

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)



BSI Standards Publication

## Water-tube boilers and auxiliary installations

---

Part 3: Design and calculation for pressure parts of the boiler

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

## National foreword

This British Standard is the UK implementation of EN 12952-3:2022. It supersedes BS EN 12952-3:2011, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PVE/2, Water Tube And Shell Boilers.

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

### Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication has been prepared under a mandate given to the European Standards Organizations by the European Commission and the European Free Trade Association. It is intended to support requirements of the EU legislation detailed in the European Foreword. A European Annex, usually Annex ZA or ZZ, describes how this publication relates to that EU legislation.

For the Great Britain market (England, Scotland and Wales), if UK Government has designated this publication for conformity with UKCA marking (or similar) legislation, it may contain an additional National Annex. Where such a National Annex exists, it shows the correlation between this publication and the relevant UK legislation. If there is no National Annex of this kind, the relevant Annex ZA or ZZ in the body of the European text will indicate the relationship to UK regulation applicable in Great Britain. References to EU legislation may need to be read in accordance with the UK designation and the applicable UK law. Further information on designated standards can be found at [www.bsigroup.com/standardsandregulation](http://www.bsigroup.com/standardsandregulation).

For the Northern Ireland market, UK law will continue to implement relevant EU law subject to periodic confirmation. Therefore Annex ZA/ZZ in the European text, and references to EU legislation, are still valid for this market.

UK Government is responsible for legislation. For information on legislation and policies relating to that legislation, consult the relevant pages of [www.gov.uk](http://www.gov.uk).

© The British Standards Institution 2022  
Published by BSI Standards Limited 2022

ISBN 978 0 539 16857 0

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

ICS 23.020.01; 27.040; 27.060.30

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2022.

**Amendments/corrigenda issued since publication**

Date	Text affected
------	---------------

---

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

## EUROPÄISCHE NORM

November 2022

ICS 27.040

Supersedes EN 12952-3:2011

English Version

## Water-tube boilers and auxiliary installations - Part 3: Design and calculation for pressure parts of the boiler

Chaudière à tubes d'eau et installations auxiliaires -  
Partie 3 : Conception et calcul des parties sous pression  
de la chaudière

Wasserrohrkessel und Anlagenkomponenten - Teil 3:  
Konstruktion und Berechnung für drucktragende  
Kesselteile

This European Standard was approved by CEN on 26 September 2022.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

<b>Contents</b>	<b>Page</b>
European foreword .....	8
1 Scope.....	10
2 Normative references.....	10
3 Terms and definitions.....	11
4 Symbols and abbreviations .....	11
5 General.....	11
5.1 Purpose.....	11
5.2 Dimensions of pressure parts .....	11
5.3 Strength of pressure parts.....	12
5.4 Design by analysis .....	12
5.5 Cyclic loading.....	12
5.6 Other design requirements.....	13
5.6.1 General.....	13
5.6.2 Access.....	14
5.6.3 Drainage and venting .....	14
5.7 Design, calculation and test pressures.....	14
5.7.1 Design pressure.....	14
5.7.2 Calculation pressure.....	14
5.7.3 Calculation pressure for pressure differences.....	15
5.7.4 Hydrostatic test .....	15
5.8 Metal wastage.....	16
5.8.1 Internal wastage.....	16
5.8.2 External wastage.....	16
5.8.3 Requirements.....	16
5.8.4 Stress corrosion.....	16
5.8.5 Mechanical requirements.....	17
5.9 Attachment on pressure parts .....	17
5.9.1 Load carrying attachments.....	17
5.9.2 Non load carrying attachments.....	17
6 Calculation temperature and nominal design stress.....	17
6.1 Calculation temperature .....	17
6.1.1 General.....	17
6.1.2 Circulation boilers.....	18
6.1.3 Once-through boilers, superheaters and reheaters.....	18
6.1.4 Hot water generators .....	18
6.1.5 Temperature allowances for unheated components.....	18
6.1.6 Headers.....	19
6.1.7 Unheated components .....	19
6.1.8 Components protected against radiation .....	19
6.1.9 Components heated by convection.....	19
6.1.10 Components heated by radiation.....	20
6.2 Maximum through-the-wall temperature difference and maximum flue gas temperature for heated drums and headers .....	21

