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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Iron and Steel Federation (JISF) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS G 3463:2012**), which has been technically revised.

However, **JIS G 3463:2012** may be applied in the **JIS** mark certification based on the relevant provisions of Article 30, paragraph (1), etc. of the Industrial Standardization Act until 19 November 2020.

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It should be noted that being in conformance with this Standard may come under the use of the patent rights and other rights held by the following:

Symbol of grade	Title of invention	Patent number	Registration date of establishment of patent right
SUS821L1TB	Alloy-saving duplex stainless steel having excellent corrosion resistance and toughness in weld heat affected zone	No. 5345070	23 August 2013

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NOTE Based on Article 9 of the Supplementary Provisions to the Unfair Competition Prevention Act etc., any submission of proposal, or employment of procedures such as deliberation by the Japanese Industrial Standards Committee under the previous Industrial Standardization Act shall be deemed to have been conducted pursuant to the provision of Article 12, paragraph (1) of the revised Industrial Standardization Act.

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Stainless steel tubes for boiler and heat exchanger

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 9329-4:1997**, Edition 1, and **ISO 9330-6:1997**, Edition 1, with some modifications of the technical contents.

In addition to the specification items in the main body, the supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer, and the requirements for U-bent tubes that are applied when specified by the purchaser, are given in Annex JA and Annex JB, respectively. The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standards. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies requirements for the stainless steel tubes (hereafter referred to as tubes) used for exchanging heat between the inside and outside of the tube, such as superheater tubes of boilers, and heat exchanger tubes, condenser tubes and catalyser tubes, etc. used in chemical and petroleum industries. It is not applicable to the steel tubes for fired heater.

This Standard is generally applicable to tubes of outside diameters 15.9 mm to 139.8 mm.

NOTE The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 9329-4:1997 *Seamless steel tubes for pressure purposes—Technical delivery conditions—Part 4: Austenitic stainless steels*

ISO 9330-6:1997 *Welded steel tubes for pressure purposes—Technical delivery conditions—Part 6: Longitudinally welded austenitic stainless steel tubes (overall evaluation: MOD)*

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

- | | |
|------------|---|
| JIS G 0320 | <i>Standard test method for heat analysis of steel products</i> |
| JIS G 0321 | <i>Product analysis and its tolerance for wrought steel</i> |
| JIS G 0404 | <i>Steel and steel products—General technical delivery requirements</i> |
| JIS G 0415 | <i>Steel and steel products—Inspection documents</i> |
| JIS G 0551 | <i>Steels—Micrographic determination of the apparent grain size</i> |

- JIS G 0567 *Method of elevated temperature tensile test for steels and heat-resisting alloys*
- JIS G 0571 *Method of oxalic acid etching test for stainless steels*
- JIS G 0572 *Method of ferric sulfate-sulfuric acid test for stainless steel*
- JIS G 0573 *Method of 65 per cent nitric acid test for stainless steels*
- JIS G 0575 *Method of copper sulfate-sulfuric acid test for stainless steels*
- JIS G 0582 *Automated ultrasonic examination of steel pipes and tubes*
- JIS G 0583 *Automated eddy current examination of steel pipes and tubes*
- JIS Z 2241 *Metallic materials—Tensile testing—Method of test at room temperature*
- JIS Z 2245 *Rockwell hardness test—Test method*
- JIS Z 8401 *Rounding of numbers*

3 Symbol of grade

Tubes shall be classified into 41 grades, and their symbols shall be as given in Table 1.

Table 1 Symbols of grade and symbols for manufacturing method

Classification	Symbol of grade	Symbol for manufacturing method		
		Tube manufacturing method	Finishing method	Marking
Austenitic series	SUS304TB, SUS304HTB, SUS304LTB, SUS309TB, SUS309STB, SUS310TB, SUS310STB, SUS312LTB, SUS315J1TB, SUS315J2TB, SUS316TB, SUS316HTB, SUS316LTB, SUS316TiTB, SUS317TB, SUS317LTB, SUS321TB, SUS321HTB, SUS347TB, SUS347HTB, SUS836LTB, SUS890LTB, SUSXM15J1TB	Seamless: S Automatic arc welded: A Laser welded: L Electric resistance welded: E	Hot-finished: H Cold-finished: C As electric resistance welded: G Weld work finished: B	As given in 14 b).
Austenitic-ferritic series	SUS821L1TB, SUS823LTB, SUS329J1TB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB			
Ferritic series	SUS405TB, SUS409TB, SUS409LTB, SUS410TB, SUS410TiTB, SUS430TB, SUS430LXTB, SUS430J1LTB, SUS436LTB, SUS444TB, SUSXM8TB, SUSXM27TB			

4 Manufacturing method

The manufacturing method shall be as follows.

- Tubes shall be manufactured by a combination of the tube manufacturing method and the finishing method which are given in Table 1. Symbols indicating the manufacturing method shall be as given in Table 1. The addition of filler metal manufactured by automatic arc welding shall be left to the discretion of the manufacturer.

- b) Tubes shall be subjected to the heat treatment given in Table 2. Other heat treatments may be applied upon agreement between the purchaser and the manufacturer.
- c) Tubes shall be finished with plain ends unless otherwise specified.
- d) When tubes are manufactured by electric resistance welding, the weld beads on external and internal surfaces shall be removed to smooth the surfaces along the contour of the tube. The weld beads on internal surface may be left unremoved if so agreed between the purchaser and the manufacturer.

Table 2 Heat treatment

Classification	Symbol of grade	Heat treatment type	Heat treatment condition °C
Austenitic series ^{b)}	SUS304TB	Solution treatment	1 010 or over, rapid cooling
	SUS304HTB		1 040 or over, rapid cooling
	SUS304LTB		1 010 or over, rapid cooling
	SUS309TB SUS309STB SUS310TB SUS310STB SUS312LTB		1 030 or over, rapid cooling
	SUS315J1TB SUS315J2TB SUS316TB		1 010 or over, rapid cooling
	SUS316HTB		1 040 or over, rapid cooling
	SUS316LTB		1 010 or over, rapid cooling
	SUS316TiTB ^{a)}		920 or over, rapid cooling
	SUS317TB SUS317LTB		1 010 or over, rapid cooling
	SUS321TB ^{a)}		920 or over, rapid cooling
	SUS321HTB		Cold-finished 1 095 or over, rapid cooling Hot-finished 1 050 or over, rapid cooling
	SUS347TB ^{a)}		980 or over, rapid cooling
	SUS347HTB		Cold-finished 1 095 or over, rapid cooling Hot-finished 1 050 or over, rapid cooling
	SUS836LTB SUS890LTB		1 030 or over, rapid cooling
	SUSXM15J1TB		1 010 or over, rapid cooling
Austenitic-ferritic series	SUS821L1TB		940 or over, rapid cooling
	SUS323LTB SUS329J1TB SUS329J3LTB SUS329J4LTB		950 or over, rapid cooling
	SUS327L1TB		1 025 or over, rapid cooling

Table 2 (concluded)

Classification	Symbol of grade	Heat treatment type	Heat treatment condition °C
Ferritic series	SUS405TB SUS409TB SUS409LTB SUS410TB SUS410TiTB SUS430TB SUS430LXTB	Annealing	700 or over, air cooling or slow cooling
	SUS430J1LTB SUS436LTB		720 or over, air cooling or slow cooling
	SUS444TB SUSXM8TB SUSXM27TB		700 or over, air cooling or slow cooling
Notes a) For tubes of SUS316TiTB, SUS321TB and SUS347TB, the stabilizing heat treatment may be specified. In this case, the temperature of heat treatment shall be 850 °C to 930 °C. b) When hot-finished seamless steel tubes made of austenitic stainless steels are subjected to hot working at the temperature specified in this table and subsequent rapid cooling, the solution treatment may be omitted unless otherwise specified by the purchaser.			

