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Timber structures — Bond performance of adhesives —

Part 1: Basic requirements

Structures en bois — Performance d'adhérence des adhésifs —

Partie 1: Exigences de base

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 20152-1 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

ISO 20152 consists of the following parts, under the general title *Timber structures — Bond performance of adhesives*:

— *Part 1: Basic requirements*

— *Part 2: Additional requirements*

Introduction

ISO 20152 has been developed by ISO/TC 165 to provide performance requirements for adhesive bond lines formed in structural wood products. It is largely based on the Canadian Standards Association's CSA O112.9[1] and CSA O112.10[2]. These CSA-based tests for 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 are designated as Method A. An alternative "pathway" to the provisions has been provided by equivalent provisions of CEN (European Committee for Standardization) standards, designated as Method B. Both the CSA and CEN standards evaluate adhesive bonds against standardized wood species having tightly prescribed specific gravities.

ISO/TC 165 is nevertheless aware that North American and European species are not readily available in many other countries. Future revisions of ISO 20152 are expected to include evaluations of bond line performance made against other species having alternative specific gravities, provided evidence is produced to show that such evaluations produce equivalent results.

ISO 20152 consists of two parts: this part gives minimum requirements for adhesive bonds in all jurisdictions; ISO 20152-2 gives requirements that are specified by building regulatory authorities (high temperature performance at or above 180 °C) in other jurisdictions or for specific applications (gap-filling performance).

In the above-mentioned Canadian standards, normative reference is made to a number of other documents, which means that they (and a standard based on them) could not be used independently of those documents. Such references have been replaced wherever possible in this part of ISO 20152 without unduly lengthening the text. Because International Standards in the wood products area are not extensive, this has not been practicable in all instances, and normative reference to CEN and ASTM (American Society for Testing and Materials) standards has been retained. The ASTM references, for example, apply only to adhesive bond requirements that are less likely to be specified or are rather lengthy.

The Method A provisions for adhesives provide assessments based on using tightly specified hardwood and/or softwood substrates; the Method B provisions, on the other hand, are confined to the use of beech substrates. The tests and provisions herein represent only a first stage of adhesive evaluation when manufacturing an adhesively bonded structural wood product. It is anticipated that product standards will specify qualification procedures that verify the capacity of the adhesive to produce effective wood bonds, given the specific species and manufacturing processes involved. Within an international context, there are many variations in species and manufacturing practices that cannot be taken into account in an adhesive standard and thus case-by-case evaluations are essential.

Creep performance criteria and tests under elevated temperatures (180 °C) contained within CSA O112.9 have been removed. The matter was discussed within ISO/TC 165 and it was agreed that high temperature performance (greater than 180 °C) is not a requirement in all jurisdictions. A number of countries do not require the bond line itself to have a fire rating. Where a wood product (either protected or unprotected) is required to have a fire rating for specific classes of building construction, the view is taken that it is the structural assembly that must be evaluated by a national fire testing standard for assessment against national building code requirements.

Timber structures — Bond performance of adhesives —

Part 1:
Basic requirements

1 Scope

This part of ISO 20152 specifies the basic performance requirements for adhesives used to bond structural timber components. These requirements depend upon the service conditions according to Service Classes 1, 2 and 3, as defined herein.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3130, *Wood — Determination of moisture content for physical and mechanical tests*

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

EN 302-1, *Adhesives for load-bearing timber structures — Test methods — Part 1: Determination of bond strength in longitudinal tensile shear strength*

EN 302-2, *Adhesives for load-bearing timber structures — Test methods — Part 2: Determination of resistance to delamination*

EN 302-3, *Adhesives for load-bearing timber structures — Test methods — Part 3: Determination of the effect of acid damage to wood fibres by temperature and humidity cycling on the transverse tensile strength*

EN 15416-2, *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*

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

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

ASTM D3535, *Standard Test Method for Resistance to Creep Under Static Loading for Structural Wood Laminating Adhesives Used Under Exterior Exposure Conditions*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
Service Class 1
service class characterized by a moisture content in the materials corresponding to a temperature of 20 °C and a relative humidity of the surrounding air exceeding 65 % for a few weeks per year

NOTE In Service Class 1, the average equilibrium moisture content of most softwoods does not exceed 12 %.

3.2
Service Class 2
service class characterized by a moisture content in the materials corresponding to a temperature of 20 °C and a relative humidity of the surrounding air exceeding 85 % for a few weeks per year

NOTE In Service Class 2, the average equilibrium moisture content 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.

3.3
Service Class 3
service class characterized by climatic conditions leading to higher moisture content than Service Class 2 such as occurs when a member is fully exposed to the weather

3.4
specific gravity
ratio of the oven-dry mass of a specimen to the mass of a volume of water equal to the volume of the specimen at the specified moisture content

3.5
oven-dry specific gravity
expression of the specific gravity based on oven-dry mass of wood and its oven-dry volume after drying to constant mass in a ventilated oven at a temperature between 100 °C and 105 °C

3.6
flat-sawn timber
back-sawn timber
timber whose growth rings make an angle of less than 45° with its wider face

3.7
wood failure percentage
percentage of wood fibre ruptured during the separation of an adhesive/adherend interface and used to evaluate the effectiveness of adhesive bonding

4 Application

The adhesive bond requirements given in this part of ISO 20152 are based on the performance of the adhesive as measured by the following properties:

a) resistance to biological degradation (see 5.2);

b) acid damage to wood fibre (see 5.3);

c) resistance to shear in the dry and wet states (see 5.4);

d) resistance to delamination during exposure to wetting and drying (see 5.5);

e) resistance to creep under static shear loading during exposure to high humidity, heat and combined heat and moisture (see 5.6).

In the cases of c), d) and e), two alternative test methods are presented. Method A is based on CSA O112.9[1] and Method B on equivalent European test methods. Adhesive suppliers shall choose to test according to either Method A or Method B for resistance to shear, resistance to delamination and resistance to creep. 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.

5 Requirements

5.1 Adhesive details, mixing and application

The adhesive shall be mixed and applied to the wood substrate in accordance with the adhesive manufacturer's specification. The adhesive mix evaluated shall contain all ingredients, including fillers, catalysts, hardeners, accelerators, modifiers, inhibitors and other additives necessary for the

— setting or curing of the mix,

— provision of specific properties to the liquid (appropriate viscosity, open and closed assembly times, etc.), and

— development of relevant properties in the final cured state such as minimum strength levels and creep resistance.

The type and amount of fillers and/or extenders used in the adhesive shall comply with the adhesive manufacturer's specification. Where the adhesive supplier specifies that adhesive and hardener are spread separately, all test specimens shall be prepared in that manner and not as a glue mix.

5.2 Anti-fungal properties

If the adhesive contains amylaceous and/or protein-based components, the adhesive, when tested in accordance with 6.1, shall possess sufficient anti-fungal properties to inhibit the growth of selected fungal species to a grading of OC, OM or NG as defined in ASTM D4300.

5.3 Acid damage to wood fibre

If, when tested in accordance with 6.2, the pH of the adhesive mix or, in the case of separately spread adhesive and hardener, one of its components, is less than 3, then the adhesive shall be tested in accordance with EN 302-3 and shall meet the requirements of EN 301.

5.4 Shear strength and wood failure

5.4.1 General

Depending on whether Method A or B is used, shear strength and wood failure results (if any) shall meet or exceed either the requirements of 5.4.2 or 5.4.3 respectively.

5.4.2 Method A (block shear)

5.4.2.1 General

When tested in accordance with 6.5, the block shear results shall meet or exceed the shear strength requirements given in 5.4.2.2 and the percentage wood failure requirements given in 5.4.2.3.

5.4.2.2 Shear strength requirements

The median shear strength requirements of samples following the treatments specified in 6.5.1.3.2 to 6.5.1.3.6 inclusive shall meet or exceed the requirements given in Table 1.

