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

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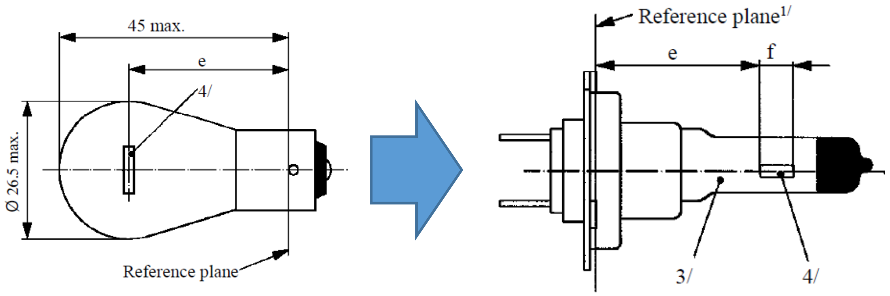


Additional / modified criteria

80th GRE adopted …

- GRE/2018/39 (R128)
- GRE/2018/40 (R.E.5, PY21W/LED)
- GRE/2018/41 (R48, …)
- GRE/2018/42* (R-LSD)

… based on:

- Equivalence Criteria GRE-80-02 →

GRE-80-02

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

For use in LSD only

TFSR-05-xx

- Specific intensity distribution
- Specific homogeneity of LEA
- Contrast
- …

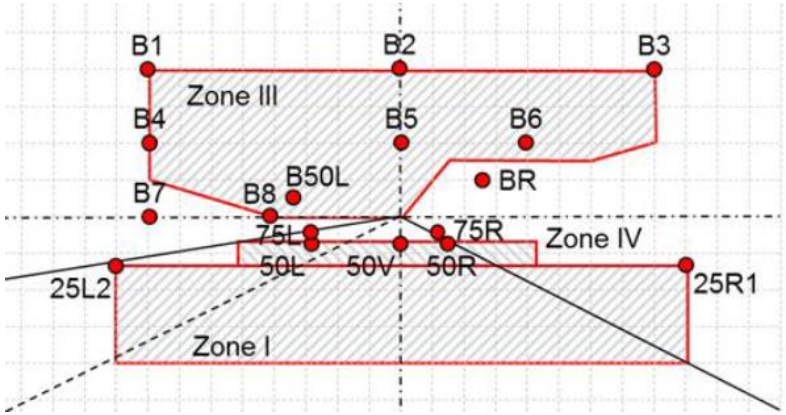
- Test voltage
- Luminous flux
- …
- Intensity distribution
- Homogeneity of LEA
- …
- Spectral content
- Thermal behavior
- …

For use in all devices

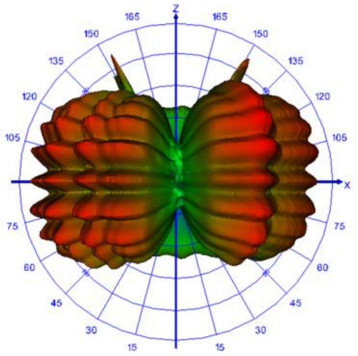
* with minor amendment, see GRE-80 report, Annex III

Main difference …

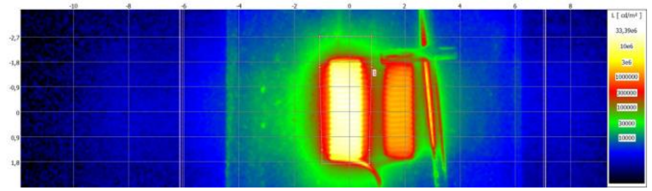
- Road illumination functions must realize beams with cut-off and with areas of limited glare



