CI/SfB (2-)
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Wood Information Sheet

WIS 1-37

Subject: Structural
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with minor corrections

Introduction to Eurocode 5

The Eurocodes are a series of standards that establish common rules across the European Economic Area (EEA) for structural design using any material. They allow a designer to prove compliance with the requirements of the European Construction Product Regulation and national Building Regulations.

BS EN 1995, more commonly known as Eurocode 5 [1] or EC5, is the standard for structural timber design.

Considerable research from most of the member states has gone into these standards and they are continually supported by a review every five years. National standards bodies are required to help in the review process by collating the information relevant to their jurisdictions.

This Wood Information Sheet (WIS) is an overview of the subject with signposts to more detailed sources that are listed at the end. It outlines the major differences between Eurocode 5 and BS 5268-2 *Structural use of timber* [2] which was withdrawn in 2010, and includes guidance on transitioning between the two.

Contents

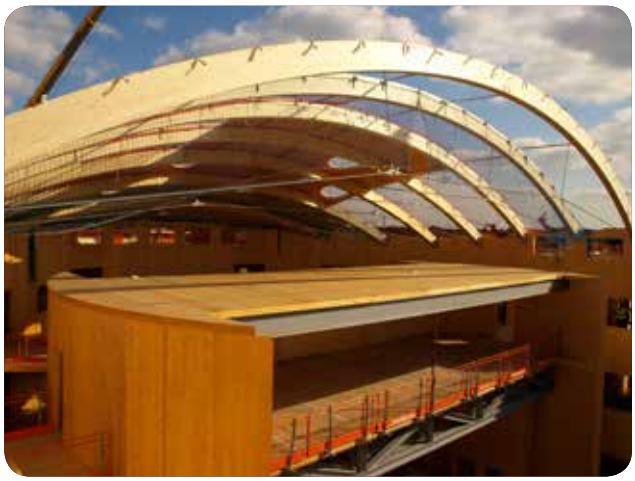

Figure 1: Glulam arches at Norwich Academy, designed by Ramboll and KLH using Eurocode 5
Photo: Ramboll

Key points

- Eurocode 5 contains only essential rules and general formulae for design, eliminating the need for the material-specific tables that were presented in the BS 5268 family of standards.
- The UK National Annex (UK NA) to Eurocode 5 contains country-specific, Nationally Determined Parameters (NDPs) and other information, where an option of national choice exists.
- *PD 6693-1 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings* [3] contains, among other things, non-contradictory practical advice extracted from the BS 5268 family of standards.
- *BS EN 1990 Eurocode. Basis of structural design* [4] and *BS EN 1991 Eurocode 1. Actions on structures* [5] must be used in conjunction with the relevant parts of Eurocode 5 as they contain general principles, design situations, and loads and combinations that apply to all types of design.
- Principles are Eurocode statements for which there are no alternatives, marked with a 'P' at the beginning.
- Application rules, marked 'A', are generally recognised rules or procedures that satisfy principles and can be replaced by alternatives if deemed necessary.
- BS 5268-2 used 'permissible stress design' whereas Eurocode 5 uses 'limit state design' with ultimate and serviceability limit states.

Background

In 1975 the Commission of the European Community began a programme to 'eliminate technical obstacles to trade and the harmonisation of technical specifications' in construction. This led to the development of the Construction Products Directive in 1989. This was subsequently replaced by the Construction Products Regulation, which came into force in 2013, as well as ten structural Eurocodes:

- EN1990 Eurocode: Basis of structural design
- EN1991 Eurocode 1: Actions on structures
- EN1992 Eurocode 2: Design of concrete structures
- EN1993 Eurocode 3: Design of steel structures
- EN1994 Eurocode 4: Design of composite steel and concrete structures
- EN1995 Eurocode 5: Design of timber structures
- EN1996 Eurocode 6: Design of masonry structures
- EN1997 Eurocode 7: Geotechnical design
- EN1998 Eurocode 8: Design of structures for earthquake resistance
- EN1999 Eurocode 9: Design of aluminium structures

Further Eurocodes are currently in development, including a Eurocode related to structural glass.

