BS EN 12952-6:2011

BSI Standards Publication

Water-tube boilers and auxiliary installations

Part 6: Inspection during construction; documentation and marking of pressure parts of the boiler

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National foreword

This British Standard is the UK implementation of EN 12952-6:2011. It supersedes BS EN 12952-6:2002 which is withdrawn.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 secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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This European Standard was approved by CEN on 25 June 2011.

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Contents

Page

Foreword

This document (EN 12952-6:2011) 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of an identical text or by endorsement, at the latest by February 2012, and conflicting national standards shall be withdrawn at the latest by February 2012.

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 12952-6:2002.

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 97/23/EC, see informative Annex ZA, which is an integral part of this document.

Annex B provides details of significant technical changes between this European Standard and the previous edition.

The European Standard series EN 12952 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.*

NOTE 1 A Part 18 on operating instructions is currently in preparation.

Although these parts may 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 European Standard to be satisfactorily fulfilled.

NOTE 2 Part 4 and Part 15 are not applicable during the design, construction and installation stages.

NOTE 3 A "Boiler Helpdesk" has been established in CEN/TC 269 which may be contacted for any questions regarding the application of European Standards series EN 12952 and EN 12953, see the following website: http://www.boiler-helpdesk.din.de

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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for the inspection during construction, documentation and marking of water-tube boilers as defined in EN 12952-1.

2 Normative references

The following referenced documents are indispensable for the application 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 287-1:2004, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 473:2008, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

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

EN 1321, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

EN 1418:1997, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN 1435, *Non-destructive testing of welds — Radiographic testing of welded joints*

EN 12952-1:2001, *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 12952-3:2011, *Water-tube boilers and auxiliary installations — Part 3: Design and calculation for pressure parts*

EN 12952-5:2011, *Water-tube boilers and auxiliary installations — Part 5: Workmanship and construction of pressure parts of the boiler*

EN ISO 148-1:2010, *Metallic materials — Charpy pendulum impact test — Part 1: Test method (ISO 148-1:2009)*

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 11666, *Non-destructive testing of welds — Ultrasonic testing — Acceptance levels (ISO 11666:2010)*

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

EN ISO 15614-1:2004, *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 15614-1:2004)*

EN ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637:2003)*

EN ISO 17638, *Non-destructive testing of welds — Magnetic particle testing (ISO 17638:2003)*

EN ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment (ISO 17640:2010)*

EN ISO 23277, *Non-destructive testing of welds - Penetrant testing of welds - Acceptance levels (ISO 23277:2006)*

EN ISO 23278, *Non-destructive testing of welds — Magnetic particle testing of welds — Acceptance levels (ISO 23278:2006)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12952-1:2001 and the following apply.

3.1
inspection
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

[EN ISO 9000:2005]

4 General organisation

4.1 General

The manufacturer shall be responsible for ensuring the boiler conforms to the requirements of this European Standard. Conformance shall be confirmed by completing a series of inspection activities as detailed in Table 4.5-1.

Except where explicitly stated otherwise in this European Standard, inspection activities applicable to a manufacturer's works shall also be applicable to operations carried out on a construction site.

4.2 Conformity assessment

Guidance in the use of the conformity assessment procedures is given in EN 12952-1:2001, Annex A.

4.3 Competency of the manufacturer

If an assessment of the competency of the manufacturer is required, guidance is given in EN 12952-5:2011, Annex F.

4.4 Calibration of equipment

The manufacturer shall establish procedures to ensure that tools, gauges, instruments and other measuring and testing devices used in the manufacture and inspection activities affecting boiler product quality, are properly controlled, calibrated and adjusted at specific intervals, to maintain accuracy within defined limits.

NOTE A system for calibration, e.g. in compliance with the EN ISO 9000 series, is be deemed to meet these requirements.

4.5 Inspection activities

The manufacturer shall confirm that the boiler components, as a minimum, conform to the requirements of this European Standard by performing and authenticating the activities listed in Table 4.5-1.

NOTE Depending upon the conformity assessment module adopted, some of the inspection activities listed should also be assessed by a responsible authority. For the guidance of the manufacturer, the specific involvement of such a responsible authority is indicated in CR 12952-17.

Table 4.5-1 — List of inspection activities to be undertaken by the manufacturer

Reference	Area of activity	Inspection operation
1	**Design and general documentation**	
1.1	Design data/calculations	Ensure that the design data/calculations conform to: — technical specifications, if applicable; — the requirements of this European Standard.
1.2	Manufacturing drawings	Ensure that drawing information conforms to: — design data and calculations; — technical specifications, if applicable; — the requirements of this European Standard.
1.3	Purchase specifications	Ensure that material and component specifications conform to: — technical specifications, if applicable; — manufacturing drawings; — the requirements of this European Standard.
1.4	Specifications for sub-contracted parts	Ensure that the specification for sub-contracted parts conform to: — technical specifications, if applicable; — manufacturing drawings; — the requirements of this European Standard.
2	**Material**	
2.1	Material certificates	Verify that certificate information and results conform to the design specification.
2.2	Welding consumables	Verify that the consumables to be used are in accordance with the design specification.
2.3	Material identification	Identify the material with the material certificates and check the markings.
2.4	Transfer of identification marks	Ensure that the transfer of identification marks is in accordance with the approved procedure.
2.5	Acceptance of sub-contracted parts	Verify that sub-contracted parts conform to the manufacturer's specification.
3	**Manufacturing and welding**	
3.1	Welding procedure specifications	Verify that appropriate welding specifications are available and that their contents are compatible with the welding procedure qualifications.
3.2	Welding procedure qualifications	Verify that the welding procedures are appropriate for the materials and the field of welding application, and that they have been approved by a responsible authority.
3.3	Welder qualification	Verify that the welder qualifications have been approved by a responsible authority and that they are available and valid.

Table 4.5-1 *(continued)*

Reference	Area of activity	Inspection operation
3.4	Forming procedures	Verify that forming procedures are available, where applicable, and their contents are appropriate to the product to be formed.
3.5	Joint preparations	Examine material cut edges where thermal cutting has been used and confirm machined preparations are to the correct profile.
3.6	Formed parts	Examine formed parts in accordance with the requirements of EN 12952-5:2011, Clause 7.
3.7	Weld assembly	Examine the weld assembly, including dimensional check.
3.8	Weld root	Examine second side of weld assembly, if applicable, after the first side of weld has been completed and the root cleaned.
3.9	Production test plates, if any	Identify and mark production test plates.
		Verify that any PWHT on production test plates independent of the component complies with the specific heat treatment applied to the component.
		Examine NDT reports on production test plates.
		Identify and mark the test specimens taken from production test plates for mechanical tests.
		Verify that the test information and results from the mechanical tests conform to the requirements of this European Standard.
4	**Non-destructive testing (NDT)**	
4.1	Non-destructive testing procedures	Verify that appropriate non-destructive testing procedures are available and ensure the qualification of the originator is appropriate.
4.2	Non-destructive testing operator qualifications	Ensure the non-destructive testing operator's qualifications are appropriate.
4.3	Non-destructive testing operation	Scrutinise any radiographs and check conformance to the acceptance criteria.
		Scrutinise the operator's ultrasonic testing reports.
4.4	Non-destructive testing reports	Verify that the information and results conform to the acceptance criteria.
5	**Post-weld heat treatment (PWHT)**	
5.1	PWHT procedures	Verify that the post-weld heat treatment procedures conform to this European Standard.
5.2	PWHT records	Verify that temperature/time recordings conform to the requirements of this European Standard.

