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European Assessment Document for

Road markings - retro-reflective elements

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD specifies assessment methods for retro-reflective elements (further called RRE).

RRE take the form of a fine powder to be applied onto a paint-based road marking. RRE are composed of a layer of small glass-ceramic spherical beads build around a core of clustered glass beads.

A resin is used to build the core and adhere the outer layer of the high refractive index beads.

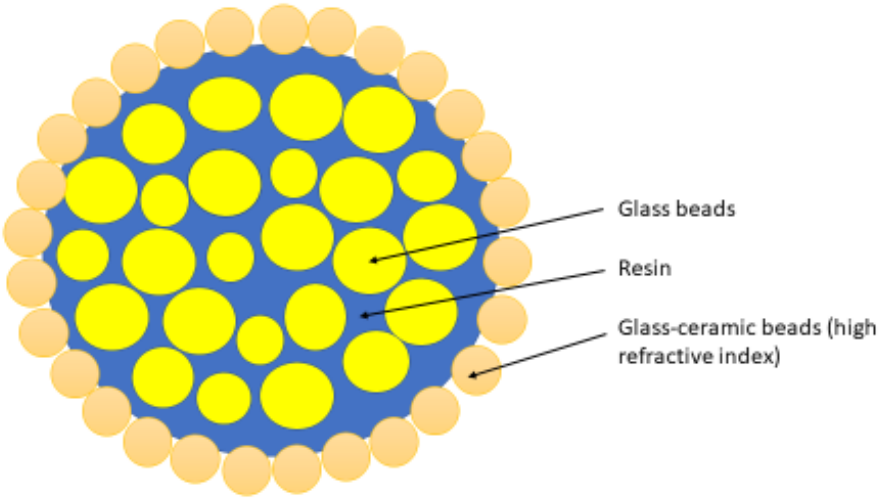

Figure 1.1.1 – section across a RRE bead

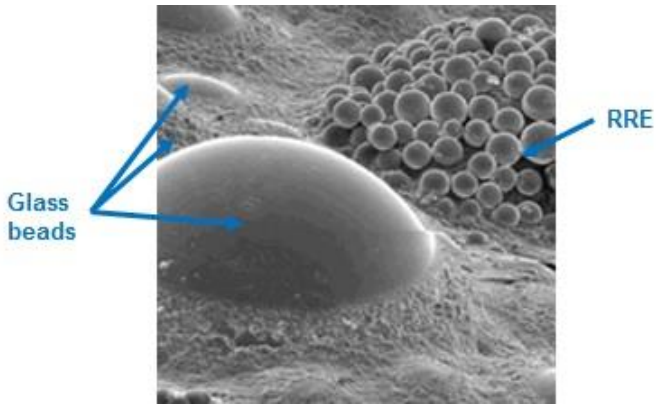

Figure 1.1.2 - Electron microscope image of RRE with very large and smaller glass-ceramic beads in a finished paint-based road marking

This resin will also serve as the reflective mirror. Where traditional glass beads have a refractive index (RI) range from 1,5 to 1,7, the refractive index of the exterior glass-ceramic beads used for these products will range from 1,9 to 2,4.

The refractive index can only be measured before the beads are processed into an RRE. The refractive index of exterior beads will determine if the element provides retro-reflective performance in dry or wet weather conditions.

RRE with glass-ceramic beads RI 1,9, provide retro-reflection of the light during dry weather conditions, or shortly after rainfall, and RRE with glass-ceramic beads RI 2,4, provide retro-reflection of the light during continuous rain conditions, or when the road marking is fully covered with water.

Due to the size of the RRE, many of the small beads will retro-reflect the light in a very efficient way. The choice of RI 1,9 beads provides high light return in dry conditions, while RRE with RI 2,4 beads compensate for deviation caused by the water layer and send the light back in the right direction as well.

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, installation, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, installation, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

RRE may be used as drop-on materials for road markings. The RRE will return the light emitted by the car head lights, back to the driver. Depending on the refractive index of the exterior beads, performances during rain and/or dry conditions may be achieved.

This is typically done in combination with the initial application of a binder system (paint, thermoplastic or cold plastic material) sprayed or extruded on the road surface, followed by a "double drop" application: firstly, the RRE and secondly drop on materials according to EN 1423[1]. The final goal of this way of application is to achieve a certain specified performance level according to EN 1436.

