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B-01 BOILERS

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Foreword:

This Guide is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

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BOILERS

1 Application

1.1 This Guideline applies to boilers of welded construction with water or steam as medium.

2 Normative references

2.1 The approval and inspection in this Guideline are to be based on the following documents:

- (1) CCS Rules for Classification of Sea-Going Steel Ships ;
- (2) CCS Rules for Materials and Welding;

2.2 The paragraphs in the above mentioned basis for approval and inspection quoted are part of this Guideline. For quoted documents marked with the date, their subsequent amendments (except corrigenda) or revisions will be inapplicable, hence, it is to meet the requirements of the latest edition of these documents during the product design, manufacture and inspection. However, for those quoted documents without any date marked, the latest edition applies to this Guideline.

3 Definitions

3.1 Relevant definitions specified in CCS Rules for Classification of Sea-Going Steel Ships are applicable to this Guideline.

4 Plans and documents

4.1 The following plans and documents are to be submitted to CCS for approval:

- (1) General arrangement;
- (2) Body construction (including details of welded connections, attachments and supports);
- (3) Construction of pressure parts (boiler shell, steam and water drum, headers, combustion chamber, furnace, superheater, desuperheater, economizer, etc.);
- (4) Arrangement of mountings and fittings;
- (5) Diameter calculations for safety valves;
- (6) Strength calculations;

- (7) Heat treatment procedures for welded connections;
- (8) Type test programme (for approval).

5 Materials and components

5.1 Materials and components are to comply with relevant requirements of CCS Rules

6 Evaluation of welding procedures

6.1 When applying for approval at the first time, the welding procedures are to be evaluated according to the relevant requirements of Guideline 3, PART THREE of CCS Rules for Materials and Welding.

7 Technical requirements for design

7.1 Selection of materials

7.1.1 The steel plates, steel pipes used in construction of pressure parts of marine boilers are to comply with the relevant requirements of Guideline 3 and Guideline 4, PART ONE of CCS Rules for Materials and Welding. The welding consumables used in welding of marine boilers are to comply with the relevant requirements of Guideline 2, PART THREE of CCS Rules for Materials and Welding.

7.2 Structural design requirements for boilers

7.2.1 The structural design of marine boilers is to comply with the relevant requirements of Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships and of CCS Rules for Materials and Welding. Mainly butt welds are to be used for boilers, and double continuous fillet welds are to be used generally for spools, flanges and bedplates. If T-shaped fillet welds are to be used for boiler shell and tube plate, the following conditions are to be met, subject to approval by CCS:

- (1) welded joints of full penetration type are to be used and edge bevels are to be machined;
- (2) edges are to be beveled on tube plates;
- (3) the weld thickness at connection of T-shaped joints is to be not less than wall thickness of tube plates and back sealing runs are to be made where this is practical, and if back sealing runs are impracticable, argon-arc welding may be applied for the first run and full penetration is to be ensured.

7.2.2 Intersection of more than two welds is to be avoided. Butt welds are not to be intersected with acute angles. Welds of non-pressure parts are not to penetrate main welds or welds of pipes

and tubes. The distance between weld edges of non-pressure parts and main welds or joint weld edges is not to be less than twice the plate thickness of pressure parts or 40 mm (whichever is the lesser). If this is not practical, welds of non-pressure parts are to penetrate main welds and to be arranged symmetrically and not to be terminated in the vicinity of main welds or pipe joint welds. Perforation in or near welds is to be avoided. Where the distance between the weld centerline and the edge of a perforation is less than 60 mm or four times the thickness of the perforated plate (whichever is the greater), the perforation is to penetrate the weld so that the weld centerline and the perforation will coincide as much as possible. The welds on both sides of the perforated weld are to be subjected to radiographic testing, and a length of at least 60 mm or four times the thickness of the perforated plate (whichever is the greater) at each side is to be examined.

7.2.3 Boilers are to be provided with manholes to facilitate internal examination. In case components of a boiler are too small to permit entry, sufficient number of sight holes is to be provided for facilitating internal examination and cleaning.

7.2.4 Splice welding of end covers or tube plates: End covers and tube plates are to be made of a whole steel plate so far as practicable. Where slicing is necessary, the end cover welds are not to pass through any plate edge hole or be completely arranged in plate edge arc. The distance between weld and plate edge is not to be less than 100 mm, and that between weld and centerline is not to be more than 0.3 times the nominal internal diameter. Welds of tube plates are to be clear of steam-water boundaries and lines of tube holes.

