BUREAU OF INDIAN STANDARDS

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Draft *Indian Standard*

CHEMICALLY TEMPERED GLASS SCREEN PROTECTOR - SPECIFICATION

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रासायनिक रूप से टेम्पर्ड ग्लास स्क्रीन रक्षक — विशिष्टि

ICS 31.120

Glass, Glassware & Laboratoryware Sectional Committee, CHD 10

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FOREWORD

(Formal clauses will be added later)

In India, demand for chemically tempered screen protectors is rising due to their durability, scratch resistance, and screen clarity. While initially popular for smartphones, these protectors are now widely used for other electronics, including tablets, laptops, smart watches, fitness trackers, and gaming consoles like the Nintendo Switch. With tablets and laptops increasingly featuring touch screens, tempered glass protectors help prevent wear and damage from daily use. Smart watches and fitness trackers, often exposed to active environments, benefit from added durability. As portable electronics become more prevalent, tempered screen protectors are valued for maintaining screen integrity across various devices.

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

IEC 61747-40-1	Mechanical testing of display cover glass for mobile devices-Guidelines
IEC 61747-40-2	Mechanical testing of display cover glass for mobile devices – Uni-axial flexural strength (4-point bend)
IEC 61747-40-3	Mechanical testing of display cover glass for mobile devices -Biaxial flexural energy to failure (ball drop)
IEC 61747-40-4	Mechanical testing of display cover glass for mobile devices – Biaxial flexural strength (ring-on-ring)

IEC 61747-40-5	Mechanical testing of display cover glass for mobile devices – Strength against dynamic impact by a sharp object with the specimen rigidly supported
IEC 61747-40-6	Mechanical testing of display cover glass for mobile devices – Retained biaxial flexural strength (abraded ring-on-ring)
ASTM C1422	Specification for Chemically Strengthened Flat Glass
BS EN 12337-1:2000	Glass in building Chemically strengthened soda lime silicate glass
BS EN 12337-2:2004	Glass in building —Chemically strengthened soda lime silicate 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.

1 SCOPE

This standard specifies the requirements, method of sampling, and tests for glass screen protector that is used as an added protection on smartphones, tablets, PC screens, E-readers, etc.

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provisions of 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 below:

IS No.	**Title**
IS 1382 : 1981	Glossary of terms relating to glass and glassware (first revision)
IS 4905 : 2015	Random sampling and randomization procedures (first revision)
IS 14900 : 2018	Transparent float glass —Specification (first revision)
IS 17004 : 2018	Testing methods for processed glass

3 TERMS AND DEFINITIONS

3.1 Depth of layer/compression (DOL) *or* Case depth

Depth of compression below the surface to the nearest zero stress plane.

3.2 Chemically strengthened/tempered glass

Glass which has been strengthened by ion exchange to produce a compressive stress layer at the treated surface.

3.3 Tempered Glass screen protector

It is a multi-layered protective covering designed for electronic device screens, made up of chemically strengthened/tempered glass and may have other components such as adhesive layer (glue), anti-shatter film, oleophobic coating, anti-glare film, blue light cutting layer, anti-finger coating, privacy films, etc.

3.4 Compressive stress

Surface stress created by tempering giving mechanical strength properties.

3.5 Ion exchange process for chemically strengthening of glass

The exchange of constituent ions in the glass with externally supplied ions (generally at temperatures near the strain point of the glass). This may be accomplished by immersing glass in a molten salt bath or solution with or without an electric field, ultrasonic or other assistance, exposing glass to plasma, applying a paste on the glass surface, or contacting glass with molten salts in a furnace.

3.6 Surface compression

An in-plane stress which tends to compact the atoms in the surface.

4 REQUIREMENTS

4.1 Dimensions and Tolerances

4.1.1 *Thickness*

Thickness shall be measured with a micrometer or callipers, which is graduated to 0.01 mm, or with a measuring instrument having an equivalent accuracy. The thickness shall not be greater than 0.70 mm. Only glass thickness shall be measured.

4.1.2 *Dimensions (Length and Width)*

4.1.2.1 The nominal dimensions, that is, width (W) and length (L) shall be as agreed to between the purchaser and the supplier. However, the finished pane shall not be larger than a prescribed rectangle of dimensions (W + v, L + v), or smaller than a prescribed rectangle of dimensions (W – v, L – v), where v is the maximum tolerance on nominal dimensions. The corresponding sides of the prescribed rectangles shall be parallel to each other, and these rectangles shall have a common centre (*see* Fig 1).

