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European Assessment Document for

Thermally curved annealed glass and laminated safety glass made of thermally curved annealed glass

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation No (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD specifies assessment methods for thermally curved annealed glass (made of soda lime silicate glass) and for curved laminated safety glass made of thermally curved annealed glass. The basic product is soda lime silicate glass according to EN 572-9[1]. This basic product is thermally bent to a circular uniaxial shape. However, this EAD covers all radii which are practically possible. The assessment methods as provided for in this EAD are also appropriate for laminated safety glass with an interlayer made of polyvinyl butyral (PVB) with a minimum thickness of 0,76 mm.

The products are not fully covered by the following harmonised technical specifications: EN 572-9 and EN 14449. Curved glass is not fully covered by those standards because the essential characteristics bending strength for the glass and the tensile strength and elongation at rupture of the PVB interlayer are not dealt with in those harmonised standards.

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

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

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA. The (range of) dimensions, thicknesses and radii shall be defined in the ETA.

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

1.2.1 Intended use(s)

The products are intended to be used vertically in façades with an inclination angle ≤ 10° and linear support. The products are not intended to be used under circumstances where bullet resistance, explosion resistance, burglar resistance or resistance to fire is requested.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of thermally curved annealed glass and laminated safety glass made of thermally curved annealed glass for the intended use of 25 years when installed in the works. These provisions are based upon the current state of the art and the available knowledge and experience.

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

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

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

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

1.3 Specific terms used in this EAD

1.3.1 Thermally curved annealed glass

The flat glass according to EN 572-1 is thermally bent to a circular uniaxial shape. The glass may be uncoated or coated according to EN 1096-4.

1.3.2 Laminated safety glass made of thermally curved annealed glass

The laminated safety glass made of thermally curved annealed glass is made of glass according to clause 1.3.1 with a PVB interlayer with a minimum thickness of 0,76 mm.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

The essential characteristics of thermally curved annealed glass and laminated safety glass made of thermally curved annealed glass are listed in two separate tables. The assessment methods apply to coated as well as to uncoated glass panes.

Table 2.1.1 shows how the performance of thermally curved annealed glass is assessed in relation to the essential characteristics.

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

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.2.1.1	class
Basic Works Requirement 4: Safety and accessibility in use			
2	Characteristic bending strength	2.2.2	Level, description
3	Pendulum body impact resistance: Shatter properties (safe breakability) and resistance to impact	EN 572-9, 4.1, 4.2.1 and 4.2.2.7	Class
4	Mechanical resistance: Resistance against sudden temperature changes and temperature differentials	EN 572-9, 4.1, 4.2.1 and 4.2.2.8	Level
5	Mechanical resistance: Resistance against wind, snow, permanent load and/or imposed loads of the glass unit	EN 572-9, 4.1, 4.2.1 and 4.2.2.9	Level
Basic Works Requirement 5: Protection against noise			
6	Direct airborne sound reduction	EN 572-9, 4.1, 4.2.1 and 4.2.2.10	Level
Basic Works Requirement 6: Energy conservation and heat retention			
7	Thermal properties	EN 572-9, 4.1, 4.2.1 and 4.2.2.11	Level
	Radiation properties:		
8	- Light transmittance and reflectance	EN 572-9, 4.1, 4.2.1 and 4.2.2.12	Level
9	- Solar energy characteristics	EN 572-9, 4.1, 4.2.1 and 4.2.2.13	Level

Table 2.1.2 shows how the performance of laminated safety glass made of thermally curved annealed glass is assessed in relation to the essential characteristics.

Table 2.1.2 Essential characteristics of laminated safety glass made of thermally curved annealed glass and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
1	Reaction to fire	2.2.1.2	Class
Basic Works Requirement 4: Safety and accessibility in use			
2	Tensile strength and elongation at rupture of the PVB interlayer	2.2.3	Level, Description
3	Pendulum body impact resistance: Shatter properties (safe breakability) and resistance to impact	EN 14449, 4.2, 4.3.1 and 4.3.2.7	Class
4	Mechanical resistance: Resistance against sudden temperature changes and temperature differentials	EN 14449, 4.2, 4.3.1 and 4.3.2.8	Level
5	Mechanical resistance: Resistance against wind, snow, permanent load and/or imposed loads of the glass unit	EN 14449, 4.2, 4.3.1 and 4.3.2.9	Level
Basic Works Requirement 5: Protection against noise			
6	Direct airborne sound reduction	EN 14449, 4.2, 4.3.1 and 4.3.2.10	Level
Basic Works Requirement 6: Energy conservation and heat retention			
7	Thermal properties	EN 14449, 4.2, 4.3.1 and 4.3.2.11	Level
	Radiation properties:		
8	- Light transmittance and reflectance	EN 14449, 4.2, 4.3.1 and 4.3.2.12	Level
9	- Solar energy characteristics	EN 14449, 4.2, 4.3.1 and 4.3.2.13	Level
Aspects of durability			
10	Durability	2.2.4	Description

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

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

2.2.1 Reaction to fire

2.2.1.1 Reaction to fire of thermally curved annealed glass

The thermally curved annealed glass is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire in accordance with the Commission Decision 96/603/EC, as amended by Commission Decisions 2000/605/EC and 2003/424/EC, without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

Therefore, the performance of thermally curved annealed glass is class A1.

