

Berlin, 19<sup>th</sup> September 2014

**Test Certificate No. 0913-2014-04  
regarding the suitability of the EasyLux MiniReflecto retroreflectometer  
for measuring the coefficient of retroreflected luminance  $R_L$   
and the luminance coefficient under diffuse illumination  $Q_d$   
of road markings**

(This test certificate comprises eight pages  
and an appendix of one additional page)

**1 Originator**

The order to draft the report was given by EASYLUX Retroreflectometers, Santo André SP, Brazil.

**2 Brief**

Determination of the suitability of the EasyLux portable retroreflectometer MiniReflecto with 30 m geometry (hereinafter called "MiniReflecto") for measuring the coefficient of retroreflected luminance  $R_L$  and the luminance coefficient under diffuse illumination  $Q_d$  of the surfaces of road markings by comparison tests on a road marking test field.

**3 Test principle**

The test involves comparison measurements with two different portable retroreflectometers (see Section 6.1), which have already been approved as suitable for this application. These retroreflectometers are the ZRM 6013+ retroreflectometer (manufactured by Zehntner GmbH Sissach/Switzerland), approved by StrausZert, test report no. 0913-2014-01 and the LTL-XL retroreflectometer (manufactured by DELTA Light & Optics, Hørsholm/Danmark), approved by StrausZert, test report 0913-2010-07. In addition, sensitivity to angles and movements was also tested in accordance with EN 1436 (see Section 6.2).

**4 Tested measuring device**

The technical data of the measuring device is determined using the originator's information and a visual inspection.

The technical data of the MiniReflecto is provided in Table 1.

Simulation distance	30 m, in accordance with geometry of EN 1436
Observation angle	2.29° (EN 1436); 1.05° (ASTM E 1710)
Illumination angle	R <sub>L</sub> : 1.24° (EN 1436); 88.76° (ASTM E 1710) Q <sub>d</sub> : diffuse
Illumination angular spread	Horizontal: 0.33°; vertical: 0.17°
Observation angular spread	± 0.1°
Illumination method	R <sub>L</sub> : Method B in accordance with EN 1436 Field of measurement: 815 mm x 75 mm Field of illumination: 280 mm x 75 mm Q <sub>d</sub> : Method B in accordance with EN 1436 Field of measurement: 815 mm x 50 mm Field of illumination: 85 mm x 75 mm
Illumination system for Q <sub>d</sub>	Multi LED
Measuring sensor	Adapted to V(λ) function by filter
Measuring ranges	0 to 4000 mcd·m <sup>-2</sup> ·lx <sup>-1</sup> (R <sub>L</sub> ) 0 to 320 mcd·m <sup>-2</sup> ·lx <sup>-1</sup> (Q <sub>d</sub> )  Profiled markings can be measured up to a profile height of 9 mm (R <sub>L</sub> )  Profiled markings can be measured up to a profile height of 5 mm (Q <sub>d</sub> )
Measurement time	Combination of R <sub>L</sub> /Q <sub>d</sub> approximately 3 sec, individually approximately 1.2 sec each
Measured value memory	Over 200.000 measured values, internal data flash
Display	Colour LED Touchscreen
Battery	Standard AA type NiMH battery (6 units)
Operating temperature	-5° C to 50° C
Storage	-15° C to +55° C
Humidity	No condensation
Dimensions (L x W x H)	255 mm x 160 mm x 220 mm (Q <sub>d</sub> measuring part closed) 450 mm x 160 mm x 170 mm (Q <sub>d</sub> measuring part open)
Weight	1 kg

*Table 1 Technical data of the MiniReflecto according to originators declaration*

## **5 Measurement location**

The measurements were taken on the road marking test field on the B 4 national highway near Torfhaus (Oberharz), Germany. There are approx. 100 road marking test patterns (new and worn) on this test field, of type I and type II, applied in the direction of travel. Each test pattern consists of eight lines that are 2 m long x 0.15 m wide.

## **6 Test procedure**

Date of measurement: 8<sup>th</sup> and 9<sup>th</sup> September 2014. Road conditions: Road and marking surface were dry and clean.