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

6.2.1	Maximum through-the-wall temperature difference.....	21
6.2.2	Headers exposed to flue gas .....	21
6.2.3	Allowable deviations.....	22
6.3	Design stress.....	22
6.3.1	General .....	22
6.3.2	Rolled and forged steels.....	23
6.3.3	Austenitic steels .....	23
6.3.4	Non-alloy and low-alloy cast steel .....	24
6.3.5	Nodular graphite cast iron .....	24
6.3.6	Design stress for welded connections operating under creep condition.....	25
6.3.7	Design stress for test pressure .....	25
7	Cylindrical shells of drums and headers under internal pressure.....	25
7.1	Shell thickness .....	25
7.1.1	Requirements.....	25
7.1.2	Required wall thickness including allowances.....	26
7.2	Basic calculation .....	26
7.2.1	Required wall thickness without allowances.....	26
7.2.2	Different thickness.....	26
7.2.3	Fabrication tolerances.....	26
7.3	Combined stress in drum or header shells.....	27
7.3.1	General .....	27
7.3.2	Stress from longitudinal loads.....	27
7.3.3	Longitudinal bending stress .....	28
7.3.4	Evaluation of ligament stress for inclined ligaments in drums .....	29
7.4	Boiler drum supports.....	30
7.5	Other stresses in cylindrical shells .....	31
8	Openings and branches in cylindrical shells of drums and headers and integral tubes .....	31
8.1	General .....	31
8.1.1	Requirements for the ligament efficiency of the main body with openings and branches.....	31
8.1.2	Effective lengths for calculation of efficiencies of components.....	36
8.1.3	Conditions for isolated openings .....	37
8.1.4	Requirements for design of branches .....	37
8.1.5	Requirements for the design of reinforcing pads.....	38
8.2	Efficiency factor, calculation by way of approximation, and maximum diameter of unreinforced openings .....	38
8.2.1	General .....	38
8.2.2	Allowable efficiency and maximum diameter of unreinforced opening.....	38
8.2.3	Isolated openings.....	39
8.2.4	Adjacent openings .....	41
8.3	Design of openings and branches in cylindrical shells (efficiency and reinforcement) .....	42
8.3.1	Symbols and abbreviations.....	42
8.3.2	Requirements for application .....	42
8.3.3	Design of isolated openings and branch connections .....	47
8.3.4	Design of adjacent openings and branch connections .....	50
8.4	Bolted connections.....	51
8.4.1	General .....	51
8.4.2	Symbols and abbreviations.....	52
8.4.3	Calculation of bolt diameter .....	53
8.4.4	Calculation of bolt load.....	54

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

8.4.6	Design strength value $K$ .....	57
8.4.7	Safety factor $S$ .....	57
8.4.8	Quality factor $q$ .....	57
8.5	Screwed and socket welded connections.....	58
8.5.1	Screwed connections into the belt.....	58
8.5.2	Screwed socket connections.....	58
8.5.3	Socket welded connections.....	59
9	Headers and plain tubes of rectangular section.....	60
9.1	General.....	60
9.2	Symbols and abbreviations.....	62
9.3	Required wall thickness.....	63
9.3.1	General.....	63
9.3.2	Minimum wall thickness at the centre of one side.....	64
9.3.3	Minimum wall thickness at the corners.....	64
9.3.4	Minimum thickness at a line of openings.....	64
9.3.5	Minimum wall thickness at staggered opening arrangement (diagonal pitch).....	65
9.3.6	Minimum wall thickness at isolated openings.....	65
10	Ends and spherical shells.....	66
10.1	Symbols and abbreviations.....	66
10.2	Spherical shells and dished heads.....	66
10.2.1	General.....	66
10.2.2	Calculation formula.....	68
10.2.3	Openings in dished ends and spherical ends.....	71
10.3	Unstayed flat ends.....	75
10.3.1	General.....	75
10.3.2	Thickness of circular unstayed flat ends.....	78
10.3.3	Thickness of non-circular and rectangular unstayed flat ends.....	78
10.4	Flat unstayed closures.....	81
11	Tubes.....	83
11.1	Symbols and abbreviations.....	83
11.2	Thickness of straight boiler tubes.....	83
11.2.1	Required wall thickness with allowances.....	83
11.2.2	Required wall thickness without allowances.....	84
11.2.3	Minimum thickness.....	84
11.2.4	Circumferentially butt welded tubes.....	85
11.3	Thickness of tube bends and elbows.....	85
11.3.1	General.....	85
11.3.2	Required wall thickness with allowances.....	85
11.3.3	Required wall thickness without allowances.....	86
11.3.4	Departure from circularity of tube bends.....	86
11.4	Flexibility of integral tubing systems.....	87
11.4.1	General.....	87
11.4.2	Analysis.....	87
11.5	Structural attachments to tubes.....	87
11.5.1	General.....	87
11.5.2	Attachments welded on tube bends.....	89
11.5.3	Length of attachments.....	89
11.5.4	Limit of intensity in the case of radial loading.....	89
11.5.5	Calculation of intensity in the case of radial loading.....	89
11.5.6	Strength of welds.....	91
11.6	Fitting and joining of heated tubes.....	92



