ANNEX B

Compliance of retroreflectometers with EN 1436

A retroreflectometer is a handheld instrument for the measurement of the coefficient of retroreflected luminance R_L of road markings (and road surfaces) in the unit of $mcd \cdot m^{-2} \cdot lx^{-1}$.

DELTA started to produce the LTL-800 in 1982 and followed up with instruments in the sequence shown in figure 1. These instruments work by collimated optics, which is described in section 1.

Many of the older instruments are still in use, but only the LTL 3000 and the LTL 3500 are presently in production at DELTA.

In addition, DELTA produces a mobile instrument, the LTL-M, which is considered in a separate note.

Figure 1: DELTA instruments.

EN 1436:2018 "*Road marking materials - Road marking performance for road users and test methods* "- sets detailed requirements to both handheld and vehicle mounted instruments in a normative annex B "*Measurement method for the coefficient of retroreflected luminance R_L*".

NOTE: Reference to EN 1436 is for convenience. There are similar requirements in ASTM E1710-18 "*Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer*". Besides, what works in Europe will work anywhere.

Table 1 below indicates a complete compliance of the DELTA instruments with this annex. Some difficult items are considered further in the following sections 2, 3, 4, 5 and 6.

Table 1: Compliance of DELTA instruments with EN 1436 annex B.

Clause in EN 1436	Requirements	Compliance by DELTA instruments	Explanations
B.2	Spectral match to allow measurement of white and yellow road markings within ± 5 %	**Yes**	This is tested for each individual instrument or inherent in the constructions
B.3	Measured area of minimum 50 cm^2 Observation angle α of 2,29° ± 0,05° Illumination angle ε of 1,24° ± 0,05° Other limitations in accordance with Clause B.3	**Yes**	
B.4.1	Measuring range of 1 to minimum 2.000 $mcd \cdot m^{-2} \cdot lx^{-1}$ with adequate linearity	**Yes**	
B.4.2.1	No influence on readings from daylight	**Yes**	
B.4.2.2	No influence on readings from internal reflections	**Yes**	
B.4.2.3	Suppression of changes of signal from tilts	**Yes**	By the use of method B, refer to section 2
	Suppression of changes of signal from shifts in height of -1, 0, 1 and 2 mm	**Yes**	By sufficient overlapping of fields, refer to section 3
B.4.2.4	Ability to measure structured road markings	**Yes**	Refer to section 4
B.5	Calibration of measuring equipment	**Yes**	Refer to section 5
B.8	Uncertainty of measurement	**Yes**	Refer to section 6

1 Collimated optics

DELTA handheld instruments use “collimated optics”, which means that the apertures for lighting and measurement are placed at the focal width behind a sufficiently large lens.

This brings the apertures at a virtual infinite distance, when seen through the lens – so that distance in front of the lens does not matter.

Additionally, apertures placed at the back of the lens, define the heights and the widths of the beams and the overlap of the beams on the surface in front.

The principle is shown in figure 1 for the optics for illumination. There are of course difficulties by avoiding that the lens conflicts with the surface and by adding the optics for measurement, but they can be solved.

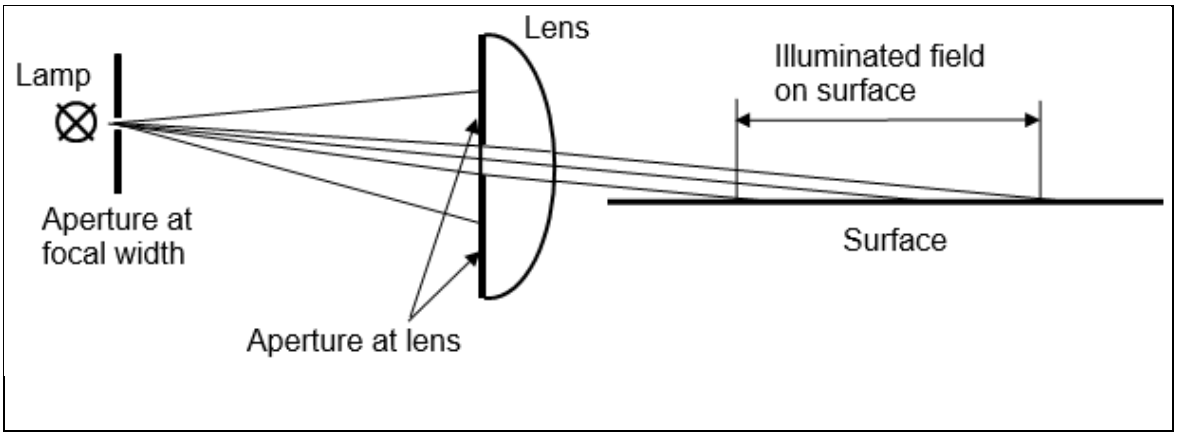

Figure 1: Collimated optics for illumination.

