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

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

Chaudieres a tubes d'eau et installations auxiliaires - Partie 5: Fabrication et construction des parties sous pression des chaudieres

Ta slovenski standard je istoveten z: **EN 12952-5:2001**

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EUROPEAN STANDARD

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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 8 September 2000.

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 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 Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This Document (EN 12952-5:2001) 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of an identical text or by endorsement, at the latest by June 2002, and conflicting national standards shall be withdrawn at the latest by June 2002.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 safety requirements of the Pressure Equipment Directive (PED)[1]).

For relationship with Pressure Equipment Directive see informative annex ZA, which is an integral Part of this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

The European Standard series EN 12952 concerning water-tube boilers and auxilliary 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: Inspecing 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 solid fuels for the boiler
Part 10: Requirements for safeguards against excessive pressure
Part 11: Requirements for limiting devices and safety circuits 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
Part 15: Acceptance tests
Part 16: Requirements for grate and fluidized bed firing systems for solid fuels.

Although these Parts may be obtained separately, it should be recognized that the Parts are inter-dependent. As such, the design and manufacture of boilers requires the application of more than one Part in order for the requirements of the European Standard to be satisfactorily fulfilled.

NOTE Part 4 is not applicable during the design, construction and installation stages.

The annexes A, C, D and E are normative. The annexes B, F and ZA are informative.

[1]) Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressuse equipment; OJEC L181.

1 Scope

This Part of the European Standard specifies requirements for the workmanship and construction of water-tube boilers as defined in EN 12952-1.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 287-1, *Approval testing of welders – Fusion welding – Part 1: Steels.*

EN 288-2, *Specification and approval of welding procedures for metallic materials – Part 2: Welding procedure specification for arc welding.*

EN 288-3, *Specification and approval of welding procedures for metallic materials – Part 3: Welding procedure tests for the arc welding of steels.*

EN 288-8, *Specification and approval of welding procedures for metallic materials – Part 8: Approval by a pre-production welding test.*

EN 571-1, *Non destructive testing – Penetrant testing – Part 1: General principles.*

EN 719, *Welding coordination – Tasks and responsibilities.*

EN 729-2, *Quality requirements for welding – Fusion welding of metallic materials – Part 2: Comprehensive quality requirements.*

EN 729-3, *Quality requirements for welding – Fusion welding of metallic materials – Part 3: Standard quality requirements.*

EN 1011-1, *Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding.*

EN 1011-2:1999, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels.*

prEN 1092-1:1997, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1: Steel flanges.*

EN 1092-2, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories – Part 2: Cast iron flanges.*

prEN 1258:1993, *Welding – Measurement of preheating temperature, interpass temperature and preheat maintenance temperature during welding.*

EN 1290, *Non-destructive examination of welds – Magnetic particle examination of welds.*

EN 1418, *Welding personnel – Approval testing of welding operators for fusion welding and resistance weld setter for fully mechanized and automatic welding of metallic materials.*

EN 1708-1, *Welding – Basic weld joint details in steel – Part 1: Pressurized components*

prEN 1759-1, F*langes and their joints – Circular flanges for pipes, valves, fittings and accessories, class designated – Part 1: Steel flanges, NPS 1/2 to 24.*

prEN 10002-1:1998, *Metallic materials – Tensile testing – Part 1: Method of test (at ambient temperature).*

EN 10025, *Hot rolled products of non-alloy structural steels – Technical delivery conditions (includes amendment A1:1993).*

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

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

EN 10045-1, *Metallic materials – Charpy impact test – Part 1: Test method.*

EN 10204, *Metallic products – Types of inspection documents.*

prEN 10216-1:1995, *Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties.*

prEN 10216-2:1998, *Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties.*

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

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

EN 12952-3, *Water-tube boilers and auxiliary installations – Part 3: Design and calculation for pressure parts.*

EN 12952-4, *Water-tube boilers and auxiliary installations – Part 4: In-service boiler life expectancy calculations.*

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

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

EN 25817, *Arc-welded joints in steel – Guidance on quality levels for imperfections (ISO 5817:1992).*