RRE are intended to be used primarily as drop-on material to be included in permanent and or temporary road markings systems; typically in products defined according to EN 1871 or EN 1790. The ETA shall specify whether the RRE has been designed to perform during dry weather or continuous rain.

RRE with 100% RI 1,9 beads are effective only during dry weather or after rain, while RRE with 100% RI 2,4 beads are only effective when covered with a water layer or during continuous rainfall. Blends of RRE with RI 1,9 and RRE with RI 2,4 beads are effective in all weather conditions.

1.2.2 Working life / durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the product for the intended use of 1 to 4 years when installed in the works (pavement marking), provided that the product is subject to appropriate installation (see 1.1). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

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1 All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4

2 The real working life of a product incorporated in a specific works depends on the environmental conditions the works is subjected to, as well as on the particular conditions of the design, execution, use and maintenance of those works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than those referred to.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Article 2)

In addition to the terminology used or referred to in EN 1423, EN 1790 and EN 1871, the terms and definitions specified below apply.

1.3.1 Retro-reflective elements (RRE)

Elements composed of a layer of small glass-ceramic spherical beads build around a core of clustered glass beads.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of RRE is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 3: Hygiene, health and the environment			
1	Content, emission and/or release of dangerous substances	2.2.1	Description
Basic Works Requirement 4: Safety and accessibility in use			
2	Granulometry	2.2.2	Level
3	Colour - Daylight Chromaticity	2.2.3	Level
4	Retro-Reflectivity	2.2.4	Level
5	Adhesion of the beads on the RRE	2.2.5	Level

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Content, emission and/or release of dangerous substances

The performance of the product related to the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer[3] after identifying the release scenarios taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The identified intended release scenarios for this product and intended use with respect to dangerous substances are:

S/W1: Product with direct contact to soil, ground- and surface water

[3] The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011).

The manufacturer is **not** obliged:
-to provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
-to provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS.

Any information provided by the manufacturer regarding the chemical composition of the products may not be distributed to EOTA or to TABs.

2.2.1.1 Arsenic, lead and antimony

Historically, glass manufacture used arsenic, lead and antimony as colouring and refining agent. It is important to control the content of those dangerous substances because RRE in their intended use are in direct contact with soil, ground- and surface water. RRE shall be assessed in order to determine the content of arsenic, lead and antimony.

The assessment method for the content of arsenic, lead and antimony is based on the raw material according to the testing method described in EN 1423, Annex I.

Since this could lead to the implementation of further assessment and determination methods, the use of recycled materials shall always be indicated. If recycled glass is used, reference is made to EAD 040394-00-1201 for the assessment of additional substances.

The ETA shall state the content of arsenic, lead and antimony separately expressed in ppm (mg/kg).

2.2.2 Granulometry

The granulometry (size distribution) of the final RRE, not to be confused with the glass-ceramic or glass beads, shall be described following the methods of determination indicated in EN 1423, Clause 4.1.3, by determining percentages by mass of the cumulative retained RRE on metal wire batch test sieves. The sieves shall be selected in accordance with the rules given in EN 1423, clause 4.1.3.

The ETA shall specify the granulometry, expressed as the retained fraction per sieve and the fraction of residual, un-attached beads of the final RRE. These un-attached beads will pass all the sieves and reach the pan at the bottom of the sieve stack.

Table 2.2.2.1 Reporting example of granulometry (RRE size distribution)

Sieve	Retained fraction (Cumulative % retention)
2,0 mm	0,12
1,7 mm	19,95
1,4 mm	73,20
1,18 mm	97,15
850 µm	99,71
600 µm	99,73
Pan (*)	0,27

* The % of unattached beads is determined by the cumulative retained fraction % on the smallest sieve: 100 % – cumulative retained fraction on smallest sieve (%)

2.2.3 Colour - Daylight Chromaticity

The daylight chromaticity coordinates (x,y) shall be measured in accordance with CIE Publication 15 Colourimetry using a calibrated “45° a:0° geometry” (45°= illumination angle, 0°= observer angle, a= annular) and shall be calculated from the total spectral radiance factors computed for the CIE standard Illuminant D65, EN ISO/CIE 11664-2, for the CIE 1931 (2°) standard colorimetric observer in accordance with EN ISO/CIE 11664-1, Chapter 5.

