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COATED GLASS – SPECIFICATION

भारतीय मानक मसौदा

लेपित काँच - विशिष्टि

ICS 81.040.20

Glass, Glassware & Laboratoryware Sectional Committee, CHD 10

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FOREWORD

(Formal clauses will be added later)

Coated glass uses the principle of increasing the direct reflection to maximize solar energy attenuation. In comparison with clear glass, its absorption of solar energy is also increased.

The advantages of such glass types are:

1) Greater performance range than body tinted glass;

2) Higher performances (greater solar energy attenuation);

3) Light/energy ratios nearer to the theoretical limit; and

4) A range of colour appearances in transmission and reflection.

The coatings may be placed on to body-tinted glass to extend the range of performances.

Compared with a float glass surface, these coatings (owing to their composition) exhibit lower levels of emissivity which improves their U-value.

In the formulation of this standard, considerable assistance has been derived from the following publications:

ISO 9050 : 2003	Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet

	transmittance and related glazing factors
ISO 11479-1 : 2011	Glass in building — Coated glass — Part 1: Physical defects
ISO 11479-2 : 2011	Glass in building — Coated glass — Part 2: Colour of façade
EN 12898 : 2001	Glass in building — Determination of the emissivity
BS EN 1096-1 : 2012	Glass in building — Coated glass Part 1: Definitions and classification
BS EN 1096-2 : 2012	Glass in building — Coated glass Part 2: Requirements and test methods for class A, B and S coatings
BS EN 1096-3 : 2012	Glass in building - Coated glass - Part 3: Requirements and test methods for class C and D coatings
ASTM C 1376	Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft *Indian Standard*
COATED GLASS - SPECIFICATION

1 SCOPE

1.1 This standard defines the characteristics, properties, test methods, sampling, classification and requirements for coatings applied on flat float glass or tempered glass which may be clear or tinted, using either pyrolytic, sol-gel or vacuum (sputtering) deposition methods for use in building glazing. This standard is applicable to coated glass used for glazing in commercial or residential applications.

1.2 This standard is not applicable to films on glass, mirrors, enameled glass, patterned glass or other optically distorting glass, or painted glass.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of and necessary adjuncts to this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated.

IS No.	*Title*
1382 : 1981	Glossary of terms relating to glass and glassware (*first revision*)
2553 (Part 1) : 2018	Safety glass – specification Part 1 Architectural, building and general uses (*fourth revision*)
4905 : 2015	Random sampling and randomization procedures (*first revision*)
14900 : 2018	Transparent float glass – specification (*first revision*)
16231 (Part 2): 2019	Use of glass in buildings - code of practice part 2 Energy and light (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions given in IS 1382, IS 2553 (part 1), IS 14900 and IS 16231 (part 2), in addition to the following shall apply.

3.1 Chemical-vapour deposition - Compounds in a vapour phase reacting chemically on the hot surface of the glass substrate.

3.2 Cluster - Accumulation of very small defects giving the impression of stain.

3.3 Coated glass - Glass substrate which has been applied a coating, in order to modify one or more of thermo-optical properties.

3.4 Coating - One or more thin solid layers of inorganic materials applied on to the surface of a glass substrate by various methods of deposition.

3.5 Coating rub - Surface abrasion of appreciable width that has a partial or complete removal of the coating, producing a hazy appearance.

3.6 Colour rendering in transmission - The change in colour of an object as a result of the light being transmitted by the coated glass.

3.7 Corrosion - Change in the colour or level of reflected or transmitted light over all or part of the glass surface as a result of degradation of the coating from external sources.

3.8 Crazing - Conglomeration of fine lines or cracks in the coating.

3.9 Light reflectance of coated side - Fraction of the incident light that is reflected by the coated glass when the light is incident on the coated side.

3.10 Light reflectance of uncoated side - Fraction of incident light that is reflected by the coated glass when the light is incident on the uncoated side.

3.11 Nominal colour in reflection of coated side - The colour the glass observed from the coated side. It is defined with a qualitative indication.

3.12 Nominal colour in reflection of uncoated side - The colour of the glass observed from the uncoated side. It is defined with a qualitative indication.

3.13 Nominal colour in transmission - Colour of the glass observed in transmission. It is defined with a qualitative indication.

3.14 Normal emissivity - The ratio of the emissive power of coated surface of the glass to the emissive power of a black body in a direction normal to surface.

3.15 Off-line coating - The application of a coating to individual pieces of glass within a manufacturer's or processor's premises.

3.16 On-line coating - The treatment of the surface of a moving continuous ribbon of a basic glass, at a stage during its manufacture, before it is cut.

3.17 Pinhole - Punctual void in the coating with partial or total absence of coating and it normally contrasts clear relative to the coating, when viewed in transmission.

3.18 Punctual defect - Punctual disturbance of the visual transparence looking through the glass and of the visual reflectance looking at the glass, such as spot, pinhole and scratch.

3.19 Scratches - Variety of linear score marks, whose visibility depend on their length, depth, width, position and arrangements.

3.20 Solar direct reflectance of coated side - Fraction the incident solar radiation that is reflected by the coated glass when the radiation is incident on the coated side.

3.21 Solar direct reflectance of uncoated side - Fraction of incidence of solar radiation reflected by the coated glass when the radiation is incident on uncoated glass.

3.22 Stain - Defect in the coating larger than punctual defect, often irregularly shaped, partially of mottled structure.

3.23 Uniformity defect - Slight visible variation in colour, in reflection or transmission, within a coated glass pane or from pane to pane.

4 CLASSIFICATION OF COATED GLASS

Coated glass can be classified into the following five classes:

4.1 ***Class A*** - The coated surface of the glass can be positioned on the outer or the inner face of the building.

4.2 *Class B* - The coated glass can be used as monolithic glazing but the coated surface shall be on the inner face of the building.

4.3 *Class C* - The coated glass shall be used only in sealed multiple glazing units and the coated surface should be facing into the unit cavity.

Note - For Class C coatings, special care in the transportation, handling, general transformation and storage of the monolithic sheets should be considered. In some instances the coating may need to be removed in the region of the unit edge seal, edge stripped, to ensure appropriate levels of adhesion of the edge seal to the glass substrate.

4.4 *Class D* - The coated glass shall be incorporated into sealed units, with the coated surface facing into the unit cavity, as soon as they are coated. They are not available as monolithic glass.

Note - For Class D coatings, the unit edge seal should be made to the glass substrate.

4.5 *Class S* - The coated surface of the glass can be positioned on the outer or the inner face of the building but these types of coated glasses can only be used in specifically defined applications, for example, shop fronts.

Note - For Class S coatings the life expectancy of the coatings is lower than the life expectancy of coated glasses for normal use in buildings.

5 CHARACTERISTICS

5.1 General

Coatings can be reflective or low-emissivity in nature to modify the visual, thermal and the functional performance of the base glass. Glasses (clear or tinted) that have been coated to reflect near and far infrared radiation striking the surface of the glass reduce the heat gain.

5.2 Luminous, solar and thermal properties

The purpose of thin coatings on glass is the modification of the spectrophotometric properties of the glass substrate. The properties of a coating cannot be considered separately from those of the glass substrate to which it is attached. The coating-glass substrate combination is the finished product, that is, the coated glass.

The following spectral distributions have to be considered according to IS 16231(Part2).

a) The spectral distribution for photopic vision,

b) The spectral distribution of the solar radiation,

c) The emission spectrum of the black body at 283 K.

Coated glass is defined according to its two reflections (generally coated side and uncoated side) and transmission properties in each spectral range (ultraviolet, visible, solar and thermal range).

NOTE:

1. The contribution of the rear surface of the pane is included.

2. Some glasses are coated on both sides; in which case they do not have an uncoated side but two coated sides.

6. REQUIREMENTS COMMON TO ALL CLASSES OF COATED GLASS

6.1 Tolerance on spectral properties

Due to the inherent variations in the manufacturing processes, the measured values may vary from the nominal values of the properties. Such deviations shall not exceed the values prescribed in table 1. The performance factors and spectral details of the coated glass shall be determined using calibrated spectrophotometer equipment. The actual size shall be dependent on the type of equipment being used for the measurements. The transmittance of the measurement sample shall be measured with radiation of normal incidence at the following wavelengths:

a) 550 nm (representative wavelength for light transmittance); and

b) 900 nm (representative wavelength for solar transmittance).

For glass claiming to have a low emissivity coating, a measurement of the reflectance shall be made at 8 µm using radiation of nearly normal incidence.