5 Chemical composition

Tubes shall be tested in accordance with 12.1 and the obtained heat analysis values shall satisfy the requirements given in Table 3. When the product analysis is requested by the purchaser, the tube shall be tested in accordance with 12.1, and the obtained product analysis values shall satisfy the requirements given in Table 3.

Table 3 Chemical composition

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Mo	Others ^{c)}
SUS304TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	— ^{b)}	—
SUS304HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	— ^{b)}	—
SUS304LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	18.00 to 20.00	— ^{b)}	—
SUS309TB	0.15 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 15.00	22.00 to 24.00	— ^{b)}	—
SUS309STB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 15.00	22.00 to 24.00	— ^{b)}	—
SUS310TB	0.15 max.	1.50 max.	2.00 max.	0.040 max.	0.030 max.	19.00 to 22.00	24.00 to 26.00	— ^{b)}	—
SUS310STB	0.08 max.	1.50 max.	2.00 max.	0.040 max.	0.030 max.	19.00 to 22.00	24.00 to 26.00	— ^{b)}	—
SUS312LTB ^{a)}	0.020 max.	0.80 max.	1.00 max.	0.030 max.	0.015 max.	17.50 to 19.50	19.00 to 21.00	6.00 to 7.00	Cu: 0.50 to 1.00 N: 0.16 to 0.25
SUS315J1TB	0.08 max.	0.50 to 2.50	2.00 max.	0.045 max.	0.030 max.	8.50 to 11.50	17.00 to 20.50	0.50 to 1.50	Cu: 0.50 to 3.50
SUS315J2TB	0.08 max.	2.50 to 4.00	2.00 max.	0.045 max.	0.030 max.	11.50 to 14.00	17.00 to 20.50	0.50 to 1.50	Cu: 0.50 to 3.50
SUS316TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—
SUS316HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.030 max.	0.030 max.	11.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—
SUS316LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 16.00	16.00 to 18.00	2.00 to 3.00	—
SUS316TiTB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	Ti: 5 × C % min.
SUS317TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—
SUS317LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—
SUS321TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 19.00	— ^{b)}	Ti: 5 × C % min.
SUS321HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.030 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	— ^{b)}	Ti: 4 × C % to 0.60
SUS347TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 19.00	— ^{b)}	Nb: 10 × C % min.
SUS347HTB	0.04 to 0.10	1.00 max.	2.00 max.	0.030 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	— ^{b)}	Nb: 8 × C % to 1.00
SUS836LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	24.00 to 26.00	19.00 to 24.00	5.00 to 7.00	N: 0.25 max.
SUS890LTB ^{a)}	0.020 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	23.00 to 28.00	19.00 to 23.00	4.00 to 5.00	Cu: 1.00 to 2.00
SUSXM15J1TB ^{d)}	0.08 max.	3.00 to 5.00	2.00 max.	0.045 max.	0.030 max.	11.50 to 15.00	15.00 to 20.00	—	—

Table 3 (continued)

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Mo	Others ^{c)}
SUS821L1TB ^{a)}	0.030 max.	0.75 max.	2.00 to 4.00	0.040 max.	0.020 max.	1.50 to 2.50	20.50 to 21.50	0.60 max.	Cu: 0.05 to 1.50 N: 0.15 to 0.20
SUS323LTB ^{a)}	0.030 max.	1.00 max.	2.50 max.	0.040 max.	0.030 max.	3.00 to 5.50	21.50 to 24.50	0.05 to 0.60	Cu: 0.05 to 0.60 N: 0.05 to 0.20
SUS329J1TB ^{e)}	0.08 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	3.00 to 6.00	23.00 to 28.00	1.00 to 3.00	—
SUS329J3LTB ^{a) f)}	0.030 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	4.50 to 6.50	21.00 to 24.00	2.50 to 3.50	N: 0.08 to 0.20
SUS329J4LTB ^{a) f)}	0.030 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	5.50 to 7.50	24.00 to 26.00	2.50 to 3.50	N: 0.08 to 0.30
SUS327L1TB ^{a)}	0.030 max.	0.80 max.	1.20 max.	0.035 max.	0.020 max.	6.00 to 8.00	24.00 to 26.00	3.00 to 5.00	Cu: 0.50 max. N: 0.24 to 0.32
SUS405TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 14.50	— ^{b)}	Al: 0.10 to 0.30
SUS409TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	10.50 to 11.75	— ^{b)}	Ti: 6 × C % to 0.75
SUS409LTB ^{a)}	0.030 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	10.50 to 11.75	— ^{b)}	Ti: 6 × C % to 0.75
SUS410TB	0.15 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 13.50	— ^{b)}	—
SUS410TiTB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 13.50	— ^{b)}	Ti: 6 × C % to 0.75
SUS430TB	0.12 max.	0.75 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 18.00	— ^{b)}	—
SUS430LXTB ^{a)}	0.030 max.	0.75 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 19.00	— ^{b)}	Ti or Nb: 0.10 to 1.00
SUS430J1LTB ^{a) g)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 20.00	— ^{b)}	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80 Cu: 0.30 to 0.80
SUS436LTB ^{a)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 19.00	0.75 to 1.25	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80
SUS444TB ^{a)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	17.00 to 20.00	1.75 to 2.50	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80
SUSXM8TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	17.00 to 19.00	— ^{b)}	Ti: 12 × C % to 1.10
SUSXM27TB ^{a) h)}	0.010 max.	0.40 max.	0.40 max.	0.030 max.	0.020 max.	0.50 max.	25.00 to 27.50	0.75 to 1.50	N: 0.015 max. Cu: 0.20 max. Cu + Ni: 0.50 max.

Table 3 (concluded)

Alloy elements not specified in this table and the element for which dashes (“—”) are entered in this table may be added as necessary.

