BS EN 302-2:2013

BSI Standards Publication

Adhesives for load-bearing timber structures — Test methods

Part 2: Determination of resistance to delamination

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National foreword

This British Standard is the UK implementation of EN 302-2:2013. It supersedes BS EN 302-2:2004, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PRI/52, Adhesives.

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

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Foreword

This document (EN 302-2:2013) has been prepared by Technical Committee CEN/TC 193 “Adhesives”, the secretariat of which is held by AENOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2013 and conflicting national standards shall be withdrawn at the latest by September 2013.

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

This document supersedes EN 302-2:2004.

The following modifications have been made:

— The glue spread for minimum and maximum assembly time is now given for aminoplastic and phenolic adhesives;

— The standard is now used for assessing the compliance for adhesives with EN 301, EN 15425 and prEN 16254.

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

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Introduction

This document is one of a series dealing with adhesives for use with timber structures, and is published in support of EN, 1995 *Eurocode 5: Design of timber structures*. The series consists of three classification and performance requirements for adhesives for load-bearing timber structures, phenolic and aminoplastic adhesives (EN 301), one component polyurethane adhesives (EN 15425) and emulsion polymerised isocyanate adhesives (prEN 16254), and all together eleven test methods (EN 302 Parts 1 to 7 and EN 15416 Parts 2 to 5).

These European Standards have the following titles:

EN 301, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures — Classification and performance requirements*

EN 15425, *Adhesives — One component polyurethane for load bearing timber structures — Classification and performance requirements*

prEN 16254, *Adhesives — Emulsion polymerized isocyanate (EPI), for load-bearing timber structures — Classification and performance requirements*

EN 302, *Adhesives for load-bearing timber structures — Test methods*

— *Part 1: Determination of longitudinal tensile shear strength*

— *Part 2: Determination of resistance to delamination*

— *Part 3: Determination of the effect of acid damage to wood fibres by temperature and humidity cycling on the transverse tensile strength*

— *Part 4: Determination of the effects of wood shrinkage on the shear strength*

— *Part 5: Determination of maximum assembly time under referenced conditions*

— *Part 6: Determination of the minimum pressing time under referenced conditions*

— *Part 7: Determination of the working life under referenced conditions*

EN 15416, *Adhesives for load bearing timber structures other than phenolic and aminoplastic — Test methods*

— *Part 2: Static load test of multiple bondline specimens in compression shear*

— *Part 3: Creep deformation test at cyclic climate conditions with specimens loaded in bending shear*

— *Part 4: Determination of open assembly time for one component polyurethane adhesives*

— *Part 5: Determination of conventional pressing time*

Safety statement

Persons using this document should be familiar with the normal laboratory practice, if applicable. This document cannot address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any regulatory conditions.

Environmental statement

It is understood that some of the material permitted in this standard can have a negative environmental impact. As technological advantages lead to better alternatives for these materials, they will be eliminated from this standard to the greatest extent possible.

At the end of the test, it is recommended that the user of the standard take care to carry out an appropriate disposal of the wastes, according to local regulations.

1 Scope

This European Standard specifies a method for determining the resistance to delamination in glue lines.

It is suitable for the following applications:

a) for assessing the compliance of adhesives with EN 301, EN 15425 and prEN 16254;

b) for assessing the suitability and quality of adhesives for load-bearing timber structures;

c) for comparing the effects on the bond strength resulting from the choice of bonding conditions, from different climatic conditioning and from the treatment of the test pieces before and after bonding.

This test is not applicable for modified and stabilised wood with strongly reduced swelling and shrinkage properties, such as acetylated wood, heat-treated wood and polymer impregnated wood.

This test is intended primarily to obtain performance data for the classification of adhesives for load-bearing timber structures according to their suitability for use in defined climatic environments.

This method is not intended to provide data for structural design, and does not necessarily represent the performance of the bonded member in service.

2 Normative references

Not applicable.

3 Principle

Bonded, laminated specimens are subjected to an impregnation-drying procedure. The specimens are impregnated with water by immersing them and applying alternating high and low (vacuum) pressure. They are then dried rapidly in a specified air stream at low humidity (see 4.4). The extent of open glue lines, delamination, as a result of these treatments is measured and compared with the total length of glue lines on both end-grain faces of the specimen.

4 Apparatus

4.1 Autoclave or similar pressure vessel, designed to safely withstand a pressure of at least 625 kPa absolute (525 kPa above nominal atmospheric pressure).