The Eurocodes harmonise design across the member states of EEA and align the principles of structural timber design with those used for most other building materials, notably concrete and steel. This now offers the potential for wider structural use of timber, especially in composite constructions.

The national standardisation body of each member state (the BSI in the UK) must publish the structural Eurocodes without changing any part of the text. Member states can, however, add a national title page, a 'Foreword' section and a National Annex. These National Annexes contain country-specific design data that allow the Eurocodes to be adapted to local conditions such as differing snow depths, wind speeds and other design parameters. These are known as the 'Nationally Determined Parameters (NDP)'. All Eurocodes are currently being revised with the aim of simplifying and reducing the NDPs.

The British Standards Institution (BSI) ratified the UK National Annex to Eurocode 5 (UK NA) in 2006, and declared BS 5268

Table 1: Replacements for the BS 5268 family

BS number	Title	Withdrawn	Replaced by
5268-2:2002	Structural use of timber. Code of practice for permissible stress design, materials and workmanship	November 2009	BS EN 1995-1-1 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings
5268-3:2006*	Structural use of timber. Code of practice for trussed rafter roofs	March 2010	
5268-4.1:1978	Structural use of timber. Fire resistance of timber structures. Recommendations for calculating fire resistance of timber members	March 2010	BS EN 1995-1-2 Eurocode 5. Design of timber structures. General. Structural fire design
5268-4.2:1990	Structural use of timber. Fire resistance of timber structures. Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions	March 2010	
5268-5:1989	Structural use of timber. Code of practice for the preservative treatment of structural timber	January 2010	Not formally replaced, but see BS 8417 [6] Preservation of wood. Code of practice
5268-6.1:1996*	Structural use of timber. Code of practice for timber frame walls. Dwellings not exceeding seven storeys	November 2009	BS EN 1995-1-1 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings
5268-6.2:2001*	Structural use of timber. Code of practice for timber frame walls. Buildings other than dwellings not exceeding four storeys	November 2009	
5268-7.1:1989 (also 7.2 to 7.7)**	Structural use of timber. Recommendations for the calculation basis for span tables. Domestic floor joists.	November 2009	Eurocode 5 Span Tables published by BM TRADA [7] provides tabulated values calculated to EC5 for a range of common joist sizes

* PD 6693-1 Recommendations for the design of timber structures to Eurocode 5 provides guidance to supplement Eurocode 5 and the UK NA on the subjects covered in these standards.

** Calculation methods within these standards are retained by Exova BM TRADA to publish Eurocode 5 Span Tables.

to be obsolescent in April 2010. Eurocodes are now referenced in Approved Document A [8] as practical guidance meeting the Building Regulations Part A requirements in the UK.

In the UK, the Eurocode 5 family of standards is comprised of the following parts and their respective UK National Annexes.

- BS EN 1995-1-1: General – Common rules and rules for buildings
- BS EN 1995-1-2: General – Structural fire design [9]
- BS EN 1995-2: Bridges [10].

UK National Annex (UK NA)

Designs for structures to be built in the UK should use the values and references in the UKNA. The UKNA covers, among other things:

- assignment of loads to duration classes
- guidance on assignment of timber constructions to service classes
- partial factors for material properties
- guidance on limiting values for deflections
- an expanded design method for domestic floor vibrations
- choice of method for design of wall diaphragms in the UK.

Designs for structures elsewhere should use the values and references in the National Annex for the relevant country.

Designers migrating to Eurocode 5 will miss much of the practical advice found in BS 5268-2, but the published document PD 6693-1 *Recommendations for the design of timber structures to Eurocode 5* incorporates some of that material updated to be non-contradictory to Eurocode 5. It includes guidance on racking design, masonry shielding, trussed rafters, allowances for holes and notches in beams, and several other subjects important to UK designers.

Eurocode 5 versus BS 5268

Eurocode 5 contains only the essential rules and general formulae for design. It is formula-driven and lacks the quick look-up tables of BS 5268-2. All parts of the BS 5268 family are now replaced by Eurocode 5 Part 1-1 or other documents, as shown in *Table 1*.

