沧州博拓国际贸易有限公司

Cangzhou Botop International Co.,Ltd.

ASTM A335 P91 Specification

- Alloy Seamless Steel Pipe

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Navigation Buttons

What is ASTM A335 P91?

ASTM A335 P91, also known as ASME SA335 P91, is a seamless ferritic alloy steel pipe for high-temperature service, UNS No. K91560.

It has a minimum **tensile strength of 585 MPa (85 ksi)** and a minimum **yield strength of 415 MPa (60 ksi)**.

P91 mainly contains alloying elements such as chromium and molybdenum, and a variety of other alloying elements are added, belonging to the high-alloy steel, so it has super strength and excellent corrosion resistance.

In addition, P91 is available in two types, Type 1 and Type 2, and is commonly used in power plants, refineries, chemical facilities critical equipment, and piping in high-temperature and high-pressure environments.

Our Supply Range

Material: ASTM A335 P91 seamless steel pipe;

OD: 1/8"- 24";

WT: in accordance with ASME B36.10 requirements;

Schedule: SCH10, SCH20, SCH30, SCH40, SCH60, SCH80, SCH100, SCH120, SCH140 and SCH160;

Identification: STD (standard), XS (extra-strong), or XXS (double extra-strong);

Customization: Non-standard pipe sizes are also available, customized sizes are available upon request;

Length: Specific and random lengths;

IBR Certification: We can contact the third-party inspection organization to get IBR certification according to your needs, our cooperation inspection organizations are BV, SGS, TUV, etc.;

End: Flat end, beveled, or composite pipe end;

Surface: Light pipe, paint, and other temporary protection, rust removal and polishing, galvanized and plastic coated, and other long-term protection;

Packing: Wooden case, steel belt or steel wire packing, plastic or iron pipe end protector, etc.

What is the Difference Between A335 P91 Type 1 and Type 2?

P91 steel pipe is categorized into two types, Type 1 and Type 2.

Both types are the same in terms of mechanical properties and other requirements such as heat treatment, with minor differences in chemical composition and specific application focus.

Chemical composition: Compared to Type 1, the chemical composition of Type 2 is more stringent and contains more alloying elements to provide better heat and corrosion resistance.

Applications: Due to the optimized chemical composition, Type 2 is more suitable for extremely high temperatures or more corrosive environments, or in applications where higher strength and durability are required.

General Requirements

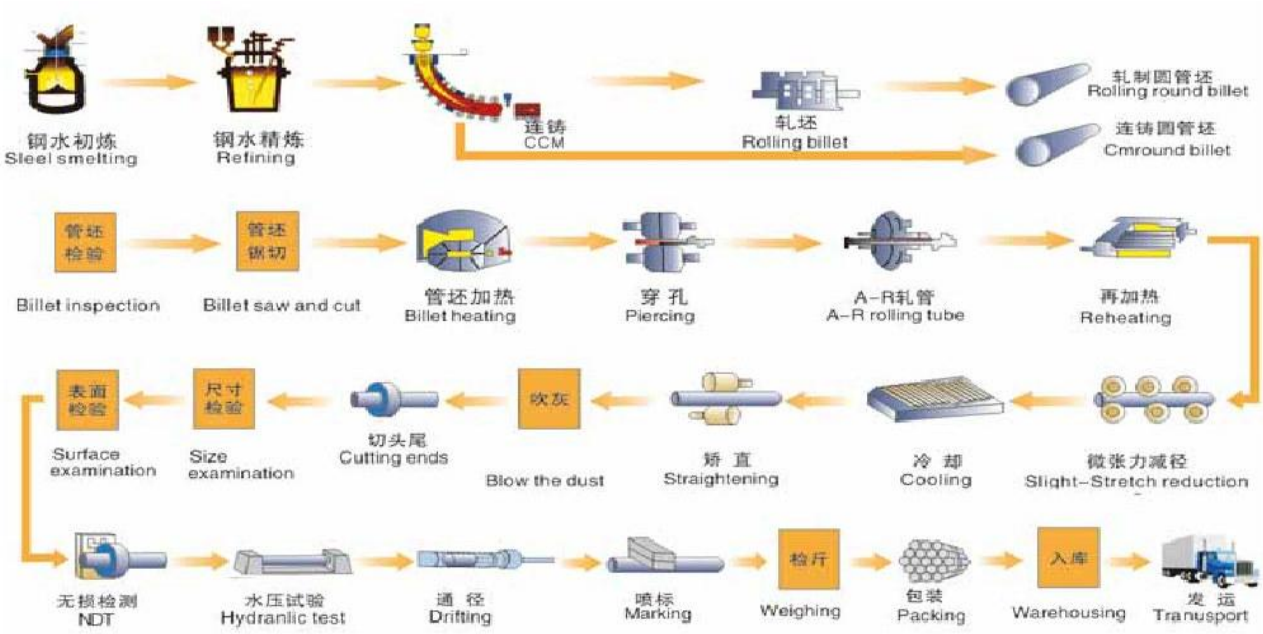
Unless otherwise specified in A335, materials furnished under this specification shall conform to the applicable requirements of the current edition of Specification A999/A999M.

