



BSI Standards Publication

Water-tube boilers and auxiliary installations

Part 5: Workmanship and construction of pressure parts of the boiler

National foreword

This British Standard is the UK implementation of EN 12952-5:2021. It supersedes BS EN 12952-5:2011, which is withdrawn.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.

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.

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.

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.

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

ISBN 978 0 539 06746 0

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 31 January 2022.

Amendments/corrigenda issued since publication

Date

Text affected

English Version

Water-tube boilers and auxiliary installations - Part 5: Workmanship and construction of pressure parts of the boiler

Chaudières à tubes d'eau et installations auxiliaires -
Partie 5: Fabrication et construction des parties sous
pression des chaudières

Wasserrohrkessel und Anlagenkomponenten - Teil 5:
Verarbeitung und Bauausführung für drucktragende
Kesselteile

This European Standard was approved by CEN on 1 November 2021.

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, Turkey 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

Contents

European foreword	8
1 Scope.....	10
2 Normative references.....	10
3 Terms and definitions	12
4 Symbols and abbreviations	12
5 General.....	12
6 Pressure part.....	13
6.1 Drums, headers and similar pressure parts	13
6.1.1 Principles for manufacturing	13
6.1.2 Manufacturing process for header ends.....	13
6.1.3 Material for header ends.....	13
6.2 Material identification	13
6.3 Material marking	13
6.3.1 General.....	13
6.3.2 Responsible personnel	13
6.3.3 Method of marking.....	14
6.3.4 Marking of non-pressure parts	14
6.3.5 Marking of bolts and nuts	14
6.4 Marking during manufacture	14
6.4.1 Temporary marking.....	14
6.4.2 Permanent marking.....	14
6.4.3 Tube bends	14
6.4.4 Location drawings	14
7 Cutting, forming and fabrication tolerances.....	15
7.1 Cutting material.....	15
7.1.1 Methods for cutting.....	15
7.1.2 Post-cutting measures.....	15
7.2 Forming of drums, headers and ends	15
7.2.1 General.....	15
7.2.2 Drum and header shells	15
7.2.3 Ends.....	16
7.2.4 Plates welded prior to hot or cold forming	16
7.2.5 Extruded openings in headers	16
7.3 Forming of tube bends	16
7.3.1 General.....	16
7.3.2 Tube bending procedure test	16
7.3.3 Requirements for dimensional testing	16
7.3.4 Thinning at the tube bend extrados for tubes of nominal outside diameter 142 mm and below.....	17
7.3.5 Thickening at the tube bend intrados for tubes of nominal outside diameter above 80 mm and including 142 mm.....	18
7.3.6 Thinning/thickening at the tube bend extrados/intrados for tubes of nominal outside diameter greater than 142 mm	18
7.3.7 Departure from circularity of the tube bends	18
7.3.8 Post bend heat treatment of tube bends	19
7.3.9 Post-bend heat treatment requirements	20
7.3.10 Ripples on the intrados of tube bends.....	21
7.3.11 The surface of tube bends.....	23

7.3.12	Gang bending of tube panels.....	23
7.3.13	Bending of composite materials tubing.....	23
7.3.14	Manufacturing of tube reducers.....	23
7.4	Drum and header fabrication tolerances.....	24
7.4.1	Assembly tolerances for shells and fabricated from plate and end to shells.....	24
7.4.2	Finished tolerances for shells	25
7.4.3	Finished tolerances for ends	26
8	Welding	26
8.1	Design and other requirements specific to welding	26
8.1.1	General	26
8.1.2	Material selection with regard to welding	27
8.1.3	Indication of the welded seams in the drawings.....	27
8.1.4	Pre-requisites for welding.....	27
8.1.5	Oxy-acetylene welding.....	27
8.1.6	Butt welds in tube bends.....	27
8.1.7	Minimum distances between adjacent seams.....	27
8.1.8	Longitudinal butt welds in drum strakes.....	28
8.1.9	Offset of longitudinal butt welds in the case of several strakes	28
8.1.10	Joints of dissimilar materials	28
8.1.11	Protection from the weather	28
8.1.12	Availability of the welding procedure specification	28
8.2	Welding consumables	29
8.3	Welding procedure qualification.....	29
8.3.1	General	29
8.3.2	Application of EN ISO 15614-1:2017, Level 2	29
8.4	Qualification of welders and welding operators.....	31
8.5	General production requirements for welding	32
8.5.1	Surface condition before welding.....	32
8.5.2	Assembly of components for welding	32
8.5.3	Temporary attachments	32
8.5.4	Stray arcing.....	32
8.5.5	Traceability of welders.....	32
8.6	Repairs to welds.....	33
8.6.1	General	33
8.6.2	Repair of longitudinal and circumferential butt welds of drums and headers requiring test plates	33
8.6.3	Non-destructive examination.....	33
8.6.4	Records of weld repairs.....	33
8.7	Pre-heating	33
8.8	Post-weld heat treatment.....	33
8.9	Welding subsequent to final post-weld heat treatment.....	34
8.10	Welded joints, connections and production test plates.....	35
8.10.1	Longitudinal and circumferential butt welds and test plates in drums and headers.....	35
8.10.2	Welded header end closures	37
8.10.3	Welded branches, nozzles, stubs and other attachments on drums and headers	37
8.10.4	Pads, reinforcing plates and manhole frames.....	38
8.11	Attachment of non-pressure parts to drums and headers by welding.....	38
8.12	Welding of tubes	39
8.12.1	General	39
8.12.2	Continuity of welding	39
8.12.3	Completion of welding.....	39
8.12.4	Proximity of butt welds in straight tubes	39

