SLOVENSKI STANDARD
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Mnogovodni kotli - 3. del: Konstruiranje in izračun tlačno obremenjenih delov

Shell boilers - Part 3: Design and calculation for pressure parts

Großwasserraumkessel - Teil 3: Konstruktion und Berechnung für drucktragende Teile

Chaudières à tube de fumée - Partie 3: Conception et calcul des parties sous pression

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ICS:

27.060.30	Grelniki vode in prenosniki toplote	Boilers and heat exchangers

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Shell boilers - Part 3: Design and calculation for pressure parts

Chaudières à tubes de fumée - Partie 3: Conception et calcul des parties sous pression

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

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European foreword

This document (EN 12953-3:2016) 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of an identical text or by endorsement, at the latest by November 2016, and conflicting national standards shall be withdrawn at the latest by November 2016.

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

This document supersedes EN 12953-3:2002.

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

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

The informative Annex E lists the significant technical changes between this European Standard and the previous edition.

EN 12953, Shell boilers, 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: Workmanship and construction of pressure parts of the boiler*

— *Part 5: Inspection during construction, documentation and marking of pressure parts of the boiler*

— *Part 6: Requirements for equipment for the boiler*

— *Part 7: Requirements for firing systems for liquid and gaseous fuels for the boilers*

— *Part 8: Requirements for safeguards against excessive pressure*

— *Part 9: Requirements for limiting devices of the boiler and accessories*

— *Part 10: Requirements for feedwater and boiler water quality*

— *Part 11: Acceptance tests*

— *Part 12: Requirements for grate firing systems for solid fuels for the boiler*

— *Part 13: Operating instructions*

— *(CR 12953) Part 14: Guideline for involvement of an inspection body independent of the manufacturer*

Although these parts can be obtained separately, it should be recognized that the parts are interdependent. As such, the design and manufacture of shell boilers requires the application of more than one part in order for the requirements of the standard 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 the European Standards series EN 12952 and EN 12953, see the following website: http://www.boiler-helpdesk.din.de

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

1 Scope

This Part of this European Standard specifies requirements for the design and calculation of pressure parts of shell boilers as defined in EN 12953-1.

For other components such as water tube walls reference should be made to EN 12952 series.

2 Normative references

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

EN 1092-1:2007+A1:2013, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

EN 12952-3:2011, *Water-tube boilers and auxiliary installations — Part 3: Design and calculation for pressure parts of the boiler*

EN 12953-1:2012, *Shell boilers — Part 1: General*

EN 12953-2:2012, *Shell boilers — Part 2: Materials for pressure parts of boilers and accessories*

EN 12953-4:2002, *Shell boilers — Part 4: Workmanship and construction of pressure parts of the boiler*

EN 12953-5, *Shell boilers — Part 5: Inspection during construction, documentation and marking of pressure parts of the boiler*

EN 12953-6:2011, *Shell Boilers — Part 6: Requirements for equipment for the boiler*

EN 12953-10:2003, *Shell boilers — Part 10: Requirements for feedwater and boiler water quality*

EN 13445-3:2014, *Unfired pressure vessels — Part 3: Design*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12953-1:2012, EN 12953-6:2011 and the following apply.

3.1
branch
nozzle, stub, stand pipe

3.2
cold start
starting the boiler from ambient pressure at room temperature to normal operating condition

3.3
warm start
starting the boiler from the hot stand-by condition

3.4
seam
generic term for welded joints, welded seams or welds

4 Symbols and abbreviations

For the purposes of this standard, the symbols given in EN 12953-1:2012, Table 1 shall apply. Throughout this standard, 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 formulas to represent different terms. However, in all such cases, the special meaning of each symbol is indicated for each formula.

5 General

5.1 Boilers

The requirements in this standard shall apply to boilers as defined in EN 12953-1:2012 designed throughout under the conditions specified herein and which are to be operated under normal operation conditions, with feedwater and boiler water in accordance with EN 12953-10:2003, and under adequate supervision.

Where there are specified operation conditions such as e.g. severe cyclic service, this shall be taken into account in the design process.

The feed water entering a steam boiler or the return water entering a hot water boiler shall not impinge directly on the furnace.

