

# Point and annular sign retroreflectometers for measuring retroreflective signs

## 1. Introduction

The following test methods apply for measurement of the retroreflective properties of sign materials such as traffic signs and symbols (vertical surfaces) using a portable retroreflectometer that can be used in the field:

ASTM E1709 - 09 "Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflectometer at a 0.2 Degree Observation Angle".

ASTM E2540 - 08 "Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflectometer at a 0.5 Degree Observation Angle".

The retroreflective properties are characterized by the coefficient of retroreflection  $R_A$  measured in geometrical situations that are specified in the test methods. The entrance angle  $\beta$  is nominally  $-4^\circ$  while the observation angle  $\alpha$  is fixed at  $0.2^\circ$  in E1709 and at  $0.5^\circ$  in E2540.

Apart from the different observation angles, the two test methods are virtually identical. Therefore reference is made directly only to E1709 in the following, but reference to E2508 is implied.

Other requirements in E1709 relate to the:

- sensitivity and range
- stability of the output
- uniformity of illumination
- spectral match
- tolerance of entrance and observation angles
- aperture angles of the source and the receiver
- standardization.

It is a further requirement that the light source and receiver shall be at optical infinity. This is achieved by the use of a collimating lens and the placement of the source and receiver apertures in the focal plane of the lens.

The RetroSign GR3 ASTM supplied by DELTA complies with both test methods by supplying the  $R_A$  values for both of the observation angles

of  $0.2^\circ$  and  $0.5^\circ$ . An additional  $R_A$  value, not covered by the test methods, is supplied for an observation angle of  $1.0^\circ$ .



**Figure 1:** The RetroSign GR3 ASTM.

*NOTE 1: Another version of the RetroSign GR3, called GR3 CEN works with an entrance angle of  $5^\circ$  and observation angles of  $0.33^\circ$ ,  $0.5^\circ$  and  $1.0^\circ$ . This version is applicable for European conditions.*

The RetroSign GR3 ASTM is a "point instrument" as opposed to an "annular instrument" in the terminology of the above-mentioned test methods.

These two types of instruments are introduced in sections 2 and 3, and various aspects are considered in section 4.

*NOTE 2: The Model 922 by RoadVista is an annular instrument.*

There is no doubt that the point instrument is the straight forward solution with its direct reference to laboratory range instruments – being in practical terms a range instrument itself. It is easy to provide traceability to national test institutes like the NIST and to test instruments independently by means of calibrated panels. The  $R_A$  measurement leans directly to specifications for retroreflective sheeting materials and to applications in tender specifications and warranties. The point instrument has the potential for the best accuracy of measurement.

The annular instrument, on the other hand, seems somewhat strange by simulating an eye that forms a circle about a headlamp. The annular instrument has a long history and the original intention was

probably to obtain a higher sensitivity by collecting light in a bigger angular space. Back in time, when only glass bead sheetings were available, the higher sensitivity was obtained without much change in the  $R_A$  measurement, because of the symmetry properties of these sheetings.

The annular instrument is like a species that should have gone extinct, because technical development has made its specialization (higher sensitivity) redundant. However, with the advent of the microprismatic sheetings, the averaging effect of the annular reception does change the  $R_A$  measurement in the way that it re-introduces a symmetry that these sheetings do not possess in themselves in the general case. This is promoted as a virtue.

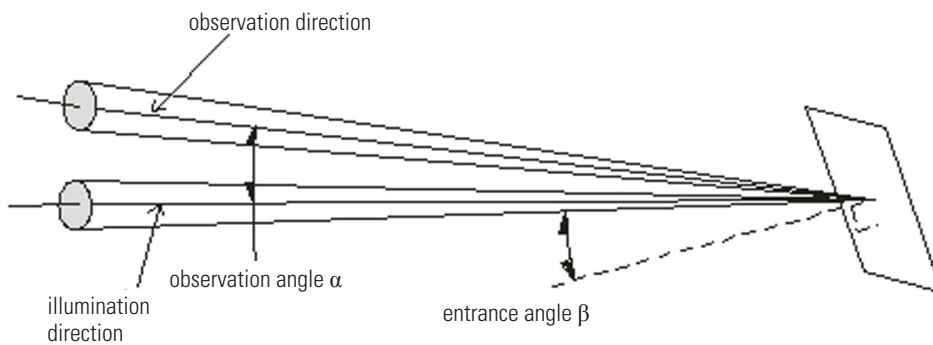
It may be debated which of the two types of instruments provides the more relevant  $R_A$  values for drivers with many pro's and con's.