### **6.1 Comparison measurements with three measuring devices**

On the test field,  $R_L$  and  $Q_d$  were measured from 20 test samples of type I or type II, in direct succession with the three portable retroreflectometers involved in the test. Three measured values and their mean value were recorded for each line (at the beginning, middle and end of the line). It was ensured that the measurements were taken as close as possible to the same measuring points. Tables 2 and 3 show the  $R_L$  and  $Q_d$  measured values determined for the three measuring devices used, the common mean value  $M$ , derived from the measured values for the three measuring devices, and the percentage deviation  $\text{Diff}_{\text{MiniReflecto}}$  of the measured value for the MiniReflecto from the common mean value  $M$ :

$$\text{Diff}_{\text{MiniReflecto}} = 100 \% \cdot (\text{Measured value MiniReflecto} - M)/M$$

Marking type according to column 1 of Table 2 and 3:

CP:	Cold plastics
CSP:	Cold spray plastics
DP:	Dispersion paint
HS:	High solid paint
PM:	Prefabricated marking
TP:	Thermo plastics
TSP:	Thermo spray plastics
2 C:	2 component high solid paint
Ag:	Marking consisting on agglomerates

Figures 1 and 2 illustrate the measured values of the three devices and the common mean value.

The measured values for the MiniReflecto and the common mean value  $M$  provided in Tables 2 and 3 were used to perform a linear regression analysis. The regression equations that were determined are provided below the tables.

Marking type	Measured values $R_L$ ( $\text{mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ )				Diff <sub>MiniReflecto</sub> (%)
	MiniReflecto	ZRM 6013+	LTL-XL	Common mean value M	
DP Ag	72.6	68.0	69.0	69.9	3.9
TP Ag	74.2	69.0	70.0	71.1	4.4
CSP	92.6	90.0	86.0	89.5	3.5
PM	142	134	131	136	4.7
TSP	152	146	149	149	2.0
CP	164	149	165	159	2.9
CSP	166	161	171	166	0.0
HS	178	202	179	186	-4.5
KP	179	200	187	189	-5.1
KP	204	204	205	204	-0.2
TP	214	206	216	212	0.9
CP	258	240	260	253	2.1
TP	274	259	259	264	3.8
CP	320	339	317	325	-1.6
2 C	387	408	406	400	-3.3
PM	413	424	406	414	-0.3
CP	501	514	486	500	0.1
KP	595	590	616	600	-0.9
DP	633	662	639	645	-1.8
CP	702	708	710	707	-0.7
	Mean value of all samples				Mean absolute deviation
	286,1	288,7	286,4	287,0	2.3

Table 2: Measurement results, sorted by ascending  $R_L$  values for the MiniReflecto measuring device (each measured value is derived from three individual measured values per line)

Regression line:

$$R_L(\text{MiniReflecto}) = 3.9 + 0.983 \cdot M \quad r^2 = 0.999$$

Marking type	Measured values $Q_d$ ( $\text{mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ )				Diff <sub>MiniReflecto</sub> (%)
	MiniReflecto	ZRM 6013+	LTL-XL	Common mean value M	
CP	139	158	138	145.0	-4,1
CP	144	166	139	149.7	-3,8
PM	144	187	134	155.0	-7,1
CP	147	171	135	151.0	-2,6
CP	149	149	148	148.7	0,2
CSP	152	153	147	150.7	0,9
DP Ag	153	148	148	149.7	2,2
CP	154	157	152	154.3	-0,2
TP Ag	154	150	151	151.7	1,5
2C	156	194	154	168.0	-7,1
CP	159	162	152	157.7	0,8
CP	162	161	156	159.7	1,5
TSP	166	185	173	174.7	-5,0
TP	167	193	169	176.3	-5,3
PM	169	176	162	169.0	0,0
CSP	189	183	182	184.7	2,3
HS	195	211	194	200.0	-2,5
TP	196	208	206	203.3	-3,6
KP	227	236	228	230.3	-1,4
DP	244	243	240	242.3	0,7
	Mean value of all samples				Mean absolute deviation
	168.3	179.6	165.4	171.1	2.6

Table 3: Measurement results, sorted by ascending  $Q_d$  values of the MiniReflecto measuring device (each measured value is derived from three individual measured values per line)

Regression line:

$$Q_d(\text{MiniReflecto}) = -1.6 + 0.993 \cdot M \quad r^2 = 0.967$$

## 6.2 Testing sensitivity to tilts and shifts

This test was carried out in accordance with the requirements of EN 1436. According to Annex A.4 and B.4 of this standard, the sensitivity to tilts and shifts must be tested, whereby the measuring device under test is raised parallel to the road marking pattern by height H (H = -1 mm; +1 mm; +2 mm) and is simultaneously moved horizontally so that the measuring area always remains at the same point of the marking surface. The

measuring device may only be raised +1 mm and +2 mm due to the marking systems present on the test field.