Table 1 — Median shear strength requirements (MPa)

Treatment and condition at test	Service Class 3		Service Classes 1 and 2
	Hardwood[a]	Softwood[b]	Softwood only
6.5.1.3.2 — Dry	19	10	10
6.5.1.3.3 — Wet (Vacuum-pressure test)	11	5,6	6,5
6.5.1.3.5 — Wet (Boil–dry-freeze test)	6,9	3,5	3,7

[a] Oven-dry specific gravity shall not be less than 0,65.

[b] Oven-dry specific gravity shall not be less than 0,49.

5.4.2.3 Wood failure

Only block shear specimens that are used in the strength analysis in connection with the requirements of 5.4.2.2 shall determine whether the percentage wood failure requirements of this section are met. The percentage wood failure in the block shear specimens for each of the treatments shall meet or exceed the values specified in Table 2.

Table 2 — Wood failure (%) requirements

Test condition	Service Class 3				Service Classes 1 and 2	
	Hardwood[a]		Softwood[b]		Softwood only	
	Lower quartile	Median	Lower quartile	Median	Lower quartile	Median
Dry	15	60	75	85	75	85
Wet	35	80	75	85	75	85

[a] Oven-dry specific gravity shall not be less than 0,65.

[b] Oven-dry specific gravity shall not be less than 0,49.

5.4.2.4 Interpretation of results

5.4.2.4.1 If a specimen fails with shear strength less than the median value specified in Table 1, but the wood failure exceeds that specified in Table 3, it is permissible to disregard that specimen when determining the median and lower quartile shear strength. If more than one-third of the specimens for any test condition are discarded for this reason, the test shall be repeated for that condition.

5.4.2.4.2 If the shear strengths for all test conditions meet the requirements of Table 1, but the wood failure of each sample fails to meet the requirements of Table 2, the percentage wood failure of the shear specimens may be re-evaluated, provided that the percent wood failure of the 30 specimens evaluated under each test condition meets the requirements of Table 4. The re-evaluation procedure shall be as follows.

Not more than three additional independent laboratories or agencies shall be identified for re-evaluating the wood failure values. These laboratories or agencies shall be noted in the test report. All block shear specimens from the tests shall be sent to the alternative laboratories or agencies to determine the median and lower-quartile wood failure in accordance with this part of ISO 20152. The findings of the additional laboratories or agencies and the procedures used shall be documented and appended to the test report.

If the requirements of Table 2 are met, the adhesive is considered to have passed the wood failure requirements of this part of ISO 20152.

Table 3 — Threshold wood failure (%) rates for discarding block shear test specimens

Test condition	Hardwood	Softwood
Dry	60	85
Wet	80	85

Table 4 — Minimum percent wood failure requirements for re-evaluation

Test condition	Hardwood		Softwood	
	Lower quartile	Median	Lower quartile	Median
Dry	10	50	65	75
Wet	50	70	65	75

5.4.3 Method B (tension shear)

When Method B is used, the tension shear test specified in EN 302-1, together with the requirements given in EN 301, shall be applied.

5.5 Delamination resistance

5.5.1 General

Delamination tests shall be carried out using either Method A or Method B and shall be in accordance with 5.5.2 or 5.5.3 respectively.

5.5.2 Method A

5.5.2.1 Requirements for hardwoods

5.5.2.1.1 Service Class 3

For adhesives intended for use in Service Class 3, the total delamination within any one bond line shall not exceed 1,6 % of the total length of the bond line in the assembly when tested in accordance with 6.6.1. In order for the adhesive to be approved, three of the four assemblies tested according to 6.6.1 shall meet these requirements.

5.5.2.1.2 Service Classes 1 and 2

There are no requirements for Service Classes 1 and 2 for hardwoods.

5.5.2.2 Requirements for softwoods — Service Classes 1, 2 and 3

For adhesives intended for use in Service Class 1, 2 or 3, the total delamination within any one bond line shall not exceed 1 % of the total length of the bond line in the assembly when tested in accordance with 6.6.1. In order for the adhesive to be approved, three of the four assemblies tested according to 6.6.1 shall meet these requirements.

5.5.3 Method B

When Method B is used, the delamination test specified in EN 302-2, together with the requirements given in EN 301, shall be applied.

5.6 Creep resistance

5.6.1 General

Creep resistance tests for all three service classes shall be carried out using either Method A or Method B and shall meet the requirements given in 5.6.2 or 5.6.3 respectively.

5.6.2 Method A

When tested in accordance with 6.7.1 and under environmental test conditions A, B and C (see Tables 5 and 6), the overall average creep displacement (see Figure 6 and Annex B) across all bonded cross-sections and within any of the six specimens (full length or full length cut into partial lengths) shall not exceed 0,05 mm; the maximum average creep displacement at any single bonded cross-section shall not exceed 0,25 mm after the prescribed load period. In order for the adhesive to be approved, a minimum of two of the three full-length specimens, or seven partial-length specimens taken from two full-length specimens, tested under each set of environmental test conditions in accordance with 6.7.1, shall meet these requirements. If any bonded section of the specimen breaks during the test or if the creep displacement requirement is not met, a retest is permitted, provided the percentage wood failure of the bonded section for that specimen is 95 % or more.

Table 5 — Environmental test conditions applicable to adhesives for use in Service Classes 1, 2 and 3

Service Class	Environmental test conditions for adhesives
3	A, B, C
1 and 2	A, B

5.6.3 Method B

When Method B is used, the compression shear tests specified in EN 15416-2, together with the requirements given in EN 15425, shall be applied.

6 Sample preparation and test methods

6.1 Anti-fungal properties

This test shall be performed in accordance with ASTM D4300.

6.2 Acid damage to wood fibre

The pH of the adhesive mix shall be determined in accordance with ASTM D1583. If required in accordance with 5.3, the test for acid damage to wood fibre shall be undertaken according to EN 302-3.

6.3 Specimen requirements

6.3.1 Evaluation on hardwoods

When adhesives for hardwoods are tested in accordance with 6.5 to 6.7, the tests shall be performed on hard maple (*acer saccharum* or *acer nigrum*) or the species specified in the relevant CEN standard.

6.3.2 Evaluation on softwoods

When adhesives for softwoods are tested in accordance with 6.5 to 6.7, the tests shall be performed on one of the following species, depending on the method chosen.

a) **Method A**

1) Lodgepole pine (*pinus contorta* var. *latifolia*)

2) Black spruce (*picea mariana*)

3) Douglas fir (psuedotsuga menziesii)

b) **Method B**

Species specified in the relevant CEN standard.

NOTE The addition of further test species will be considered if additional test data become available in the future.

6.3.3 Wood-specific gravity

6.3.3.1 A 25-mm-long full cross-section shall be cut at least 150 mm from the end of each board used to provide wood samples for the tests specified in 6.5 to 6.7.

6.3.3.2 The oven-dry specific gravity shall be

a) not less than 0,65 for hardwoods,

b) not less than 0,49 for softwoods.

6.4 Wood moisture content

6.4.1 The moisture content shall be determined in accordance with ISO 3130.

6.4.2 The moisture content of the wood samples at the time of assembly shall be as specified by the adhesive manufacturer.

6.4.3 When the adhesive sample is designated as suitable for bonding green timber, the moisture content of each piece being bonded shall be greater than 30 % at the time of bonding.

6.5 Shear test and wood failure assessment

6.5.1 Method A — Block shear

6.5.1.1 Preparation of test assemblies

6.5.1.1.1 Six separate test assemblies for each of the tests indicated in 6.5.1.3.2 to 6.5.1.3.6 shall be prepared: three for each of the minimum and maximum assembly times recommended by the adhesive manufacturer. A total of 18 test assemblies are required to complete all tests in this section.

6.5.1.1.2 Laminations approximately 20 mm thick × 65 mm wide × 350 mm along the grain shall be prepared 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.