7.2.5 Longitudinal welds of boiler shell: The number of longitudinal welds for each section of the boiler shell is not to be more than two and the length of the external circular arc between centerlines of both welds is not to be less than 300 mm. The splice welds of end covers, tube plates and the longitudinal welds of adjacent portions of the boiler shell are to be staggered. The arc length between two weld centerlines is to be not less than three times the thicker steel plate and not less than 100 mm. The distance between circumferential welds of the boiler shell is to be not less than 300 mm.

7.2.6 Arrangement of boiler tube holes in tube plates

- (1) Welded tube holes are to be clear of welds so far as practicable and coincidence of heat-affected zones of tube hole welds and adjacent welds is to be avoided. If unavoidable, the following conditions are to be met: the welds within 1.5 times the tube hole diameter d (if the diameter is less than 60 mm, $0.5d + 60$ mm is to be taken) around the tube hole center are to be tested satisfactorily without edge defects (except defects which can be rectified by cutting holes).
- (2) The distance between expansion tube hole center and weld edge and that between tube hole center and starting point of tube plate edge arc are not to be less than 0.8 times the tube hole diameter d , and not to be less than $0.5d + 12$ mm.

7.2.7 Main welds of pressure parts and their heat-affected zones are to be clear of welded parts. If unavoidable, the welds of such parts may pass through main welds and are not to terminate in welds and their heat-affected areas so as to avoid stress concentration in these areas.

7.2.8 Structural members and their connection are to comply with the relevant requirements in Section 2, Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

7.2.9 Number, specification and arrangement of boiler mountings and fittings are to comply with the relevant requirements in Section 3, Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

7.2.10 Diameter of safety valve: The diameter of safety valve for boilers is to be calculated according to the relevant requirements in Section 3, Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

7.2.11 Boilers are to be provided with means indicating highest part of the heating surfaces according to the relevant requirements in Section 3, Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

7.2.12 The post-welding heat treatment is to be carried out after completion of welding and prior to hydraulic test according to requirements of CCS Rules for Materials and Welding.

7.3 Strength requirements

7.3.1 The design strength of pressure parts for marine boilers is to comply with relative provisions as specified in Guideline 6, PART THREE of CCS Rules for Classification of Sea-going Steel Ships and CCS Rules for Materials and Welding.

8 Type test

8.1 Selection of typical samples

8.1.1 The marine boiler used for works approval test is to be, in respect of performance, characteristics and manufacturing quality, capable of representing or covering the products for which approval is sought. In general, a boiler with large design pressure and thick boiler shell is to be selected.

8.2 Type test items and requirements

8.2.1 Type test items are to include non-destructive testing of welds, mechanical test of welded test plates, and visual examination, hydraulic strength test of the boiler body and tightness test.

8.2.2 Test methods and related technical criteria for type test are to comply with the following requirements:

- (1) Non-destructive testing of welds: The extent, methods and requirements of non-destructive testing are to comply with plans approved by CCS as well as requirements as specified in Guideline 7, PART THREE of CCS Rules for Materials and Welding. The quality of welds which are subject to non-destructive testing is to be evaluated according to standards acceptable to CCS.
- (2) Mechanical test of welded test plates: Preparation of test plates, test items and results are to comply with the relevant requirements in Section 2, Guideline 7, PART THREE of CCS Rules for Materials and Welding.
- (3) Visual examination is to comply with the following requirements:
 - ① surfaces of butt welds and essential fillet welds are to be uniform and sound, and free from cracks, overlaps, undercuts, porosities, slag inclusions, craters and unfilled cavities;
 - ② internal examination after completion: Examine the internal welds of boilers and external quality of tunnel wall and defects such as craters, depressions, overlaps, splashes, undercuts and mechanical damages are not allowed;

