

Berlin, 19th September 2014

**Test Certificate No. 0913-2014-04
regarding the suitability
of the Easylux Classic retroreflector with 30 m geometry
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 classic, portable retroreflector with 30 m geometry (hereinafter called "Easylux Classic") 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+ retroreflector (manufactured by Zehntner GmbH Sissach/Switzerland), approved by Strauszert, test report no. 0913-2014-01 and the LTL-XL retroreflector (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 Easylux Classic 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 _L : 1.24° (EN 1436); 88.76° (ASTM E 1710) Q _d : diffuse |
| Illumination angular spread | Horizontal: 0.33°; vertical: 0.17° |
| Observation angular spread | ± 0.17° |
| Illumination method | R _L : Method B in accordance with EN 1436 Field of measurement: 360 mm x 70 mm Field of illumination: 215 mm x 70 mm Q _d : Method B in accordance with EN 1436 Field of measurement: 200 mm x 75 mm Field of illumination: 100 mm x 90 mm |
| Illumination system for Q _d | Multi LED |
| Measuring sensor | Adapted to V(λ) function by filter |
| Measuring ranges | 0 to 2000 mcd·m ⁻² ·lx ⁻¹ (R _L) 0 to 318 mcd·m ⁻² ·lx ⁻¹ (Q _d) Profiled markings can be measured up to a profile height of 3 mm (R _L) (Q _d) |
| Measurement time | Combination of R _L /Q _d approximately 2 s, individually approximately 1 s each |
| Measured value memory | Over 4000 measured values, internal data flash |
| Display | Character LCD with backlight |
| Battery | Sealed battery 2.2 Ah 12 V |
| Operating temperature | -10° C to 65° C |
| Storage | -15° C to +55° C |
| Humidity | No condensation |
| Dimensions (L x W x H) | 590 x 160 x 260 mm |
| Weight | 6 kg |

Table 1 Technical data of the Easylux Classic 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: 8th and 9th 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 $\text{Diff}_{\text{EasyLux Classic}}$ of the measured value for the EasyLux Classic from the common mean value M :

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

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 EasyLux Classic 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 _{Easylux Classic} (%) |
|--------------|---|-----------|--------|---------------------|-------------------------------------|
| | Easylux Classic | ZRM 6013+ | LTL-XL | Common mean value M | |
| TP Ag | 68.0 | 69.0 | 70.0 | 69.0 | -1.4 |
| DP Ag | 74.3 | 68.0 | 69.0 | 70.4 | 5.5 |
| CSP | 89.0 | 90.0 | 86.0 | 88.3 | 0.8 |
| PM | 135 | 134 | 131 | 133 | 1.2 |
| CP | 145 | 149 | 165 | 153 | -5.2 |
| TSP | 155 | 146 | 149 | 150 | 3.3 |
| CSP | 164 | 161 | 171 | 165 | -0.8 |
| CP | 183 | 200 | 187 | 190 | -3.7 |
| CP | 213 | 204 | 205 | 207 | 2.7 |
| HS | 219 | 202 | 179 | 200 | 9.5 |
| TP | 230 | 206 | 216 | 217 | 5.8 |
| CP | 274 | 240 | 260 | 258 | 6.2 |
| TP | 285 | 259 | 259 | 268 | 6.5 |
| CP | 335 | 339 | 317 | 330 | 1.4 |
| 2 C | 371 | 408 | 406 | 395 | -6.1 |
| PM | 400 | 424 | 406 | 410 | -2.4 |
| CP | 512 | 514 | 486 | 504 | 1.6 |
| CP | 562 | 590 | 616 | 589 | -4.6 |
| DP | 649 | 662 | 639 | 650 | -0.2 |
| CP | 721 | 708 | 710 | 713 | 1.1 |
| | Mean value of all samples | | | | Mean absolute deviation |
| | 289.2 | 288.7 | 286.4 | 288.1 | 3.4 |