6.5.1.1.3 The slope of grain of the laminations on the wide or narrow face shall not be greater than 1 in 15. The laminations 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 flat-sawn (also known as back-sawn) wood shall be used.

6.5.1.1.4 The timber shall be cut to the lamination length specified above. The laminations shall be weighed and assembled in two piles so that laminations of approximately the same weight are bonded 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 bond line.

6.5.1.1.5 Bonding shall be performed within 24 h after the timber is planed. The assemblies shall be prepared under ambient conditions such 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.

6.5.1.1.6 The test adhesive shall be mixed and applied to each contacting surface of the laminations according to the adhesive manufacturer's instructions. At the end of the minimum assembly time, three assemblies shall be pressed and, at the end of the maximum assembly time, the other three assemblies shall be pressed, in accordance with the time-temperature schedule and pressure recommended by the adhesive manufacturer.

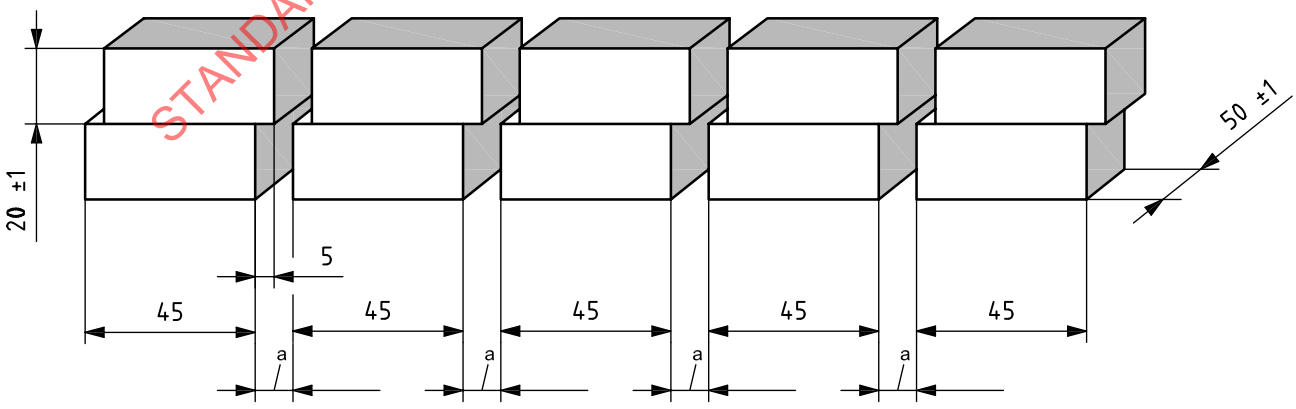
6.5.1.1.7 The pressure shall be maintained throughout the curing period.

6.5.1.2 Preparation of test specimens

6.5.1.2.1 The bonded assemblies shall be conditioned at 20 ± 2 °C and 65 ± 5 % relative humidity for at least two days prior to the preparation of the block shear test specimens.

6.5.1.2.2 After conditioning, the assemblies shall then be removed from the conditioning atmosphere for specimen preparation. Each assembly shall be reduced to a width of 50 ± 1 mm by trimming along both of its longer sides, after which the assembly shall be reduced to a length of approximately 300 mm by trimming approximately 50 mm from one end of the assembly. Next, five specimens, each 50 mm long, shall be cut from the trimmed end of the assembly as shown in Figures 1 and 2. The specimens shall be cut so that the grain direction is parallel to the direction of loading during the test. The loaded surfaces shall be smooth and parallel to each other and perpendicular to the height. In making the notch on one end of the specimen, the saw cut shall extend through the thickness of the other ply to the bond line. Care shall be taken to ensure that saw cuts do not extend beyond the bond line.

Dimensions in millimetres



[a] Saw kerf.

Figure 1 — Shear block assembly dimensions

Dimensions in millimetres

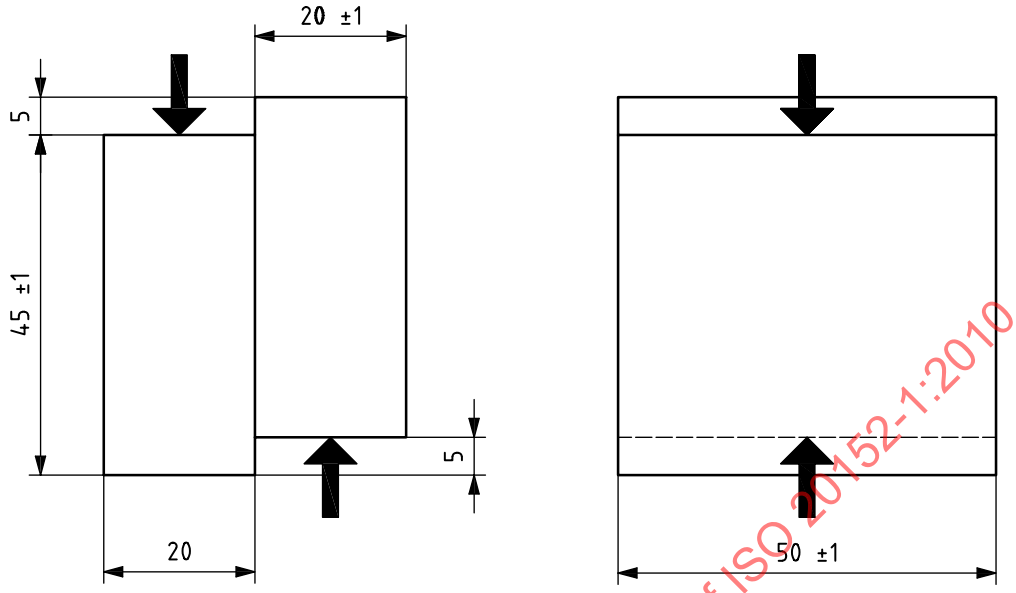


Figure 2 — Shear block dimensions

6.5.1.3 Test conditions

6.5.1.3.1 General

The specimens shall be subjected to three tests: a dry test, a vacuum-pressure test and a boil–dry-freeze test. There shall be 30 specimens for each test: 15 from the assemblies prepared using the minimum assembly time and 15 prepared using the maximum assembly time.

6.5.1.3.2 Dry test

The dry specimens shall be conditioned at 20 ± 2 °C and 65 ± 5 % relative humidity until they attain a practical constant weight. They shall be retained in this condition until tested.

NOTE "Constant weight" is defined as the state of time change in weight by which the specimen neither gains nor loses weight by more than 0,05 % in a 24 h period. It is helpful in determining the end point in conditioning to plot weight change against time. Practical constant weight is reached when the curve becomes asymptotic to the time axis.

6.5.1.3.3 Vacuum-pressure test for Service Class 3

The specimens shall be placed in the pressure vessel, separated by stickers, wire screens or other similar means such that all end grain surfaces are freely exposed to water and weighted down. Sufficient water shall be admitted at a temperature of 22 ± 5 °C so that the specimens are completely submerged. A vacuum of 75 ± 10 kPa shall be drawn and held for 30 min, then the vacuum shall be released and a pressure of 540 ± 20 kPa shall be applied for a period of 2 h. If all of the specimens are not fully submerged at this stage, then the vacuum-pressure cycle shall be repeated once more. The specimens shall be removed from the water and shall be tested in the wet condition. All specified vacuum and pressure levels shall be taken as relative to atmospheric conditions.

6.5.1.3.4 Vacuum-pressure test for Service Classes 1 and 2

The test shall be identical to that for Service Class 3 except that the specimens shall be conditioned at 20 ± 2 °C and 65 % relative humidity for at least two days then weighed prior to testing shear.

6.5.1.3.5 Boil–dry-freeze test for Service Class 3

6.5.1.3.5.1 The initial mass of each specimen after conditioning and prior to the boil–dry-freeze cycle exposure shall be recorded.

