Prüf-, Überwachungs- und Zertifizierungs-gemeinschaft der Straßenausstatter

Notified under 0913 by DIBt in accordance with the European Construction Products Regulation

Berlin, 22th May 2018

Test Certificate No. 0913-2018-02 regarding the suitability of the Zehntner ZRM 6010 retroreflectometer for measuring the coefficient of retroreflected luminance R_L of road markings

(This test certificate comprises seven pages)

1 Originator

The order to draft the report was given by Zehntner GmbH Testing Instruments, Gewerbestrasse 4, CH-4450 Sissach, Switzerland.

2 Brief

Determination of the suitability of the Zehntner portable external beam retroreflectometer ZRM 6010 with 30 m geometry (hereinafter called "ZRM 6010") for measuring the coefficient of retroreflected luminance R_L 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 R_L/Q_d retroreflectometer (manufactured by Zehntner GmbH Sissach/Switzerland), approved by Bundesanstalt für Strassenwesen (BASt, German Federal Highway Research Institute), test report BASt V 4 22/2006, and the LTL-X retroreflectometer (manufactured by DELTA Light & Optics, Hørsholm/ Danmark), approved by BASt, test report BASt V 4 60-2002. In addition, sensitivity to angles and movements was also tested in accordance with EN 1436:2018-03 (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 ZRM 6010 is provided in table 1.

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Simulation distance	30 m, in accordance with geometry of EN 1436
Observation angle	EN 1436: 2.29°; ASTM E1710: 1.05°
Illumination angle	EN 1436: 1.24°; ASTM E1710: 88.76°
Observation angular spread	Horizontal: 0.33°; vertical: 0.33°
Illumination angular spread	Horizontal: 0.33°; vertical: 0.17°
Illumination method	Method B in accordance with EN 1436:2018-03, annex B.4.2.3
Measuring area (W x L)	52 mm x 489 mm (2.05´´ x 19.25´´)
Illumination area (W x L)	50 mm x 100 mm (1.97´´ x 3.94´´)
Measuring sensor	Adapted to V(λ) function by filter
Measuring range	0 to 4000 mcd·m^{-2}·lx^{-1} (R_L)
Measuring range profiled markings	Up to a height of 15 mm (0.59´´) (R_L)
Repeatability	± 2 %
Reproducibility	± 5 %
Measurement time	≈ 1 sec, without pictures
Memory	Internal flash memory, 1 GB
Memory capacity	1000000 measurements without pictures
Interface	Host USB (type A), Client Mini USB (type B)
Touchscreen display	5,7´´ colour TFT (LCD), LED Backlight, VGA resolution
Pictures (resolution/format)	600 x 800 px, 1200 x 1600 px or 2592 x 1944 px, jpg
Accumulator	Li-Ion 14.4 V / 6.5 Ah
Operating temperature	-10° C to +50° C (14° F to 122° F)
Storage temperature	-20° C to +60° C (-4° F to 140° F)
Humidity	No condensation
Material housing	Anodised aluminium
Dimensions (L x W x H)	340 mm x 152 mm x 575 mm (13.39´´ x 5.98´´ x 22.64´´)
Weight	6.4 kg (14.11 lbs)
Standards	EN 1436 (R_L), ASTM E1710 (R_L), ASTM E2177 (R_L, wet), ASTM E2832 (R_L, continuous wetting)

Table 1 Technical data of the ZRM 6010 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 approximately 100 road marking test patterns 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: 14th May 2018. Measuring conditions: The weather was sunny, air temperature between 17° C and 21° C. Road and marking surface were dry and clean.

6.1 Comparison measurements with three measuring devices

On the test field, R_L was measured from 20 test samples of type I or type II, in direct succession with the three portable retroreflectometers involved in the test. In the test were included 17 white and 3 yellow markings. 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. The mean value for the three measurement values was calculated for each stripe. Table 2 shows the R_L mean 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 $Diff_{ZRM6010}$ of the measured value for the ZRM 6010 from the common mean value M:

$$Diff_{ZRM\ 6010} = 100\ \% \cdot (\text{Measured value ZRM 6010} - M)/M$$

Marking type according to column 1 of table 2:

CP:	Cold plastics
CSP:	Cold spray plastics
PMP:	Prefabricated marking, profiled
TP:	Thermo plastics
Ag:	Marking consisting on agglomerates

Figure 1 illustrates the measured values of the three devices and the common mean value.

