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BSI Standards Publication

Glass in building — Coated glass

Part 5: Test method and classification for the self-cleaning performances of coated glass surfaces

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National foreword

This British Standard is the UK implementation of EN 1096-5:2016.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Verre dans la construction - Verre à couche - Partie 5: Méthode d'essai et classification des performances autonettoyantes des surfaces de verre à couche

Glas im Bauwesen - Beschichtetes Glas - Teil 5: Prüfverfahren und Klasseneinteilung für das Selbstreinigungsverhalten von beschichteten Glasoberflächen

This European Standard was approved by CEN on 30 November 2015.

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European foreword

This document (EN 1096-5:2016) has been prepared by Technical Committee CEN/TC 129 “Glass in building”, the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2016, and conflicting national standards shall be withdrawn at the latest by July 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This part of the standard is published to allow the test methodology to be used.

As stated in the scope, at the present time, the test procedure does not specifically address the durability of the coating's self-cleaning functionality. Work is on-going to develop applicable testing.

EN 1096, *Glass in building — Coated glass*, is composed of the following parts:

— *Part 1: Definitions and classification;*

— *Part 2: Requirements and test methods for A, B and S coatings;*

— *Part 3: Requirements and test methods for C and D coatings;*

— *Part 4: Evaluation of conformity/Product standard;*

— *Part 5: Test method and classification for the self-cleaning performances of coated glass surfaces.*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard defines a test method to establish the self-cleaning performances for coatings on glass which utilize sun, rain or a combination of sun and rain to enhance the cleanliness of the glass.

The European Standard applies to class A coated glass as defined in EN 1096-1 and EN 1096-2 for use in outdoor building applications. The test is designed to be applicable for coatings on glass which use hydrophilic or photocatalytic active functionalities to enhance the cleanliness of the glass.

The test procedure does not specifically address the durability of the coating's self-cleaning functionality.

2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1096-1, *Glass in building - Coated glass - Part 1: Definitions and classification*

EN ISO 4892-3:2013, *Plastics - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps (ISO 4892-3:2013)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1096-1 and the following apply.

3.1
glass substrate
basic glass, special basic glass, chemically strengthened basic glass, thermally treated basic and special basic glass, laminated glass or laminated safety glass

3.2
coating
one or more thin solid layers of inorganic materials applied onto the surface of a glass substrate by various methods of deposition

Note 1 to entry: Methods of deposition are described in EN 1096–1.

3.3
glass with dual coating
glass substrates to which coatings have been applied on both sides

Note 1 to entry: The second coating should not necessarily be a self-cleaning coating.

3.4
coated glass
glass substrate to which has been applied a coating, in order to modify one or more of its properties

3.5
self-cleaning coating
coating on glass substrates allowing obtaining or maintaining in time a cleaner surface as compared to untreated glass

3.6
hydrophilic coating
coating allowing maintaining a water contact angle of less than 20°

3.7
photocatalytic coating
coating containing a substance that performs one or more functions based on oxidation and reduction reactions under photo irradiation, inducing decomposition and removal of contaminants

3.8
secondary coating
coating deposited on the opposite side of a self-cleaning coating, in case of dual coatings

3.9
haze
wide angle scattering of light expressed as the percentage of the total transmitted light which, in passing through the glass, deviates from the incident beam by more than 2,5°

4 Symbols and abbreviations

For the purpose of this document, the following symbols and abbreviations apply.

RH	Relative humidity
S_{global}	Global standard deviation
T_t	Total light transmittance
T_d	Diffuse light transmittance
H	Haze
$\overline{\Delta H_{Global}}$	Mean global change of haze
$H_{initial}$	Haze after initial preparation of the sample (cleaning / activation)
$H_{cycle1dirt}$	Haze after cycle 1 dirt application
$H_{cycle1sun}$	Haze after cycle 1 UV exposure
$H_{cycle1rain}$	Haze after cycle 1 water spray
$H_{cycle2dirt}$	Haze after cycle 2 dirt application
$H_{cycle2sun}$	Haze after cycle 2 UV exposure
$H_{cycle2rain} = H_{final}$	Haze after cycle 2 water spray
$\Delta H = H_{final} - H_{initial}$	Haze variation between initial cleaning stage and end of cycle 2

5 Principle of the test

Standardized glass samples shall be submitted to a spray of a standardized dirt mixture, followed by a simulation of natural weathering action by applying UV irradiation (to simulate sun) and water spray (to simulate rain). This cycle shall be repeated twice to ensure better stability of results.

The haze shall be measured at initial preparation (after cleaning) and final stage (at the end of the second cycle).

The evaluation criteria shall be the haze variation (ΔH) between the sample after initial preparation ($H_{initial}$) and the sample at the final stage of the test (H_{final}), see Formula (1).

$$\Delta H = H_{final} - H_{initial} \tag{1}$$

NOTE The incident light on glass samples with dirt deposit is diffused scattered and the effect in transmission is seen as reduction of contrast of objects observed through the glass.

It is strongly recommended to measure haze at each step of the test (as explained in Clause 10) in order to check that there is no deviation of the test.

The test and all handling of the product to be tested shall be performed in a clean environment, i.e. exempt from any source of contamination (organics, silicones, dust) which could modify the surface, affect the functionality, the test conditions or the haze measurements. An example of contamination checking procedure is given in Annex C.

6 Instrumentation

6.1 UVA-Illumination chamber

A UV illumination chamber[1)] shall be equipped with UVA-340 lamps, such as described in EN ISO 4892-3:2013, Table 1 (“type I” lamps).

A closed chamber is recommended.

The irradiation power shall be set to 0,68 $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm on the surface of the samples, which is the maximal irradiance of solar light according to CIE 85 Table 4. The irradiation level shall be maintained constant and uniformly distributed such as to ensure a same level of irradiation on all the samples.

NOTE The irradiation level can be monitored with a radiometer. The intensity of the lamp can be controlled continuously and adjusted to balance aging of the lamps.

Relative Humidity (RH) shall be maintained between 15 % and 50 % inside the chamber during the irradiation period. The air temperature in the illumination chamber shall remain between 25°C and 40°C. The UVA cabinet shall be placed in a well-ventilated area and its vents shall be fully opened, to ensure that the temperature inside the cabinet remains in the indicated values. The temperature and RH shall be monitored and given in the test report. The cabinet shall be clean and exempt of any contamination source, especially silicone source, see Annex C.

6.2 Sample support

For the spraying steps, the sample shall be installed on a support, with an inclination of 10° from vertical. The description of the support is given in Annex A.

[1)] Equipment UV2000 or UVCon from Atlas or QUV from QPannel have been used during the Round Robin tests and found to be suitable. This equipment is an example of a suitable product available commercially. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of this product.

6.3 Spraying nozzle

The spraying nozzle[2] shall be fixed horizontally and aligned with the centre of the haze measurement area on the glass samples. The distance between the nozzle tip and the glass sample shall be 300 mm, as described in Annex A. The nozzle shall be a full cone airless nozzle with a large spray angle (120°).