6.5.1.3.5.2 The specimens shall be fully submerged in boiling water for at least 4 h, dried in an oven at a temperature of 60 ± 3 °C for 19 ± 1 h and then placed in a freezer tunnel maintained at a temperature of less than −30 °C for at least 4 h. The specimen shall be separated so that all surfaces are freely exposed to the specified conditions. When drying, sufficient air circulation shall be provided to reduce the moisture content of the specimens to within ±3 % of its original mass as per 6.5.1.3.5.1.

6.5.1.3.5.3 The boil–dry-freeze cycle shall be repeated seven more times. Following the final boil-dry-freeze cycle, the specimens shall again be fully submerged in boiling water for at least 4 h before being cooled in water at 22 ± 5 °C and then tested in the wet condition.

6.5.1.3.5.4 When transferring the specimens to the cool water bath following the final boil, care shall be taken to minimize drying of the hot specimens by gradually replacing the hot water in the boil tank with cool water before removing the specimens.

NOTE Annex A provides guidance on accommodating interruptions in the boil–dry-freeze conditioning.

6.5.1.3.6 Boil–dry-freeze test for Service Classes 1 and 2

6.5.1.3.6.1 The initial mass of each specimen after conditioning and prior to the boil–dry-freeze cycle exposure shall be recorded.

6.5.1.3.6.2 The specimens shall be fully submerged in boiling water for at least 4 h, dried in an oven at a temperature of 60 ± 3 °C for 19 ± 1 h and then placed in a freezer tunnel maintained at a temperature of less than −30 °C for at least 4 h. The specimen shall be separated so that all surfaces are freely exposed to the specified conditions. When drying, sufficient air circulation shall be provided to reduce the moisture content of the specimens to within ±3 % of its original mass as per 6.5.1.3.6.1.

6.5.1.3.6.3 The boil–dry-freeze cycle shall be repeated two more times. Following the final boil-dry-freeze cycle, the specimens shall again be fully submerged in boiling water for at least 4 h before being cooled in water at 22 ± 5 °C and then tested in the wet condition.

6.5.1.3.6.4 When transferring the specimens to the cool water bath following the final boil, care shall be taken to minimize drying of the hot specimens by gradually replacing the hot water in the boil tank with cool water before removing the specimens.

6.5.1.3.6.5 The test specimens shall be conditioned at 20 ± 2 °C and 65 % relative humidity for at least two days then weighed prior to testing shear.

NOTE Annex A provides guidance on accommodating interruptions in the boil–dry-freeze conditioning.

6.5.1.4 Test procedure

6.5.1.4.1 Loading rate and measurements

6.5.1.4.1.1 The testing machine shall be fitted with a compression-shearing tool containing a self-aligning seat to ensure uniform lateral distribution of the load. The load shall be applied with a continuous motion of the movable head at a rate not exceeding 15 mm/min. The testing machine shall be located in an atmosphere such that the moisture content of the specimens is not noticeably altered during testing.

6.5.1.4.1.2 The width and height of the specimen at the bond line at test shall be measured to the nearest 0,1 mm to determine the shear area. This area shall be used to compute the shear stress at failure.

6.5.1.5 Wood failure assessment

6.5.1.5.1 The percentage wood failure for specimens tested wet shall be determined after drying the specimens to less than 15 % moisture content using a temperature not exceeding 28 ± 2 °C. The percentage wood failure for specimens tested dry shall be determined without further conditioning.

6.5.1.5.2 The percentage wood failure shall be estimated to the nearest 5 % of the total bond line area.

6.5.2 Method B — Tension shear

Tension shear tests shall be conducted in accordance with EN 302-1.

6.6 Delamination resistance test

6.6.1 Method A

6.6.1.1 General

The test methods are identical for Service Classes 1, 2 and 3.

6.6.1.2 Preparation of wood materials

6.6.1.2.1 Four separate assemblies shall be prepared: two each for the maximum and the minimum assembly times recommended by the adhesive manufacturer.

6.6.1.2.2 Twelve pairs of side-matched laminations approximately 20 mm thick × 140 mm wide × 400 mm along the grain shall be prepared from timber with a minimum width of 285 mm and a length suitable for planing. The slope of grain of the laminations on the wide or narrow face shall not be greater than 1 in 15, and shall not contain knots larger than 3 mm in diameter. The laminations shall be free from defects including decay, pith on the surface, pitch pockets/streaks on the surface, unusual discolouration within the bond line 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 flat-sawn timber (also known as back-sawn timber) shall be used (see 6.5.1.1.3).

6.6.1.2.3 Assemblies shall be laid up so that each assembly glued using the minimum time is side-matched with an assembly glued using the maximum time. The direction of the growth rings shall be oriented, when viewed on the end of the laminations in the assembly, so that they are alternated. The surfaces shall not be sanded and shall be free from dirt or other substances that might interfere with bonding.

6.6.1.3 Bonding of test assemblies

6.6.1.3.1 Bonding shall be performed within 24 h after the timber is planed. The assemblies shall be prepared under ambient conditions such that the specified minimum and maximum assembly times can be used. If necessary, the ambient conditions shall be adjusted so that the recommended assembly can be used. The ambient conditions under which the assemblies are prepared shall be reported.

6.6.1.3.2 The test adhesive shall be mixed and applied to each contacting surface of the laminations according to the adhesive manufacturer's instructions. At the end of the minimum assembly time, two assemblies shall be pressed and, at the end of the maximum assembly time, the other assemblies shall be pressed in accordance with the time-temperature schedule and pressure recommended by the adhesive manufacturer. The pressure shall be maintained throughout the curing period.

6.6.1.3.3 Only the third bond line in the six-ply assembly can be formed with an adhesive other than that being evaluated. The adhesive for this bond line shall meet the delamination requirements of this part of ISO 20152.

NOTE The purpose of this provision is to enable six-ply assemblies with high-temperature curing adhesives to be pressed and cured using conventional hot platen techniques. Two, three-ply hot-pressed assemblies can be bonded together to form a six-ply assembly using cold- or room-temperature setting adhesive for the final bond line.

6.6.1.3.4 Any suitable adhesive curing technique is permitted in the pressing of the assembly.

6.6.1.4 Preparation of test specimens

6.6.1.4.1 The pressed assemblies shall be conditioned at 20 ± 2 °C and 65 ± 5 % relative humidity for at least two days prior to the preparation of the delamination test specimens.

6.6.1.4.2 The assemblies shall then be removed from the conditioning atmosphere for specimen preparation. Each assembly shall be trimmed along both edges to leave a width of 130 mm, and one end shall be trimmed by approximately 75 mm, and the trimmings discarded. Three specimens, each 75 mm along the grain, shall be cut from the trimmed end of each assembly.

6.6.1.4.3 Each test specimen shall be marked to note the position of the bond line with respect to a designated face of the test assembly. The purpose of labelling the bond lines is to facilitate the determination of the percentage delamination within a bond line from the same assembly. For example, the first bond line from the designated face shall be the same for all the specimens prepared from the same assembly.

6.6.1.4.4 The specimens shall be conditioned at 20 ± 2 °C and 65 ± 5 % relative humidity until they attain a constant weight prior to testing. The requirement is identical to that detailed in 6.5.1.3.2.

6.6.1.5 Delamination cycle

6.6.1.5.1 The specimens shall be placed in the pressure vessel and weighted down. They shall be separated by stickers, wire screens or other means so that all end-grain surfaces are freely exposed to water. Sufficient water shall be admitted at a temperature of 22 ± 5 °C so that the specimens are completely submerged and a vacuum of 75 ± 10 kPa shall be drawn and held for 2 h. The vacuum shall then be released and a pressure of 540 ± 20 kPa shall be applied for a period of 2 h while the specimens remain submerged. The pressure shall then be released and a vacuum of 75 ± 10 kPa shall again be drawn and held for 2 h while the specimens remain submerged. The vacuum shall be released again and a pressure of 540 ± 20 kPa shall be applied to the submerged specimens and held for 2 h. After this soaking period, the specimens shall be dried for 88 h at 28 ± 2 °C with sufficient air circulation to lower their weight to within 10 % of the original specimen weight. The entire four-day cycle (vacuum, pressure, soaking and drying) shall be repeated twice for a test duration totalling 12 days. All specified vacuum or pressure levels are relative to atmospheric conditions.

