Informal document **GRE-83-08**

83rd GRE, 19-23 October 2020

Agenda item 9

Transmitted by the GRE-IWG SLR

Scientific notation

IWG Simplification of the Lighting and Light Signalling Regulations (SLR)

Table of content

Introduction

With the introduction of the 01 series of amendments to UN Regulations Nos. 112 and 113, the transition was made from measurements in “lux” at approximately 12 V to measurements in “cd” at approximately 13.2 V. With this transition a factor of 625*1.34 (for the calculation of values from “lux” to “cd” and for the calculation of values at 12 V to 13.2 V) was applied to all required values.

Example of the consequence from this transition for a class B headlamp		
Measurement point	Reg. 112, 00-Series of amendments	Reg. 112, 01-Series of amendments
B50L	≤ 0.4 lux [2 sign. Digits]	350 cd [3 sign. Digits]
50R	≥ 12 lux [2 sign. Digits]	10,100 cd [5 sign. Digits]

Introduction

United Nations Editorial Manual (Page 439):
http://dd.dgacm.org/editorialmanual/United%20Nations%20Editorial%20Manual.pdf

Decimal fractions

In decimal fractions expressing a number less than one, a zero should be inserted before the point, e.g. 0.064. Note, however, that zeros should not be added at the end just to ensure that all the numbers in a series or table have the same number of digits after the point, since the addition of a final zero would imply a greater degree of accuracy. (See, however, article E 5, chapter VI.)

Changing the number of digits imply a greater degree of accuracy

Problem statement

- The basis for the accreditation and nomination of test houses is ISO/IEC 17025
- In 2018 a new version of this standard was issued
- New paragraph § 6.4.5
  6.4.5 *The equipment used for measurement shall be capable of achieving the measurement accuracy and/or measurement uncertainty required to provide a valid result*.
- The measurement uncertainty in lighting technology is not small enough to allow many digits.
- **Changing the number of digits imply a greater degree of accuracy and therefore can cause a problem**
- **10,100 cd implies to be able to measure with an accuracy of at least 1 cd which is 1/10,100 = 0.01% → impossible**

Solution:
Scientific notation

Transformation of values

- There are four regions of values to distinguish
- A) < 1
- B) $1 \leq X < 10$
- C) $10 \leq X < 100$
- D) ≥ 100

Transformation of values

- Region A: (values < 1)

0.X, 0.0X, 0.00X, 0.000X… → $X \cdot 10^{-N}$ with N = number of zeros after the dot + 1.

0.XY, 0.0XY, 0.00XY … → $X.Y \cdot 10^{-N}$ with N = number of zeros after the dot + 1.

0.XYZ, 0.0XYZ … → $X.YZ \cdot 10^{-N}$ with N = number of zeros after the dot + 1.

Remark: Mathematical rounding is sometimes necessary to allow only three significant digits.

- Region B: (values $1 \leq X < 10$)

X → $X \cdot 10^{0}$

X.Y → $X.Y \cdot 10^{0}$

X.YZ → $X.YZ \cdot 10^{0}$

Transformation of values

- Region C: (values $10 \leq X < 100$)

XY → $X.Y \cdot 10^1$

XY.Z → $X.YZ \cdot 10^1$

Remark: If the value is a multiple of 10 the zero at the end shall remain, to stay at the same accuracy level.

- Region D: (values ≥ 100)

XYZ, XYZ0, XYZ00, XYZ000 → $X.YZ \cdot 10^N$ with N = number of digits (including zeros) – 1

Examples

0.05 cd → $5 \cdot 10^{-2}$ cd
0.3 cd → $3 \cdot 10^{-1}$ cd
4 cd → $4 \cdot 10^{0}$ cd
60 cd → $6.0 \cdot 10^{1}$ cd
625 cd → $6.25 \cdot 10^{2}$ cd
1,250 cd → $1.25 \cdot 10^{3}$ cd
10,100 cd → $1.01 \cdot 10^{4}$ cd
215,000 cd → $2.15 \cdot 10^{5}$ cd

Remark: The multiplication sign is dot (·)

Example from draft R148-01 (doc. SLR-37-14) – Table 3

Front position lamps, front end-outline marker lamp of categories	Minimum luminous intensity in HV	Maximum luminous intensity in any direction when used as		Standard light distribution (Par. 4.8.3.1.)	Angles of geometric visibility (Par. 4.8.3.)	Minimum luminous intensity within the angles of geometric visibility (Par. 5.1.2.)
		A single lamp	A lamp marked "D" (Par. 3.3.2.5.2.)			
A, MA or AM	4 cd	140 cd	70 cd	Figure A3-I	Table A2-1	0.05 cd