Table 4.5-1 *(continued)*

Reference	Area of activity	Inspection operation
6	**Final inspection and marking**	
6.1	Pre-hydrostatic pressure test inspection	Carry out dimensional checking, visual examination and identification of accessible parts after component completion, prior to hydrostatic pressure test.
6.2	Hydrostatic pressure test	Ensure the final hydrostatic pressure test is carried out in accordance with the requirements of this European Standard.
6.3	Post-hydrostatic pressure test inspection	Perform visual examination on completion of the hydrostatic pressure test.
		Check marking on nameplate.
6.4	Safety devices	Ensure the provision of safety equipment.
6.5	Manufacturer's data dossier	Ensure completeness of the data dossier — see Clause 11.

5 Non-destructive testing (NDT) of parent materials

The NDT of parent materials shall be in accordance with EN 12952-2.

6 Qualification of welding procedure specification

6.1 General

The welding procedure specifications shall be qualified for all welds in components forming the pressure circuit or attached to that circuit.

For application to water-tube boilers, these qualifications shall be in accordance with EN ISO 15614-1:2004 or EN ISO 15613:2004 as appropriate. Qualification records and fusion welding procedure specifications shall be approved as part of the design qualification process. The general rules of EN ISO 15614-1:2004 shall be supplemented for the purpose of this European Standard by application of the specific rules detailed in 6.2.

The manufacturer shall include as part of the technical documentation, a list of all the welding procedure specifications required for the manufacturing of the water-tube boiler.

Where a manufacturer has previously carried out successful procedure qualification tests in accordance with the requirements of this European Standard, he shall be deemed exempt from the necessity for re-qualification is not required, as long as the current welding procedure specification standard is met within the essential variables covered by the previous test.

NOTE A document on ‘Flash butt welding procedures’ is in preparation. See Bibliography.

In addition to the requirements of EN ISO 15613:2004, procedure qualification test for welded water-tube wall construction shall comply with the requirements of EN 12952-5:2011, Annex A.

6.2 Application of EN ISO 15614-1

6.2.1 Tests required

The welding procedure tests shall be in accordance with the requirements of EN ISO 15614-1:2004.

In addition, the following requirements shall be met for drums and headers made from steel groups 1, 2.1, 4 or 5:

a) Boiler drums: For longitudinal and circumferential welded joints in drums of thicknesses greater than 20 mm, the welding procedure qualification test shall include a longitudinal tensile test on weld metal. This test shall be performed at not less than the following minimum temperatures:

   1) 250 °C for steel group 1.1 and 1.2;

   2) 350 °C for steel group 2.1, 4 or 5.

b) Headers: For headers containing longitudinal welds having a thickness greater than 20 mm, the welding procedure qualification test for the longitudinal welds shall include a longitudinal tensile test on weld metal. This test shall be performed at not less than the following minimum temperatures:

   1) 250 °C for steel group 1.1 and 1.2;

   2) 350 °C for steel group 2.1, 4 or 5.

6.2.2 Mechanical tests

6.2.2.1 General

All mechanical tests performed during the welding procedure qualification shall be carried out in accordance with EN ISO 15614-1:2004.

The Charpy V-notch impact tests shall be carried out at room temperature in accordance with EN ISO 148-1.

The test values to be achieved shall be as defined in EN ISO 15614-1:2004 and 6.2.2.2 to 6.2.2.5.

6.2.2.2 Longitudinal tensile test on weld metal

The test result shall meet the specified minimum $R_{p0,2}$ value for parent material at testing temperature (see 6.2.1).

6.2.2.3 Transverse tensile test

The test results shall meet the following requirements, depending on the position where the fracture occurs during the test:

— if the fracture occurs in parent material, the minimum ultimate tensile strength specified for the relevant parent material used for the qualification;

— if the fracture occurs in the weld, the minimum ultimate tensile strength specified for the relevant parent material used for the qualification, or, for designs based on the $R_{p0,2}$ proof strength, 90 % of the minimum ultimate tensile strength specified for the relevant parent material used for the qualification.

6.2.2.4 Charpy V-notch impact tests

The test results shall meet the following requirements, depending on the parent material and the position where the tests are performed:

a) For ferritic steels:

   1) Charpy V-notch impact test in the weld deposit:

— minimum average value: the average value specified for the parent material used in the welding procedure qualification at the test temperature (room temperature);

— minimum single value: one single value may be lower than the value required for the minimum average value, but shall not be less than 70 % of the minimum average value;

2) Charpy V-notch impact tests in the heat affected zone:

— minimum average value of 27 J, except for steel group 6 where 24 J is permitted;

— minimum single value: one single value may be lower than the value required for the minimum average value, but shall not be less than 21 J, or 19 J for steel group 6;

b) For austenitic steels:

Impact testing shall not be required for austenitic steels.

6.2.2.5 Hardness survey

Depending on the parent material and whether post-weld heat treatment is required in accordance with EN 12952-5:2011, 10.4, hardness values shall be as specified in EN ISO 15614-1:2004.

For non-heat treated steel group 5, the maximum value shall not exceed 380 HV10.

Provided that the ductility of the weld has been adequately demonstrated in accordance with the bend tests as specified in EN ISO 15614-1:2004 and the impact tests as specified in 6.2.2.4, local deviations in the heat affected zone hardness values shall be acceptable.

6.2.2.6 Dissimilar joints

In the case of dissimilar joints, the weld metal values shall meet the lower of the specified minimum values for the parent material as required in 6.2.2.2, 6.2.2.3 and 6.2.2.4.

7 Welder and welding operator qualification

All welders and welding operators engaged on the welding of pressure parts of water-tube boilers fabricated in accordance with this European Standard shall pass the welder qualification tests which are designed to demonstrate their ability to make sound welds of the types on which they are to be employed.

Qualification testing of welders and welding operators shall be carried out, recorded and reported in accordance with EN 287-1:2004 or EN 1418:1997, 4.2.1 and 4.2.2, as appropriate. Verification of qualification of welders testing shall be part of final inspection.

When a welder or and welding operator is qualified according to EN 287-1:2004 or EN 1418:1997, 4.2.1 and 4.2.2, as appropriate, for the welding of butt welds, no additional qualification shall be required for the welding of branches, nozzles or attachments, provided that the welding operations are carried out in the range of qualification of the welder or and welding operator qualification given in EN 287-1:2004 or EN 1418:1997, 4.2.1 and 4.2.2 as appropriate.

A list of welders and welding operators, together with records of their qualification tests, shall be retained by the manufacturer who may be required to provide evidence of qualification of any welder engaged in the manufacturing of water-tube boilers.