## 2. Point instruments

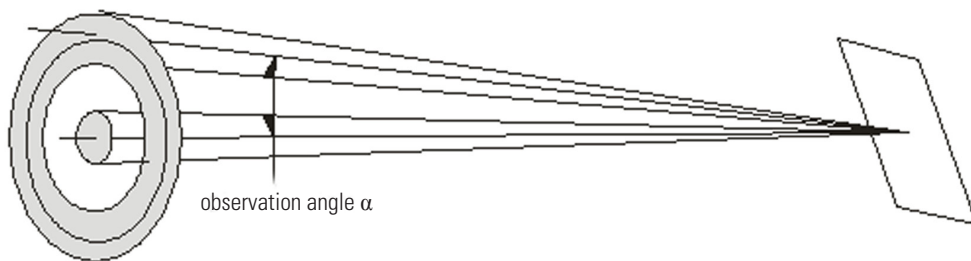
The word "point" refers to reception of light in a small cone about the observation axis, refer to figure 2.

The point instrument makes an  $R_A$  measurement virtually identical to an  $R_A$  measurement made on a laboratory range instrument following the procedure of the basic Test Method E 810 "Test Method for Coefficient of Retroreflection of Retroreflective Sheetting".

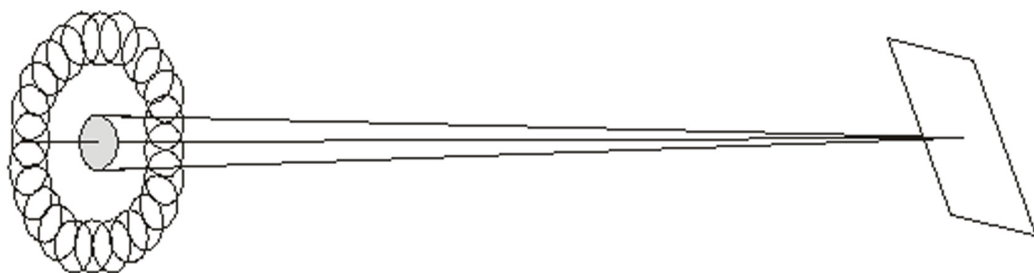
NOTE: A point instrument complies with the same geometrical requirements as a range instrument and works optically with a long distance (optically infinite) due to the use of a collimating lens.



**Figure 2:** Illustration of the geometrical arrangement of a point instrument.



**Figure 3:** Illustration of the geometrical arrangement of an annular instrument.



**Figure 4:** Illustration of the illumination directions needed on a range instrument in order to simulate the annular measurement.

### 3. Annular instruments

The word “annular” refers to reception of light in an annulus about the observation axis, refer to figure 3.

The annular instrument makes an  $R_A$  measurement similar to an average of a great number of  $R_A$  measurements on a range instrument in which the illumination direction is varied. This is illustrated in figure 4.

The actual number of measurements is 24 according to E1709. The procedure is a bit awkward, because a change from one illumination direction to another involves a change of three angles. Refer to E1709 regarding these angles and their settings.

### 4. Discussion of point and annular instruments

#### 4.1 $R_A$ values may be different for prismatic retroreflectors

The  $R_A$  value measured with a point instrument relates to the intensity at a particular location in the retroreflected beam, while the  $R_A$  value measured with an annular instrument relates to the average intensity over the annulus.

In case the retroreflected beam has rotational symmetry about the illumination direction, the two  $R_A$  values are identical, or practically identical. This applies to some approximation for glass bead sheetings, which justifies a statement in E1709 that the point and annular instruments will make practically identical measurements of  $R_A$  for signs made with glass bead sheetings.

Most prismatic retroreflectors do not have this rotational symmetry of the retroreflected beam. The difference of  $R_A$  measurements made with the two types of instrument on prismatic signs may be judged from the diagrams of figures 5, 6 and 7, which show the  $R_A$  values measured with a RetroSign GR3 ASTM with rotations of  $0^\circ$ ,  $5^\circ$ ,  $10^\circ$  ...  $90^\circ$ . The three figures are for 3 M products, respectively EGP, HIP and DG3. These products have symmetries up/down and right/left, so that the rotations from  $0^\circ$  to only  $90^\circ$  are representative for rotations in a full circle.

The diagrams show variations with the rotation angle that stem from two sources. One source is the above-mentioned lack of symmetry of the retroreflected beam. The other source is a variation of the retroreflectance with a rotation of the illumination direction about the normal to the sign, refer to E1709.

The last-mentioned source of variation is fairly weak compared to the first-mentioned source at the entrance angle of  $-4^\circ$  used by the instruments (but may be strong at higher entrance angles). Therefore, the values at  $0^\circ$  would be the values provided by a conventional measurement with a point instrument, while the average value over the angular range would approximately be the values provided by an annular instrument.

The diagrams confirm a statement in E1709 that the difference of  $R_A$  measurements made with the two types of instrument on prismatic signs may become as great as 25 % in extreme cases, but is generally on the order of 10 %.

#### 4.2 Angular positioning

E1709 contains a statement that “An annular instrument cannot gage the variation of  $R_A$  with rotation angle. Accordingly, repeatable  $R_A$  measurement of prismatic signs with an annular instrument does not require care in angular positioning. Positioning to within  $\pm 15^\circ$  is sufficient”. This statement is justified in section 4.1.