Tilt test for  $R_L$  according EN 1436, B.4: For method A, the measuring device must be moved horizontally by  $H/\sin 2.29^\circ$  simultaneously as it is raised and for method B by  $H/\sin 1.24^\circ$ . According to Table 1, method B is used for the MiniReflecto for measuring  $R_L$ ; the horizontal movement is therefore 46 mm ( $H = 1$  mm) resp. 92 mm ( $H = 2$  mm).

Tilt test for  $Q_d$  according EN 1436, A.4: For method A, the measuring device must be moved horizontally by  $H/\sin 2.29^\circ$  simultaneously as it is raised; the instrument is not to be moved for method B. According to Table 1, method B is used for the MiniReflecto for measuring  $Q_d$ ; a movement can be omitted.

Table 4 provides the measured values for the zero setting (device on the marking surface) and when raised 1 mm and 2 mm absolute, and as a percentage of the zero setting value.

Height H of the MiniReflecto (mm)	Measured value $R_L$		Measured value $Q_d$	
	( $\text{mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ )	%	( $\text{mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ )	%
0	402	100	227	100
1	398	99.0	216	95.2
2	394	98.0	207	91.2

Table 4: Variation of the measured value when raising the measuring device

## 7 Assessment of the measurement results

### 7.1 Assessment of comparison measurements with three measuring devices

The suitability of a device for measuring  $R_L$  and  $Q_d$  of road markings can be confirmed if the following conditions are met:

- The percentage deviation  $\text{Diff}_{\text{MiniReflecto}}$  of the measured values  $R_L$  and  $Q_d$  for the MiniReflecto retroreflectometer from the common mean value  $M$  of all devices used must not exceed the value  $\pm 7.5\%$  in 95 % of all cases (i.e. in 19 out of 20 test samples in this test).
- Assessment of sensitivity to tilts and shifts: In accordance with EN 1436, Annex A.4 and B.4, when the height setting changes by a maximum of +2 mm the measured  $R_L$  and  $Q_d$  values must not change by more than  $\pm 10\%$  compared to the values at 0 mm.

### **7.1.1 Coefficient of retroreflected luminance $R_L$**

The absolute deviations  $\text{Diff}_{\text{MiniReflecto}}$  of the measured values for the MiniReflecto instrument, based on the common mean value  $M$  of all three devices, are 2.3 % on average. These deviations undercut for all 20 test samples the limit value  $\pm 7.5$  %; the maximum deviation is -5.1 %. Therefore condition 'a' outlined in Section 7.1 is fulfilled. The regression equation and the corresponding curves in Figure 1 show that the MiniReflecto instrument obtained practically the same measured values as the other two devices. The value of the coefficient of determination  $r^2 = 0.999$  indicates that the variation of the measured values is very low.

### **7.1.2 Luminance coefficient under diffuse reflection $Q_d$**

The absolute deviations  $\text{Diff}_{\text{MiniReflecto}}$  of the measured values for the MiniReflecto instrument, based on the common mean value  $M$  of all three devices, are 2.6 % on average. These deviations undercut for all 20 test samples the limit value  $\pm 7.5$  %; the maximum deviation is -7.1 %. Therefore condition 'a' outlined in Section 7.1 is fulfilled. The regression equation and the corresponding curves in Figure 2 show that the MiniReflecto instrument obtained practically the same measured values as the other two devices. The value of the coefficient of determination  $r^2 = 0.967$  indicates that the variation of the measured values is very low.

## **7.2 Assessment of sensitivity to tilts and shifts**

When the height setting is changed to +2 mm, maximum, the measured  $Q_d$  and  $R_L$  values change by less than  $\pm 10$  % compared to the value at 0 mm. Condition 'b' outlined in Section 7.1 is therefore met with regard to the sensitivity to angles and movements.

## **8 Overall assessment**

The deviations of the measurement results specified under Section 6 for comparison measurements and for testing the sensitivity to tilts and shifts are low overall, especially considering that the difficult measuring conditions (different measuring areas, uneven marking surface, non-homogenous structure of the marking surface, non-homogenous bead distribution) cause inaccuracies that are not attributable to device inaccuracy.

By meeting the conditions specified in Section 7.1, the MiniReflecto retroreflectometer is hereby deemed suitable for measuring the coefficient of retroreflected luminance  $R_L$  and the luminance coefficient under diffuse illumination  $Q_d$  of road markings.



(Dr. H. Meseberg)  
Chairman of StrausZert

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This test certificate has been issued to the best of my knowledge and belief.

