measurements

Additional: 12V versus 24V version

Categories H11 and H11B **Sheet H11/3**

Dimensions in mm		*Filament light sources of normal production*		*Standard filament light source*
		12 V	*24 V*	*12 V*
e [11/]		25.0 [12/]		25.0 ± 0.1
f [11/]		4.5	5.3 [12/]	4.5 ± 0.1
g		0.5 min.		u.c.
h1		0 [12/]		0 ± 0.1
h2		0 [12/]		0 ± 0.15
γ1		50° min.		50° min.
γ2		40° min.		40° min.
γ3		30° min.		30° min.
Cap:	H11: PGJ19-2	in accordance with IEC Publication 60061 (sheet 7004-110-2)		
	H11B:PGJY19-2	in accordance with IEC Publication 60061 (sheet 7004-146-1)		
Electrical and photometric characteristics				
Rated values	Volts	12	24	12
	Watts	55	70	55
Test voltage	Volts	13.2	28.0	13.2
Objective values	Watts	62 max.	80 max.	62 max.
	Luminous flux	1,350 ± 10 %	1,600 ± 10 %	
Reference luminous flux at approximately			12 V	1,000
			13.2 V	1,350

[11/] The ends of the filament are defined as the points where, when the viewing direction is View A as shown in Figure 1 on sheet H11/1, the projection of the outside of the end turns crosses the filament axis.
[12/] To be checked by means of a "Box system"; sheet H11/4.

- Inherent to **<u>incandescent technology</u>**
  - ➢ higher voltage means a longer wire / larger filament
- To achieve similar beam performance*
  - ➢ Higher luminous flux required
    (e.g. 1600 lm / 1350 lm ≈ 5.3 mm / 4.5 mm)
- Consequence for **<u>LED technology</u>**
  - ➢ **Similar discrimination is not necessary**

** note: 24V headlamp is type-approved with 12V Etalon*

Additional: Standard („Etalon“) light source

Categories H11 and H11B — **Sheet H11/3**

Dimensions in mm		*Filament light sources of normal production*		*Standard filament light source*
		12 V	*24 V*	*12 V*
e [11/]		25.0 [12/]		25.0 ± 0.1
f [11/]		4.5	5.3 [12/]	4.5 ± 0.1
g		0.5 min.		u.c.
h1		0 [12/]		0 ± 0.1
h2		0 [12/]		0 ± 0.15
γ1		50° min.		50° min.
γ2		40° min.		40° min.
γ3		30° min.		30° min.
Cap:	H11: PGJ19-2	in accordance with IEC Publication 60061 (sheet 7004-110-2)		
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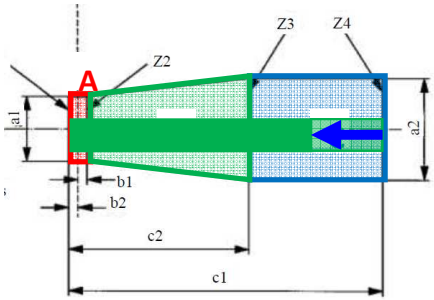
[12/] To be checked by means of a "Box system"; sheet H11/4.

- „Etalon“ vs. production light source in **<u>incandescent technology</u>**:

➢ The main difference is a more compact filament.

- Translated in **<u>LED technology</u>**:

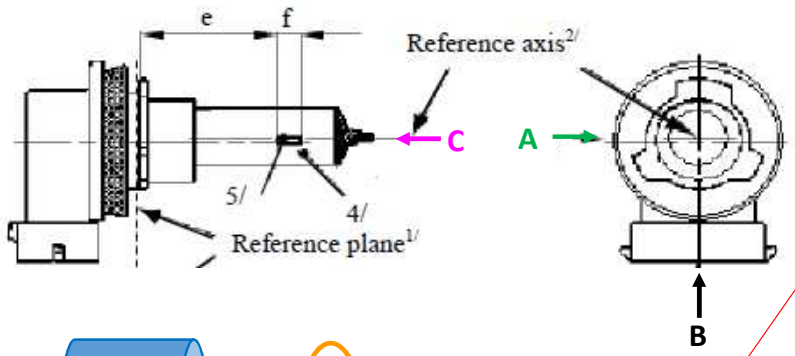
➢ Higher min. light emission from central part of the box *(see slide 9)*

