Measurement of the retroreflection of road signs in the USA and Latin America using a RetroSign GRX

General

In the United States, road signs are, for the most part, standardized by federal regulations, most notably in the Manual on Uniform Traffic Control Devices (MUTCD) and its companion volume the Standard Highway Signs (SHS).

Some examples of road signs in the United States are shown in annex A.

A range of states in Latin America and elsewhere have adopted these road signs with, however, national deviations.

Retroreflection of road signs

CIE 54.2:2001 "*Retroreflection: Definition and measurement*" defines measures for retroreflection and angular systems.

The retroreflection is described by the coefficient of retroreflection R_A with the unit of $cd \cdot lx^{-1} \cdot m^{-2}$.

The angular situations are described by:

a) The observation angle α,
b) The two components β1 and β2 of the entrance angle β,
c) The rotation angle ε.

However, the component of the entrance angle β_2 and the rotation angle ε are both 0°, leaving only the observation angle α and the component of the entrance angle β_1. See figure 1.

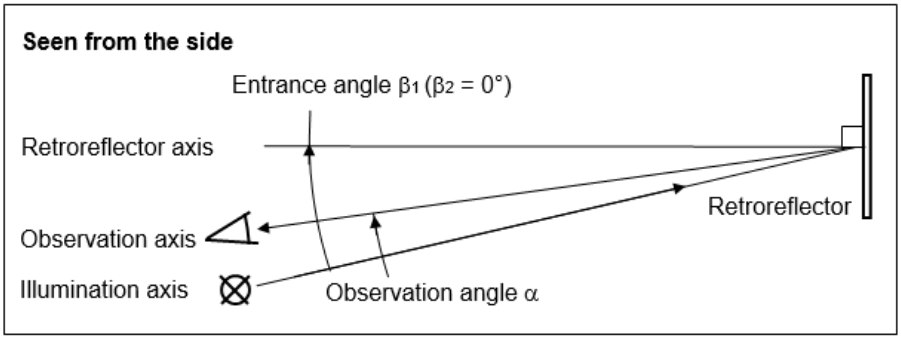

Figure 1: The geometry for road signs.

CIE 54.2 also gives advice regarding laboratory measurements, including maximum apertures, in a clause 6.

ASTM standards for the retroreflection of road signs

These are ASTM standards for the measurement of retroreflective road signs using a portable retroreflectometer:

a) ASTM E1709-16 "*Standard test method for Measurement of retroreflective Signs Using a Portable Retroreflectometer at a 0,2 Degree Observation Angle"* defines a test for road signs with α = 0,20° and β_1 = -4° (β_2 = 0°).
b) ASTM E2540 "*Standard test method for Measurement of retroreflective Signs Using a Portable Retroreflectometer at a 0,5 Degree Observation Angle"* defines a test for road signs with α = 0,50° and β_1 = -4° (β_2 = 0°).

These standards define the measuring geometries for portable retroreflectometers shown in table 1.

	ASTM E1709	ASTM E2540
α	0,20°	0,50°
β_1 (β_2 = 0°)	-4°	-4°

Table 1: Geometries for portable retroreflectometers.

ASTM D4956-19 *"Standard specification for retroreflective sheeting for traffic control"* sets requirements for the retroreflection of retroreflective sheeting materials at specified angular combinations. This standard aims probably at laboratory measurements, but handheld instruments can also be used.

This standard involves the geometries shown in table 2.

	ASTM D4956	
α	0,20°	0,50°
β_1 (β_2 = 0°)	-4°	-4°
β_1 (β_2 = 0°)	30°	30°

Table 2: Additional geometries defined in ASTM D4956.

It is seen that table 2 includes the geometries of table 1 and adds further geometries for β_1 = 30° (β_2 = 0°).

Needs for testing the retroreflection of installed road signs

A road administration is responsible for the performance of the road signs on its roads and may want to test the R_A values of:

a) road signs installed in accordance with a contract at the end of the warranty period. The requirement may for instance be that the R_A values shall not be reduced by more than 20 % compared to the R_A values of the contract. The warranty period is typically 5 years in Europe.
b) old road signs to address the possible need for replacement.

Tests may not include all the relevant road signs, but only a selection.

In case a), the roads signs should be cleaned before measurement. In case b), it may be desirable to measure both before and after cleaning.

Measuring equipment

The RetroSign GRX is a handheld instrument that measures the retroreflection of surfaces at angular combinations given in standards and regulations.

Figure 2: The RetroSign GRX.

The GRX uses a lens to provide a virtually infinite measuring distance and well-defined apertures of illumination and measurement. These apertures comply with the maximum apertures of CIE 54.2.

The calibration standards are calibrated at the laboratory at DELTA with accreditation by DANAK (the national accreditation body in Denmark).

When measuring at the geometries shown in table 1, the equipment needed is a GRX-3 with α = 0,20° and 0,50° and an ASTM calibrator.

When measuring at the geometries shown in table 2, an ASTM+30 adapter is needed in addition to the above-mentioned equipment.

NOTE: Measurement at the geometries of both table 1 and 2 is time consuming as the ASTM calibrator and the ASTM+30 adapter must be switched. Therefore, it should be considered to measure at the geometries of only one of the tables. Both values of a table are obtained in a single measurement.

In case a road sign has a text thinner than 25 mm, an ASTM Ø10 calibrator for thin lines should be included. This applies of cause only, when the text is retroreflective – not when it is black or otherwise not retroreflective.

Additionally, an extension pole with a remote display is needed for cases where a sign cannot be reached from the ground.

The GRX has:

a) GNSS for location identification and mapping,
b) Camera for taking photos of signs,
c) Camera for scanning of barcodes and QR codes for asset management,
d) Wireless communication.

Preparations, measurements, and report

Preparations before leaving

a. Identify the road signs whose R_A values are to be measured,
b. Collect the measuring equipment that is needed,
c. Include an extension pole and/or a ladder,
d. Charge the GRX,
e. Bring cloths, water, and a mild detergent in case the road signs need to be in the cleaned state,

Preparations at a location

a. Decide if it is safe to get to the road sign even when using an extension pole and/or a ladder,
b. Clean the road sign if it needs to be in the cleaned state and allow time for it to dry,
c. Note the type of road sign and the colours of the background and the legends,
d. Turn the GRX on, check the calibration and recalibrate, if necessary,
e. Check that the GNSS signal is received (if used),
f. If the extension pole is needed, mount the GRX on the extension pole and prepare the remote display.

Measurements

a. Measure the R_A values of each retroreflective color of the sign at a small number of locations while positioning the GRX vertically and ensuring full contact,
b. Check if the R_A values of each of the retroreflective colors are realistic and reasonably uniform and redo measurements at the locations where the R_A values seem unrealistic.

Examples of measuring locations are shown in figure 3.

Figure 3: Examples of measuring locations.

Report

The report should be based on the output from the facilities of the GRX. Additionally, unusual events should be recorded.

Annex A: Examples of road signs in the United States

Road signs in the United States fall into these categories: regulatory signs, warning signs, guide signs and school Zone signs of which examples are shown below.

It is characteristic that the signs are text oriented to a much higher degree than signs of the Vienna convention used in Europe.

The number of signs is too high to show them all. Refer to:
https://en.wikipedia.org/wiki/Road_signs_in_the_United_States#W1_series:_Horizontal_alignment