8.12.5	Alignment of tube bores	39
8.12.6	Angular alignment of butt welded tubes	40
8.12.7	Fabricated bends.....	40
8.12.8	Backing rings	40
8.12.9	Purging of welds.....	40
8.12.10	Welding of branches, nozzles and stubs to tubes	40
8.12.11	Attachment by welding of non-pressure parts to tubes	41
8.13	Flash butt welding of tubes	41
8.14	Welded tube water walls.....	41
8.15	Arc stud welding.....	41
9	Mechanical connections	41
9.1	General.....	41
9.2	Access openings.....	41
9.2.1	Types	41
9.2.2	Size	42
9.2.3	Internal doors	42
9.2.4	External doors.....	42
9.3	Branches and nozzles mechanically connected to the main pressure parts.....	43
9.3.1	Scope and restrictions.....	43
9.3.2	Screw connections	43
9.3.3	Studded connections.....	43
9.4	Tube connections.....	43
9.4.1	Expanded connections	43
9.4.2	Tube to tube mechanical connections.....	46
9.4.3	Connection of non-pressure parts to pressure parts.....	46
10	Thermal treatment.....	46
10.1	General.....	46
10.2	Heating cycles and heat treatment(s) associated with plate forming operations	46
10.2.1	Heating cycles associated with hot forming.....	46
10.2.2	Heat treatment associated with forming.....	47
10.2.3	Shells and strakes	47
10.2.4	Ends.....	47
10.2.5	Production test requirements for formed components	48
10.3	Pre-heating for welding and thermal cutting	48
10.3.1	General.....	48
10.3.2	Pre-heating for welding.....	48
10.3.3	Pre-heating for thermal cutting.....	49
10.3.4	Measurement of pre-heat	49
10.4	Post weld heat treatment.....	50
10.4.1	General.....	50
10.4.2	Methods of post weld heat treatment.....	55
10.4.3	Post-weld heat treatment procedures	58
10.5	Heat treatment of production test plates.....	59
Annex A	(normative) Tube bending procedure tests.....	60
A.1	General.....	60
A.2	Hot or cold formed bends in tubes with outside diameter ≤ 142 mm	60
A.2.1	Types of bending processes	60
A.2.2	Post bending heat treatment (PBHT)	61
A.2.3	Validity range of tests.....	61

A.2.4 Qualification test requirements	62
A.2.4.1 General	62
A.2.4.2 Ripples on intrados of the bend	62
A.2.4.3 Surface defects	62
A.2.4.4 Bend geometry	63
A.2.4.5 Hardness test	63
A.2.4.6 Mechanical tests	63
A.2.4.7 Gang bending of tube panels	63
A.3 Cold formed bends in tubes with outside diameter > 142 mm	63
A.3.1 Types of bending processes	63
A.3.2 Post bending heat treatment	63
A.3.3 The validity range of the test	64
A.3.4 Qualification test requirements	64
A.3.4.1 General	64
A.3.4.2 Ripples on intrados of the bend	64
A.3.4.3 Surface imperfections	64
A.3.4.4 Bend geometry	64
A.3.4.5 Hardness test	64
A.3.4.6 Mechanical testing	65
A.4 Hot formed bends in tubes with outside diameter > 142 mm	65
A.4.1 Types of bending processes	65
A.4.2 Post bending heat treatment	65
A.4.3 The validity range of the test	65
A.4.4 Qualification test requirements	65
A.4.4.1 General	65
A.4.4.2 Ripples on intrados of the bend	66
A.4.4.3 Surface imperfections	66
A.4.4.4 Bend geometry	66
A.4.4.5 Mechanical testing	66
A.4.4.5.1 General	66
A.4.4.5.2 Metallographic examination	66
A.4.4.5.3 Definitive and comparative tests	66
A.4.4.5.4 Tensile test in accordance with EN ISO 6892-1:2019	67
Annex B (informative) Welded pressure connections and non-pressure containing attachments	69
Annex C (normative) Manufacture of welded tubewalls	70
C.1 General	70

C.2	Methods of manufacture	70
C.2.1	General.....	70
C.2.2	Tubes finned by welding	70
C.2.3	Integrally finned tubes.....	70
C.2.4	Other methods	70
C.3	Allowable materials	70
C.3.1	Tubes.....	70
C.3.2	Fins.....	70
C.3.3	Filler materials	71
C.4	Manufacturing processes and controls.....	71
C.4.1	Welding process	71
C.4.2	Specific requirements for manufacturers.....	71
C.4.2.1	Surface cleanliness	71
C.4.2.2	Fin to tube attachment welds	71
C.4.2.3	Welding imperfections in fin to tube welds	72
C.4.2.4	Site welding.....	72
C.4.3	Heat treatment.....	72
C.4.3.1	Pre-heating.....	72
C.4.3.2	Post-weld heat treatment	72
C.5	Welding procedure approvals.....	72
C.6	Production tests	72
C.7	Non-destructive examination (NDE).....	73
	Annex D (normative) Coiled boilers and coiled superheaters	77
D.1	General.....	77
D.2	Special requirements	77
	Annex E (normative) Special requirements for chemical recovery boilers	78
E.1	General.....	78
E.2	Special requirements for forming of composite tube bends.....	78
E.2.1	General.....	78
E.2.2	Application of forming rules to composite tubing	78
E.2.2.1	Range of tube bending procedure test approval	78
E.2.2.2	Additional tests required for composite tubes	78
E.2.2.2.1	Ultrasonic testing of a composite tube bend concerning the metallurgical bonding	78
E.2.2.2.2	Hardness test	78
E.3	Special requirements for manufacture of welded tubewalls from composite tubes	78
E.3.1	General.....	78

E.3.2	Fins.....	79
E.3.3	Fin-to-tube attachment welds on composite tubes	79
E.4	Material marking	79
E.5	Flash butt welding	79
E.6	Special requirements of qualification of welding procedures for fusion welding.....	79
E.6.1	General	79
E.6.2	Application of EN ISO 15614-1:2017, Level 2 to composite tubes	79
E.6.2.1	Range of qualification	79
E.6.2.2	Additional tests required.....	79
E.6.2.2.1	Depth of penetration of clad weld.....	79
E.6.2.2.2	Hardness test	80
E.6.2.2.3	Bend test.....	80
E.6.2.2.4	Transverse tensile test.....	80
E.6.2.2.5	Microscopic examination	80
E.7	Special requirements for welder's qualification for fusion welding of composite tubes	80
E.7.1	General	80
E.7.2	Application of EN ISO 9606-1:2017 to composite tubes	80
E.7.2.1	Range of qualification	80
E.7.2.2	Additional tests required - Macroscopic examination.....	81
Annex F (informative)	Guidelines for the determination of the competency of boiler manufacturers	82
F.1	General	82
F.2	Responsibility of the purchaser	82
F.3	Responsibility of the manufacturer	82
F.4	Requirements concerning the manufacturer's competency.....	82
F.5	Manufacturer's competency declaration	83
Annex G (informative)	Significant technical changes between this document and the previous edition	94
Annex ZA (informative)	Relationship between this European Standard and the Essential Requirements of EU Directive 2014/68/EU aimed to be covered	95
Bibliography		96

European foreword

This document (EN 12952-5:2021) 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 June 2022, and conflicting national standards shall be withdrawn at the latest by June 2022.