ASTM A335 Manufacturing Processes

ASTM A335 steel pipe must be seamless.

The seamless manufacturing process is categorized into hot finish and cold drawn.

Below is a diagram of the hot finish process.



In particular, P91, a high-alloy steel pipe, which is often used in harsh environments subject to high temperatures and pressures, seamless steel pipe is uniformly stressed and can be made into thick-walled, thus ensuring higher safety and better cost-effectiveness.

Heat Treatment

P91 All pipes must be heat-treated to optimize the microstructure of the pipe, improve its mechanical properties, and enhance the resistance to high temperature and pressure.

Grade	Heat Treat Type	Normalizing Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering Temperature, min or range °F [°C]
P91 Type 1 and Type 2	normalize and temper or	1900 - 1975 [1040 - 1080]	—	1350 - 1470 [730 - 800] [C]
	quench and temper	1900 - 1975 [1040 - 1080]	—	1350 - 1470 [730 - 800]

[C] Except when Supplementary Requirement S7 is specified by the purchaser.

ASTM A335 P91 Chemical Composition

P91 Type 1 Chemical Components

P91 Type 1	**K90941**	**C** (Carbon)	**Mn** (Manganese)	**P** (Phosphorus)	**S** (Sulfur)	**Si** (Silicon)	**Cr** (Chromium)	**Mo** (Molybdenum)
		0.08 - 0.12	0.30 - 0.60	0.020 max	0.010 max	0.20 - 0.50	8.00 - 9.50	0.85 - 1.05
		V (Vanadium)	**N** (Nitrogen)	**Ni** (Nickel)	**Al** (Aluminum)	**Nb** [F] (Niobium)	**Ti** (Titanium)	**Zr** (Zirconium)
		0.18 - 0.25	0.030 - 0.070	0.40 max	0.02 max	0.06 - 0.10	0.01 max	0.01 max
F: The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.								

P91 Type 2 Chemical Components

P91 Type 2	**K90941**	**C** (Carbon)	**Mn** [D] (Manganese)	**P** [D] (Phosphorus)	**S** [D] (Sulfur)	**Si** [D] (Silicon)	**Cr** [D] (Chromium)	**Mo** (Molybdenum)
		Heat: 0.08 - 0.12 Product: 0.07 - 0.13	0.30 - 0.50	0.020 max	0.005 max	0.20 - 0.40	8.00 - 9.50	Heat: 0.85 - 1.05 Product: 0.80 - 1.05
		V (Vanadium)	**Ni** [D] (Nickel)	**Al** [D] (Aluminum)	**N** [D] (Nitrogen)	**N/Al ratio**	**Nb** [F] (Niobium)	**Ti** [D] (Titanium)
		heat: 0.18 - 0.25 Product: 0.16 - 0.27	0.20 max	0.02 max	0.035 - 0.070	≥ 4.0	Heat: 0.06 - 0.10 Product: 0.05 - 0.11	0.01 max
		Zr [D] (Zirconium)	**Sn** [D] (Tin)	**Sb** [D] (Antimony)	**As** [D] (Arsenic)	**B** [D] ((Boron)	**W** [D] (Tungsten)	**Cu** [D] (Copper)
		0.01 max	0.01 max	0.003 max	0.01 max	0.001 max	0.05 max	0.10 max
D: Applies to both heat and product analyses. F: The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.								

With the two images above, it's easy to see the difference between Type 1 and Type 2 chemical elements and restrictions.

ASTM A335 P91 Mechanical Properties

1. Tensile Property

The tensile test is commonly used to measure the **yield strength**, **tensile strength**, and **elongation** of the steel pipe experimental program, and is widely used in the material properties of the test.