EN 26520, *Classification of imperfections in metallic fusion welds, with explanations (ISO 6520:1982).*

EN ISO 4063, *Welding and allied precesses – Nomenclature of processes and reference number (ISO 4063:1998).*

EN ISO 4759-1:1999, *Tolerances for fasteners – Part 1: Bolts, screws, studs and nuts – Product grades A, B and C (ISO/DIS 4759-1:1999).*

EN ISO 9692-2, *Welding and allied processes – Joint preparation – Part 2: Submerged arc welding of steels (ISO 9692-2:1998).*

EN ISO 14555, *Welding – Arc stud welding of metallic materials (ISO 14555:1998).*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel subtrates and of steel substrates after overall removal of previous coatings.*

CR ISO 15608, *Welding – Guideless for a metallic material grouping system (ISO/TR 15608:2000).*

3 Definitions

For the purposes of this standard the definitions given in EN 12952-1 and the following apply.

3.1
cold forming
for ferritic steels, it is forming at temperatures below the maximum permissible temperature for post-weld heat treatment in accordance with table 10.4-1. Cold forming for austenitic materials is forming at temperatures below 300 °C.

3.2
hot forming
for ferritic steels, it is forming at temperatures at or above the maximum permissible temperature for post-weld heat treatment in accordance with table 10.4-1.

4 Symbols and abbreviations

For the purposes of this European Standard, the symbols given in table 4 – 1 of EN 12952-1 shall apply. Throughout this European 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 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. 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 clauses 7 and 9.2 of EN 12952-6.

Appropriate records of manufacturing operations shall be maintained.

6 Pressure parts

6.1 Drums, headers and similar pressure parts

6.1.1 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 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 figure 10.3-1 of EN 12952-3;

c) bolted flanges in accordance with the relevant European Standards e.g prEN 1092-1 or prEN 1759-1.

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

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

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 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 Marking transfer shall be performed by the manufacturer's nominated representative(s) except for materials requiring certificate (3.1.A/3.1.C) to EN 10204 not classified as small parts.

In the case of materials for which a certificate 3.1.A to EN 10204 is required, the markings shall be transferred in accordance with the requirements of EN 12952-6.

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

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

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 may be provided in the case of welders marks, radiographs etc.

7 Cutting, forming and fabrication tolerances

7.1 Cutting of material

7.1.1 Steel shall be cut by thermal means, shearing, sawing, machining or a combination of these methods. Thermal cutting may 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 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.

NOTE 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 forgemasters 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, and a welding procedure qualification test has been performed to EN 288-3 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 as shown in figure B-2 of annex B.

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.

Tube bends which do not conform to these requirements may be acceptable if the manufacturer can ensure their use will not impair the safety of the boiler.

NOTE 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 7.3-2, 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 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 7.3-1 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.

NOTE 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 7.3-1.

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 7.3.1 — Requirements for dimensional testing of a production run of tube bends

Tube size - Nominal outside diameter d_0 mm	Testing during a production run of tube bends
$d_0 \leq 80$	a) Measure non-destructively 2 % of the production run, including the first bend, for thinning and departure from circularity u. b) Additionally, where $r_b/d_0 < 1{,}3$, a sample test bend is required before production commences.
$80 < d_0 \leq 142$	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 $r_b/d_0 < 1{,}3$ a sample test bend is required before production commences.
$d_0 > 142$	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 to be 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 to be measured at the apex of the bend.

NOTE 4 The radius of the bend r_b measured to the centre-line of the tube.

NOTE 5 The outside diameter d_0 of the tube 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:

$$e_{ext} = e_{act} \times \frac{2\ r_b/d_0 + 0{,}5}{2\ r_b/d_0 + 1} \qquad (7.3\text{-}1)$$

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_0 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 11.3 of EN 12952-3.

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 up to and including 142 mm

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

$$e_{int} = e_{act} \times \frac{2\ r_b/d_0 - 0{,}5}{2\ r_b/d_0 - 1} \qquad (7.3\text{-}2)$$

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_0 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 11.3 of EN 12952-3.