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 12952-5:2011.

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

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;*
- *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 safeguards 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 liquefied 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.*

- *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 the document to be satisfactorily fulfilled.

NOTE A “Boiler Helpdesk” has been established in CEN/TC 269 which can be contacted for any questions regarding the application of EN 12952 series and EN 12953 series, 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, Turkey and the United Kingdom.

1 Scope

This document specifies requirements for the workmanship and construction of water-tube boilers as defined in EN 12952-1:2015.

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 10025-2:2019, *Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10028-2:2017, *Flat products made of steels for pressure purposes - Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 10216-2:2013, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10253-2:2007, *Butt-welding pipe fittings - Part 2: Non alloy and ferritic alloy steels with specific inspection requirements*

EN 10253-4:2008,¹ *Butt-welding pipe fittings - Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements*

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 12952-3:2011, *Water-tube boilers and auxiliary installations - Part 3: Design and calculation for 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 ISO 148-1:2016, *Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016)*

¹ Document impacted by EN 10253-4:2008/AC:2009.

EN ISO 3452-1:2013, *Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1:2013, Corrected version 2014-05-01)*

EN ISO 4759-1:2000, *Tolerances for fasteners - Part 1: Bolts, screws, studs and nuts - Product grades A, B and C (ISO 4759-1:2000)*

EN ISO 6507-1:2018, *Metallic materials - Vickers hardness test - Part 1: Test method (ISO 6507-1:2018)*

EN ISO 6892-1:2019, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2019)*

EN ISO 9606-1:2017, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2012 including Cor 1:2012 and Cor 2:2013)*

EN ISO 14555:2017, *Welding - Arc stud welding of metallic materials (ISO 14555:2017)*

EN ISO 15609 (all parts), *Specification and qualification of welding procedures for metallic materials — Welding procedure specification (ISO 15609, all parts)*

EN ISO 15613:2004, *Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test (ISO 15613:2004)*

EN ISO 15614-1:2017,² *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2017)*

EN ISO 15614-7:2019, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 7: Overlay welding (ISO 15614-7:2016)*

EN ISO 14732:2013, *Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013)*

EN ISO 17638:2016, *Non-destructive testing of welds - Magnetic particle testing (ISO 17638:2016)*

EN ISO 17639:2013, *Destructive tests on welds in metallic materials - Macroscopic and microscopic examination of welds (ISO 17639:2003)*

EN ISO 17663:2009, *Welding - Quality requirements for heat treatment in connection with welding and allied processes (ISO 17663:2009)*

EN ISO 23277:2015, *Non-destructive testing of welds - Penetrant testing - Acceptance levels (ISO 23277:2015)*

EN ISO 23278:2015, *Non-destructive testing of welds - Magnetic particle testing - Acceptance levels (ISO 23278:2015)*

CEN ISO/TR 15608:2017, *Welding — Guidelines for a metallic material grouping system (ISO/TR 15608:2017)*

² Document impacted by EN ISO 15614-1:2017/A1:2019.

3 Terms and definitions

For the purposes of this document the terms and definitions given in EN 12952-1:2015 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

cold forming

for ferritic steels, it is forming at temperatures below the maximum permissible temperature for post-weld heat treatment and for austenitic materials it is forming at temperatures below 300 °C

Note 1 to entry: See Table 12.

3.2

hot forming

for ferritic steels, it is forming at temperatures at or above the maximum permissible temperature for post-weld heat treatment

Note 1 to entry: See Table 12.

4 Symbols and abbreviations

For the purposes of this document, the symbols given in EN 12952-1:2015 shall apply. Throughout this document, additional terminology and symbols have been included, where necessary, to meet the requirements of the specific text concerned. It should also be noted that in some clauses the same additional symbol is used in different equations to represent different terms. However, in all such cases, the special meaning of each symbol is indicated for each equation.

5 General

Water-tube boilers shall be manufactured and assembled in accordance with approved drawings, procedures and specifications and good engineering practice.

The workshops and sites associated with the construction of water-tube boilers shall be properly equipped and have suitable provisions for all the inspection and testing specified in EN 12952-6:2021. The relevant manufacturing procedures shall be adequate and manufacturing personnel shall be competent and properly qualified for their assigned tasks. The procedures for the approval of welding and NDE personnel are given respectively in 8.4 of this document and EN 12952-6:2021, 7.2.

Appropriate records of manufacturing operations shall be maintained.

6 Pressure part

6.1 Drums, headers and similar pressure parts

6.1.1 Principles for manufacturing

Drums, headers and similar pressure parts shall be constructed from tubes, forgings, plates or castings. Drums and headers shall be in a suitably clean condition, both internally and externally, to enable proper visual inspection of the surface to be carried out before drilling of holes for tube stubs, branches, etc. and before welding of any permanent connections.

6.1.2 Manufacturing process for header ends

The ends of forged or other seamless steel tube headers shall be carried out by any one of the following methods:

- a) forging or spinning;
- b) welding in accordance with Clause 8, see also EN 12952-3:2011, Figure 10.3-1;
- c) bolted flanges in accordance with relevant European Standards e.g. EN 1092-1:2018 or EN 1759-1:2004.

Bolted flanges in accordance with c) shall not be used where the bolts would be exposed to gases of combustion.

6.1.3 Material for header ends

Header ends shall be forged or machined from steel of a grade compatible with the bodies of the headers and profiled as shown in EN 12952-3:2011, Figure 10.3-1.

6.2 Material identification

The manufacturer shall maintain a system of material identification for all pressure parts and drum lifting lugs.