No load cycle calculation shall be carried out if all the following requirements are satisfied:

a) The number of start-ups from zero pressure to the foreseen operating pressure (full pressure cycles) is ≤ 1000;

b) For material with specified yield strength at room temperature ≤ 295 MPa the number of partial pressure cycles in the range of ΔP = 20 % of PS is ≤ 100 000 or, alternatively, in the range of ΔP = 40 % of PS is ≤ 10 000;

c) For material with specified yield strength at room temperature > 295 MPa the number of partial pressure cycles in the range of ΔP = 10 % of PS is ≤ 100 000 or, alternatively, in the range of ΔP = 20 % of PS is ≤ 10 000;

d) The weld for set-in end plates to shell and/or to furnace shall be at least 10 % UT tested during construction.

Otherwise if the load cycle situation is more complicated a load cycle calculation shall be performed.

The requirements for the load cycle calculation are not applicable for the weld factor 0,7 (see 5.4).

5.2 Hot-water boilers

For directly fired hot-water boilers the difference between the outlet temperature and the inlet temperature should not exceed 50 K. If the difference between these two temperatures is greater than 50 K, either internal or external mixing devices shall be used to limit the differential temperature within the boiler to 50 K.

The difference between the saturation temperature corresponding to the maximum operating pressure, and the outlet temperature, should not normally exceed 80 K. If the difference is greater than 80 K, the distances in accordance with 10.1 shall be increased by 50 %. Furthermore the maximum heat input in accordance with Figure 1 shall be reduced by 20 %.

5.3 Main welds

The types of weld used in the design of the boiler shall be in accordance with EN 12953-4.

Non-destructive testing (NDT) shall be in accordance with the requirements of EN 12953-5. The design of the weld joints shall be such that the required NDT can be carried out.

5.4 Weld factor

The weld factors v used in the calculation of the pressure parts shall be either 1 or 0,85 or 0,7 depending on the extent of NDT.

The extent of NDT shall be in accordance with EN 12953-5.

A welding efficiency v = 0,7 is only acceptable, if an increased test pressure is used as given by Formula (1):

$$p_t = 2{,}2\, p_c \frac{R_{p0,2\,20}}{R_{p0,2\,tc}} \cdot \frac{e_{cs} + c_2}{e_{cs}} \qquad (1)$$

5.5 Thermal design of furnaces tubes

5.5.1 Design conditions

Burners with a fixed firing rate (also called on/off or single stage burners) shall not be used for heat inputs exceeding 1 MW per furnace.

Combustion shall be completed in the furnace.

Calculation temperature shall be in accordance with 6.1 e).

In order to ensure safe burner/boiler combinations with a heat input more than 2 MW, the minimum diameter of the furnace d_i shall not be less than the following values (see Figure 1):