2.2.1.2 Reaction to fire of laminated safety glass made of thermally curved annealed glass

Laminated safety glass made of thermally curved annealed glass with an organic PVB interlayer is comparable to panel products with organic layer that are excluded from the list of Commission Decision 96/603/EC, as amended by Commission Decisions 2000/605/EC and 2003/424/EC. The laminated safety glass made of thermally curved annealed glass shall be tested, using the test method(s) relevant for the corresponding reaction to fire class. The laminated safety glass made of thermally curved annealed glass shall be classified according to Commission Delegated Regulation (EU) No 2016/364 in connection with EN 13501-1.

Concerning mounting and fixing conditions see Annex A.

The class of the reaction-to-fire-performance shall be given in the ETA together with those conditions (see relevant parameters addressed in Annex A) for which the classification is valid.

2.2.2 Characteristic bending strength

Purpose of the test

The purpose of the test is to determine the characteristic bending strength $f_{g,kk}$ of thermally curved annealed glass.

Test conditions

The minimum and maximum thickness as covered by the ETA, with the respective minimum radius, shall be tested.

For each thickness 15 specimens with the dimensions 1100 mm (dimension of the chord; the length of the specimen depends on the minimum radius that shall be tested and may deviate) x 360 mm shall be tested on the basis of EN 1288-3. In addition to EN 1288-3, the specifications in figure 2.2.2.1 shall be respected. The specimens shall be allowed to bend freely, without obstacle, during the test.

Assessment

To evaluate the test results, the normal stresses, respecting the radius, the thickness and the related tolerances shall be considered.

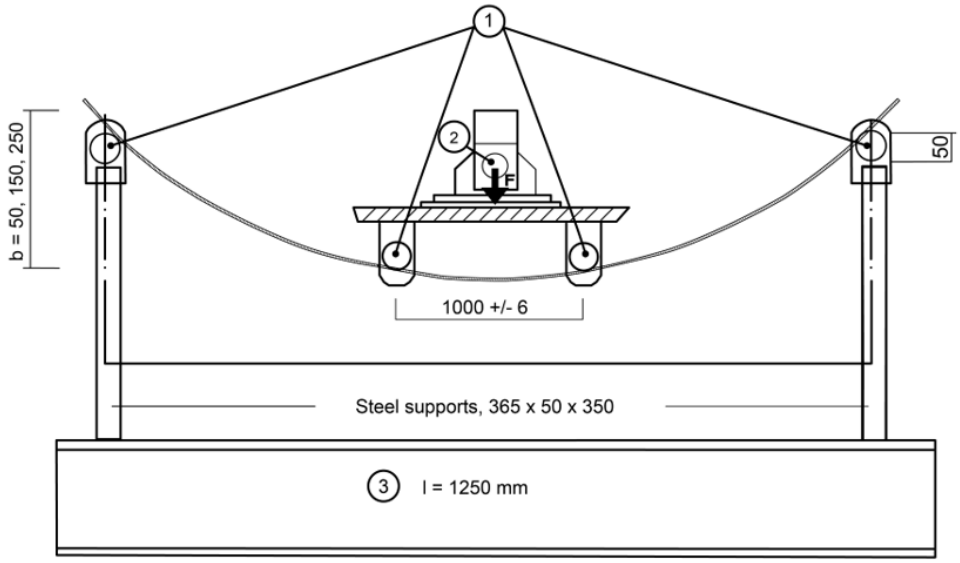
Due to the nonlinear deformation behaviour of the curved panes during the four-point bending test, the formulas given in EN 1288-3 are inappropriate to calculate the breaking stress. Therefore, the tensile strain

shall be measured by a strain gauge, which is applied on three identical specimens in the middle of the longitudinal axis (see Figure 2.2.2.1). For this purpose, uniaxial strain gauges (120Ω or 350Ω) with a gauge length of ≥ 2.5 mm are to be bonded in the center of the specimen on the surface under tensile stress. The measuring axis of the gauge has to be oriented parallel to the long side of the specimen. A bonding with cyanoacrylate is suitable.