Example from draft R148-01 (doc. SLR-37-14) – New Table 3

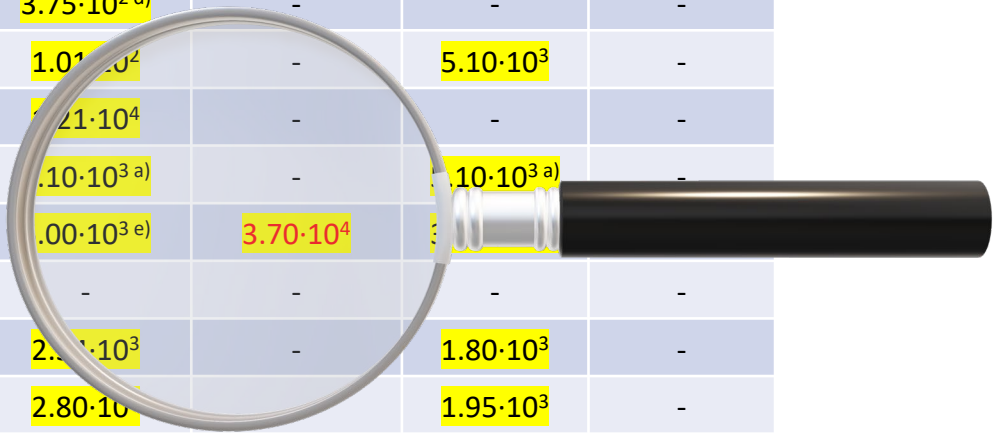
Front position lamps, front end-outline marker lamp of categories	Minimum luminous intensity in HV	Maximum luminous intensity in any direction when used as		Standard light distribution (Par. 4.8.3.1.)	Angles of geometric visibility (Par. 4.8.3.)	Minimum luminous intensity within the angles of geometric visibility (Par. 5.1.2.)
		A single lamp	A lamp marked "D" (Par. 3.3.2.5.2.)			
A, MA or AM	$4 \cdot 10^{0}$ cd	$1.40 \cdot 10^{2}$ cd	$7.0 \cdot 10^{1}$ cd	Figure A3-I	Table A2-1	$5 \cdot 10^{-2}$ cd

Example from draft R149-01 (doc. SLR-37-04/Rev.1) – Part of Table 6

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	-	350	-	350
	2	BR	2.50 R	-	1.00 U	-	1 750	-	1750
	3	Segment BLL	8 L	20 L	0.57 U	-	625	-	625
	4	P	7 L	-	H	63	-	63	-
	5	Zone III	As specified in part C			-	625	-	625
	6	S50+S50LL+S50RR[3]	-	-	4.00 U	190[4]	-	-	-
	7	S100+S100LL+S100RR[3]	-	-	2.00 U	375[4]	-	-	-
	8	50 R	1.72 R	-	0.86 D	10 100	-	5 100	-
	9	75 R	1.15 R	-	0.57 D	12 100	-	-	-
	10	50 V	V	-	0.86 D	5 100[1]	-	5 100[1]	-
	11	50 L	3.43 L	-	0.86 D	5 000[5]	36 960	3 550[5]	36 960
	12	Segment 20 and below	3.50 L	V	2.00 D	-	-	-	-
	13	Segment 50	6.84 L	6.84 R	0.86 D	2 540	-	1 800	-
	14	40R	9 R		1.07 D	2 800	-	1 950	-