➢ 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)*

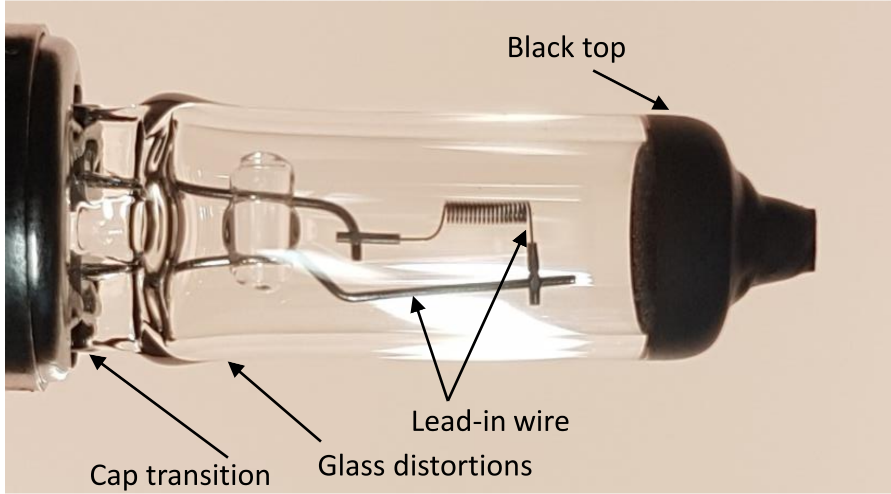


#1: Intensity distribution ("far field")

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

➢Specify light emission !

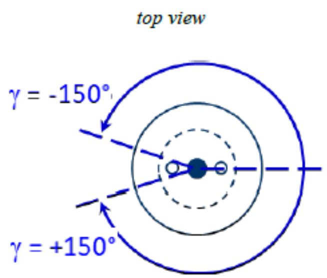
  - predominantly including directions of undistorted glass envelope
  - generally excluding:
    - transition region of the cap
    - proximity of the filament axis
    - area of strong glass distortions *(e.g. tips)*
    - shading region due to internal elements *(e.g. lead-in wires, second filament,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

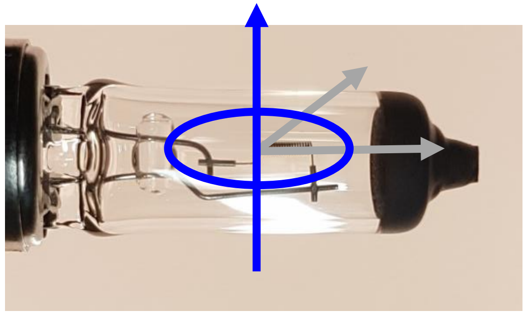


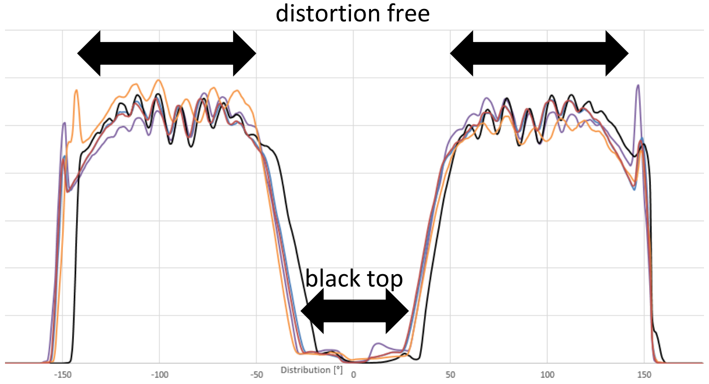
#1: Intensity distribution ("far field")

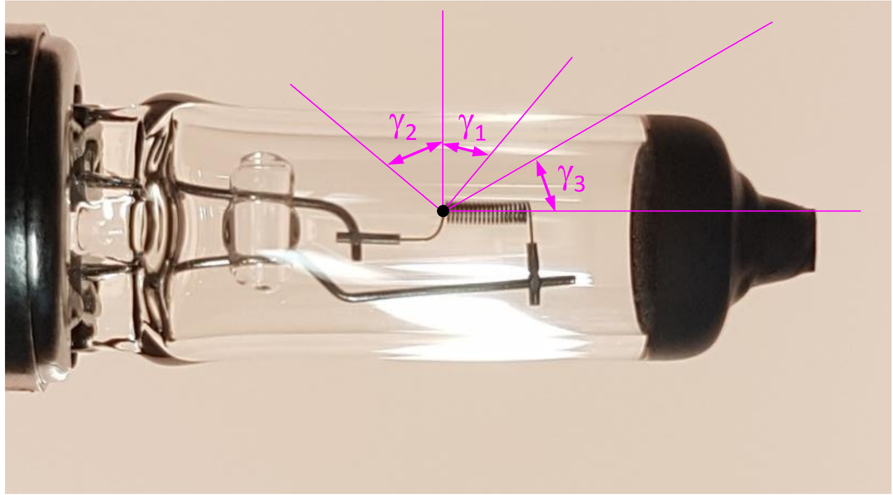
Proposal:

- Check in three C-γ planes representing 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