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

Regression line:

$$R_L(\text{Easylux Classic}) = 5.4 + 0.985 \cdot M \quad r^2 = 0.996$$

| Marking type | Measured values Q_d ($\text{mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$) | | | | Diff _{Easylux Classic} (%) |
|--------------|---|------------|------------|---------------------|-------------------------------------|
| | Easylux Classic | ZRM 6013+ | LTL-XL | Common mean value M | |
| TP Ag | 139 | 150 | 151 | 146.7 | -5.2 |
| CP | 145 | 161 | 135 | 147.0 | -1.4 |
| CP | 146 | 158 | 138 | 147.3 | -0.9 |
| CSP | 149 | 153 | 147 | 149.7 | -0.4 |
| CP | 155 | 157 | 152 | 154.7 | 0.2 |
| DP Ag | 157 | 148 | 148 | 151.0 | 4.0 |
| CP | 159 | 166 | 139 | 154.7 | 2.8 |
| CP | 161 | 161 | 156 | 159.3 | 1.0 |
| CP | 161 | 149 | 148 | 152.7 | 5.5 |
| PM | 163 | 187 | 134 | 161.3 | 1.0 |
| KSP | 166 | 183 | 182 | 177.0 | -6.2 |
| 2 C | 167 | 194 | 154 | 171.7 | -2.7 |
| CP | 174 | 162 | 152 | 162.7 | 7.0 |
| TP | 178 | 193 | 169 | 180.0 | -1.1 |
| PM | 179 | 176 | 162 | 172.3 | 3.9 |
| TSP | 191 | 185 | 173 | 183.0 | 4.4 |
| HS | 214 | 211 | 194 | 206.3 | 3.7 |
| TP | 223 | 208 | 206 | 212.3 | 5.0 |
| DP | 260 | 243 | 240 | 247.7 | 5.0 |
| CP | 265 | 236 | 228 | 243.0 | 9.1 |
| | Mean value of all samples | | | | Mean absolute deviation |
| | 177.6 | 179.1 | 165.4 | 174.0 | 3.5 |

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

Regression line:

$$Q_d(\text{Easylux Classic}) = -24.1 + 1.159 \cdot M \quad r^2 = 0.973$$

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 Easylux Classic 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 Easylux Classic 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 Easylux Classic (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 | 229 | 100 | 206 | 100 |
| 1 | 223 | 97.4 | 201 | 97.6 |
| 2 | 222 | 96.9 | 209 | 101.5 |

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:

a. The percentage deviation $\text{Diff}_{\text{Easylux Classic}}$ of the measured values R_L and Q_d for the Easylux Classic retroreflector 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).

b. 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 $\text{Diff}_{\text{EasyLux Classic}}$ of the measured values for the EasyLux Classic instrument, based on the common mean value M of all three devices, are 3.4 % on average. These deviations only exceed the value ± 7.5 % in one instance (9.5 %; **bold** in Table 2) and therefore meet condition 'a' outlined in Section 7.1. The regression equation and the corresponding curves in Figure 1 show that the EasyLux Classic instrument obtained practically the same measured values as the other two devices. The value of the coefficient of determination $r^2 = 0.996$ indicates that the variation of the measured values is very low.

7.1.2 Luminance coefficient under diffuse reflection Q_d

The absolute deviations $\text{Diff}_{\text{EasyLux Classic}}$ of the measured values for the EasyLux Classic instrument, based on the common mean value M of all three devices, are 3.5 % on average. These deviations only exceed the value ± 7.5 % in one instance (9.1 %; **bold** in Table 3) and therefore meet condition 'a' outlined in Section 7.1. The regression equation and the corresponding curves in Figure 2 show that the EasyLux Classic instrument obtained practically the same measured values as the other two devices. The value of the coefficient of determination $r^2 = 0.973$ 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 ± 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 Easylux Classic 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