6.4 Dirt mixture pressure tank

The dirt mixture shall be placed in a dedicated pressure vessel equipped with a mechanical stirrer. The turning velocity of the stirrer shall be adapted to avoid particles precipitation. Pressure vessel and mechanical stirrer shall be made of inert material resistant to acid corrosion and shall not contain any silicone contamination source[3]. Attention shall be paid to ensure sufficient height of liquid (at least 5 cm) in the container in order to avoid air bubbles in the pulverization system, which could affect final results.

The section of container may be lowered by using a narrower container inside the pressure tank to reduce the necessary solution volume.

6.5 Water pressure tank

The same precautions against air bubbles as described in 6.4. shall be taken.

The water pressure tank may be a simple clean pressurized tank.

6.6 Timer for spray

The time of pulverization of the dirt mixture shall be measured in order to control the volume sprayed.

It is recommended to use an automatic timer (such as a solenoid valve) to obtain better precision on pulverization time, thus on sprayed volumes.

6.7 Furnace used to dry the glasses

The temperature set to dry the glasses shall be (60 ± 2) °C on the glass surface. Before starting the test, furnace shall be calibrated by placing the same amount of glasses that will normally be used for the test inside the furnace. A thermocouple shall be affixed on the glass surface to check the conformity to the target temperature.

The duration of the drying stage shall be counted after stabilization of the glass surface temperature. The time for the glass surface to reach the (60 ± 2) °C shall not be included in the drying time.

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[2] The nozzle SSD-VKL-1-120°-1.4571 from Spraying Systems Germany has been used during the Round Robin tests and found to be suitable. This nozzle is an example of a suitable product available commercially. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of this product.

[3] Commercial equipment 83S-211-AT SS pressure tank with direct rotary agitation from ITW-Binks has been used for Round Robin tests and found to be suitable. This pressure tank is an example of a suitable product available commercially. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of this product.

7 Preparation of the glass samples

7.1 General

The test shall be performed on monolithic samples of the products.

Dual coating shall be tested according to one of the following options:

- an equivalent glass, with only the self-cleaning coating on one side, shall be tested; or
- the secondary coating shall be removed by polishing, providing it does not damage the self-cleaning coating on the opposite side; or
- the use an of an adapted protection of secondary coating shall be provided (e.g. protective film with electrostatic or low adhesive charge, or laminated glass assembly), in order to protect the secondary coating during the spraying of the dirt mixture . This protective film shall be removed after the spray, and the secondary coating side shall be cleaned before haze measurements.

Insulating glass units (IGU) shall not be used.

NOTE 1 Assembly in IGU can distort the haze measurements.

The test shall be performed on glass with a light transmittance ≥ 10 %.

NOTE 2 For tinted glass and absorbing layers (self-cleaning or dual coatings) the light absorption may affect the precision of haze measurements.

7.2 Tested sample

A minimum of 6 samples shall be tested for a given self-cleaning coating. The chosen number of samples shall be indicated as “*n*”.

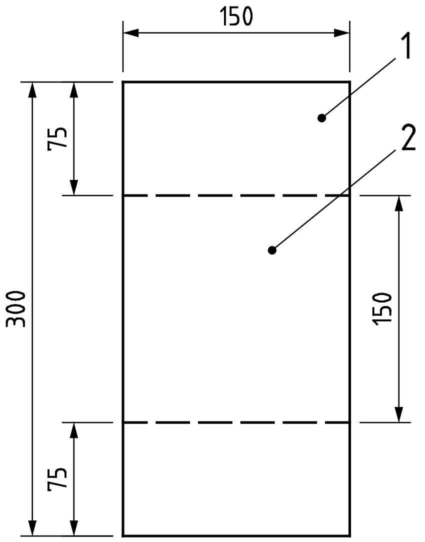
In case the product to be tested has to be toughened to become active, the test shall be performed on toughened samples. In case the product can be used annealed or toughened, both types shall be tested, with a minimum of 6 annealed samples and 6 toughened samples.

The size of the samples shall be 150 mm x 300 mm.

The central zone shall be analysed and the sample shall be positioned vertically, as described in Figure 1.

The sample shall be engraved with references on the upper left corner of the opposite side from the side to be tested i.e. non coated side.

All dimensions are in mm



Key

1 sample

2 test zone on the sample

Figure 1 — Description of test sample

7.3 Control sample

A minimum of 6 control samples shall be tested along with the self-cleaning products to be tested. Control samples shall have a behaviour known in advance.

A commercial product can be used. The use of clear float glass as control sample should be avoided, due to the sensibility of its surface to its history.

Control samples shall fulfil these criteria:

- stability of performances and homogeneity;
- availability;
- low visible absorption;
- low initial haze.

EXAMPLE Examples of references samples are:

- silica sheets;
- float glass coated with a given oxide layer, resistant to corrosion (such as silica or photocatalytic coating);
- commercially available photocatalytic self-cleaning glass.

If control samples do not give the expected results a new test shall be performed, ensuring that all test conditions are respected.

8 Haze measurement

8.1 Unexposed surface cleaning

Before each haze measurement the unexposed surface (i.e. the surface opposite to the surface to be tested) shall be cleaned in order not to distort the haze measurement.

NOTE 1 Commercial glass cleaner and clean soft paper tissue can be used.

No traces from residual cleaner or contamination shall be visible on the unexposed surface. Touching the surface to be measured when cleaning the unexposed surface shall be avoided.

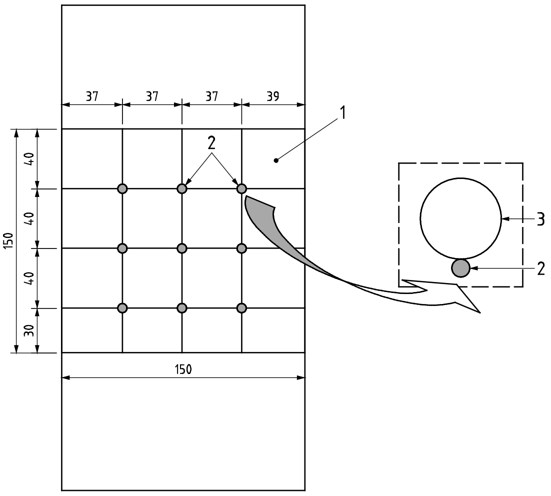
If the haze measurements show values clearly outside the average amongst the 9 measured points, the unexposed surface shall be cleaned again. The haze measurement shall be done a second time and the new values shall replace the values of the first measurement.

NOTE 2 If there are still peculiar values after the second cleaning, it is most probably due the intrinsic sample characteristics. See also 10.5.

8.2 Position of haze measurements on the samples

Haze measurements shall be performed on each sample in 9 positions, identical at each step of the test. To achieve identical positioning for each haze measurement steps, the haze measurement points shall be marked with a felt-tip (or diamond pen) on the opposite side from the tested side of the samples, as described in Figure 2.