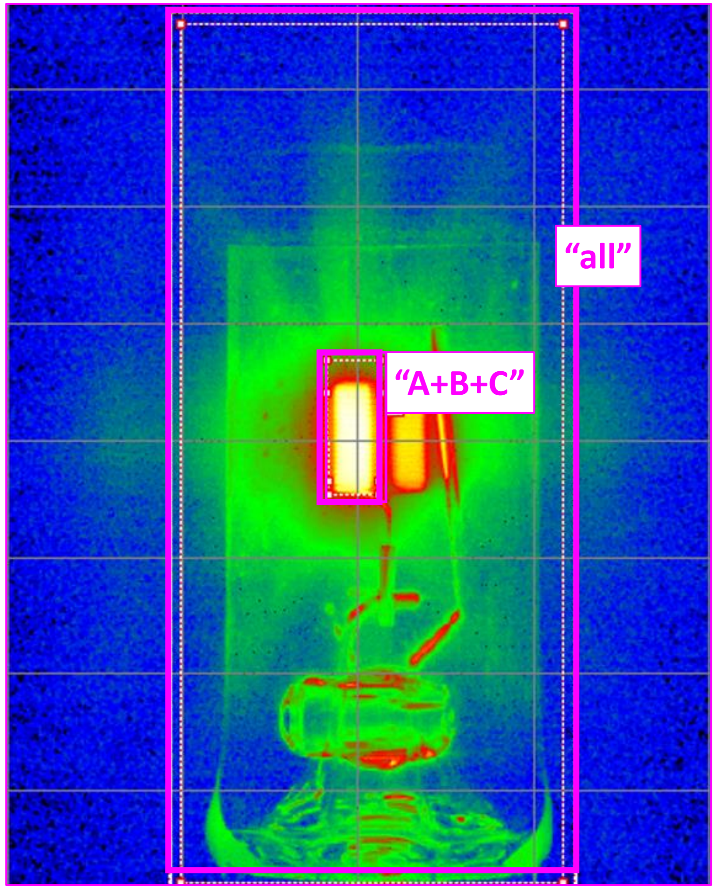


From R37 sheet

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 filament box (“A+B+C”)
  - Relative to luminous flux emitted from whole bulb (“all”)
  - $DFR = \frac{A+B+C}{"all"} > [90\%]$

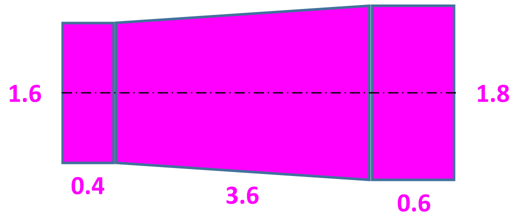


From R37 sheet

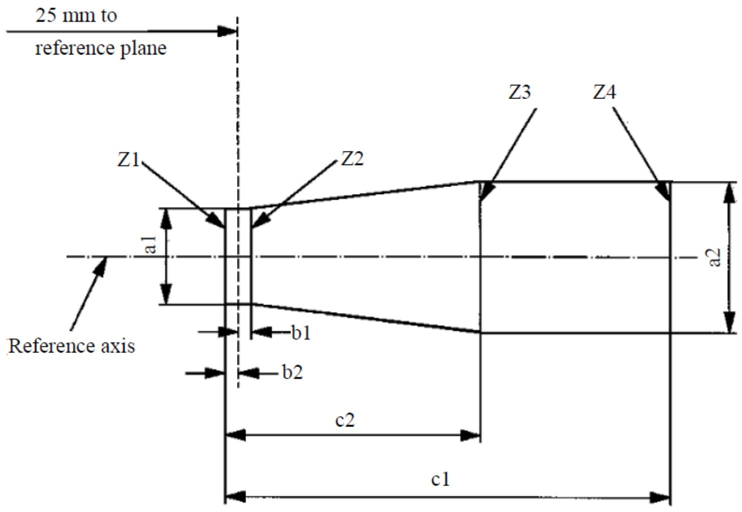
From measurements

#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)*



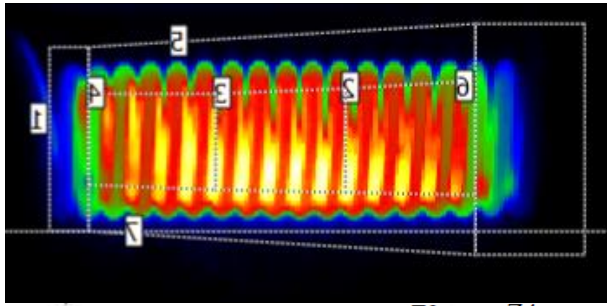
Example of H7
(d=1.3mm)