- ③ examination of welding and expanding quality: the weld sizes for smoke tubes, stay tubes and stays as well as the projected length of tube ends are to comply with the requirements as specified in 4, 5 and 6, Annex 2, Guideline 6, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships. Defects such as deep undercuts, overlaps, cracks or unfilled cavities are not allowed in the tube ends after welding. The quality of expanding tubes is to comply with the requirements as specified in 6.2.11, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships;
- ④ examination of heat treatment quality: Examination for burnt or deformed parts. Any burnt part is to be ground and subjected to metallographic examination for widmanstatten structure exists
(in case of any widmanstatten structure, re-austenitization may be achieved by annealing, normalizing or multiple high-temperature tempering so as to refine the grains). Check for cracks in welds and their heat-affected zones. If necessary, the welds of high strength alloy steels and complex welds are to be subjected to radiographic testing or ultrasonic retesting.
- (4) Hydraulic strength test for boiler body: After completion of assembling and satisfactory non-destructive testing, the boiler body is to be subjected to hydraulic strength test when it is not painted and not fitted with insulation. When heat treatment is required, the hydraulic strength test is to be carried out after heat treatment. The test pressure is to be 1.5 times the design pressure and kept for at least 20 min. The test results are satisfactory when:
 - ① no leakage is found on welds or boiler shell;
 - ② no abnormal noise or obvious deformation occurs; and
 - ③ no leakage is found in expanding holes or at connection of fittings and attachments when the pressure is reduced to working pressure.
- (5) Tightness test: The boiler is to be subjected to tightness test after completion of assembly of its mountings and fittings. Heat insulation may be provided in test and when necessary, part or whole of the insulation may be removed. The test pressure is to be 1.25 times the design pressure. The inspection requirements are the same as those for strength test.
- (6) Performance test (only carried out for new product approval): The automatic and manual control and safety protection test, safety valve test, value effectiveness test, furnace inspection, etc. are to be carried out in order to verify the performances of boiler. (For those boilers without conditions to carry out performance test in manufacturers, such as exhaust gas boiler and oil-fired auxiliary and exhaust gas composite boiler, interim approval certificates and type test certificates for product may be issued by manufacturers based on the thermodynamic calculations, the performance tests are to be carried out after the boilers are installed onboard ships, the work approval certificates will be renewed after all type test reports are received and reported.)

9 Unit/batch inspection

9.1 Unit/batch inspection for issuing marine products certificates is to include the following items:

- (1) raw material inspection;
- (2) inspection of pressure parts;
- (3) assembly inspection prior to welding and welding inspection, and review of report of non-destructive testing of welds;
- (4) inspection of completed body;
- (5) test of welded test plates;
- (6) inspection after assembly of mountings and fittings.

9.2 Inspection requirements

9.2.1 Raw material inspection: Steel plates, steel pipes and welding consumables used in manufacturing of marine boilers are to be furnished with products certificates issued by CCS or equivalent documents. Their types and specifications are to comply with the plans approved by CCS and to be consistent with delivered products, shown by a complete quality assurance document. The material marks are to comply with certificates, including steel grade, type, cast no., specification, manufacturer's inspectors stamp and CCS stamp. The steel plates and steel pipes not certified by CCS are to be fabricated by manufacturers accepted by CCS and subject to CCS inspection. The steels used in manufacturing of boilers are to be of a uniform quality and the surface is to be free from cracks, blisters, scabs, laps or slag inclusions. Steel plates are to be free from laminations. The internal and external surfaces of seamless steel pipes and tubes are to be free from defects such as cracks, laps, laminations, scabs, pinches, hair-line cracks. The dimensions of steel plates and steel pipes are to comply with plans approved by CCS.

After completion of the above-mentioned inspection, the materials from which pressure parts will be made or suitable positions of intended welded test plates are to be marked by the Surveyor with CCS stamp, for confirmation in subsequent inspections so as to ensure proper use of materials.

9.2.2 Inspection of pressure parts: For the finished pressure parts, the Surveyor is to confirm the stamp affixed in the raw material inspection for ensuring that the materials used have been inspected. In addition, visual examination and dimension examination are to be carried out.

9.2.3 Inspection prior to welding: included angles and butt gaps are to comply with the plans and welding procedure specifications approved by CCS as well as the requirements as specified in Section 3, Guideline 7, PART THREE of CCS Rules for Materials and Welding.

9.2.4 Welding inspection is to include the following:

9.2.4.1 Welding process inspection: Welding of boilers is to be carried out under supervision of the manufacturer's inspector, and the Surveyor is to make spot checks at the welding site on regular basis, mainly covering the following:

(1) In the case of any of the following ambient conditions and in the absence of effective protective measures, welding is prohibited:

- ① the wind speed is more than 10 m/s for manual welding, or more than 2 m/s for gas shielded arc welding;
- ② relative humidity is more than 90%; or
- ③ outdoor operation in rain or snow.