8 Production test plates for drums

8.1 General

The material used for production test plates shall comply with the same standard and grade, or the same specification, as that used for the construction of the drums of the water-tube boiler. As a minimum, plates shall be from the same steel making process and of the same nominal thickness as the drum plates. Where possible, the plates shall be selected from the same cast as that used for the manufacture of the drum.

The dimensions of the test plates shall be large enough to allow the preparation of all the test specimens required by 8.3.2, and in no case shall their length be shorter than 350 mm.

The test plates shall be attached, wherever practical, to the drum plate so that the weld carried out on the production test plate is a continuation of the longitudinal weld.

Production test plates shall receive an identical post-weld heat treatment or stress relief as that applied to the production weld.

8.2 Number of production test plates

The number of production test plates required shall be as follows:

a) longitudinal welds: One production test plate per welding procedure qualification per drum and per header;

b) circumferential welds: If the welding procedure qualification is the same as that for the longitudinal seam of the drum, no additional production test plate is required. If the welding procedure qualification differs from that of the longitudinal joint, then one production test plate shall be performed per welding procedure qualification per year.

8.3 Tests required

8.3.1 Non-destructive testing

The test plates shall be subjected to non-destructive testing identical with the production welds they are representing.

8.3.2 Destructive tests

The test plates and methods of testing shall be in accordance with the requirements of EN ISO 15614-1 for welding procedure qualification.

The following destructive test shall be performed on each production test plate:

a) 1 transverse tensile test at room temperature;

b) 1 longitudinal tensile test on weld metal for production test plates with thickness greater or equal to 20 mm. The test shall be performed at the design temperature of the drum;

c) 1 transverse root bend test;

d) 1 transverse face bend test;

e) 1 transverse side bend test;

f) a series of Charpy V-notch impact tests at room temperature on the deposited material, the number of test specimens depending on the thickness of the parent material:

1) 3 specimens for thickness less than or equal to 50 mm – taken at the mid thickness;

2) 6 specimens for thickness greater than 50 mm – 3 at the surface of the material, and 3 at the mid thickness;

g) a series of impact tests at room temperature in the heat affected zone, the number of test specimens depending on the thickness of the parent material:

1) 3 specimens for thickness less than or equal to 50 mm – taken at the mid thickness;

2) 6 specimens for thickness greater than 50 mm – 3 at the surface of the material, and 3 at the mid thickness;

h) 1 macroscopic examination;

i) 1 hardness test in accordance with EN ISO 15614-1.

8.4 Acceptance criteria

8.4.1 Non-destructive testing

The results obtained from the non-destructive testing of production test plates shall meet the same acceptance criteria as those required for production welds.

8.4.2 Transverse tensile test

The test results shall meet the following requirements, depending on the position where the fracture occurs during the test:

— if the fracture occurs in the parent material: the minimum ultimate tensile strength specified for the relevant parent material;

— if the fracture occurs in the weld: the minimum ultimate tensile strength specified for the relevant parent material or, for designs based on the $R_{p0,2}$ proof strength, 90 % of the minimum ultimate tensile strength specified for the relevant parent material.

8.4.3 Longitudinal tensile test on weld metal

The test result shall meet the specified minimum $R_{p0,2}$ value for parent material at the design temperature.

8.4.4 Bend tests

During testing, the test specimens shall not reveal any open imperfections greater than 3 mm in any direction. Imperfections appearing at the corners of a test specimen during testing, shall be ignored in the evaluation.

8.4.5 Impact values

The test results shall meet the following requirements, depending on the parent material and the position where the tests for ferritic steels are performed:

a) Charpy V-notch impact tests in the weld deposit:

1) minimum average value: the average value specified for the parent material used in the welding procedure qualification at the test temperature;

2) minimum single value: one single value may be lower than the value required for the minimum average value, but shall not be less than 70 % of the minimum average value;

b) Charpy V-notch impact tests in the heat affected zone:

1) minimum average value: 27 J, except for steel group 6 where 24 J is permitted;

2) minimum single value: one single value may be lower than the value required for the minimum average value, but not be less than 21 J, or 19 J for steel group 6.

8.4.6 Macroscopic examination

Imperfections detected shall be accepted in accordance with the acceptance levels in 9.3 and 9.4.

In addition, the sequence of weld deposition in multi-layer welds, shall be examined, and shall show no significant deviations in layer sequence, or in weld bead shape, from those defined in the relevant welding procedure specification.

8.4.7 Hardness survey

For non-post-weld heat treated situations, the maximum acceptable hardness value shall be 350 HV10. Where post-weld heat treatment is applied, the maximum acceptable hardness value shall be 320 HV10.

Provided that the ductility of the weld has been adequately demonstrated in accordance with the bend tests as specified in 8.4.4 and the impact tests as specified in 8.4.5, local deviations in the heat affected zone hardness values specified above shall be acceptable.

8.4.8 Dissimilar joints

In the case of joints of dissimilar joints, the weld metal values shall meet the lower of the specified minimum values for the parent material as required by 8.4.2, 8.4.3, 8.4.5 and 8.4.7.

8.5 Non-conformance of results

8.5.1 General

If the results from any test performed on a production test plate do not comply with the requirements of 8.4, the reasons for the failure shall be investigated by the manufacturer who shall ensure that any remedial action considered necessary will not impair the safety of the boiler.

When the failure of a destructive test is due to a weld defect in the section, two identical additional tests shall be performed:

— if both retests comply with the requirements of 8.4, the test results shall be deemed to comply with this European Standard;

— if either retest does not comply with the requirements of 8.4, the cause shall be investigated by the manufacturer who shall ensure that any remedial action considered necessary will not impair the safety of the boiler.

8.5.2 Specific case for Charpy V-notch impact tests

In the event of the results of the Charpy V-notch impact re-test failing to comply with the requirements of 8.4.5, the provisions of either a) or b) shall be permitted:

a) the manufacturer shall carry out further heat treatment of the production test plate provided that the same heat treatment cycle is applied to those parts of the boiler drum(s) represented, and provided that no significant adverse effects are caused. After such repeat heat treatment, all the tests required on a production test plate shall be carried out. The results shall comply with the initial requirements;

b) the welds represented by the test specimens having particular Charpy V-notch values less than required by 8.4.5 shall be accepted as fit for the intended purpose after due consideration of the specified cause and level of impact test results and of the weld quality.

NOTE There are no requirements in this European Standard for fracture mechanics testing. Where such tests are carried out, they should be carried out at the manufacturer's responsibility using the latest state of the art procedures which should ensure that, by their use, the safety of the boiler is not impaired.

9 Non-destructive testing of welds

9.1 Type and extent of non-destructive testing

9.1.1 General

Non-destructive testing (NDT) shall be carried out by experienced personnel following written procedures. Personnel responsible for non-destructive testing, including interpretation, evaluation and reporting, shall be certified in accordance with the requirements of 9.2.

All welds carried out during the manufacture and erection of a water-tube boiler shall be visually examined.