Table 1 Tolerance on the spectral properties of coated glass

(*Clause* 6.1)

Sl. No.	**Characteristic**	**Measured Value**	**Declared value**	**Requirement**	**Method of test**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
i.	Light transmittance	$\tau_{v,m}$	$\tau_{v,d}$	$\tau_{v,m} = \tau_{v,d} \pm 3\ unit$	**5.11.4** of IS 16231 (part 2)
ii.	Light reflectance: – *Internal side* – *External side*	$\rho_{v,m}$ $\rho'_{v,m}$	$\rho_{v,d}$ $\rho'_{v,d}$	$\rho_{v,m} = \rho_{v,d} \pm 3\ unit$ $\rho'_{v,m} = \rho'_{v,d} \pm 3\ unit$	**6** of IS 16231 (part 2)
iii.	Energy reflectance – *Internal side* – *External side*	$\theta_{e,m}$ $\theta'_{e,m}$	$\theta_{e,d}$ $\theta'_{e,d}$	$\theta_{e,m} = \theta_{e,d} \pm 3\ unit$ $\theta'_{e,m} = \theta'_{e,d} \pm 3\ unit$	**7.4** of IS 16231 (part 2)
iv.	Emissivity (Corrected) – *Internal side* – *External side*	ε_m ε'_m	ε_d ε'_d	$\varepsilon_m \leq \varepsilon_d + 0.02$ $\varepsilon'_m \leq \varepsilon'_d + 0.02$	**Annex-A**
v.	Solar Heat Gain Coefficient / Solar Factor	g_m	g_d	$g_m = g_d \pm 3\ unit$	**7** of IS 16231 (part 2)

NOTE 1: Internal side: coated side, External side: non-coated side

NOTE 2: ± 3 unit depicts that if the declared value of Light transmittance is 50% then the measured value of Light transmittance shall lie from 47% to 53%.

6.2 Defects in coated glass

6.2.1 When examined as specified in **Annex B**, the acceptance criteria for faults shall be as prescribed in table 2. Colour Delta (ΔE) shall be measured as per the method prescribed in **Annex C**.

Table 2 Acceptance criteria for coated glass defects
(*Clause* 6.2.1)

Sl. No.	Defect types	Acceptance criteria	
		Central area	Edge area
(1)	(2)	(3)	(4)
i.	Uniformity/stain	Allowed as long as not visually disturbing and ΔE shall be ≤ 4.5.	Allowed as long as not visually disturbing and ΔE shall be ≤ 4.5.
ii.	Spots and pinholes	>3.0 mm: not allowed. >2.0 mm and ≤ 3.0 mm: not more than 1/m^2. ≤ 2.0 mm: allowed.	>3.0 mm: not allowed. >2.0 mm and ≤ 3.0 mm: not more than 1/m^2. ≤ 2.0 mm: allowed.
iii.	Scratches	>75 mm: not allowed. ≤ 75 mm: allowed.	>75 mm: allowed as long as they are not visually disturbing. ≤ 75 mm: allowed.
iv.	Coating rub	None	≤ 20 mm in the largest dimension
v.	Crazing	None	None
vi.	Corrosion	None	None
vii.	Stain	None	None
NOTE: For more information on central and edge area, *see* **Fig. 4.**			

6.2.2 As a global restriction, the total number of spots, pinholes and scratches shall be less than or equal to five per 300 mm × 300 mm square region.

7 EVALUATION OF DURABILITY OF TYPES A, B AND S

7.1 General

To evaluate the durability of coated glass, the following tests shall be performed – condensation resistance test, acid resistance test, neutral salt spray test and abrasion resistance test.

These tests are evaluated by their effect on the visual quality of the product and its spectrophotometric properties. While it would be feasible to evaluate the spectrophotometric properties across the entire spectrum, a number of representative wavelengths have been selected. These wavelengths represent transmission of light and energy, together with reflectance relating to emissivity, where appropriate.

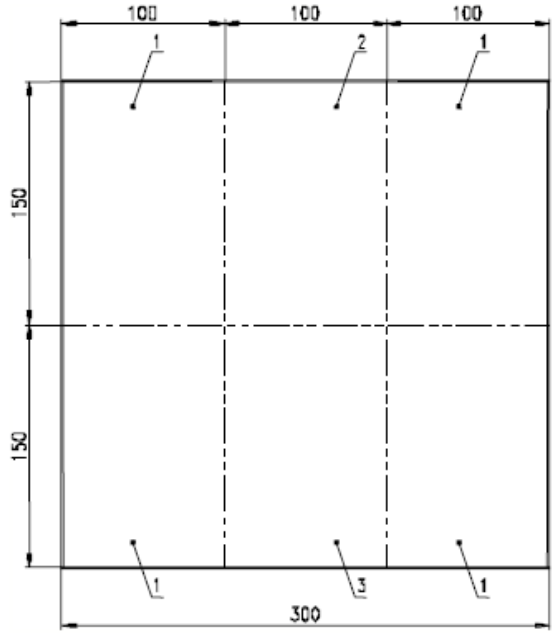
Each test shall be carried out without interruption. The only exception is the acid resistance test which can be interrupted after each cycle. However, any interruption shall not exceed three days. Testing shall start as soon as possible after the test pieces have been cleaned. The exception is the abrasion resistance test where testing shall commence within 30 min of the test piece being cleaned. Care shall be taken to ensure the test pieces are clean and uncontaminated.

7.2 Test specimen

7.2.1 *Coated annealed glass*

A sample of 300 mm × 300 mm shall be taken for each test. For the three chemical durability tests (condensation resistance, acid resistance, neutral salt spray), the test pieces are obtained by cutting the sample as shown in Fig.1. The abrasion test is undertaken on a 300 mm × 300 mm test piece.

NOTE - It is recommended that a spare sample be supplied in the event of one sample not being defect free.



KEY:

1 Test pieces
2 Reference test piece for visual inspection
3 Reference test piece for spectrophotometric measurement

FIG.1 PLAN FOR CUTTING A SAMPLE INTO TEST PIECES

7.2.2 *Toughened or heat strengthened coated glass*

As the test pieces cannot be cut from test samples, a special procedure has to be employed to obtain the test pieces (*see* **Annex D**).

7.3 Sample storage

The test pieces shall be stored inside a room at a temperature of 27 ± 2°C with a relative humidity less than 80%. Storage shall prevent dust, chemicals or condensation reacting with the test pieces. The test pieces shall not be stored for more than three months before performing the test.

7.4 Sample marking

The test pieces shall be marked on the uncoated glass surface. The following information shall be marked:

- Manufacturers' coating reference
- test pieces number 1 to 4
- Code for test.

Glasses with coating on both surfaces shall be marked without damaging the coating. The two reference test pieces shall be marked as the test pieces plus "ref".

7.5 Initial evaluation of test pieces

7.5.1 *Preparation*

All test pieces shall be cleaned with demineralized water having conductivity lower than 30µS/cm and with a soft tissue. Drying shall also be done with a soft tissue. If necessary this cleaning procedure can be repeated.

7.5.2 *Visual inspection*

The test pieces shall be subjected to a visual inspection under an artificial sky in accordance with **B-2.1**.The inspection shall take place in both transmission and reflection. The test pieces shall be observed at a distance of 600 mm. All test pieces shall be defect free. No scratches or pinholes shall be observed. If a test piece contains defects, it shall be replaced.

Note - The replacement of test pieces is to avoid any misinterpretation of the testing results.

7.5.3 *Spectrophotometric measurements*

7.5.3.1 *Coated annealed glass*

A measurement sample shall be cut from the centre of the reference test piece. The actual size shall be dependent on the type of equipment being used for the measurements. The transmittance of the measurement sample shall be measured with radiation of normal incidence at the following wavelengths-

- 550 nm (representative wavelength for light transmittance);
- 900 nm (representative wavelength for solar transmittance).

For glass claiming to have a low emissivity coating, a measurement of the reflectance shall be made at 8µm using radiation of nearly normal incidence.

7.5.3.2 *Toughened or heat strengthened coated glass*

As the measurement sample cannot be cut from the reference test piece, a special procedure has to be employed to make the measurement (*see* **Annex D**).

7.6 Performing durability tests

The durability tests namely condensation resistance, acid resistance, neutral salt spray test (*optional*), and abrasion resistance shall be performed on the samples as specified in Annex E, Annex F, Annex G, and Annex H respectively for duration as specified in the table 3 for Class A, B and S.

Table 3 Duration of Durability Tests for Class A, B and S
(*Clause* 7.6)

Sl. No.	Test	Method of test, Ref to Annex of this Standard	Test duration for class		
			A	B	S
(1)	(2)	(3)	(4)	(5)	(6)
i.	Condensation resistance	Annex E	21 days	4 days	14 days
ii.	Acid resistance	Annex F	5 cycles	1 cycle	5 cycles
iii.	Neutral Salt Spray Test (*optional*)	Annex G	21 days	10 days	-
iv.	Abrasion resistance	Annex H	500 strokes	50 strokes	500 strokes

7.7 Final evaluation of test pieces

Test specimen having completed the specified length of time under the test conditions, for the appropriate class, shall be cleaned and if necessary have their surfaces polished before undergoing final evaluation. Depending on the class, evaluation shall consist of visual inspection and measurement of spectrophotometric properties.