The system shall be such that material used in major pressure parts (drums, tubes for header shells with $d_o > 142$ mm) can be traced back to its origin. The identification of tubes which are not used for header shells and tubes for header shells with $d_o \leq 142$ mm shall be controlled by a system which permits positive identification of cast, on receipt into the manufacturer's works and maintenance of the material type identification throughout manufacturing operations by marking.

6.3 Material marking

6.3.1 General

The marking of materials shall be maintained throughout the process of manufacture. If original markings are discarded or parts without markings could be created by dividing up parts during the course of manufacture, markings shall be transferred, normally before fabrication.

Appropriate measures shall be taken to ensure that there is no possibility of confusion in the transfer of markings.

6.3.2 Responsible personnel

Marking transfer shall be performed by the manufacturer's nominated representative(s) except for materials for which an inspection certificate (3.2) to EN 10204:2004 is required and also not for components classified as small parts.

In the case of materials for which an inspection certificate (3.2) to EN 10204:2004 is required, the markings shall be transferred in accordance with the requirements of EN 12952-6:2021.

This does not apply to small parts which are those made from certified products, such as nipples, nozzles, flanges, compensating rings, with outside diameters equal to or less than 142 mm.

6.3.3 Method of marking

In general, material marking should be done by hard stamping using a low stress type metal stamp or etching.

Other marking methods may be used if the manufacturer can ensure that their use will not impair the safety of the boiler.

6.3.4 Marking of non-pressure parts

For welded non-pressure parts, marking need only be transferred if the identification of materials is not evident from the drawing or parts list.

6.3.5 Marking of bolts and nuts

Bolts and nuts for pressure purposes shall be marked with the manufacturer's brand mark and property class symbol, or the steel grade code number in accordance with EN ISO 4759-1:2000.

6.4 Marking during manufacture

6.4.1 Temporary marking

Temporary marks for the purpose of identification during manufacture e.g. parts numbers, welder numbers, radiograph numbers, etc. shall be made by any one, or a combination, of the following methods:

- a) painting or pen, provided they are compatible with the material being marked;
- b) vibro etching or other etching tool;
- c) metal stamps of the low stress type.

6.4.2 Permanent marking

Permanent marks complying with the requirements of 6.2 shall be made by any one or a combination, of the following methods:

- a) vibro etching or other etching tools;
- b) metal stamps of the low stress type;
- c) stamped data plates welded directly to the component using an approved welding procedure specification.

6.4.3 Tube bends

Metal stamping shall not be permitted on the curved area of tube bends.

6.4.4 Location drawings

Location drawings can be provided in the case of welders marks, radiographs, etc.

7 Cutting, forming and fabrication tolerances

7.1 Cutting material

7.1.1 Methods for cutting

Steel shall be cut by thermal means, shearing, sawing, machining or a combination of these methods. Thermal cutting can necessitate the use of preheating, depending on the type of steel and the thickness in question, which shall be applied in accordance with 10.3.3. It is recognized that the cold worked zone resulting from the shearing process need not be eliminated before welding if this zone will be fused during welding.

7.1.2 Post-cutting measures

Any material damaged metallurgically in the process of cutting to size or forming the edge or end preparation shall be removed by machining, grinding, chipping or thermal-cutting back to sound metal.

Surfaces that have been thermally cut shall be cut back by machining or grinding so as to remove all burnt metal, harmful notches, slag and scale, but slight discoloration of machine thermally cut edges on mild steel shall not be regarded as detrimental. If alloy steels are prepared by thermal cutting, the surface shall be dressed back by grinding or machining for a distance of at least 1,5 mm, unless it can be shown that the material has not been damaged by the cutting process.

These requirements for dressing do not apply to surfaces that are prepared for electro-slag welding, where a thermally cut surface is generally acceptable without further treatment.

After the edges of the material have been prepared for welding, they shall be visually examined for flaws, cracks, laminations, slag inclusions or other defects before further work is carried out. Any weld repairs that are required to materials damaged as a result of thermal cutting shall be to an approved welding procedure specification.

7.2 Forming of drums, headers and ends

7.2.1 General

Drums, headers and ends shall be rolled or pressed from plate, solid forged, drawn or extruded, or made by a combination of these processes. Components made by a forging, drawing or extrusion process shall be produced in accordance with the forgemaster's specification, as agreed with the boiler manufacturer.

Components formed from ferritic steel plate shall be heat treated in accordance with 10.2.2 to 10.2.4 inclusive. The heating associated with forming operations and the heat treatment requirements after forming are given in 10.2.

The forming requirements applicable to austenitic steel plate are the subject of development. In the meantime, the methods used shall be in accordance with the manufacturer's own proven procedure which shall ensure that, by their use, the safety of the boiler is not impaired.

7.2.2 Drum and header shells

Shell plates shall be formed, either hot or cold, to ensure compliance with the tolerances specified in 7.4. Each shell plate shall be formed to the correct contour up to the extreme edges of the plate. The bending or pressing shall be done entirely by machine. The definitions of hot and cold forming are given in 3.1 and 3.2.

Local heating and hammering shall not be employed.

7.2.3 Ends

Dishing and peripheral flanging, either hot or cold, shall be carried out to ensure compliance with the tolerances specified in 7.4. The operations shall be performed by machine. Sectional flanging shall not be employed.

7.2.4 Plates welded prior to hot or cold forming

Where practicable, shells and ends shall be rolled or pressed from one piece of plate. Where this is impracticable, butt welding of plate, prior to forming shall be permitted, provided that the welded joints are non-destructively examined after forming in accordance with the requirements of EN 12952-6:2021, and a welding procedure qualification test has been performed to EN ISO 15614-1:2017/A1:2019, Level 2 taking into account any heat treatment cycles involved. A production test plate as specified in 10.2.5 shall be provided.

7.2.5 Extruded openings in headers

Extruded openings in headers shall have a fillet with a radius not less than the thickness of the neck of the extrusion.

7.3 Forming of tube bends

7.3.1 General

Tubes which are bent hot or cold shall conform to 7.3.2 to 7.3.12.

This subclause does not apply to fittings in accordance with EN 10253-2:2007 and EN 10253-4:2008/AC:2009.