Non-destructive testing shall be performed on each component of a water-tube boiler as given in 9.1.2, 9.1.3 and 9.1.4, to the following extent:

a) Surface imperfection detection:

   1) on drums: magnetic particle testing shall be used;

   2) on headers and tubes: magnetic particle testing shall be used, except in the cases of steel group 1 and steel group 8 and for pressure connection welds for tube stubs on headers with a nominal diameter less than or equal to 80 mm for steel group 2 and steel group 5, where penetrant testing may be used;

b) Volumetric imperfection detection:

   1) in general, ultrasonic testing shall be preferred to radiographic testing for ferritic steels. The volumetric imperfection detection requirements are specified in 9.1.2, 9.1.3 and 9.1.4.

For steel group 1.1 and 1.2, the required non-destructive testing of welds shall be performed before or after any required post-weld heat treatment. For all other materials, the required non-destructive testing of welds shall be performed after any required post-weld heat treatment, except in the case of circumferential welds in tubes of steel group 5.1 and 5.2 with an outside diameter less than 120 mm and a nominal thickness less than 13 mm, where testing may be carried out before final post-weld heat treatment.

When in 9.1.2, 9.1.3 and 9.1.4, the non-destructive testing is specified on a basis of 10 %, the selected welds for testing shall include a sample of each welder's work for each welding procedure specification on the component concerned. The number of welds to be fully examined shall then be, as a minimum, 10 % of the total number of welds performed by this welder following the same welding procedure specification on the same component.

Where this European Standard requires non-destructive testing on a percentage of 10 % of welds, and when that testing reveals imperfections that do not comply with the acceptance levels stated in 9.3 and 9.4, the percentage rate of testing for the concerned welder shall be increased in accordance with 9.1.5.

When examined welds reveal imperfections that do not comply with the acceptance levels stated in 9.3 or 9.4, these imperfections shall be repaired. After repairing, these welds shall be post-weld heat treated in accordance with the requirements specified for the original weld. The original non-destructive testing shall then be repeated.

9.1.2 Drums

Drums shall be examined to the requirements of Table 9.1-1.

Table 9.1-1 — NDT of drum welds

Types of welds	Surface imperfection detection [a]	Volumetric imperfection detection		
		Radiographic testing		Ultrasonic testing
Longitudinal and circumferential welds	100 % [b]	100 % [c]	OR	100 % [c]
Pressure connection welds				
e [d] ≥ 25 mm (full penetration)	100 %	—		100 % [e]
15 mm ≤ e [d] < 25 mm (full penetration)	100 %	—		10 % [e]
All other welds, including seal welds	10 %	—		—
Attachment welds				
Load carrying	100 %	—		—
Non-load carrying	10 %	—		—

[a] Magnetic particle testing; with lacking accessibility if necessary PT testing.

[b] For steel group 1.1 and 1.2 and mechanized welding, if the thickness e ≤ 25 mm : 10 % plus T-junctions (over a length of 250 mm for T-junctions).

[c] For steel group 4 only ultrasonic testing is permitted.

[d] e is the thickness of pressure connection.

[e] No ultrasonic testing is required if d_o < 142 mm.

9.1.3 Headers

Headers shall be examined to the requirements of Table 9.1-2.

Table 9.1-2 — NDT of header welds

Types of welds	Surface imperfection detection [a]	Volumetric imperfection detection		
		Radiographic testing		Ultrasonic testing
Longitudinal and circumferential welds	100 % [b]	100 % [c]	OR	100 % [c]
Pressure connection welds				
e [d] ≥ 25 mm (full penetration)	100 % [e]	100 % [c f]	OR	100 % [c f]
15 mm ≤ e [d] < 25 mm (full penetration)	10 % [e]	10 % [c f]	OR	10 % [c f]
All other welds, including seal welds	10 % [g]	—		—
Attachments welds				
Load carrying	100 %	—		—

Table 9.1-2 *(continued)*

Types of welds	Surface imperfection detection [a]	Volumetric imperfection detection	
		Radiographic testing	Ultrasonic testing
Non-load carrying	10 %	—	—
End plate welds	100 %	—	100 % [h]

[a] Magnetic particle testing, but penetrant testing is acceptable for steel groups 1 and 8.

[b] For steel groups 1 and 8 with a thickness $d_o \leq 25$ mm: 10 % of circumferential welds.

[c] For steel groups 4 and 6 only ultrasonic testing is permitted.

[d] e is the thickness of the pressure connection.

[e] Only 10 % for steel groups 1 and 8.

[f] No volumetric imperfection detection is required if $d_o < 142$ mm.

[g] Penetrant testing is also acceptable for tube stubs in steel groups 2 and 5 with a nominal diameter $d_o \leq 80$ mm.

[h] Only for full penetration welds with outside diameter $d_o > 70$ mm and for end plate thickness $e > 8$ mm.

9.1.4 Tubes

Tubes shall be examined to the requirements of Table 9.1-3. For circumferential welds at boiler tubes with $d_o < 76{,}1$ mm tested by using elliptical radiographic technique it is sufficient to have 1 partial image per weld; percentage in Table 9.1-3 relates to the number of welds.

Table 9.1-3 — NDT of tube welds

Types of welds	Surface imperfection detection [a]	Volumetric imperfection detection		
		Radiographic testing		Ultrasonic testing
Circumferential welds				
e [d] > 25 mm or $d_o > 142$ mm	100 %	100 % [b c]	OR	100 % [b]
Dissimilar welds between austenitic and martensitic steels with $d_o < 76{,}1$ mm	100 % [i]	100 % [h i]		----
Flash welded or pressure welded butt welds	see 6.1	see 6.1		see 6.1
Other welds [j]	–	10 % [c]	OR	10 % [c] or 10 % [h]
Pressure connection welds				
e [d] ≥ 25 mm (full penetration)	100 % [b]	100 % [c e f]	OR	100 % [e f]
15 mm ≤ e [d] < 25 mm (full penetration)	100 % [b]	10 % [c e f]	OR	10 % [e f]
All other welds	10 %	—		—

Table 9.1-3 *(continued)*

Types of welds	Surface imperfection detection [a]	Volumetric imperfection detection	
		Radiographic testing	Ultrasonic testing
Attachments welds			
Load carrying	100 %	—	—
Non-load carrying	10 %	—	—
Welds between fins and tubes for panel construction	g	—	—

[a] Magnetic particle testing; with lacking accessibility if necessary PT testing, penetrant testing is acceptable for steel group 1.

[b] Only 10 % for steel groups 1 and 8.

[c] For outside diameters above 80 mm in steel groups 4 and 6 only ultrasonic testing is permitted.

[d] e is the thickness of the pressure connection.

[e] Radiographic testing is acceptable instead of ultrasonic testing when ultrasonic testing is not possible.

[f] No volumetric imperfection detection is required if d_o < 142 mm.

[g] Limited to 100 % visual examination.

[h] When applying the elliptical technique a partial image of the weld is sufficient.

[i] For joints being welded with machines an inspection scope of 10 % is sufficient.

[j] In case of the application ot the elliptical technique, a partial image is sufficient for the radiographic testing of welds with d_o < 76,1 mm.

