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**Water-tube boilers - Part 6: Inspection, testing and
acceptance**

水管锅炉 第 6 部分: 检验、试验和验收

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Water-tube boilers - Part 6: Inspection, testing and acceptance

1 Scope

This document specifies the material inspection, product size, forming process and appearance inspection of welded joints, ball inspection, spectral inspection, non-destructive testing, mechanical performance inspection of product welded joints, hydraulic test, inspection documents, exit-factory information, metal nameplates and marking requirements for pressure elements of water-tube boilers and non-pressure elements directly connected to the load.

This document is applicable to the inspection, test and acceptance of the pressure elements of water-tube boilers defined in GB/T 16507.1 and the non-pressure elements directly connected to them.

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.

GB/T 2652, *Destructive tests on welds in metallic materials - Longitudinal tensile test on weld metal in fusion welded joints*

GB/T 2900.48, *Electrotechnical terminology of boilers*

GB/T 16507.1, *Water-tube boilers - Part 1: General requirements*

GB/T 16507.5, *Water-tube boilers - Part 5: Fabrication*

JB/T 3375, *Rules for receiving acceptance of materials for boiler construction*

NB/T 47013.2, *Nondestructive testing of pressure equipment - Part 2: Radiographic testing*

NB/T 47013.3, *Nondestructive testing of pressure equipment - Part 3: Ultrasonic testing*

NB/T 47013.4, *Nondestructive testing of pressure equipment - Part 4: Magnetic particle testing*

NB/T 47013.5, *Nondestructive testing of pressure equipment - Part 5: Penetrant testing*

NB/T 47013.10, *Nondestructive testing of pressure equipment - Part 10: Ultrasonic time of flight diffraction technique*

NB/T 47013.11, *Nondestructive testing of pressure equipment - Part 11: Standard practice for X-ray digital radiography*

NB/T 47013.14, *Nondestructive testing of pressure equipment - Part 14: X-ray Computed radiographic testing*

NB/T 47013.15, *Non-destructive testing of pressure equipment - Part 15: Phased array ultrasonic testing*

NB/T 47016, *Mechanical property tests of product welded test coupons for pressure equipment*

Catalog of Special Equipment (General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China No. 114 in 2014)

3 Terms and definitions

The terms and definitions defined in GB/T 2900.48 and GB/T 16507.1 as well as the followings apply to this document.

3.1 hydrostatic test pressure

During the hydrostatic test, the pressure applied to the boiler system or pressure components (elements) according to regulations.

4 Material acceptance

4.1 General requirements

Boiler manufacturers shall formulate material procurement standards. According to the regulations, steel plates for boilers, steel pipes for boilers, structural steel plates (used to manufacture flanges and webs of large plate girders), steel strips, section steel (height is 250mm and above, or angle steel side width is 250mm and above), round steel (for the manufacture of tie rods and suspenders with a diameter of 40mm and above), forgings, steel castings, iron castings, welding materials (including welding rods, welding wires, flux-cored welding wires and fluxes), are subject to enter-factory acceptance.

4.2 Material quality certification

records.

5.3 The finished product shall be tested for the corresponding size. The testing results shall comply with the provisions of GB/T 16507.5.

5.4 Welded joints of pressure elements (including joints welded between non-pressure elements and pressure elements) shall be visually inspected and at least meet the following requirements.

- a) The overall dimensions of the weld shall meet the requirements of design drawings and process documents.
- b) Butt weld height shall not be lower than base metal surface. The weld and base metal shall transition smoothly. There are no cracks, slag inclusions, arc craters, incomplete fusion and pores on the surface of the weld and heat-affected zone.
- c) Longitudinal and circular seams of drum, start-up (steam-water) separator, water storage tank, header or pipeline, and splicing welds of heads have no undercuts. The undercut depth of other welds shall not be greater than 0.5mm. The total length of the undercut on both sides of the pipe weld shall not exceed 20% of the circumference of the pipe. It shall not exceed 40mm.
- d) Concave depth: no more than 2mm.
- e) Start-up (steam water) separators, water storage tanks, headers, and roots of pipes protrude: not more than 3mm.
- f) Butt weld reinforcement:
 - 1) Drum, start-up (steam-water) separator, water storage tank, header, pipeline: not more than 15%t and not more than 4mm;

NOTE: For single-sided welding, t is the nominal thickness of the plate or pipe; for double-sided welding, t is the groove depth of the front and back sides.