Annex A requires procedure tests to be carried out on tube bends. Attention is drawn to the fact that not all the combinations of materials and bending processes permitted, and the associated thermal treatments nominated in Table 2, will satisfy the requirements for the procedure test given in 7.3.2 to 7.3.13 and Annex A. The manufacturer should ensure that any combination of material, bending process and the chosen bend geometry will produce bends that satisfy the requirements of 7.3. If a chosen bend geometry is found not to comply with the requirements of 7.3, the manufacturer should adjust the design to enable the requirements to be met.

7.3.2 Tube bending procedure test

It shall be demonstrated for tubes $d_o > 33,7$ mm by means of a tube bending procedure test (see Annex A) that tubes can be satisfactorily bent to the requirements of 7.3.1. The tests shall be performed to represent combinations of tube sizes, materials and bend radii which demonstrate the adequacy of the bending method chosen. The range and scope of the qualification of tube bends resulting from these procedure tests are also given in Annex A. The results from the bending procedure tests shall be documented and used as a basis for all future tube bends falling within the scope of the combinations tested.

When specific pre-production test bends are manufactured in accordance with Table 1 and which conform to the requirements of 7.3.1 the resulting documented data shall serve as qualification for subsequent production runs and may be considered to satisfy the requirements of Annex A.

Documented evidence of previous satisfactory tube bending procedure tests may be accepted as fulfilling these requirements.

7.3.3 Requirements for dimensional testing

Thinning at the bend extrados, thickening at the bend intrados (where required) and departure from circularity limits shall be demonstrated by the methods given in Table 1.

NOTE This test relates to the forming of tubes for conventional water-tube boilers. For the special case of coiled boilers and coiled superheaters, see Annex D.

Table 1 — Requirements for dimensional testing of a production run of tube bends

Tube size – Nominal outside diameter d_o mm	Testing during a production run of tube bends
$d_o \leq 80$	a) Measure non-destructively 2 % of the production run, including the first bend, for thinning and departure from circularity u . b) Additionally, where $r_b/d_o < 1,3$, a sample test bend is required before production commences.
$80 < d_o \leq 142$	a) Measure non-destructively 2 % of the production run, including the first bend, for thinning, thickening (where practicable) and the departure from circularity u . b) Additionally, where $r_b/d_o < 1,3$ a sample test bend is required before production commences.
$d_o > 142$	Measure all bends for thinning, thickening and the departure from circularity u .
NOTE 1 A sample test bend consists of the sectioning and measuring of a trial bend to establish the maximum thinning, thickening (where practicable), and the maximum departure from circularity. The measured values are checked against the requirements given in 7.3.4, 7.3.5 and 7.3.7 respectively. NOTE 2 A production run is defined as a series of tubes of the same size and material being bent on a specific machine within the same machine set-up. NOTE 3 The departure from circularity u is measured at the apex of the bend. NOTE 4 The radius of the bend r_b is measured to the centre-line of the tube. NOTE 5 The outside diameter d_o of the tube is measured on the straight. NOTE 6 This table does not apply to coil type boilers (see Annex D).	

7.3.4 Thinning at the tube bend extrados for tubes of nominal outside diameter 142 mm and below

The thickness at any point after bending shall not be less than that given by equation:

$$e_{\text{ext}} = e_{\text{act}} \times \frac{2r_b / d_o + 0,5}{2r_b / d_o + 1} \quad (1)$$

where

- e_{ext} is the required minimum thickness at the extrados, in mm;
- e_{act} is the nominal thickness of the supplied tube minus the supplier's maximum negative thickness tolerance, in mm;
- r_b is the radius of the bend measured to the centre-line of the tube in mm;
- d_o is the nominal outside diameter of the tube, in mm.

When the measured value on the tube bend is less than e_{ext} reference shall be made to the minimum calculated thickness given in EN 12952-3:2011, 11.3.

The thinning on the extrados of bends formed in two stages i.e. hot formed after initial hot or cold bending, shall not exceed 30 % of the thickness of the straight tube local to the bend as measured during a procedure test.

7.3.5 Thickening at the tube bend intrados for tubes of nominal outside diameter above 80 mm and including 142 mm

The thickness at any point after bending shall not be less than that given by equation:

$$e_{\text{int}} = e_{\text{act}} \times \frac{2r_b / d_o - 0,5}{2r_b / d_o - 1} \quad (2)$$

where

- e_{int} is the required minimum thickness at the intrados, in mm;
- e_{act} is the nominal thickness of the supplied tube minus the supplier's maximum negative thickness tolerance, in mm;
- r_b is the radius of the bend measured to the centre-line of the tube, in mm;
- d_o is the nominal outside diameter of the tube, in mm.

When the measured value on the tube bend is less than e_{int} reference shall be made to the minimum calculated thickness given in EN 12952-3:2011, 11.3.

7.3.6 Thinning/thickening at the tube bend extrados/intrados for tubes of nominal outside diameter greater than 142 mm

For tubes above 142 mm diameter comparison shall be made directly with the calculated thickness given in EN 12952-3:2011, 11.3. The calculated thickness shall be stated on the drawing.

7.3.7 Departure from circularity of the tube bends

The departure from circularity of tube bends shall be calculated from the equation:

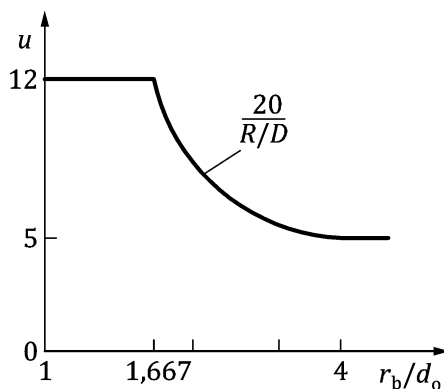
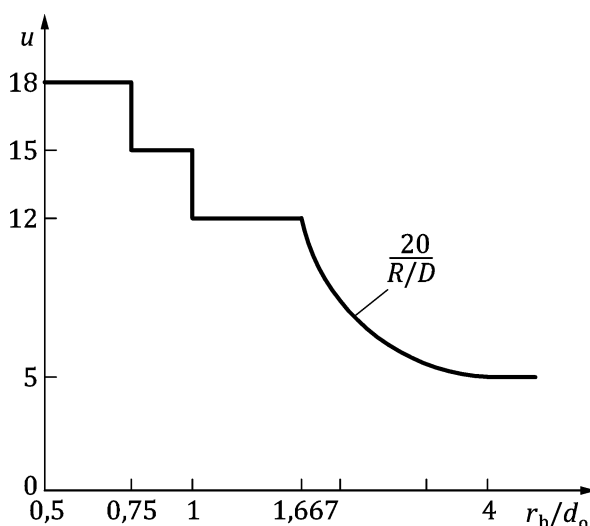
$$u = 2 \times \frac{\hat{d}_o - \check{d}_o}{\hat{d}_o + \check{d}_o} \times 100 \quad (3)$$

where

- u is the departure from circularity, in %;
- $\hat{d}_o$ is the maximum outside diameter measured at the tube bend apex, in mm;
- $\check{d}_o$ is the minimum outside diameter measured at the same cross-section as $\hat{d}_o$, in mm.