Example from draft R149-01 (doc. SLR-37-04/Rev.1) – Same part of New Table 6

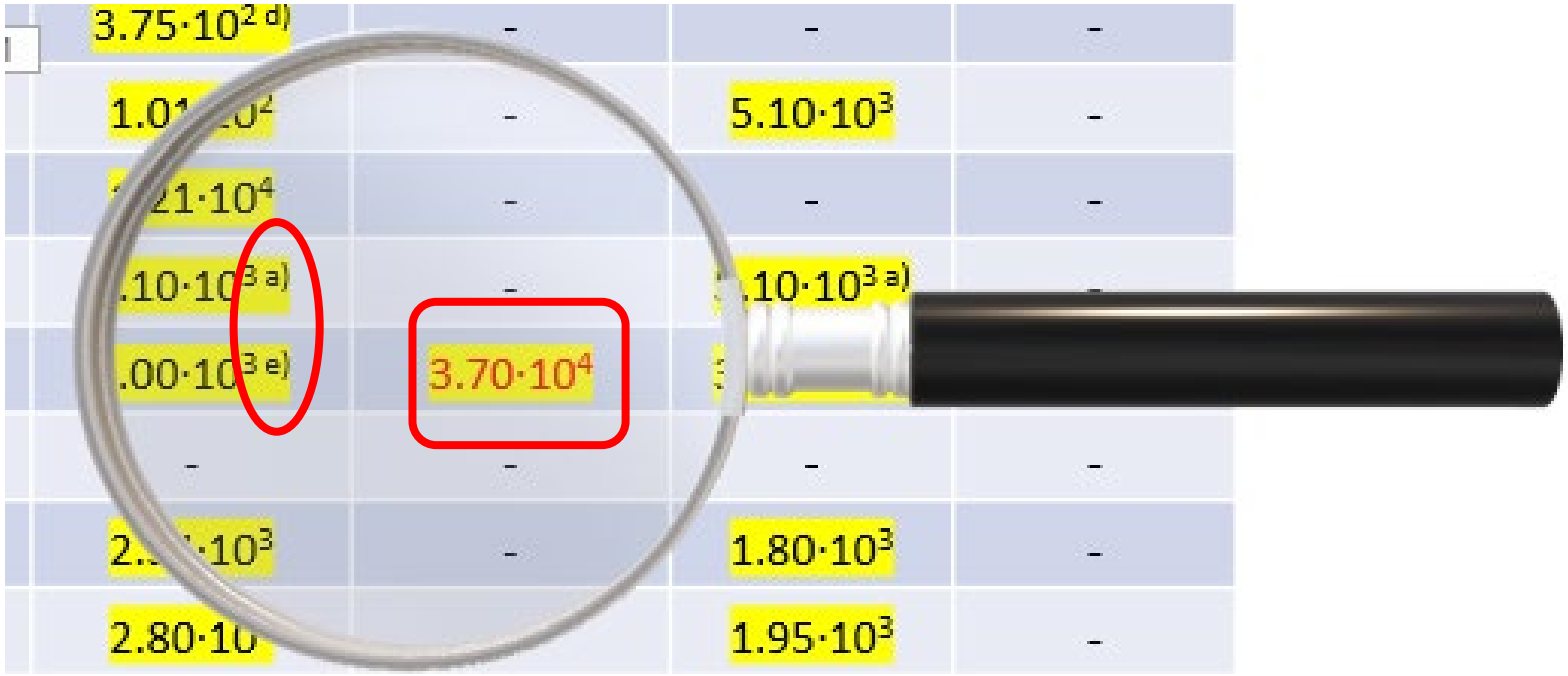
Tabled requirements expressed in cd			Position / deg.						
			horizontal		vertical	Class C		Class V	
	No.	Element	at/from	to	at	min	max	min	max
Part A	1	B50L	3.43 L	-	0.57 U	-	$3.50 \cdot 10^2$	-	$3.50 \cdot 10^2$
	2	BR	2.50 R	-	1.00 U	-	$1.75 \cdot 10^3$	-	$1.75 \cdot 10^3$
	3	Segment BLL	8 L	20 L	0.57 U	-	$6.25 \cdot 10^2$	-	$6.25 \cdot 10^2$
	4	P	7 L	-	H	$6.3 \cdot 10^1$	-	$0.63 \cdot 10^2$	-
	5	Zone III	As specified in part C			-	$6.25 \cdot 10^2$	-	$6.25 \cdot 10^2$
	6	S50+S50LL+S50RR[3]	-	-	4.00 U	$1.90 \cdot 10^2$ d)	-	-	-
	7	S100+S100LL+S100RR[3]	-	-	2.00 U	$3.75 \cdot 10^2$ d)	-	-	-
	8	50 R	1.72 R	-	0.86 D	$1.01 \cdot 10^2$	-	$5.10 \cdot 10^3$	-
	9	75 R	1.15 R	-	0.57 D	$1.21 \cdot 10^4$	-	-	-
	10	50 V	V	-	0.86 D	$.10 \cdot 10^3$ a)	-	$.10 \cdot 10^3$ a)	-
	11	50 L	3.43 L	-	0.86 D	$.00 \cdot 10^3$ e)	$3.70 \cdot 10^4$		
	12	Segment 20 and below	3.50 L	V	2.00 D	-	-	-	-
	13	Segment 50	6.84 L	6.84 R	0.86 D	$2.1 \cdot 10^3$	-	$1.80 \cdot 10^3$	-
	14	40R	9 R		1.07 D	$2.80 \cdot 10$		$1.95 \cdot 10^3$	-



Example, special details

The footnotes have to be converted into letters instead of numbers to distinguish between the number from the power to 10.

