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| Transmitted by the experts from The International Automotive Lighting and Light Signalling Expert Group (GTB) | **SLR-37-02** |

**Scientific notation of the photometric requirements in the headlamp regulations**

**Problem statement:**

After the conversion of headlamp Regulations, the illuminance requirements such as 0,7 lux and 12 lux were converted into luminous intensities such as 625 cd and 10,100 cd respectively. It resulted in more significant digits, in fact some more digits than the measurement uncertainty and even the measurement resolution allows. It might result in strange discussions like displaying and reporting measurement values like 10,137 cd. In addition, an accreditation body might insist in measuring in the same number of significant digits as the requirement is using. This is impossible e.g. in the case of a requirement of 10,100 cd.

**General remarks to measurement-uncertainty**

Every measurement has a measurement uncertainty. In lighting technology those measurement uncertainties are typically between 3 and 5% for good laboratories (K=2 🡪 U=95%). This means, that the true value, which nobody knows, is in 95% of all cases within the measurement uncertainty.

For example:

Measured value: 100 cd

Measurement uncertainty: 5% (this accuracy will be taken for all further examples)

With a probability of 95% the true value is between 95 cd and 105 cd.

1. **General remarks to the nomination of a laboratory**

The basis for a nomination is in all cases a quality management system according to ISO/IEC 17025. Normally a laboratory has in addition to the nomination an accreditation from the national accreditation authority. Thus, a laboratory has to be aware of its measurement uncertainty and during an audit the measurement uncertainty calculation of a measurement system is checked.

1. **General remarks to the acceptance interval**

The following figure shows the acceptance interval from the viewpoint of an accreditation authority



If you take a closer look to the drawing you can see, that the acceptance interval is the tolerance interval minus the measurement uncertainty.

Example B50L: if the minimum value is 50 cd and the maximum value is 350 cd. The acceptance interval is 52.5 cd to 332.5 cd. (To be sure, that even within a conformity of production checked by the authority the samples will pass, the manufacturer has to take in addition his measurement accuracy into account. This means that the acceptance interval for the manufacturer will be 55 cd to 316 cd.)

**According to some accreditation bodies: If a test house would measure 333 cd, the sample fails!**

1. **General remarks to the process capability**

As a common rule the smallest value that can be measured shall be approximately 10 times higher than the resolution of the measurement system – including measurement uncertainty.

Example: smallest value which has to measured 0.05 cd

The measurement system shall be able to distinguish measurements with a resolution of 0,005 cd.

A value of 10,100 cd implies that the resolution of measurement system is 10 cd, which is a measurement uncertainty of less than 0,1% which nobody can reach.

1. **General remarks to rounding off or up**

Rounding off or up is not allowed! The value which is measured has to be taken and then the comparison with the requirement has to be done.

**Step forward: Scientific notation**

Example for passing beam

Table 8 in UN Regulation No. 149 (*based on the SLR-36 draft consolidation, doc. SLR-36-05/Rev.3*)