7.7.1 *Cleaning*

All test pieces shall be cleaned with demineralized water and with a soft tissue. Drying shall also be done with a soft tissue. If necessary, this cleaning procedure can be repeated. The non-coated surface of the glass might have been damaged during the tests. If this deterioration would affect the evaluation of the degradation of the coated surface it is permissible to polish the non-coated surface. The polishing can be undertaken using fine abrasive powder, for example, cerium oxide and/or alumina. Care shall be taken to ensure that the polishing compound does not contaminate the coated surface. Coated glasses with coatings on both surfaces shall not be polished.

7.7.2 *Final inspection and spectrophotometric measurements*

Visual inspection shall be carried out as per **7.5.2**. A 15 mm wide band around the edge of the pieces shall be excluded from the inspection. All defects shall be noted. The acceptance criteria for the characteristics are given in Table 4.

Spectrophotometric measurements of the test pieces shall be made as per **7.5.3**. The acceptance of the coated glass related to the different classes is given in Table 4.

Table 4 Requirements for classes A, B and S

(*Clause* 7.7.2)

Sl. No.	Characteristic	Test Method	Visual Inspection	Spectrophotometric measurements
(1)	(2)	(3)	(4)	(5)
i.	Condensation resistance	Annex D	No defect greater than 3 mm in length. Maximum one defect having length between 2 mm and 3 mm. Maximum five defects having length between 1 mm and 2 mm In addition, no scratches, staining of the coating or clusters of pinholes having size greater than 1 mm shall be allowed. When compared with the reference test piece, in both reflection and transmission, there shall be no significant colour change. This observation shall be made within 20 s.	The transmittance measured at 550 nm and 900 nm shall differ by no more than 3 unit from the corresponding measured value on the reference test piece. For a glass claiming to have a low emissivity coating, the reflectance at 8μm shall not decrease by more than 2 unit.
ii.	Acid resistance	Annex E	No requirements	Same as above
iii.	Neutral Salt spray Test	Annex F	No defect greater than 3 mm length. Maximum one defect having length between 2 mm and 3 mm. Maximum five defects having length between 1 mm and 2 mm In addition, no scratches, staining of the coating or clusters of pinholes having size greater than 1 mm shall be allowed. When compared with the reference test piece, in both reflection and transmission, there shall be no significant colour change. This observation shall be made within 20 s.	Same as above

iv.	Abrasion resistance	Annex G	No requirement other than to ensure that the abraded area is uniform	Total (diffuse plus direct) transmittance measured at 550 nm and 900 nm shall differ by no more than 5 unit from the corresponding value measured for the reference test piece.

NOTE: The time for observation is fixed to 20s in order to have a reference period which can influence the visual inspection.

8 EVALUATION OF DURABILITY OF TYPES C AND D

8.1 Test Specimen

8.1.1 *Coated annealed glass*

A sample of size 1000 mm × 500 mm shall be taken. Two square test pieces of minimum size 250 mm × 250 mm shall be cut from the sample.

8.1.2 *Toughened or heat strengthened coated glass*

As the test piece cannot be cut from the test sample, a special procedure has to be employed to obtain the test piece (*see* **Annex D**).

8.2 Preparation of test specimens

Two insulating glass units shall be manufactured as test specimens. The insulating glass units shall consist of one of the test pieces, 12 mm airspace and a piece of 4 mm clear float glass (in compliance with IS 14900). The dew point of the test specimens shall not be higher than -25°C, when measured at 27 ± 2°C.

The edge area of the test specimens shall be covered with a reflecting aluminum foil 40 ± 5 mm wide as a means of protection for the sealant components.

8.3 Initial evaluation of test pieces

Cleaning and visual inspection shall be conducted as per **7.7.1** and **7.5.2**.

8.4 Test method for exposure to simulated solar radiation

8.4.1 *Radiation source*

Radiation sources shall be used which emit radiation with a spectral distribution similar to the spectral solar global distribution as given in IS 16231 (part 2) and with percentages of UVB and UVA as given in table 5. Such a spectral distribution can be obtained using different kinds of lamps (for examples of test apparatus, *see* **Annex J**).

Table 5 Spectral characteristics of the lamps used for the test

(*Clause* 8.4.1)

Sl. No.	Radiation	Range of wavelength (nm)	Percentage of total energy (%)
(1)	(2)	(3)	(4)
i.	ultraviolet range UVB	280 to 315	1 to 4
ii.	ultraviolet range UVA	315 to 380	3 to 9
iii.	visible and infrared range	> 380	balance

8.4.2 *Test conditions*

The total irradiance level measured on the surface of the test pieces (surface facing the test lamps) shall be 900 ± 100 W/m^2.

Note - Calibrated pyranometers with a spectral sensitivity in the 305 nm to 2 800 nm range should be used for the determination of the total irradiance level. Using these detectors, the measured irradiance level on the surface of the test pieces should be 730 ± 80 W/m^2.

The exposure time for the radiation test shall be:

- (1 000 ± 24) h in the case of test apparatus given in **J-1**;
- (2 000 ± 24) h in the case of test apparatus given in **J-2**.

The test specimen shall be placed with the coating orientated towards the radiation source. When tested, the coating shall be on surface 3. However, when the coating is only to be used on surface 2, then it shall be tested on surface 2.

Figures **J-1** (planar array) or **J-2** (circular array) shows the arrangement of the test specimens and the reference glass piece. The reference glass piece has a thermocouple placed on its surface facing the test lamps. The temperature of the reference glass piece shall be 56 ± 3°C.

8.4.3 *Reference glass piece*

An opaque thermally toughened soda lime silicate safety glass (*see* IS 2553 (part 1)) shall be used as a reference glass piece. It shall be manufactured from of a piece of float glass (*see* IS 14900), up to 10 mm thickness, with an enameled black frit on the surface facing the array of lamps.

The reference glass piece shall have the following properties:

- Dimensions not less than 250 mm;
- Solar direct absorption $\alpha_e \geq 0.92$ measured according to **7.5.3** with radiation of normal incidence onto the surface of the reference glass piece facing the test lamps;
- Normal emissivity $\varepsilon_n \geq 0.84$ at 27 ± 2°C of both outer surfaces of the reference glass piece, measured according to **7.5.3** with radiation of nearly normal incidence;
- Thermal conductance between the two outer surfaces $\Lambda \geq 100$ W/(m^2.K).

8.4.4 *Test procedure*

The test procedure shall include the following steps:

- Initial visual inspection of the two test pieces;

- Checking for the appearance of humidity between the panes;
- Exposure of one test piece under simulated solar radiation and storage of the second test piece in a dark room at a temperature of 27 ± 2°C;
- Final visual inspection of the exposed and unexposed test pieces;
- Checking for the appearance of humidity between the panes;
- Opening of both test pieces and preparation of a test portion;
- Spectrophotometric measurements.

8.5 Final evaluation of exposed test pieces

8.5.1 *Visual inspection*

The exposed test specimens shall be subjected to the same cleaning and the visual inspection procedure as for the initial test pieces.

8.5.2 *Spectrophotometric measurements*

Spectrophotometric measurements of the test pieces shall be made as per **7.5.3**.

8.5.3 The acceptance criteria for the characteristics are given in *Table 6*.

Table 6 Requirements for Coating types Class C and D type
(*Clause* 8.5.3)

Sl. No.	Test piece	Visual inspection	Spectrophotometric measurements
(1)	(2)	(3)	(4)
i.	Exposed test specimens	No additional defects on the coating shall be observed when compared to the unexposed double glass test specimens	No requirements
ii.	Exposed single coated glass test piece	No requirements	The transmittance values at 550 nm and 900 nm shall differ from the corresponding values of the unexposed single coated glass sample by no more than 3 unit. For a glass claimed to have a low emissivity coating, the reflectance at 8µm shall decrease by no more than 2unit.

NOTE: The frequency of this test may be kept lower such as once in a fortnight production. Reason missing. The characteristic which is prone to change/ get affected during the manufacturing process should be performed on each batch to maintain the quality. Certain parameters depend only on the design of the product, for only such parameters type testing is performed instead of regular testing.

9 PACKING AND MARKING

9.1 Packing

Coated glass shall be packed as agreed to between the manufacturer and the purchaser. The packet shall be marked with the following information:

a) Indication of the source of manufacture,
b) Code or batch number,
c) Month and year of manufacture, and
d) Type of coated glass.

9.2 Marking

Each pane shall be marked with the following information:

a) Indication of the source of manufacture,
b) Code or batch number,
c) Month and year of manufacture,
d) Type of coated glass.

9.3 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

10 SAMPLING

Representative samples of the material for lot testing may be drawn as prescribed in *Annex K*.

NOTE: The sampling plan provided here is for the reference and guidance of second party testing purposes only, it has nothing to do with the sampling plans provided in the BIS product manual and SIT.

Annex A
(*Clause* 6.1)

EMISSIVITY MEASUREMENT

A-1 GENERAL

This test method may be used to determine the corrected emissivity of coated glass surface at 283 K by the help of Infrared spectrophotometer.