The measured values for the ZRM 6010 and the common mean value M provided in table 2 were used to perform a linear regression analysis. The regression equation that was determined is provided below the table.

Marking type	Measured values R_L (mcd·m^{-2}·lx^{-1})				Diff$_{ZRM\ 6010}$ (%)
	ZRM 6010	ZRM 6013	LTL-X	Common mean value M	
CSP	54.3	55.0	54.0	54.4	-0.2
CSP Ag	91.0	87.7	91.7	90.1	1.0
CP, yellow	92.3	90.7	91.7	91.6	0.8
CP	96.0	93.3	94.0	94.4	1.7
CP Ag	106	103	107	105	0.4
CP Ag	119	117	115	117	1.7
CP Ag, yellow	126	122	124	124	1.5
CP	133	130	124	129	3.3
CP Ag	174	173	173	173	0.3
CP Ag	171	172	186	176	-3.0
CP	236	233	226	232	1.7
TP	263	253	269	262	0.5
CP Ag	282	266	264	271	4.1
CP Ag	283	288	279	283	0.0
CP	311	308	304	308	1.1
TP	352	314	349	338	4.0
CP Ag	354	367	359	360	-1.7
CP Ag	419	406	410	412	1.8
PMP, yellow	413	409	419	414	-0.2
PMP	833	854	810	832	0.1
	Mean value of all samples				Mean absolute deviation
	245.4	242.1	242.5	243.3	1.5

Table 2: Measurement results, sorted by ascending R_L values for the ZRM 6010 measuring device (each measured value is derived from three individual measured values per line)

Regression line:

$R_L(ZRM\ 6010) = 1.51 + 1.002 \cdot M \qquad r^2 = 0.9994$

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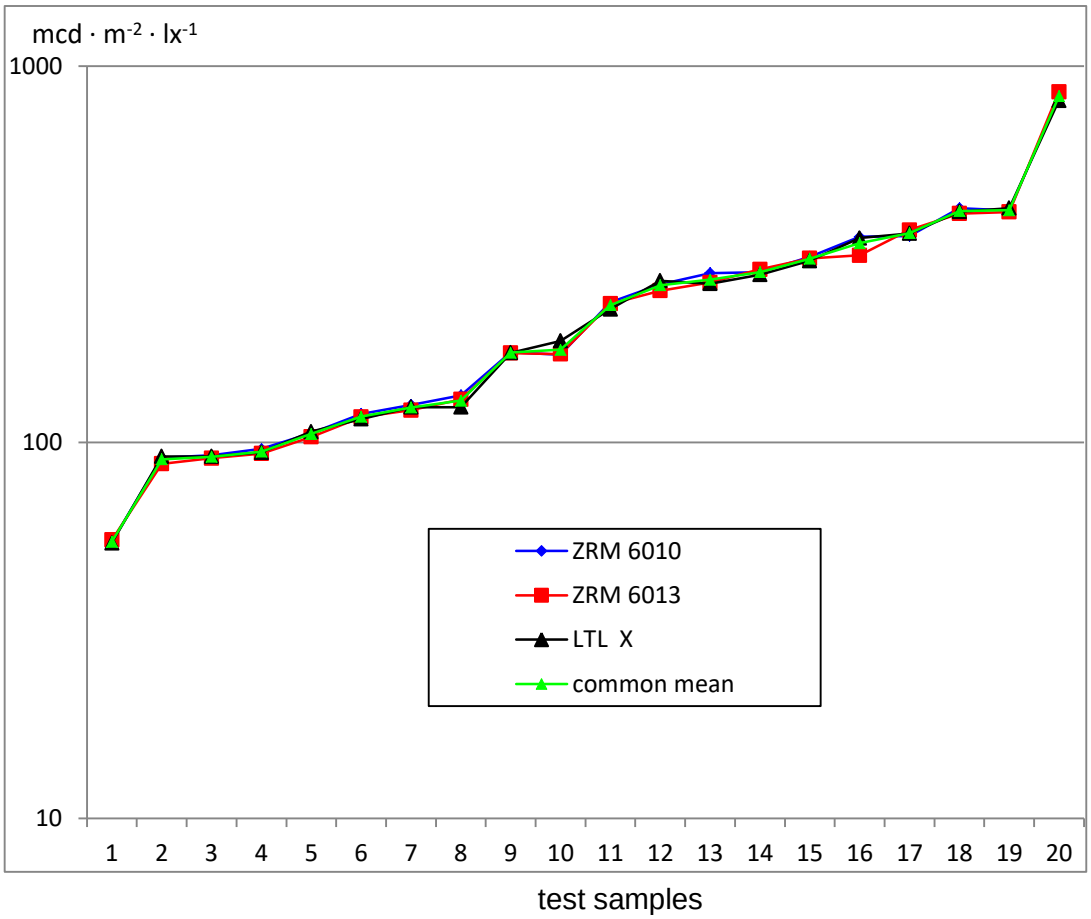