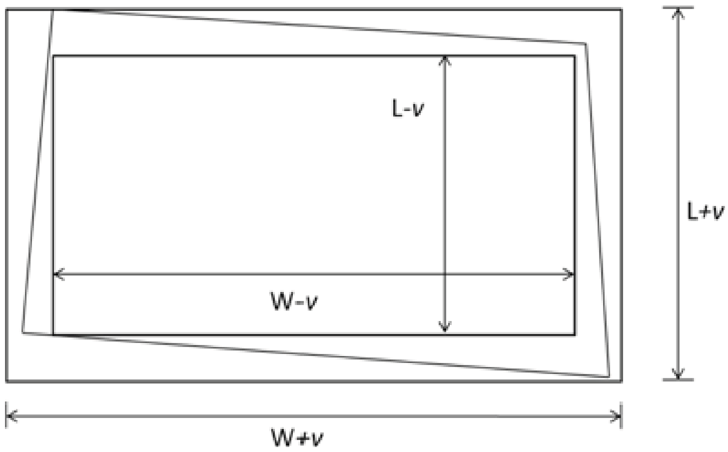

FIG. 1 TOLERANCE LIMITS FOR DIMENSIONS OF RECTANGULAR PANES

4.1.2.2 The length and width of the screen protector on cut sizes shall be measured with a Calliper which is graduated to 0.01 mm. The measurement shall be made on adjacent two sides. The tolerance (v) on nominal dimensions length L, and width W, shall be ± 0.05 mm.

4.2 Visual Light Transmission

The minimum value for visual light transmission for a screen protector, when measured as per the method specified in ***Annex B of IS 14900***, shall be greater than 90%. However, In case of privacy films used in screen protectors, the VLT shall not be less than 80%.

4.3 Visual Faults

4.3.1 *Spot Faults*

Spot faults are categorized based on their size. Determination of spot faults shall be done in accordance with ***Annex D of IS 14900***. The maximum permissible spot faults shall be as follows:

Pinholes: None allowed

Inclusions: None allowed

Bubbles: None allowed

Scratches: None allowed

4.3.2 *Reams, Strings, and Lines*

There shall be no reams, strings, and lines distinguished visually when tested in accordance with ***Annex E of IS 14900***.

4.3.3 *Linear / Extended Faults*

There shall not be any linear/extended faults when tested in accordance with ***Annex E of IS 14900***.

4.4 Defects on Cut Side

Defects in shape such as chipping of cut side, shelling, protrusion, slicing off, corners on/off, etc, shall be such that the deviation from the cutting line when viewed perpendicularly to the surface of the thin glass is not more than 0.1 mm.

4.5 Surface Compression

Chemically tempered screen protector glass shall be tested for surface compression in accordance to test method specified in **Annex-A**. The surface compression of chemically tempered screen protector glass shall not be less than 500 MPa.

4.6 Mechanical Strength Requirements

4.6.1 *Uniaxial Flexure Strength (four-point bend)*

Chemically tempered screen protector glass shall be subjected to four point bending test in accordance to the test method specified in **Annex-B**. The 10^{th} percentile weibull fracture stress calculated as prescribed in the **Annex-B** shall not be less than 200 MPa.

5 PACKING AND MARKING

5.1 Packing

5.1.1 Chemically tempered screen protector glass shall be packed as agreed to between the manufacturer and the purchaser.

5.1.2 The packet shall be marked with the following information:

a) Indication of the source of manufacture,

b) Nominal thickness of screen protector,

c) Code or batch number

d) Month and year of manufacture

5.2 Marking

5.2.1 Each piece of chemically tempered screen protector glass shall be marked legibly using fog marking with the following information:

a) Indication of the source and year of manufacture.

5.2.2 *BIS Certification Marking*

Each glass may also be marked with the standard mark. The use of the Standard Mark is governed by the provisions of The Bureau of Indian Standards Act, 2016 and the Rules and Regulations made thereunder. The details of the conditions under which the licence for use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

6 SAMPLING

Representative samples of the material shall be drawn as prescribed in Annex C. (Sampling plan will be developed once the requirements are finalized).

Annex A

(*Clause* 4.5)

Test Method for Surface Compression Stress and Case Depth

A-1 Apparatus for measuring of the surface stress and case depth in a section microscope

A-1.1 *Microscope*, used with a minimum objective times eyepiece magnification of 25x. Case depths <50 microns shall use a minimum magnification of 50x. The optimum magnification shall be selected based on the case depth.

A-1.2 *Polarizers*, installed in mutually crossed orientation, aligned at $+45^{o}$ to the symmetry plane of the microscope.

A-1.3 *Means of measuring distances between the black fringe and the edge*, including a fine-graduated reticle, an eyepiece reticle, or stage micrometer of appropriate resolution. The measuring system must resolve 1 µm or 2% of the case depth, whichever is greater.

A-2 Procedure for measurement of case depth

A-2.1 Using white light, identify the black fringe representing the transition from mid-plane tension to surface compression. Make the measurement of case depth from the center of that black fringe to the nearest fabrication surface using the reticle or micrometer. Compute the separation between the center of the dark fringe and the nearest surface using the known calibration and report as the case depth.

A-3 Procedure for measurement of surface compression stress

A-3.1 The retardation at the edge of the slice removed from the witness specimen, in other words, the surface stress of the sheet, can be measured and converted into stress units by using a microscope defined in A-1, either in conjunction with a suitable compensator or by photoelastic color pattern observation. The retardation can be converted to stress using the stress optic coefficient obtained from equation 1.

A-3.2 When visibility of the edge is inadequate, extrapolation techniques are permitted. To implement the extrapolation, measure the optical retardation or birefringence at several points between the zero fringe and the edge, typically in 10-µm intervals (a minimum of three points is required). The profile must be then extrapolated to the edge as shown in Fig. 2.