4.2 Vacuum pump or similar device, capable of reducing the pressure in the vessel (4.1) to below 20 kPa absolute (80 kPa below nominal atmospheric pressure).

4.3 Pump or similar device, for obtaining a pressure of at least 600 kPa absolute (500 kPa above nominal atmospheric pressure).

4.4 Air-circulating oven(s) or chamber(s), capable of drying the test pieces (see 5.4) in the following climate condition:

a) for low temperature procedure (type II adhesive) a temperature of (27,5 ± 2,5) °C, circulating the air within the chamber, maintaining a constant relative humidity of (30 ± 5) %; and

b) for high temperature procedure (type I adhesive) a temperature of (65 ± 3) °C, circulating the air within the chamber, maintaining a relative humidity of (12,5 ± 2,5) %.

NOTE Air speed velocity of 2 m/s to 3 m/s in empty chamber has shown to be suitable to achieve drying times according to 5.4.2 and 5.4.3.

4.5 Balance, allowing measurements with an accuracy of ± 1 g.

4.6 Wood chisel and hammer, or similar devices capable of opening the glue lines.

5 Method

5.1 Selection of timber

Use flat-sawn, straight-grained Norway spruce (*Picea abies* L.), free of reaction wood, with a density of (450 ± 25) kg/m³ at (12 ± 1) % moisture content. Preferably, knot-free wood should be used, but allowances are made for boards with knots up to a maximum of 20 mm in diameter, but splay (spike) knot is not allowed. The test with Norway spruce also covers approval of silver fir (*Abies alba*) and Scots pine (*Pinus sylvestris*).

If the adhesive is to be used on wood from other conifer species like larch (*Larix decidua*), Douglas fir (*Pseudotsuga menziesii*) and pines with coloured heartwood (other than Scots pine (*Pinus sylvestris*)), from hardwood species and/or on preservative treated wood, also prepare four laminated members using representative samples using wood with mean density.

Condition the timber in the standard climate [20/65] ((20 ± 2) °C and a relative humidity of (65 ± 5) %) for at least 7 days prior to bonding, ensuring that the timber has a moisture content of (12 ± 1) %.

5.2 Preparation of the bonded members

Make four laminated members, two with short assembly time and two with long assembly time. For each laminated member, prepare six lamellae at least (150 ± 5) mm wide, (30 ± 1) mm thick and approximately 500 mm long from six different boards. The desired thickness is achieved by planing 38 mm thick lamellae. Store the lamellae in standard climate [20/65] before planing and gluing. Bond the lamellae in accordance with Table 1, within 8 h of planing. Within each assembly, ensure that the six lamellae present the same growth ring symmetry.

Table 1 — Preparation of the bonded members

Parameters	Members 1 and 2	Members 3 and 4
Adhesive spread, single sided (can be 2 faces for hardwood) Mixed and/or separate	For aminoplastic and phenolic adhesives: 250 g/m² For other adhesives as recommended by the adhesive manufacturer	For aminoplastic and phenolic adhesives: 400 g/m² For other adhesives as recommended by the adhesive manufacturer
Air temperature	(20 ± 2) °C	(20 ± 2) °C
Open assembly time	Maximum 5 min [c]	Maximum 5 min [c]
Closed assembly time	Minimum [d]	Maximum [d]
Pressure (conifers) [a]	(0,6 ± 0,1) N/mm²	(0,6 ± 0,1) N/mm²
Pressure time [b]	As recommended [b]	As recommended [b]

[a] For hardwood species, larch, Douglas fir and pines with coloured heartwood, the pressure shall be that recommended by the adhesive manufacturer.

[b] As recommended by the adhesive manufacturer for a curing temperature of (20 ± 2) °C.

[c] Or as recommended by the adhesive manufacturer.

[d] As recommended by the adhesive manufacturer at standard climate.

If the adhesive system is intended for only separate application, then premixed adhesive and hardener shall not be tested by this standard.

After bonding and pressing and before cutting and testing, condition the assembly for 7 days to 14 days in the standard climate [20/65].

5.3 Preparation of test pieces

Trim the bonded member to a width of at least 145 mm. From a full cross-section of each of the four laminated members to be tested, cut two test pieces using a sharp saw or other tool that produces a smooth surface. Remove sections 75 mm long by cutting perpendicularly to the surface of the assembly and not less than 50 mm from either end of the member. Record the time elapsed between the preparation of the test pieces and testing.