E1709 also contains a statement that “A point instrument can gage the variation of  $R_A$  with rotation angle by placing it with different angular positions upon the sign face.  $R_A$  variation of 5 % for  $5^\circ$  rotation is not unusual. Accordingly, repeatable  $R_A$  measurement of prismatic signs with a point instrument, requires care in angular positioning”.

The second part of this statement is misleading. Firstly, a  $5^\circ$  rotation is quite large, and it does not require particular care to provide an angular position with less than  $5^\circ$  rotation. Secondly, microprismatic sheeting materials have generally right/left symmetry, so that a small rotation with respect to the vertical has little effect. The largest change with a rotation from  $0^\circ$  to  $5^\circ$  in figures 5, 6 and 7 is approximately 3 %.

It is true that a point instrument can gage the variation of  $R_A$  with the rotation angle, but it does not require particular care in angular positioning to obtain repeatable  $R_A$  measurement of prismatic signs.

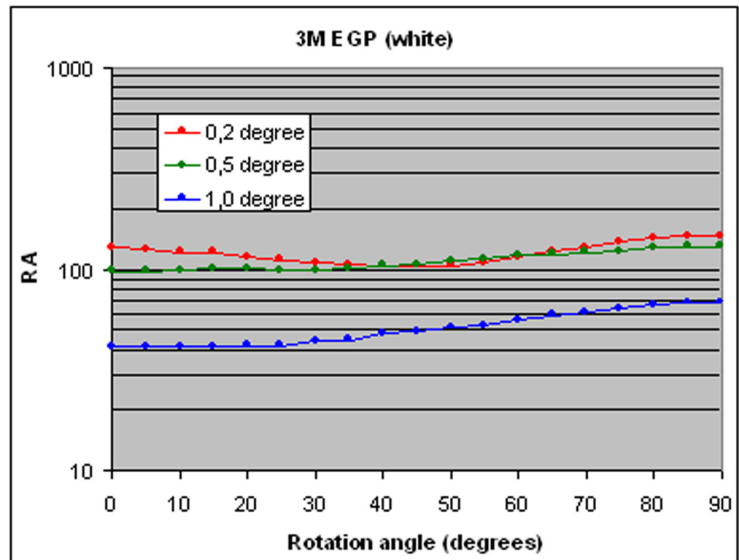
#### 4.3 Other aspects regarding accuracy of measurement

An annular instrument can in principle have a higher sensitivity than a point instrument by collecting light in a larger angular range within the annulus. However, sensitivity is sufficient for point instruments when using the available technology and does not present any problem.

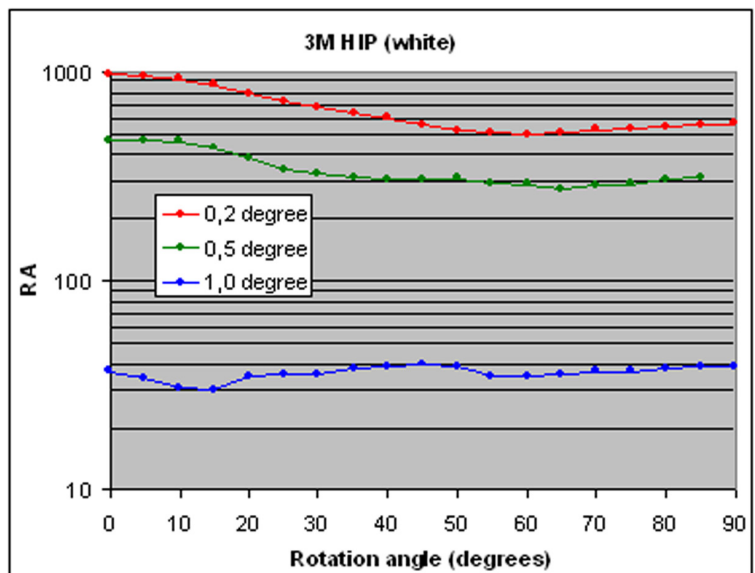
On the other hand, an annular instrument needs to provide a uniform sensitivity over the angular range of the annulus or there will be a bias in the observation angle or a variation with rotations. A point instrument needs also to have uniform sensitivity over the angular range, but that is fairly easy for a small cone. Therefore, point instruments lean more naturally towards providing reproducibility than annular instruments.

The matter that a point instrument makes an  $R_A$  measurement virtually identical to an  $R_A$  measurement made on a laboratory range instrument makes it easy to provide traceability to national test institutes like the NIST and to test an instrument independently by means of calibrated panels.

**Figure 5:**  $R_A$  values measured with a RetroSign GR3 ASTM on 3M EGP material.



**Figure 6:**  $R_A$  values measured with a RetroSign GR3 ASTM on 3M HIP material.



**Figure 7:**  $R_A$  values measured with a RetroSign GR3 ASTM on 3M DG3 material.