6.6.1.5.2 At the end of the final drying period, the total length of delamination (open bond lines) on the two end-grain faces of all test specimens shall be measured immediately to the nearest millimetre. Failure in the wood due to checking or open bond lines due to knots shall not be regarded as delamination. Also, delamination that is less than 2,5 mm in length and more than 5 mm away from any recordable delamination shall be ignored.

6.6.2 Method B

When Method B is used, delamination resistance tests shall be conducted in accordance with EN 302-2.

6.7 Creep resistance test

6.7.1 Method A

6.7.1.1 General

The test methods are identical for Service Classes 1, 2 and 3.

6.7.1.2 Preparation of test assemblies

6.7.1.2.1 Nine full-length test assemblies shall be prepared, i.e. three for each of environmental test conditions A, B and C (see Table 6).

6.7.1.2.2 For each test assembly, two outer laminations approximately 16 mm thick × 60 mm wide × 300 mm along the grain and eight wood centre sections 16 mm thick × 60 mm wide × 29 mm along the grain shall be prepared from timber of a length suitable for planing. The surfaces shall not be sanded and shall be free of debris and loose particles. The slope of grain of the materials on the wide or narrow face shall be not greater than 1 in 15. The materials shall be free of knots larger than 3 mm in diameter and shall be free of defects such as decay, pith, pitch pockets/streaks, unusual discolouration, 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 flat-sawn wood (also know as back-sawn wood) shall be used.

6.7.1.2.3 Bonding shall be performed within 24 h after the timber is planed.

6.7.1.2.4 Each assembly shall be prepared by alternately laying seven release-coated metal spacers or other material that will not bond to the assembly [e.g. polytetrafluoroethylene (Teflon®)[1)]], 6 mm thick × 16 mm wide × 70 mm long, on-edge and tightly adjacent to the eight wood centre sections. The grain direction of the centre sections shall be parallel to the length of the specimen and oriented such that the growth ring direction of adjacent sections alternates. The spacers shall be slightly thinner than the wood sections to allow adequate pressure transfer to the bond lines. The test adhesive shall be mixed and applied to each contacting surface of the two outer laminations and not the centre sections. The outer laminations shall be laid with an overlap of approximately 10 mm on each end, such that the orientation of the growth rings when viewed on the end of the laminations in the assembly has the convex or bark side of the wood towards the bond line.

6.7.1.2.5 The average of the minimum and maximum assembly times recommended by the adhesive manufacturer shall be used in preparing the assemblies. If necessary, the ambient conditions shall be adjusted to meet this requirement. The average conditions under which the assemblies are prepared shall be recorded.

6.7.1.2.6 The entire assembly shall be pressed in accordance with the time-temperature schedule and pressure recommended by the adhesive manufacturer. The pressure shall be maintained throughout the curing period.

6.7.1.2.7 While the assembly is under pressure or after the adhesive has cured, the spacers shall be pushed gently out (not impact driven) and the excess adhesive in the resulting slots shall be removed.

6.7.1.3 Preparation of test specimens

6.7.1.3.1 The bonded specimens shall be conditioned at 20 ± 2 °C and 65 ± 5 % relative humidity for at least two days after the adhesive has cured before further processing is performed.

6.7.1.3.2 After conditioning, each specimen shall be trimmed along both edges to leave a width of 50 ± 1 mm. The overlapping boards at both ends shall be trimmed flush with the inner section; see Figure 5.

6.7.1.3.3 Lines perpendicular to the longitudinal axis of the specimen and running to the specimen edges shall be marked across the mid-length of all of the centre sections (line D–D in Figure 6). The specimen shall then be transversely notched as shown in Figure 5, with the 3 mm notches being visually centred on the above lines. Marking shall be up to, but not beyond, the bond line.

6.7.1.3.4 A line perpendicular to the exposed bond lines across the middle of each of the lapped areas shall be scribed using a square and razor blade; see Figure 6.

6.7.1.3.5 A vertical notch approximately 10 mm deep shall also be cut on both outer plies as shown in Figures 5 and 6.

6.7.1.3.6 Each of the full-length specimens described in 6.7.1.2 is permitted to be cut into four short specimens consisting of two joints each, for a total of 24 or 32 partial-length specimens; see Figure 7. The four partial-length specimens shall constitute a single full-length specimen.

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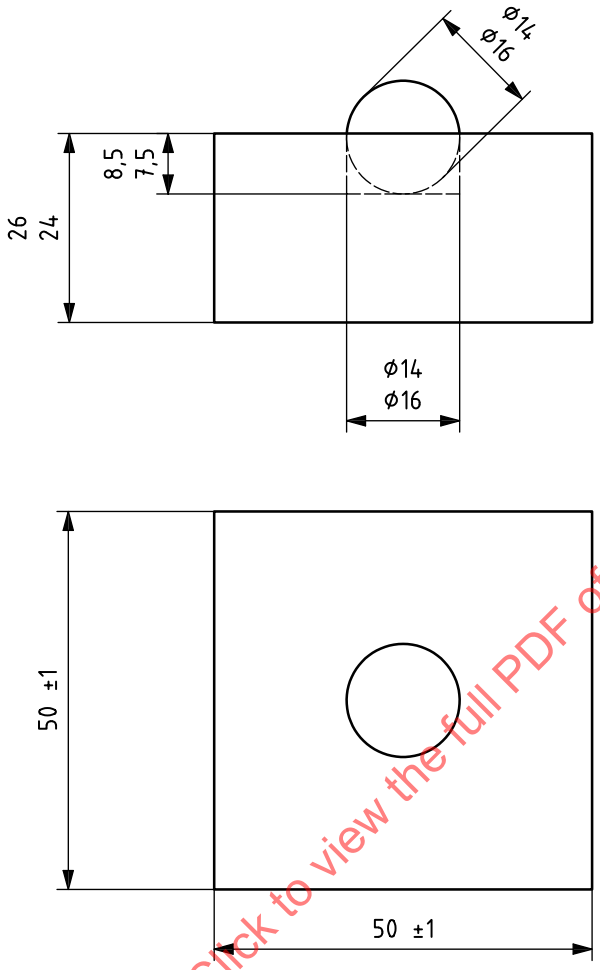
1) Teflon® is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 20152 and does not constitute an endorsement by ISO of this product.

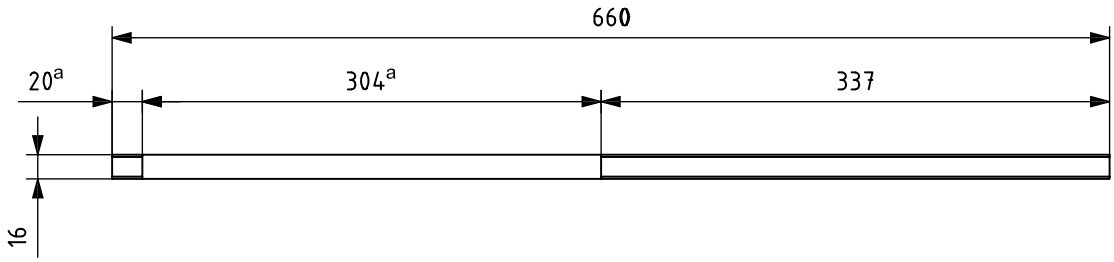
Dimensions in millimetres



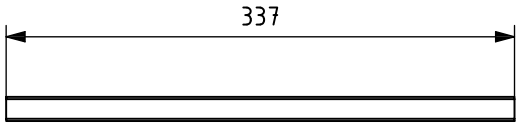
NOTE The bearing plate consists of a 50 mm × 50 mm × 25 mm cold-rolled block with a 14 mm – 16 mm ball hole drilled 7,7 mm – 8,5 mm into the centre of the block. A 14 mm – 16 mm ball bearing is placed in the hole and the whole assembly is placed between spacer plate No. 2 in the creep test rig (see Figure 4).