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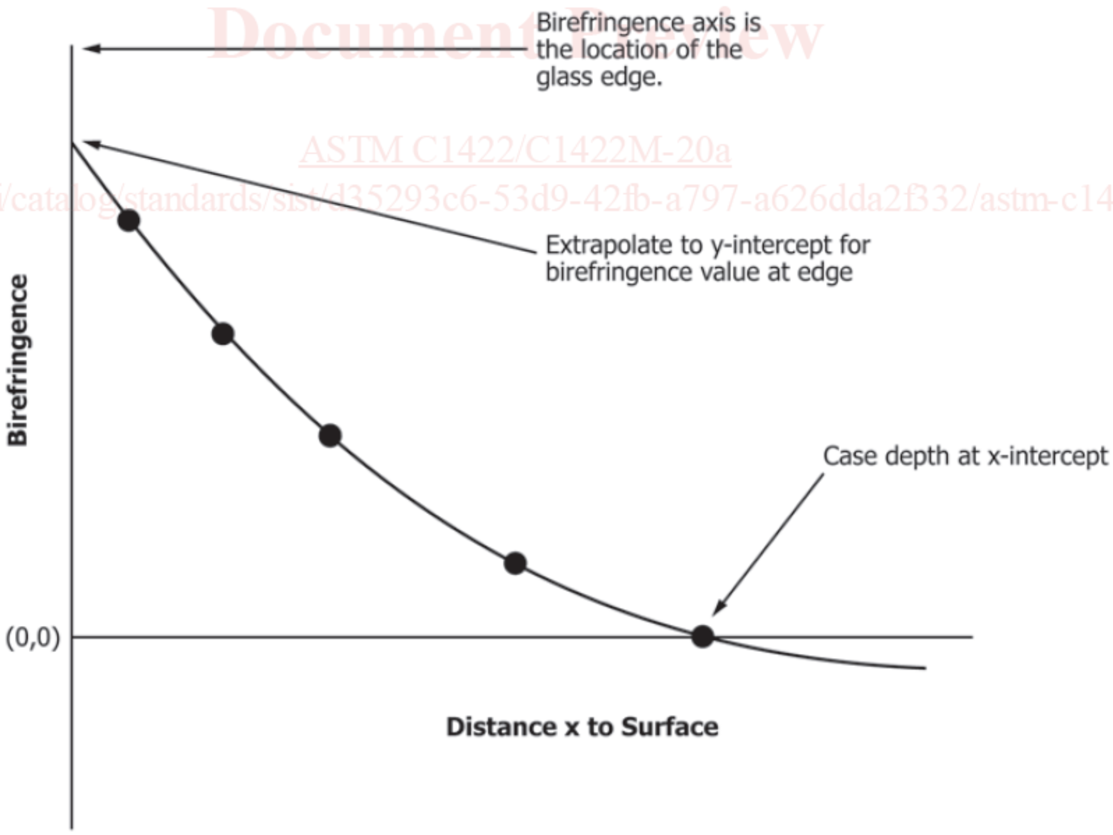


FIG. 2 Extrapolation Plot of Birefringence Versus Depth in Glass

A-4 Calculation of surface compression stress

A-4.1 When surface polarimetry is used, the manufacturer's calibration is required to convert the instrument reading to surface stress.

A-4.2 When edge retardation is measured in accordance with A-3.1 or in A-3.2, calculate stress using the following:

$$S = R / [tC (1 - v)] \qquad \text{…………………equation 1}$$

where:

S = stress, MPa;

R = measured retardation, nm;

t = slice thickness, mm;

v = Poisson's ratio (0.22 for most float glasses); and

C = stress-optic coefficient, 10^{-12} Pa^{-1} (Brewster) units, appropriate for the parent glass.

A-5 A test report shall include case depth and surface compression values (measured in accordance with the above test method.

Annex B

(*Clause* 4.6)

Uniaxial Flexure Strength (four-point bend) Test

B-1 APPARATUS

B-1.1 *Testing frame*

B-1.1.1 The testing frame provides the aspects needed for the controlled vertical movement of some mechanical elements relative to a test fixture surface. It also includes a load cell to indicate the applied force of these mechanical elements against other mechanical elements that are attached to the test surface and detectors to indicate displacement from the start of motion. A controller is also required to coordinate the necessary motions. These may be driven by external commands or by load cell responses. Examples of motion directives include:

- Jog up or down.
- Slow manual up or down until the stop button is pushed.
- Return to a preset start of test.
- Traverse downward at a fixed rate until fracture is detected, then stop.
- Emergency stop.

B-1.1.2 In addition to providing motion control and measurement of load, the controller shall, at minimum, report the fracture load, allow the setting of the load rate and the display load as a function of time and/or deflection from the start of the test. Other features can include:

- The collection, organization, storage, and reporting information entered for the sample, its specimens, fracture load data, and statistical analysis results.
- Calculating individual specimen fracture strength using data input for the specimen and the fracture load.