List	Classification		P91 Type 1 and Type 2
Tensile strength ,min	ksi		85
	MPa		585
Yield strength ,min	ksi		60
	MPa		415
Elongation	**Longitudinal**	Elongation in 2 in. or 50 mm, (or 4D), min, %; Basic minimum elongation for wall 6 in. [8 mm] and over in thickness, strip tests, and for all small sizes tested in full section	20
		When standard round 2-in. or 50-mm gage length or proportionally smaller size specimen with the gage length equal to 4D (4 times the diameter) is used	20
		For strip tests a deduction for each 1/32 in. [0.8 mm] decrease in wall thickness below 5/16 in. [8 mm] from the basic minimum elongation of the following percentage points shall be made	1.00 [A]
	Transverse	Elongation in 2 in. or 50 mm, (or 4D), min, %; Basic minimum elongation for wall 6 in. [8 mm] and over in thickness, strip tests, and for all small sizes tested in full section	—
		When standard round 2-in. or 50-mm gage length or proportionally smaller size specimen with the gage length equal to 4D (4 times the diameter) is used	13
		For strip tests a deduction for each 1/32 in. [0.8 mm] decrease in wall thickness below 5/16 in. [8 mm] from the basic minimum elongation of the following percentage points shall be made	—

A Table 5 gives the calculated minimum values.

ASTM A335 P91 Mechanical Properties

Table 5 Calculated Minimum Elongation Values		
Wall Thickness		P91 Type 1 and Type 2
		Elongation in 2 in. or 50 mm, min, %
in.	mm	Longitudinal
5/16 (0.312)	8.0	20
9/32 (0.281)	7.2	19
1/4 (0.250)	6.4	18
7/32 (0.219)	5.6	17
3/16 (0.188)	4.8	16
5/32 (0.156)	4.0	15
1/8 (0.125)	3.2	14
3/32 (0.094)	2.4	13
1/16 (0.062)	1.6	12

Where the wall thickness lies between the two values above, the minimum elongation value is determined by the following formula:

Longitudinal, P91: E = 32t + 15.00 [E = 1.25t + 15.00]

where:

E = elongation in 2 in. or 50 mm, %,

t = actual thickness of specimens, in. [mm].

ASTM A335 P91 Mechanical Properties

2. Hardness

A variety of hardness testing methods can be used, including Vickers, Brinell, and Rockwell.

Grade	Brinell	Vickers	Rockwell
P91 Type 1 and Type 2	190 - 250 HBW	196 - 265 HV	91 HRBW - 25HRC

Wall thickness <0.065 in. [1.7 mm]: No hardness test required;

0.065 in. [1.7 mm] ≤ wall thickness <0.200 in. [5.1 mm]: Rockwell hardness test shall be used;

Wall thickness ≥ 0.200 in. [5.1 mm]: optional use of Brinell hardness test or Rockwell hardness test.

The Vickers hardness test is applicable to all wall thicknesses of tubing. The test method is carried out in accordance with the requirements of E92.

3. Flattening Test

Experiments shall be conducted in accordance with Section 20 of the ASTM A999 standard.

ASTM A335 P91 Mechanical Properties

4. Bend Test

Bend 180° at room temperature, no cracks shall appear on the outside of the bent part.

Size > NPS25 or D/t ≥ 7.0: Bending test should be performed without flattening test.

5. P91 Optional Experimental Programs

The following experimental items are not required test items, if necessary can be determined by negotiation.

S1: Product Analysis

S3: Flattening Test

S4: Metal Structure and Etching Tests

S5: Photomicrographs

S6: Photomicrographs for Individual Pieces

S7: Alternative Heat Treatment-Grade P91 Type 1 and Type 2

Hydrostatic Test

- The P91 hydro test shall comply with the following requirements.

Outside diameter＞10in. [250mm] and wall thickness ≤ 0.75in. [19mm]: this should be a hydrostatic test.

Other sizes for non-destructive electrical testing.

- For ferritic alloy steel and stainless steel tubes, the wall is subjected to a pressure of not less than **60% of the specified minimum yield strength**.
- The hydro test pressure shall be maintained for at least 5s without leakage or other defects.
- Hydraulic pressure can be calculated using the formula:

$$P = 2St/D$$

P = hydrostatic test pressure in psi [MPa];

S = pipe wall stress in psi or [MPa];

t = specified wall thickness, nominal wall thickness according to specified ANSI schedule number or 1.143 times the specified minimum wall thickness, in. [mm];

D = specified outside diameter, outside diameter corresponding to specified ANSI pipe size, or outside diameter calculated by adding 2t (as defined above) to the specified inside diameter, in. [mm].