- 2) Pipe: no more than 3mm.

g) Connection weld between flat steel and pipe:

- 1) The welding between the flat steel and the pipe shall be continuous. There shall be no missing welding;
- 2) Weld formation shall be smooth and flat. The transition between the weld and the base metal shall be smooth. There shall be no cracks, slag inclusions, arc craters and other defects on the surface of the weld;
- 3) There shall be no single air hole with a diameter greater than 2mm on the surface of the weld between the flat steel and the pipe. At the same time, there

passing ball.

6.4 When the ball passes the internal threaded pipe, the steel ball as the passing ball shall be selected according to the minimum inner diameter given in the internal threaded pipe standard. If a pipe specification chosen that is not specified in the internal thread pipe standard or if the minimum inner diameter is not specified, then the minimum inner diameter is the nominal outer diameter of the pipe minus 2 times the sum of the nominal wall thickness of the pipe and the thread height. That is, $d = D - 2 \times (\text{nominal wall thickness of the pipe} + \text{thread height})$.

6.5 If the passing ball is blocked according to the provisions of 6.1~6.4, select the steel ball to pass according to the minimum inner diameter of the pipe actually measured.

6.6 Sponge ball can be used for passing ball inspection to ensure the cleanliness inside the pipe. The pressure of the compressed air used for the test is about 0.4MPa.

7 Spectral inspection

Alloy steel pipe (pipe fittings) butt joint welds and base metals shall be verified by 100% chemical composition spectrum analysis. Issue a spectral analysis test report.

8 Non-destructive testing

8.1 Basic methods for non-destructive testing

Non-destructive testing methods mainly include ray (RT), ultrasonic (UT), magnetic particle (MT), penetrant (PT), eddy current (ET) and other testing methods. Radiographic testing methods (RT) include film ray testing (F-RT), digital imaging testing (DR), computer-aided imaging testing (CR). Ultrasonic testing methods (UT) include pulse echo ultrasonic testing (PE), phased array ultrasonic testing (PAUT) and time-of-flight diffraction ultrasonic testing (TOFD). The manufacturer shall select the testing method according to the design, process and related technical conditions, and formulate the corresponding testing process.

When time-of-flight diffraction (TOFD) is selected, it shall be combined with pulse-echo ultrasonic testing (PE). The testing conclusion is judged comprehensively based on the results of TOFD and PE methods.

8.2 Non-destructive testing personnel

Non-destructive testing personnel shall be assessed in accordance with relevant technical specifications. Only after obtaining the qualification certificate can they engage in the non-destructive testing work of the corresponding method and technical level.

8.6.1 The local non-destructive testing position of pressure parts shall be determined by the manufacturer. However, the intersecting butt joints of longitudinal seams and circular seams shall be included.

8.6.2 For welded joints that have undergone partial nondestructive testing, if a defect that may extend is found at any end of the test site, supplementary testing shall be carried out in the direction of the extension of the defect. When a defect exceeding the standard is found, a supplementary inspection of no less than 200mm shall be carried out at the extension parts of the two ends of the defect. If it is still rejected, all the welded joints shall be tested.

8.6.3 For the rejected pipe butt joints, supplementary testing shall be carried out to double the number of random inspections of the pipe butt joints welded by the welder on the day. If it is still rejected, the welder shall take over all welded joints for testing on the same day.

8.6.4 When performing non-destructive testing spot checks on pipe seat fillet joints, lifting lugs, and load-carrying accessories, if rejected defects are found, supplementary non-destructive testing shall be performed twice the number of spot checks on the welds welded by the welder on that day. If the supplementary test is still rejected, all welded joints of the welder shall be tested on that day.