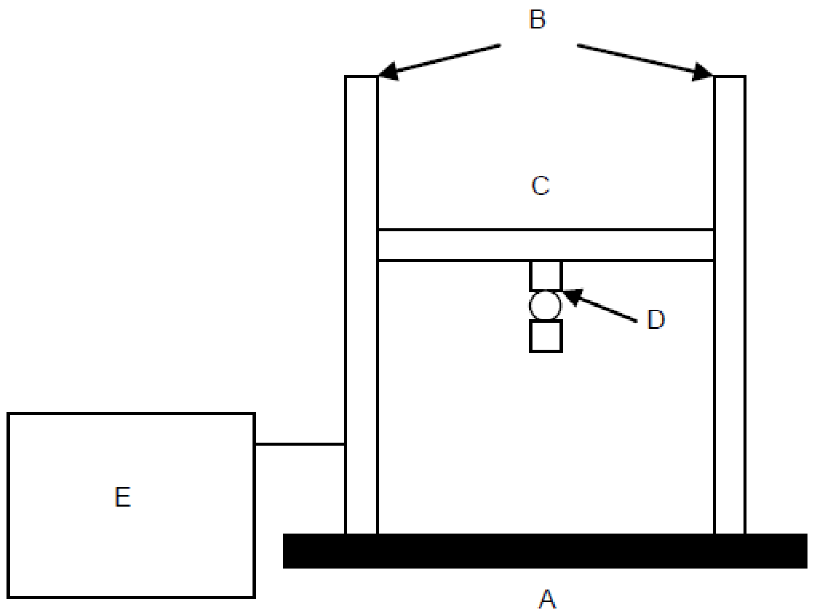
B-1.1.3 The main structural elements of the testing frame shall be made of steel with dimensions large enough so compliance is essentially zero with respect to the maximum force that will be applied. This maximum force depends on the specimens being tested, but should generally be less than 10 kN. These elements include:

- the testing surface,
- vertical support columns,
- a cross head,
- motion tractors within the support columns,
- load cell assembly and attachment mechanisms.

B-1.1.4 The minimum and maximum rates of motion shall encompass the range of 0.001 mm/min and1000 mm/min.

B-1.1.5 The controller shall sample the load cell and displacement detectors at a minimum rate of 10 kHz.

B-1.1.6 The load cell shall be calibrated against a known weight, force gauge or load cell and be linear to within 1 % over the maximum applied force. The load cell shall be capable of being reset to zero after the attachment of mechanical elements to it before the apparatus setup is complete. It shall also include an attaching mechanism. Fig. 3 illustrates some of the elements of the testing frame.



Key:

A Test surface

B Support columns

C Cross head (moves up and down)

D Load cell assembly

E Controller

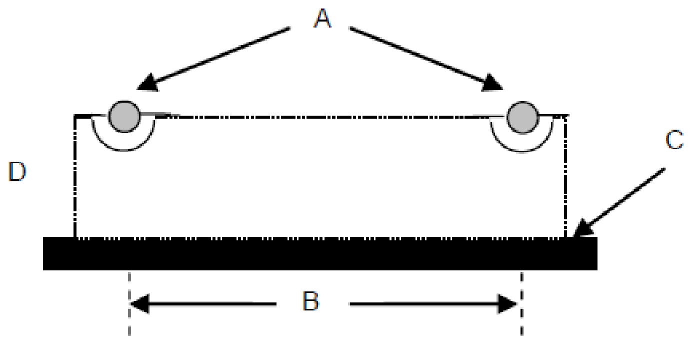
Fig.3 TESTING FRAME

B-1.2 ***Test fixture and setup***

B-1.2.1 This sub-clause outlines the generic test fixture elements and setup procedure. B-1.3 identifies the requirements of the dimensional characteristics, which can depend on specimen characteristics.

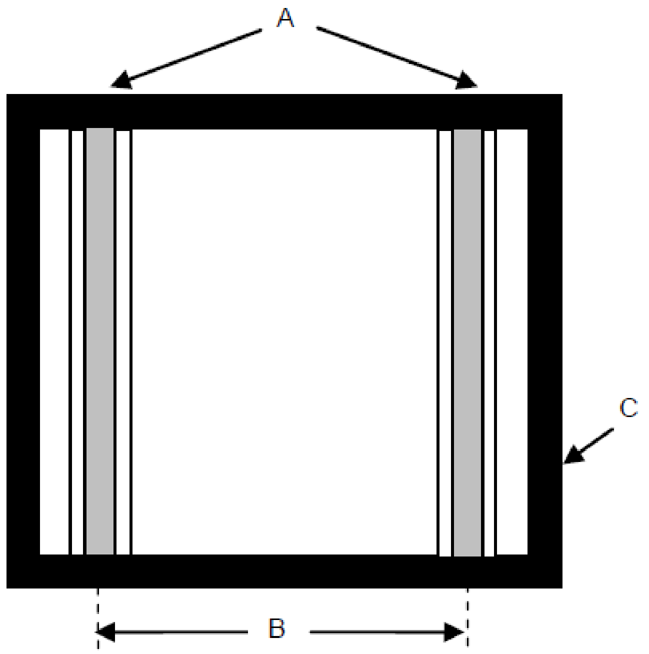
The primary test fixture elements are the support assembly and the load assembly. These are illustrated from Fig. 4 to Fig. 7. Other test fixture elements include:

- Clamps used to fasten the support assembly to the test frame testing surface.
- PTFE tape used to cover the support bars.
- Machined installation gage to align the support and load assemblies.
- Micrometer with flat anvil faces and resolution of 0,002 mm or better.