a) No 1 Material grade P265GH/P295GH: Coal firing (grate): $d_i = 400 + 175 * H$

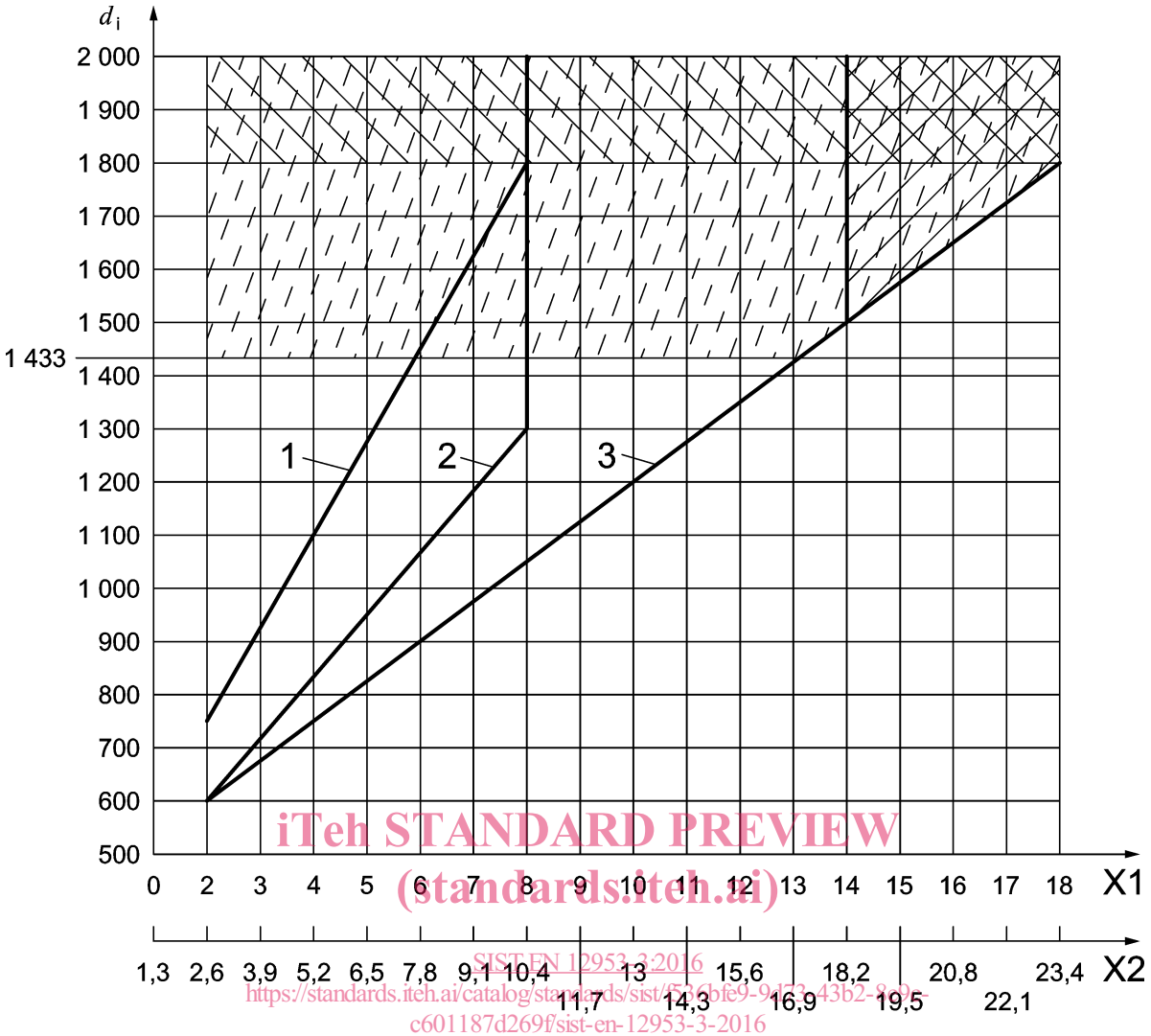
b) No 2 Material grade P265GH: Oil firing: $d_i = 365 + 117 * H$ Gas firing: $d_i = 365 + 90{,}4 * H$

c) No 3 Material grade P295GH/P355GH: Oil firing: $d_i = 450 + 75 * H$ Gas firing: $d_i = 450 + 57{,}7 * H$

where:

d_i = inner diameter in mm for plain furnaces (with or without stiffeners or bowling hoops) or average diameter mm for corrugated furnaces (with or without stiffeners);

H = heat input in MW (product of the fuel flow rate and the lower calorific value; air preheating should be taken into account if the air temperature is greater than 100 °C).



Key

1 coal firing P265GH/P295GH

2 P265GH

3 P295GH / P355GH

d_i inner diameter for plain furnaces (with or without stiffeners or bowling hoops) or average diameter for corrugated furnaces (with or without stiffeners) [mm]

X1 heat input H_{oil} / H_{coal} [MW]