Limit states

The fundamental difference between Eurocode 5 and BS 5268-2 is their approach to design. BS 5268-2 used 'permissible or allowable stress design' whereas Eurocode 5 uses 'limit state design', bringing timber design in line with other materials such as steel and concrete. Using Eurocode 5, the designer generally has to check two limit states:

- ultimate limit states, beyond which parts of the structure may fail
- serviceability limit states, beyond which, under normal use, excessive deflection or vibration compromises the functioning of the structure, its appearance or user comfort.

To check ultimate limit states, the designer starts with the characteristic values of the loads (termed 'actions' in Eurocode 5) and of the material properties. These values are modified by partial factors to arrive at design values that are usually higher for the loads and lower for the material properties than their respective characteristic values.

Materials and design data

Eurocode 5 uses 'characteristic' values of materials that are different from the 'grade stress' values that were given in BS 5268-2. Grade stress values were already reduced for long-term load duration and included a safety factor. Characteristic values, on the other hand, are derived from a statistical analysis of laboratory test results and are generally higher than the grade stress values. Eurocode 5 does not list any characteristic values, for which the designer should consult other standards or manufacturer's data. Compulsory factors to take account of safety, load duration and environmental conditions are commonly applied to convert the characteristic values to 'design' values.

About decimal point

It is important to note that, in line with continental European notation, the Eurocodes use a comma (,) as the decimal point indicator. However, TRADA guidance for Eurocode 5 follows the practice common in most English-speaking countries of using a full stop/period (.) to indicate a decimal point.

Strength grading

Solid timber must be strength graded, either visually or by machine, to comply with the Construction Products Regulation. Eurocode 5 cites the relevant standards with which all timbers and panel products must comply and specifies some design factors such as reference dimensions for calculations. Once graded, the characteristic values for design purposes can be obtained from other European standards depending on the strength classes the timbers are assigned to.

New and innovative materials can be accommodated within the existing rules of Eurocode 5 without the need for re-writing the standard which is an advantage to development of new building technologies.

Table 2: Sources of information on material properties and design data

Material	Material – requirements	Material - characteristic properties
Structural solid timber*	BS EN 14081-1 [11] BS EN 14081-2 [12] BS EN 14081-3 [13]	BS EN 338 [29]
Glulam	BS EN 14080 [14]	
LVL	BS EN 14374 [15] BS EN 14279 [16]	manufacturer data
All wood-based panels	BS EN 13986 [17] Also, relevant product standard(s) below.	
Fibreboards	BS EN 622-1 [18] BS EN 622-2 [19] BS EN 622-3 [20] BS EN 622-4 [21] BS EN 622-5 [22]	BS EN 12369-1 [30]
OSB	BS EN 300 [23]	
Particleboards	BS EN 312 [24] BS EN 14755 [25] BS EN 634-1 [26] BS EN 634-2 [27]	
Plywood	BS EN 636 [28]	BS EN 12369-2 [31]
* The way in which the species and grades of timber commonly available in the UK relate to these strength classes is given in *WIS 4-7: Timber Strength grading and strength classes* [32]. PD 6693-1 lists the values for oak and sweet chestnut.		

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Wood-based panels

Wood-based panels for permanent incorporation within a building must comply with the Construction Products Regulation, achieved by compliance with *BS EN 13986*. This standard in turn refers to a series of product standards for specifications and requirements for each panel product type.

Adhesive types suitable for use in particular service classes are specified by reference to *BS EN 301 Adhesives, phenolic and aminoplastic, for loading bearing timber structures* [33], and *BS EN 15425 Adhesives* [34].

Table 2 lists the standards with which timber and timber-based materials should comply and where the characteristic values used in design can be found.

Timber composites

Exova BM TRADA's *WIS 1-42: Timber I-joists: applications and design* [35] provides guidance on timber I-joists, applications and design.

Adhesives

BS EN 16254 Adhesives. Emulsion polymerized isocyanate (EPI) for load-bearing timber structures. Classification and performance requirements [36] gives the classification and performance requirements for these types of adhesives where they are intended to be used in timber structures. Exova BM TRADA's *WIS 2-3/31: Adhesives for structural use* [37] provides further information on adhesively bonded timber connections.