- Notes
- a) When the product analysis is requested by the purchaser, the carbon content rate shall be as follows: SUS304LTB, SUS316LTB, SUS317LTB, SUS836LTB, SUS821L1TB, SUS323LTB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB, SUS409LTB, SUS430LXTB: 0.035 % or under; SUS430J1LTB, SUS436LTB, SUS444TB: 0.030 % or under; SUS312LTB, SUS890LTB: 0.025 % or under; SUSXM27TB: 0.015 % or under.
 - b) Addition of Mo is permitted to a level where chemical composition of the grade concerned remains distinguishable, after the addition of Mo, from those of all other grades.
 - c) Addition of an alloy element is permitted to a level where chemical composition of the grade concerned remains distinguishable, after the addition of the alloy element, from those of all other grades.
 - d) If either Cu, Mo, Nb, Ti, N, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.
 - e) When either Cu, W, N, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.
 - f) When Cu and/or W is added as necessary, the content rate of the added element(s) shall be reported.
 - g) When V is added as necessary, the content rate shall be reported.
 - h) When either V, Ti, Nb, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.

6 Mechanical properties

6.1 Tensile strength, proof stress and elongation

Tubes shall be tested in accordance with 12.2.3, and the tensile strength, proof stress and elongation shall be as given in Table 4. When the tensile test is carried out on Test piece No. 12 for the tube under 8 mm in wall thickness, the elongation shall be in accordance with Table 5.

Table 4 Tensile strength, proof stress and elongation

Symbol of grade	Tensile strength ^{a)}	Proof stress	Elongation %		
			Outside diameter		
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over
			Test piece No. 11	Test piece No. 11	Test piece No. 11 Test piece No. 12
			Tensile test direction		
			Parallel to tube axis	Parallel to tube axis	Parallel to tube axis
SUS304TB	520 min.	205 min.	25 min.	30 min.	35 min.
SUS304HTB					
SUS304LTB	480 min.	175 min.			
SUS309TB	520 min.	205 min.			
SUS309STB					
SUS310TB					
SUS310STB					
SUS312LTB	650 min.	300 min.			
SUS315J1TB	520 min.	205 min.			
SUS315J2TB					
SUS316TB					
SUS316HTB					
SUS316LTB	480 min.	175 min.			
SUS316TiTB	520 min.	205 min.			
SUS317TB					
SUS317LTB	480 min.	175 min.			
SUS321TB	520 min.	205 min.			
SUS321HTB					
SUS347TB					
SUS347HTB					
SUS836LTB					
SUS890LTB	490 min.	215 min.			
SUSXM15J1TB	520 min.	205 min.			
SUS821L1TB	600 min.	400 min.	12 min.	15 min.	20 min.
SUS323LTB					
SUS329J1TB	590 min.	390 min.	10 min.	13 min.	18 min.
SUS329J3LTB	620 min.	450 min.			
SUS329J4LTB					
SUS327L1TB	795 min.	550 min.	7 min.	10 min.	15 min.

Table 4 (concluded)

Symbol of grade	Tensile strength ^{a)}	Proof stress	Elongation %					
			Outside diameter					
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over			
			Test piece No. 11	Test piece No. 11	Test piece No. 11 Test piece No. 12			
			Tensile test direction					
			Parallel to tube axis	Parallel to tube axis	Parallel to tube axis			
SUS405TB	410 min.	205 min.	12 min.	15 min.	20 min.			
SUS409TB								
SUS409LTB	360 min.	175 min.						
SUS410TB	410 min.	205 min.						
SUS410TiTB		245 min.						
SUS430TB								
SUS430LXTB	360 min.	175 min.						
SUS430J1LTB	390 min.	205 min.						
SUS436LTB	410 min.	245 min.						
SUS444TB		205 min.						
SUSXM8TB								
SUSXM27TB						245 min.		
NOTE 1 N/mm ² = 1 MPa								
Note ^{a)} Exclusively for the heat exchanger tubes, the purchaser may, where necessary, specify the maximum value of tensile strength. In this case, the maximum tensile strength value shall be the value obtained by adding 200 N/mm ² to the value in this table.								

Table 5 Elongation for Test piece No. 12 of tube under 8 mm in wall thickness (direction parallel to tube axis)

Unit: %

Classification	Symbol of grade	Wall thickness						
		Over 1 mm up to and incl. 2 mm	Over 2 mm up to and incl. 3 mm	Over 3 mm up to and incl. 4 mm	Over 4 mm up to and incl. 5 mm	Over 5 mm up to and incl. 6 mm	Over 6 mm up to and incl. 7 mm	Over 7 mm to and excl. 8 mm
Austenitic series	All grades	26 min.	28 min.	29 min.	30 min.	32 min.	34 min.	35 min.
Austenitic-ferritic series	SUS821L1TB	11 min.	12 min.	14 min.	16 min.	17 min.	18 min.	20 min.
	SUS323LTB							
	SUS329J1TB	9 min.	10 min.	12 min.	14 min.	15 min.	16 min.	18 min.
	SUS329J3LTB							
	SUS329J4LTB							
	SUS327L1TB	6 min.	8 min.	9 min.	10 min.	12 min.	14 min.	15 min.
Ferritic series	All grades	11 min.	12 min.	14 min.	16 min.	17 min.	18 min.	20 min.
NOTE The elongation values in this table are calculated by subtracting 1.5% from the elongation value given in Table 4 for each 1 mm decrease of tube wall thickness from 8 mm, and by rounding the result to an integer according to Rule A of JIS Z 8401.								

6.2 Flattening resistance

Tubes shall be tested in accordance with 12.2.4. When flattened until the distance H between two platens reaches the value obtained by Formula (1), the test piece shall be free from cracks.

$$H = \frac{(1+e)t}{e + \frac{t}{D}} \quad (1)$$

where, H : distance between platens (mm)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

e : constant defined for each grade of tube

Austenitic series: 0.09

Austenitic-ferritic series and ferritic series: 0.07

NOTE For the detailed procedure for flattening test, see 12.2.4.

6.3 Flaring property

Tubes shall be tested in accordance with 12.2.5. When flared until the outside diameter is enlarged 1.2 times the original size for austenitic steel tubes and 1.14 times the original size for austenitic-ferritic steel tubes and ferritic steel tubes, the test piece shall be free from cracks. For tubes of outside diameter exceeding 101.6 mm, this requirement shall apply when the flaring test is requested by the purchaser.

NOTE For the detailed procedure for flaring test, see 12.2.5.

6.4 Reverse flattening resistance

The automatic arc welded steel tubes, laser welded steel tubes and electric resistance welded steel tubes shall be tested in accordance with **12.2.6**, and the test piece shall be free from cracks in the weld.

NOTE For the detailed procedure for reverse flattening test, see **12.2.6**.

7 Austenitic grain size

Tubes of SUS321HTB shall be tested in accordance with **12.3**, and the austenitic grain size of the tube shall be of Index 7 or coarser.