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 11.3 of EN 12952-3. 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:

$$u = 2 \times \frac{(\hat{d}_0 - \check{d}_0)}{(\hat{d}_0 + \check{d}_0)} \times 100\ \% \qquad (7.3\text{-}3)$$

where

u is the departure from circularity, in %;

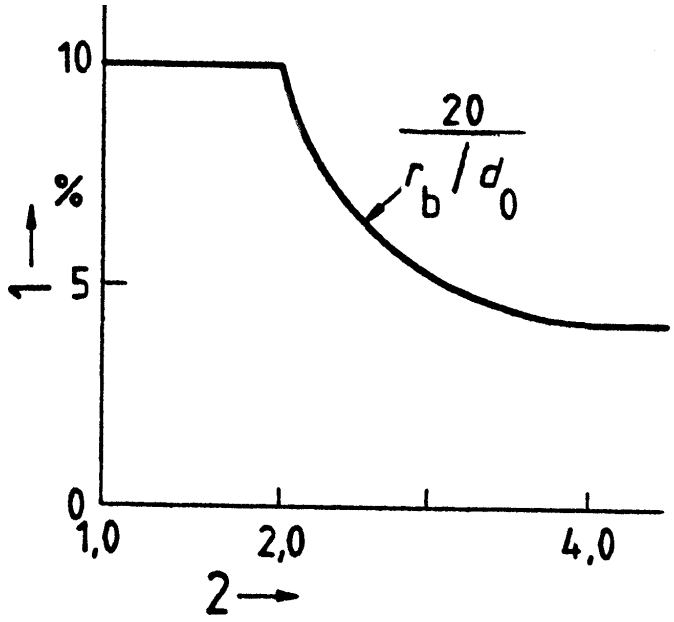
$\hat{d}_0$ is the maximum outside diameter measured at the tube bend apex, in mm;

$\check{d}_0$ is the minimum outside diameter measured at the same cross-section as $\hat{d}_0$, in mm.

The permitted departure from circularity shall be within the limits given in figures 7.3-1 and 7.3-2.

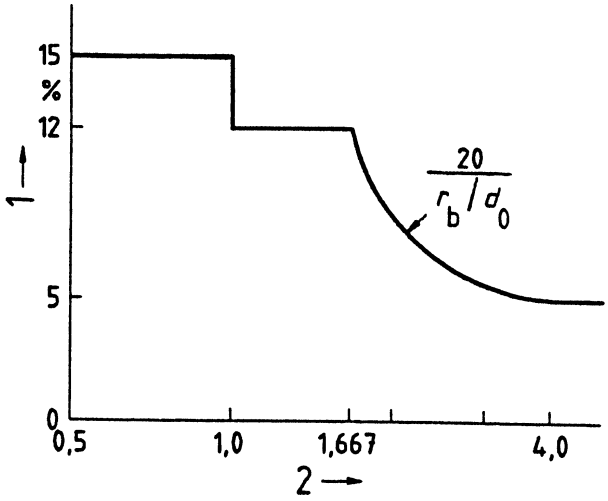
a) The departure from circularity of tube bends, which are bent in a single continuous operation, shall not exceed the limits shown in figure 7.3-1.

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 7.3-2, shall not exceed the limits shown in figure 7.3-2.



key
1 Departure from circularity u
2 Ratio r_b/d_0

Figure 7.3-1 — Limits of departure from circularity for single operation bending



key
1 Departure from circularity u
2 Ratio r_b/d_0

Figure 7.3-2 — 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 7.3-2 shall be carried out in accordance with the requirements of 7.3.9.

Table 7.3-2 — Post-bend heat treatment applicable to cold formed tube bends

d_0 mm	Bend ratio	Heat treatment
$d_0 > 142$	$r_b/d_0 > 2,5$	No post-bend heat treatment required
$d_0 > 142$	$r_b/d_0 \leq 2,5$	Stress relieve
$d_0 \leq 142$	$r_b/d_0 > 1,3$	No post-bend heat treatment required
$d_0 \leq 142$	$r_b/d_0 \leq 1,3$	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 normalising shall encompass the bend and adjacent straight lengths of 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 normalising 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 tables 10.4-1 and 10.4-2, 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.