A-2 ABBREVIATIONS USED

ε	Total corrected emissivity at 283 K
ε_n	Total normal emissivity at 283 K.
E	Reading of the spectrophotometer with the sample placed on the sample support of the reflectance accessory.
E_0	The instrument reading without placing anything on the sample support.
E_{st}	The instrument reading with the reference mirror replacing sample.
R_n	Total normal reflectance at 283 K.
$R_n(\lambda)$	Spectral normal reflectance.
$E_{n,st}$	Spectral normal reflectance of the reference mirror.
$T_n(\lambda)$	Spectral normal transmittance.
T_n	Total normal transmittance at 283 K.

A-3 TEST APPARATUS

A-3.1 Infrared Spectrophotometer (range from 5μm to 50 μm).

A-3.2 A reference mirror whose spectral regular reflectance at near normal incidence $R_{n,st}(\lambda)$ is traceable to a standard material by a metrological laboratory.

A-3.3 A specular reflectance accessory consisting of a suitable array of mirrors and a sample support.

NOTE: When the accessory and the sample (or reference mirror) are placed in the sample compartment and sample support of the spectrophotometer respectively, the instrument beam reaches the detector after specularly reflected on the surface of the sample (or reference mirror) at an angle of incidence $\leq 10^0$.

A-4 PROCEDURE

A-4.1 Preparation of samples

Suitable size of samples is obtained by the cutting or drilling, and ensures that the coated surface should be free of damage or any surface contamination.

Before starting the experiment, ensure that the measuring spot falls on a flat part during transmittance and reflectance measurements.

A-4.2 Measurement of Spectral Regular Reflectance

A-4.2.1 Follow the steps given below to measure the spectral regular reflectance of non-infrared transparent glazing component at near normal incidence $R_n(\lambda_i)$ using the relative method (reference mirror) and infrared spectrophotometer:

a) Note the instrument reading without placing anything on the sample support E_0.

b) Note the instrument reading with the sample placed on the sample support of the reflecting accessory E.

c) Note the instrument reading with the standard replacing the sample E_{st}.

d) Calculate the sample spectral regular reflectance using the equation 1.

$$R_n(\lambda_i) = \frac{E - E_0}{E_{st} - E_0} . R_{n,st}(\lambda_i) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

e) Repeat the steps from a) to d) again for different wavelengths specified in the table 7.

Table 7 Wavelengths at which spectral regular reflectance to be measured

(*Clause* A-4.2.1)

S No.	Ordinal number(i)	Wavelength(λ_i) µm	Ordinal number(i)	Wavelength(λ_i) µm
(1)	(2)	(3)	(4)	(5)
i.	1	5.5	16	14.8
ii.	2	6.7	17	15.6
iii.	3	7.4	18	16.3
iv.	4	8.1	19	17.2
v.	5	8.6	20	18.1
vi.	6	9.2	21	19.2
vii.	7	9.7	22	20.3
viii.	8	10.2	23	21.7
ix.	9	10.7	24	23.3
x.	10	11.3	25	25.2
xi.	11	11.8	26	27.7
xii.	12	12.4	27	30.9
xiii.	13	12.9	28	35.7
xiv.	14	13.5	29	43.9
xv.	15	14.2	30	50.0[a]

NOTE: [a] 50µm has been chosen because this wavelength is the limit of the most commercially available

spectrophotometers. This approximation has a negligible effect on the accuracy of the calculation

A-4.3 Calculation of Total Normal Reflectance, R_n

Calculate the total normal reflectance at 283 K (R_n), by taking the average of spectral regular reflectance values ($R_n(\lambda_i)$) determined in **A-4.2** using the equation 2.

$$R_n = \frac{1}{30}\sum_{i=1}^{i=30} R_n(\lambda_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

A-4.4 Calculation of Total Normal Emissivity, ε_n

Total normal emissivity, ε_n, shall be calculated from the total normal reflectance.

$$\varepsilon_n = 1 - R_n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

A-4.5 Calculation of Corrected Emissivity, ε_n

The corresponding corrected emissivity (ε), shall be determined by multiplying normal emissivity by the ratio $\varepsilon/\varepsilon_n$ from the table 8.

Table 8 Ratio of normal emissivity to corrected emissivity
(*Clause* A-4.5)

S No.	Total normal emissivity (ε_n)	Ratio ($\varepsilon/\varepsilon_n$)
(1)	(2)	(3)
i.	0.03	1.22
ii.	0.05	1.18
iii.	0.1	1.14
iv.	0.2	1.10
v.	0.3	1.06
vi.	0.4	1.03
vii.	0.5	1.00
viii.	0.6	0.98
ix.	0.7	0.96
x.	0.8	0.95
xi.	0.89	0.94

NOTE: Intermediate values are obtained with sufficient accuracy by linear interpolation or extrapolation.

ANNEX B

(*Clause* 6.2.1, 7.5.2)

EVALUATION OF DEFECTS

B-1 APPEARANCE

The defects affecting appearance are; a) specific to the glass substrate, and b) specific to the coating. Defect specific to the glass substrate is more visible because of the coating, and will be treated as a coating defect.

B-2 DETECTION OF DEFECTS

The defects are detected visually by an observation of the coated glass in transmission and/or reflection. An artificial sky or daylight may be used, as the source of illumination.

B-2.1 Artificial sky

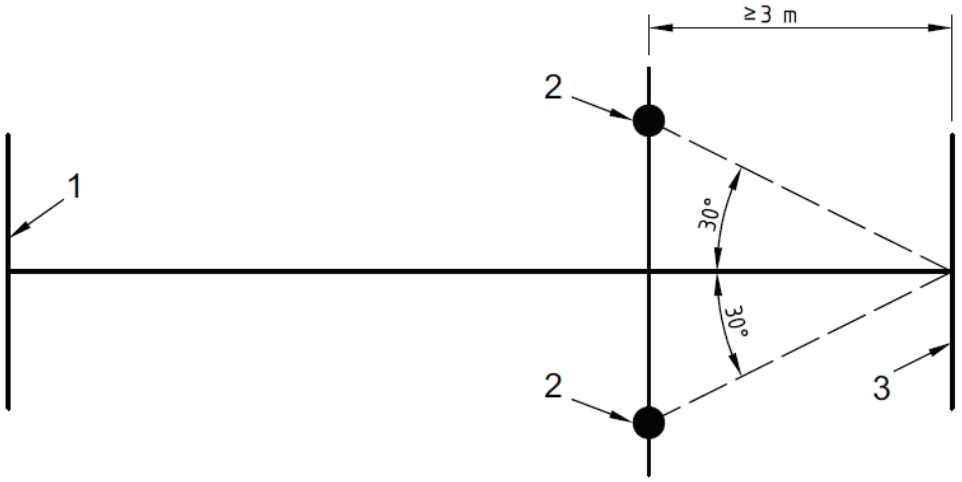
The artificial sky is a plane emitting diffuse light with a uniform brightness and a general colouring index Ra higher than 70. It is obtained by using a light source whose correlated colour temperature is in the range between 4 000 K and 6 000 K. In front of the arrangement of light sources is a light scattering panel, without spectral selectivity. The illuminance level, on the glass surface shall be between 400 lux and 20 000 lux.

B-2.2 Daylight illumination

Daylight illumination is a uniform overcast sky, without direct sunlight.

B-3 CONDITIONS OF EXAMINATION

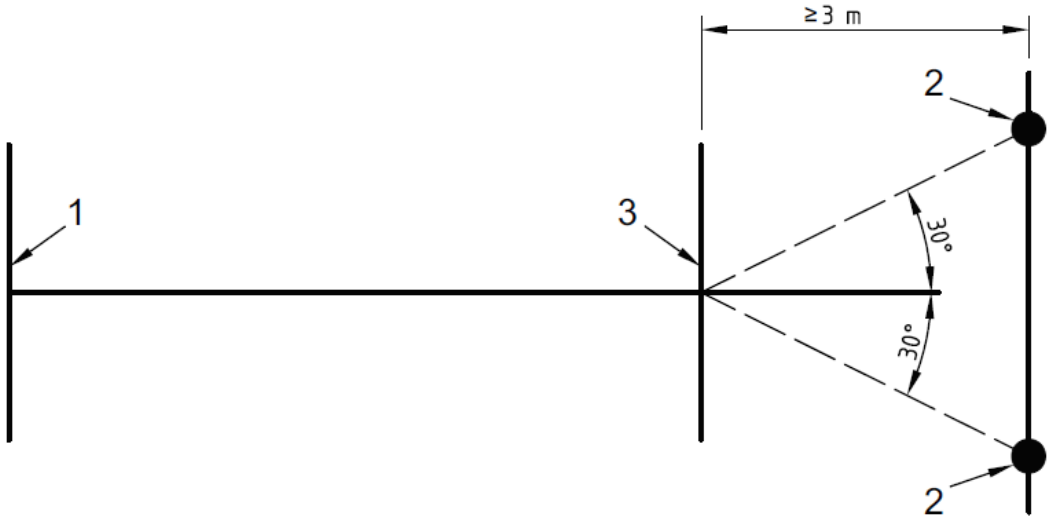
Coated glass may be examined in stock size plates or in finished sizes ready for installation. The examination may be undertaken in the factory or on site when glazed. The pane of coated glass being examined is viewed from a minimum distance of 3 m with illumination behind the observer for reflected observation, and behind the glass for transmitted observation. The actual distance will be dependent on the defect being considered and which illumination source is being used. The examination of the coated glass in reflection is performed by the observer looking at the side which will be the outside of the glazing. The examination of the coated glass in transmission is performed by the observer looking at the side which will be the inside of the glazing. During the examination the angle between the normal to the surface of the coated glass and the light beam proceeding to the eyes of the observer after reflection or transmission by the coated glass shall not exceed 30° (*see* **Fig. 2** and **3**).