8 Hydraulic test characteristics or non-destructive test characteristics

Tubes shall be tested in accordance with **12.4**, and their hydraulic test characteristics or non-destructive test characteristics shall conform to either of the following. The decision on which characteristics to test shall be left to the discretion of the purchaser. If not specified, it shall be left to the discretion of the manufacturer.

a) **Hydraulic test characteristics** Hydraulic test characteristics shall be as follows.

- 1) When a hydraulic test pressure is not specified by the purchaser, the tube shall be subjected to the minimum hydraulic test pressure P calculated by Formula (2) (10 MPa if P exceeds 10 MPa), and shall withstand the pressure without leakage.

$$P = \frac{2st}{D} \dots\dots\dots (2)$$

where, P : test pressure (MPa)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

s : 60 % of the minimum value of proof stress given in Table 4 (N/mm²)

- 2) When a hydraulic test pressure is specified by the purchaser, the tube shall be subjected to the pressure, which is regarded as the minimum hydraulic test pressure, and shall withstand the pressure without leakage. If the pressure specified by the purchaser is greater than either the test pressure P calculated by Formula (2) or 10 MPa, the test pressure to be applied shall be as agreed between the purchaser and the manufacturer. The test pressure shall be specified in 0.5 MPa increments if lower than 10 MPa, and in 1 MPa increments if 10 MPa or higher.

b) **Non-destructive test characteristics** Tubes shall be tested by either the ultrasonic examination or the eddy current examination, and their non-destructive test characteristics shall be as follows. Other non-destructive tests specified in relevant Japanese Industrial Standards (JISs) may replace these tests upon agreement between the purchaser and the manufacturer, in which case the judgement criteria shall be at least equal to those applied in the ultrasonic examination or the eddy current examination.

- 1) For the ultrasonic examination characteristics, the signals from the reference sample containing category UD reference standard specified in **JIS G 0582** shall be regarded as alarm level, and there shall be no signals equivalent to or greater

than the alarm level. When the tube to be tested is finished by other methods than cold finishing, the minimum depth of square notch shall be 0.3 mm.

- 2) For the eddy current examination characteristics, the signals from the reference sample containing category EY reference standard specified in **JIS G 0583** shall be regarded as alarm level, and there shall be no signals equivalent to or greater than the alarm level.

9 Dimensions, unit masses and dimensional tolerances

9.1 Dimensions and unit masses

The outside diameters, wall thicknesses and unit masses of tubes shall be as given in Table 6 to Table 14. Dimensions not specified in Table 6 to Table 14 may be used upon agreement between the purchaser and the manufacturer. In this case, the unit mass shall be determined by the formula given in Table 15, and the result shall be rounded off to 3 significant figures according to Rule A of **JIS Z 8401**. The result value exceeding 1 000 kg/m shall be rounded to a four-digit integer.

NOTE 1 The unit mass values given in Table 6 to Table 14 are the results of the calculation given above.

NOTE 2 The standard unit mass used in transaction is to be the value given in Table 6 to Table 14 increased by 15 % for the hot-finished seamless steel tube, and by 10 % for the cold-finished seamless steel tube, automatic arc welded steel tube, laser welded steel tube and electric resistance welded steel tube.

Table 15 Calculation formula for unit mass of tube

Symbol of grade	Basic mass ^{a)} g	Formula ^{b)}
SUS304TB, SUS304HTB, SUS304LTB, SUS321TB, SUS321HTB	7.93	$W=0.024\ 91\ t\ (D-t)$
SUS309TB, SUS309STB, SUS310TB, SUS310STB, SUS315J1TB, SUS315J2TB, SUS316TB, SUS316HTB, SUS316LTB, SUS316TiTB, SUS317TB, SUS317LTB, SUS347TB, SUS347HTB	7.98	$W=0.025\ 07\ t\ (D-t)$
SUS821L1TB, SUS323LTB, SUS329J1TB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB	7.80	$W=0.024\ 50\ t\ (D-t)$
SUS430TB, SUS430LXTB, SUS430J1LTB, SUS436LTB, SUSXM8TB	7.70	$W=0.024\ 19\ t\ (D-t)$
SUS405TB, SUS409TB, SUS409LTB, SUS410TB, SUS410TiTB, SUS444TB, SUSXM15J1TB	7.75	$W=0.024\ 35\ t\ (D-t)$
SUSXM27TB	7.67	$W=0.024\ 10\ t\ (D-t)$
SUS836LTB	8.06	$W=0.025\ 32\ t\ (D-t)$
SUS890LTB	8.05	$W=0.025\ 29\ t\ (D-t)$
SUS312LTB	8.03	$W=0.025\ 23\ t\ (D-t)$

Notes ^{a)} Basic mass is the mass of 1 cm³ of steel.

^{b)} Symbols used for the formulae are as follows.

W: unit mass of tube (kg/m), *t*: wall thickness of tube (mm), *D*: outside diameter of tube (mm)

The factor used for each formula is the unit conversion factor.

9.2 Dimensional tolerances

The dimensional tolerances for tubes shall be as follows.

- The tolerances on outside diameter of tubes shall be as given in Table 16.
- The tolerances on wall thickness and eccentricity of tubes shall be as given in Table 17. For the tolerance on wall thickness in the weld for tubes manufactured by automatic arc welding, the lower limit of tolerance on wall thickness as given in Table 17 shall apply and the upper limit of tolerance shall be in accordance with 9.3.
- The tolerances on length of tubes shall be as given in Table 18.

Table 16 Tolerances on outside diameter ^{a)}

Unit: mm

Outside diameter range	Hot-finished seamless steel tube	Cold-finished seamless steel tube	Automatic arc welded steel tube Laser welded steel tube Electric resistance welded steel tube
Under 40	+ 0.4 − 0.8	± 0.25 ^{b) c)}	± 0.25 ^{b) c)}
40 or over to and excl. 50			
50 or over to and excl. 60			
60 or over to and excl. 80			
80 or over to and excl. 100			
100 or over to and excl. 120	+ 0.4 − 1.2	+ 0.40 − 0.60	+ 0.40 − 0.60
120 or over to and excl. 160		+ 0.40 − 0.80	+ 0.40 − 0.80
160 or over to and excl. 200	+ 0.4 − 1.8	+ 0.40 − 1.20	+ 0.40 − 1.20
200 or over	+ 0.4 − 2.4	+ 0.40 − 1.60	+ 0.40 − 1.60
Notes ^{a)} The tolerances on outside diameter in this table do not apply to local repaired parts. ^{b)} The tolerances on outside diameter for ferritic cold-finished seamless steel tubes, automatic arc welded steel tubes, laser welded steel tubes, and electric resistance welded steel tubes shall be ± 0.10 mm for tubes of outside diameter under 25 mm, ± 0.15 mm for tubes of outside diameter 25 mm or over to and excluding 40 mm, and ± 0.20 mm for tubes of outside diameter 40 mm or over to and excluding 50 mm. ^{c)} The purchaser may specify the tolerance on outside diameter to be ± 0.20 mm for cold-finished seamless steel tubes, automatic arc welded steel tubes, laser welded steel tubes and electric resistance welded steel tubes of outside diameter under 40 mm.			