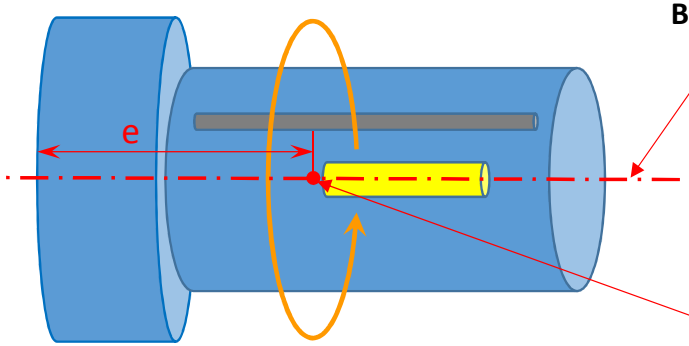


➢ *Example of H11/LED:*

- *Minimum for part B: min.* $< \frac{B}{A+B+C} = \frac{c2-b1-b2}{c1}$
  - *Production light sources: 3.6/5.0 = 72%*
  - ***„Etalon“ light sources: 3.6/4.5 = 80%***

Additional: choice of C-γ-system *(1/3)*





γ=90°, (C_0 … C_{330}, excluding C_{180}; step 30°)

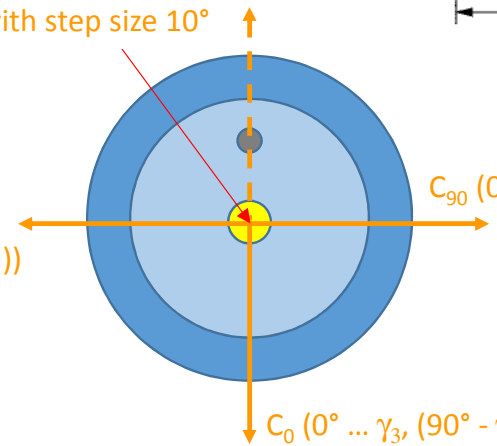
Origin of C-γ-system
at distance e
from reference plane

View from A

Intersection of C-γ-planes
=
Reference axis

C_{180} (0° … γ_3) with step size 10°

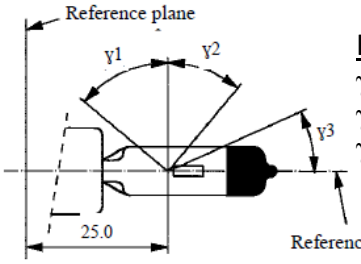
C_{270} (0° … γ_3, (90° - γ_2) … (90° + γ_1))
with step size 10°