Key
1 illumination source
2 observer position
3 coated glass sample

Note: This is a plan view.

FIG. 2 SCHEMATIC FOR REFLECTED LIGHT OBSERVATION OF COATED GLASS

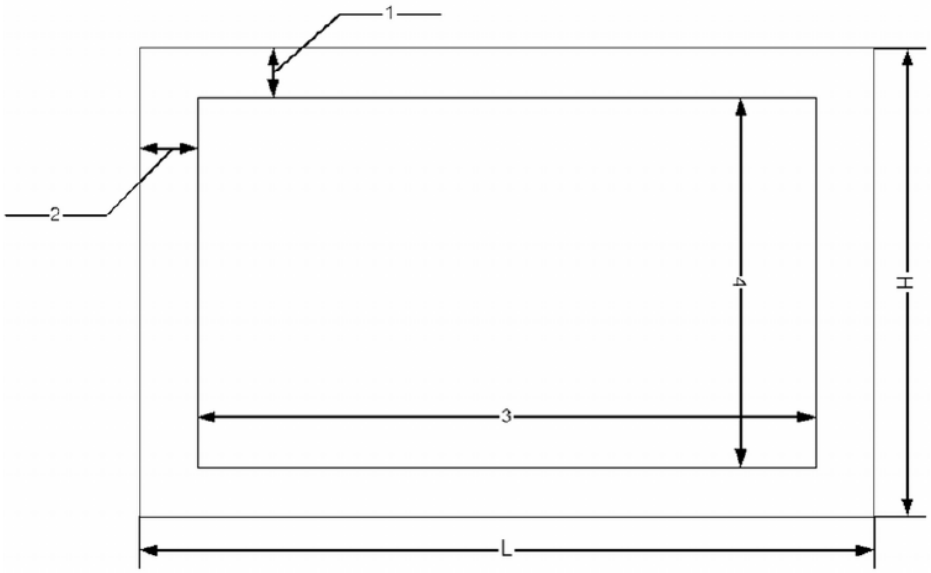


Key
1 illumination source
2 observer position
3 coated glass sample

Note: This is a plan view.

FIG. 3 SCHEMATIC FOR TRANSMITTED LIGHT OBSERVATION OF COATED GLASS

For panes of coated glass in finished sizes ready to be installed both the main area and an edge area of the pane shall be examined (*see* **Fig. 4**).



Key

1 edge area height is 5% of H dimension
2 edge area length is 5% of L dimension
3 central area length is 90% of L dimension
4 central area height is 90% of H dimension

FIG. 4 AREAS TO BE EXAMINED ON FINISHED SIZES READY FOR GLAZING

Each examination will take no more than 20 seconds.

B-4 UNIFORMITY DEFECTS AND STAINS

Under the conditions of examination given in **B-3**, note any coating variations either within one pane or between neighboring panes which are visually disturbing.

B-5 PUNCTUAL DEFECTS

Under the conditions of examination given in **B-3**, note any spots, pinholes and/or scratches that are visually disturbing. For spots/pinholes measure the size and note the number relative to the size of the pane. If there are any clusters found their position relative to the through vision area shall be determined. For scratches determine whether or not they are in the main or edge area. Measure the length of any scratches noted. For scratches >75 mm long, determine the distance between adjacent scratches. For scratches ≤ 75 mm long, note any area where their density produces visual disturbance.

ANNEX C
(*Clause* 6.2.1)

UNIFORMITY TEST (Delta E)

C-1 GENERAL

A test method is specified for the determination of colour delta (ΔE) value based on CIELAB L, a, b values and the use of any standard illuminant as specified in the table 9.

C-2 APPARATUS

C-2.1 Colour meter capable to check L, a, b values in visible region (380 to 780 nm).

C-3 PROCEDURE

C-3.1 Take samples of glass as per the instrument cavity from Left, Center & right.

C-3.2 Clean all the samples gently with tissue paper.

C-3.3 Standardize the instrument in Transmission mode by using black card & white tile or as per the instrument calibration system & same do for reflectance mode.

C-3.4 To measure the white tile & green tile treating it as sample & ensure its standard readings within $\pm$ 0.50 point.

C-3.5 To keep the sample in transmission compartment & measure the color co-ordinates in Transmittance mode.

C-3.6 Then keep sample at reflection port with light trap & measure color co-ordinates in Reflection mode from Glass side & Film side.

C-3.7 Pick up the average values of colour co-ordinates (X, Y, Z) & compare with the specification standard of respective product. Then calculate Delta-E in Glass & Film side.

C-4 CALCULATION

C-4.1 Calculate the values of L, a, b using the equations 1, 2, and 3 respectively.

$$L = 100\sqrt{\frac{Y}{Y_n}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$a = K_a\left(\frac{X/X_n - Y/Y_n}{\sqrt{Y/Y_n}}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$b = K_b\left(\frac{Y/Y_n - Z/Z_n}{\sqrt{Y/Y_n}}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where

X, Y, and Z are the CIE tristimuluis values found in C-3.7.
X_n, Y_n, and Z_n are the tristimulus values for the illuminant.
Y_n is 100.00.

X_n and Z_n values are listed in the table 9.

K_a and K_b are chromaticity coefficients for the illuminant and are listed in the table 9.

Table 9 Standard Illuminant Properties

(*Clause* C-4.1)

Sl No	**Illuminant**	**X_n**	**Z_n**	**K_a**	**K_b**
(1)	(2)	(3)	(4)	(5)	(6)
i.	A	109.83	35.55	185.20	38.40
ii.	C	98.04	118.11	175.00	70.00
iii.	D_{65}	95.02	108.82	172.30	67.20
iv.	F2	98.09	67.53	175.00	52.90
v.	TL 4	101.40	65.90	178.00	52.30
vi.	UL 3000	107.99	33.91	183.70	37.50
vii.	D_{50}	96.38	82.45	173.51	58.48
viii.	D_{60}	95.23	100.86	172.47	64.72
ix.	D_{75}	94.96	122.53	172.22	71.30

C-4.2 Calculate the values of ΔL, Δa, Δb using the equations 4, 5, and 6 respectively.

$\Delta L = L - L^*$ ……(4)

NOTE: + ΔL means sample is lighter
- ΔL means sample is darker

$\Delta a = a - a^*$ ……(5)

NOTE: + Δa means sample is redder
- Δa means sample is greener

$\Delta b = b - b^*$ ……(6)

NOTE: + Δb means sample is yellower
- Δb means sample is bluer

Where

L, a, and b are the determined values as calculated in C-4.1.

L*, a*, and b* are the values declared by the manufacturer.

C-4.3 Calculate the value of Colour Delta **(**ΔE) using the equation 7.

$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$ ……(7)

ANNEX D
(*Clauses* 7.2.2, 7.5.3.2 *and* 8.1.2)

SPECIAL PROCEDURES FOR TOUGHENED OR HEAT STRENGTHENED COATED GLASS

D-1 SAMPLES AND TEST PIECES

A sample of the coated glass representative of the production shall be taken. The test pieces shall be cut from the sample and shall then be toughened or heat strengthened under the same conditions. The following test pieces shall be prepared –

D-1.1 For coating types A, B and S –

i) *Chemical tests* – 18 test pieces: 100 mm wide × the shortest length, not less than 150 mm, which can be manufactured;
ii) *Abrasion test* – one test piece 300 mm × 300 mm or the nearest size to those which can be manufactured.

D-1.2 For coating types C and D – Two square test pieces of dimensions 250 mm × 250 mm or the nearest size to those that can be manufactured.

D-2 Spectrophotometric measurements

As measurement samples cannot be cut from the test pieces, the measurements cannot be made using standard spectrophotometric equipment. The measurements can however be done using non-standard spectrophotometric equipment or by other means, for example, laser.

ANNEX E
(*Clause* 7.6)

CONDENSATION RESISTANCE TEST

E-1 GENERAL

This test consists of subjecting the coated glass to a water saturated atmosphere at constant temperature. The samples have condensation continually forming on them and it is this condensation that may cause surface degradation.