2 Suppression of changes of signal from tilts

EN 1436 introduces methods A and B in clause B.3. These are illustrated in figure 2.

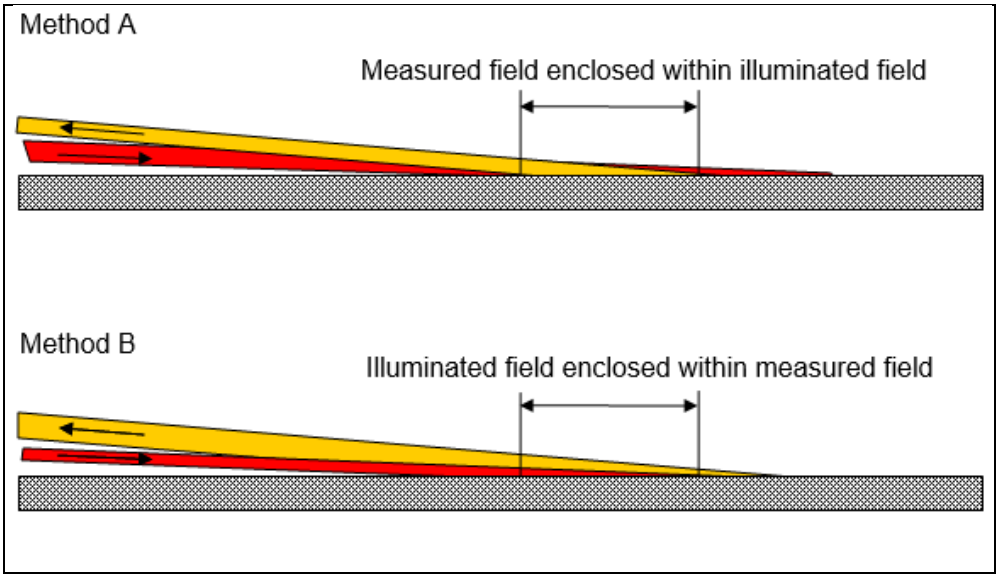

Figure 2: Methods A and B.

Method A is natural as the R_L value is measured directly. However, the R_L value measured this way is in proportion with ε/α, where ε is the actual illumination value and α is the actual observation angle. Therefore, the R_L value measured in method 1 tends to vary with tilt in proportion to $(\varepsilon/\alpha)/0{,}542$.

EXAMPLE: If an instrument working by method A has a distance between the feet of 400 mm and has the back feets lifted by 2 mm, the measured R_L value increases by 9,3 %.

Method B avoids this variation with tilts as it leads to measurement of the coefficient of luminous intensity R_I as defined in CIE 54.2. This value is transformed to the R_L value by a calibration that includes multiplication with 0,542.

All DELTA instruments use the arrangement B.

3 Suppression of changes of signal from shifts in height

EN 1436 requires in clause 4.4.2.3 that the measured R_L value shall not change by more than ±10 %, when the height position is shifted from '0 mm' to -1 mm, 1 mm and 2 mm.

Figure 3 shows a set up for the test, where the instrument is placed on a road marking sample with indication of the illuminated and measured fields. The method is B as the illuminated field is enclosed within the measured field.

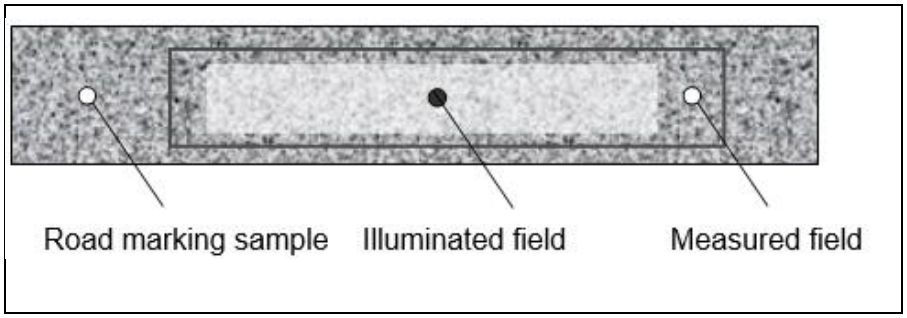

Figure 3: Set-up for testing changes of signal from shifts in height.