Table 17 Tolerances on wall thickness and eccentricity

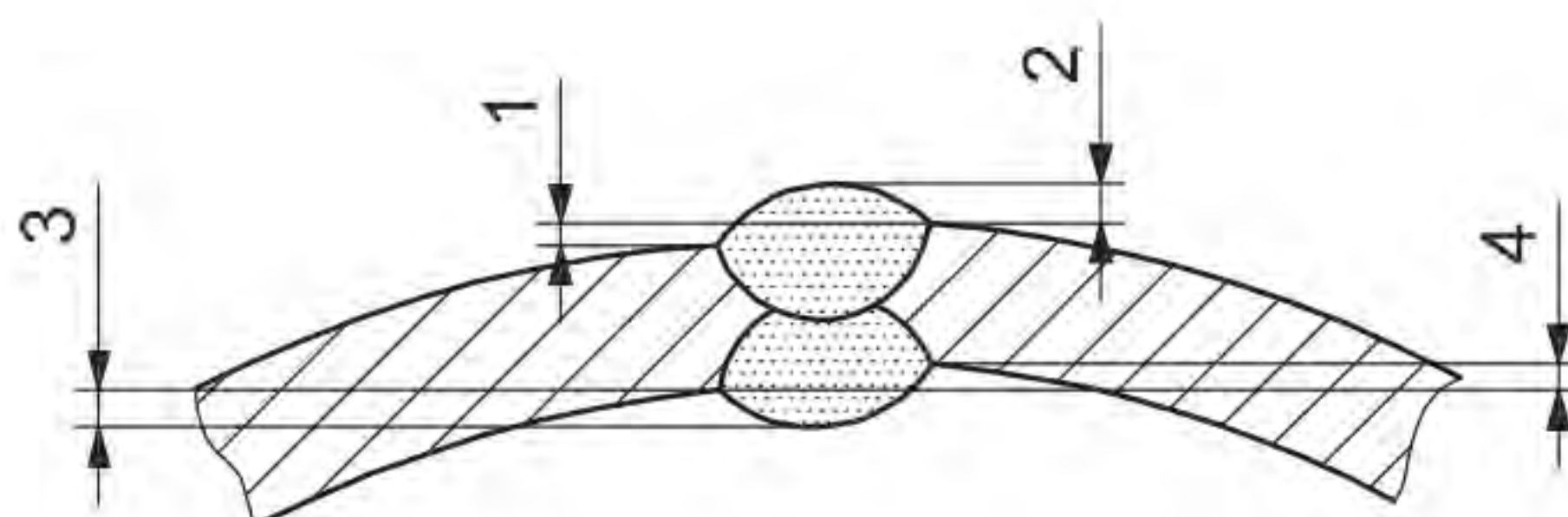
Classification of tolerance	Wall thickness mm	Hot-finished seamless steel tube		Cold-finished seamless steel tube		Automatic arc welded steel tube Laser welded steel tube Electric resistance welded steel tube	
		Outside diameter mm					
		Under 100	100 or over	Under 40	40 or over	Under 40	40 or over
Tolerance on wall thickness	Under 2	a) 0	a) 0	+ 0.4 mm 0	+ 22 % 0	+ 0.4 mm 0	+ 22 % 0
	2 or over to and excl. 2.4	+ 40 % 0	a) 0	+ 20 % 0		+ 20 % 0	
	2.4 or over to and excl. 3.8	+ 35 % 0	+ 35 % 0				
	3.8 or over to and excl. 4.6	+ 33 % 0	+ 33 % 0				
	4.6 or over	+ 28 % 0	+ 28 % 0				
Tolerance on eccentricity ^{b)}	5.6 or over	22.8 % max. of wall thickness		—		—	
Notes ^{a)} The plus tolerance is not specified. ^{b)} Eccentricity is expressed by the ratio, in percentage, of the difference between the maximum value and the minimum value of the wall thickness measured on the same cross-section of the tube to the wall thickness value specified in the order. This requirement does not apply to tubes under 5.6 mm in wall thickness.							

Table 18 Tolerances on length

Range		Tolerance on length
Outside diameter 50 mm or under	Length 7 m or under	+ 7 mm 0
	Length over 7 m	Add 3 mm to the plus tolerance above for each increase of 3 m or its fraction in length. The maximum value of the plus tolerance shall be +15 mm.
Outside diameter over 50 mm	Length 7 m or under	+ 10 mm 0
	Length over 7 m	Add 3 mm to the plus tolerance above for each increase of 3 m or its fraction in length. The maximum value of the plus tolerance shall be +15 mm.
The tolerances on length may be +30 mm and 0 mm upon agreement between the purchaser and the manufacturer.		

9.3 Weld bead height

For tubes manufactured by automatic arc welding, the height of weld beads on external and internal surfaces, measured from the adjacent steel tube surface, shall not be greater than 3.0 mm. For steel strips or steel plates with radial offset of edges, the heights of weld beads shall be measured as shown in Figure 1.



Key

- 1 outside radial offset
- 2 height of outer weld bead
- 3 height of inner weld bead
- 4 inside radial offset

Figure 1 Height of weld bead with radial offset

10 Appearance

Appearance shall be as follows.

- a) Tubes shall be straight for practical purposes with both ends at right angles to the tube axis.
- b) The inside and outside surfaces of tubes shall be finished smoothly and free from defects detrimental to use.
- c) The surfaces of tubes may be repaired by grinding, machining or other methods, provided that the wall thickness after repair is within the specified tolerance on wall thickness.
- d) The surface of the repaired part shall be smooth along the contour of the tube.

11 Supplementary quality requirements and U-bent tubes

The supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer, and the requirements for U-bent tubes that are applied when specified by the purchaser, are given in Annex JA and Annex JB, respectively.

12 Tests

12.1 Chemical analysis

12.1.1 General requirements and sampling method

General requirements for analysis and the sampling method for heat analysis shall be in accordance with Clause 8 of JIS G 0404. When the product analysis is requested by the purchaser, the sampling method for product analysis shall be in accordance with Clause 4 of JIS G 0321.

12.1.2 Analysis method

The heat analysis method shall be in accordance with JIS G 0320. The product analysis method shall be in accordance with JIS G 0321.

12.2 Mechanical tests

12.2.1 General

General requirements for mechanical tests shall be in accordance with Clauses 7 and 9 of **JIS G 0404**. However, the sampling method for mechanical tests shall be in accordance with Class A in 7.6 of **JIS G 0404**.