Fasteners and connectors

Exova BM TRADA's *WIS 2/3-52 Fasteners for structural timber: nails, staples, screws, dowels and bolts* [38] provides further information on timber engineering hardware and connectors.

Eurocode terms and requirements

Principles versus application rules

In accordance with *BS EN 1990 Eurocode. Basis of structural design*, Eurocode 5 makes a distinction between 'principles' and 'application rules'. Principles are statements and requirements for which there are no alternatives. They are designated by the letter 'P' in front of the paragraph number. Application rules are generally recognised rules or procedures that satisfy the principles. They can be replaced by alternatives as long as the alternatives can be demonstrated to satisfy the same principles.

Actions

In accordance with *BS EN 1990*, Eurocode 5 sets out the fundamental requirements for the design of structures and requires that the timber structures be fit for their intended use under all applied actions.

Actions in this context are both direct (forces applied to the structure) and indirect (imposed deformations such as temperature-induced effects or settlement). Actions are classified as:

- permanent, such as self-weight of the structure
- variable, such as imposed loads and accidental loads.

The characteristic values for actions are modified by partial factors to take account of design situations and load combinations.

Service and load duration classes

Eurocode 5 defines three service classes similar to those of the BS 5268 family of standards. The UK National Annex to Eurocode 5 includes examples of relevant environmental conditions for each of the three service classes. There are, however, five load duration classes in Eurocode 5 as opposed to the four in BS 5268, with differing load durations to suit the conditions set out in *BS EN 1990*. Modification factors for service class and load duration class are combined in Eurocode 5 to form one modification factor, which is tabulated for solid timber, glued laminated timber and wood-based board materials.

Durability

BS EN 335 Durability of wood and wood-based products [39] defines the durability of wood and wood-based products with reference to five 'Use classes', of which only the first three are likely to occur in structures. Eurocode 5 specifies that the wood or wood-based product must have adequate natural durability for the Use class or be preservative treated.

Metal components of fasteners and other structural connections must be inherently corrosion resistant or protected against corrosion to a level appropriate to the service class. Eurocode 5 gives guidance on the minimum coating thicknesses for each service class for various types of fastener.

Both naturally durable timbers and preservative-treated wood can fulfil the durability requirements of Eurocode 5. The specification of preservative treatment levels in the European standards is included in *BS 8417*.

Ultimate limit states

The section of Eurocode 5 on ultimate limit states sets out the design procedure for members of solid timber, glulam, laminated veneer lumber or panel products. Design rules for bending, shear, compression both parallel and perpendicular to grain, tension and torsion, as well as rules for combined actions, are presented. Stability and bi-axial bending of columns are now discussed in detail. Design rules for tapered, curved, pitched or cambered elements for glulam designs are also presented.

Discussions on notching are also included, but guidance on drilling holes in beams is not presented; for this the designer must refer to *PD 6693-1*.

Serviceability limit states

The section on serviceability deals with the requirements for limiting deflection and vibration, and gives the principles and equations for their calculation. Detailed discussions on joint slip and vibration are now included. UK NA gives guidance on vibration for UK constructions and can be seen as an extension of the information contained in Eurocode 5. Serviceability limit states design is often regarded as one of the more complex areas of Eurocode 5, so Exova BM TRADA has produced a number of guidance publications on these topics (see *Further advice*).

Connections and assemblies

Connections

Connections is the longest and the most complex topic covered in Eurocode 5. This section covers the design of connections made with dowel-type fasteners based on Johansen formulations and gives detailed guidance for other forms of connections as well. Detailed design methods for laterally loaded nails, staples, screws, bolts and steel dowels are presented. Connection situations for two- and three-member timber to timber and steel or wood-based panel to timber joints are covered. No tables of capacities are presented; the designer is required to apply equations specific to the design situation.

Also covered in this section are design procedures for connections with connectors, including punched plate metal fasteners, toothed plates, shear plates and split rings. However, glued-in rods are not covered, although guidance is available in TRADA's manual on Eurocode 5 (see *Further advice*).