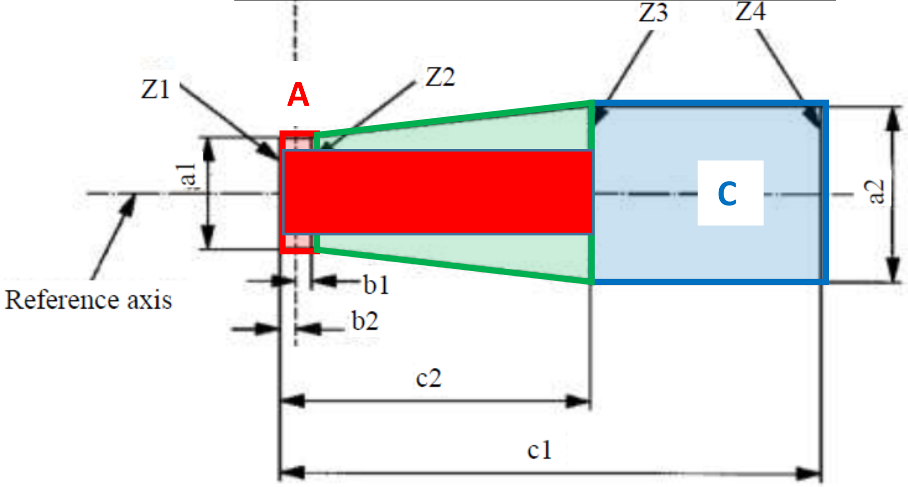


From R37 sheet
From measurements

#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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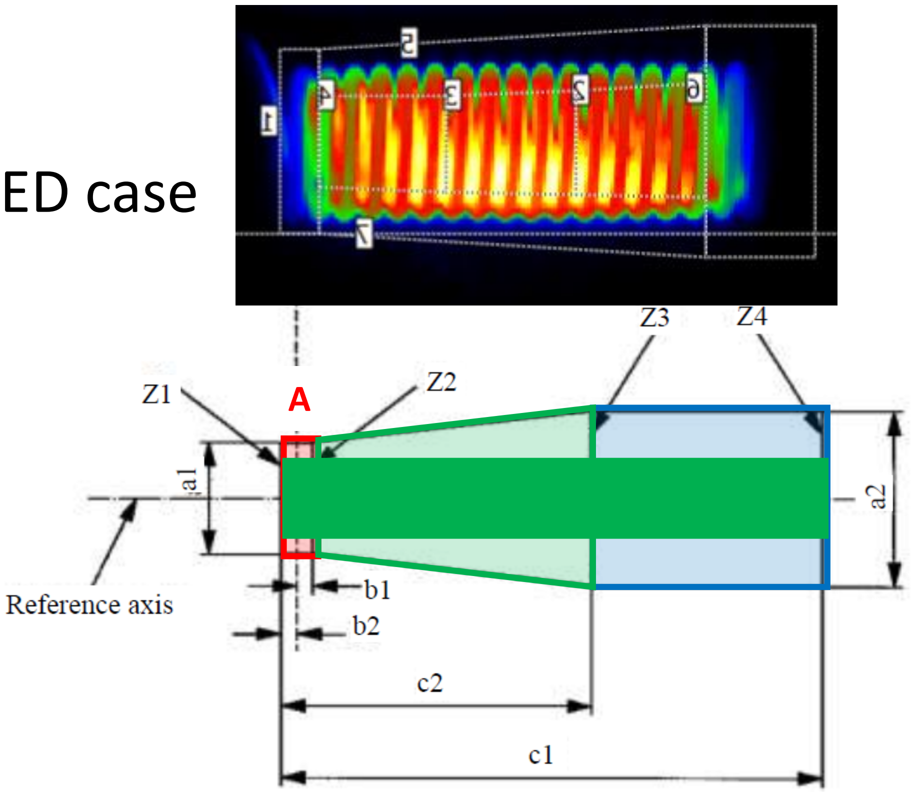

