

Australian/New Zealand Standard™

# Timber—Bond performance of structural adhesives



## **AS/NZS 4364:2010**

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee TM-004, Glued Laminated Timber Products. It was approved on behalf of the Council of Standards Australia on 27 October 2010 and on behalf of the Council of Standards New Zealand on 29 October 2010. This Standard was published on 1 December 2010.

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# Australian/New Zealand Standard™

## Timber—Bond performance of structural adhesives

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## PREFACE

This Australian/New Zealand Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee TM-004, Glued Laminated Timber Products, to supersede AS/NZS 4364:1996, *Adhesives, phenolic and aminoplastic for load-bearing timber structures—Classification and performance requirements*, and AS/NZS 4364(Int):2007.

The objective of this Australian/New Zealand Standard is to provide requirements for bond performance of adhesives formed in structural finger-jointed timber and glulam products. It is largely based on the Canadian Standards Association document CSA O112.9, *Evaluation of adhesives for structural wood products (exterior exposure)*. Alternative requirements, taken from the European Standards, are also included.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

## CONTENTS

|                                                                                  | <i>Page</i> |
|----------------------------------------------------------------------------------|-------------|
| FOREWORD.....                                                                    | 4           |
| 1 SCOPE.....                                                                     | 5           |
| 2 APPLICATION .....                                                              | 5           |
| 3 NORMATIVE REFERENCES .....                                                     | 5           |
| 4 DEFINITIONS.....                                                               | 6           |
| 5 NOTATION.....                                                                  | 6           |
| 6 REQUIREMENTS.....                                                              | 7           |
| 6.1 Classification and specification.....                                        | 7           |
| 6.2 Adhesive formulation and application.....                                    | 7           |
| 6.3 Fillers and extenders .....                                                  | 7           |
| 6.4 Anti-fungal properties.....                                                  | 7           |
| 6.5 pH of cured adhesive film .....                                              | 7           |
| 6.6 Shear strength and wood failure.....                                         | 8           |
| 6.7 Delamination resistance .....                                                | 9           |
| 6.8 Creep resistance .....                                                       | 9           |
| 7 SAMPLE PREPARATION AND TEST METHODS.....                                       | 10          |
| 7.1 Anti-fungal properties.....                                                  | 10          |
| 7.2 pH of cured adhesive film .....                                              | 10          |
| 7.3 Wood species and density .....                                               | 10          |
| 7.4 Wood moisture content .....                                                  | 11          |
| 7.5 Shear test and wood failure assessment.....                                  | 11          |
| 7.6 Delamination resistance test.....                                            | 16          |
| 7.7 Creep resistance test.....                                                   | 20          |
| 8 REPORT .....                                                                   | 28          |
| 8.1 General .....                                                                | 28          |
| 8.2 Product details .....                                                        | 28          |
| 8.3 Specimen preparation and testing.....                                        | 28          |
| 8.4 Test results.....                                                            | 29          |
| APPENDICES                                                                       |             |
| A MEASUREMENT AND COMPUTATION OF BONDLINE CREEP FOR ENVIRONMENTS A, B AND C..... | 30          |
| B INTERRUPTING THE BOIL-DRY-FREEZE CONDITIONING .....                            | 31          |
| C EXAMPLE OF CALCULATING TOTAL DELAMINATION WITHIN AN INDIVIDUAL BONDLINE.....   | 32          |
| BIBLIOGRAPHY .....                                                               | 34          |

## FOREWORD

This Australian/New Zealand Standard focuses on bondline performance and is directed principally at the evaluation of wood adhesives. When used in this manner the tests and assessments are made against standardized wood species. It is expected that product Standards (e.g., for glulam, laminated veneer lumber, etc.) would insist that selected requirements be met in the establishment of a new production line or the introduction of a new product, new adhesive, new species, etc., on an existing production line as part of qualification procedures.

## STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

## Australian/New Zealand Standard

### Timber—Bond performance of structural adhesives

**1 SCOPE**

This Australian/New Zealand Standard specifies performance requirements for adhesives according to their suitability for use in prefabricated timber components for structural use in defined environmental conditions and for such adhesives for the manufacture of structural finger-jointed timber and glulam.

NOTE: This Australian/New Zealand Standard does not cover the performance requirements for adhesive bonds between structural timber components in plywood, LVL, and wood-based panel products; however, the adhesive bond requirements may be applicable to these products.

**2 APPLICATION**

This Australian/New Zealand Standard is intended to be used primarily by adhesive manufacturers.

The requirements of the adhesive bond are based on the performance of the adhesive as measured by the following properties:

- (a) Resistance to biological degradation .....Clause 6.4.
- (b) pH of cured adhesive film .....Clause 6.5.
- (c) Resistance to shear in the dry and wet states by compression loading .....Clause 6.6.
- (d) Hydro-mechanical response or resistance to delamination  
during exposure to wetting and drying .....Clause 6.7.
- (e) Resistance to creep under static shear loading during exposure  
to high humidity, heat and combined heat and moisture .....Clause 6.8.

Either Method A or Method B shall be chosen for testing resistance to shear, resistance to delamination, and resistance to creep (Section 7). There shall be no mixing of Methods A and B (for example, Method A for shear resistance and Method B for delamination) nor shall retesting of the same adhesive be permitted once the choice of the test method family (A or B) is made.

**NOTES:**

- 1 In the case of resistance to shear in the dry and wet states, resistance to delamination during exposure to wetting and drying, and resistance to creep static shear loading during exposure to high humidity, heat and combined heat and moisture, two alternative requirements are provided. Method A is based on CSA O112.9 and Method B is based on EN test methods (see Clause 3).
- 2 The current product Standards refer to Type I and II adhesives, which prescribe requirements for use in Service Classes 1, 2, 3, as defined in Table 6.1.1.

**3 NORMATIVE REFERENCES**

The following are the normative documents referenced in this Standard:

**AS/NZS**

1080 Timber—Methods of test

1080.1 Method 1: Moisture content

1080.3 Method 3: Density

4491 Timber—Glossary of terms in timber-related Standards

## ASTM

D1583 Standard Test Method for Hydrogen Ion Concentration of Dry Adhesive Films

D4300 Standard Test Methods for Ability of Adhesive Films to Support or Resist the Growth of Fungi

## EN

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

302 Adhesives for load-bearing timber structures—Test methods

302-1 Part 1: Determination of bond strength in longitudinal tensile shear strength

302-2 Part 2: Determination of resistance to delamination

302-3 Part 3: Determination of the effect of acid damage to wood fibres by temperature and humidity cycling on the transverse tensile strength

15416 Adhesives for load bearing timber structures other than phenolic and aminoplastic—Test Methods

15416-2 Part 2: Static load test of multiple bondline specimens in compression shear

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

**4 DEFINITIONS**

For the purpose of this Standard, the definitions in AS/NZS 4491 and those below apply.

**4.1 Back-sawn timber**

Timber in which the growth rings make an angle of less than 45° with its wider face.

**4.2 Service Class****4.2.1 Service Class 1**

A service class characterized by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air exceeding 65% for a few weeks per year.

**4.2.2 Service Class 2**

A service class characterized by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air exceeding 85% for a few weeks per year.

NOTE: In Service Class 2, the average equilibrium moisture content (EMC) of most softwoods does not exceed 20%. Such conditions include resistance to the effects of moisture on structural performance due to construction delays, or other conditions of similar severity.

**4.2.3 Service Class 3**

A service class characterized by climatic conditions leading to higher moisture contents than Service Class 2 such as when a member is fully exposed to the weather.

**4.3 Wood failure percentage**

The percentage of wood fibre ruptured during the separation of an adhesive/adherent interface and used to evaluate the effectiveness of adhesive bonding.