9.1.5 Extension procedure of random testing in case of repairs

When performing a 10 % rate of non-destructive testing, as permitted in 9.1.2, 9.1.3 and 9.1.4, and when the result of the testing is not acceptable in accordance with the requirements of 9.3 or 9.4, the principle for the extension of the rate of that NDT shall be as follows:

a) the basis for an extension of the rate of testing shall always be related to each individual component, to each welder involved in the manufacture of this component, and to the same type of welds (referring to an identical welding procedure specification);

b) when performing the random testing, if one weld, or more than one weld, is (are) revealed as not being acceptable according to the requirements of 9.3 or 9.4, the testing shall be extended to two additional welds of the same type, for each rejected weld;

c) if all the examined welds of that extension are acceptable, then the initial rate of 10 % may be resumed;

d) when one or more of the welds examined during that extension is (are) not acceptable, then the testing shall be extended to ten additional welds for each weld rejected during the first extension;

e) the extension procedure shall be continued on this principle until all the extension welds are acceptable;

f) if the extension procedure continues to reveal unacceptable welds, the extension procedure shall be increased until a rate of 100 % testing is being carried out.

9.2 Qualification of non-destructive testing (NDT) personnel

Personnel responsible for non-destructive testing, including interpretation, evaluation and reporting shall be certified in accordance with the general requirements of EN 473:2008.

An exception to this requirement shall be made for visual examination of welds and final inspection of boilers, for which EN 473:2008 is not applicable.

Magnetic particle testing shall be performed under the direct supervision of personnel qualified to level 2 of EN 473:2008 as a minimum.

Penetrant testing shall be performed under the direct supervision of personnel qualified to level 2 of EN 473:2008 as a minimum.

Ultrasonic testing shall be performed by an operator qualified to level 2 of EN 473:2008 as a minimum for UT.

Radiographs shall be viewed by personnel qualified to level 2 of EN 473:2008 as a minimum.

Visual examination shall be carried out by experienced personnel having sufficient knowledge in welding techniques, and a full comprehension of this European Standard, to identify and interpret imperfections that might occur at the surface of the weld and the heat affected zone.

9.3 The detection of surface imperfections

9.3.1 General

For application to water-tube boiler inspection during manufacture or erection, the welds shall be accepted in the undressed condition, unless dressing is necessary to carry out satisfactory non-destructive testing.

Indications which cannot be identified as being acceptable in accordance with Table 9.3-1, or which cannot be positively identified as not being cracks, lack of fusion, lack of penetration, overlap or poor stop or re-start, shall be identified by other means. If the indication cannot be identified, it shall be assumed to be an imperfection and shall be removed.

9.3.2 Visual examination

Visual examination shall be carried out in accordance with EN ISO 17637.

The acceptance criteria for the surface imperfections of welds shall be in accordance with Table 9.3-1.

Acceptance limits for imperfections occurring at the surface of welded components have been derived by reference to EN ISO 5817 and EN ISO 6520-1.

The requirements of the above standards have been supplemented to reflect current water-tube boiler manufacturing practice. Where this has been done, an identifying letter “S” has been utilized in the Table 9.3-1 in the column “EN ISO 5817 level”.

For the special case of longitudinal fin to tube welds, the acceptance criteria shall be in accordance with EN 12952-5:2011, Annex C.

9.3.3 Penetrant testing

Penetrant testing shall be carried out in accordance with the provisions of EN 571-1 and EN ISO 23277.

Acceptance levels shall be in accordance with EN ISO 23277.

9.3.4 Magnetic particle testing

Magnetic particle testing shall be carried out in accordance with the provisions of EN ISO 17638:2009 and EN ISO 23278.

Acceptance levels shall be in accordance with EN ISO 23278.

9.3.5 Acceptance criteria for weld surface imperfections

Table 9.3-1 — Acceptance criteria for weld surface imperfections

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Refer-ence No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
1	100X	Cracks (all)	B	Not permitted
2	201X 202X	Gas cavity (all) Shrinkage cavity (all)	"S" (B)	— $d \leq 2 \times e$, max. 2 mm, with additional conditions that: — it does not occur at a stop or restart. Where d is the diameter of pore in mm, e is the thickness of base material, in mm.
3	301X 302X 303X 304X	Slag inclusions (all) Flux inclusions (all) Oxide inclusions (all) Metallic inclusions (all)	"S"	Not permitted when occurring at the surface (shall be removed e.g. by grinding).
4	401X	Lack of fusion (all)	B	Not permitted.
	402 4021	Lack of penetration Lack of root penetration	B	Not permitted if a full penetration weld is required.
5	5011 5012	Undercut, continuous Undercut, intermittent	C	$h \leq 0{,}1\ e$, max. 0,5 mm (irrespective of length). A smooth transition is required where h is depth of the notch and e is thickness of base material, in mm.
	5013	Shrinkage groove	C	$h \leq 0{,}1$ e, max. 1,0 mm (irrespective of length). a smooth transition is required where h is depth of the notch and e is thickness of base material, in mm.
	502	Excess weld metal (butt joint)	C	Height ≤ 1 mm + 0,15 b, maximum 7 mm where b is width of weld, in mm. A smooth transition is required.

Table 9.3-1 *(continued)*

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Refer-ence No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
	503	Excessive convexity (fillet weld)	C	Height ≤ 1 mm + 0,15 b, maximum 4 mm where b is width of weld, in mm. A smooth transition is required.
5	504	Excess penetration	C	Height ≤ 1 mm + 0,6 b, maximum 4 mm where b is the width of the penetration, in mm.
	5041	Local excess penetration	"S"	Occasional local excess (see No. 504) is permitted with a maximum that shall be related to the operating conditions.
	505	Abrupt weld transition	B	butt welds: α ≥ 150° fillet welds: α ≥ 110°
	506	Overlap	B	Not permitted.
	507	Linear misalignment		See EN 12952-5:2011, 7.4 and 8.11.
	508	Angular misalignment		See EN 12952-5:2011, 7.4 and 8.11.
	509	Sagging	C	Long imperfections (> 25 mm) not permitted. Short imperfections (≤ 25 mm) not permitted if $h \geq 0{,}10\ e$, Maximum 1,0 mm where h is the depth of sagging, in mm, e is the thickness of parent material, in mm.
	510	Burn through	B	Not permitted.
	511	Incompletely filled groove	C	Same as for sagging No. 509.
	512	Excessive asymmetry of fillet weld	D	$h \leq$ 2 mm + 0,2 a where h is the excess of one leg, in mm; a is the throat of weld, in mm.
	515	Root concavity	C	Long imperfections (> 25 mm) are not permitted. Short imperfections (≤ 25 mm) are permitted if $h \leq$ 0,1 x e , max. 1 mm where h is the root concavity, in mm; e is the thickness of base material, in mm. A smooth transition is required.
	516	Root porosity	B	Not permitted.
	517	Poor restart	B	Not permitted.

