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Longitudinal Submerged-Arc Welded Steel Pipe for High Pressure Service at High Temperatures

高温高压管道用直缝埋弧焊接钢管

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Foreword

This Standard was drafted as per the rules specified in GB/T 1.1-2009.

This Standard was proposed by China Iron and Steel Industry Association.

This Standard shall be under the jurisdiction of National Technical Committee for Standardization of Steel (SAC/TC 183).

Drafting organizations of this Standard: Jiangsu Tongyu Steel Pipe Group Co., Ltd., Panyu Chu Kong Steel Pipe (Zhuhai) Co., Ltd., and China Metallurgical Information and Standardization Institute.

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Longitudinal Submerged-Arc Welded Steel Pipe for High Pressure Service at High Temperatures

1 Scope

This Standard specifies the terms and definitions, ordering contents, dimension, shape, weight and permissible deviation, technical requirements, test methods, inspection rules, as well as package, mark and quality certificate of the longitudinal submerged-arc welded steel pipe for high pressure service at high temperature (hereinafter referred to as steel pipe).

This Standard is applicable to the carbon steel and alloy steel longitudinal submerged-arc welded steel pipe used by petroleum refining and coal chemical high temperature and high pressure pipes.

2 Normative Reference

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 223.3 Methods for Chemical Analysis of Iron, Steel and Alloy - the Diantipyrylmethane Phosphomolybdate Gravimetric Method for the Determination of Phosphorus Content

GB/T 223.10 Methods for Chemical Analysis of Iron, Steel and Alloy - the Cupferron Separation-Chrome Azurol S Photometric Method for the Determination of Aluminum Content

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

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 223.17 Methods for Chemical Analysis of Iron, Steel and Alloy - The Diantipyrylmethane Photometric Method for the Determination of Titanium Content

GB/T 223.18 Methods for Chemical Analysis of Iron, Steel and Alloy - The Sodium Thiosulfate Separation Iodimetric Method for the Determination of Copper Content

GB/T 223.23 Iron, Steel and Alloy - Determination of Nickel Content - The Dimethylglyoxime Spectrophotometric Method

GB/T 223.26 Iron, Steel and Alloy - Determination of Molybdenum Content - The Thiocyanate Spectrophotometric Method

GB/T 223.40 Methods for Chemical Analysis of Iron, Steel and Alloy; the Anion-Exchange Separation - Sulphochlorophenol S Photometric Method for the Determination of Niobium Content

GB/T 223.43 Iron Steel and Alloy - Determination of Tungsten Content – Gravimetric Method and 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 223.68 Methods for Chemical Analysis of Iron, Steel and Alloy - The Potassium Iodate Titration Method after Combustion in the Pipe Furnace for the Determination of Sulfur Content

GB/T 223.69 Iron, Steel and Alloy-Determination of Carbon Contents - Gas-volumetric Method after Combustion in the Pipe Furnace

GB/T 226 Etch Test for Macrostructure and Defect of Steels

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 229 Metallic Materials - Charpy Pendulum Impact Test Method

GB/T 231.1 Metallic Materials - Brinell Hardness Test - Part 1: Test Method

GB/T 241 Metal Materials Tubes - Hydrostatic Pressure Test

GB 713 Steel Plates for Boilers and Pressure Vessels

GB/T 2102 Acceptance, Packing, Marking and Quality Certification of Steel Pipe

GB/T 2650 Method of Impact Test on Welded Joints

GB/T 2651 Method of Tensile Test for Welded Joint

GB/T 2653 Method of Bend and Compression Test for Welded Joint

GB/T 2975 Steel and Steel Products - Location and Preparation of Test Pieces for Mechanical Testing

GB/T 4336 Carbon and Low-Alloy 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 21835 Dimensions and Masses per Unit Length of Welded Steel Pipes

SY/T 6423.1 Petroleum and Natural Gas Industries - Non-Destructive Testing (NDT) Methods of Steel Tubes - Part1: Radiographic Testing of Weld Seam of Welded Steel Tubes for Detection of Imperfections

SY/T 6423.2 Petroleum and Natural Gas Industries - Non-Destructive Testing (NDT) Methods of Steel Tubes - Part2: Automated Ultrasonic Testing of the Weld Seam of Welded Steel Tubes for the Detection of Longitudinal and/or Transverse Imperfections

SY/T 6423.4 Petroleum and Natural Gas Industries - Non-Destructive Testing(NDT) Methods of Steel Tubes - Part4: Automated Ultrasonic Testing of Seamless and Welded Steel Tubes for the Detection of Laminar Imperfections

SY/T 6423.5 Petroleum and Natural Gas Industries - Non-Destructive Testing (NDT) Methods of Steel Tubes - Part 5: Digital Radiographic Testing of the Weld Seam of Welded Steel Tubes for the Detection of Imperfections

3 Terms and Definitions

The following terms and definitions are applicable to this document.

3.1 Jointer

The steel pipe formed through the butt welding of multiple (two and above) steel pipes.

6 Technical Requirements

6.1 Steel grades and chemical compositions

The steel grades and chemical compositions (melting analysis and finished product analysis) shall conform to the provisions of Table 3. According to the demand of the purchaser, through the negotiation between purchaser and supplier, the steel pipe with grade beyond the provisions of Table 3 can be supplied.

6.2 Manufacturing method

6.2.1 Raw materials

The raw materials used for manufacturing the steel pipe shall conform to the following provisions:

- a) The steel shall be smelted by the oxygen converter or electric furnace; and shall be the fine-grained killed steel through the out-of-furnace melting;
- b) The steel plate shall conform to the provisions of GB713, or the quality requirements shall be no less than the provisions of GB 713;
- c) Any lubricant, oil stain and the like contaminating the welding groove or surrounding area shall be cleaned before welding.