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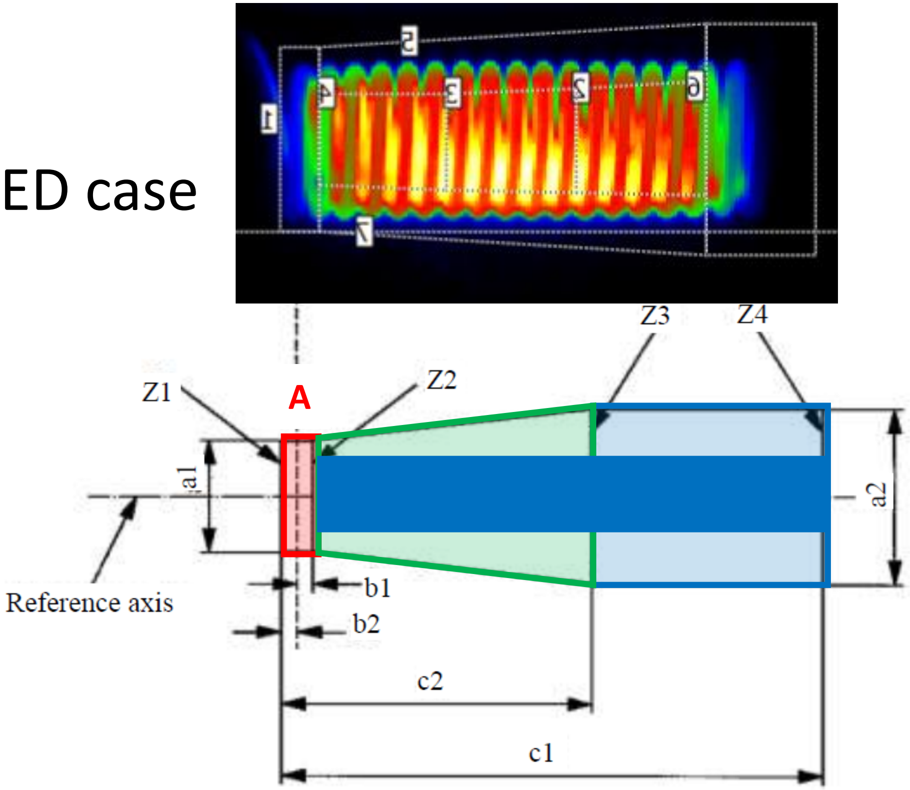


From R37 sheet

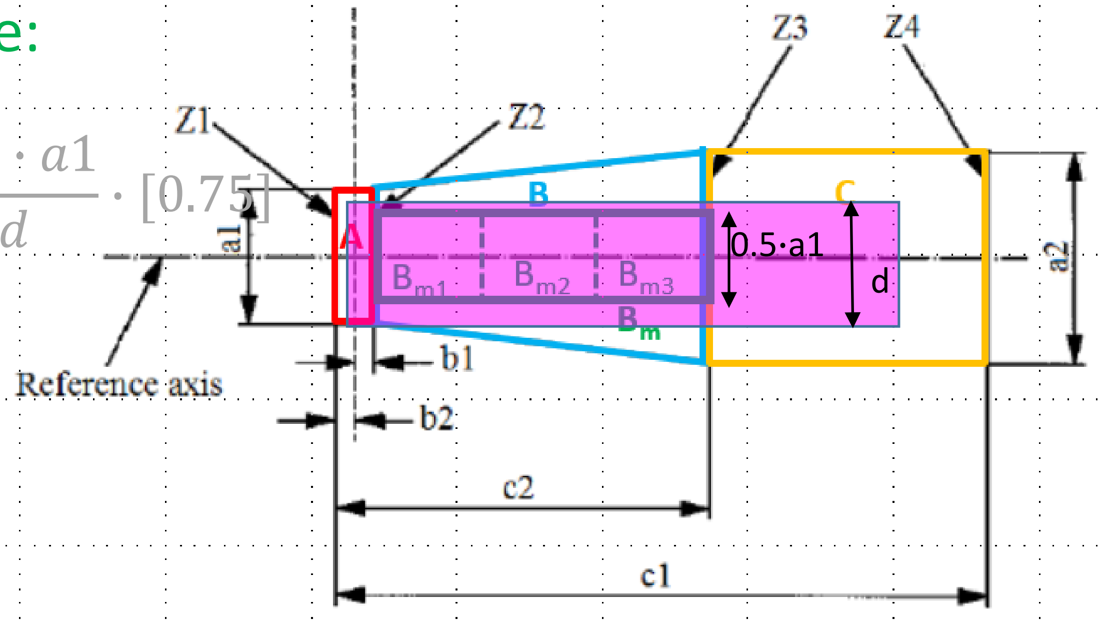
From measurements

#4: homogeneity of LEA ("near field")