The permitted departure from circularity shall be within the limits given in Figure 1 and Figure 2.

- a) the departure from circularity of tube bends, which are bent in a single continuous operation, shall not exceed the limits shown in Figure 1;
- b) the departure from circularity of tube bends on tubes not exceeding 80 mm nominal outside diameter, which are bent by a double operation i.e. hot pressed after the primary bending operation then post-bend heat treated in accordance with Table 2, shall not exceed the limits shown in Figure 2.

**Key** u departure from circularity r ratio r_b/d_o **Figure 1 — Limits of departure from circularity for single operation bending****Key** u departure from circularity r ratio r_b/d_o **Figure 2 — Limits of departure from circularity for double operation bending****7.3.8 Post bend heat treatment of tube bends**

The post-bend heat treatment (PBHT) of hot or cold formed bends shall be in accordance with the following rules:

- a) all hot formed tube bends and cold formed bends requiring heat treatment after bending, including bends hot formed after cold bending, shall be heat treated in accordance with the requirements of 7.3.9 except as defined in b) or e) below;
- b) hot formed tube bends in steel group 1, with outside diameters of 80 mm or less, need not receive a post-bend heat treatment if it can be demonstrated that the bending operation was completed within

the normalizing range as defined in the relevant base material standard, or data sheet, as appropriate;

- c) all cold bent tube bends with thinning greater than 25 % as measured in the procedure test, shall be heat treated in accordance with the requirements of 7.3.9;
- d) PBHT of cold formed tube bends in accordance with Table 2 shall be carried out in accordance with the requirements of 7.3.9;

Table 2 — Post-bend heat treatment applicable to cold formed tube bends

d_o mm	Bend ratio	Heat treatment
$d_o > 142$	$r_b/d_o > 2,5$	No post-bend heat treatment required
$d_o > 142$	$r_b/d_o \leq 2,5$	Stress relieve
$d_o \leq 142$	$r_b/d_o > 1,3$	No post-bend heat treatment required
$d_o \leq 142$	$r_b/d_o \leq 1,3$	Stress relieve

- e) post-bend heat treatment may be waived if it can be demonstrated by a suitable procedure test, that heat treatment shall not be required;
- f) for hot formed bends local post bend heat treatment of the tube bend shall not be acceptable. Any post-bend heat treatment involving normalizing shall encompass the bend and adjacent straight lengths of the tube.

7.3.9 Post-bend heat treatment requirements

7.3.9.1 Ferritic tubing

With the exception of those cases in accordance with 7.3.8, all tube bends shall receive a post-bending heat treatment as follows:

a) Hot formed bends

All hot formed bends, including bends which have been hot pressed after cold forming, shall be heat treated in order to restore the material properties to their optimum condition. The post bending heat treatment applied shall be in accordance with the requirements given in the relevant base material standard, or data sheet, as appropriate.

For hot formed bends local post bend heat treatment of the tube bend is not acceptable. Any post bend heat treatment involving normalizing operation shall encompass the bend and adjacent straight lengths of tube.

b) Cold formed bends

When a stress relief heat treatment is specified in the case of normalized and tempered or quenched and tempered materials, the requirements for tempering given in the relevant base material standard, or data sheet, shall be followed as appropriate.

When a stress relief heat treatment is specified in the case of normalized only materials, the requirements for post-weld heat treatment given in Table 12 and Table 13 shall be followed.

Other stress relief heat treatment methods may be used if it can be demonstrated to be adequate by means of the procedure test.

7.3.9.2 Austenitic tubing

Post-bending heat treatment will normally not be required for cold bent austenitic tubing.

Hot formed tube bends of austenitic tubes inclusively bends which are formed by two operations require a new heat treatment by solution annealing and subsequently and adequately accelerated cooling using water and air according to the material specification.

The heat treatment process should take account of measures to ensure no component deformation.

7.3.10 Ripples on the intrados of tube bends

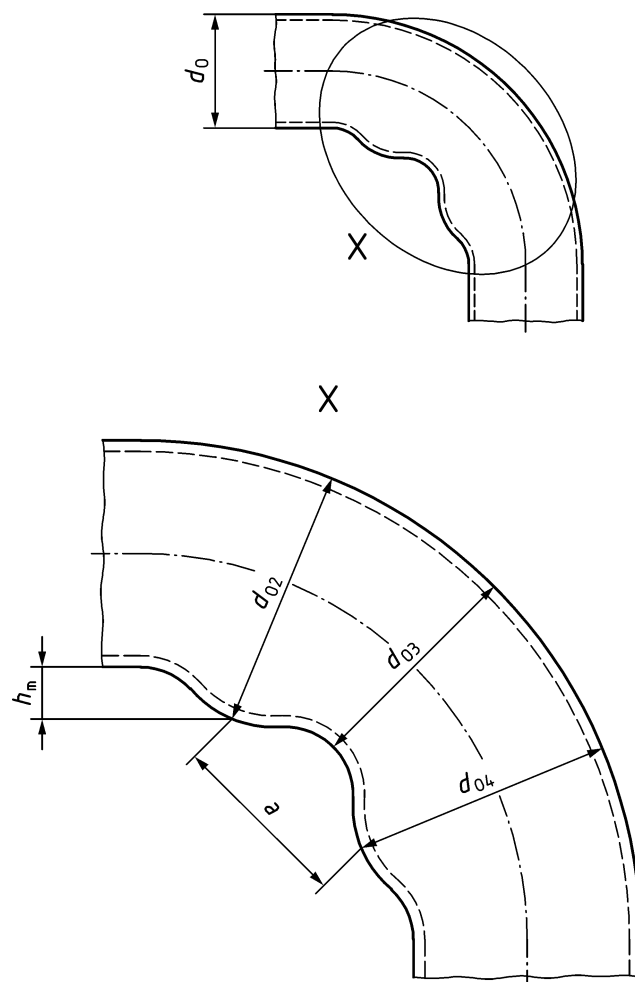
7.3.10.1 General

Ripples are multiple waves like undulations on the intrados of tube bends, see Figure 3.