This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

11.6.1	Fitting of tubes .....	92
11.6.2	Joining of heated tubes .....	92
11.7	Joining of unheated tubes .....	92
11.7.1	General .....	92
11.7.2	Flanges and bolting .....	92
11.7.3	Butt welded joints .....	92
11.7.4	Screwed or screwed and seal welded joints .....	92
11.8	Standardized fittings .....	92
12	Pressure parts of irregular shape .....	93
12.1	Hydrostatic test for determining the allowable internal pressure .....	93
12.1.1	General .....	93
12.1.2	Proof test to produce yielding .....	93
12.1.3	Proof test to destruction .....	94
12.2	Numerical methods .....	94
12.2.1	General .....	94
12.2.2	Methods .....	94
12.2.3	Evaluation of stress .....	95
13	Fatigue .....	95
13.1	General .....	95
13.1.1	Procedure .....	95
13.1.2	Fatigue loading .....	95
13.1.3	Calculation of fluctuating stress .....	96
13.1.4	Fatigue assessment .....	96
13.2	Symbols and abbreviations .....	96
13.3	Exemption rule for fatigue analysis .....	98
13.3.1	General .....	98
13.3.2	Materials .....	98
13.3.3	Loadings .....	99
13.3.4	Temperature differences during transient operating conditions .....	100
13.4	Stress analysis for fatigue calculation .....	106
13.4.1	Principal and equivalent stresses .....	106
13.4.2	Temperature of a load cycle .....	106
13.4.3	Protection of the magnetite layer .....	107
13.4.4	Allowable circumferential stress range at the inside corner of a bore .....	107
13.4.5	Circumferential stress caused by pressure at the inside corner of a bore .....	107
13.4.6	Stresses on the branch caused by external forces and moments .....	108
13.4.7	Thermal stresses .....	108
13.4.8	Upper and lower limit of the circumferential stress at the inside corner of a bore .....	108
13.4.9	Admissible through-the-wall temperature differences .....	112
13.4.10	Allowable temperature transients .....	113
13.4.11	Components with oblique and/or non-radial branches .....	113
13.5	Example calculations .....	113
Annex A (normative)	Calculation of tube bends and elbows .....	117
A.1	General .....	117
A.2	Symbols and abbreviations .....	117
A.3	Calculation .....	118
A.3.1	Required wall thickness .....	118
A.3.2	Calculation of the wall thickness .....	118
A.3.3	Calculation of stress .....	120

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

A.3.3.2	The strength conditions for the extrados of the bend shall be: .....	120
Annex B (normative) Fatigue cracking – Design to allow for fluctuating stress .....		127
B.1	General.....	127
B.2	Conditions.....	127
B.3	Symbols and abbreviations .....	129
B.4	Cyclic stress range and mean cyclic stress in the case of uniaxial and multiaxial fluctuating stress.....	130
B.4.1	General.....	130
B.4.2	Uniaxial stress state .....	130
B.4.3	Multiaxial stress state with principal stress directions constant .....	130
B.5	Correction factors for taking into account the influences of surface finish and weldments.....	132
B.6	Controlling stress range .....	140
B.6.1	General.....	140
B.6.1.1	Controlling stress range .....	140
B.6.1.2	Elastic range.....	140
B.6.1.3	Partly elastic range.....	140
B.6.1.4	Fully plastic range.....	140
B.6.2	Correction factor .....	141
B.7	Permissible stress range with a known number of load cycles .....	142
Annex C (informative) Examples of calculating the effects of fatigue.....		143
C.1	General.....	143
C.2	Calculation of the admissible number of load cycles.....	143
C.3	Calculation of the admissible temperature gradient.....	146
Annex D (informative) Physical properties of steels .....		150
D.1	General.....	150
D.2	Symbols and abbreviations .....	150
D.3	Physical properties .....	150
D.3.1	Density.....	150
D.3.2	Differential coefficient of linear thermal expansion.....	150
D.3.3	Heat capacity .....	151
D.3.4	Thermal diffusivity.....	151
D.3.5	Poisson’s ratio.....	151
D.4	Physical properties of steels.....	151
D.4.1	Data sheet (tables) .....	151
D.4.2	Graphs.....	153
D.4.3	Polynomials .....	157

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

<b>Annex E (informative) Consideration of external wastage due to flue gas exposure .....</b>	<b>160</b>
<b>E.1 General .....</b>	<b>160</b>
<b>E.2 Symbols and abbreviations.....</b>	<b>160</b>
<b>E.3 Wall thickness of straight tubes in accordance to Clause 11 .....</b>	<b>160</b>
<b>E.3.1 Required wall thickness with allowance .....</b>	<b>160</b>
<b>E.3.2 Required wall thickness without allowances.....</b>	<b>160</b>
<b>E.3.3 Circumferentially butt welded tubes.....</b>	<b>160</b>
<b>E.4 Wall thickness of tube bends and elbows in accordance with Clause 11 .....</b>	<b>161</b>
<b>E.4.1 Required wall thickness with allowance .....</b>	<b>161</b>
<b>E.4.2 Required wall thickness without allowances.....</b>	<b>161</b>
<b>E.5 Wall thickness of tube bends and elbows in accordance with Annex A.....</b>	<b>161</b>
<b>Annex F (informative) Significant technical changes between this European Standard and the previous edition.....</b>	<b>162</b>
<b>Annex ZA (informative) Clauses of this European Standard addressing essential safety requirements of the Pressure Equipment Directive 2014/68/EU .....</b>	<b>163</b>
<b>Bibliography .....</b>	<b>165</b>

