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**Seamless austenitic stainless steel pipes for high pressure
hydrogenation unit**

高压加氢装置用奥氏体不锈钢无缝钢管

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Seamless austenitic stainless steel pipes for high pressure hydrogenation unit

1 Scope

This document specifies the classification and code, order content, size, shape and weight, technical requirements, test methods, inspection rules, packaging, marking and quality certificate of seamless austenitic stainless steel pipes for high pressure hydrogenation unit.

This document applies to seamless austenitic stainless steel pipes for high pressure hydrogenation units (hereinafter referred to as “steel pipes”); it also applies as a reference for seamless austenitic stainless steel pipes for other hydrogen condition devices.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 222, Permissible tolerances for chemical composition of steel products

GB/T 223.11, Iron, steel and alloy - Determination of chromium content - Visual titration or potentiometric titration method

GB/T 223.25, Methods for chemical analysis of iron, steel and alloy. The dimethylglyoxime gravimetric method for the determination of nickel content

GB/T 223.28, Methods for chemical analysis of iron, steel and alloy. The α -benzoinoxime gravimetric method for the determination of molybdenum content

GB/T 223.37, Iron, steel and alloy - Determination of nitrogen content - Indophenol blue spectrophotometric method after distillation separation

GB/T 223.40, Iron, steel and alloy - Determination of niobium content by the sulphochlorophenol S spectrophotometric method

GB/T 223.59, Iron, steel and alloy - Determination of phosphorus content - Bismuth phosphomolybdate blue spectrophotometric method and antimony phosphomolybdate blue spectrophotometric method

GB/T 223.60, Methods for chemical analysis of iron, steel and alloy - The perchloric acid dehydration gravimetric method for the determination of silicon content

GB/T 223.63, Methods for chemical analysis of iron, steel and alloy - The sodium (potassium) periodate photometric method for the determination of manganese content

GB/T 223.82, Steel and iron - Determination of hydrogen content - Thermal conductivity/infrared method after fusion under inert gas

GB/T 223.84, Steel and iron - Determination of titanium content - Diantipyrylmethane spectrophotometric method

GB/T 223.85, Steel and iron - Determination of sulfur content - Infrared absorption method after combustion in an induction furnace

GB/T 223.86, Steel and iron - Determination of total carbon content - Infrared absorption method after combustion in an induction furnace

GB/T 228.1, Metallic materials - Tensile testing - Part 1: Method of test at room temperature

GB/T 228.2, Metallic materials. Tensile testing. Part 2: Method of test at elevated temperature

GB/T 230.1, Metallic materials - Rockwell hardness test - Part 1: Test method

GB/T 231.1, Metallic materials - Brinell hardness test - Part 1: Test method

GB/T 232, Metallic materials - Bend test

GB/T 241, Metal materials - Tube - Hydrostatic pressure test

GB/T 242, Metal materials - Tube - Drift-expanding test

GB/T 246, Metallic materials - Tube - Flattening test

GB/T 1031, Geometrical product specifications (GPS) - Surface texture: Profile method - Surface roughness parameters and their values

GB/T 2102, Acceptance, packing, marking and quality certification of steel pipe

GB/T 2975, Steel and steel products - Location and preparation of samples and test pieces for mechanical testing

GB/T 4334-2020, Corrosion of metals and alloys - Test methods for intergranular corrosion of austenitic and ferritic-austenitic (duplex) stainless steels

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 6394, Determination of estimating the average grain size of metal

GB/T 7735-2016, Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for detection of imperfections

GB/T 10561-2005, Steel - Determination of content of nonmetallic inclusions - Micrographic method using standards diagrams

GB/T 11170, Stainless steel. Determination of multi-element contents. Spark discharge atomic emission spectrometric method (Routine method)

GB/T 11261, Steel and iron - Determination of oxygen content - The pulse heating inert gas fusion-infra-red absorption method

GB/T 17395, Dimensions, shapes, masses and tolerances of seamless steel tubes

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

GB/T 20490, Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes - Ultrasonic testing for the detection of laminar imperfections

GB/T 30062, Terminology of steel pipes and tubes

NB/T 47013.5-2015, Nondestructive testing of pressure equipment - Part 5: Penetrant testing

YB/T 4307, Iron, Steel and Alloy - Determination of Oxygen, Nitrogen and Hydrogen Contents - TOF-mass Spectroscopy Method after Fusion in a Current of Inert Gas

YB/T 5137, Hot rolled and wrought round blank for high-pressure seamless steel tube

3 Terms and definitions

Terms and definitions determined by GB/T 30062 are applicable to this document.