Appendix

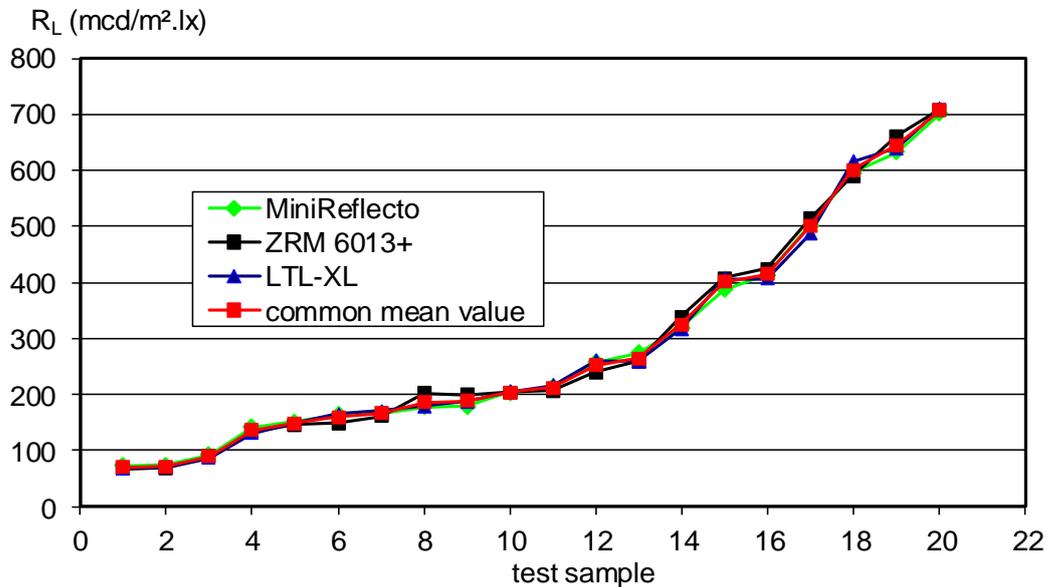


Figure 1: Measured values  $R_L$  for the three measuring devices used and common mean value (red line) for 20 test samples

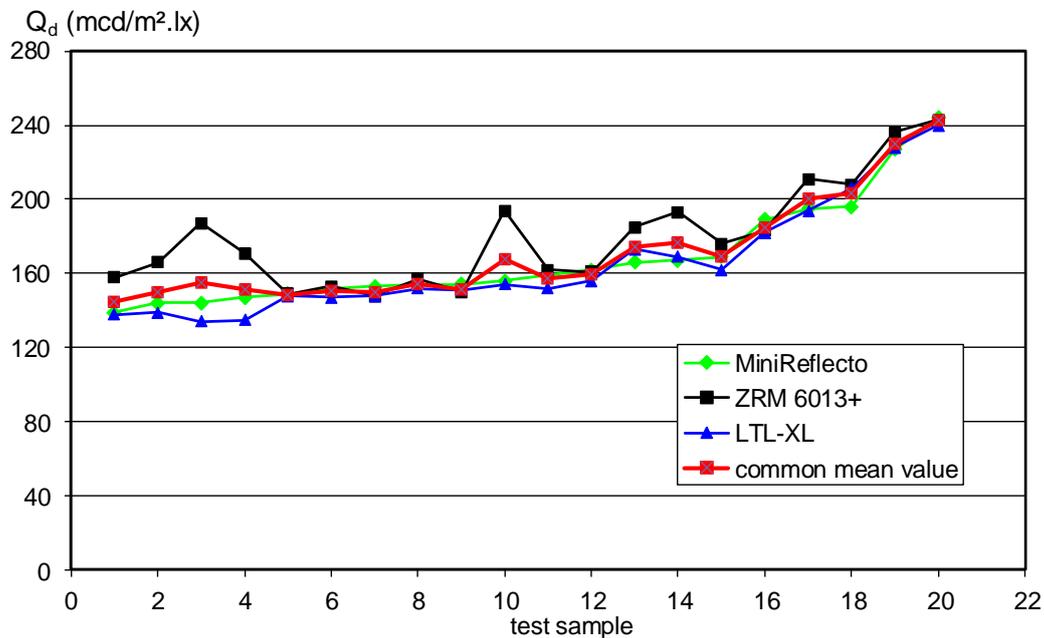


Figure 2: Measured values  $Q_d$  for the three measuring devices used and common mean value (red line) for 20 test samples