Figure 3 — Spacer block for creep test jig

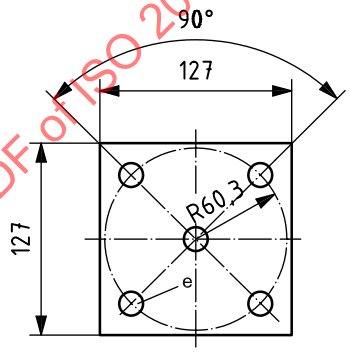
Dimensions in millimetres



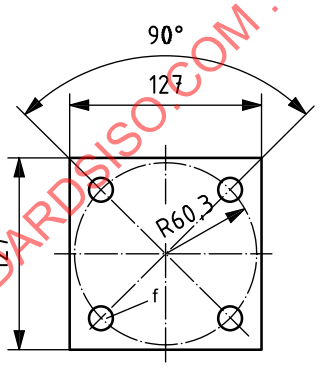
a) Tension rod
(stainless steel, four required)



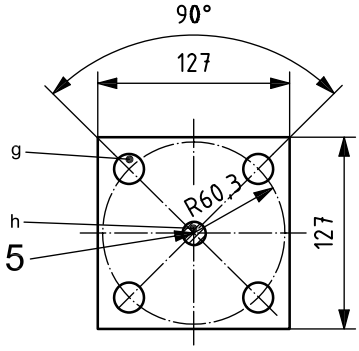
b) Centre rod
(stainless steel, one required)



c) Spacer plate No. 1, 10 mm
(stainless steel, one required)



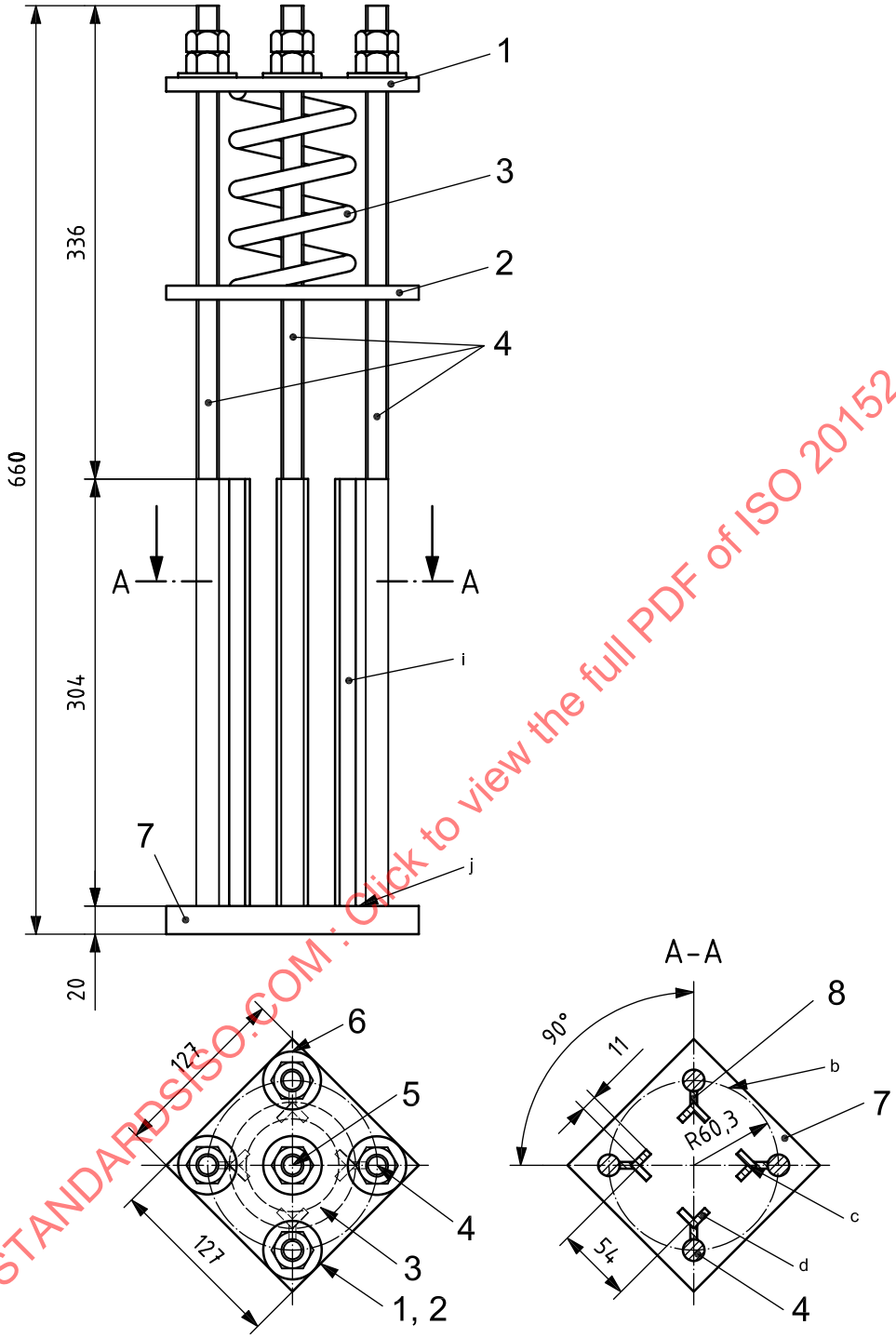
d) Base plate (7), 20 mm
(stainless steel, one required)



e) Spacer plate No. 2, 10 mm
(stainless steel, one required)

Figure 4 — Test rig used for creep test (*continued*)

Dimensions in millimetres



f) **Assembly views**

Figure 4 — Test rig used for creep test (*continued*)