6.2.2 Manufacturing processes

The steel pipe shall be manufactured by the longitudinal double submerged arc welding (SAWL) method.

			tempering temperature 700°C~750°C; normalizing temperature 900°C~960°C; tempering temperature 700°C~750°C, but shall be sharp quenching after normalizing
10	12Cr5Mo	650~760	1. Complete annealing or isothermal annealing; 2. Normalizing and tempering: normalizing temperature 930°C~980°C; tempering temperature 730°C~770°C.

6.4 Tensile properties

6.4.1 The tensile properties of steel pipe at room temperature shall conform to the provisions of Table 5.

6.4.2 The steel pipe base metal tensile specimen shall be cut horizontally from the position about 180° from the welding line.

6.4.3 The welded joint tensile specimen shall be cut from the steel pipe perpendicular to the welding line; and the welding line shall be at the center of the specimen; the weld reinforcement of specimen shall be eliminated, and its value shall be no less than the lower limit of tensile strength specified in Table 5.

6.4.4 According to the demand of the purchaser, through the negotiation between purchaser and supplier, and test temperature is indicated in the contract, the steel pipe can conduct the high-temperature tensile test, and the high-temperature proof strength of plastic extension ($R_{p0.2}$) of the corresponding temperature shall conform to the provisions of Table 6.

6.5 Impact test

6.5.1 The base metal, welding line and heat affected zone of the steel pipe shall conduct the Charpy V-notch transverse impact test; the test results shall conform to the provisions of Table 5. The impact absorption energy values in Table 5 are the Charpy V-notch absorption energy requirements for full-size specimens.

6.5.2 When preparing the steel pipe welding line specimen, the notch axis shall be as close as possible to the centerline of outer welding line; sampling shall be taken as close as possible to the outer diameter surface of the steel pipe.

Figure 2 Specimen Position of Charpy Impact Test in Heat Affected Zone

6.5.5 Single specimen's impact absorption energy shall no less than 75% specified average value.

6.6 Hardness test

The welding line of steel pipe shall conduct the hardness test, its hardness value shall conform to the provisions of Table 5.

6.7 Welding line guided bend test

6.7.1 The steel pipe shall perform welding line guided bend test (face bend and back bend). The guide bend specimen shall be taken from the steel pipe vertical welding line; the welding line shall be at the center of specimen; the specimen shall have no complement welding joint; the weld reinforcement shall be eliminated; the specimen shall bend approximately 180° within the bending mold; the diameter of bending pressure head shall be 8 times of the wall thickness of steel pipe. Due to the capability of the tester, the steel pipe with thickness greater than 30mm can replace the guided bend by side bend; the thickness of side bend is full size, and its width is 10mm. After test, the following provisions shall be conformed to:

- a) The specimen shall not be broken completely;
- b) There shall be no any length of cracks or breaches within the welding metal on the specimen;
- c) There shall be no any length of cracks or breaches in the base metal, heat affected zone or fusion line.

6.7.2 After test, if the specimen edge occurs the cracks with length less than 6.4mm, which shall not be regarded as the rejection basis.

6.8 Macroscopic inspection

The weld misalignment of welding lines in and out of the steel pipe shall not exceed 3mm. The weld misalignment shall be checked and accepted by the macroscopic inspection method; the supplier is required to take a cross-section specimen of welding line from each batch of steel pipe to perform the macrostructure morphology inspection.

6.9 Hydrostatic pressure test

6.9.1 The steel pipe shall perform hydrostatic pressure test piece by piece; the test pressure P shall be calculated as per the Formula (2); the test result shall be rounded off to the nearest 0.1MPa. For the steel pipe with $D \leq 457$ mm, the pressure retention time shall be no less than 5s; for the steel pipe with $D > 457$, the pressure retention time shall be no less than 10s.

- Repair-welding as per the requirements of 6.14;
- Within the allowable length range, cut the steel pipe section with defects;
- Determine the entire steel pipe is disqualified.

6.14 Grinding and repairing requirements

6.14.1 The grinding area shall be smoothly transferred to the original surface of the steel pipe.

6.14.2 The base metal defect of the steel pipe shall not be repaired by welding, while the welding line can repair by welding, the number of repair-welding shall not exceed twice at the same place.

6.14.3 The welding line defects with intervals less than 100mm shall be repaired as the continuous single welding line. Single welding line shall be at least repair two layers/ways; the minimum length of complement weld joint shall be 50mm.

6.14.4 The total length of complement welding joint of each steel pipe shall be no greater than 5% total length of welding line.

6.14.5 The complement weld joint shall be repairing and ground, after the repairing and grinding, the complement weld joint shall be smoothly transferred to the original surface of the steel pipe.

6.14.6 After repairing, the steel pipe shall perform hydrostatic pressure test as per the requirements of 6.9; and perform the non-destruction test as per the requirements of 6.10.

6.15 Welding line deviation

6.15.1 Weld reinforcement

6.15.1.1 If steel pipe wall thickness is no greater than 20mm, the internal and external weld reinforcement shall be no greater than 3mm; if steel pipe wall thickness is greater than 20mm, the internal and external weld reinforcement shall be no greater than 4.5mm. When the weld reinforcement exceeds the stipulated value, it shall be allowed to repair and grind.

6.15.1.2 The welding line about minimum 100mm-long from the pipe end shall be repaired and ground; after repairing and grinding, the weld reinforcement shall not exceed 0.5mm.

6.15.1.3 All welding lines shall be smoothly transferred to the steel pipe surface.

6.15.2 Misalignment

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