E-2 TEST CABINET

A vapour-tight climatic cabinet is essential for a test in a warm and humid atmosphere. The materials used for the inner walls shall be corrosion-resistant and shall not affect the test pieces.

Note - Experience has shown that preferable corrosion-resistant materials are stainless steel and glass: they help to maintain pH at a level higher than 5 and do not generate emissions.

The climatic cabinet shall be equipped with a floor which acts as the receptacle for the quantity of water. The test cabinet shall be conditioned only by heating the water on the floor. In order to give good reproducibility, the volume of the climatic cabinet shall be 300 *l*. The temperature measurement on the central reference glass piece shall control the heating constancy of the bath.

The climatic cabinet shall be provided with a suitable door or other aperture capable of being closed, which allows the test cabinet to be charged with test pieces, to be ventilated and to be visually observed.

Note - Condensation on the cover should not generate drips on the glass pieces, nor on the objects present in the cabinet.

An example of a cabinet device is shown in Fig. 5.

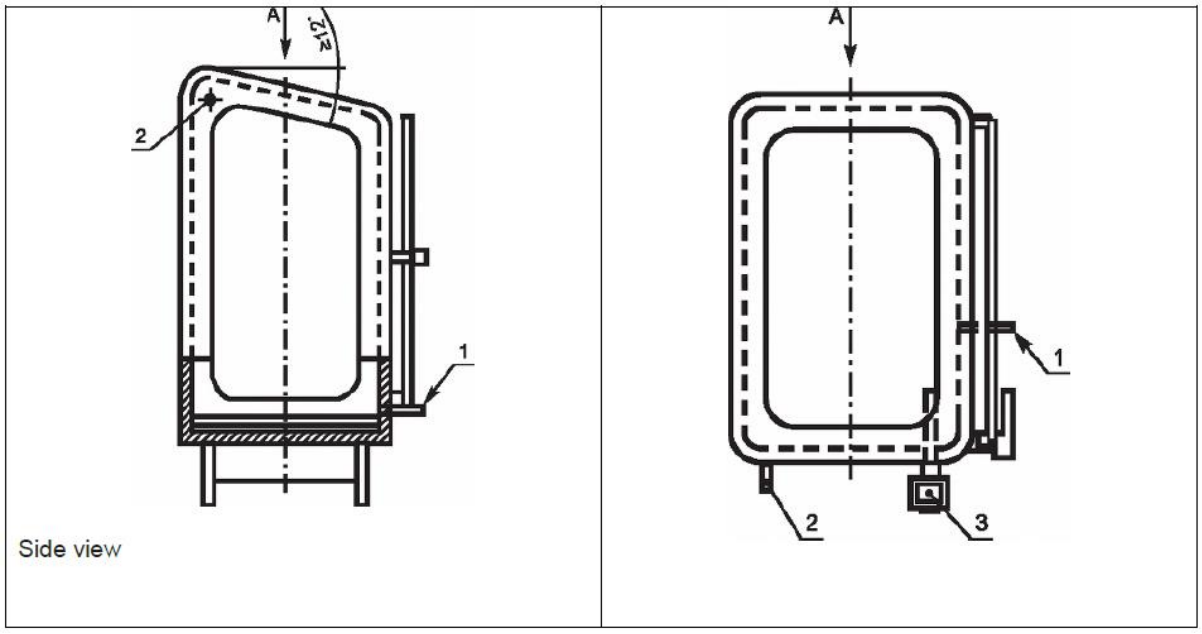


FIG. 5 EXAMPLE OF CABINET DEVICE

Key:

1. Vacuum relief valve and gas inlet nozzle
2. Pressure relief valve
3. Temperature control device

E-3 PROCEDURE

The four test pieces shall be mounted on a test piece holder. The water tank shall be filled with demineralized water, having conductivity lower than 30 µS/cm and a *p*H higher than 5. The internal temperature of the cabinet shall be controlled by means of the reference thermocouple keeping a temperature of the reference glass piece of 40 ± 1.5°C. The test cabinet shall be in a room with an ambient temperature of 27 ± 2°C. Care shall be taken to ensure that draughts, dust, moisture and solar radiation do not interfere with the test cabinet.

The reference temperature shall be reached within 2 h of commencing heating. Condensation shall be seen to form on the glass pieces. The test is continued without interruption for the required time. Both the internal reference and the external air temperature shall be regularly checked.

ANNEX F
(*Clause* 7.6)

ACID RESISTANCE TEST

F-1 GENERAL

This test consists of subjecting the coated glass to a sulphur dioxide saturated atmosphere at constant temperature. The samples shall have condensation continually forming on them. It is this condensation together with the quantity of sulphur dioxide that may cause surface degradation.

F-2 PROCEDURE

The test cabinet shall contain 2 l of demineralized water having conductivity lower than 30 µS/cm. The four test pieces shall be mounted on a test piece holder. When the cabinet is closed, 0.2 l of SO_2 shall be added and the heating system shall be switched on. The test consists of a repetition of 24 h cycles. Each cycle consists of high temperature plus condensation period and an ambient temperature without condensation period.

The details of the cycle are shown in *Fig. 6*.

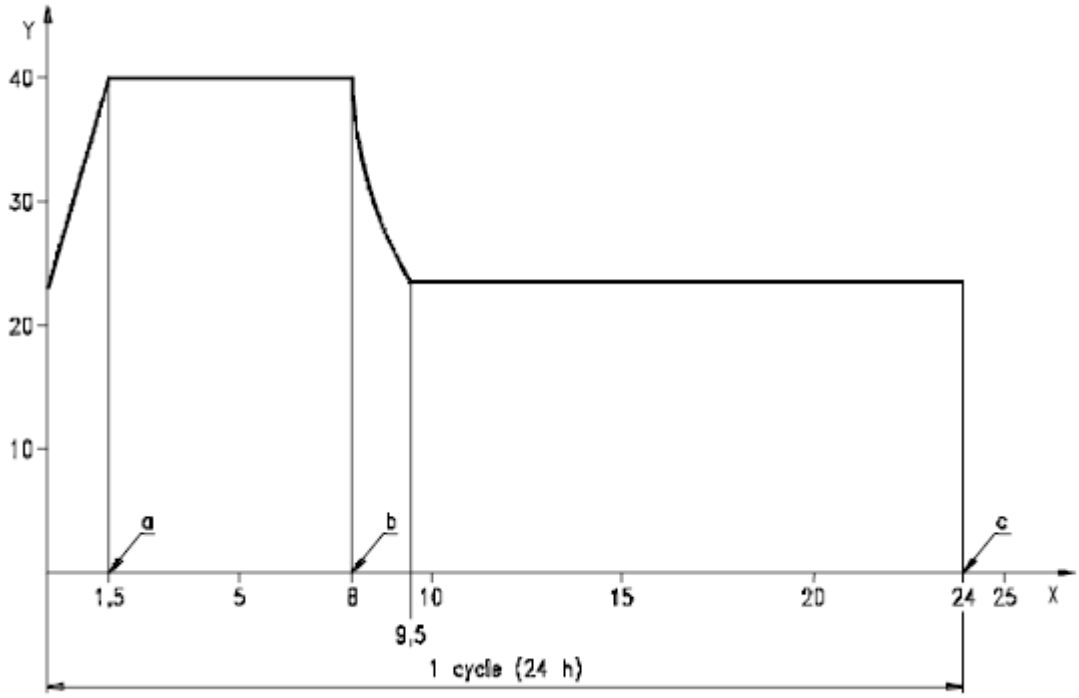


FIG. 6 TEMPERATURE CYCLE FOR ACID RESISTANCE TEST

Key

x - Time (h)
y - Temperature (°C)
a - Maximum time to reach 40°C

b - Cessation of heating the cabinet and ventilation of the cabinet
c - Solution removal rinsing of cabinet

The temperature shall be controlled by means of the reference thermocouple. The temperature shall increase to 40 ± 1.5°C in less than 1.5 h. During the next 6.5 h the test pieces shall be subjected to condensation in the SO_2 atmosphere. After the high temperature period the heating system is switched off and the cabinet is ventilated.

The temperature should drop to ambient temperature within 1.5 h of the heater being switched off. When the SO_2 atmosphere is being ventilated the cabinet shall be placed in a fume cupboard or a suitable extraction system shall be installed.

The cabinet shall be prepared before each cycle.

F-3 TEST CABINET

A vapour-tight climatic cabinet is essential for a test in a warm and humid acidic atmosphere. The material used for the inner walls shall be corrosion-resistant and shall not affect the test pieces. The climatic cabinet shall be equipped with a floor which acts as the receptacle for the quantity of water. The test cabinet shall be conditioned only by heating the water on the floor.

In order to give good reproducibility, the volume of the climatic cabinet shall be 300 l. The temperature measurement on the central reference glass piece shall control the heating constancy of the bath.

The climatic cabinet shall be provided with a suitable door or other aperture capable of being closed, which allows the test cabinet to be charged with test pieces, to be ventilated and to be visually observed.