8.7 Non-destructive testing timing

8.7.1 The non-destructive testing of welded joints shall be carried out after the shape, size and visual inspection are accepted.

8.7.2 For welded joints of materials with delayed crack tendency, non-destructive testing shall be carried out 24h after welding.

8.7.3 For welded joints of materials prone to reheat cracks, surface non-destructive testing re-inspection shall be carried out after final heat treatment.

8.7.4 The non-destructive testing of the head splicing joint shall be carried out after processing and forming. If it is carried out before forming, non-destructive testing shall be carried out in the small arc transition area after forming.

8.8 Radiographic inspection acceptance requirements

8.8.1 Radiographic detection technology level shall not be lower than level AB. The quality level of welded joints shall not be lower than level II.

8.8.2 Film sensitization method ray detection shall be carried out according to NB/T 47013.2. Digital imaging ray detection shall be carried out according to NB/T 47013.11. Computer-aided imaging method ray detection shall be carried out according to NB/T 47013.14. Radiographs and inspection digital images shall be preserved.

8.9 Acceptance requirements for ultrasonic testing

8.9.1 Ultrasonic testing shall use a recordable ultrasonic testing instrument.

8.9.2 Ultrasonic testing by pulse echo method shall be carried out according to NB/T 47013.3. The detection technology level shall not be lower than level B. The quality level of welded joints shall not be lower than level I.

8.9.3 Ultrasonic testing by diffraction time-of-flight method shall be carried out in accordance with NB/T 47013.10. Diffraction time-of-flight method ultrasonic testing technology level shall not be lower than level B. The quality level of welded joints shall not be lower than level II.

8.9.4 Phased array ultrasonic testing shall be carried out according to NB/T 47013.15. Phased array ultrasonic testing technology level shall not be lower than level B. The quality level of welded joints shall not be lower than level I.

8.10 Acceptance requirements for magnetic particle testing

8.10.1 Magnetic particle testing shall be carried out in accordance with NB/T 47013.4.

8.10.2 The acceptance level for magnetic particle testing shall not be lower than level I.

8.11 Acceptance requirements for penetration testing

8.11.1 Penetration testing shall be carried out according to NB/T 47013.5.

8.11.2 The acceptance level for penetration testing shall not be lower than level I.

9 Mechanical performance inspection for product welded joints

9.1 To test the mechanical properties of the welded joints of the product, the welded test piece of the product shall be welded. For manufacturers with stable welding quality, welding test pieces may be exempted upon approval by the technical director. However, if it falls under any of the following circumstances, the longitudinal seam welding test piece shall be made:

- a) The first 5 boilers manufactured by the manufacturer in accordance with the new welding procedure regulations;
- b) Drum or header parts that are made of alloy steel (except carbon-manganese steel) and require heat treatment;
- c) The design requires the fabrication of welded test pieces.

9.2 The requirements for product welding test pieces are as follows:

less than 16mm), specimens shall be taken from the welded test piece for the Charpy V-notch room temperature impact test of the weld metal and the heat-affected zone. The Charpy V-notch impact test at room temperature shall comply with the provisions of NB/T 47016. When NB/T 47016 has no specified value for the corresponding material, the average value of the impact energy absorbed by the three standard specimens shall not be less than 27J. It is allowed at most one specimen whose impact absorbed energy is lower than the specified value, but not lower than 70% of the specified value.

9.7 If there is any rejected item in the mechanical performance test, double specimens shall be taken from the original welded inspection test piece for the rejected item for reinspection (three specimens shall be taken for reinspection for the impact test item). Or reinspect the original test piece and product after heat treatment once.