Deviations from the nominal bend profile are local isolated deviations from a smooth normal profile of the intrados of the bend, e.g. irregularities sometimes found at the commencement of mandrel assisted bends in small diameter tubes.

7.3.10.2 Acceptance standards

- a) In tubes up to and including 80 mm nominal outside diameter, ripples shall not be acceptable. Deviations from nominal bend profile may be accepted provided the departure from circularity at the peak and trough of the deviation meets the requirements of 7.3.7;
- b) for tubes above 80 mm nominal outside diameter up to and including 142 mm nominal outside diameter, ripples and deviations from the nominal bend profile shall not be permitted;
- c) tubes with nominal outside diameters greater than 142 mm shall be permitted to contain ripples on the intrados of the bend within the limits shown in Figure 3, provided they have a smooth profile and blend into the surface of the bend. Deviations from the nominal bend profile shall not be permitted.

**Key**

$d_0, d_{02}, d_{03}, d_{04}, \text{---etc}$ is the actual outside diameter of the tube at the position being measured.

NOTE For clarity, the ripples have been exaggerated.

Figure 3 — Ripples on tube bends

For such ripples to be acceptable, both the following conditions shall be satisfied:

$$h_m = 0,5 (d_{02} + d_{04}) - d_{03} < 0,03 d_0 \quad (4)$$

$$a > 12 h_m \quad (5)$$

where

h_m is the amplitude of the ripples

$d_0, d_{02}, d_{03}, d_{04}$ is the actual outside diameter of the tube at the position being measured

a is the wave pitch

7.3.11 The surface of tube bends

The surface of tube bends shall be free of defects such as cracks, indentions, laps and scabs. Surface defects may be removed by grinding. In such cases the resulting thickness shall not be less than the minimum calculated thickness given in EN 12952-3:2011, 11.3.

The surface of the tube bend shall be such as to permit effective visual examination.

Areas of the tube bend which have been ground to remove defects shall be examined by surface flaw detection methods to ensure that complete removal of the defect has been effected.

Repairs to the tube surface by welding are generally not permitted. However, in special cases of tubes of 142 mm nominal outside diameter and above, such repairs may be acceptable, when supported by an approved welding procedure specification and taking into account the following:

- a) the extent of the zone to be repaired;
- b) the grade of the material involved;
- c) the diameter and thickness of the bend;
- d) the heat treatment conditions involved;
- e) the operating temperature of the tube bend.

7.3.12 Gang bending of tube panels

The tube bends produced by the gang bending method shall conform, in all respects, with the requirements of tubes bent singly, see A.2.4.7.

The departure from circularity shall be measured during production on the two outermost tubes of the panel. The results shall be compared with the requirements of 7.3.7. For practical reasons, $\hat{d}_0$ in the Formula (3) should be replaced by the outside diameter of the tube measured straight.

7.3.13 Bending of composite materials tubing

The bending procedures adopted for metallurgically bonded composite materials tubing shall be in accordance with the requirements of 7.3 and E.3. In addition, any special requirements recommended by the tube manufacturer shall be taken into consideration.

7.3.14 Manufacturing of tube reducers

7.3.14.1 Ferritic materials

- a) Cold formed reducers

Ferritic tubing with $d_o < 100$ mm may be cold formed by reducers. The procedure should be proved by a test.

When forming leads to an increase of material hardness of > 80 HV10, the formed parts should be annealed at a temperature being in accordance with those indicated in Table 12.

- b) Hot formed reducers

Reducers of ferritic tubing with $d_o \geq 100$ mm are to be manufactured by hot forming. This procedure should be proved by a test. Hot reduced tubes should be treated like hot formed bending (see 7.3.9.1 a)). Reduced tubes being normalized or heat-treated, should undergo heat treatment completely.

7.3.14.2 Austenitic materials

a) Cold formed reducers

Cold formed reducers of austenitic tubing are to be treated like cold formed tube bending in accordance with 7.3.9.2.

b) Hot formed reducers

Hot formed reducers of austenitic tubing should completely undergo a new heat treatment with the appendent undeformed tube according to the material specification.

7.4 Drum and header fabrication tolerances

7.4.1 Assembly tolerances for shells and fabricated from plate and end to shells

7.4.1.1 General

Middle line and surface alignment tolerances shall be permitted as follows, where e_a is the actual thickness of the thinnest plate at the joint.

7.4.1.2 Middle line alignment tolerances

The root faces of the weld preparations shall be aligned within the tolerances permitted by the welding procedure specification and the components shall be aligned as indicated on the drawings within the following tolerances.

- a) For longitudinal joints in cylindrical components, the middle lines of adjacent plates shall be aligned within the tolerances given in Table 3.

Table 3 — Offset of middle lines for longitudinal joints in cylindrical components

Plate thickness e_a mm	Offset of middle lines mm
$e_a \leq 10$	≤ 1
$10 < e_a \leq 50$	$\leq e_a/10$ or 3, whichever is the smaller
$e_a > 50$	$\leq e_a/16$ or 10, whichever is the smaller

- b) For circumferential joints, the middle lines of adjacent plates shall be aligned within the tolerances given in Table 4.