All dimensions are in mm



Key

1	sample
2	positioning dots
3	haze meter port

Figure 2 — Location of the 9 positioning dots and of the hazemeter port in the test zone

8.3 Measurement of transmission haze

The total light transmittance, T_t, and the diffused light transmittance, T_d, shall be measured at each of the nine positions defined in 8.2, according to the procedure described in Annex B. The reference of the sample shall always be on the top right corner, when viewed from the coated side. The haze measurements shall be made just above the marked dots, on the side opposite to the surface to be tested in order to avoid contact between the self-cleaning coating and the measurement equipment.

The haze value, H, shall be expressed as the ratio of scattered transmittance to total light transmittance, in percent, see Formula (2):

$$H = \frac{T_d}{T_t} 100 \qquad (2)$$

The value of haze for each measurement point shall be registered as H^{ij}

where:

i is the number of haze measurement point as described in Figure 2 (i = 1 to 9);

j is the number of the sample (j = 1 to n).

NOTE The initial haze of coated glass samples may vary depending on the product, but typically uncoated clear float glass after cleaning has an initial haze below 0,3 %.

9 Preparation of dirt mixture

9.1 General

The tolerance on the masses of all organic and inorganic compounds shall be1 %.

9.2 Stearic acid solution

In a wide-necked bottle with a plastic cork equipped with a magnetic stirrer, 2,5 g of stearic acid (CAS N° 57-11-4, purity > 90 %) shall be dissolved in 500 ml of absolute ethanol.

The solution shall be stirred until complete dissolution of the acid is achieved.

NOTE This may take 10 min to 45 min at standard laboratory temperature (i.e. temperature between 20°C and 23°C).

9.3 Adipic acid solution

The following products shall be put in a wide-necked bottle with a plastic cork equipped with a magnetic stirrer, respecting the order given:

1) 10 g of 99,6 % pure adipic acid;

2) 200 ml of propan-2-ol;

3) 200 ml of deionized water.

The solution shall be stirred until complete dissolution of the adipic acid is achieved.

NOTE This may take 15 min to 20 min and may require heating via a water bath.

9.4 Solid compound suspension

The products listed in Tables 1 and 2 shall be put into a 3 l wide-necked bottle with a plastic cork.

Table 1 — Soluble components

Weight (g)	Component	CAS number	Purity
0,15	copper nitrate trihydrate	10031–43–3	99 %
0,15	zinc nitrate hexahydrate	10196–18–6	99 %
0,80	calcium nitrate tetrahydrate	13477–34–4	98 %
0,30	sodium chloride	7647–14–5	99 %
0,40	potassium sulphate	7778–80–5	99 %
0,30	sodium sulphate	7757–82–6	99,5 %

Table 2 — Non soluble components

Weight (g)	Component	CAS number	Purity	Granulometry (µm)
0,50	kaolin	1332–58–7	98 %	d50 = 2,5 µm
0,30	calcium sulphate dihydrate	10101–41–4	99 %	Not specified

50 ml of deionized water shall be added to the solid compounds and the solution shall be stirred. Then, 50 ml of propan-2-ol shall be added, and the mixture shall be stirred vigorously.

In case that the solid compound visibly tends to aggregate, a light grounding (to break aggregates) is recommended.

9.5 Final dirt mixture

Prepare the final mixture by adding the component in the following order:

— the adipic acid solution prepared in 9.2 shall be mixed with the solid compound suspension prepared in 9.3;

— the stearic acid solution prepared in 9.1 shall be added;

— the mixture shall be diluted by adding 2 l of a (2:1:1) ethanol / propan-2-ol/deionized water mixture.

The resulting mixture shall be stirred for a further two hours to get a good homogeneity.

This suspension shall be kept for the full length of the test (2 cycles). The dirt mixture shall be stored in a closed vessel with continuous agitation to avoid evaporation and segregation of particles. The solution shall be maintained in standard laboratory conditions during all the procedure (20 °C to 23 °C).

The maximal dirt mixture conservation time shall be 120 h.

A new dirt mixture shall be prepared for a new test run.

10 Test procedure

10.1 General

The environment and the equipment where the test is performed (storage, cleaning, activation, UV chambers) shall be clean and free of silicone (see checking procedure in Annex C).

10.2 Initial activation

10.2.1 Glass samples cleaning

The glass surface shall be carefully cleaned.

Silicone- and powder-free latex gloves shall be worn while doing these operations. Such gloves shall be worn whenever the glass samples are manipulated during the test.

The two sides of the samples shall be rubbed with a piece of cotton wool (absorbent cotton) soaked with a surfactant.

NOTE 1 Woven cotton tissues or other textiles are not suitable for cleaning as they could leave residual traces.

NOTE 2 RBS 25MD diluted in DI water (2 % vol.) has been used for the Round Robin tests and found to be suitable.

NOTE 3 The use of an alcoholic solution is not suitable in this case.

The glass samples shall be rinsed under deionized water, rubbed with the hand to eliminate any remaining trace, and then rinsed again under deionized water. After this, the samples shall be dried with nitrogen or with filtered clean compressed air.

No traces of residues shall be visible on both sides of the glass. If traces are observed after cleaning, the procedure shall be repeated using more pressure to rub the cotton wool with surfactant on the glass surface.

To be sure that the cleaning procedure is done properly, a clear float glass can be used as control sample. The haze of a clear float glass is usually less than 0,3 % with dispersion smaller than 0,1 % across the sample. If significantly higher haze values or bigger dispersions are observed, the sample is most likely not correctly cleaned and should be cleaned again.

When handled, the coated surface shall not be touched and the glass samples shall be held by its edges only.

A closed box is recommended for the transport of the samples at all stages of the test, to prevent surface contamination.

10.2.2 UV irradiation

The glass samples shall be exposed to UVA radiation with the equipment described in 6.1, for a duration specified by the supplier, with a minimum of 12 h.

NOTE This exposition to UVA will activate the functionality of the self-cleaning coating.

10.2.3 Initial haze measurement

The haze of the glass samples shall be measured according to Clause 8. The haze measurement shall be carried out within 1 h after illumination.

The nine haze measurements per sample shall be recorded as: $H_{initial}^{i,j}$

The difference between the maximum and the minimum values obtained among the nine haze measurements shall be smaller than 0,3 % at initial stage. If the dispersion of haze is higher, the samples shall be cleaned again and re-measured.

NOTE The glass supplier may give information about haze value and dispersion for coated glasses in order to determine if variations in the initial haze measurements are intrinsic to the sample or due to insufficient cleaning.

10.3 First cycle

10.3.1 General

The dirt mixture shall be poured into a dedicated pressure vessel with mechanical stirrer. The stirring shall be continuous and vigorous so that the non-dissolved particles (i.e. kaolin, potassium and sodium sulphate) stay in suspension in the solution.