5.4 Test procedures

5.4.1 General

Weigh and record the original mass (m_0) of the test pieces to the nearest gram. Place the test pieces in the pressure vessel and secure them to prevent them from floating. Add water at a temperature of 10 °C to 25 °C to completely submerge the test pieces. Separate the test pieces by using at least 5 mm thick stickers, wire screens or other means in such a way that all end-grain surfaces are freely exposed to the water. Carry out either the high temperature procedure according to 5.4.2 for testing compliance with the requirements for type I adhesives for use in severe climatic conditions, or the low temperature procedure according to 5.4.3 for testing compliance with the requirements for type II adhesives for use in moderate climatic conditions.

5.4.2 High temperature procedure (for type I adhesives)

Reduce the pressure in the vessel to (25 ± 5) kPa absolute and maintain that pressure for 15 min. Release the vacuum and apply a pressure of (600 ± 25) kPa absolute for one hour. With the test pieces still completely immersed, repeat this vacuum-pressure treatment once again to give a two-cycle impregnating period requiring a total of about 2 h 30 min.

Dry the test pieces for (20 ± 2) h in an oven or chamber as described in 4.4 at (65 ± 3) °C and a relative humidity of (12,5 ± 2,5) %. During drying, place the test pieces at least 50 mm apart with the end-grain surfaces parallel to the air stream.

After an 18 h drying period, control the mass of the test pieces on a weighing scale to the nearest gram. The end of an impregnating-drying cycle for any given test piece shall only be considered when the mass of the test piece is between 102 % and 108 % of the original mass (m_0). Should the mass of any given test piece exceed its original mass (m_0) by more than 8 % after the 18 h drying treatment has elapsed, place the test piece in the drying duct once again, and subject it to further identical drying conditions. Remove the test piece and re-weigh its mass after 1 h. Repeat this process until the test piece is within the required mass range. All test pieces shall be dried within 22 h. Some hardwood species may need longer drying time, but the drying period shall not exceed 30 h. If a test piece does not fulfil the requirement, the test piece shall be rejected and new pieces shall be made and tested. Record the mass of the test piece after every impregnating-drying cycle and record the total drying time needed to reach the required mass of the respective test piece. Should the mass of the test piece be lower than its original mass (m_0) after the drying treatment, the test piece shall be rejected, and new test pieces shall be made and tested.

Test pieces may be removed and subjected to a weight inspection during the drying treatment before the 18 h have elapsed, so as to ensure that the test pieces are not over-dried. The drying time can be shorter than 18 h when the samples fulfil the delamination requirement.

Repeat the entire impregnating-drying cycle twice to achieve three cycles, comprising a total test period of just over three days.

Interruption after each cycle (for several days) is allowed.

5.4.3 Low temperature procedure (for type II adhesives)

Reduce the pressure in the vessel to (25 ± 5) kPa absolute and maintain that pressure for 15 min. Release the vacuum and apply a pressure of (600 ± 25) kPa absolute for 1 h. With the test pieces still completely immersed, repeat this vacuum-pressure cycle once more to give a two-cycle impregnating period requiring a total of 2 h 30 min.

Dry the test pieces for (90 ± 6) h in an oven or chamber described in 4.4 at (27,5 ± 2,5) °C and (30 ± 5) % relative humidity. During drying, place the test pieces at least 50 mm apart with the end-grain surfaces parallel to the air stream.

After the elapsed drying period, control the mass of the test pieces on a weighing scale to the nearest gram. The end of an impregnating-drying cycle for any given test piece shall only be considered when the mass of the test piece is between 102 % and 108 % of the original mass (m_0). Should the mass of any given test piece exceed its original mass (m_0) by more than 8 % after the 90 h drying treatment has elapsed, place the test piece in the drying duct again, and subject it to further identical drying conditions. Remove the test piece and re-weigh its mass after 2 h. Repeat this process until the test piece is within the required mass range. Record the mass of the test piece after every impregnating-drying cycle and record the total drying time needed to reach the required mass of the respective test piece. Should the mass of the test piece be lower than its original mass (m_0) after the drying treatment, the test piece shall be rejected, and new test pieces shall be made and tested.

Test pieces may be removed and subjected to a weight inspection during the drying treatment before the 90 h have elapsed, so as to ensure that the test pieces are not over-dried.

Repeat the entire impregnating-drying cycle once to achieve two cycles comprising a total test period of eight days.

Interruption after each cycle (for several days) is allowed.