The end faces of both ends of the steel pipe shall be perpendicular to the axis of the steel pipe; the cut burrs shall be removed. As required by the buyer, negotiated between the supplier and the buyer, and indicated in the contract, the two ends of the steel pipe can be processed with grooves, and the groove type shall be determined through negotiation between the supplier and the buyer.

6.5 Out-of-roundness and unevenness in wall thickness

The out-of-roundness and unevenness in wall thickness of the steel pipe shall not exceed 80% of the outside diameter allowance and the wall thickness allowance, respectively.

6.6 Weight

6.6.1 Steel pipes shall be delivered by actual weight. After it is negotiated between the supplier and the buyer, and indicated in the contract, the steel pipes can also be delivered according to the theoretical weight. The theoretical weight of the steel pipe per meter is calculated according to Formula (1):

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

Where:

W – theoretical weight of the steel pipe, in kilograms per meter (kg/m);

π – pi, which shall be 3.141 6;

ρ – density of steel, in kilograms per cubic decimeter (kg/dm³), as shown in Table 4;

S – wall thickness of the steel pipe, in millimeters (mm);

D – nominal outside diameter of the steel pipe, in millimeters (mm).

6.6.2 For steel pipes delivered according to the nominal outside diameter and minimum wall thickness, the theoretical weight shall be calculated by the average wall thickness. The average wall thickness is the average value of the maximum and minimum wall thicknesses calculated according to the wall thickness and its permissible deviation.

6.6.3 When the steel pipes are delivered according to the theoretical weight, the supplier and the buyer can negotiate the weight permissible deviation and indicate it in the contract.

7 Technical requirements

7.1 Steel designation and chemical composition

The tube blank shall be manufactured by hot rolling (forging) method, and shall comply with the provisions of YB/T 5137; the total elongation coefficient of processing deformation shall not be less than 3.

Note: The total elongation coefficient of processing deformation is usually expressed by the cross-sectional area ratio, length ratio or height ratio before and after deformation.

7.2.3 Manufacturing method of steel pipes

Steel pipes shall be manufactured by cold rolling (drawing) or hot rolling (extruding, upsetting, forging). Where the buyer specifies a certain manufacturing method, it shall be indicated in the contract.

7.3 Delivery state

7.3.1 Steel pipes shall be delivered after heat treatment and pickling. All steel pipes that have been wholly ground, bored or heat-treated in protective atmosphere can be delivered without pickling. See Table 4 for the recommended heat treatment system for steel pipes.

7.3.2 06Cr18Ni11Ti, 07Cr19Ni11Ti, 06Cr18Ni11Nb and 07Cr18Ni11Nb steel pipes shall be subjected to stabilization heat treatment after solution heat treatment. The stabilization heat treatment system shall be determined through negotiation between the supplier and the buyer.

7.3.3 For hot-rolled (extruded, upset, forged) steel pipes, if direct water cooling or other rapid cooling is carried out within the heat treatment temperature range specified in Table 4 after hot deformation, it shall be deemed that the steel pipe solution heat treatment requirements have been met.

7.3.4 After it is negotiated between the supplier and the buyer, and indicated in the contract, other heat treatment systems other than those specified in Table 4 can be adopted for the steel pipe.

7.4.1 Mechanical properties

7.4.1 Room temperature mechanical properties

The room temperature mechanical properties of the steel pipes in the delivery state shall comply with the requirements in Table 4.

$$p = 2SR/D \quad \dots\dots\dots (2)$$

Where:

p – test pressure, in megapascals (MPa), which shall be rounded off to the nearest 0.5 MPa when $p < 7$ MPa, and to the nearest 1 MPa when $p \geq 7$ MPa;

S – wall thickness of the steel pipe, in millimeters (mm);

R – allowable stress, which shall be 60% of the minimum plastic elongation strength specified in Table 4, in megapascals (MPa);

D – nominal outside diameter of the steel pipe, in millimeters (mm).

7.5.2 The chloride ion (Cl⁻) content (mass fraction) in the water used for the hydraulic test shall not exceed 25×10^{-6} .

7.5.3 With the consent of the buyer, the supplier may use eddy current testing instead of the hydraulic test. In eddy current testing, the acceptance grade shall meet the requirements of E4H or E4 in GB/T 7735-2016.

7.6 Process performance

7.6.1 Flattening

7.6.1.1 The steel pipes shall be subjected to a flattening test. Flattening shall be performed in the following two steps.