NOTE If the stirring is not performed properly, those particles can aggregate and form a deposit which can affect the solution performances.

10.3.2 Dirt mixture spraying

The dirt mixture spraying shall be carried out in the first hour following the UV irradiation to avoid any pollution on the samples and deactivation.

The dirt mixture shall be stirred vigorously in the pressure vessel with a mechanical stirring.

The pressure of liquid, controlled with a pressure gauge, shall be set up at (2 ± 0,2) bars.

The dirt mixture shall be sprayed at a flow rate of (0,6 ± 0,03) l/min, for a minimum period of 6 s, to allow the spray to get up to pressure and to eliminate the air bubbles of the liquid circuit. The flow rate shall be controlled with a graduate beaker placed over the nozzle. A volume of (30 ± 1,5) ml of liquid shall correspond to 3 s of spray.

The glass sample shall be placed on its support in the spray rig as shown in Annex A. The side to be tested shall face the spray nozzle, so that the reference of the sample is visible in the upper right corner of the sample when viewed from the tested side. A volume of (30 ± 1,5) ml of dirt mixture shall be sprayed at a flow rate of (0,6 ± 0,03) l/min, on each glass sample. This shall correspond to a time spray of 3 s.

The sample shall be removed to let it dry vertically as indicated in 10.3.3.

Any excess dirt on the specimen holder frame shall be wiped off, to prevent contamination of the test specimen due to accumulation on the holder.

If abnormalities are observed during the spray (e.g. in the cone angle or shape, size of droplets, pulses in the spray), the test shall be stopped and the tested sample shall be discarded. The nozzle shall be cleaned. New calibration for the volume shall be performed. There shall be no air bubbles or particles blocking the tubes or the spray system. The test shall be re-started from the beginning (cycle 1) after these parameters have been checked.

When series of spray have been completed, the remaining dirt mixture shall be stored for the next cycle as recommended in 9.4. The spraying unit (circuit) shall be rinsed by spraying 100 ml ethanol, followed by 300 ml deionized water, from the pressure vessel used for the dirt mixture.

10.3.3 Drying

The glass samples shall dry vertically (e.g. by posing them on a glass support, the unsprayed side against the support) at standard laboratory temperature, until there are no liquid droplets left. The samples shall not be placed in horizontal position during drying as it will affect test results.

NOTE This operation may take up to several hours in case of non-hydrophilic coatings.

The glass samples shall be placed vertically in a furnace for (60 ± 5) min at (60 ± 2)°C, allowing complete drying to take place. The duration of the drying shall be counted after temperature stabilization (see 6.7).

The furnace shall be clean and exempt from any type of organic contamination.

The temperature calibration of the furnace should be performed as described in 6.7.

Caution shall be taken for not touching the tested side during these handlings.

10.3.4 Haze measurement after dirt spray

The haze measurement shall be carried out within 1 h after complete drying, to avoid any pollution on the samples.

The unexposed surface of sample shall be clean, and if necessary, shall be cleaned again as recommended in 8.1.

The haze of the glass samples shall be measured as explained in Clause 8.

The nine haze measurements per sample shall be recorded as $H_{cycleX-DIRT}^{i,j}$

where

x is the cycle number (1st or 2nd)

NOTE On reference photocatalytic self-cleaning and clear float glasses used in the round robin tests, the range of “dirt haze” values has been observed to be between 5 % and 10 %.

10.3.5 UV-A irradiation

The glass samples shall be exposed to UVA according to 6.1, for 16 h ± 5 min.

10.3.6 Haze measurement after UV irradiation

The haze measurement shall be carried out within 1 h following the UV irradiation to avoid any pollution on the samples.

The haze of the glass samples shall be measured as explained in Clause 8.

The nine haze measurements per sample shall be recorded as $H_{cycleX-SUN}^{i,j}$

where:

x is the cycle number (1st or 2nd)

10.3.7 Deionized water spraying

The water spraying shall be carried out immediately after the haze measurement and in any case within 6 h following the last UV irradiation, to avoid any pollution on the samples and deactivation.

The pressure vessel dedicated to water shall be filled with deionized water. The pressure of liquid, controlled with pressure gauge, shall be set up at (1 ± 0,1) bar above atmospheric pressure.

The deionized water shall be sprayed at a flow rate of (0,48 ± 0,024) l/min, for a minimum period of 6 s, to allow the spray to get up to pressure and to eliminate the air bubbles of the liquid circuit. The flow rate shall be controlled with a graduate beaker placed over the nozzle. A volume of (120 ± 6) ml of liquid shall correspond to 15 s of spray.

The glass sample shall be placed on its support in the spray rig as shown in Annex A. The side to be tested shall face the spray nozzle, so that the reference of the sample is visible in the upper right corner of the sample when viewed from tested side. A volume of (120 ± 6) ml of deionized water shall be sprayed on the glass sample at a flow rate of (0,48 ± 0,024) l/min, on each glass sample.

10.3.8 Drying

The glass samples shall dry vertically (e.g. by posing them on a glass support, the unsprayed side against the support) at standard laboratory temperature, until the surface is completely dry (no droplets left). In case the deionized water transported dirt residues to the unexposed surface of the glass, this side shall also be cleaned once the sample is dry.

10.3.9 Haze measurement after deionized water spray

The haze measurement shall be carried out within 1 h after complete drying, to avoid any pollution on the samples.

The haze of the glass samples shall be measured as explained in Clause 8.

The nine haze measurements per sample shall be recorded as $H_{cycleX-RAIN}^{i,j}$

where:

x is the cycle number (1st or 2nd).

10.4 Second cycle

The spray of dirt mixture of second cycle shall be performed within 6 h after the last UV illumination. If the second cycle is not started within 6 h, the test shall be stopped and a new test shall be performed with new samples, from the first cycle.

For the second cycle, all stages from 10.3.2 to 10.3.9 of the first cycle shall be performed again.

10.5 Collection of the results

The mean value $\overline{\Delta H^{j}}$ and the standard deviation s^{j} shall be calculated for each sample.

The global mean $\overline{\Delta H_{Global}}$ and the global standard deviation s_{Global} per product shall be calculated according to Annex D.

For self-cleaning products, s_{global} shall be below 0,25 to ensure that the test has been run properly.

NOTE This was observed during the round robin tests.

If s_{global} is above 0,25, one or two samples showing peculiar values can be put aside, provided that the final number of samples used for evaluation stays above 5.

If despite this s_{global} remains above 0,25, this is an indication that either:

- the test was not performed correctly and shall be performed again on new samples or,
- the product has no self-cleaning properties.

It is recommended to calculate the average haze at each stage of the test by averaging the measurements on the nine measurement points of each sample, in order to detect unexpected results. This can help to asses if each step of the test has been run properly. An example of typical results is given in Annex E.