Table 9.3-1 *(continued)*

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Refer-ence No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
6	601	Stray arc	"S"	Not permitted. Grinding is required plus penetrant testing or magnetic particle inspection to ensure that no crack is left.
	602	Spatter	"S"	Shall normally be removed from all pressure parts and from both load and non-load carrying attachment welds. Isolated, non-systematic spatter may however be permitted on components made from steel group 1. NOTE In the special case of circumferential welded fins which are attached to tubes by a mechanized welding process, spatter should be minimized, but any produced may remain, regardless of the material or heat treatment involved.
	603	Torn surface	"S"	Not permitted. Shall be ground. A smooth transition is required.
	604	Grinding mark	"S"	Not permitted. Shall be flushed by grinding. A smooth transition is required.
	605	Chipping mark	"S"	Not permitted, shall be flushed by grinding. A smooth transition is required.
	606	Underflushing	"S"	Not permitted. Any local underflushing shall be related to the design characteristics (calculated thickness + corrosion allowance = minimum thickness for parent material). Thickness shall be measured by ultrasonic method in case of doubt.

9.4 Testing for volumetric imperfections

9.4.1 Radiographic testing

9.4.1.1 Method

Radiographic testing of welds shall be carried out in accordance with EN 1435.

9.4.1.2 Acceptance criteria for imperfections

The acceptance criteria for internal imperfections of welds detected by radiography shall be in accordance with Table 9.4-1.

Acceptance limits for imperfections occurring in the body of the weldment have been derived by reference to EN ISO 5817 and EN ISO 6520-1.

The requirements of the above standards have been supplemented to reflect current water-tube boiler manufacturing practice. Where this has been done, an identifying letter “S” has been utilized in Table 9.4-1 in the column “EN ISO 5817 level”.

Table 9.4-1 — Acceptance criteria for weld internal imperfections detected by radiography

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Reference No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
1	100X	Cracks (all)	B	Not permitted
2	2011	Gas pore (isolated or individual in a group)	"S" (C-D)	$d \leq 0{,}3\ e$, maximum 4 mm for $e \leq 60$ mm and maximum 5 mm for $e > 60$ mm where d is the diameter of a single pore, in mm; e is the thickness of parent material, in mm.
	2012	Uniformly distributed porosity	C	For any individual pore, see gas pore No. 2011.
			B	Not permitted if the total projected surface of porosity exceeds 2 % of the considered projected surface of weld.
	2013	Localized (clustered) porosity	"S"	For any individual pore, see gas pore No. 2011.
			B	Not permitted if the total projected surface of porosity exceeds 4 % of the considered projected surface of the weld, which is the greatest of the 2 following areas: area 1: an envelope surrounding all the pores; area 2: a circle with a diameter corresponding to the weld width.
	2014	Linear porosity	"S"	Same as for uniformly distributed pores No. 2012, but the distance between two pores shall always be greater than twice the diameter of the bigger one, and not be less than 4 mm (to ensure that there is no chance of having a lack of fusion)
	2015	Elongated cavities	"S" (better than B)	$l \leq 0{,}3\ e$, maximum 5 mm, and $w \leq 2$ mm where l is the length of the projected indication, in mm; e is the thickness of parent material, in mm; w is width of the projected indication, in mm.
	2016	Worm holes	"S"	Same as for elongated cavity No. 2015.

Table 9.4-1 (*continued*)

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Refer-ence No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
	202	Shrinkage cavities	"S" (D)	$l \leq 0{,}3\ e$, maximum 4 mm, and $w \leq 2$ mm where l is the length of the projected indication, in mm; e is the thickness of parent material, in mm; w is the width of the projected indication, in mm.
3	301	Slag inclusions	"S" (C)	$w \leq 0{,}3\ e$, maximum 3 mm and to the application: a) yield range $l \leq e$, max. 50 mm b) creep range $l \leq 0{,}5\ e$, max. 25 mm where w is the width of projected indication, in mm; l is the length of projected indication, in mm; e is the thickness of parent material, in mm. NOTE In the case of several linear slag inclusions with a distance between two of them less than twice the longest of them, the total length needs to be considered as a defect.
	302	Flux inclusion	"S" (C)	Same as for slag inclusion No. 301.
	303	Oxide inclusion	"S" (C)	Same as for slag inclusion No. 301.
	304	Metallic inclusion	"S"	Copper inclusions not permitted Tungsten inclusions: same as for gas pore No. 2011 – 2012 – 2013.
4	401X	Lack of fusion (all)	B	Not permitted.
	402	Lack of penetration	B	Not permitted if a full penetration weld is required.
5	500	Imperfect shape	These defects are normally accepted or rejected by visual examination. Nevertheless, such defects can occur on surfaces which have no access for visual examination (internal tubes for example).	
	5011	Undercut, continuous		
	5012	Undercut, intermittent		
	5013	Shrinkage groove		

Table 9.4-1 (*continued*)

Identification of imperfection			Limit of imperfection	
EN ISO 6520-1 Group No.	**EN ISO 6520-1 Refer-ence No.**	**Type of imperfection**	**EN ISO 5817 level**	**Maximum permitted**
	504	Excess penetration		
	5041	Local excess penetration		
	515	Root concavity		
	516	Root porosity		
	517	Poor restart		

9.4.2 Ultrasonic testing

9.4.2.1 Method

Ultrasonic testing of welds shall be carried out in accordance with EN ISO 17640.

EN ISO 17640 shall be fully applied to ultrasonic testing of welds during manufacture of water-tube boilers in accordance with this European Standard. However, the following specific requirements shall be met and specified in a testing procedure when options are permitted by these standards:

a) austenitic steels: ultrasonic testing of fusion welded joints in austenitic materials shall be carried out in accordance with written procedures based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired;

b) partial penetration welds: ultrasonic testing of partial penetration welds shall be carried out in accordance with written procedures based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired;

c) the examination level B shall be in accordance with EN ISO 11666. The specific test requirements for the testing shall be specified in a written instruction according to EN ISO 17640 and be made available for the UT-operator. The assessment shall be in accordance with acceptance level 2 according to EN ISO 11666;

d) transverse defects: ultrasonic testing for transverse defects shall be performed:

   1) on steel group 1.2, where the thickness of parent material is 40 mm and over;

   2) on steel groups 2, 3, 4 and 5 for all parent material thicknesses;

e) tandem testing technique: the tandem testing technique shall not normally be applied to water-tube boilers;

f) probe frequencies: probes with a frequency between 1,5 MHz and 5 MHz shall be used for normal application. Specific applications requiring frequencies outside this range shall be based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired;

g) parent metal testing: parent metal in the area of the scanning zone shall be ultrasonically tested with a normal probe before testing with an angle probe if the edge zone of the parent metal has not been previously examined before welding;

h) preparation of the surface: scanning surfaces and surfaces from which the sound beam is reflected shall be assumed to be satisfactory if the surface roughness is not greater than 12,5 µm;

NOTE 1 Roughnesses greater than this value can still be acceptable if it can be demonstrated that effective ultrasonic testing can be achieved.

i) signal to noise ratio: during the testing of a weld, the noise level, excluding spurious surface indications, shall be at least 12 dB below the evaluation level required;

j) measurement of the length of defects: the length of reflectors, in either the longitudinal or transverse direction shall be normally determined by using the half amplitude method (6 dB technique);

NOTE 2 Other methods can be used, based on the manufacturer's own proven practices which should ensure that, by their use, the safety of the boiler is not impaired.

k) height measurements; where EN ISO 17640 is applicable, defect height measurement shall not be necessary. For application outside the scope of EN ISO 17640, the examination level and the acceptance criteria shall be based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired;

l) application of ultrasonic testing for thicknesses less than 8 mm: ultrasonic testing of fusion welded joints in material 8 mm thick, or less, shall be carried out in accordance with written procedures based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired;

m) the examination level B shall be in accordance with EN ISO 11666. The specific test requirements for the testing shall be specified in a written instruction according to EN ISO 17640 and be made available for the UT-operator. The assessment shall be in accordance with acceptance level AL 2.