Key

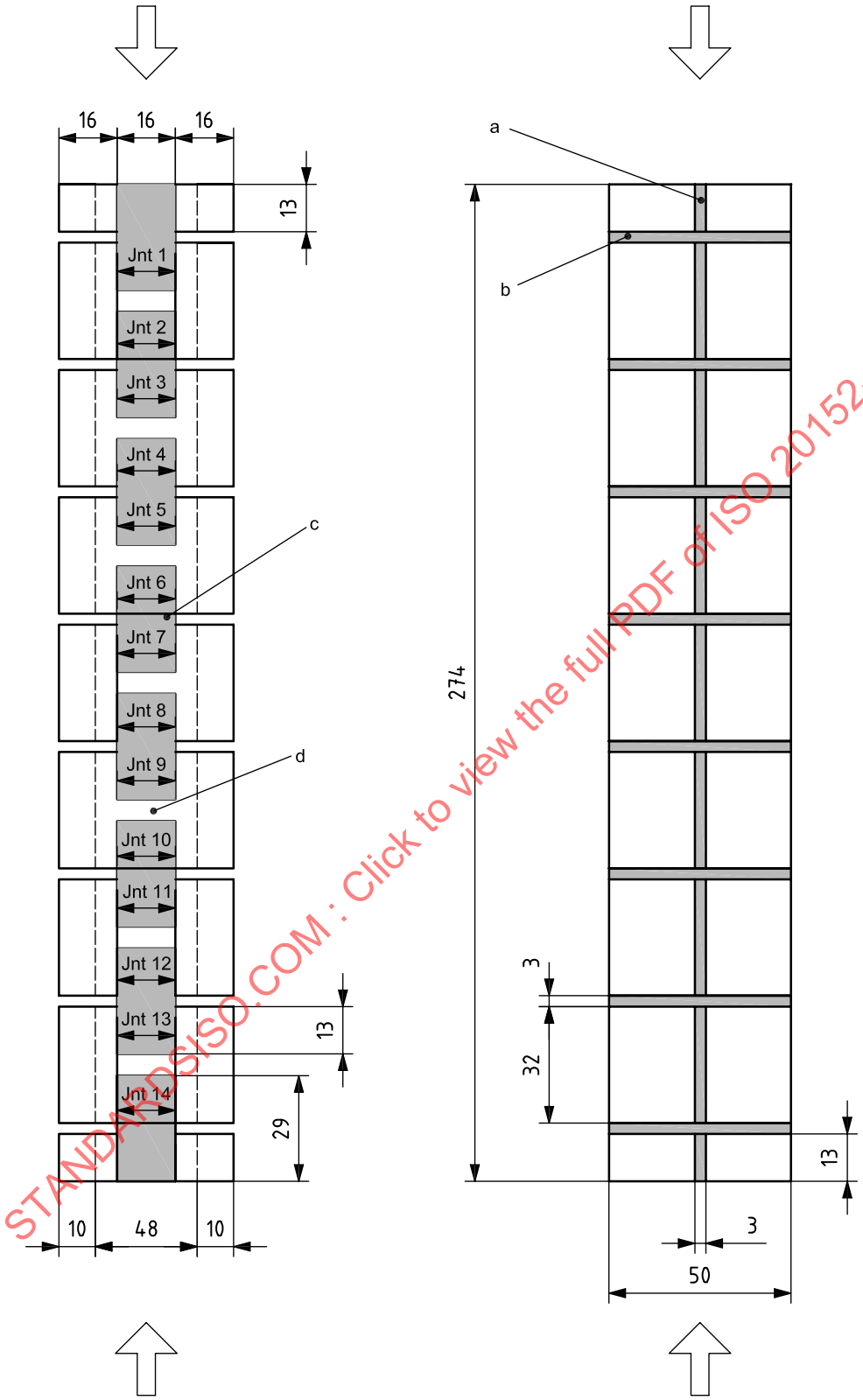
1 spacer plate No. 1
2 spacer plate No. 2
3 spring
4 tension rod
5 centre rod
6 washer
7 base plate
8 filler piece, 6 mm thick, stainless steel

The spring shall fit into the space provided of approximately 110 mm maximum outside diameter and 300 mm overall length. It shall be of corrosion resistant equipment (stainless steel, cadmium or zinc-plated steel), have a spring constant of 35 000 ± 7 000 N/m and a load when fully compressed to a solid height of approximately 4 500 N.

[a] M16 thread.
[b] Tension column drilling circle.
[c] Square inside corners.
[d] 40 mm × 40 mm stainless steel equal angle (machine 15 mm × 15 mm × 304 mm), four.
[e] Drill, diam. 19 mm, five.
[f] Tap M16, four.
[g] Drill, diam. 19 mm, four.
[h] Tap M16, weld rod to plate.
[i] Chain weld the angle to the filler piece and the filler piece to the angle rod.
[j] Weld the tension rods, filler pieces and outside face of angles to the base plate.

Figure 4 — Test rig used for creep test

Dimensions in millimetres



a 10-mm-deep longitudinal saw cut: one on each outer ply.

b Typical saw cut down to bond line (16 mm deep): eight saw cuts on each outer ply.

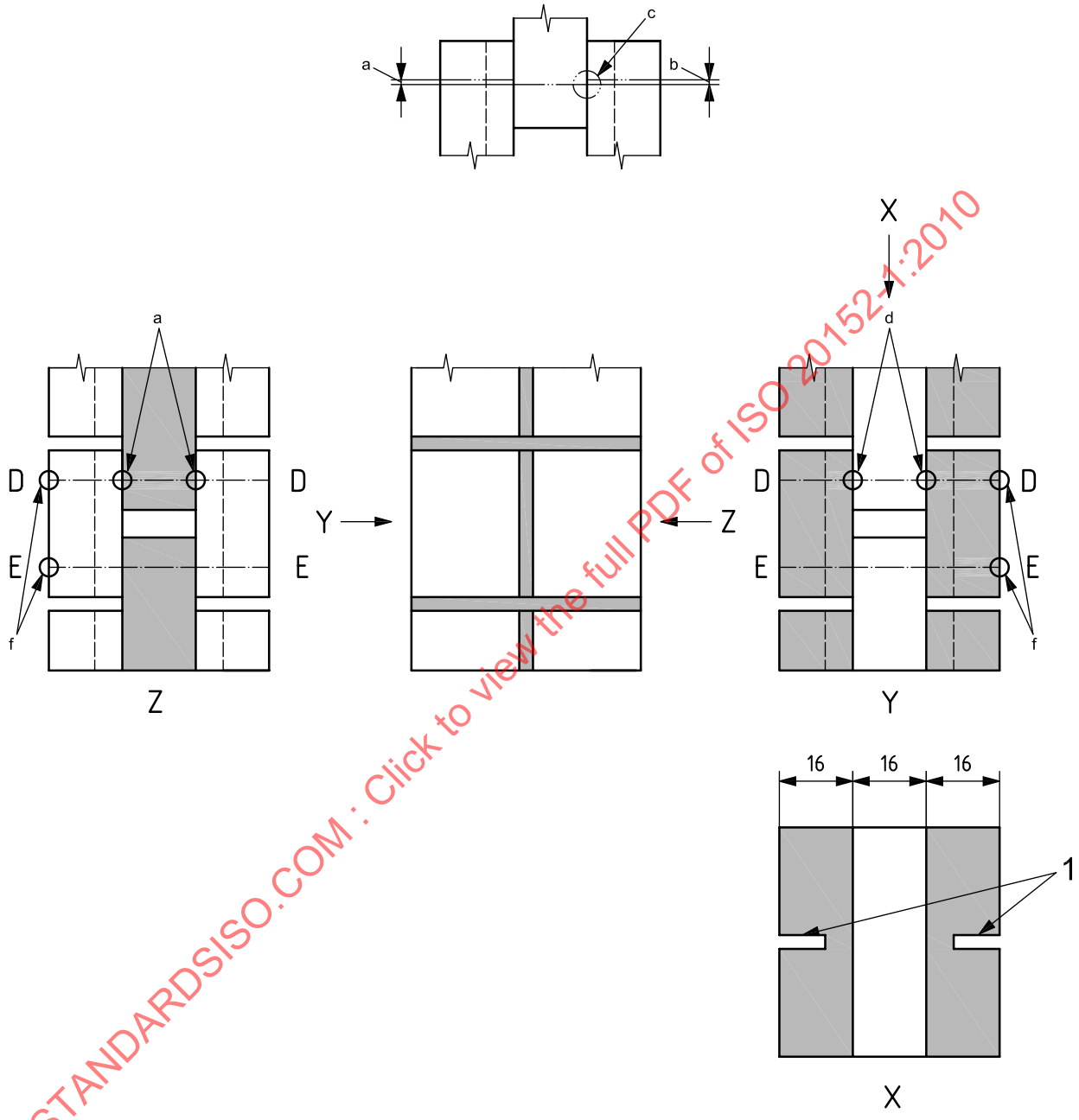
c Typical cross-section for slip measurement (1 of 14). Determine the average slip at both bond lines and on faces.

d Insert spacer blocks to maintain spacing during specimen preparation. Remove excess adhesive from these slots.

Figure 5 — Creep specimen dimensions

Dimensions in millimetres

Determining average creep displacement at a cross-section



Key

1 longitudinal saw cuts

Creep displacement at D = average (D_1, D_2, D_3, D_4), where D is the creep displacement in the razor line at the bond line. Repeat the measurement for joints at each cross-section (joints 1–14).

a Displacement D_1 (D_3 is on the opposite face).

b Displacement D_2 (D_4 is on the opposite face).

c Offset in line scribed by the surface of a razor.