11 Classification

A product shall be classified as self-cleaning glass if the two following conditions are fulfilled:

$\overline{\Delta H_{Global}} \leq 1\%$ and $s_{global} \leq 0,25$

Uncoated glass substrate can be tested according to this test method. However it presents a large dispersion of performances: for instance, $\overline{\Delta H_{Global}}$ is usually higher than 2 % but present a large variability (from 1,5 % to 6 %). This is dependent upon a number of factors including the history of the glass, its age and how it has been cleaned. As such, uncoated glass should not be classified by this test method.

12 Test report

The test report shall at least include the following information:

a) all necessary information to identify the product:
  - supplier or manufacturer;
  - trademark of the product;
  - description of the samples (substrate, coating(s),…);
  - if relevant, toughening (precise if the coating is toughenable or to be toughened);

b) identification of the test laboratory and the responsible of the test;

c) reference of this standard (EN 1096-5);

d) date of tests;

e) description of equipment used:
  - brand of equipment (UV, haze, pressure tanks…);
  - type / reference / brand of nozzle;

f) details of operating mode:
  - type of illuminant, intensity or UV radiation at 340 nm;
  - time of UV illumination in activation step;
  - temperature / Relative humidity in illumination chamber;
  - glass surface temperature;
  - number of samples tested per product;

g) test results:
  - initial and final haze (mean values);
  - global mean haze $\overline{\Delta H_{Global}}$;
  - global standard deviation s_{global};
  - result: self-cleaning product or non-self-cleaning product;

h) any other element necessary to assess the correctness of the results:
  - control sample performance;
  - any deviation from operating mode or test results and justification.

Annex A
(normative)

Sample support and spray installation

A.1 Spray rig

The samples shall be placed on a specific support for the dirt spray and the water spray phases.

The sample shall be inclined at 10° from vertical, with a distance between the spray nozzle and the centre of the sample of 300 mm, see Figure A.1. The nozzle shall be adjusted with the centre (horizontally and vertically) of the test area on the glass sample.

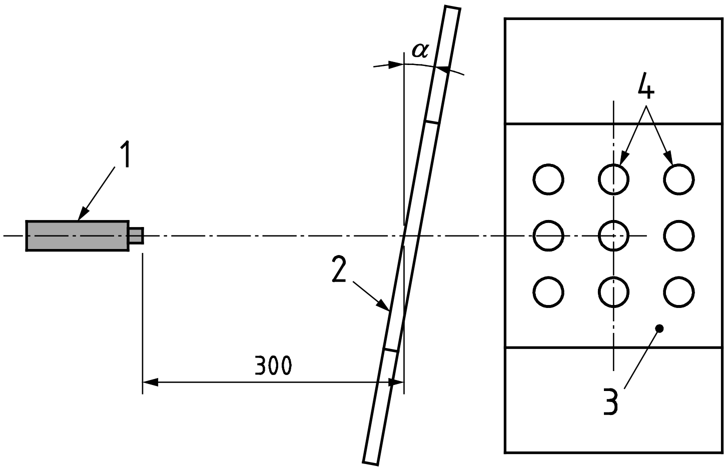
NOTE A sample support as described in Figure A.2 can be used for the spray steps.

Standing water on the bottom and on the unexposed surface of the samples shall be avoided.

It is recommended to foresee drainage holes or use punctual support.

No back plate may be used behind the sample in order to let the flow pass freely around the sample.

Dimension in mm



Key

1 spray nozzle

2 glass sample, side view

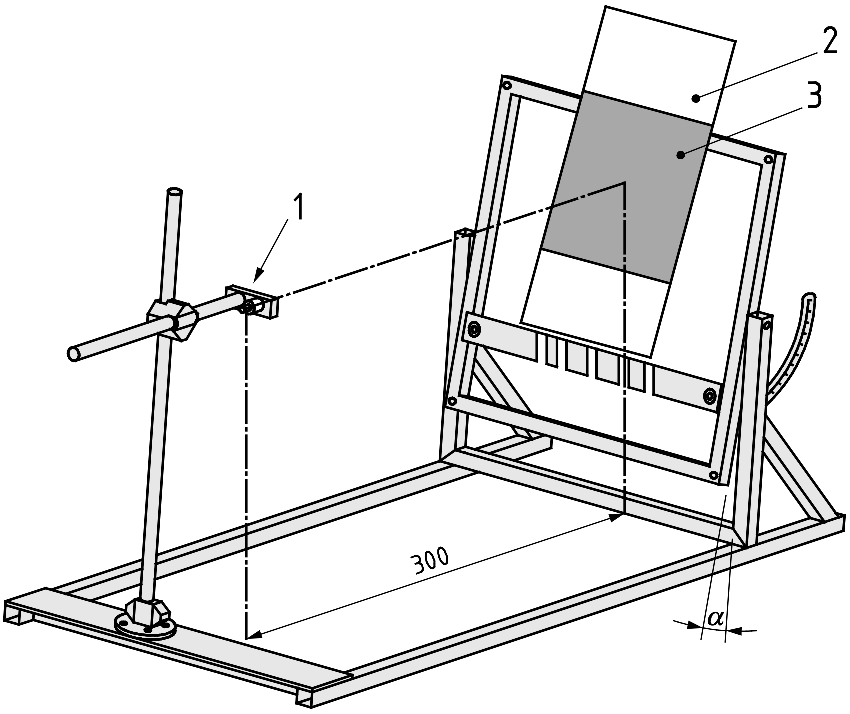
3 glass sample, front view

4 haze measurement area

α angle of the sample to the vertical = 10°

Figure A.1 — Relative position of glass sample and spray nozzle

Dimension in mm



Key

1	spray nozzle
2	sample
3	haze measurement area
α	angle of the sample to the vertical = 10°

Figure A.2 — Example of spray rig

A.2 Spray system

The spraying system shall use an airless nozzle and two pressure vessels: one for the water, one for the dirt mixture. A spraying circuit as shown in Figure A.3 shall be used.

The pressure vessel of the dirt mixture shall have a mechanical stirring system, in order to keep the dirt mixture homogeneous.

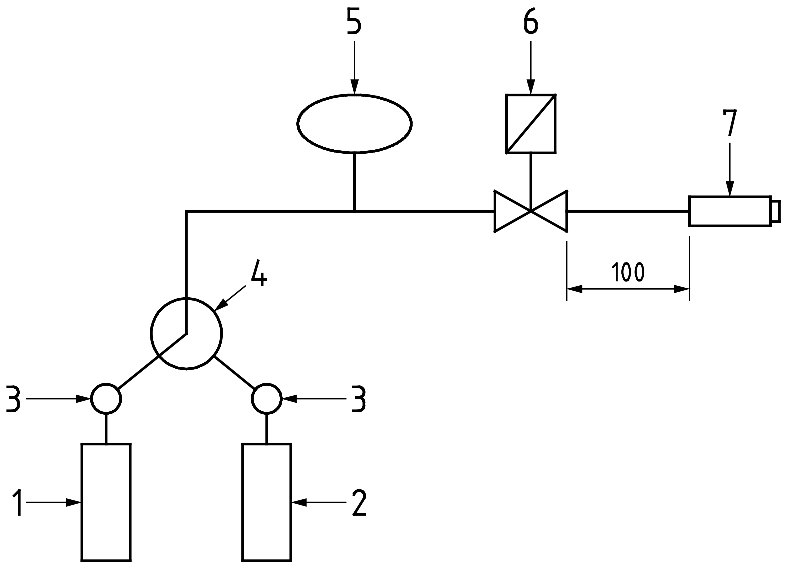
The pressure in the pressure tank shall be regulated with a pressure gauge, placed as close as possible before the spray nozzle.