12.2.2 Sampling method and number of test pieces

One sample shall be taken from each group of 50 tubes or its fraction that are of the same dimensions and of the same heat treatment batch. From each sample thus obtained, one tensile test piece, one flattening test piece, one flaring test piece and one austenitic grain size test piece shall be taken. The term “same dimensions” refers to the same outside diameter and the same wall thickness. The “same heat treatment batch” of continuous furnace refers to a group of tubes from continuous furnace operation under consistent heat treating conditions. Tubes which are heat treated after any stop of furnace operation do not belong to the same heat treatment batch. In the case of sampling from a group of tubes from the same cast, the term “same heat treatment batch” may be replaced with “same heat treatment conditions”.

In addition, for automatic arc welded steel tubes, laser welded steel tubes and electric resistance welded steel tubes, one sample shall be taken from each group of 100 tubes or its fraction that are of the same dimensions and of the same heat treatment batch. From each sample thus obtained, one reverse flattening test piece shall be taken.

12.2.3 Tensile test

The tensile test piece and the test method shall be as follows.

- a) **Test piece** The test piece shall be either Test piece No. 11 or No. 12 (12A, 12B or 12C) specified in **JIS Z 2241** and shall be taken from the sample in the direction parallel to tube axis. Test piece No. 12 shall be used for the testing of tubes of outside diameter 20 mm or over.

Test piece No. 12A, 12B or 12C for the tensile test of automatic arc welded steel tubes, laser welded steel tubes and electric resistance welded steel tubes shall be taken from a portion not containing the weld.

- b) **Test method** The test method shall be in accordance with **JIS Z 2241**.

12.2.4 Flattening test

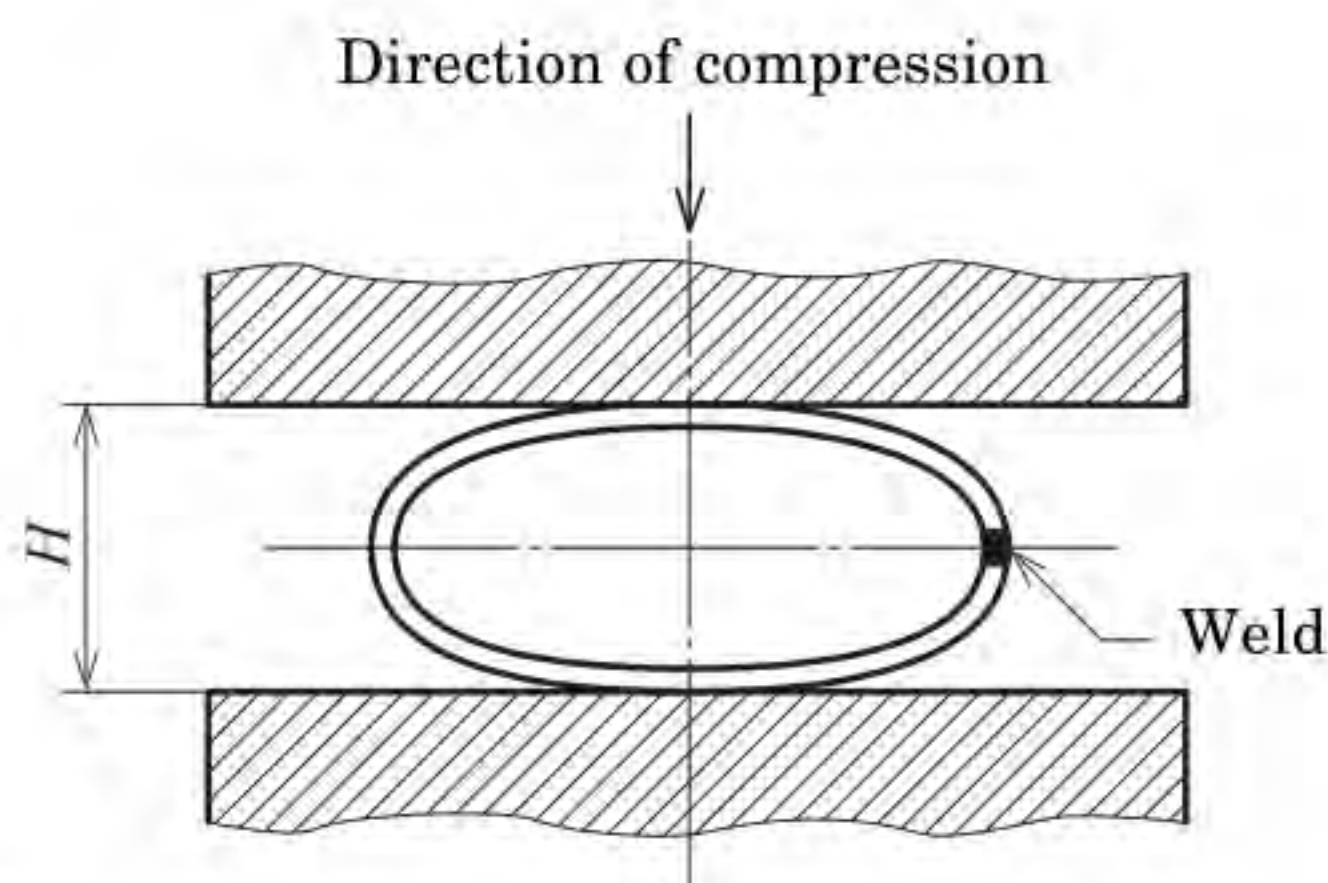
The flattening test piece and the test method shall be as follows.

The flattening test for seamless steel tubes may be omitted unless otherwise specified by the purchaser¹⁾.