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

Appendix

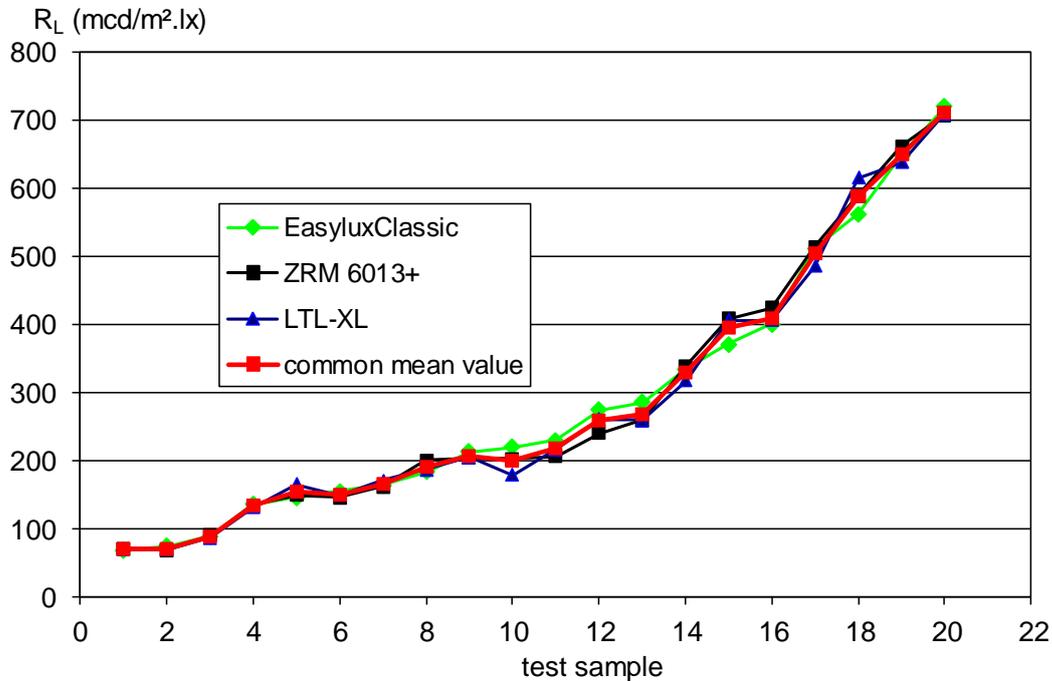


Figure 1: Measured values R_L for the three measuring devices used and common mean value (red line) for 20 test samples

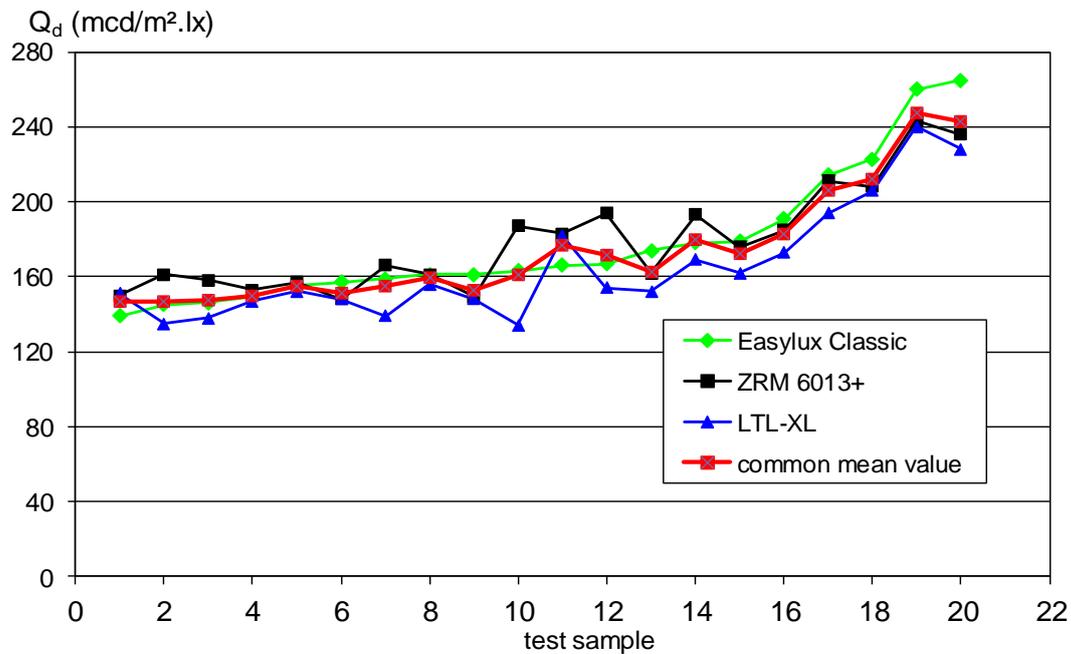


Figure 2: Measured values Q_d for the three measuring devices used and common mean value (red line) for 20 test samples