Mathematical rounding has to be sometimes done to get 3 significant digits



The value
36960
has been transferred to
$3.70 \cdot 10^4$

Example from draft R150-01 (doc. SLR-36-10/Rev.1) – Table 3

				Minimum requirements for CIL values [cd·lx-1]					
Class	Colour	Illumination angles [º]	Vertical ß1	0°	±10°	±5°	0	0	0
			Horizontal ß2	0°	0°	±20°	±30	±40	±50
IA, IB	White	Angle of divergence α	20'	1200	800	400	--	--	--
			1°30'	20	11,2	10	--	--	--
	Amber		20'	750	500	250	--	--	--
			1°30'	12,5	7	6,25	--	--	--
	Red		20'	300	200	100	--	--	--
			1°30'	5	2,8	2,5	--	--	--
IIIA, IIIB	White		20'	1800	800	600	--	--	--
			1°30'	48	32	32	--	--	--
	Amber		20'	1125	500	375	--	--	--
			1°30'	30	20	20	--	--	--
	Red		20'	450	200	150	--	--	--
			1°30'	12	8	8	--	--	--
IV	White		20'	1800	1200	--	540	470	400
			1°30'	34	24	--	15	15	15
	Amber		20'	1125	750	--	335	290	250
			1°30'	21	15	--	10	10	10
	Red		20'	450	300	--	135	115	100
			1°30'	9	6	--	4	4	4

Example from draft R150-01 (doc. SLR-36-10/Rev.1) – New Table 3

				Minimum requirements for CIL values [cd·lx-1]					
Class	Colour	Illumination angles [º]	Vertical ß1	0°	±10°	±5°	0	0	0
			Horizontal ß2	0°	0°	±20°	±30	±40	±50
IA, IB	White	Angle of divergence α	20'	$1.20 \cdot 10^3$	$8.00 \cdot 10^2$	$4.00 \cdot 10^2$	--	--	--
			1°30'	$2.0 \cdot 10^1$	$1.12 \cdot 10^1$	$1.0 \cdot 10^1$	--	--	--
	Amber		20'	$7.50 \cdot 10^2$	$5.00 \cdot 10^2$	$2.50 \cdot 10^2$	--	--	--
			1°30'	$1.25 \cdot 10^1$	$7 \cdot 10^0$	$6,.25 \cdot 10^0$	--	--	--
	Red		20'	$3.00 \cdot 10^2$	$2.00 \cdot 10^2$	$1.00 \cdot 10^2$	--	--	--
			1°30'	$5 \cdot 10^0$	$2.8 \cdot 10^0$	$2.5 \cdot 10^0$	--	--	--
IIIA, IIIB	White		20'	$1.80 \cdot 10^3$	$8.00 \cdot 10^2$	$6.00 \cdot 10^2$	--	--	--
			1°30'	$4.8 \cdot 10^1$	$3.2 \cdot 10^1$	$3.2 \cdot 10^1$	--	--	--
	Amber		20'	$1.13 \cdot 10^3$	$5.00 \cdot 10^2$	$3.75 \cdot 10^2$	--	--	--
			1°30'	$3.0 \cdot 10^1$	$2.0 \cdot 10^1$	$2.0 \cdot 10^1$	--	--	--
	Red		20'	$4.50 \cdot 10^2$	$2.00 \cdot 10^2$	$1.50 \cdot 10^2$	--	--	--
			1°30'	$1.2 \cdot 10^1$	$8 \cdot 10^0$	$8 \cdot 10^0$	--	--	--
IV	White		20'	$1.80 \cdot 10^3$	$1.20 \cdot 10^3$	--	$5.40 \cdot 10^2$	$4.70 \cdot 10^2$	$4.00 \cdot 10^2$
			1°30'	$3.4 \cdot 10^1$	$2.4 \cdot 10^1$	--	$1.5 \cdot 10^1$	$1.5 \cdot 10^1$	$1.5 \cdot 10^1$
	Amber		20'	$1.13 \cdot 10^3$	$7.50 \cdot 10^2$	--	$3.35 \cdot 10^2$	$2.90 \cdot 10^2$	$2.50 \cdot 10^2$
			1°30'	$2.1 \cdot 10^1$	$1.5 \cdot 10^1$	--	$1.0 \cdot 10^1$	$1.0 \cdot 10^1$	$1.0 \cdot 10^1$
	Red		20'	$4.50 \cdot 10^2$	$3.00 \cdot 10^2$	--	$1.35 \cdot 10^2$	$1.15 \cdot 10^2$	$1.00 \cdot 10^2$
			1°30'	$9 \cdot 10^0$	$6 \cdot 10^0$	--	$4 \cdot 10^0$	$4 \cdot 10^0$	$4 \cdot 10^0$

Conclusion

Scientific notation for the requirements
for lighting technical equipment on vehicles,
assures that
not more than 3 significant digits are shown,
which is close to the historically given accuracy in the regulations
and the measurement capability of laboratories