Components and assemblies

Engineered wood products are supported by Eurocode 5 by including design rules for glued thin-webbed beams, glued thin-flanged beams and mechanically jointed and glued columns. Eurocode 5 also includes assemblies and guidance on trusses, roof and floor diaphragms, wall diaphragms and bracing systems.

Structural detailing and control

Eurocode 5 acknowledges the importance of quality control and materials handling. It sets requirements for materials, joints assembly, common fixings, transportation and erection, all to ensure the materials satisfy the quality assumptions made in the design process. However, compared to BS 5268 and due to variations in national construction practices, Eurocode 5 stops short of giving detailed rules.

The *National Structural Timber Specification* [40], produced by Exova BM TRADA, provides detailed guidance as well as an editable version of a specification to aid the designer to specify timber and related products to suit the Eurocode 5 requirements. Discussions were taking place at the time of writing about the possibility of a timber 'Execution' standard to be produced as part of Eurocode 5.

Informative annexes

Eurocode 5 includes three Informative Annexes (not to be confused with the National Annexes). Annex A advises on possible shear failure types and limits at multiple dowel-type, steel-to-timber connections. Annex B offers a method of simplified analysis for mechanically jointed beams. This annex is widely used by cross-laminated timber (CLT) designers to calculate the stiffness of CLT products. Annex C is a design method for built-up columns, including lattice columns.

Two new chapters or annexes are also under development at the time of writing for the design of CLT elements and timber reinforcements for the prevention on splitting.

Further advice

Exova BM TRADA publishes downloadable PDF Guidance Documents (GD) for engineers and specialist designers, including:

- GD2: How to calculate the design values of loads using Eurocodes [41]
- GD5: How to calculate deformations in timber structures using Eurocodes [42]
- GD6: Vibration in timber floors (Eurocode 5) [43]
- GD7: Multiple fastener joints: design recommendations for BS 5268-2 and Eurocode 5 [44]
- GD10: Cross-laminated timber design guide for project feasibility (Eurocode 5) [45].

Books:

- Eurocode 5 Span tables
- Eurocode 5: timber design essentials for engineers [46]
- Manual for the design of timber building structures to Eurocode 5 [47].

Software for structural design using EC5:

- Timbersizer [48]
- Timberconnections [49]

All of the above are available from **www.trada.co.uk**.