Table 2 — Cyclic treatments for the delamination test

Treatment	Parameters	Units	High temperature procedure for Type I adhesive	Low temperature procedure for Type II adhesive
Water impregnation	Water temperature	°C	10 to 25	10 to 25
	Absolute pressure	kPa	25 ± 5	25 ± 5
	Duration	min	15	15
	Absolute pressure	kPa	600 ± 25	600 ± 25
	Duration	h	1	1
	Nr impregnation cycles	-	2	2
Drying	Air temperature	°C	65 ± 3	27,5 ± 2,5
	Air humidity	%	12,5 ± 2,5	30 ± 5
	Air circulation [a]	m/s	-	-
	Duration	h	(20 ± 2)	(90 ± 6)
	Number of complete cycles (A cycle consists of two water impregnation treatments and one drying treatment.)	-	3	2

[a] Air circulation of 2 m/s to 3 m/s in empty chamber has proven to be suitable.

5.5 Measurement and evaluation of delamination

Mark all the delamination immediately after removing the test pieces from the drying chamber. The evaluation and the calculation of the delamination can be done at a later stage. The total delamination and the total length of the glue lines on both end-surfaces shall be measured in millimetres.

The use of a magnifying glass with a magnification of approximately 10 x and strong lighting is recommended to determine whether the opening in the glue line is a valid delamination or not.

Consider the following glue line openings as being **valid delamination**:

a) cohesive failure within the body of the adhesive;

b) adhesive failure of an adhesive bond (glue line) such that the separation appears to be at the adhesive/adherend interface (between the adhesive layer and the wood);

c) a wood failure which is invariably within the first layers of cells beyond the adhesive layer, in which the fracture path is not influenced by the grain angle and the growth-ring structure. It is characterised by a fine, woolly appearance of the wood fibres which border the interface between the wood laminate and the adhesive layer.

Do **not** regard the following glue line openings as delamination:

d) a solid wood failure in which the fracture path is strongly influenced by the grain angle and the growth-ring structure;

e) isolated openings in the glue line which are less than 2,5 mm long and more than 5 mm away from the nearest delamination;

f) openings in the glue line which are found along knots or resin pockets which border the glue line, or openings in the glue line which are caused by hidden knots in the glue line. When the cause of an opening in the glue line due to the presence of a knot is suspected, the glue line shall be opened with a wedge and hammer (or similar device) and be inspected for the presence of a hidden knot. Should the cause of the opening be due to a hidden knot, the opening shall not be considered a delamination;

g) a failure in the latewood area of an annual ring which is adjacent and parallel to the glue line.

The delaminated glue lines shall be opened for a more careful examination when the maximum delamination requirement has been exceeded.

NOTE This can be achieved using a wood chisel and hammer (or similar device).

6 Expression of results

The delamination shall be expressed in percentage and shall be calculated for each of the test pieces. It shall be rounded off to the nearest 0,1 % point. Delamination is calculated using the following formula:

$$D = \frac{l_1}{l_2} \times 100$$

where

D is the delamination, in percent;

l_1 is the total delamination length on both end-grain surfaces, in millimetres;

l_2 is the total nominal length of the glue lines on both end-grain surfaces after trimming, in millimetres.

7 Test report

7.1 The adhesives

The following information about the adhesive shall be included in the test report:

a) chemical nature and origin of the adhesive sample;

b) manufacturer's name and batch number or other means of uniquely identifying the sample;

c) number of components and method of preparation and application.

7.2 Preparation of test pieces and testing procedure

The following information about the preparation of the test pieces and the testing procedure shall be included in the test report:

a) wood species with botanical name;

b) wood density expressed in kg/m³ at 12 % moisture content;

c) chemical treatment of the wood, if any;

d) any special treatment of the lamellae to be bonded;

e) bonding procedure (i.e. adhesive spread, closed assembly time and pressure time);

f) time elapsed between the bonding and the preparation of the test pieces and also between the preparation of the test pieces and testing;

g) method of test (low or high temperature procedure).

7.3 Test results

The following information about the test results shall be included in the test report:

a) that the test was carried out in accordance with EN 302-2;

b) total length of open joints on the two end-grain surfaces of each test piece expressed as a percentage of the total nominal length of the glue lines on these two end-grain surfaces;

c) date of issue of the report;

d) any other factors that may have affected the results.

Bibliography

[1] EN 301, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures — Classification and performance requirements*

[2] EN 15425, *Adhesives — One component polyurethane for load bearing timber structures — Classification and performance requirements*

[3] prEN 16254, *Adhesives — Emulsion polymerized isocyanate (EPI) for load-bearing timber structures — Classification and performance requirements*

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