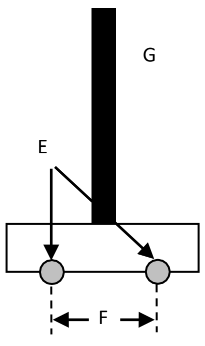
NOTE: *The key to the letters is provided in Fig. 7.*

Fig. 4 SUPPORT ASSEMBLY (SIDE VIEW)



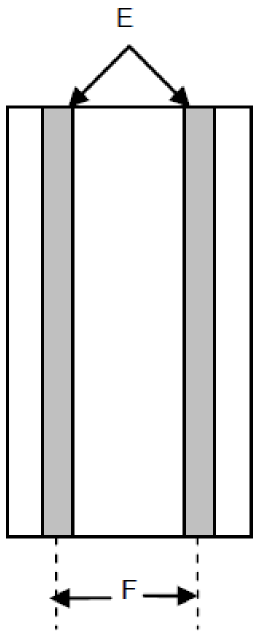
NOTE: *The key to the letters is provided in Fig. 7.*

FIG. 5 SUPPORT ASSEMBLY (TOP VIEW)



NOTE: *The key to the letters is provided in Fig. 7.*

FIG. 6 LOAD ASSEMBLY (SIDE VIEW)



Key:

A Support bars with optional rollers

B Support bar separation, d_S

C Support assembly attachment surface

D Support assembly body

E Load bars

F Load bar separation, d_L

G Compression bar

FIG. 7 LOAD ASSEMBLY (BOTTOM VIEW)

B-1.2.2 *Setup steps include:*

a) Attach the load assembly to the test frame load cell assembly at the compression bar.

b) Reset to zero on the load cell.

c) Cover the support bars with PTFE tape.

d) Roughly center the support assembly below the load assembly.

e) Place the installation gage onto the support bars so the bottom grooves contain the bars.

f) Slowly, lower the cross head and adjust the support assembly until the load bars are contained in the installation gage top grooves.

g) Clamp the support assembly onto the test frame testing surface.

h) Raise the cross head until the separation of the load and support bars is suitable forloading a specimen and set the start point.

B-1.2.3 The installation gage bar is a machined metal block with top and bottom grooves corresponding to the load bars and support bars respectively. It is used to assure parallel alignment of the two assemblies. When assembled, the bars shall be parallel to 0.05 mm per 25 mm in length and concentric to within 0.25 mm. The parallelism requirement applies to:

- Support bar to support bar.
- Load bar to load bar.
- Support bars to load bars.

B-1.3 ***Test fixture dimensions***

B-1.3.1 The test fixture dimensions are driven by the specimen dimensions: length, *l*, width, *w*, and thickness, *h*. The radius of the load and support bars shall be greater than *h/*2. The load and support bar lengths shall be large enough to accommodate the maximum specimen width.

B-1.3.2 The height of the support assembly body shall be sufficient to accommodate the maximum specimen deflection. This is influenced by several factors such as the following, and best determined experimentally:

- Young's modulus of the material under test.
- Fracture strength of the specimens under test.
- Specimen thickness and width.

B-1.3.3 The support bar separation, d_S, and load bar separation, d_L, are set in terms of the nominal specimen length, l_{nom}, as in equations (2) and (3).

$$d_S \leq \frac{4}{5}\, l_{nom} \qquad \text{(2)}$$

$$d_L \leq \frac{1}{2}\, D_S \qquad \text{(3)}$$

B-1.3.4 The support bar separation is critical to obtaining comparable testing results because it can affect the Weibull scaling parameter. Unless otherwise specified, the support bar separation is 36 mm ± 0.5 mm.

B-1.3.5 These dimensions are partly intended to prevent non-linearities in loading behavior due to large specimen deflection, slippage and/or run-out failure. The latter occurs when the deflection is large enough to draw the specimen ends past the support bars. In this case, the failure load does not correspond to specimen fracture, but rather to the load at which the specimen slipped out of the support bars. The associated load values shall be suspended. This failure mode can often be observed as an unusual discontinuity in the applied load graph. Fig. 8 shows a normal load versus time graph, as well as a case of large deflection with associated slippage due to non-optimized span distances.

B-1.3.6 Support bar separation of 36 mm is needed to avoid excessive run-out failure on strengthened glasses. It provides 20% excess glass on each side of the support bar rather than the base recommendation of 10% excess glass.