**5 NOTATION**

The symbols used in this Standard are as follows:

$D$  = creep displacement at a cross-section, in millimetres [see Figure 7.7.1(B)]

$n$  = dummy suffix

- $N$  = number of cross-sections considered in assessing creep displacements  
 $\partial$  = delamination percentage (see Clause 7.6.1.6)

## 6 REQUIREMENTS

### 6.1 Classification and specification

#### 6.1.1 Classification

The adhesive shall be classified as being suitable for Service Class 1, Service Class 2 or Service Class 3 conditions, as specified in Table 6.1.1.

**TABLE 6.1.1**  
**ADHESIVE FOR GIVEN SERVICE CONDITIONS**

| Service Class | Description            | Timber equilibrium moisture content (EMC) | Temperature | Suitable adhesive type* |
|---------------|------------------------|-------------------------------------------|-------------|-------------------------|
| 1             | Interior               | ≤12%                                      | <50°C       | II                      |
| 2             | Exterior but protected | Untreated timber—≤18%;                    | <50°C       | II                      |
|               |                        | Multi-salts treated softwood—≤20%         | Any         | I                       |
| 3             | Exterior               | Any                                       | Any         | I                       |

\* The adhesive type is referenced in the EN Standards referred to in Method B procedures of this Standard and also in AS/NZS 1328.1 and AS 5068.

#### 6.1.2 Specification

The evaluated adhesive formulation shall contain all ingredients, including fillers, catalysts, hardeners, accelerators, modifiers, inhibitors and other additives necessary for—

- the setting or curing of the adhesive;
- the provision of specific properties to the liquid such as appropriate viscosity, open and closed assembly times, etc.; and
- the development of relevant properties in the final cured state (e.g., strength, creep resistance, etc.).

### 6.2 Adhesive formulation and application

The adhesive formulation shall be applied to the wood substrate in accordance with the specification for that adhesive.

### 6.3 Fillers and extenders

The type and amount of fillers and/or extenders used in the adhesive shall comply with the specification for that adhesive.

### 6.4 Anti-fungal properties

If the adhesive contains amylaceous and/or protein-based components, the adhesive, when tested in accordance with Clause 7.1, shall possess sufficient anti-fungal properties to inhibit the growth of selected fungal species to a grading of OC, OM, NG, as defined in ASTM D4300.

### 6.5 pH of cured adhesive film

When determined in accordance with Clause 7.2, the cured adhesive film shall have a pH of not less than 3.0. If the pH is less than 3.0, the adhesive shall be tested in accordance with EN 302-3 and shall meet the requirements of EN 301.

## 6.6 Shear strength and wood failure

### 6.6.1 General

#### 6.6.1.1 Adhesives for use within Service Class 1 and Service Class 2

Shear strength results shall meet or exceed the requirements specified in Clause 6.6.3.

#### 6.6.1.2 Adhesives for use within Service Class 3

Shear strength and wood failure results shall meet or exceed the requirements specified in Clause 6.6.2 or 6.6.3.

### 6.6.2 Method A—Block shear

#### 6.6.2.1 General

When tested in accordance with Clause 7.5.1, the block shear test results shall meet or exceed the shear strength requirements specified in Clause 6.6.2.2 and the percentage wood failure requirements of Clause 6.6.2.3.

#### 6.6.2.2 Block shear requirements

Following the treatments specified in Clauses 7.5.1.3, 7.5.1.4, and 7.5.1.5, the median shear strength requirements of samples shall meet or exceed the requirements specified in Table 6.6.2(A).

**TABLE 6.6.2(A)**  
**MEDIAN STRENGTH REQUIREMENTS**

| Treatment and condition at test           | Megapascal |          |
|-------------------------------------------|------------|----------|
|                                           | Hardwood   | Softwood |
| Dry—Clause 7.5.1.3                        | 19         | 10       |
| Wet (vacuum-pressure test)—Clause 7.5.1.4 | 11         | 5.6      |
| Wet (boil-dry-freeze test)—Clause 7.5.1.5 | 6.9        | 3.5      |

NOTE: Not more than 50% of specimens shall have a shear strength less than that specified in this Table.

#### 6.6.2.3 Wood failure

The percentage wood failure shall be assessed on the same specimens used to determine the block shear strength in accordance with Clause 6.6.2.2.