- a) The first step is the ductility test. The sample shall be pressed to H, the distance between the two plates, and shall not have cracks or breaches. H shall be calculated according to Formula (3).

$$H = \frac{(1 + \alpha)S}{\alpha + S/D} \quad \dots\dots\dots (3)$$

Where:

H – the distance between the two plates, in millimeters (mm);

α – deformation coefficient per unit length, which shall be 0.09;

S – wall thickness of the steel pipe, in millimeters (mm);

D – nominal outside diameter of the steel pipe, in millimeters (mm).

- b) The second step is the integrity test (closed flattening). The flattening shall be continued until the sample ruptures or the sample collides with opposite walls;

the sample shall not show any visible separation, white spots or inclusions during the entire flattening test.

7.6.1.2 The following conditions shall not be used as the basis for judging whether the flattening test is qualified or not:

- a) cracks or breaches caused by defects on the inner surface of the sample;
- b) cracks or breaches on the inner surface of the sample at the 6 o'clock (bottom) and 12 o'clock (top) positions, when $S/D > 0.1$.

7.6.2 Bending test

7.6.2.1 For steel pipes with an outside diameter greater than 600 mm or a ratio of wall thickness to outside diameter greater than 15%, a bending test may be adopted instead of a flattening test. A set of bending tests shall include a forward bending (the surface of the sample near the outer surface of the steel pipe is deformed in tension) and a reverse bending (the sample near the inner surface of the steel pipe is deformed in tension).

7.6.2.2 The diameter of the bending core of the bending test is 25 mm; the sample shall be bent 180° at room temperature. After bending, there shall be no visible cracks or breaches on the tensile surface and sides of the sample.

7.6.2.3 The sample for the bending test shall be taken along the transverse direction of the steel pipe; the sample preparation shall comply with the provisions of GB/T 232. When the sample is taken, the forward bending sample shall be as close as possible to the outer surface, and the reverse bending sample shall be as close as possible to the inner surface. There shall be no obvious scars or other defects on the surface of the sample under bending and tension deformation. The sectional dimensions of the sample after processing shall be 12.5 mm × 12.5 mm or 25 mm × 12.5 mm (width × thickness); the four corners on the section shall be rounded, the radius of the rounded corners shall not be greater than 1.6 mm, and the length of the sample shall not be greater than 150 mm.

7.6.3 Flaring

Steel pipes whose outside diameter is not more than 150 mm and wall thickness is not more than 10 mm shall be subjected to a flaring test. The taper of the top core of the flaring test is 60°; the flaring rate of the outside diameter after flaring shall meet the requirements of Table 6; the sample shall not have cracks or breaches after flaring.

groove depth shall be 0.2 mm; when the wall thickness is not greater than 40 mm, the maximum groove depth shall be 1.0 mm; when the wall thickness is greater than 40 mm, the maximum groove depth shall be 1.5 mm.

7.11.1.2 When the steel pipes are delivered as per the minimum wall thickness, the groove depth of the comparative sample pipe shall be calculated according to the average wall thickness of the steel pipe.

7.11.1.3 The ends of steel pipes that cannot be completely detected by automatic inspection shall be cut off or manually ultrasonically inspected. The sensitivity of the manual detection method shall be at least the same as that of the automatic detection method; the steel pipe used to correct the sensitivity shall be the steel pipe used for automatic detection.

7.11.1.4 As required by the buyer, negotiated between the supplier and the buyer, and indicated in the contract, the steel pipe can be ultrasonically tested by methods specified in other standards.

7.11.2 Lamination detection

As required by the buyer, negotiated between the supplier and the buyer, and indicated in the contract, the steel pipe can be subjected to ultrasonic testing for lamination.

7.11.3 Penetrant testing

The outer surface, ends and accessible inner surfaces of the steel pipe shall be tested for liquid penetration. The liquid penetration test shall comply with the provisions of NB/T 47013.5-2015, and shall be accepted according to the quality level I of other components.

8 Test methods

8.1 Sampling for chemical composition analysis of steel pipes shall comply with the provisions of GB/T 20066. Usually, follow GB/T 11170, GB/T 11261, GB/T 20123, GB/T 20124, YB/T 4307 or other general methods for chemical composition analysis, and GB/T 223.11, GB/T 223.25, GB/T 223.28, GB/T 223.37, GB/T 223.40, GB/T 223.59, GB/T 223.60, GB/T 223.63, GB/T 223.82, GB/T 223.84, GB/T 223.85, GB/T 223.86, GB/T 11261 and YB/T 4307 for arbitration.

8.2 For steel pipes with an outside diameter of not less than 219 mm, when the wall thickness allows, the tensile test samples shall be preferentially intercepted for transverse test pieces.

8.3 The size and shape of the steel pipe shall be measured one by one by gauges that meet the accuracy requirements.

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