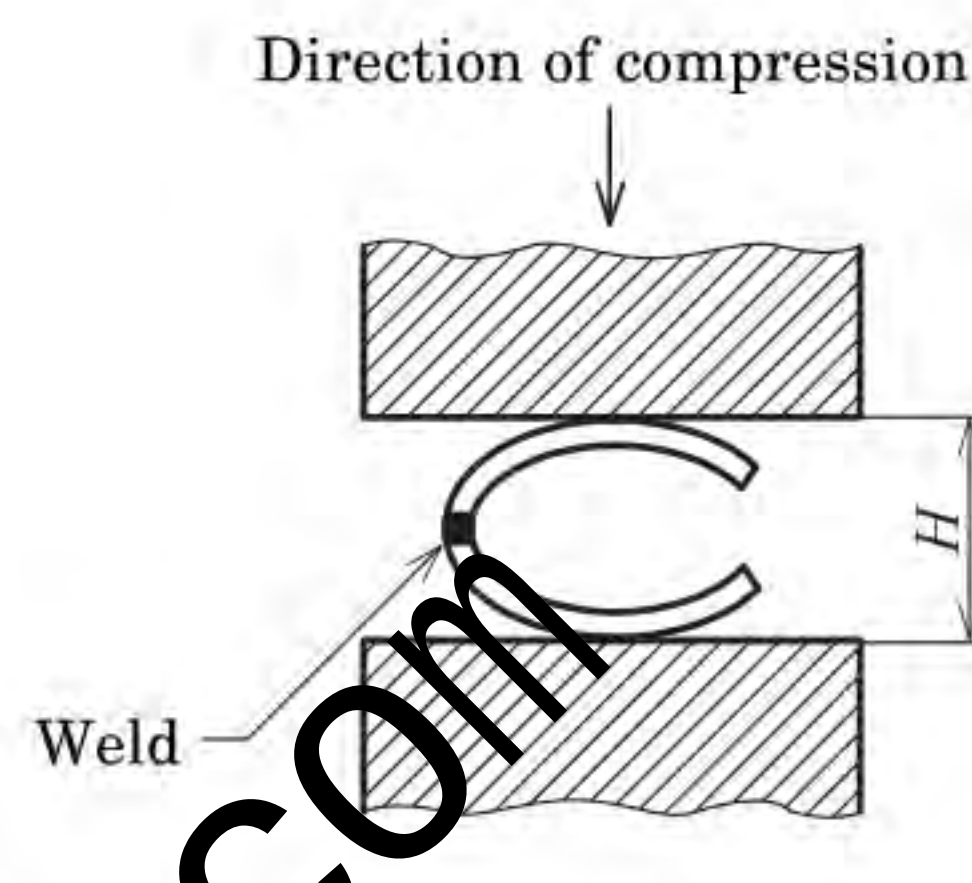
Note ¹⁾ This means that the flattening test may be omitted at the discretion of the manufacturer, provided that the tubes satisfy the specified flattening resistance.

- a) **Test piece** The test piece shall be of at least 50 mm in length. For tubes of wall thickness 15 % or over of the outside diameter, C-shaped test piece prepared by removing a part of the circumference of a ring-shaped test piece may be used.

- b) **Test method** Place the test piece between two platens at ordinary temperature (5 °C to 35 °C), compress to flatten until the distance H between the two platens reaches the value specified in 6.2, and then examine the test piece for cracks. For testing the automatic arc welded steel tube, laser welded steel tube and electric resistance welded steel tube, place the test piece, as shown in Figure 2, such that the line connecting the weld and the centre of the tube is perpendicular to the direction of compression. The C-shaped test piece shall be placed as shown in Figure 3.



**Figure 2 Flattening test
(ring-shaped test piece)**



**Figure 3 Flattening test
(C-shaped test piece)**

12.2.5 Flaring test

The flaring test piece and the test method shall be as follows.

The flaring test for seamless steel tubes may be omitted unless otherwise specified by the purchaser²⁾.

Note ²⁾ This means that the flaring test may be omitted at the discretion of the manufacturer, provided that the tubes satisfy the specified flaring property.

- a) **Test piece** The test piece shall be of the proper length for the flaring test.
- b) **Test method** Place one end of the test piece at ordinary temperature (5 °C to 35 °C) into a trumpet shape with a conical tool having a 60° angle until the outside diameter is enlarged to the size specified in 6.3, and examine for cracks.

12.2.6 Reverse flattening test

The reverse flattening test piece and the test method shall be as follows.

When flaring test is performed, the reverse flattening test may be omitted unless otherwise specified by the purchaser³⁾.

Note ³⁾ This means that the reverse flattening test may be omitted at the discretion of the manufacturer, provided that the tubes satisfy the specified reverse flattening resistance.

- a) **Test piece** Cut off a sample having a length of 100 mm from one end of the tube. Cut this sample into half at a position circumferentially displaced by 90° from the weld line to both sides, and take one of the split halves which contains the weld as a test piece.

- b) **Test method** Flatten the test piece out into a plate shape at ordinary temperature (5 °C to 35 °C) with the weld line at the top and examine if any cracks are present in the weld of the test piece.

12.3 Austenitic grain size test

The austenitic grain size test shall be as follows.

- a) **Test piece** Cut off a test piece having a length of about 20 mm from one end of the tube.
- b) **Test method** The test method shall be in accordance with **JIS G 0551** unless otherwise specified.

12.4 Hydraulic test or non-destructive test

Either the hydraulic test or the non-destructive test described below shall be carried out.

- a) **Frequency of test** Either the hydraulic test or the non-destructive test shall be carried out on each tube.
- b) **Test method** The method of hydraulic test or non-destructive test shall be as follows.
- 1) **Hydraulic test** Apply to the tube the minimum or higher hydraulic test pressure specified in Clause 8 a), hold for at least 5 s, and then examine if the tube withstands the pressure without leakage.
 - 2) **Non-destructive test** The non-destructive test methods shall be as follows. When other non-destructive tests specified in relevant **JISs** are carried out upon agreement between the purchaser and the manufacturer, the test method shall be in accordance with the **JIS** to be applied.
 - 2.1) The ultrasonic examination shall be in accordance with the method specified in **JIS G 0582**. The test may be carried out by a category of reference standard stricter than Category UD. The alarm level may be set lower than signals from the reference standard at the discretion of the manufacturer.
 - 2.2) The eddy current examination shall be in accordance with the method specified in **JIS G 0583**. The test may be carried out by a category of reference standard stricter than Category EY. The alarm level may be set lower than signals from the reference standard at the discretion of the manufacturer.

13 Inspection and reinspection

13.1 Inspection

The inspection shall be as follows.

- a) General requirements for inspection shall be in accordance with **JIS G 0404**.
- b) The chemical composition shall conform to the requirements specified in Clause 5.
- c) The mechanical properties shall conform to the requirements specified in Clause 6.

- d) The austenitic grain size of SUS321HTB tubes shall conform to the requirements specified in Clause 7.
- e) The hydraulic test characteristics or non-destructive test characteristics shall conform to the requirements specified in Clause 8.
- f) The dimensions shall conform to the requirements given in Clause 9.
- g) The appearance shall conform to the requirements given in Clause 10.
- h) When the supplementary quality requirements are applied upon agreement between the purchaser and the manufacturer, and/or the requirements for U-bent tubes to be applied are specified by the purchaser, the inspection results shall conform to the requirements specified in Clause 11.

13.2 Reinspection

The tubes having failed in the mechanical tests may be subjected to a retest according to 9.8 of JIS G 0404 for further acceptance judgement.

14 Marking

Each tube having passed the inspection shall be marked with the following items. When the marking on each tube is difficult due to its small outside diameter or when so requested by the purchaser, the marking may be given on each bundle of tubes by a suitable means. The order of items to be marked is not specified. A part of the following items may be omitted upon agreement between the purchaser and the manufacturer as far as the product can still be identified.

- a) Symbol of grade
- b) Symbol for manufacturing method

Symbols indicating the manufacturing method shall be as follows. The dash (“—”) may be replaced with a blank.