C_{90} (0° … γ_3, (90° - γ_2) … (90° + γ_1))
with step size 10°

C_0 (0° … γ_3, (90° - γ_2) … (90° + γ_1))
with step size 10°

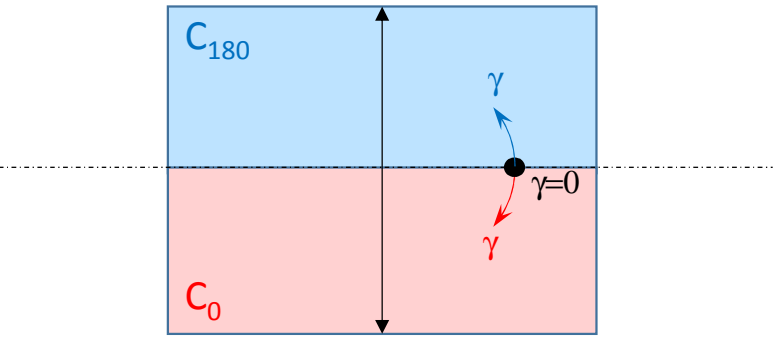
View from C



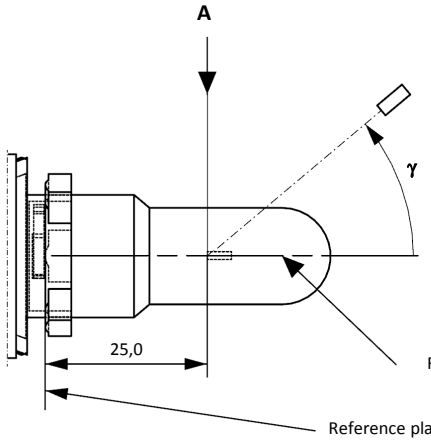
H11 case
γ_1= 50° min.
γ_2= 40° min.
γ_3= 30° min.

Additional: choice of C-γ-system *(2/3)*

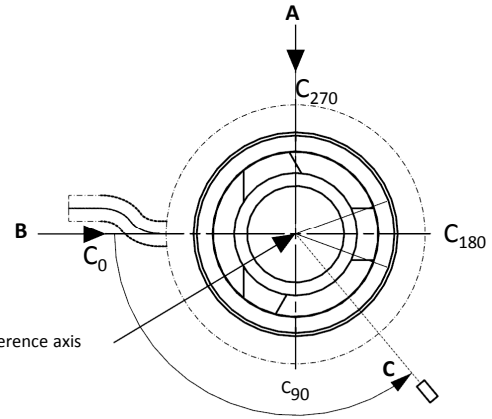
Note, the choice of γ = 0°



View from B

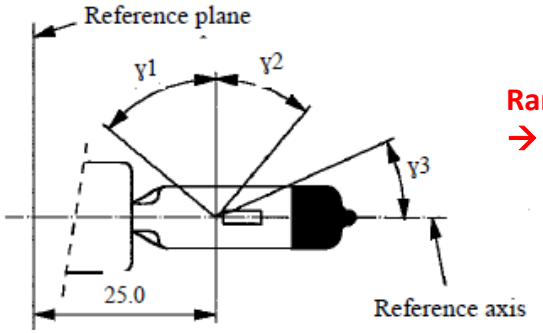


View from B



View from C

Additional: choice of C-γ-system *(3/3)*



Range of black top („γ3“),
→ set upper limit (< 10cd/klm)

Range of distortion free area („γ1 and γ2“),
→ specify lower and upper limit (80…130 cd/klm)

	Minimum intensity (cd/klm)		Maximum intensity (cd/klm)		
γ	C_0 C_{90} C_{270}	C_{30}, C_{60}, C_{120}, C_{150}, C_{210}, C_{240}, C_{300}, C_{330}	C_0 C_{90} C_{270}	C_{180}	C_{30}, C_{60}, C_{120}, C_{150}, C_{210}, C_{240}, C_{300}, C_{330}
0°	-	-	[10]	[10]	-
10°	-	-	[10]	[10]	-
20°	-	-	[10]	[10]	-
30°	-	-	[10]	[10]	-
50°	[80]		[130]	-	
60°	[80]	-	[130]	-	-
70°	[80]	-	[130]	-	-
80°	[80]	-	[130]	-	-
90°	[80]	[80]	[130]	-	[130]
100°	[80]	-	[130]	-	-
110°	[80]	-	[130]	-	-
120°	[80]	-	[130]	-	-
130°	[80]	-	[130]	-	-
140°	[80]	-	[130]	-	-

Next Steps

Proposal:

- Update “Equivalence Criteria” *(GRE-80-02)* to cover categories used in road illumination devices
- Draft first R.E.5 category sheet, e.g. “H11/LED”
- No further amendment to R128 body text
- Amend R-RID, corresponding to amendment of R-LSD
- No further amendment to installation regulations