A distance of maximum 100 mm between the pressure gauge and the spray nozzle is recommended.

The opening of the spraying circuit is preferably driven by a solenoid valve linked to a timer for precise control of spraying volume. If a solenoid valve is not used, the timer should be started when the liquid goes out of the nozzle.

The tubes used to bring the dirt mixture from the container to the spray shall be transparent to allow the observation of possible air bubbles formed inside. The tubes shall be as short as possible.

Dimension in mm



Key

1	pressure vessel for demineralized water
2	pressure vessel for dirt mixture
3	compressed air
4	selection valve (demineralized water or dirt mixture)
5	pressure gauge
6	selection valve (nozzle or exhaust)
7	nozzle

Figure A.3 — Spraying system

Annex B
(normative)

Haze measurement method

B.1 General

The method described in this annex is based on ASTM D1003 — 11e1: Standard Test method for Haze and Luminous Transmittance of Transparent Plastics.

B.2 The instrument[4)]

Haze measurements shall be performed by use of a haze meter where an integrating sphere collects the transmitted light. The samples shall be placed against the entrance port with the dirty surface facing away from the entrance port.

The light source and the detector in combination shall provide an output corresponding to the luminous response of the 1931 CIE Standard Colourimetric Observer (2 degrees) with CIE Standard Illuminant C (D_{65}). Output shall be proportional within 1 % of the incident flux.

The total port areas of the sphere shall not exceed 4 % of the internal reflecting areas of the sphere.

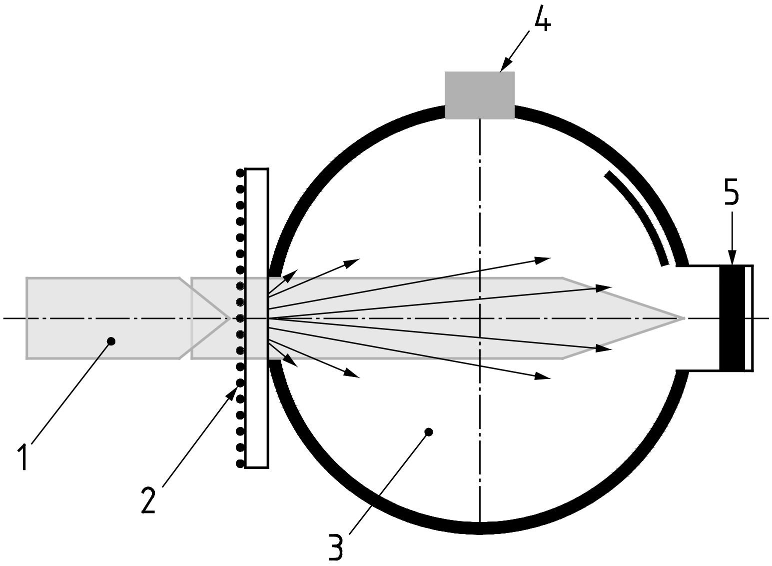
NOTE Integrating sphere can be of any diameter as long as the above requirement is respected.

The sphere at the exit port shall be equipped with a light trap or electronic device with a similar function, or have a design which obviates the need for a light trap.

When no sample is present, the incident light shall be completely absorbed by the light trap or the design with a similar function as the light trap.

When the sample is placed against the entrance port, the angle between the perpendicular to the sample and the line connecting the entrance port and the exit port of the integrating sphere shall not exceed 0,14 rad. (8°).

[4)] Haze meters made by BYG-Gardner (for instance Haze-Guard Plus) satisfy these requirements This Haze meter is an example of a suitable product available commercially. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of this product.



Key

1 collimated light beam – Illuminant C

2 glass sample – dirt deposit on surface facing away from the entrance gate

3 integrating sphere

4 detector

5 light trap or device with similar function at the exit gate

Figure B.1 — Schematic arrangement of the haze meter

B.3 Calculation

Haze, *H,* in percent shall be calculated according to Formula (B.1):

$$H = \frac{T_d}{T_t} 100 \quad = \quad \frac{T_3}{T_2} 100 \tag{B.1}$$

Where

T_t = total light transmittance = $\frac{T_2}{T_1}$

T_d = diffuse light transmittance = $\frac{T_3}{T_1}$

T_1 = incident light

T_2 = total light transmitted by the sample

T_3 = light scattered by the instrument and the sample. Here it is assumed that the light scattered by the instrument is negligible.

B.4 Values

The total light transmittance, T_t, the diffuse light transmittance, T_d, and the haze shall be given to the nearest 0,1 %.

B.5 Short cut procedures

NOTE 1 This procedure can be used with many commercial haze meters.

With the haze meter set to measure the total transmittance, the instrument output shall be adjusted to 100,0.

With the haze meter set to measure the light scattered by the instrument, the instrument output shall be adjusted to 0,0.

With the haze meter set to measure the total transmittance, the sample shall be placed against the entrance port of the sphere.

NOTE 2 The instrument output can be adjusted to 100,0.

The instrument shall be set to measure light scattered by the sample and the reading shall be recorded as percent haze.

Annex C

(normative)

Contamination checking procedure

C.1 General

A check of the testing equipment contamination shall be performed before starting the self-cleaning test.

NOTE 1 The behaviour of self-cleaning glass products may be affected by silicone contamination from the environment or from the testing equipment. This contamination reduces the self-cleaning properties of the product.

NOTE 2 Possible sources of silicone contamination are the sealants used to produce insulated glass units, mastics, hand creams, eye-glass cleaning tissues.

C.2 Evaluation of the contamination of the test environment

A known photocatalytic self-cleaning glass shall be used as test sample. The sample shall be cleaned according to 7.1. It shall be activated under UVA 340 nm lamp (0,68 $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm) for 16 h.

The water contact angle shall be measured according to ASTM C813-90 (2009) within 1 h after UV illumination. The measurement shall be done at minimum five different points. The water contact angle shall be below 10°.

The sample shall be placed in the chamber or laboratory to be evaluated.

The contact angle shall be measured at different time. A classical behaviour of a photocatalytic self-cleaning glass shows a progressive increase of contact angle up to 30° to 40° in a few days in absence of UV illumination.