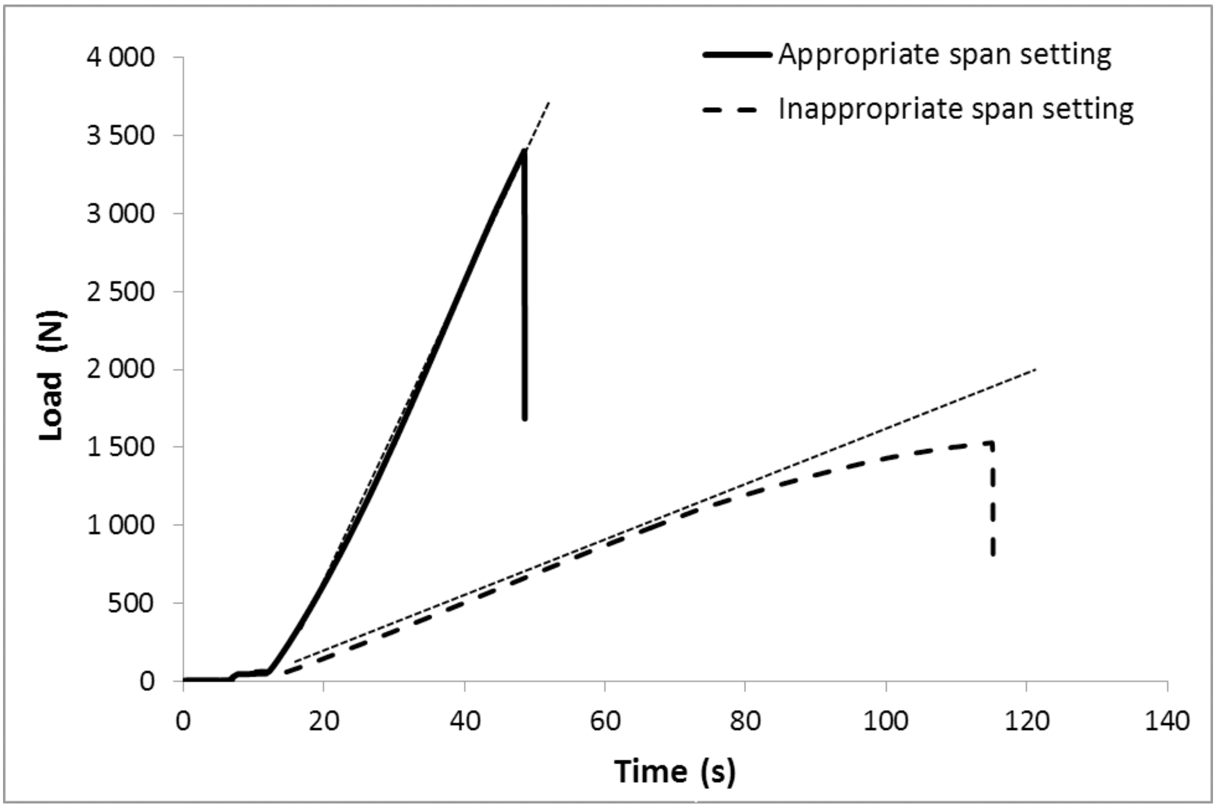


FIG. 8 EXAMPLE LOAD TRACES FOR APPROPRIATE AND INAPPROPRIATE SPAN SETTINGS

B-1.4 ***Loading rate***

B-1.4.1 The loading rate during testing shall be constant. It is given in terms of the cross head traverse rate. Unless otherwise specified the rate is 5 mm/min. As with fixture dimensions, data generated from testing at different loading rates are not directly comparable.

B-2 PROCEDURE

B-2.1 Sample

The sample size is 30, excluding any specimens rejected for pre-existing damage. Values associated with test run-out failure, surface breaks or edge breaks originating from outside of the load bar are included in the sample, but the values are treated as late suspensions. If there are more than 10 suspensions, the testing fails and a new sample shall be selected.

Upon receipt of a new sample, the following steps shall be taken:

a) Determine whether existing test fixtures are compatible. If not, change them as per B-1.

b) Set and record the loading rate.

c) Set the start-of-test height for the testing frame.

d) Zero the micrometer. This is done by gently closing the anvils with no specimen present,and pressing the reset button.

B-2.2 Individual specimen

Complete the following steps on each specimen of the sample. The working surfaces should be clean and free of anything that can induce damage.

a) Determine and record the specimen identification number.

b) Inspect for any damage. If damaged, report this, but do not include in the testing.

c) Return the test frame to the start-of-test position and place the specimen onto the support bars with the polymeric adhesive tape side up.

NOTE: The load bars will touch the polymeric adhesive tape side.

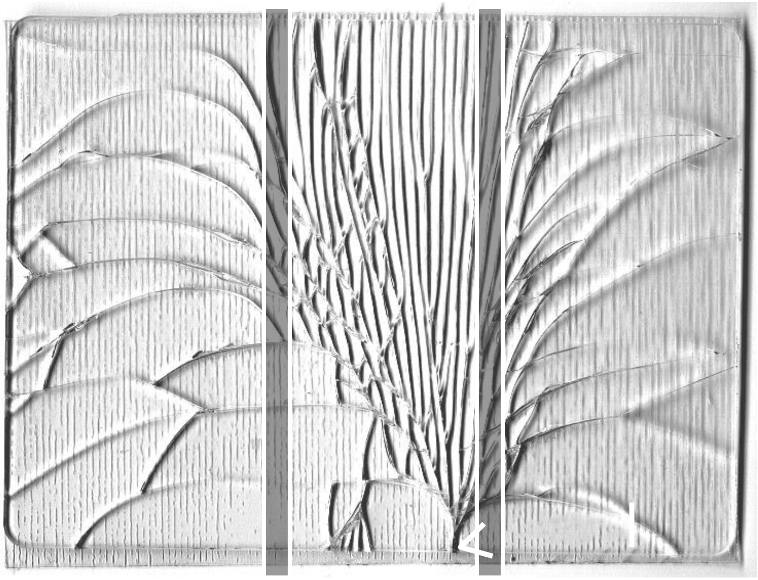
d) Start the test sequence.

e) Observe the load vs. time graph and other signs of testing progress for any abnormalities.

f) Record the failure load. Following this, calculate and record the failure stress.