9.4.2.2 Acceptance criteria

The acceptance criteria for ultrasonic testing of welds shall be acceptance level AL 3 according to EN ISO 11666.

9.5 Non-destructive testing reports

The following information shall be provided as a minimum in the test reports:

a) identification of the water-tube boiler component;

b) identification of the welds examined and the scanning pattern used;

c) identification of the fusion welding procedure specifications;

d) the stress relief or heat treatment condition;

e) the surface preparation prior to the testing (e.g. machined, ground, as welded);

f) the testing procedure reference;

g) the details of application of the procedure (e.g. type of magnetization, consumables used, type of radiographic source, type of probes);

h) the reference for acceptance criteria;

i) the results of the testing, including the details of any repairs;

j) in the case of percentage testing, the extension zones of testing, if any are required, and their results;

k) the conformity of the results with this European Standard;

l) the date when the testings were carried out;

m) the name and qualification of the personnel responsible for the testing, the evaluation and interpretation;

n) the date of the report.

10 Final inspection

10.1 Visual and dimensional examinations

Visual and dimensional examinations shall be carried out using the approved drawings.

All inspection shall be carried out visually, but may be supplemented by the use of suitable auxiliary means when necessary. The type and performances of any additional examinations shall be based on the manufacturer's own proven practices which shall ensure that, by their use, the safety of the boiler is not impaired.

The final inspection shall be carried out on each pressure part of the water-tube boiler. The inspection shall be carried out in the manufacturer's workshop or at the erection site.

The safety-relevant dimensions and the location of the components in the water-tube boiler, the departure of circularity, and the deviations from straight line of cylindrical components and drums shall be examined. The pitches and the conformance to the design of tube holes shall be spot-checked.

The surfaces shall be examined for imperfections, especially in the case of formed components. In cases where the components have not been formed, or where the examination of surface imperfections has already been carried out during manufacture, the final inspection shall be restricted to the inter-connection areas.

The installation of drums and headers, connecting pipework and tube walls, separators, coolers in water-tube boilers shall be checked for the adequacy of support and support expansion arrangements.

The internal attachments in drums and other components shall be checked where practicable.

The accessibility of access and inspection openings, and the suitability of such openings for the insertion of inspection equipment, shall be checked.

For major components designed to operate in the creep range, the provision and location of the creep measuring devices shall be spot-checked (e.g. measuring points of expansion, surface replications).

10.2 Hydrostatic pressure test

10.2.1 General

The test pressure to be used on water-tube boiler components and complete boiler assemblies shall be determined in accordance with EN 12952-3:2011, 5.7.4.

10.2.2 Test procedure

The hazards involved in pressure testing shall be considered by the manufacturer and adequate precautions shall be taken.

NOTE 1 Since it is necessary to avoid the risk of repeated over-pressurization, it is recommended that, prior to the witnessed hydrostatic test, a preliminary examination of the water-tube boiler or component should be carried out at the maximum allowable pressure for the purpose of identifying any significant leaks.

NOTE 2 Care should be taken to ensure that the complete pressure envelope, its supports and its foundations are capable of withstanding the total load that will be imposed upon them during the pressure test.

Water shall be used as the pressurizing agent. The quality of the water used shall be such as to prevent both corrosion and any residue of injurious solids.

The completed water-tube boiler, and any components which are required to be hydrostatically tested before assembly into the water-tube boiler, shall be tested with a water at a temperature such that the risk of freezing is avoided. The temperature of the water used for the pressure test shall be selected by the manufacturer taking into account the risk of brittle fracture of the pressure parts, but in any case the temperature selected for the pressure test shall not exceed 50 °C.

The water-tube boiler, or component being tested, and their connections shall be vented, or evacuated, to prevent the formation of air pockets. However, small pockets of trapped air may remain after filling, and the procedure with regard to these shall be based on the manufacturer's own proven practices which shall ensure that, the safety of the boiler is not impaired.

All temporary tubes, connections and blanking devices shall be designed to withstand the appropriate test pressure.

No component undergoing pressure testing shall be subjected to any form of shock loading, e.g. hammer testing, thermal shock, or rapid pressure changes.

The full test pressure shall be maintained for 30 min for completed water-tube boilers and large components, and for an appropriately lesser time for smaller components.

Prior to close examination, the test pressure shall be reduced to not less than the maximum allowable pressure.

Pressure parts which have been repaired following the hydrostatic test shall again be hydrostatically tested in accordance with 10.2, after completion of the repair and any required post-weld heat treatment and non-destructive testing, unless otherwise agreed. Such an agreement shall be based on the manufacturer's own proven practices which shall ensure that, the safety of the boiler is not impaired.

11 Documentation

The manufacturer shall produce a design and manufacturing data dossier.

This dossier shall be delivered to the purchaser on completion of the contract.

As a minimum, the manufacturer's data dossier shall contain:

a) a description of the water-tube boiler;

b) the location of the identification markings of the water-tube boiler (see Clause 12);

c) the water-tube boiler general arrangement drawings;

d) the pressure parts general drawings;

e) a resume of the different pressure parts thicknesses and corrosion/erosion allowances;

f) the list of parent materials, together with a copy of material certificates;

g) the list of filler materials;

h) the list of welding procedure specifications used which make reference to corresponding approved welding procedures;

i) the list of welders involved in the manufacture and erection with the reference number(s) of their qualification;

j) the extent and location of non-destructive testing, together with a list of non-destructive testing procedures used and a list of operators with the reference number(s) of their qualifications;

k) details of any approved design modifications/manufacturing concessions (deviations) which have been carried out during the manufacturing stage;

l) the hydrostatic test certificate(s).

12 Marking

Each water-tube boiler and each component submitted to the individual test shall be permanently and legibly marked to show the identity and origin of the boiler, and the permissible operating parameters.

For each water-tube boiler or component, this marking shall be affixed above the manhole of the main steam and water drum, or preferably on a plate permanently attached to a principal pressure part of the boiler.

The marking shall include the following:

a) name and address of the manufacturer;

b) serial number;

c) year of manufacture;

d) maximum allowable pressure and temperature;

e) date of first hydrostatic test and test pressure;

f) number of this European Standard;

g) reference number of the responsible third party organization, if applicable;

h) CE marking, if applicable;

i) MCR (Maximum Continuous Rating).

Annex A
(normative)

Special requirements for composite tubes

A.1 General

This annex specifies requirements for the inspection during construction; documentation and marking of chemical recovery boilers as defined in EN 12952-5:2011, E.2. These special requirements are additional to all the other requirements of this European Standard which shall continue to apply.

A.2 Special requirements of qualification of welding procedures for fusion welding

A.2.1 General

The general requirements of this European Standard, mainly Clause 6, shall be supplemented by application of the specific requirements in A.2.2.