In case of silicone or other heavy organic contamination on the full surface of the samples, water contact angle after contamination will reach more than 60° or 80° in a few hours up to a few days. In that case, the equipment shall not be used.

C.3 Irregular contamination of the sample

A spray test shall be used to show irregular contaminations (border effects for instance). After activation or contamination, the sample shall be placed vertically and demineralized or deionized water shall be sprayed (for instance with use of a clean "manual spray").

Non contaminated surfaces will display a good water sheeting effect (continuous water film).

A contaminated area will lead to de-wetting, rupture of water film and appearance of droplets on the surface of the sample. In that case, the sample shall not be used.

Annex D
(normative)

Statistical analysis of test results – Calculation of statistical numbers to obtain a self-cleaning functionality used for classification of coated glass

The evaluation parameter shall be the increase of haze after two cycles of the test run.

For each measurement point (*i*) on each sample (*j*), change of haze shall be determined according to Formula (D.1).

$$\Delta H^{i,j} = H_{final}^{i,j} - H_{initial}^{i,j} \tag{D.1}$$

For each sample the mean of the change of haze (9 measurement points) shall be determined according to Formula (D.2).

$$\overline{\Delta H^{j}} = \frac{1}{9}\sum_{i=1}^{9} \Delta H^{i,j} \tag{D.2}$$

The estimated standard deviation shall be calculated for each sample according to Formula (D.3).

$$s^{j} = \sqrt{\frac{\sum_{i=1}^{9}(H^{i,j} - \overline{\Delta H^{j}})^{2}}{8}} \tag{D.3}$$

For each tested product, the mean global change of haze for the product *(n* is the number of samples of a single product) shall be calculated with Formula (D.4).

$$\overline{\Delta H}_{Global} = \frac{1}{n}\sum_{j=1}^{n} \overline{\Delta H^{j}} \tag{D.4}$$

The estimated global standard deviation shall be calculated with Formula (D.5).

$$s_{Global} = \sqrt{\frac{\sum_{j=1}^{n}(\overline{\Delta H^{j}} - \overline{\Delta H}_{Global})^{2}}{n-1}} \tag{D.5}$$

The standard deviations shall be used to evaluate point to point variation and sample to sample variation.

NOTE The Round Robin test (see Annex E) has given the typical values shown in Table D.1.

Table D.1 — Maximum standard deviation estimated from the Round Robin test

Estimated standard deviation	Self-cleaning products	Non self-cleaning products
s_{Global}	< 0,25	< 0,5

Global standard deviation values higher than 0,25 for self-cleaning coatings indicate a too large sample-to-sample variation. If $s_{Global} > 0{,}25$ the test is not properly done. It shall be repeated on new samples following the experimental procedure described in Clause 10.

Annex E
(informative)

Round Robin tests

E.1 General

Round Robin tests have been performed as described below:

- 4 laboratories, 3 industrial laboratories and 1 independent laboratory, have been running the tests.
- 3 glass products have been tested:
  - 2 different commercial self-cleaning glasses complying with the scope of the standard (definition 3.5), referenced as SC1 and SC2;
  - 1 SiO_2 coated float glass referenced as SiO_2. (non-self-cleaning).

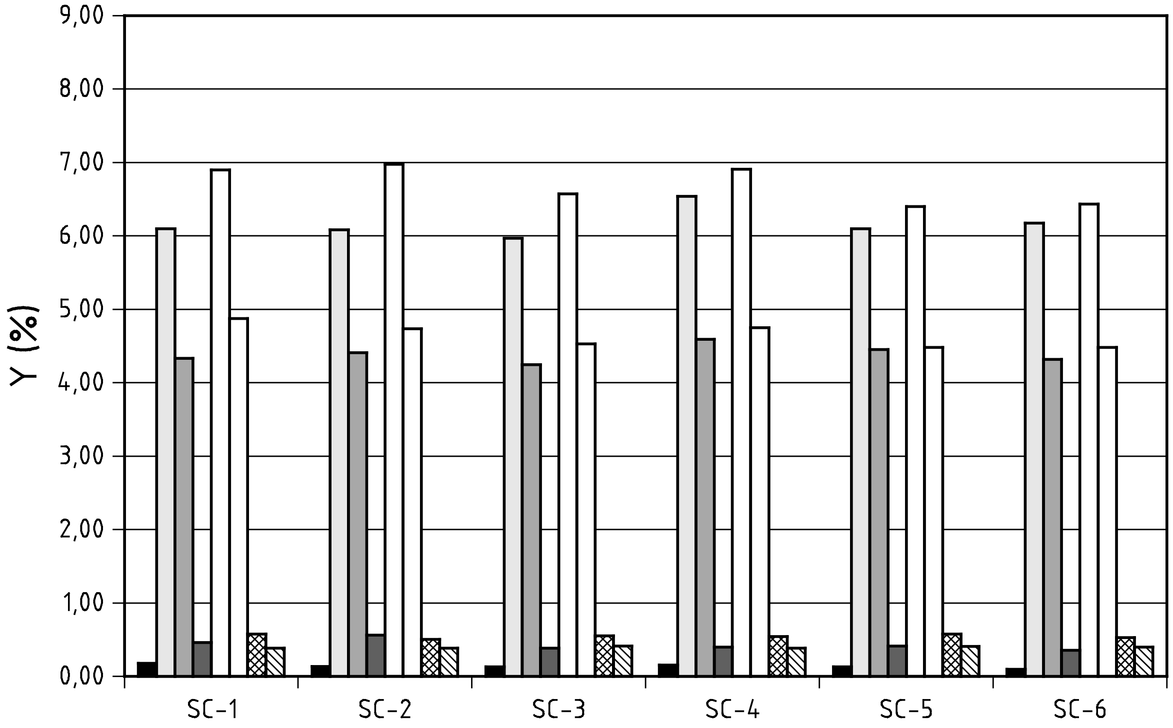
E.2 Typical results

Typical tests results with a self-cleaning (SC1) and a non-self-cleaning coating (SiO_2) are illustrated in Figures E.1 and E.2. Haze values indicated in the figures are mean values per sample (average of the 9 measurement points).

Values measured are defined and identified as in Table E.1.