The percentage wood failure in the block shear specimens for each of the treatments shall meet or exceed the values specified in Table 6.6.2(B).

**TABLE 6.6.2(B)**  
**WOOD FAILURE REQUIREMENTS**

| Test condition     |                                     | Hardwood       |        | Softwood       |        |
|--------------------|-------------------------------------|----------------|--------|----------------|--------|
|                    |                                     | Lower quartile | Median | Lower quartile | Median |
| Dry—Clause 7.5.1.3 |                                     | 15%            | 60%    | 75%            | 85%    |
| Wet                | Vacuum-pressure test—Clause 7.5.1.4 | 55%            | 80%    | 75%            | 85%    |
|                    | Boil-dry-freeze test—Clause 7.5.1.5 |                |        |                |        |

NOTES:

- Not more than 25% of the samples shall have a percentage wood failure less than the lower quartile value.
- Not more than 50% of the samples shall have a percentage wood failure less than the median value.

### 6.6.3 *Method B—Tensile shear*

When tested in accordance with EN 302-1, the tensile shear test result shall meet the requirements specified in EN 301.

## 6.7 Delamination resistance

### 6.7.1 *General*

Delamination tests shall be carried out in accordance with Method A, as specified in Clause 7.6.1, or Method B, as specified in Clause 7.6.2, and shall meet the requirements specified in Clause 6.7.2 or 6.7.3, as appropriate.

### 6.7.2 *Method A*

#### 6.7.2.1 *Evaluation for hardwoods*

When tested in accordance with Clause 7.6, the total delamination within any one bondline shall not exceed 1.6% of the total length of the bondline in the assembly.

#### 6.7.2.2 *Evaluation for softwoods*

When tested in accordance with Clause 7.6, the total delamination within any one bondline shall not exceed 1% of the total length of the bondline in the assembly.

### 6.7.3 *Method B*

When tested in accordance with EN 302-1, the delamination result shall meet the requirements specified in EN 301.

## 6.8 Creep resistance

### 6.8.1 *General*

Creep resistance tests for all Service Classes shall be carried out in accordance with Method A or Method B, and shall meet the requirements specified in Clause 6.8.2 or 6.8.3, as appropriate.

NOTE: Based on documented historical evidence, phenolic formulations that, prior to the publication of this Standard, have been tested and met the requirements of AS/NZS 4364:1996 may be exempted from the creep resistance test.

### 6.8.2 *Method A—Creep displacement under environments A, B and C (see Table 7.7)*

When tested in accordance with Clause 7.7.1—

- (a) the overall average creep displacement (see Figure 7.7.1(B) and Appendix A) across all bonded cross-sections within any of the six specimens (full-length or full-length cut into partial lengths) tested under environments A, B, and C shall not exceed 0.05 mm; and
- (b) the maximum average creep displacement at any single bonded cross-section shall not exceed 0.25 mm after the prescribed load period.

### 6.8.3 *Method B*

When tested in accordance with EN 15416-2, the creep resistance result shall meet the requirements specified in EN 15425.

## 7 SAMPLE PREPARATION AND TEST METHODS

### 7.1 Anti-fungal properties

Testing for anti-fungal properties shall be in accordance with ASTM D4300.

### 7.2 pH of cured adhesive film

Testing for pH of cured adhesive film shall be in accordance with ASTM D1583.

### 7.3 Wood species and density

#### 7.3.1 Hardwood

When adhesives for hardwoods are tested in accordance with Clauses 7.5 to 7.7, the tests shall be performed on hard maple (*acer saccharum* or *acer nigrum*) of density specified in Clause 7.3.3, or the species specified in the relevant EN Standard.

#### 7.3.2 Softwood

##### 7.3.2.1 General

Except as specified in Clause 7.3.2.2, when adhesives for softwoods are tested in accordance with Clauses 7.5, 7.6 and 7.7, the tests shall be performed on one of the following species:

- (a) For testing to Method A—
  - (i) lodgepole pine (*Pinus contorta* var. *latifolia*);
  - (ii) black spruce (*Picea mariana*); or
  - (iii) Douglas fir (*Pseudotsuga menziesii*).
- (b) For testing to Method B, a species specified in the relevant CEN Standard.