The colour measurements shall be performed on the final elements, as the colour is influenced by both the colour of the beads and the resin. The final elements shall be prepared by pouring elements in e.g., a Petri dish with a diameter of 100 mm, making sure that the layer of final elements is at least 5 mm thick to avoid that the bottom of the dish will influence the colour measurement. If the measurement is performed repeatedly, it shall be determined on different samples each prepared separately and a single root mean square value of each of the x and y co-ordinates of the (x,y) chromaticity are calculated.

The chromaticity co-ordinates CIE (x,y) of the glass-ceramic RRE shall be reported as a single (x,y) value falling within a defined colour box with 4 (x,y) corner points, examples of which are shown in Table 2.2.3.1.

Table 2.2.3.1 Chromaticity coordinates CIE (x,y)

Example for	CIE (x,y) Colour box corner points			
White beads (clear, transparent)	(0,30 , 0,30)	(0,31, 0,38)	(0,39, 0,39)	(0,38, 0,31)
Yellow beads (yellow, transparent)	(0,39, 0,36)	(0,39, 0,44)	(0,49, 0,44)	(0,47, 0,37)

The reference method for expressing the chromacity is the CIE(x,y) method. Other measurements for colour coordinates may be used, if they can be mathematically converted to CIE (x,y). For instance, L*a*b* colour coordinates can be converted mathematically or by using the following links:

- http://colormine.org/convert/lab-to-yxy
- http://www.easyrgb.com/index.php?X=CALC

2.2.4 Coefficient of retro-reflection of the RRE

As RRE are composed of beads and a binder, also performing as a mirror, retro-reflectivity shall be measured on the product itself prior to application on the road marking. According to the refractive index of the beads, the elements will only show R_L values when dry or immerged in water (never "and"). As commercial products shall be blends of various types of RRE (mixture of beads with R.I. 1,9 and beads with R.I. 2,4; of same or different chromaticity), both the dry and immerged in water performance shall be obtained.

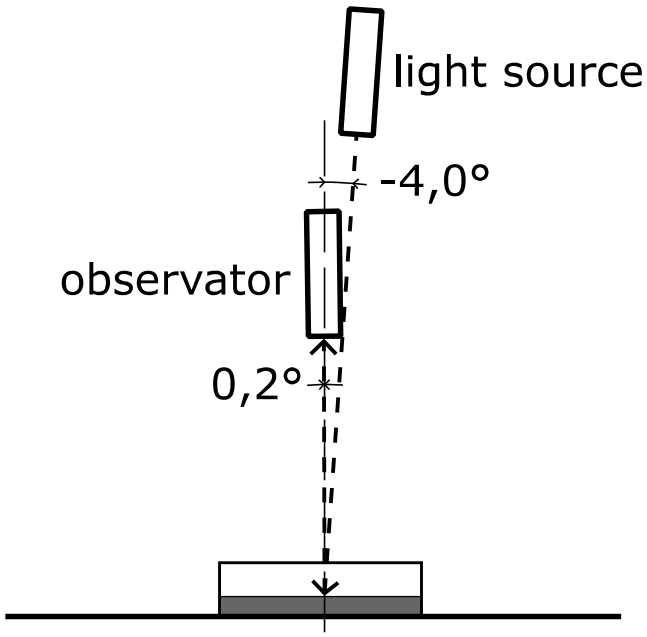
A coefficient of retro-reflection is measured in accordance with CIE Publication No. 54.2 Retro-reflection using CIE Standard Illuminant A and expressed in $cd.lux^{-1}.m^{-2}$.

Any of the retro-luminometers (photometer) according to and calibrated as foreseen in CIE publication N° 54.2 shall be used.

The specimen shall be prepared by pouring elements in a dish, making sure that the layer is at least 5 mm thick to avoid that the bottom of the dish will influence the measurement.

Because RRE specimens are loose elements in a dish, the requirement is that a photometer has to look down vertically from above at the specimen at a -4.0° entrance angle. While the observation angle is set at 0,2° (see Figure 2.2.4.1 below).

Figure 2.2.4.1 – Determination of coefficient of retro-reflection



For the “immerged in water” measurements, the loose elements are completely flooded with a water/detergent solution. Any pH neutral household detergent shall be diluted at 5 g/l water and used as a wetting agent to avoid air inclusions at the RRE – water interface, which would interfere with the light transmission.