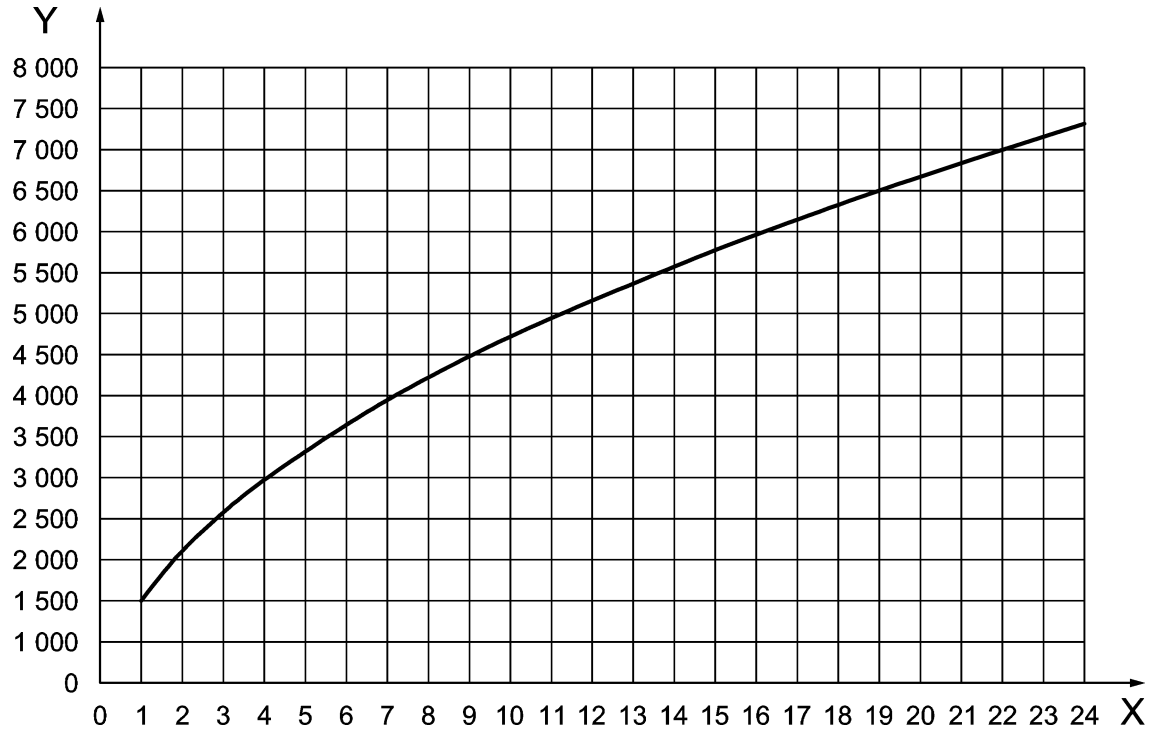
X2 heat input H_{gas} [MW]

temperature monitoring necessary if d_i > 1800 mm

temperature monitoring necessary if H_{oil} > 14 MW respectively, H_{gas} > 18,2 MW

monitoring of operation conditions if d_i > 1433 mm

Figure 1 — Relation between heat input and inside diameter of the furnace d_i



Key

Y minimum furnace tube length [mm]

X heat input [MW]

Figure 2 — Relation between heat input and length of the furnace *L*

5.5.2 Furnace dimensions

The minimum furnace length shall be determined either by using the Figure 2 or the Formula (2):

$$L\,[mm] = 150000 * (H\,[MW] / 10100)^{0.5} \quad (2)$$

If the furnace diameter is less than the minimum diameter (see Figure 1) or the furnace length is less than the min req. length (see Figure 2) the following conditions shall be fulfilled:

— Verification of heat flux and calculation temperature of furnace (e.g. according to 6.1 e)). Lower calculation temperatures than in Formula 12 shall not be used.

— Continuous monitoring of water quality (see EN 12953-6:2011, 4.8.2, 4.8.3 and 4.8.4)

If the furnace diameter is greater than 1800 mm the following conditions shall be fulfilled:

— A separate stress analysis of the furnace (e.g. by a suitable FEA calculation) is necessary to prove the factor of safety against deformation and rupture

5.5.3 Heat input

If the heat input is more than H_{gas} = 18,2 MW / H_{oil} = 14 MW the following conditions shall be fulfilled:

— Verification of heat flux and calculation temperature of furnace (e.g. according to 6.1 e).

— The design documentation demonstrates satisfactory integration of the burner with the boiler and the operating instructions contain the full specification details for the boiler/burner combination.

5.5.4 Additional operating conditions

For H_{gas}> 18,2 MW/H_{oil} >14 MW, the boiler manufacturer shall consider additional operating requirements as follows. The risk analysis shall be adapted accordingly:

More stringent operating conditions specified such as improved water quality requirements in addition to the requirements of EN 12953-10:2003, shorter maintenance and/or inspection intervals.