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

    … and specify a minimum for each of those:

$$\frac{B_{m1}}{B} = \frac{B_{m2}}{B} = \frac{B_{m3}}{B} = {}^{1}/_{3} \cdot \frac{0.5 \cdot a1}{d} \cdot [0.75]$$



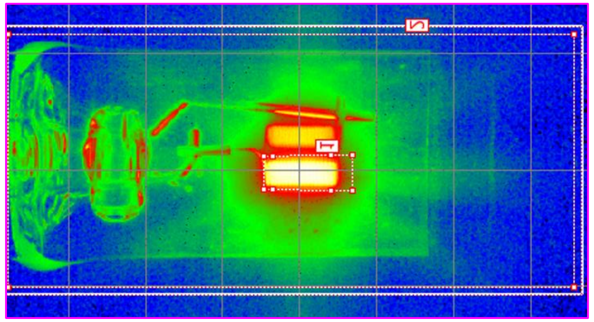
  - Check in three viewing directions

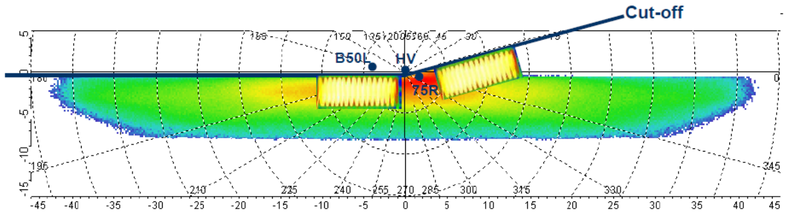
    (excluding direction of lead-in wire position)

From R37 sheet

From measurements

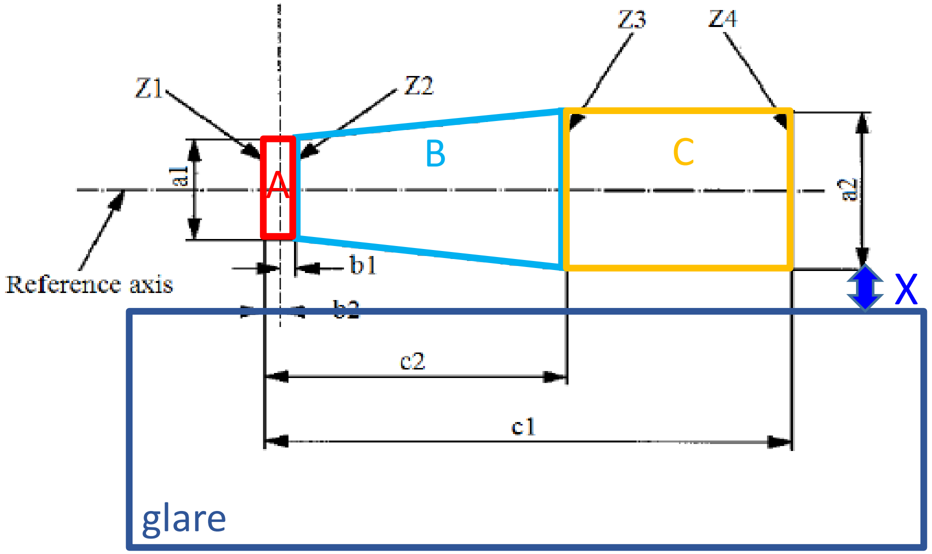
#5: Contrast





- 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]**



„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

* 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 H7 filament samples)

From R37 sheet

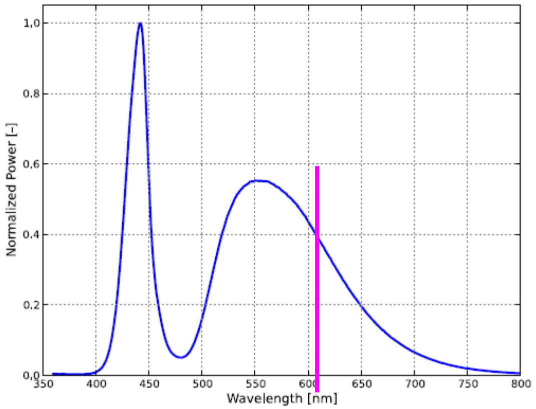
From measurements

#6: CCT resp. spectral content

- Substitute categories for road illumination devices (e.g. H7/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

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. "H7/LED"
- If needed, amend R128 body text
- Amend R-RID, corresponding to amendment of R-LSD
- No further amendment to installation regulations