Record the average R_L value based on average of the 3 measurements, each on a different specimen out of the same batch.

By default, the coefficient of retro-reflection “dry” and “immerged in water” shall be performed; as a second option the manufacturer may select either “dry” or “immerged in water” based on the nature of the RRE blend.

RRE blends are typically produced by physically blending 2 fully finished RRE elements (different RI beads, same colour and size).

Note: For FPC, tests are performed on the individual RRE types first and only a second retro-reflectivity validation, according to clause 2.2.4, is made on the final blend.

Both “dry” and “immerged in water” are tested on the same specimen. The dry specimen is completely flooded with the water/detergent liquid, without removing it from under the retro-luminometer (photometer). The “immerged in water” value is recorded when all air around the RRE has been replaced by the liquid and the measured value remains stable.

The ETA shall state the levels of retro-reflectivity for “dry” and “in water” in **cd.lux^{-1}.m^{-2}**. Table 2.2.4.1 shows possible examples of levels of retro-reflectivity for “dry” and “in water”. This both for blends and pure RRE.

Table 2.2.4.1 Reporting examples of retro-reflectivity for RRE

White Blend Ratio (% RRE with 2,4 R.I. beads)	"Dry" in $cd.lux^{-1}.m^{-2}$	"In Water" in $cd.lux^{-1}.m^{-2}$
50 %	10	3
70 %	4,5	5
80 %	1,5	6
100% (only 2,4 R.I. beads)	NA	9
0 % (only 1,9 R.I. beads)	30	NA
NA : not applicable – not designed for this performance characteristic, as only one type of bead is used.		

The reference method uses vertically positioned retro-luminometers; other (e.g., horizontally positioned) retro-luminometers shall be used only if a correlation of results with vertically positioned retro-luminometers has been established.

2.2.5 Adhesion of the beads to the RRE

A test specimen is made by a mono-layer of RRE cured onto thick layer of resin. The resulting coin shaped specimen is submitted to a controlled jet stream of abrasive elements (similar to a sandblasting process). The retro-reflectivity of the specimen is tested according to clause 2.2.4, before and after the blasting process.

See Annex A for detailed specimen preparation and test procedure.

Any damage to the RRE, resulting in a loss of gloss or glass-ceramic beads releasing from the core of the RRE will automatically result in a loss of retro-reflection**.**

The retention of retro-reflectivity shall be reported (examples of reporting are being given in Table 2.2.5.1). The ETA shall specify or report the min % of retention guaranteed by the production process followed.

According to the intended use of the RRE, the retro-reflectivity tests shall be done dry or immerged in water.

Note: The reference value (specimen measured before the adhesion test) will be different compared with the value measured and reported in clause 2.2.4, for the same type of RRE, due to the impact of the resin to fix a monolayer of RRE.

Table 2.2.5.1 Reporting examples of adhesion of the beads of the RRE

RRE specimen	R_A measurement initial ($cd.lux^{-1}.m^{-2}$)	R_A measurement after adhesion test ($cd.lux^{-1}.m^{-2}$)	Retention
RRE White – 1,9 RI beads	29,3	26,9	91,7%
RRE Yellow – 1,9 RI beads	20,3	18,2	89,7%
RRE White – 2,4 RI beads	10,9	8,6	78,8%
RRE Yellow – 2,4 RI beads	9,1	7,6	84,0%

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Decision 96/579/EC, as amended by Decision 1999/453/EC.

The system is 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 – Control plan for the manufacturer; cornerstones