The other height positions are now created one by one as shown in figure 4.

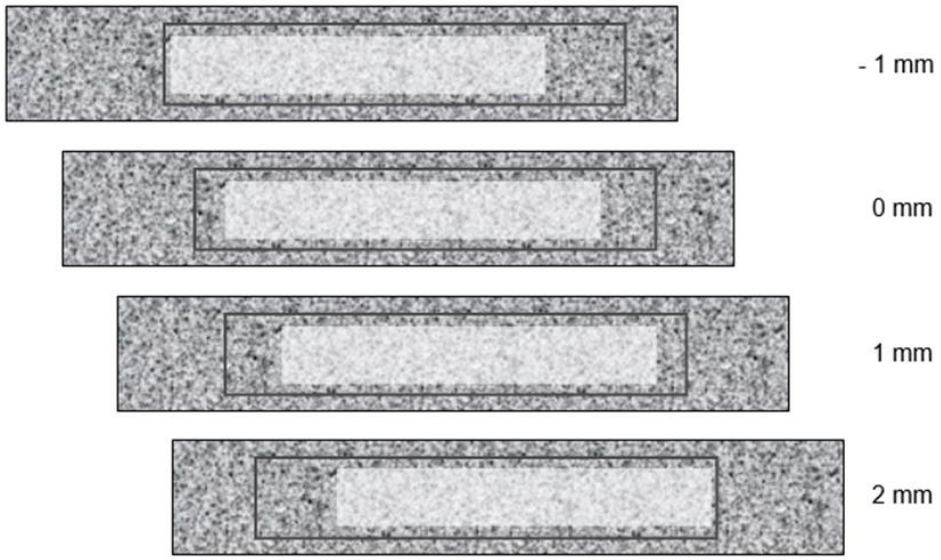

Figure 4: Height positions.

Note that the road marking sample is moved for each of the height positions. This is to ensure that the illuminated field has the same location relative to the instrument so that variations along the road marking sample do not influence the results.

This movement is by 46 mm for each mm of lift.

In this case, further increases of the height would provide incomplete overlap of the fields and, therefore, the measured R_L value would decrease. This is not the case for DELTA instruments that have much more overlap of the fields.

4 Ability to measure structured road markings

EN 1436 clause B.4.2.4 defines the ability to measure structured road markings. Figure 5 illustrates this ability.