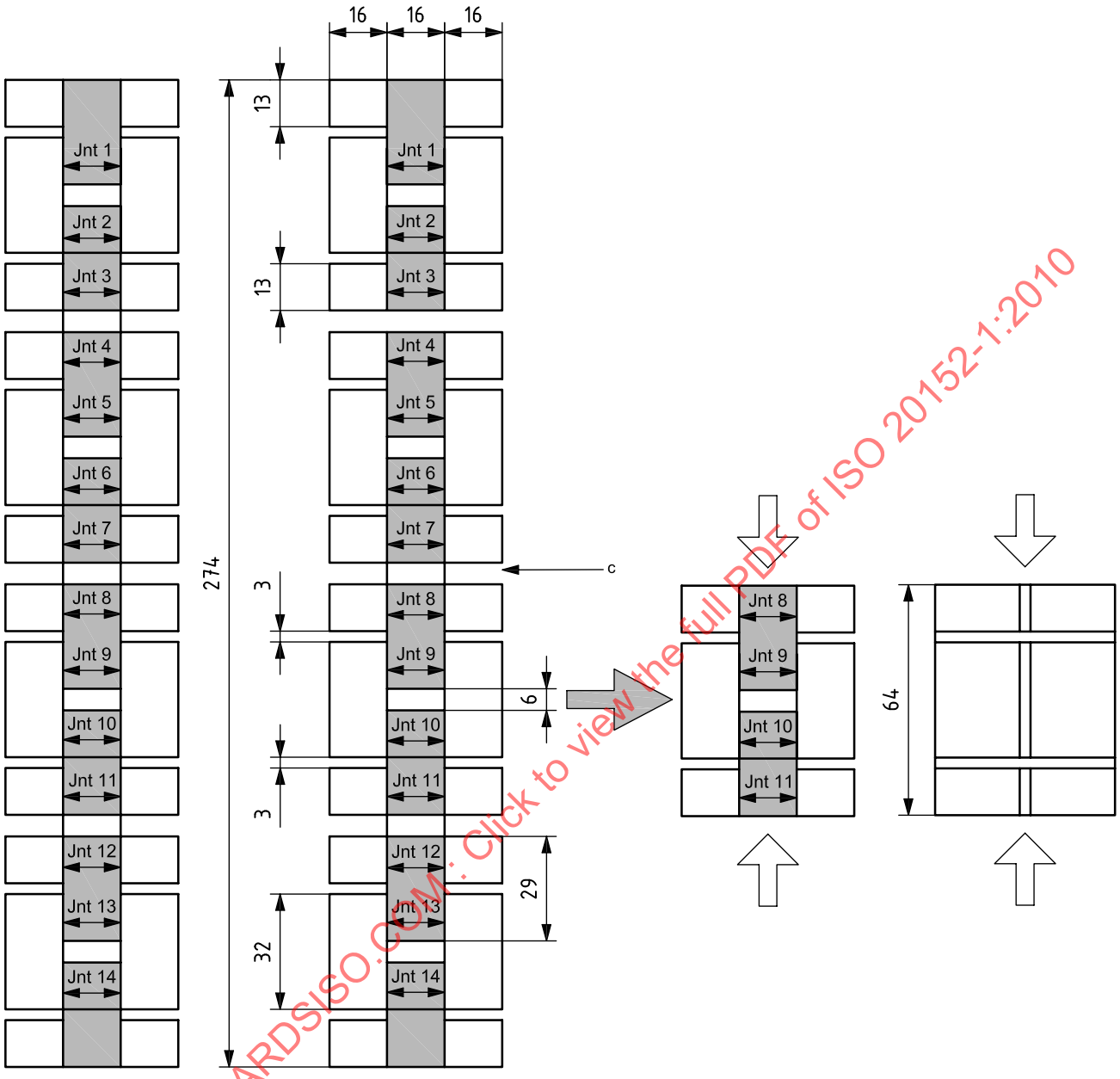
d Measure displacement D_1 and D_2.

e Measure displacement D_3 and D_4.

f Lines scribed on the surface by a razor (two shown, D–D and E–E).

Figure 6 — Details of creep specimens and dimensions

Dimensions in millimetres



a) Edge view **b) Face view**

[a] One of two full-length specimens for each condition.

[b] Cut each full-length specimen into four partial-length specimens.

[c] For each full-length specimen, cross-cut between joints 3 and 4, 7 and 8, and 11 and 12 to produce four partial-length specimens each of two joints (1–2, 5–6, 9–10 and 13–14).

[d] Apply the specified constant load to each partial-length specimen. Analyse the joint creep results from all four partial-length specimens using the same procedures used for full length specimens.

Figure 7 — Partial-length creep specimen details

Table 6 — Environmental test conditions for creep resistance test specimens

Environmental test conditions	Condition prior to loading	Condition while under load	Stress level MPa
A	At least seven days at 20 ± 2 °C and minimum 95 % relative humidity.	20 ± 2 °C, 95 % relative humidity for a period of seven days.	2,5 ± 0,1
B	At 20 ± 2 °C and 65 ± 5 % relative humidity until a constant weight is attained (see note to 6.5.1.3.2).	Minimum 70 ± 2 °C and ambient relative humidity for a period of seven days.	2,5 ± 0,1[a]
C	Cold water vacuum-pressure soak as specified in 6.5.1.3.3.	Wrap specimen to prevent moisture loss and maintain at 50 ± 2 °C for a period of 28 days.[b]	2,1 ± 0,1[a]

[a] The applied stress level shall be increased to compensate for the decrease in the spring constant when the creep jig is heated to 50 °C or 70 °C. This can be determined by comparing the spring constant of the spring at room temperature to that when the spring is heated to the specified temperature.

[b] The wrapping shall be clear, flexible film (such as polyvinylidene chloride) with sufficient thickness to resist puncture. The seams shall be sealed using sheathing tape or a similar product with sufficient flexibility and resistance to heat. During the load period, there should be condensation visible on the inside surfaces of the wrap to ensure that the specimen moisture content is above the fibre saturation point.

6.7.1.4 Conditioning of test specimens

6.7.1.4.1 The specimens tested under environmental test conditions A shall be conditioned for at least seven days at 20 ± 2 °C and at a minimum 95 % relative humidity before testing, in accordance with Table 6.

6.7.1.4.2 The specimens tested under environmental test conditions B shall be conditioned before testing at 20 ± 2 °C and 65 ± 5 % relative humidity until a constant weight is attained, in accordance with Table 6.

6.7.1.4.3 The specimens tested under environmental test conditions C shall be subjected to a cold water vacuum-pressure soak before testing, as specified in 6.5.1.3.3, in accordance with Table 6.

6.7.1.5 Test procedure

6.7.1.5.1 The specimen shall be inserted within the guides of the compression creep jig described as shown in Figure 4. A bearing plate, as described in Figure 3, shall be inserted between the top of the specimen and spacer plate No. 2. (In case the specimen does not extend slightly beyond the guides, additional filler blocks shall be used on top of the specimen.) The spring shall be inserted, and the spacer plate No. 1 positioned on top of the spring. A gentle compression shall be exerted and the corner nuts positioned.

6.7.1.5.2 The entire unit shall be loaded in any type of compression testing machine to a stress given in Table 6 and the corner nuts tightened by hand to maintain spring compression. The keeper nut on the centre rod shall be positioned and tightened to within 10 mm on the top plate.

6.7.1.5.3 The entire unit shall then be placed in a chamber maintained at the conditions and for the duration given in Table 6.

6.7.1.5.4 At the end of the applicable load period specified in Table 6, the creep in the specimen shall be measured immediately upon the specimen's removal from the environmental chamber, with the specimen still under the load specified in Table 6.

6.7.1.5.5 For each cross-section in the specimen (see Figure 6), the creep displacement at each of the four exposed bond lines shall be measured to the nearest 0,1 mm and the average creep displacement shall be recorded.

NOTE The creep displacement can be measured with the aid of a cathetometer, computerized displacement transducer, computerized camera, or any other measuring device with the required precision.