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# GB/T 24591-2019

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# Seamless Steel Tubes for High Pressure Feedwater Heater

高压给水加热器用无缝钢管

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# Table of Contents

# Seamless Steel Tubes for High Pressure Feedwater Heater

## 1 Scope

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-Benzoy-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)

GB/T 20124 Steel and Iron - Determination of Nitrogen Content - Thermal Conductimetric Method after Fusion in a Current of Inert Gas

YB/T 5137 Round Blank of Hot-rolled and Forged Seamless Steel Tube for High Pressure

## 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;

*β* – 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 × wall thickness × length of straight tube section, bending radius, in mm);

f) Ordering quantity (total weight or total length);

g) Package requirements;

h) Special requirements.

# 5 Size, Shape, Weight and Allowable Deviation

## 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):

$$W = \frac{\pi}{1\,000}\rho S(D - S) \qquad \cdots\cdots (2)$$

Where:

$W$ – theoretical weight of steel tube per meter, in kg/m;

$\pi$ - 3.1416;

$\rho$ – the density of the steel, in kg/dm$^3$; 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 Technical Requirements

### 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.

$$H = \frac{(1+\alpha)S}{\alpha + S/D} \qquad \cdots\cdots(4)$$

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 inclusions.

#### 6.6.2 Flaring

The steel tube shall be conducted the flaring test. The top core taper of the flaring test is 60°. The flaring ratio of the outer diameter of the specimen after flaring shall conform to the provisions of Table 8. After flaring, the specimen shall not appear cracks or breaches.

determined by the supplier; or determined through the negotiation between the supplier and the purchaser; and indicated in the contract.

# 8 Test Methods

**8.1** The analysis sampling for the chemical compositions of the steel tube shall be conducted as per the rules specified in GB/T 20066. The analysis of chemical compositions is generally conducted as per GB/T 4336, GB/T 11170, GB/T 20123, GB/T 20124 or other general methods. The arbitration shall be conducted as per the provisions of GB/T 223.5, GB/T 223.11, GB/T 223.12, GB/T 223.14, GB/T 223.19, GB/T 223.23, GB/T 223.25, GB/T 223.26, GB/T 223.36, GB/T 223.59, GB/T 223.63, GB/T 223.85, GB/T 223.86.

**8.2** The dimensions of steel tubes shall be measure one by one by the measuring gauges that meet the accuracy requirements.

**8.3** The inner and outer surfaces of the steel tubes shall be visually inspected one by one under full lighting conditions.

**8.4** The sampling quantity, sampling method and test methods of other inspection items of the steel tubes shall conform to the provisions of Table 10.

**Table 10 – Sampling Quantity, Sampling Method and Test Methods for Inspection items of Steel Tubes**

| SN | Inspection items | Sampling quantity | Sampling method | Test methods |
|---|---|---|---|---|
| 1 | Chemical composition | 1 specimen for each furnace | GB/T 20066 | See 8.1 |
| 2 | Tensile at room temperature | Take 1 specimen from each two steel tubes per batch | GB/T 2975 | GB/T 228.1 |
| 3 | Tensile at high temperature | Take 1 specimen from each two steel tubes per batch | GB/T 2975 | GB/T 228.2 |
| 4 | Hardness | Take 1 specimen from each two steel tubes per batch | GB/T 230.1, GB/T 4340.1 | GB/T 230.1, GB/T 4340.1 |
| 5 | Hydraulic pressure | One by one | --- | GB/T 241 |
| 6 | Flattening | Take 1 specimen from each two steel tubes per batch | GB/T 246 | GB/T 246 |
| 7 | Flaring | Take 1 specimen from each two steel tubes per batch | GB/T 242 | GB/T 242 |
| 8 | Decarburization layer | Take 1 specimen from each two steel tubes per batch | GB/T 224 | GB/T 224 |
| 9 | Intergranular | Straight tube: take 1 specimen from | GB/T 4334- | Method-E in |

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