Table 4 — Offset of middle lines for circumferential joints in cylindrical components

Plate thickness e_a mm	Offset of middle lines mm
$e_a \leq 10$	≤ 1
$10 < e_a \leq 60$	$\leq 10\%$ of thickness of thinner part plus 1, or 6, whichever is the smaller
$e_a > 60$	$\leq 10\%$ of the thickness of thinner part

7.4.1.3 Surface alignment tolerances

a) not exceed the maximum tolerances:

- 1) For longitudinal joints given in Table 5

Table 5 — Offset of surfaces of longitudinal joints in cylindrical components

Plate thickness e_a mm	Offset of surfaces mm
$e_a \leq 12$	$\leq e_a/4$
$10 < e_a \leq 50$	≤ 3
$e_a > 50$	$\leq e_a/16$ or 10, whichever is the smaller

- 2) For circumferential joints given in Table 6

Table 6 — Offset of surfaces of circumferential joints in cylindrical components

Plate thickness e_a mm	Offset of surfaces mm
$e_a \leq 20$	$\leq e_a/4$
$20 < e_a \leq 40$	≤ 5
$e_a > 40$	$\leq e_a/8$ or 20, whichever is smaller

or

- b) if the maximum alignment tolerances in a) are exceeded, they may be reduced by tapering the surface(s) at a slope no steeper than 15° for welds exposed to bending stresses and 30° for welds exposed to membrane stresses only, as appropriate, over a width that includes the width of the weld.

Either of the following methods of tapering shall be permitted:

- 1) building up the surface of the thinner plate with added weld metal in accordance with an approved welding procedure specification to provide the required taper; or
- 2) tapering one or both of the thicker plate surfaces.

The tapering method of 2) shall not be permitted if it would reduce the plate thickness below the specified minimum or the component at the location in question.

7.4.2 Finished tolerances for shells

7.4.2.1 Tolerances on diameter

The diameter of a drum shall not deviate from the nominal diameter by more than $\pm 1\%$.

7.4.2.2 Circularity (out-of-roundness)

The difference between the maximum and minimum internal diameters at any one cross section shall not exceed 1% of the nominal internal diameter. If the drum is made of plates of unequal thicknesses, the measurements shall be corrected for plate thicknesses, as they may apply, to determine the diameters at the middle line of the plates.

Irregularities in profile, checked using a template embracing an arc of 20°, shall not exceed 3 mm plus 5 % of the minimum plate thickness. A 25 % increase in the maximum value shall be permitted if the length of the irregularity does not exceed one quarter of the length of the shell ring with a maximum of 1 000 mm.

There shall be no flats at welded seams and any local departure from circularity shall be gradual. Small departures from circularity may be rectified by cold rolling. However, any non-destructive examination as required by EN 12952-6:2021 shall be carried out after the cold rolling operation.

7.4.2.3 Straightness

The maximum deviation of the complete shell from a straight line shall not exceed 0,3 % of the total cylindrical length. Measurements shall be made to the surface of the parent plate and not to a weld, fitting or other raised part.

7.4.3 Finished tolerances for ends

7.4.3.1 Tolerances on diameters

The requirements of 7.4.2.1 shall apply.

7.4.3.2 Circularity (out-of-roundness)

The requirements of 7.4.2.2 shall apply.

7.4.3.3 Thickness

Variations in thickness (thinning) arising during manufacture shall be gradual. In no case shall the thickness of the end be less than the design thickness given in EN 12952-3:2011, 10.2.

7.4.3.4 Profile

The depth of dishing, measured from the plane passing through the point where the straight flange joins the knuckle radius, shall in no case be less than the theoretical depth, nor shall this depth be exceeded by more than 1,25 % of the diameter, for diameters of ends up to and including 3 000 mm. Variations of the profile shall not be abrupt, but shall merge gradually into the specified shape. The knuckle radius shall not be less than specified, and shall have common tangents with both the straight flange and the dished profile, at each junction.

8 Welding

8.1 Design and other requirements specific to welding

8.1.1 General

The following special requirements specific to welding shall be considered before any manufacturing is commenced.

NOTE 1 General guidance on welding of ferritic steels is given in EN 1011-1 and EN 1011-2 as well as for austenitic steels in EN 1011-3 which can be used to supplement the welding requirements of this document.

NOTE 2 CEN ISO/TR 15608:2017 describes the principle of group classification regarding weldable materials which have comparably typical characteristics. CEN ISO/TR 20172 includes the detailed assignment of the EN-materials to groups being based on this document.

8.1.2 Material selection with regard to welding

The selection of materials for the pressure parts, and for any attachments to be made to them, shall be such that any welding operations which are to be carried out will not render the component unfit for its intended duty.

The selection of welding consumables shall be such as to ensure the cross-weld strength required by the design is achieved. The effects of post-weld heat treatment on the completed joint as given in 8.8, shall also be taken into consideration.

8.1.3 Indication of the welded seams in the drawings

The dimensioned drawings of main pressure parts shall include the location of all main joints and attachments to be made to the components, clearly showing details of the main joint weld preparations, all attachment welds, and their location relative to the longitudinal and circumferential joints and openings.

8.1.4 Pre-requisites for welding

Welding of the joints of the component parts of a water-tube boiler shall only be undertaken when the following conditions are satisfied:

- a) welding procedure specifications shall be compiled by the manufacturer in accordance with EN ISO 15609 (all parts) for each joint or family of joints;
- b) the welding procedure specifications selected by the manufacturer shall be approved for the field of application;
- c) the welders and welding operators shall be qualified for the work allocated to them and their approvals shall be valid.

8.1.5 Oxy-acetylene welding

Where the use of oxy-acetylene welding is proposed, the manufacturer shall demonstrate that the location of such welds in the boiler will not result in subsequent problems in the operation. See 8.3 for detailed information.

8.1.6 Butt welds in tube bends

Butt welds shall not be permitted on the bends of tubes, except in the special case of coil boilers – see Annex D.

8.1.7 Minimum distances between adjacent seams

The toes of welds of attachments to main pressure parts should, wherever practicable, not be located closer than 40 mm to main joint welds.

If, for reasons of design, this spacing cannot be achieved the welds shall be capable of being non-destructively examined within the area of influence of the attachments and the welds shall be ground to a smooth profile to remove all notches in this area.

Where local grinding of the welds is required, as indicated above, the ground surface shall be 100 % non-destructively examined in accordance with the requirements of EN 12952-6:2021, Clause 7.

If this latter condition is not practicable, the attachment weld shall cross the main joint weld completely. In such cases, the surface of the main joint weld and the attachment welds shall be ground locally after the welding-on of the attachment has been completed.