|  |  |
| --- | --- |
| *Tabled requirements expressed in cd* | *Position / deg.* |
| *horizontal* | *vertical* | *Class C* | *Class V* |
|  | *No.* | *Element* | *at/from* | *to* | *at* | *min* | *max* | *min* | *max* |
| Part A | 1 | B50L | 3.43 L | - | 0.57 U |  | 3.50 102 |  | 3.50 102 |
| 2 | BR | 2.50 R | - | 1.00 U |  | 1.75 103 |  | 1750 |
| 3 | Segment BLL | 8 L | 20 L | 0.57 U |  | 6.25 102 | - | 6.25 102 |
| 4 | P | 7 L | - | H | 0.63 102 | - | 0.63 102 | - |
| 5 | Zone III | As specified in part C | - | 6.25 102 | - | 6.25 102 |
| 6 | S50+S50LL+S50RR3 | - | - | 4.00 U | 1.90 102 4) | - | - | - |
| 7 | S100+S100LL+S100RR3 | - | - | 2.00 U | 3.75 102 4) | - | - | - |
| 8 | 50 R | 1.72 R | - | 0.86 D | 1.01 104 | - | 5.1 103 | - |
| 9 | 75 R | 1.15 R | - | 0.57 D | 1.21 104 | - | - | - |
| 10 | 50 V | V | - | 0.86 D | 5.10 103 1) | - | 5.10 103 1) | - |
| 11 | 50 L | 3.43 L | - | 0.86 D | 5.00 103 5) | 3.70 104 | 3.55 103 5) | 3.70 104 |
| 12 | Segment 20 and below | 3.50 L | V | 2.00 D | - | - | - | - |
| 13 | Segment 50 | 6.84 L | 6.84 R | 0.86 D | 2.54 103 | - | 1.80 103 | - |
| 14 | 40R | 9 R |  | 1.07 D | 2.80 103 | - | 1.95 103 | - |
| 15 | 40L | 9 L |  | 1.07 D | 2.80 103 | - | 1.95 103 | - |
| 16 | Segment 40RR | 14 R | 9 R | 1.07 D | 8.50 102 | - | 6.00 102 | - |
| 17 | Segment 40LL | 14 L | 9 L | 1.07 D | 8.50 102 | - | 6.00 102 | - |
| 18 | Segment 25R | 9 R | 16 R | 1.72 D | 1.18 103 | - | 8.50 102 | - |
| 19 | Segment 25 | 9 R | 9 L | 1.72 D | 1.70 103 | - | 1.20 103 | - |
| 20 | 25V | 0 |  | 1.72 D | 2.50 103 | - | 1.75 103 | - |
| 21 | Segment 25L | 16 L | 9 L | 1.72 D | 1.18 103 | - | 8.25 102 | - |
| 22 | Segment 15 | 20 L | 20 R | 2.86 D | 4.25 102 | - | 3.00 102 | - |
| 23 | Segment 10 and below | 4.50 L | 2.00 R | 4.00 D |  | 0,8xthe actual measured valued at 50R |  | 0,8xthe actual measured valued at 50R |
| 24 | Segment 10 | 4.50 L | 2.00 R | 4.00 D | 5.00 102 |  | 3.50 102 |  |
| 25 | Imax2 | - | - | - |  |  |  | 4.41 104 |

Example for driving beam

Table 5 in UN Regulation No. 149 (*based on the SLR-36 draft consolidation, doc. SLR-36-05/Rev.3*)

|  |  |  |
| --- | --- | --- |
| *Test point* | *Angular coordinates\* [Degrees]* | *Minimum luminous intensity [cd]* |
|  |  | *Class A Driving Beam* | *Class B Driving Beam* | *Auxiliary* *Driving Beam* |
| H-12L | 12 L, 0.0 | 6.00 102 | 1.50 103 |  |
| H-9L | 9L, 0.0 | 2.00 103 | 3.40 102 |  |
| H-6L | 6L, 0.0 | 3.40 103 | 5.00 103 |  |
| H-3L | 3L, 0.0 | 1.20 104 | 1.75 104 |  |
| H-V \*\* | 0.0, 0.0 | 80% of Imax | 80% of Imax | 80% of Imax |
| H-3R | 3R, 0.0 | 1.20 104 | 1.75 104 |  |
| H-6R | 6R, 0.0 | 3.40 103 | 5.00 103 |  |
| H-9R | 9R, 0.0 | 2.00 103 | 3.40 103 |  |
| H-12R | 12R, 0.0 | 6.00 102 | 1.50 102 |  |
| 2U-V | 0.0, 2U | 1.00 103 | 1.70 103 |  |
| Imax\*\*\* |  | 2.70 104 | 4.00 104 | 1.00 104 |

**Scientific notation:**

By writing 10.1 \*103 cd instead of 10,100 cd as the minimum required value, a rounding is automatically given, since 10,099 cd will automatically give 10.1 \* 103 cd.

**Next step:**

CIE Working Group TC2-67 is preparing a CIE- standard which will give a typical minimum value for an acceptable measurement accuracy of a laboratory in automotive lighting. The first version is expected at the end of this year. After that standard will be published, we can have a proposal to say, that for laboratories having at least that measurement accuracy the readout from the measurement system can be taken and the measurement accuracy must not be taken into account for the judgement. Then a clear rule is given how to treat the measured values.