(2) When the temperature of weldment is below 0°C, preheating till about 15°C is necessary within 100 mm from both sides of the welding.

9.2.4.2 Welders engaged in welding of marine boilers are to hold Qualification Certificate of Welder issued or accepted by CCS, which enables them to be engaged in the certified range of work only.

9.2.4.3 Welding equipment is to comply with the following requirements:

- (1) the equipment is to be fitted in a sheltered place and reliably earthed; and
- (2) the required welding quality is to be ensured, an effective working condition maintained and suitable facilities are to be provided to measure current and voltage. The ammeter and voltmeter are to be within the valid calibration period.

9.2.4.4 Welding consumables: All welding wires, electrodes and fluxes are to be furnished with CCS products certificates or equivalent documents. Their types and specifications are to comply with approved welding procedures. The electrodes are to be baked and stored prior to welding according to the instructions. The welding wires are to be free from water, rust and oil.

9.2.4.5 Welding methods and welding positions are to comply with approved welding procedures.

9.2.4.6 Inspection of tack welding: The tack welding procedure (welding methods, welding consumables and preheating temperature) is to be consistent with the first run. The slags of tack welds are to be thoroughly removed prior to completion of welding and a careful examination for cracks is to be carried out. If any crack is found, it is to be removed by grinding and re-welding is to be carried out and repairing by welding is not to be used to obscure the crack. The tack welds where no cracks are found may remain. The welding consumables of tack welds are to be the same as that for the finished welds.

9.2.5 Welding quality inspection: Butt welds and essential fillet welds are to be visually examined by the Surveyor prior to heat treatment. The surface of welds is to be uniform and sound and free from cracks, overlaps, undercuts, porosities, slag inclusions, craters and unfilled cavities.

9.2.6 Non-destructive testing of welds is to be carried out according to 8.2.2(1) of this Guideline. Generally the Surveyor may check the manufacturer's testing reports and note that personnel engaged in non-destructive testing of marine boilers and their parts are to be well trained and to hold the "Qualification Certificate of NDT Personnel" issued or accepted by CCS and that they can only be engaged in the non-destructive testing appropriate to the certified range of work and are to assume related technical responsibilities.

9.2.7 Mechanical test of welded test plates is to be carried out according to 8.2.2(2) of this Guideline.

9.2.8 Visual examination of the completed body is to be carried out according to 8.2.2(3) of this Guideline.

9.2.9 Hydraulic test is to be carried out after completion of body manufacturing process, including repairing, grinding, heat treatment and other internal cleaning work and prior to heat insulation according to 8.2.2(4) of this Guideline.

9.2.10 Inspection after assembly of mountings and fittings: Examination for completeness of assembled fittings and mountings of the boiler and for their correct and secure assembly. The tightness test is to be carried out according to 8.2.2 (5) of this Guideline, after completion of such assembly. If only the boiler body is fabricated by the manufacturer and the boiler mountings and fittings are assembled in the manufacturer after delivery by assembling suppliers directly, when the test could not be carried out, the certificate is to be marked: This certificate will be valid after the following inspection and verification are carried out:

- (1) to check the consistency of inspection marks between certificate and the boiler.
- (2) to check the boiler fittings type, installation position and quantities etc. which are to be in

compliance with the requirements of approved drawings and the comments provided by the unit issued the certificate, according to the approved arrangement drawings or boiler general drawings or the part lists.

- (3) to check the burner suitable furnace volume could be suitable for the boiler's furnace according to the boiler body certificate and burner approval certificate.
- (4) to check the safety valve could meet the parameters listed in the boiler body certificate according to the boiler body certificate and safety valves approval certificate.
- (5) to verify that the automation condition which recorded in the boiler control box certificate could meet the requirement of CCS's Automation Notation.
- (6) the hydraulic test (watertightness test) is to be witnessed and record is to be signed according to the requirements of Section 5, Guideline 6, PART Three in CCS Rules for Classification of Sea-going Steel Ships after completion installation of fittings.
- (7) the safety valve is to be tested to comply with the requirement of item 6.3.5.3 of Guideline 6, PART Three of CCS Rules for Classification of Sea-going Steel Ships at sea trial test.