An example of a cabinet device is shown in *Fig. 5*.

Note - Condensation on the cover should not generate drips on the test pieces, nor on the other objects present in the cabinet.

ANNEX G
(*Clause* 7.6)

NEUTRAL SALT SPRAY TEST

G-1 GENERAL

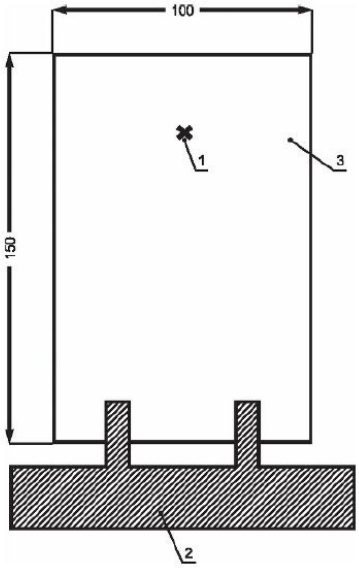
This test consists of subjecting the coated glass to neutral, water saline atmosphere at constant temperature. It is the water saline spray that may cause surface degradation. All components in contact with the spray or the test solution shall be made of materials resistant to corrosion by the sprayed solution and which do not influence the corrosivity of the sprayed test solutions.

The four test pieces shall be mounted in a rack which is supported by the two collectors and placed in the test cabinet as defined below.

G-2 POSITIONING OF TEST PIECES IN THE TEST CABINETS

The test pieces shall have their coated side oriented upwards, the pieces presenting an angle of 15 ± 5° with the vertical, and the coated side shall face away from the door. For consistent results, a certain quantity of glass shall be present. For 300 l cabinet, the total weight of the glasses shall be 7.5 ± 0.5kg. An insufficient quantity of coated glass shall be compensated with uncoated clear glasses.

In the centre of the test pieces a piece of 6 mm clear glass is placed, with the reference thermocouple attached (*see* **Fig. 7**).



KEY:

1. position of the thermocouple
2. substrate holder
3. 6 mm clear glass used for temperature control inside cabinet

FIG. 7 6MM CLEAR GLASS WITH REFERENCE THERMOCOUPLE

The following spacing shall be maintained:

-distance from the walls not less than 100 mm

-distance between bottom of the test pieces and water not less than 200 mm

-spacing between adjoining test pieces not less than 20 mm not more than 40 mm

Where there is an insufficient quantity of coated glass for testing, it is required to use uncoated clear glasses to fill up a cabinet.

G-3 APPARATUS

The apparatus shall include the following components:

G-3.1 Spray cabinet

Cabinet volume shall not be less than 0.4 m^3. Care should be taken to ensure homogeneous distribution of the sprayed solution. Design of the cabinet shall be so that drops of sprayed

solution formed on its surfaces shall not fall on the test pieces being tested. The level of the salt solution in the salt reservoir shall be automatically maintained to ensure uniform spray delivery throughout test.

The test cabinet shall be prepared and run for a minimum period of 24 h before the test pieces are placed within it. The neutral salt solution is made up by dissolving NaCl, in demineralised water having conductivity lower than 30 µS/cm, to produce a concentration of 50 ± 5 g/l at 25 ± 2°C.

G-3.2 Heater and temperature control

An appropriate system maintains the cabinet and its components at a specified temperature. The temperature shall be measured at least at a distance of 100 mm from any wall.

G-3.3 Spraying device

The device for spraying the salt solution comprises a clean air supply, of controlled pressure and humidity, a reservoir to contain the solution to be sprayed, and one or more spray nozzle.

The compressed air supplied to the spray nozzle shall be passed through a filter to remove all traces of oil or solid matter and shall be at an absolute pressure of 70 kPa to 170 kPa through a saturator at 40 ± 1.5°C. The spray nozzle shall be made of inert material, with baffles to prevent direct impact of spray on the test pieces.

ANNEX H
(*Clause* 7.6)

ABRASION RESISTANCE TEST

H-1 GENERAL

This test consists of subjecting the coated surface of the coated glass to rubbing with a felt pad in dry conditions. It is the type of pad, the loading on it and the number of strokes that may cause surface degradation.

H-2 TEST EQUIPMENT

The test equipment consists of the following:

a) A rotating wheel
b) A metal finger
c) Felt pad holder and rotation device
d) Test piece support
e) The equipment is shown in below figure

The metal finger shall be approximately 15 mm to 20 mm in diameter and shall be driven so as to produce a frequency of 60 + 6 strokes/min alternating forwards and backwards. The stroke length shall be 120 + 5mm. The strokes shall be parallel and ensure a constant pressure over the zone to be tested.

The abrasive felt pad shall have the following characteristics:

- a density of 0.52 ± 0.052 g/cm^2 ;
- a thickness of 10 ± 1 mm ;
- a circle shape with a diameter of 14.5 ± 0.5 mm ;
- and is cut or punched in such a way that the intersections of the abrasion surface and the edges are perpendicular.

The pad is fixed to the metal finger. The felt pad shall rotate continuously at 6 rpm or it shall rotate by an angle of between 10° and 30° at the end of each stroke.

The test piece shall be cleaned in accordance with **7.7.1** prior to commencement of the test. The test sequence shall commence within 30 min of the sample being cleaned.

H-3 PROCEDURE

The test piece shall be mounted in the equipment in such a way that movement is not possible. The metal finger containing the felt pad shall be lowered on to the glass surface and a load of 4 N applied perpendicular to the glass surface via the felt pad.

The appropriate number of strokes, as given in **7.6**, shall be applied. A minimum of four tests shall be done on the sample (*see* **Fig 9**). Each test shall be done using a fresh felt pad.

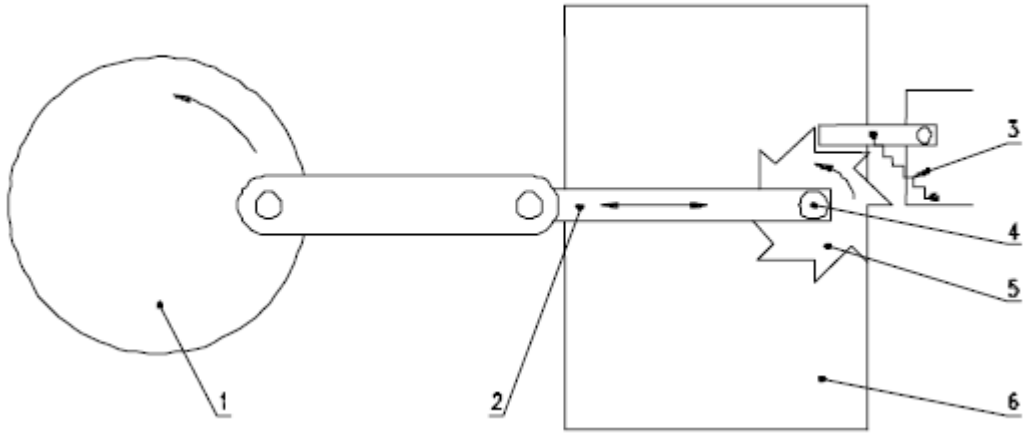


FIG. 8 AN ILLUSTRATION OF THE PRINCIPLE OF ABRASION EQUIPMENT

KEY:

1 Rotating wheel
2 Finger
3 Spring
4 Felt
5 Felt rotating wheel
6 Glass specimen

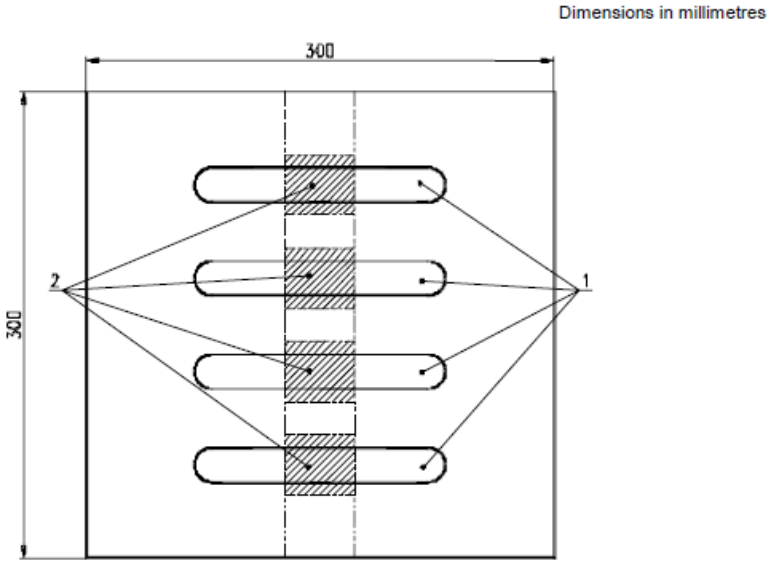


FIG. 9 TRACKS OF ABRASION ON THE SAMPLE

KEY:

1 Typical wear tracks
2 Areas from which the four samples, to be submitted to spectrophotometric measurements shall be cut

ANNEX J
(*Clause* 8.4)

RADIATION EXPOSURE TEST

The following are examples of two test apparatus which satisfy the exposure conditions.