Table E.1 — Definition and identification of measured hazes

■	$H_{initial}$	Haze after preparation of the sample (cleaning / activation)
░	$H_{cycle1dirt}$	Haze after cycle 1 dirt application
▒	$H_{cycle1sun}$	Haze after cycle 1 UV exposure
▓	$H_{cycle1rain}$	Haze after cycle 1 water spray
□	$H_{cycle2dirt}$	Haze after cycle 2 dirt application
□	$H_{cycle2sun}$	Haze after cycle 2 UV exposure
▩	$H_{cycle2rain} = H_{final}$	Haze after cycle 2 water spray
▧	$\Delta H = H_{final} - H_{initial}$	Delta haze after cycle 2

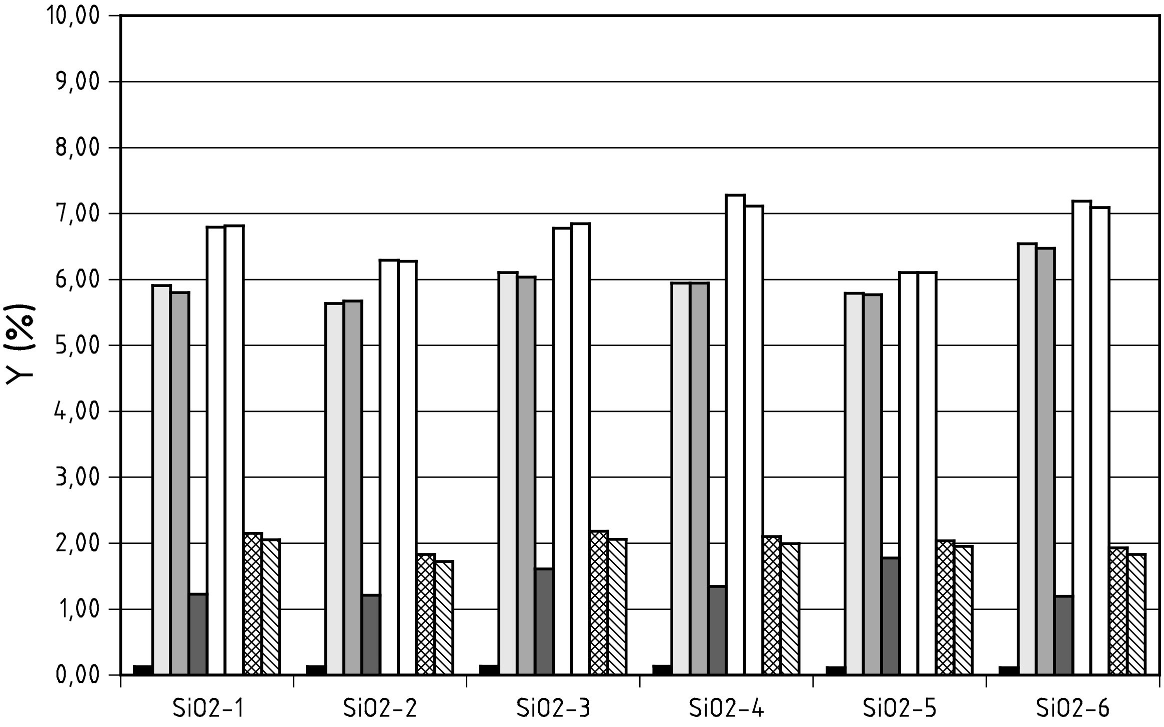


Key

Y Haze (%)

SC 1 – 1 to SC 1 – 6: identification of the samples of Self Cleaning coated glass 1.

Figure E.1 — Typical results obtained on Self Cleaning coated glass 1 in Lab A



Key

Y Haze (%)

SiO_2 – 1 to SiO_2 – 6: Identification of the samples of SiO_2 coated glass.

Figure E.2 — Typical results obtained on SiO_2 coated glass in Lab A

E.3 Results interpretation

Figure E.3 summarizes the results obtained by the 4 laboratories on each type of glass. It presents the Global mean values $\overline{\Delta H}_{Global}$ with a 95 % confidence interval (calculated from the global standard deviation s_{Global} as calculated in Annex D), obtained for each product on the different test sites.

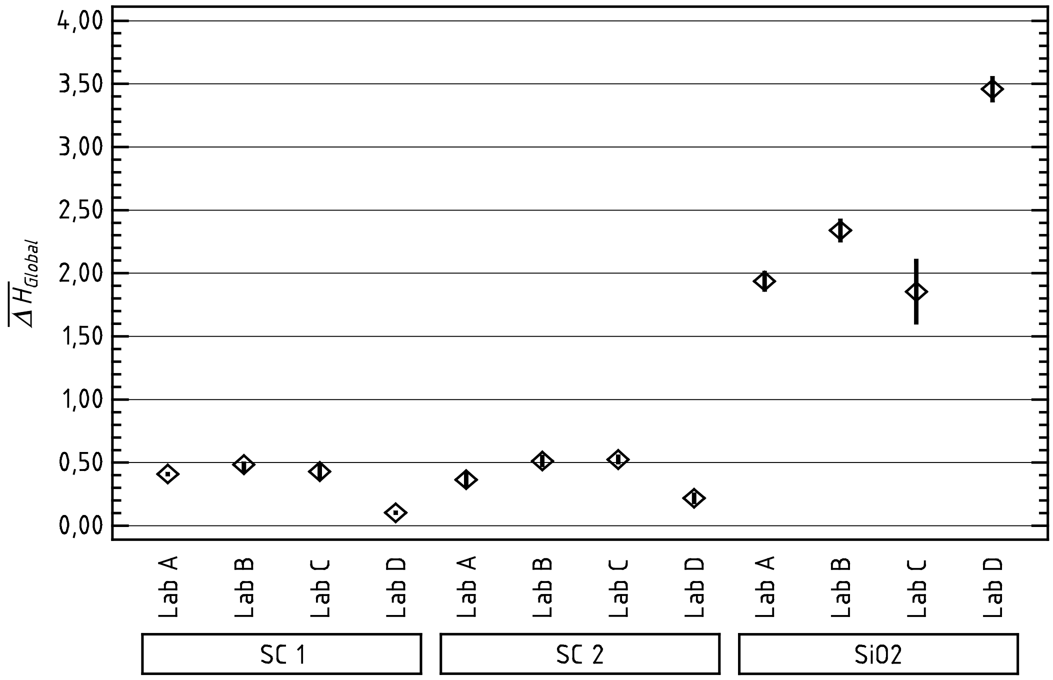
The conclusions are:

— The products SC1 and SC2 obtain self-cleaning ranking at all test sites.

— The SiO_2 coated glass is not classified as self-cleaning glass.

NOTE 1 The indications of the confidence intervals are only for informative use.

NOTE 2 The ranking is based on average values only.



Key

$\overline{\Delta H}_{Global}$:	global average delta Haze, as defined in Annex D
SiO2:	SiO_2 Coated Glass
SC 1 and SC 2:	Self Cleaning glasses
A, B, C, D:	codes of the 4 laboratories performing the round robin tests

The vertical bars are representing the 95 % confidence intervals for the means, i.e. 95 % probability of mean values are within the interval.

Figure E.3 — Ranking analysis for products and test sites in the RR test

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[1] ISO 4892-1:1999, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

[2] ASTM C813-90:2009, *Standard Test Method for Hydrophobic Contamination on Glass by Contact Angle Measurement*

[3] ASTM D1003-11e1, *Standard Test method for Haze and Luminous Transmittance of Transparent Plastics*

[4] EN 1096-2, *Glass in building - Coated glass - Part 2: Requirements and test methods for class A, B and S coatings*

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