After the load-strain curve has been recorded and evaluated by a curve fitting, the breaking stress shall be calculated by a finite element analysis (implementing the radius, thickness). Curve fitting is a technique that attempts to best fit a given mathematical model function to data points. A torsion or tensile spring shall be used to adjust the strain values of the measurement with the strain values in the finite element analysis. The model of the finite element analysis is calibrated with the results of test. After having calibrated the finite element model the stress can be calculated from the strain depending on the loads which have been measured in the bending tests on the 15 specimens.

The strain measurement shall be carried out on the surface of tensile stress.

The characteristic bending strength $f_{g,kk}$ shall be determined on the basis of 5 % breakage probability, statistically evaluated at the lower limit of the 95 % confidence interval and stated in the ETA.



① Self-aligning ball bearing protected by EPDM seals (EPDM shore 60°, thickness 5 mm)

② Test stamp, bearing mounted

③ Steel section HE 160 B according to EN 10365

Figure 2.2.2.1 Test set-up for determining the characteristic bending strength

2.2.3 Tensile strength and elongation at rupture of the PVB-interlayer

For laminated safety glass made of thermally curved annealed glass an interlayer made of polyvinyl butyral (PVB) is present. Tensile strength and elongation at rupture of the PVB-interlayer shall be determined according to EN ISO 527-3 with a test speed of 50 mm/min at 23 °C, test specimen type 5 according to figure 2 of this standard. Tensile strength and elongation at rupture of the PVB interlayer (arithmetic mean values) shall be given in the ETA.

2.2.4 Durability of the laminated safety glass made of thermally curved annealed glass

The durability of the laminated safety glass made of thermally curved annealed glass shall be tested according to EN ISO 12543-4, clauses 4 to 5.3.3. If coated glass is used with the coating towards the interlayer, the durability tests shall be done for this composition as well. The tests shall be done under conditions of high temperature and of humidity, see clauses 5 (method A) and 6.3.1 or, alternatively, as an equivalent procedure, 6.3.2 of the standard. In addition, the dimensions, respectively the tolerances, according to EN ISO 12543-5, Table 5, and the appearance according to EN ISO 12543-6 shall be recorded.

In the ETA it shall be stated whether defects have been detected after the test according to EN 12543-4, clause 5.4, and the dimensions, respectively the tolerances, according to EN ISO 12543-5, figure 2, and the appearance as described in EN ISO 12543-6 shall be recorded (not taking into account the maximum number of defects as indicated in this standard).

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

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

For the products covered by this EAD the applicable European legal act is Commission Decision 2000/245/EC, as amended by Commission Decision 2001/596/EC.

The systems are

- 3 or 4 for uses subject to reaction to fire regulations, depending on the conditions set out in the said Decision,
- 3 or 4 for uses subject to external fire performance, depending on the conditions set out in the said Decision,
- 3 for uses liable to present 'safety-in-use' risk, other than as anti-bullet or anti-explosion glazing, and subject to such regulations
- 3 for uses related to energy conservation and/or noise reduction, and
- 4 for other uses.

3.2 Tasks of the manufacturer

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

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Check of initial raw materials (glass, PVB-interlayer)	Inspection documents in accordance with EN 10204	According to control plan	---	Every production unit
2	Durability of laminated safety glass made of thermally curved annealed glass	2.2.4	According to control plan	Three	Once a month
3	Appearance of laminated safety glass made of thermally curved annealed glass	2.2.4	According to control plan	Two	Permanently

4 REFERENCE DOCUMENTS

EN 572-1:2012+A1:2016	Glass in building – Basic soda lime silicate glass products – Part 1: Definitions and general physical and mechanical properties
EN 572-9:2004	Glass in building – Basic soda lime silicate glass products – Part 9: Evaluation of conformity / Product standard
EN 1096-4:2018	Glass in building – Coated glass – Part 4: Product standard
EN 1288-2:2000	Glass in building – Determination of the bending strength of glass – Part 2: Coaxial double ring test on flat specimens with large test surface areas
EN 1288-3:2000	Glass in building – Determination of the bending strength of glass – Part 3: Test with specimen supported at two points (four point bending)
EN 10204:2004	Metallic products - Types of inspection documents
EN 10365:2017	Hot rolled steel channels, I and H sections – Dimensions and masses
EN 13501-1:2018	Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests
EN 13823:2020	Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item
EN 14351-1:2006+A2:2016	Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets
EN 14449:2005+AC:2005	Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity / Product standard
EN ISO 527-3:2018	Plastics – Determination of tensile properties – Part 3: Test conditions for films and sheets (ISO 527-3:2018)
EN ISO 1716:2018	Reaction to fire tests for products – Determination of the gross heat of combustion (calorific value) (ISO 1716:2018)
EN ISO 12543-4:2021	Glass in building – Laminated glass and laminated safety glass – Part 4: Test methods for durability (ISO 12543-4:2021)
EN ISO 12543-5:2021	Glass in building – Laminated glass and laminated safety glass – Part 5: Dimensions and edge finishing (ISO 12543-5:2021)
EN ISO 12543-6:2021	Glass in building – Laminated glass and laminated safety glass – Part 6: Appearance (ISO 12543-6:2021)