J-1 PLANE ARRANGEMENT OF THE TEST PIECES

The test pieces and the reference glass piece should be arranged in mounting supports in one vertical plane. The radiation field shall be formed by arranging the lamps in a parallel plane facing the plane of the test pieces. The axes of lamps are horizontal and the distances between them shall be the same for all lamps to obtain a sufficiently uniform irradiance on the test pieces and the reference glass piece. The minimum distance between the array of the test pieces and the floor of the test room shall be maintained at 400 mm. The air space behind the array shall be not less than 500 mm to ensure undisturbed free natural convection upwards. In order to obtain a sufficiently uniform irradiance, test pieces shall not exceed the area A of the lamp array, given by the relation:

$A = n \times l_1^2$

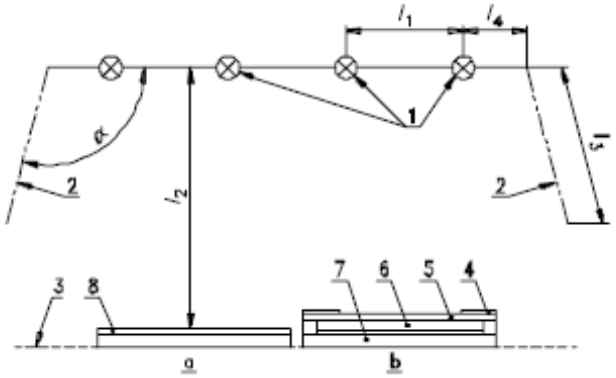
Where:

n is the number of lamps

l_1 is the distance between the axis of neighboring lamps.

At least 16 lamps of 300W are arranged in a square of 4 × 4 lamps with a distance of l_3 = 250 mm between the lamps forming a radiation field of 1 m × 1 m. The lamp array is framed by an aluminium foil of width l_3 = 1 000 mm with a specular reflective surface. The distance between the aluminium foil and the outer row of lamps on each side is l_4 = 125 mm. The angle between the plane of the radiation field and the aluminium foil is 100°. The test specimens are placed in a parallel plane facing the lamps at a distance l_2 = 1 100 mm forming an area of 1 m × 1 m (*see* **Fig 10** and **11**).

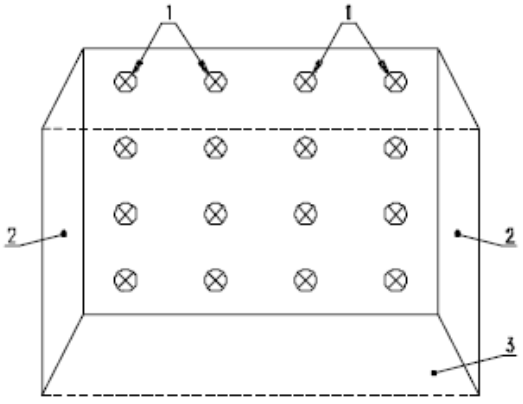
Note - In order to ensure that the percentages of UVB and UVA parts of the radiation established in *Table 4* are fulfilled, the lamps should be replaced after 2000 h use.



KEY:

1 Lamps	6 12 mm cavity
2 Aluminium foil	7 Coated glass with coating faced to cavity
3 Samples plane	8 Enamelled black frit
4 Protective aluminium foil	a Reference glass piece
5 4 mm clear float glass	b Test piece

FIG. 10 FLAT PLAN ARRANGEMENT FOR THE RADIATION EXPOSURE TEST



KEY:

1 Lamps
2 Aluminium foil

3 Samples plane

FIG. 11 CROSS SECTION ARRANGEMENT FOR THE RADIATION EXPOSURE TEST

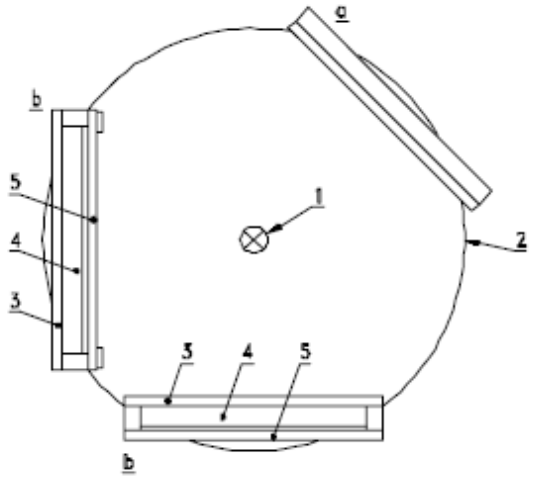
J-2 CIRCULAR ARRANGEMENT OF THE TEST PIECES

Test pieces and the reference glass piece should be arranged in a vertical position around a circular support of approximately 500 mm diameter with a vertical axis (*see* **Fig 12**). The test pieces and the reference glass piece should face a lamp used as radiation source which shall be positioned on the vertical axis of the circular support.

The chamber shall be heated at the selected temperature. The circular support with the reference glass piece and the test pieces shall rotate around its axis in order to ensure uniform temperature and radiation distributions on the test pieces and reference glass piece.

The radiation source shall be an Arc Xenon lamp of 6500 W, equipped with a quartz inner filter and a borosilicate outer filter.

Note - In order to ensure that the percentages of UVB and UVA parts of the radiation established in *Table 4* are fulfilled, the lamps should be replaced after 1 000 h use.



KEY:

1 Xenon lamp
2 Circular support
3 4 mm clear float glass
4 12 mm cavity
5 Coated glass with coating faced to cavity
a Reference glass piece
b Test pieces

FIG. 12 PLAN VIEW OF THE SETUP OF THE CIRCULAR RADIATION EXPOSURE TEST

ANNEX K
(*Clause* 10)

SAMPLING OF COATED GLASS

K-1 SCALE OF SAMPLING

K-1.1 Lot - In a single consignment, glass of the same quality and nominal thickness and belonging to the same batch of manufacture shall constitute a lot.

K-l.2 Samples shall be tested separately from each lot for ascertaining conformity of coated glass to the requirements of this specification.

K-l.3 The number of coated glass panes to be sampled from a lot for this purpose shall depend on lot size and shall be in accordance with co1 1 and 3 of Table 10. If the panes are packed in boxes or cartons, at least 20 percent of them, subject to minimum of 2 boxes shall be selected at random and opened for taking out the samples. Approximately equal number of sheets shall be selected from the middle and both the ends of each selected box or carton to give the required sample size. In order to ensure randomness of selection of coated glass from the lot, procedures given in IS 4905 may be adopted.

Table 10 Scale of Sampling and Criteria for Conformity
(*Clauses* K-1.3, K-2.1, K-2.2)

Lot	**Defects in coated glass, spectral properties and evaluation of durability**						**Nominal thickness and dimensional tolerance**	
	Stage	Sample size (no. of panes)	Combined size (no. of panes)	C_1	C_2	C_3	Sample size	C_4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
< 500 tonnes	First	8	8	0	2	2	4	0
	Second	10	18					
≥500, up to 1 500 tonnes	First	14	14	0	2	2	5	1
	Second	16	30					
≥ 1 500, up to 2 500 tonnes	First	20	20	1	3	4	8	1
	Second	20	40					
≥ 2 500	First	22	22	1	3	5	10	1

tonnes	Second	25	47					

K-2 NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

K-2.1 Defects in Coated Glass, Spectral Properties and Evaluation of Durability

Samples selected in **K-l.3** shall be examined for the requirements of defects in coated glass, spectral properties and evaluation of durability in two stages as shown in co1 2 of Table 10. A glass sample failing to satisfy any of these requirements shall be considered as defective. If the number of defective pieces found in the sample in the first stage is less than or equal to the corresponding number given in co1 5 of Table 10, the lot shall be accepted. If it is equal to or greater than the corresponding number given in co1 6 of Table 10, the lot shall be rejected without any further testing.

If the number of defective sheets found in the sample in the first stage lies between C_1 and C_2, a second such sample of the size prescribed in co1 3 of Table 10 shall be taken and examined. The lot shall be considered as conforming to these requirements if the combined number of defectives in the first and second stage is less than the corresponding number C_3, given in co1 7 of Table 10; otherwise the lot shall be rejected.

K-2.2 Nominal Thickness and Dimensional Tolerance

The lot, which has satisfied the requirements given in **K-2.1**, shall be examined for these requirements. The sample sheets required for testing these characteristics shall be selected from those examined under **K-2.1** and found satisfactory. The sample size for these tests shall be as given in co1 8 of Table 10. The lot shall be considered to have met these requirements, if the number of defective sheets found in the sample is less than or equal to the corresponding number C_4, given in co1 9 of Table 10.