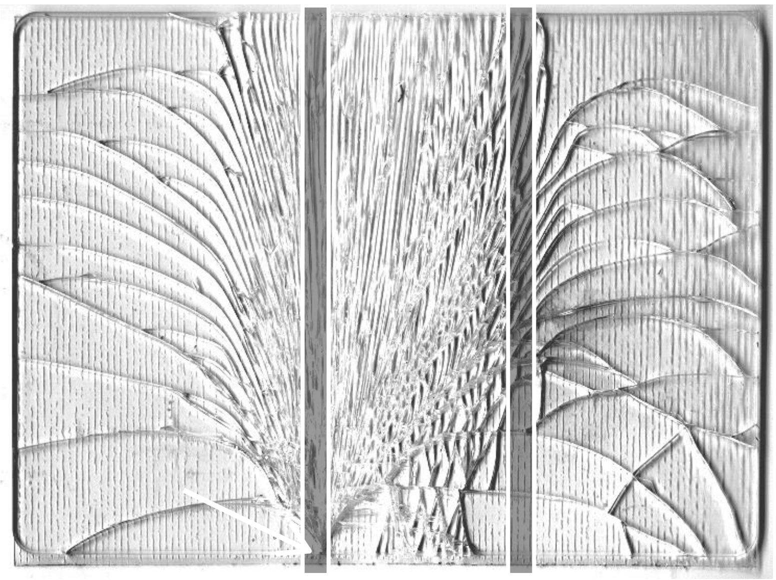
g) Inspect the fracture pattern to determine whether the break source originated from the edge between the load bars, the edge underneath the load bars, the edge outside of the load bars, or away from any edge. All but the first and second type listed, in which failure originates from an edge either underneath or between the load bars, shall be suspended. Fig. 9 illustrates a normal edge fracture pattern illustrating the desired failure mode. Fig. 10 illustrates an edge failure underneath the load bar, while Fig. 11 illustrates a surface fracture.

h) Remove the broken glass and thoroughly clean the area for the next test.



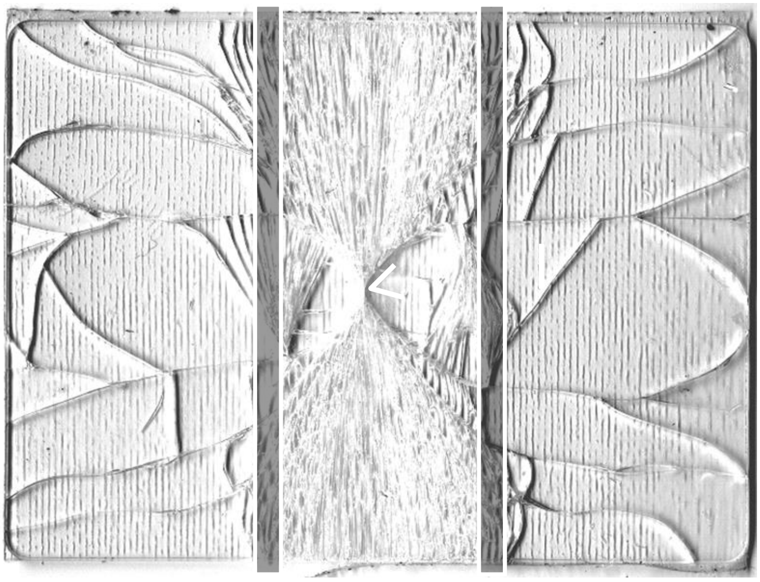
NOTE: Such a fracture represents the desired failure mode, and thus the resulting data point is treated as non- suspended. The dark vertical bars indicate the approximate load bar positions, while the white arrow tip represents the failure origin location.

FIG. 9 EDGE FRACTURE ORIGINATING FROM BETWEEN THE LOAD BARS



NOTE: Such a fracture originates from underneath the load bar, and thus the resulting data point is treated as non-suspended. The dark vertical bars indicate the approximate load bar positions, while the white arrow tip represents the failure origin location.

FIG. 10 EDGE FRACTURE ORIGINATING FROM UNDERNEATH THE LOAD BAR



NOTE: Such a fracture represents an undesired failure mode, and thus the resulting data point is suspended. The dark vertical bars indicate the approximate load bar positions, while the white arrow tip represents the failure origin location.

