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**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 24591-2019

Replacing GB/T 24591-2009

Seamless steel tubes for high-pressure feedwater heaters

高压给水加热器用无缝钢管

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1 Scope

China's national standard for the seamless steel tube used in high-pressure feedwater heaters. It specifies the order content, the dimensions, shape and weight, the technical requirements, the test methods, the inspection rules and the packaging, marking and quality certificate for these tubes. A feedwater heater is the heat exchanger that takes steam bled from the turbine and uses it to warm the boiler feedwater before it reaches the boiler. It is the least glamorous vessel in a power station and one of the most consequential: recovering that heat is what raises the cycle efficiency by several points, and a station operates with several heaters in series, the high-pressure ones sitting between the feed pump and the boiler where the water is at full boiler pressure. That is the condition the tube works in. The water side is at the highest pressure in the plant, above the boiler drum pressure, while the steam side is at bleed pressure - so the tube carries a large pressure differential from inside, is thin-walled for heat transfer, and is U-bent, which work-hardens and thins it at the bend. It also sees the two attacks that end feedwater heater tubes: flow-accelerated corrosion on the water side, where high-velocity slightly reducing water strips the protective oxide film, and impingement and droplet erosion on the steam side where the bled steam enters wet. Failure means a tube leak that puts feedwater into the steam space and, if undetected, water into the turbine. So the standard specifies the grades, the wall thickness and its tolerance, the mechanical properties, the hydrostatic and non-destructive examination over the full length, the flattening and flaring tests, the surface condition, and the requirements on the bent portion. Issued on 18 October 2019 and in

force since 1 September 2020, it replaces GB/T 24591-2009.

This Standard specifies the classification and code, ordering contents, size, shape, weight and allowable deviation, technical requirements, anti-rust, test methods, inspection rules, package, marking and quality certificate of seamless steel tubes for high pressure feedwater heater. This Standard is applicable to the straight tube, U-shaped tube and serpentine tube (hereinafter referred to as "steel tube") for high-pressure feedwater heater.

2 Normative References

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this document.

GB/T 222 Permissible Tolerances for Chemical Composition of Steel Products

GB/T 223.5 Steel and Iron - Determination of Acid-Soluble Silicon and Total Silicon Content - Reduced Molybdosilicate Spectrophotometric Method

GB/T 223.11 Iron, Steel and Alloy - Determination of Chromium Content - Visual Titration or Potentiometric Titration Method

GB/T 223.12 Methods for Chemical Analysis of Iron, Steel and Alloy - the Sodium Carbonate Separation-Diphenyl Carbazide Photometric Method for the Determination of Chromium Content

GB/T 223.14 Methods for Chemical Analysis of Iron, Steel and Alloy - The N-Benzoyl-N-Phenylhydroxylamine Extraction Photometric Method for the Determination of Vanadium Content

GB/T 223.19 Methods for Chemical Analysis of Iron, Steel and Alloy - The Neocuproine-Chloroform Extraction Photometric Method for the Determination of Copper Content

GB/T 4336 Standard Test Method for Spark Discharge Atomic Emission Spectrometric Analysis of Carbon and Low-Alloy Steel (Routine Method)

GB/T 4340.1 Metallic Materials - Vickers Hardness Test - Part 1: Test Method

GB/T 5777-2019 Automated Full Peripheral Ultrasonic Testing of Seamless and Welded (except Submerged Arc-Welded) Steel Tubes for the Detection of Longitudinal and/or Transverse Imperfections

GB/T 7735-2016 Automated Eddy Current Testing of Seamless and Welded (except Submerged Arc-Welded) Steel Tubes for Detection of Imperfections

GB/T 11170 Stainless Steel - Determination of Multi-Element Contents - Spark Discharge

Atomic Emission Spectrometric Method (Routine Method)

GB/T 20066 Steel and Iron - Sampling and Preparation of Samples for the Determination of Chemical Composition

GB/T 20123 Steel and Iron - Determination of Total Carbon and Sulfur Content Infrared Absorption Method after Combustion in an Induction Furnace (Routine Method)

3 Classification and Code

The steel tube can be divided into three types, such as straight tube, U-shaped tube and serpentine tube according to the product shape. The outline diagram and size code of U-shaped tube can refer to Figure 1; while the schematic diagram of serpentine tube can refer to Figure 2. Key: 1 - header; 2 - serpentine tube; r - bending radius, in mm; beta - flatness, in mm. NOTE: The header is the equipment component that connects with the serpentine tube, it does not belong to the specified scope of this Standard. Figure 2 - Serpentine Tube Schematic Diagram

4 Ordering Contents

The contract or ordering form ordering the steel tubes according to this Standard shall include but not limited to the following contents:

- a) This Standard number;
- b) Product name;
- c) Steel designation;
- d) Product shape (straight tube, U-shaped tube or serpentine tube);
- e) Drawing or size specification (nominal outer diameter x wall thickness x length of straight tube section, bending radius, in mm);
- f) Ordering quantity (total weight or total length);
- g) Package requirements;
- h) Special requirements.

5.1 Outer diameter

5.1.1 The nominal diameter of the steel tube is generally 12mm~32mm.

5.1.2 The allowable deviation for the outer diameter of the straight section of steel tube shall conform to the provisions of Table 1. ring gauge shall be the maximum allowable outer diameter of the steel tube; its allowable deviation is +0.05 0 mm; its length shall be no less than 50mm. The degree of bending for the straight section of other shape of steel tube shall

be no more than 1.5mm/m. Through the negotiation between the supplier and the purchaser, indicated in the contract, take other methods to check the degree of bending of the steel tube.

5.4.6 For U-shaped tube, the flatness beta of the elbow measured at the two tangent points shall not exceed 1.5mm (see Figure 1). For serpentine tube, unless otherwise is specified, the flatness beta of the elbow shall not exceed 4.0mm.

5.4.7 The actual size and shape of the serpentine tube shall conform to the provisions of the drawings.

5.5 Weight The steel tube shall be delivered according to the theoretical weight. The theoretical weight per square meter of the steel tube shall be calculated as per Formula (2): Where: W - theoretical weight of steel tube per meter, in kg/m; π - 3.1416; ρ - the density of the steel, in kg/dm³; austenitic stainless steel is 7.93, other steel is 7.85; S - wall thickness of steel tube, in mm; the steel tube delivered by the minimum wall thickness shall take the average value between the allowable max. wall thickness and the allowable min. wall thickness; D - nominal outer diameter of the steel tube, in mm.

6.1 Designations and chemical compositions of steel

6.1.1 The designations and chemical compositions (smelting analysis) of steel shall conform to the provisions of Table 5. According to the requirements of the purchaser, through the negotiation between the supplier and the purchaser, indicated in the contract, the steel tubes with other requirements of chemical compositions may be supplied.

6.5.3 The blind area on the tube end during the hydraulic test shall be removed.

6.6 Process performance

6.6.1 Flattening The steel tube shall be conducted the flattening test. The flattening test shall be carried out as per the following two steps:

a) The first step is ductility test. Press the specimen till the distance between two plates is H ; the Value- H shall be calculated as per Formula (4). When the specimen is pressed to the distance H between two plates, there shall be no cracks or breakages on the specimen. Where: H - distance between two plates, in mm; α - deformation coefficient per unit length;

0.09 for austenitic stainless-steel, and

0.08 for other steels; S - wall thickness of steel tube, in mm; D - nominal outer diameter of steel tube, in mm.

b) The second step is integrity test (closed flattening). The flattening shall be continued till the specimen breaks or the two opposite walls of the specimen collide. During the whole flattening test period, the specimen shall not appear visible delamination, white spots and