N°	Subject/type of control	Test or control method	Criteria	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Glass Ceramic Beads	EN 1423 or alternative and the RI and granulometry	Verification of the purchasing specification documentation, given by the manufacturer or calibration certificate of the refractive index test method used	3 samples per bead type in case of bead change + according to Control plan	According to Control plan
2	Other Raw material	Incoming raw material to be tested according to Control plan	Verification of the purchasing specification documentation, given by the manufacturer	Sample verification according to Control plan	According to Control plan
3	Production process (all necessary steps)	According to Control plan	According to the QS manual of the manufacturer	According to Control plan	According to Control plan
4	Content and/or release of dangerous substances, other than those referred to below	Chemical analysis according to Control plan	Verification of the material specification given by the raw material supplier	Sample verification according to Control plan	According to Control plan
5	Content of Sb, As and Pb	See 2.2.1	Verification of the material specification given by the raw material supplier or accredited test institute.	1 sample per production batch. Reduced to 1 sample per type per year, if < 25 ppm	According to Control plan
6	Granulometry	See 2.2.2	EN 1423	Min 1 sample per production batch, but generally 1 time/hr	According to Control plan
7	Colour: Daytime Chromaticity	See 2.2.3	Verification and documentation of the calibration certificate of the instrument	Min 1 sample per batch, but generally 1 time/hr	According to Control plan
8	Retro-Reflectivity	See 2.2.4	Verification and documentation of the calibration certificate of the instrument	Min 1 sample per batch but generally 1 time / hr	According to Control plan

N°	Subject/type of control	Test or control method	Criteria	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
9	Adhesion of the beads on the RRE	See 2.2.5	Verification and documentation of the calibration certificate of the instrument	Min 1 sample per batch	According to Control plan
10	Verification of the RRE blends (if relevant)	According to control plan	Verification and documentation of the calibration certificate of the instrument	Min 1 sample per batch	According to Control plan
11	Storage	Storage condition according to the provisions of the manufacturer. Measuring the ambient room temperature and relative humidity	According to Control plan	Inspection of the storage condition during the yearly FPC	One time per year during the factory production control (FPC)

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for RRE are laid down in Table 3.3.1.

Table 3.3.1 – Control plan for the notified body; cornerstones

N°	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control *(for systems 1+, 1 and 2+ only)*					
1	The Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the RRE.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to control plan	According to control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control *(for systems 1+, 1 and 2+ only)*					
2	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacture	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1	According to control plan	According to control plan	1/year

4 REFERENCE DOCUMENTS

EN 1423:2012/AC:2013	Road marking materials - Drop on materials - Glass beads, antiskid aggregates and mixtures of the two
EN 1436:2018	Road marking materials – Road marking performance for road users and test methods
EN 1790:2013	Road marking materials - Preformed road markings
EN 1871:2020	Road marking materials - Paint, thermoplastic and cold plastic materials - Physical properties
EN ISO/CIE 11664-1:2019	Colorimetry - Part 1: CIE standard colorimetric observers
EN ISO/CIE 11664-2:2022	Colorimetry - Part 2: CIE standard illuminants
CIE Publication 15:2004	CIE Technical Report Colorimetry
CIE Publication No. 54.2:2001	Retroreflection: definition and measurement

ANNEX A ADHESION TEST OF THE BEADS TO THE RRE

A.1. Principle

During transport or after application on to the road marking, any damage to the RRE caused by abrasion and friction will result in a loss of gloss (due to e.g., damage to bead surface, loss of the resin which acts as reflective mirror) or ceramic beads being released from the core of the RRE. This will result in a loss of retro-reflection.

This test attempts to predict how well the beads adhere to the core and how they will resist to surface damage.

A.2. Apparatus

- Sand blast cabinet
- 200 g or 400 g 1.9 RI glass ceramic beads as sandblast media (same as used to produce the RRE with RI 1.9). Unless otherwise specified, 400 g shall be used.
- Retro-luminometer as in clause 2.2.4.

A.3. Specimens

Collect 100 g of representative RRE from the production batch to produce 3 specimens.

In order to fix a monolayer of RRE, following specimen preparation has to be followed:

Pour a layer of clear fast curing epoxy resin + curing agent, in a mould. Immediately followed by a layer of RRE.

Allow the 3 specimens to be fully cured at ambient temperature before de-moulding and excess loose elements are removed.

Specimen overall dimensions: 40 mm (± 1 mm) diameter by minimum 2 mm thick (thickness of expoy with RRE).

A.4. Test procedure

A.4.1. Before the durability test

The retro-reflectivity of each specimen is measured according to clause 2.2.4 (dry or immerged in water). These reference values will be different than the values measured in clause 2.2.4 on loose RRE for the same type of loose RRE, due to the visible presence of the epoxy resin to fix a monolayer of RRE.