ANNEX A: TESTING OF LAMINATED GLASS PANES, LAMINATED SAFETY GLASS PANES IN SBI-TEST

A.1 General

When glass panes have to be tested in the SBI test according to EN 13823 then the mounting and fixing and the direct rules of application of the test result shall be as described in the following:

Parameters which are relevant for the test procedure:

- Design of the glass panes,
- Type and thickness of the glass used for the external glass pane layers,
- Type (chemical composition) and thickness of the intermediate layers,
- Type of the external coatings of the glass plane,
- Symmetrical or unsymmetrical construction of the glass pane.

A vertical joint at a distance of 200 mm from the internal edge of the SBI test specimen and the horizontal joint arrangement will not be considered (if they shall be considered then the product shall be treated as a window, handled, e.g., in EN 14351-1), because this configuration can be seen as "worst case" with regard to the intended use described in clause 1.2.1.

The two wings of the test specimen shall be arranged on the trolley according to EN 13823, figure 2. A support frame made out of metal profiles shall be arranged on the backside. The function of this support frame is just to hold the glass against the lower U-profile and the upper stop for preventing the glass panes to fall over. The distance of the backside of the glass panes to the backing board shall be at least 80 mm. The measures for having free ventilation (see EN 13823, clause 5.2.2 a)) shall be taken.

When doing tests in the SBI-test, sealing and spacer bars shall be included in the test specimens.

Comment: When determining the PCS-values according to EN ISO 1716, sealings and spacer bars shall not be considered. That is also valid for the calculation of the PCS-values used as base for the purpose of classification according to EN 13501-1.

Irrespective of the above rule, results of SBI tests are only valid for the assembly of the glass panes with those sealing and spacer bars that were used for the test specimens. The assessed performance is only valid if sealing and spacer bars are used with the same or smaller dimensions and with a PCS-value (related to the mass) equal or lower than the value of those sealing and spacer bars that were part of the SBI test specimens.

A.2 Symmetrical construction of the glass panes

A.2.1 Symmetrical construction of the glass panes with one intermediate layer

A.2.1.1 One single test (one test specimen) shall be carried out with a glass which has the thinnest thickness of the external glass panes (per type of glass to be used) and the intermediate layer which shows the maximum thickness and which verified the maximum heat value (PCS value) according to EN ISO 1716.

A.2.1.2 One single test (one test specimen) shall be carried out with a glass which has the thinnest thickness of the external glass panes (per type of glass to be used) and the intermediate layer which shows the maximum thickness and which verified the maximum heat value (PCS value) according to EN ISO 1716 and a possible external coating (e.g., foils, markings or enamels, etc.) with the most critical coating to be verified first by determination of the heat value according to EN ISO 1716.

A.2.1.3 With the most critical variant found from the tests A . 2 .1.1 and A . 2 .1.2 another two test specimens are tested so that the three test results on hand for this variant will be the basis for classifying the reaction to fire of the laminated safety glass made of thermally curved annealed glass.

The results with the smallest thickness of the glass can also be taken for glass with a larger thickness.

The results based on an assessment with an intermediate layer with the largest thickness and the most critical PCS can also be taken for intermediate layers with the same or a smaller thickness and/or a smaller PCS.

A.2.2 Symmetrical construction of the glass panes with multi-layer intermediate layers

Tests in accordance with clause A.2.1 shall be carried out with the maximum number of intermediate layers, testing with both the thinnest and thickest layers.

A.3 Asymmetrical construction of the glass panes

A.3.1 Asymmetrical construction of the glass panes – single-layer intermediate layer

For each side of the glass pane one single test (one test specimen) shall be performed according to clause A.2.1.1.

For the variant, which shows the more critical test result, tests following section A.2.1.2 and B.2.1.3 shall be carried out.

A.3.2 Asymmetrical construction of the glass panes – multi-layer intermediate layers

The test shall be done following test A.1 with the maximum number of intermediate layers.

Comment: Using the above-mentioned rules it is possible to make a grouping for getting different classifications and, therefore, families depending on

- the thickness, the type, the PCS-value and the number of the intermediate layers,
- the type and thickness of the glass, and
- the type of the external coating.