Flash butt welding shall be carried out in accordance with EN 12952-5:2011, E.6.

A.2.2 Application of EN ISO 15614-1 to composite tubes

A.2.2.1 Range of qualification

Only a qualification of WPS obtained with composite tubes shall be applied for welding of composite tubes.

The nominal thickness t is the total nominal thickness of a composite tube. Diameter D is the nominal diameter of a composite tube.

The range of qualification for types of welded joints shall only be the same used in the welding procedure tests. A welding procedure test shall cover only that material combination of the composite tube it represents.

A.2.2.2 Additional tests required

A.2.2.2.1 Depth of penetration of clad weld

In a macroscopic examination, the depth of penetration of the clad weld to the ferritic pressure retaining inner core material or weld shall be defined. The penetration shall not penetrate essentially below the surface of the ferritic pressure retaining inner core material. Unpenetrated minimum thickness shall always be maintained.

The clad welding may penetrate to the calculated minimum wall thickness of the ferritic pressure retaining core material with the following conditions:

a) filler and weld metal strength and toughness properties are fulfilling the ferritic pressure retaining inner core material properties;

b) qualification of welding procedures shall correspond completely the requirements of EN ISO 15614-1 and EN 12952 special requirements;

c) maximum cladding weld penetration to the calculated minimum thickness area of the ferritic inner core material is 1,5 mm;

d) in prior to production a production test shall be carried out. In manual welding the test shall be done by every welder. In mechanical welding the test shall be done per each welding procedure;

e) non-destructive testing shall be carried out after cladding welding with the extent of standard EN 12952 requirements.

A.2.2.2.2 Hardness test

Hardness tests shall be done from the outer surface of ferritic pressure retaining inner core material and from the surface of cladding. The requirements of 6.2.2.5 shall be met. The hardness values of the clad weld shall correspond to those given by the manufacturer of filler materials.

A.2.2.2.3 Bend test

Bend tests shall be carried out on clad tubes.

A.2.2.2.4 Transverse tensile test

Transverse tensile tests shall be carried out when the cladding is peeled off.

A.2.2.2.5 Microscopic examination

The test specimen shall be prepared and etched in accordance with EN 1321 on one side to clearly reveal the fusion line, the HAZ and the build up of layers.

A photograph of the parent material, transition to the parent material and the cladding shall be taken. Generally, micro-cracks in the heat affected zone (HAZ) and in the weld metal shall not be permitted.

A.3 Special requirements for welder's qualification for fusion welding of composite tubes

A.3.1 General

The general requirements of this European Standard, mainly Clause 7, shall be supplemented by the application of the specific requirements in A.3.2.

A.3.2 Application of EN 287-1 to composite tubes

A.3.2.1 Range of qualification

Only a welder's qualification obtained with composite tubes shall be applied for welding of composite tubes. Test specimen thickness t is the total nominal thickness of the composite tube. Diameter D is the nominal diameter of the composite tube. A welder qualification shall cover only that material combination of the composite tube it represents.

A.3.2.2 Additional tests required

A.3.2.2.1 Macroscopic examination

Macroscopic examination shall be carried out when the cladding is made by TIG-welding. The depth of penetration of a clad weld in the ferritic pressure retaining inner core material or weld shall be defined. The penetration shall not be below the outer surface of the ferritic pressure retaining inner core material.

A.4 Special requirements for non-destructive testing (NDT) of welds

A.4.1 General

The general requirements of this European Standard, mainly Clause 9, shall be supplemented by the application of the specific requirements in A.4.2.

A.4.2 Special requirements for NDT of welds in a chemical recovery boiler

A.4.2.1 Volumetric testing

All the welds that are in a position in which a leak could result in a water/smelt explosion shall be subjected to 100 % volumetric testing.

A.4.2.2 Methods of testing

If it is possible, the volumetric testing shall be carried out by radiographic testing in accordance with EN 1435, class B. When choosing the radiographic technique for the tube panels, it shall be ensured that the area located next to the fins on the inside of the chemical recovery boiler furnace will be reliably inspected. If only one X-ray exposure per weld has been carried out, then a possible complementary test method and technique shall be used, in accordance with written procedures and by agreement as part of the design qualification process. A volumetric testing shall be performed on finished welds. An exception is composite tubes, where the testing can be carried out after the pressure bearing weld of parent material is ready before welding the cladding.

In addition, all composite tube welds in the position where a leak can result in a water/smelt explosion shall be examined 10 % by a penetrant test method. Inspection shall be carried out inside the furnace on finished welds. This addition is not necessary if radiography has been carried out with the cladding included.

Annex B
(informative)

Significant technical changes between this European Standard and the previous edition

Clause/Paragraph/Table/Figure	Change
General	Numbering system of tables and drawings has changed.
2 / Normative references	References updated.
Table 9.1.1 / NDT of drum welds	Footnotes corrected.
Table 9.1.2 / NDT of header welds	Footnotes corrected.
9.1.4 / NDT of welds - Tubes	Requirements modified.
Table 9.1-3 / NDT of tube welds	— Dissimilar welds between austenitic and martensitic steels with d_o < 76,1 mm added as a new type of welds. — Footnotes added.
9.2 / Qualification of non-destructive testing (NDT) personnel	Requirements modified.
9.3.3 / Penetrant testing	Requirements modified.
9.3.4 / Magnetic particle testing	Requirements modified.
Table 9.3.1 / Acceptance criteria for weld surface imperfections	Limits of imperfection revised on basis of EN ISO 5817 instead of EN 25817.
Table 9.4.1 / Acceptance criteria for weld internal imperfections detected by radiography	Limits of imperfection revised on basis of EN ISO 5817 instead of EN 25817.
9.4.2.2 / UT - Acceptance criteria	Requirements modified.
Annex A / Special requirements for composite tubes	Title changed from “Chemical recovery boiler”.
A.2.2.2.1 / Depth of penetration of clad weld	Requirements specified.

NOTE The technical changes referred include the significant technical changes from the EN revised but is not an exhaustive list of all modifications from the previous version.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 97/23/EC

Clauses of this European Standard	Content	Essential Safety Requirements (ESRs) of Directive 97/23/EC, Annex I
4.5	Inspection	3.2.1
6	Qualification of weld procedures	3.1.2
7 to 8.2	Qualification of welding personnel	3.1.2
9.2	Non-destructive tests	3.1.3
10.1	Final inspection	3.2.1
10.2	Proof test	3.2.2
12	Marking and labelling	3.3 a)

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

EN 10204, *Metallic products — Types of inspection documents*

EN ISO 9000:2005, *Quality management systems — Fundamentals and vocabulary (ISO 9000:2005)*

EN ISO 9001, *Quality management systems — Requirements (ISO 9001:2008)*

EN ISO 15614-13, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 13: Resistance butt and flash welding (ISO 15614-13:2005)*

EN ISO 23279, *Non-destructive examination of welds — Ultrasonic testing — Characterization of indications in welds (ISO 23279:2010)*

CEN/CR 12952-17, *Water boilers and auxiliary installations — Part 17: Guideline for the involvement of an inspection body independent of the manufacturer*

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