References

1. BS EN 1995-1-1:2004+A2:2014 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings, BSI
2. BS 5268-2:2002+A1:2007 Structural use of timber. Code of practice for permissible stress design, materials and workmanship, BSI [withdrawn]
3. PD 6693-1:2012 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures, Part 1: General – Common rules and rules for buildings, BSI
4. BS EN 1990:2002+A1:2005 Eurocode. Basis of structural design, BSI
5. BS EN 1991 Eurocode 1. Actions on structures, BSI
6. BS 8417:2011+A1:2014 Preservation of wood. Code of practice, BSI
7. Eurocode 5 Span tables, 4th edition, ISBN 978-1909594142, BM TRADA, 2014
8. England and Wales Building Regulations: Approved Document A (Structure), NBS, 2010, available at www.planningportal.gov.uk
9. BS EN 1995-1-2:2004 Eurocode 5. Design of timber structures. General. Structural fire design, BSI
10. BS EN 1995-2:2004 Eurocode 5. Design of timber structures. Bridges, BSI
11. BS EN 14081-1:2016 Timber structures. Strength graded structural timber with rectangular cross section. General requirements, BSI
12. BS EN 14081-2:2010+A1:2012 Timber structures. Strength graded structural timber with rectangular cross section. Machine grading. Additional requirements for initial type testing, BSI
13. BS EN 14081-3:2012 Timber structures. Strength graded structural timber with rectangular cross section. Machine grading; additional requirements for factory production control, BSI
14. BS EN 14080:2013 Timber structures. Glued laminated timber. Requirements, BSI
15. BS EN 14374:2004 Timber structures. Structural laminated veneer lumber. Requirements, BSI
16. BS EN 14279:2004+A1:2009 Laminated veneer lumber (LVL). Definitions, classification and specifications, BSI
17. BS EN 13986:2004+A1:2015 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI
18. BS EN 622-1:2003 Fibreboards. Specifications. General requirements, BSI
19. BS EN 622-2:2004 Fibreboards. Specifications. Requirements for hardboards, BSI
20. BS EN 622-3:2004 Fibreboards. Specifications. Requirements for medium boards, BSI
21. BS EN 622-4:2009 Fibreboards. Specifications. Requirements for softboards, BSI
22. BS EN 622-5:2009 Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI
23. BS EN 300:2006 Oriented strand boards (OSB). Definitions, classification and specifications, BSI
24. BS EN 312:2010 Particleboards. Specifications, BSI
25. BS EN 14755:2005 Extruded particleboards. Specifications, BSI
26. BS EN 634-1:1995 Cement-bonded particle boards. Specification. General requirements, BSI
27. BS EN 634-2:2007 Cement-bonded particleboards. Specifications. Requirements for OPC bonded particleboards for use in dry, humid and external conditions, BSI
28. BS EN 636:2012+A1:2015 Plywood. Specifications, BSI
29. BS EN 338:2016 Structural timber. Strength classes, BSI
30. BS EN 12369-1:2001 Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards, BSI
31. BS EN 12369-2:2011 Wood-based panels. Characteristic values for structural design. Plywood, BSI
32. WIS 4-7: Timber strength grading and strength classes, TRADA Technology, 2011
33. BS EN 301:2013 Adhesives, phenolic and aminoplastic, for loading bearing timber structures. Classification and performance requirements, BSI
34. BS EN 15425:2017 Adhesives. One component polyurethane for load-bearing timber structures. Classification and performance requirements, BSI
35. WIS 1-42: Timber I-joists: applications and designs, Exova BM TRADA Technology, 2016
36. BS EN 16254:2013+A1:2016 Adhesives. Emulsion polymerized isocyanate (EPI) for load-bearing timber structures. Classification and performance requirements, BSI
37. WIS 2/3-31 Adhesives for structural use, Exova BM TRADA, 2016
38. WIS 2/3-52 Fasteners for structural timber: nails, staples, screws, dowels and bolts, Exova BM TRADA, 2016
39. BS EN 335:2013 Durability of wood and wood-based products. Use classes: definition, application to solid wood and wood-based products, BSI
40. National Structural Timber Specification, ISBN 978-1909594340, BM TRADA, 2015
41. GD2: How to calculate the design values of loads using Eurocodes, TRADA Technology, 2006
42. GD5: How to calculate deformations in timber structures using Eurocodes, TRADA Technology, 2006
43. GD6: Vibration in timber floors (Eurocode 5), TRADA Technology, 2009
44. GD7: Multiple fastener joints: design recommendations for BS 5268-2 and Eurocode 5, TRADA Technology, 2008
45. GD10: Cross-laminated timber design guide for project feasibility (Eurocode 5), TRADA Technology, 2009
46. Eurocode 5: timber design essentials for engineers, ISBN 978-1900510707, TRADA Technology, 2009
47. Manual for the design of timber building structures to Eurocode 5, ISBN 978-0901297440, IStructE/TRADA, 2007
48. Timbersizer, TRADA Technology, 2009, software at www.trada.co.uk
49. Timberconnections, TRADA Technology, 2010, software at www.trada.co.uk

About TRADA

The Timber Research and Development Association (TRADA) is an internationally recognised centre of excellence on the specification and use of timber and wood products.

TRADA is a company limited by guarantee and not-for-profit membership-based organisation. TRADA's origins go back over 80 years and its name is synonymous with independence and authority. Its position in the industry is unique with a diverse membership encompassing companies and individuals from around the world and across the entire wood supply chain, from producers, merchants and manufacturers, to architects, engineers and end users.

Our aim

To provide members with the highest quality information on timber and wood products to enable them to maximise the benefits that timber can provide.

What we do

We seek to achieve this aim through active and on-going programmes of information and research. Information is provided through our website, an extensive collection of printed materials and our training courses.

Research is largely driven by the desire to update and improve our information so that it continues to meet our members' needs in the future.

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Exova BM TRADA is contracted by the Timber Research and Development Association to prepare and publish all Wood Information Sheets.

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