— Temperature monitoring of the furnace shell or equivalent safety / technical measures, if required according to Figure 1.

— More stringent start up conditions, e.g. limitation of the heating rate in the cold start (either automatically within the control system or in the operating instructions) as determined from the boiler/burner integration evaluation.

— Twin furnace boiler: requirements for possible single furnace operation, where the operating requirements necessitate a wide range of heat input.

a) For steam boilers:

   — Monitoring of the conductivity of the boiler water shall be in accordance with EN 12953-6:2011.

   — Improvement in the circulation during start-up.

b) For hot water boilers:

   — Monitoring of the make-up water shall be in accordance with EN 12953-6:2011 as well as the monitoring of the returns for contamination.

   — Reliable monitoring of returns for sudden changes in flow rate or temperature.

Where refractory is attached to the furnace shell, the length shall not be longer than one third of the inside diameter of the furnace. The length is defined as starting from the end of the burner. Further refractory or other internals in the furnace for the purpose of storing or retaining heat are not permitted except where they are in accordance with the specification of the burner manufacturer.

5.6 Dimensions of pressure parts

The wall thickness and other dimensions of pressure parts shall be sufficient to withstand the calculation pressure at calculation temperature and shall be determined in accordance with this Part of the European Standard.

5.7 Determination of pressures

5.7.1 Maximum allowable pressure

The maximum allowable pressure *PS* is the maximum pressure for which the boiler is designed and shall be measured at the highest point of the boiler.

5.7.2 Calculation pressure

The calculation pressure p_c shall be not less than the sum of the maximum allowable pressure and the hydrostatic head. If the latter is less than 3 % of the maximum allowable pressure, the effect of hydrostatic head may be ignored.

NOTE Calculation pressure p_c is also referred to as design pressure p_d. The term calculation pressure p_c is used throughout this European Standard.

5.7.3 Safety valves set pressure

The safety valve(s) set pressure shall not exceed the maximum allowable pressure (see also EN 12953-8:2001).

5.7.4 Hydrostatic test pressure

The standard hydrostatic test pressure shall be not less than that given by Formula (3):

$$p_t = 1{,}25\, p_c \frac{R_{p0,2\,20}}{R_{p0,2\,tc}} \quad (3)$$

or

$$p_t = 1{,}43\, p_c \quad (4)$$

whichever is the higher;

where

$R_{p0,2\,20}$ is the specified value of the yield point at 20 °C;

$R_{p0,2\,tc}$ see EN 12953-1:2012, Table 1.

The highest ratio of $R_{p0,2\,20}/R_{p0,2\,tc}$ shall be taken for the boiler shell and front tube plate (or front plate depending on the configuration) and rear plate (or rear tube plate depending on the configuration) at their calculation temperatures.

In all cases:

a) The stress in all pressure parts of the boiler and/or the boiler assembly shall not exceed 95 % of their specified yield strength at test temperature;

b) p_t shall not exceed the calculation pressure for the furnace under test conditions (see 13.1). The value of modulus of elasticity (E) at room temperature shall be used.

c) For boilers with smoke tubes that are expanded only, the value of p_t = 1,43 p_c shall be used.

5.8 Allowances

5.8.1 Allowance for material supply tolerances and forming processes

The minus tolerance on the ordered nominal wall thickness c_1 is to compensate for minus tolerances resulting from the supply condition of the material.

For subsequent forming processes, the minimum thickness that shall be achieved by the supplier or manufacturer shall be at least the minimum thickness specified in the relevant documents (i.e. drawings, calculation sheets, etc.).

5.8.2 Allowance for metal wastage

For the purpose of design, allowance for metal wastage c_2 shall include corrosion and also erosion and abrasion if these effects are expected to occur.

For components working under normal conditions:

a) wall thickness ≤ 30 mm a minimum wastage allowance of 0,75 mm shall be taken;

b) wall thickness > 30 mm and for all flat components, a wastage allowance of 0 mm may be used.

In the case of severe wastage conditions an increased c_2 value shall be selected accordingly.

5.9 Additional material requirements for plates

UT tests according to EN 10160 shall be performed for plates ≥ 30 mm.