Nondestructive Examination

P91 pipe is inspected by means of the E213 test method. The E213 standard is primarily concerned with ultrasonic testing (UT).

If specifically specified in the order, it can also be inspected according to the E309 or E570 test method.

The E309 standard usually deals with electromagnetic (eddy current) inspection, while E570 is an inspection method involving eddy current arrays.

Dimensional Tolerances

Permissible Variations in Diameter

Diameter deviations can be classified according to either 1. based on the inner diameter or 2. based on the nominal or outer diameter.

1. Inner diameter: ±1%.

2. NPS [DN] or outside diameter: This conforms to the permissible deviations in the table below.

Permissible Variations in Outside Diameter			
NPS	DN	Permissible Variations	
		in.	mm
1/8 - 1 1/2， inch.	6 - 40， inch.	±1/64 (0.015)	±0.40
Over 1 1/2 to 4 inch.	Over 40 to 100 inch.	±1/32 (0.031)	±0.79
Over 4 to 8 inch.	Over 100 to 200 inch.	-1/32 (0.031) - +1/16 (0.062)	-0.79 - +1.59
Over 8 to 12 inch.	Over 200 to 300 inch.	-1/32 (0.031) - +3/32 (0.093)	-0.79 - +2.38
Over 12	Over 300	±1% of specified outside diameter	

Dimensional Tolerances

Permissible Variations in Wall Thickness

The thickness of the pipe wall at any point shall not exceed the specified tolerance.

Permitted Variations in Wall Thickness		
NPS	**DN**	**Tolerance, % form Specified**
1/8 to 2 1/2 incl. all t/D ratios	6 to 65 incl. all t/D ratios	-12.5 - +20.0
Above 2 1/2, t/D ≤ 5 %	Above 65, t/D ≤ 5 %	-12.5 - +22.5
Above 2 1/2, t/D ＞ 5 %	Above 65, t/D ＞ 5 %	-12.5 - +15.0
t = Specified Wall Thickness; D = Specified Outside Diameter.		

The minimum wall thickness and outside diameter for inspection for compliance with this requirement for pipe ordered by NPS [DN] and schedule number is shown in **ASME B36.10M**.

Defects or Imperfections and Repair

Defects

Surface imperfections are considered defects if they exceed 12.5% of the nominal wall thickness or exceed the minimum wall thickness.

Imperfections

Mechanical marks, abrasions, and pits, any of which imperfections are deeper than 1/16 in. [1.6 mm].

Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, die marks, and the like.

Repair

Defects may be removed by grinding, provided that the remaining wall thickness is not less than the minimum wall thickness.

Repairs can also be made by welding but must comply with the relevant requirements of A999.

P91 pipe should be heat treated at 1350-1470 °F [730-800°C] after weld repair.

Marking

The external surface of the inspected steel pipe shall contain the following elements:

Manufacturer's name or trademark; standard number; grade; length and additional symbol "**S**".

The markings for hydrostatic pressure and non-destructive testing in the table below should also be included.

Ultrasonic	Flux Leakage	Eddy Current	Hydrostatic	Marking
No	No	No	Yes	Test Pressuer
Yes	No	No	No	UT
No	Yes	No	No	FL
No	No	Yes	No	EC
Yes	Yes	No	No	UT / FL
Yes	No	Yes	No	UT / EC
No	No	No	No	NH
Yes	No	No	Yes	UT / Test Pressuer
No	Yes	No	Yes	FL / Test Pressuer
No	No	Yes	Yes	EC / Test Pressuer
Test Pressuer is to be in psi [MPa].				

If the pipe is repaired by welding, it shall be marked "**WR**".

p91 The type (Type 1 or Type 2) should be indicated.

ASTM A335 P91 Equivalent

- EN 10216-2: X10CrMoVNb9-1 or 1.4903;
- JIS G 3462: STPA 28;
- GB/T 5310: 10Cr9Mo1VNb;

These equivalents are very close in chemical composition and mechanical properties to ASTM A335 P91.

About Us

Since its establishment in 2014, **Botop Steel** has become a leading supplier of carbon steel pipe in Northern China, known for excellent service, high-quality products, and comprehensive solutions.

The company offers a variety of carbon steel pipes and related products, including seamless, ERW, LSAW, and SSAW steel pipe, as well as a complete lineup of pipe fittings and flanges. Its specialty products also include high-grade alloys and austenitic stainless steels, tailored to meet the demands of various pipeline projects.

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