Figure 1: Measured values R_L for the three measuring devices used and common mean value (green line) for 20 test samples (in semilogarithmically representation)

6.2 Testing sensitivity to tilts and shifts

This test was carried out in accordance with the requirements of EN 1436:2018-03. According to annex B.4.2.3 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 (and eventually higher) due to the marking systems present on the test field.

Tilt test for R_L according EN 1436:2018-03, B.4.2.3: According to table 1, method B is used for the ZRM 6010 for measuring R_L; the horizontal movement is therefore 46 mm (H = 1 mm) resp. 92 mm (H = 2 mm). On request of the originator, this part of

the test was also performed for a height of the instrument of 15 mm; the horizontal movement for this height is 69,3 cm (the movement values are rounded to 1 mm).

Table 3 provides the measured values for the zero setting (device on the marking surface) and when raised 1 mm, 2 mm and 15 mm absolute, and as a percentage of the zero setting value.

Height H of the ZRM 6010 (mm)	Measured value R_L	
	(mcd·m^{-2}·lx^{-1})	%
0	280	100
1	280	100
2	280	100
15	279	99,6

Table 3: Variation of the measured value R_L when raising the measuring device

7 Assessment of the measurement results

The suitability of a device for measuring R_L of road markings can be confirmed if the conditions described in sections 7.1 and 7.2 are met.

7.1 Assessment of comparison measurements with three measuring devices

The percentage deviation $Diff_{ZRM\ 6010}$ of the measured values R_L for the ZRM 6010 retroreflectometer from the common mean value M of all devices used must not exceed the value ± 7.5 % in 95 % of all cases (i.e. in 19 out of 20 test samples in this test).

The absolute deviations $Diff_{ZRM\ 6010}$ of the measured values for the ZRM 6010 instrument, based on the common mean value M of all three devices, are 1.5 % on average. These deviations undercut for all 20 test samples the limit value ± 7.5 %; the maximum deviation is 4.1 %. Therefore above mentioned condition is fulfilled. The regression equation and the corresponding curves in Figure 1 show that the ZRM 6010 instrument obtained practically the same measured values as the other two retroreflectometers. The value of the coefficient of determination $r^2 = 0.9994$ indicates that the variation of the measured values is very low.

7.2 Assessment of sensitivity to tilts and shifts

In accordance with EN 1436:2018-03, annex B.4.2.3, the measured R_L values must not change by more than ± 10 % compared to the value at 0 mm when the height setting changes to +2 mm.

When the height setting is changed to +1 mm or +2 mm, the measured R_L values remain constant at the value at 0 mm (280 mcd·m^{-2}·lx^{-1}). Even at the height of 15 mm the measured R_L value decreases only to 99.6 % of the value at 0 mm. The instrument ZRM 6010 meets also the requirement of standard EN 1436:2018-03 regarding sensitivity to tilts and shifts.

8 Overall assessment

The deviations of the measurement results specified under section 6.1 for comparison measurements and for testing the sensitivity to tilts and shift specified under section 6.2 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. In this respect the requirements of the standard EN 1436:2018-03 are fulfilled.

By meeting the conditions specified in section 7 of this test report, the ZRM 6010 retroreflectometer is hereby deemed well suited for measuring the coefficient of retroreflected luminance R_L of road markings.

(Dr. H. Meseberg)
Chairman of StrAus-Zert e.V.

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