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

This document (EN 12952-3:2022) has been prepared by Technical Committee CEN/TC 269 "Shell and water-tube boilers", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2023, and conflicting national standards shall be withdrawn at the latest by May 2023.

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

This document supersedes EN 12952-3:2011.

Annex F provides details of significant technical changes between this document and the previous edition.

The EN 12952 series, concerning water-tube boilers and auxiliary installations, consists of the following parts:

- *Part 1: General*
- *Part 2: Materials for pressure parts of boilers and accessories*
- *Part 3: Design and calculation for pressure parts of the boiler*
- *Part 4: In-service boiler life expectancy calculations*
- *Part 5: Workmanship and construction of pressure parts of the boiler*
- *Part 6: Inspection during construction, documentation and marking of pressure parts of the boiler*
- *Part 7: Requirements for equipment for the boiler*
- *Part 8: Requirements for firing systems for liquid and gaseous fuels for the boiler*
- *Part 9: Requirements for firing systems for pulverized solid fuels for the boiler*
- *Part 10: Requirements for safety devices against excessive pressure*
- *Part 11: Requirements for limiting devices of the boiler and accessories*
- *Part 12: Requirements for boiler feedwater and boiler water quality*
- *Part 13: Requirements for flue gas cleaning systems*
- *Part 14: Requirements for flue gas DENOX-systems using liquified pressurized ammonia and ammonia water solution*
- *Part 15: Acceptance tests*
- *Part 16: Requirements for grate and fluidized-bed firing systems for solid fuels for the boiler*
- *CR 12952 Part 17: Guideline for the involvement of an inspection body independent of the manufacturer*

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

— *Part 18: Operating Instructions*

Although these parts can be obtained separately, it should be recognized that the parts are inter-dependent. As such, the design and manufacture of water-tube boilers requires the application of more than one part in order for the requirements of this document to be satisfactorily fulfilled.

NOTE A "Boiler Helpdesk" has been established in CEN/TC 269 which may be contacted for any questions regarding the application of European Standards series EN 12952 and EN 12953, see the following website: <http://www.boiler-helpdesk.din.de>.

This document has been prepared under a Standardization Request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) / Regulation(s).

For relationship with EU Directive(s) / Regulation(s), see informative Annex ZA, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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

This is a preview of "BS EN 12952-3:2022". [Click here to purchase the full version from the ANSI store.](#)

This document specifies the requirements for the design and calculation of water-tube boilers as defined in EN 12952-1.

The purpose of this document is to ensure that the hazards associated with water-tube boilers are reduced to a minimum by the proper application of the design according to this part of EN 12952.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 1092-1:2018, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges*

EN 1759-1:2004, *Flanges and their joint - Circular flanges for pipes, valves, fittings and accessories, Class designated - Part 1: Steel flanges, NPS 1/2 to 24*

EN 10028-1:2017, *Flat products made of steels for pressure purposes - Part 1: General requirements*

EN 10164:2018, *Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions*

EN 10253-2:2021, *Butt-welding pipe fittings — Part 2: Non alloy and ferritic alloy steels with specific inspection requirements*

EN 10266:2003, *Steel tubes, fittings and structural hollow sections - Symbols and definitions of terms for use in product standards*

EN 12952-1:2015, *Water-tube boilers and auxiliary installations - Part 1: General*

EN 12952-2:2021, *Water-tube boilers and auxiliary installations - Part 2: Materials for pressure parts of boilers and accessories*

EN 12952-5:2021, *Water-tube boilers and auxiliary installations - Part 5: Workmanship and construction of pressure parts of the boiler*

EN 12952-6:2021, *Water-tube boilers and auxiliary installations - Part 6: Inspection during construction, documentation and marking of pressure parts of the boiler*

EN 12952-7:2012, *Water-tube boilers and auxiliary installations - Part 7: Requirements for equipment for the boiler*

EN 12952-12:2003, *Water-tube boilers and auxiliary installations - Part 12: Requirements for boiler feedwater and boiler water quality*

EN 12953-3:2016, *Shell boilers - Part 3: Design and calculation for pressure parts*

EN 13445-3:2021, *Unfired pressure vessels — Part 3: Design*