10 Hydrostatic test

10.1 Basic requirements

The basic requirements for hydrostatic test are as follows:

- a) The hydrostatic test of boiler pressure elements shall be carried out after non-destructive testing and heat treatment;
- b) The hydraulic test site shall have reliable safety protection facilities;
- c) The hydrostatic test shall be carried out when the ambient temperature is not lower than 5°C. Antifreeze measures shall be taken when the temperature is lower than 5°C;
- d) The water used in the hydrostatic test shall be clean water. The water temperature shall be kept above the surrounding dew point to prevent condensation on the surface. But it shall not be too high temperature to prevent vaporization and excessive temperature difference stress;
- e) The water temperature of the hydraulic test for alloy steel pressure elements shall be higher than the brittle transition temperature of the steel used. Generally, it is 20°C~70°C;
- f) During the hydrostatic test of austenitic pressure elements, the chloride ion content in the water shall be controlled not to exceed 25mg/L. If the requirements cannot be met, the water stains shall be removed immediately after the hydrostatic test;
- g) Water pressure test shall be carried out after the factory manufactures the pressure parts. In-plant water pressure may be exempted when the provisions of 10.3.3e) are met.

10.2 Test conditions

12 Exit-factory information, product nameplate and marking

12.1 Exit-factory information

12.1.1 When the product leaves the factory, the boiler manufacturer shall provide technical information related to safety. At least the following shall be included:

- a) Boiler drawings, including general drawings, installation drawings and drawings of main pressure elements;
- b) Strength calculation sheet or summary table of calculation results of pressure elements;
- c) Calculation sheet or summary table of calculation results for safety valve discharge;
- d) Thermal calculation book or summary table of thermal calculation results;
- e) Smoke and wind resistance calculation book or summary table of calculation results;
- f) Boiler quality certificate, including product qualification certificate (including boiler product data sheet, compiled according to the provisions of Annex A), metal material quality certificate, welding quality certificate and water (resistant) pressure test certificate. The product qualification certificate shall have the signatures and seals of the responsible inspection engineer, the quality assurance engineer, and the special seal for product quality inspection (or the official seal of the organization);
- g) Boiler installation instructions and operating instructions;
- h) Change information of pressure elements inconsistent with design documents;
- i) Water flow chart of hot water boiler and hydrodynamic calculation book or summary table of calculation results.

12.1.2 For boilers with a rated working pressure not less than 3.8MPa, in addition to meeting the relevant requirements of 12.1.1, the following technical information shall also be provided:

- a) Superheater, reheater wall temperature calculation sheet or summary table of calculation results;
- b) Thermal expansion system diagram;
- c) High pressure boiler water circulation (including steam-water resistance) calculation book or summary table of calculation results;

- d) Steam-water system diagram of boilers with high pressure and above;
- e) Setting values of various safety protection devices for high pressure and above boilers.

12.1.3 Before the start-up and acceptance of the complete set of power plant boiler units, the boiler manufacturer shall provide complete exit-factory technical information of boilers.

12.2 Product nameplates and marking

12.2.1 The boilers delivered as a whole shall be equipped with product nameplates in obvious positions. The product nameplate shall be a metal nameplate. At least the following items shall be stated on the nameplate:

- a) Manufacturer name;
- b) Boiler model;
- c) Equipment code (the numbering method is in accordance with the provisions of Annex B);
- d) Product number;
- e) Rated evaporation capacity (t/h) or maximum continuous evaporation capacity (t/h) or rated thermal power (MW);
- f) Rated working pressure (MPa);
- g) Rated steam temperature (°C) or rated outlet and inlet water temperature (°C);
- h) Reheat steam inlet and outlet temperature (°C) and inlet and outlet pressure (MPa);
- i) Level and number of boiler manufacturing license;
- j) Date of manufacture (year, month).

12.2.2 The nameplate shall have a space for marking the mark of manufacturing supervision and inspection.

12.2.3 For boilers delivered in spare parts, at the appropriate positions of the heads, end caps or cylinders of main pressure components such as drums, superheater headers, reheater headers, water-cooled wall headers, economizer headers, desuperheaters, and start-up (steam-water) separators, the product marks shall be marked.

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