The density of softwood shall be as specified in Clause 7.3.3.

##### 7.3.2.2 Environment C requirements in creep resistance test

When adhesives for softwoods are tested in accordance with the requirements of Clause 7.7 for environment C, the test shall be performed on any suitable softwood species capable of sustaining the specified load under the prescribed conditions.

Where the suitable softwood species is not available, for the purpose of this performance test, the test shall be performed on hard maple.

### 7.3.3 Wood density

#### 7.3.3.1 Method A test

A 25 mm long full cross-section shall be cut a minimum of 150 mm from the end of each board used to provide wood samples for the tests specified in Clauses 7.5, 7.6 and 7.7.

The oven-dry density shall be determined in accordance with AS/NZS 1080.3 for each full cross-section and shall meet the following requirements:

- (a) For hardwoods ..... 650 kg/m<sup>3</sup> or greater.
- (b) For softwoods ..... 490 kg/m<sup>3</sup> or greater.

When a softwood species is specified for testing in accordance with the requirements of Clause 7.7 for environment C, the oven-dry density shall be reported.

#### 7.3.3.2 Method B test

The density requirements shall be as specified in the relevant EN Standards.

## 7.4 Wood moisture content

The following shall apply:

- (a) The moisture content shall be determined in accordance with the oven-dry method specified in AS/NZS 1080.1.
- (b) The moisture content variation of the wood samples shall not vary more than  $\pm 3\%$  when the average moisture content is less than 25%.
- (c) When the adhesive sample is designated as suitable for bonding green timber, the moisture content of all the samples shall be greater than 25% at the time of bonding.

## 7.5 Shear test and wood failure assessment

### 7.5.1 Method A—Block shear

#### 7.5.1.1 Preparation of test assemblies

The test assemblies shall be prepared as follows:

- (a) Prepare 18 test assemblies, 9 for the minimum assembly time and the other 9 for the maximum assembly time, as specified for that adhesive.

Three test assemblies from the minimum assembly time and three from the maximum assembly time shall be used for each of the tests indicated in Clauses 7.5.1.3, 7.5.1.4 and 7.5.1.5.

- (b) For each test assembly, prepare two laminae, approximately 20 mm thick  $\times$  65 mm wide  $\times$  350 mm long along the grain, from timber of length suitable for planing. The timber shall be of sufficient thickness so that the entire surface to be bonded can be planed. Surfaces to be bonded shall not be sanded and shall be free of contaminants.

The slope of grain of the billets on the wide or narrow face shall be not greater than 1 in 15. They shall be free from knots larger than 3 mm in diameter. They shall also be free from defects such as decay, pith, pitch pockets/streaks, unusual discolouration within the shearing area, machining defects (chipped grain, feed roll polish, coarse knife marks and feed roll compression), and any drying defects (case hardening, collapse, splits and checks). Only back-sawn (back-cut) wood shall be used.

- (c) Cut the timber to the lamina length specified above, weigh and sort in two piles of approximately the same weight, then bond to each other.

The direction of the growth rings shall be oriented, when viewed on the end of the laminations in the assembly, so that they are concave away from the bondline.

- (d) Bond within 24 h after the timber is planed.

The assemblies shall be prepared under ambient conditions so that the specified minimum and maximum assembly times can be used. If necessary, the ambient conditions shall be adjusted and controlled so that the recommended assembly time can be used. The ambient conditions under which the assemblies are prepared shall be reported.

- (e) Mix the test adhesive and apply to each contacting surface of the laminations according to the specification for that adhesive. At the end of the minimum assembly time, press three assemblies and, at the end of the maximum assembly time, press the other three assemblies in accordance with the time-temperature schedule and pressure specified for that adhesive.

- (f) Maintain the pressure throughout the curing period.