(Note that the specimen should be dry, fully cured before performing the next step)

A.4.2. Sandblasting step

A sandblasting gun with a ceramic nozzle type is chosen to create a round and evenly distributed pattern and a maximum of the beads hitting the specimen over the complete surface: the exit hole measures 6,4 mm internal diameter, the overall diameter is 12,7 mm, the length is 54 mm (see Figure A.4.2.1).

Reference example: Ceramic nozzle by McMaster Carr: part number 3425K55.

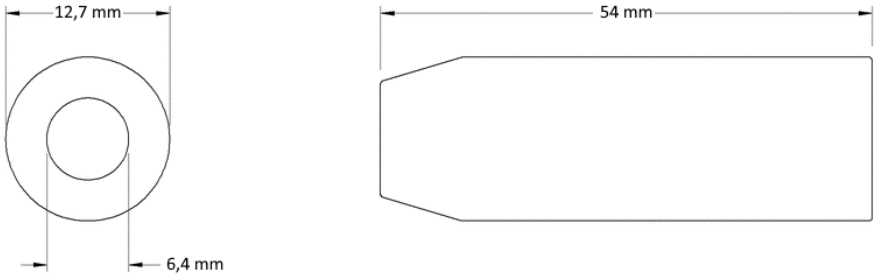


Figure A.4.2.1 – Sandblasting ceramic nozzle

Calibrate the nozzle settings in order for the sandblast media to be blown at the specimen within a timeframe of about 30 s / 200 g. For example, start calibration with a back pressure of 4,2 kg/cm² and air flow rate of about 54 l/min.

The specimen is mounted in a vertical position at 25 cm from nozzle. The blasting is done horizontally in a special designed cabinet to contain the beads and dust (see Figure A.4.2.2).

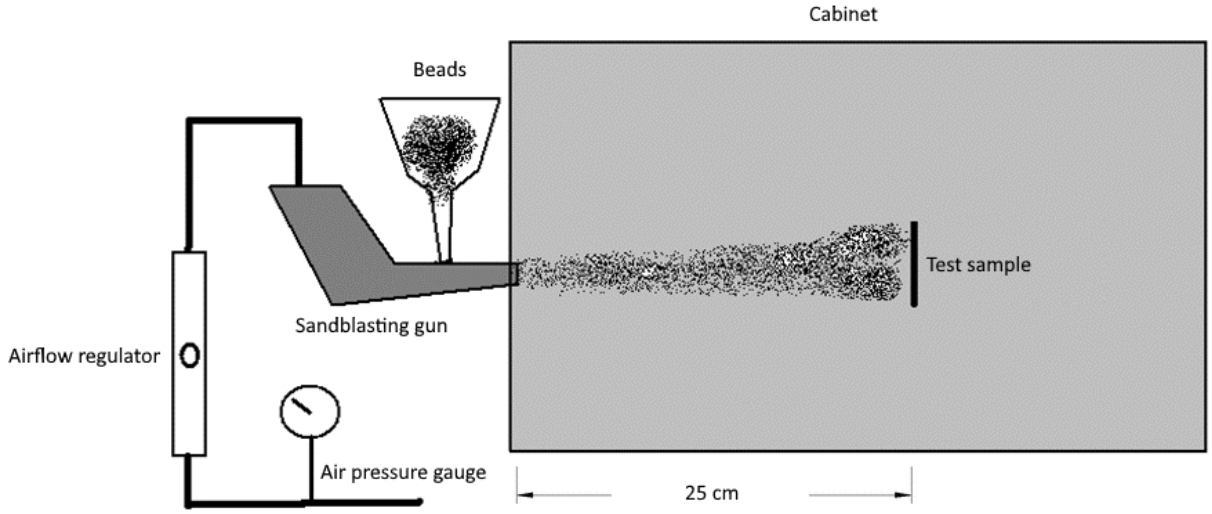


Figure A.4.2.2 – Sandblasting cabinet setup

A.4.3. Blow off clinging debris

A.4.4. Measurement of retro-reflectivity

The retro-reflectivity of the 3 sandblasted specimens each specimen is measured according to clause 2.2.4 (dry or immerged in water).

A.5. Results

Calculate the average % retained of retro-reflectivity based on the results obtained out of step A.4.1 and step A.4.4, for a sandblasting media load of 400 g. Additionally the average % retained of retro-reflectivity for a sandblasting media load of 200 g can be calculated if the assessment using this amount of sandblasting media load was also performed.