FIG. 11 SURFACE FRACTURE ORIGINATING FROM BETWEEN THE LOAD BARS

B-3 CALCULATIONS

B-3.1 Strength calculations

Strength σ, (MPa) is given as a function of fracture load (N) as equation (4).

$$\sigma = \frac{3L\,(d_S - d_L)}{2wh^2} \qquad \text{.................. (4)}$$

where:

d_S = support bar separation

d_L = load bar separation

w = specimen width (mm)

h = specimen thickness (mm)

L = fracture load (N)

B-3.2 Statistical calculations

B-3.2.1 The following maximum likelihood estimate (MLE) method of calculation shall be used to calculate the following Weibull parameters.

- Weibull scale parameter, η (MPa).
- Weibull shape parameter, β.
- the 10th percentile failure stress, B_{10} (MPa).

B-3.2.2 Let t_i represent valid failure strength values, with i = 1 to r, and let T_j represent the suspended values, with j = 1 to s. The shape parameter is the value of β that satisfies equation (5).

$$\frac{\sum_{i=1}^{r} t_i^{\beta} \ln t_i + \sum_{j=1}^{s} t_j^{\beta} \ln t_j}{\sum_{i=1}^{r} t_i^{\beta} + \sum_{j=1}^{s} t_j^{\beta}} - \frac{1}{\beta} - \frac{1}{r}\sum_{i=1}^{r} \ln t_i = 0 \qquad \text{………..…….. (5)}$$

B-3.2.3 Given this value for the shape parameter, the scale parameter, η is given as equation (6).

$$\eta = \left[\frac{1}{r}\left\{\sum_{i=1}^{r} t_i^{\beta} + \sum_{j=1}^{s} t_j^{\beta}\right\}\right]^{\frac{1}{\beta}} \qquad \text{..…………….. (6)}$$

B-3.2.4 The point estimate of the 10th percentile, B_{10}, is calculated using 9.8 of IEC 61649:2008 and equation (20) of IEC 62649:2008, which is repeated here as equation (6). In Clause 9, this parameter is recommended to be specified for performance standards. It combines the scale and shape parameters to single, meaningful, metric.

$$\beta_{10} = \eta[-\ln(0.9)]^{1/\beta} \qquad \text{……………… (7)}$$

B-3.2.3 In addition to the calculation of statistical parameters, a Weibull plot is required. An example of Weibull plot is shown in Fig. 12.

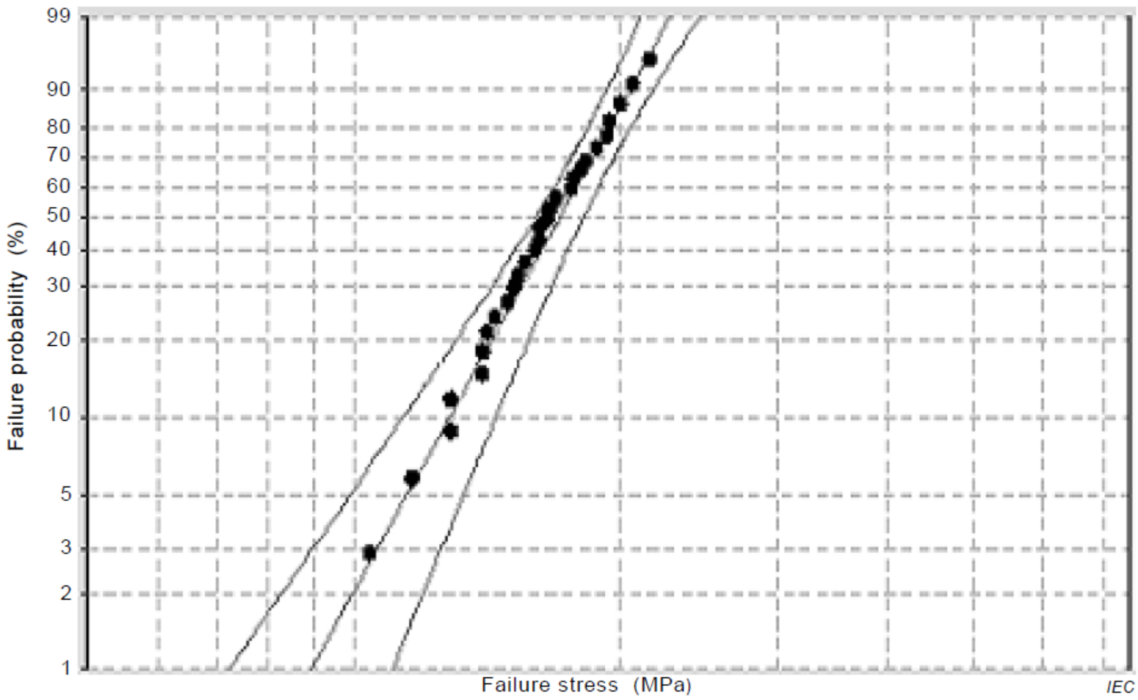


FIG. 12 EXAMPLE OF WEIBULL PROBABILITY PLOT OF FOUR-POINT BEND PERFORMANCE

B-4 TEST REPORT

Report the following for each test.

- Sample identification and nominal dimensions.
- Support bar separation, d_S (mm).
- Weibull scale parameter, η (MPa).
- Weibull shape parameter, β.
- Fracture strength 10th percentile, β_{10} (MPa).