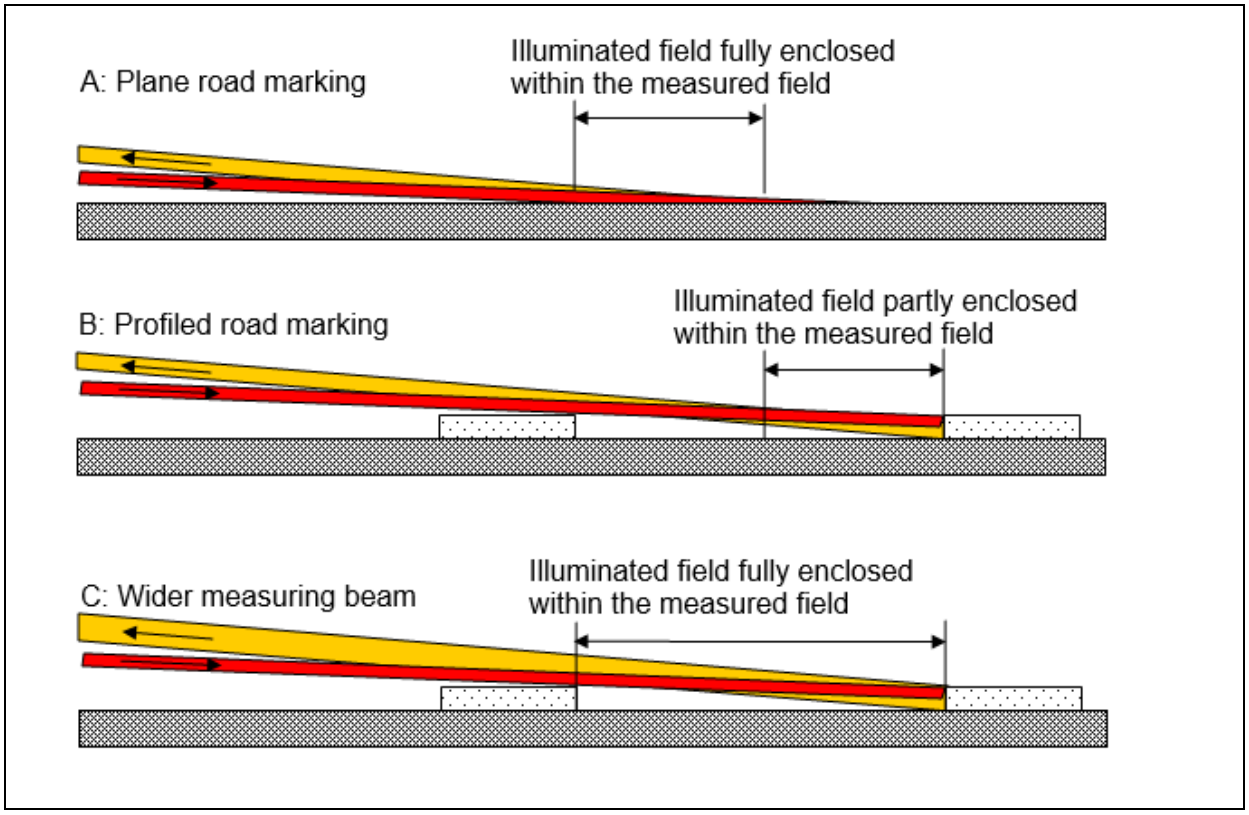

Figure 5: Ability to measure structured road markings.

Figure 5A shows a situation for a plane road marking, where the illuminated field is enclosed within the measured field.

Figure 5B shows a situation for a profiled road marking, where the beams travel a further distance across a gap between two profiles onto the front of a profile, where the fields only overlap partly. This means that the measured R_L value becomes too low.

Figure 5C shows the same situation with, however, a wider measuring beam. This brings the illuminated field fully within the measured field and provides a correct R_L value.

The general rule is that an instrument that can perform at a height position H, is able to measure structured road markings when the structure height is at most H or the gaps between structures is at most 25 × H.

DELTA instruments can measure road markings with even extreme structure.

NOTE: It is pointed out that even when all measured R_L values of a structured road marking are valid, they can vary from one location of the instrument to another. As an example, one measurement can predominantly include the top of a profile while another measurement can predominantly include the front of a profile. Therefore, an instrument should be moved in a few steps covering a module of the structured road marking. This is much the same as for a plane road marking and is considered in another note.

5 Calibration

A sample in the form of a tilted white ceramic surface, as shown in figure 6, is particularly suitable for calibration.

Calibration standards for DELTA instruments are as shown in figure 5 and are calibrated in the DELTA laboratory with accreditation by DANAK with an expanded uncertainty of 3 $mcd \cdot m^{-2} \cdot lx^{-1}$. As DELTA instruments use method B, the measured value is multiplied by 0,542 – refer to section 1.

The final values are generally close to 145 $mcd \cdot m^{-2} \cdot lx^{-1}$. This agrees with a reflectance value of a ceramic surface of 0,85.

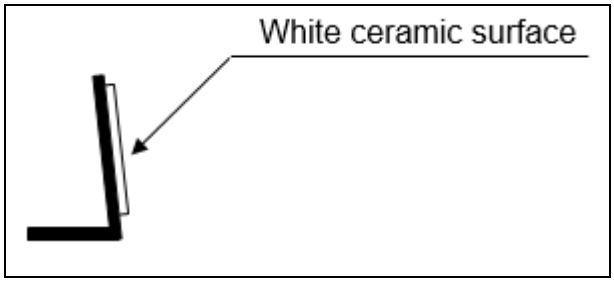

Figure 6: Calibration standard.

6 Uncertainty of measurement

Reference is made to the thorough clause B.8 of EN 1436. This is one of the statements:

Accordingly, uncertainty of measurement can be addressed in the following steps:

- calibration, refer to B.5,
- ability to cope with practical conditions including applicability for structured pavement markings, refer to B.4,
- compliance with the standard measuring condition, refer to B.3,
- spectral match including applicability in terms of colors of road markings, refer to B.2,
- precision (repeatability and reproducibility).

DELTA handheld instruments always did well in comparison measurements.