Hot-finished seamless steel tube —S—H

Cold-finished seamless steel tube —S—C

Automatic arc welded steel tube —A

Cold-finished automatic arc welded steel tube —A—C

Weld work finished automatic arc welded steel tube —A—B

Laser welded steel tube —L

Cold-finished laser welded steel tube —L—C

Weld work finished laser welded steel tube —L—B

As electric resistance welded steel tube —E—G

Cold-finished electric resistance welded steel tube —E—C

- c) Dimensions: outside diameter and wall thickness
- d) Manufacturer's name or identifying brand
- e) Symbol Z indicating the supplementary quality requirements (if specified)

15 Report

Unless otherwise specified, the manufacturer shall submit the inspection documents to the purchaser. The report shall be in accordance with Clause 13 of JIS G 0404. Unless otherwise specified at the time of ordering, the type of inspection document to be submitted shall be in accordance with 5.1 of JIS G 0415.

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Table 6 Outside diameters, wall thicknesses and unit masses of SUS304TB, SUS304HTB, SUS304LTB, SUS321TB and SUS321HTB

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																			
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5	
15.9	0.439	0.570	0.692	0.779	0.861	0.939														
19.0	0.532	0.693	0.847	0.957	1.06	1.16														
21.7	0.613	0.801	0.981	1.11	1.24	1.36	1.47													
25.4	0.723	0.949	1.17	1.32	1.48	1.63	1.77	1.91												
27.2	0.777	1.02	1.26	1.43	1.59	1.76	1.91	2.07	2.31											
31.8	0.915	1.20	1.48	1.69	1.89	2.09	2.28	2.47	2.77	3.06										
34.0		1.29	1.59	1.82	2.03	2.25	2.46	2.66	2.99	3.31	3.61									
38.1		1.45	1.80	2.05	2.30	2.54	2.78	3.02	3.40	3.77	4.12	4.47								
42.7			2.03	2.31	2.60	2.88	3.15	3.42	3.86	4.28	4.70	5.10	5.49							
45.0			2.14	2.45	2.75	3.04	3.33	3.62	4.09	4.54	4.98	5.41	5.83	6.23						
48.6			2.32	2.65	2.98	3.30	3.62	3.93	4.44	4.94	5.43	5.90	6.37	6.82	7.25					
50.8			2.43	2.78	3.12	3.46	3.79	4.12	4.66	5.19	5.70	6.21	6.70	7.17	7.64	8.53	9.77	10.9	11.9	
54.0			2.59	2.96	3.33	3.69	4.05	4.40	4.98	5.55	6.10	6.64	7.17	7.69	8.20	9.17	10.5	11.8	12.9	
57.1			2.75	3.14	3.53	3.92	4.30	4.67	5.29	5.80	6.29	6.77	7.07	7.64	8.19	8.74	9.78	11.3	12.6	13.9
60.3			2.90	3.32	3.74	4.15	4.55	4.95	5.61	6.05	6.49	6.89	7.51	8.12	8.71	9.29	10.4	12.0	13.5	14.9
63.5				3.51	3.94	4.38	4.81	5.23	5.93	6.61	7.29	7.95	8.59	9.23	9.85	11.1	12.8	14.4	15.9	
65.0				3.59	4.04	4.49	4.93	5.36	6.08	6.78	7.47	8.15	8.82	9.47	10.1	11.4	13.1	14.8	16.3	
70.0				3.88	4.37	4.85	5.32	5.79	6.53	7.34	8.10	8.84	9.57	10.3	11.0	12.4	14.3	16.2	17.9	
76.2				4.23	4.77	5.30	5.82	6.34	7.19	8.04	8.87	9.69	10.5	11.3	12.1	13.6	15.8	17.9	19.8	
82.6							6.33	6.90	7.83	8.75	9.67	10.6	11.4	12.3	13.2	14.9	17.3	19.6	21.8	
88.9							6.83	7.45	8.46	9.46	10.4	11.4	12.4	13.3	14.3	16.1	18.8	21.3	23.8	
101.6								8.55	9.72	10.9	12.0	13.2	14.3	15.4	16.5	18.7	21.8	24.8	27.7	
114.3									11.0	12.3	13.6	14.9	16.2	17.5	18.7	21.2	24.8	28.3	31.7	
127.0									12.3	13.7	15.2	16.6	18.1	19.5	20.9	23.7	27.8	31.8	35.7	
139.8													18.4	20.0	21.6	23.2	26.3	30.8	35.3	39.6

Table 7 Outside diameters, wall thicknesses and unit masses of SUS309TB, SUS309STB, SUS310TB, SUS310STB, SUS315J1TB, SUS315J2TB, SUS316TB, SUS316HTB, SUS316LTB, SUS316TiTB, SUS317TB, SUS317LTB, SUS347TB and SUS347HTB

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.442	0.574	0.697	0.784	0.867	0.945													
19.0	0.535	0.698	0.852	0.963	1.07	1.17													
21.7	0.617	0.806	0.988	1.12	1.24	1.37	1.48												
25.4	0.728	0.955	1.17	1.33	1.49	1.64	1.78	1.92											
27.2	0.782	1.03	1.26	1.44	1.60	1.77	1.93	2.08	2.33										
31.8	0.921	1.21	1.49	1.70	1.90	2.10	2.29	2.48	2.79	3.08									
34.0		1.30	1.60	1.83	2.05	2.26	2.47	2.68	3.01	3.33	3.64								
38.1		1.46	1.81	2.06	2.31	2.56	2.80	3.04	3.42	3.79	4.15	4.50							
42.7			2.04	2.33	2.61	2.89	3.17	3.44	3.88	4.31	4.73	5.13	5.52						
45.0			2.16	2.46	2.76	3.06	3.35	3.64	4.11	4.57	5.01	5.45	5.87	6.27					
48.6			2.34	2.67	3.00	3.32	3.64	3.96	4.47	4.98	5.47	5.94	6.41	6.86	7.30				
50.8			2.45	2.80	3.14	3.48	3.82	4.15	4.69	5.22	5.74	6.25	6.74	7.22	7.69	8.58	9.84	11.0	12.0
54.0			2.61	2.98	3.35	3.72	4.08	4.43	5.01	5.58	6.14	6.69	7.22	7.74	8.25	9.23	10.6	11.9	13.0
57.1			2.76	3.16	3.55	3.94	4.32	4.70	5.32	5.93	6.53	7.11	7.69	8.25	8.79	9.85	11.3	12.7	14.0
60.3			2.92	3.34	3.76	4.17	4.58	4.98	5.65	6.30	6.93	7.56	8.17	8.77	9.35	10.5	12.1	13.6	15.0
63.5				3.53	3.97	4.41	4.84	5.26	5.97	6.66	7.33	8.00	8.65	9.29	9.92	11.1	12.9	14.5	16.0
65.0				3.62	4.07	4.51	4.96	5.40	6.12	6.83	7.52	8.20	8.87	9.53	10.2	11.4	13.2	14.9	16.5
70.0				3.90	4.39	4.88	5.36	5.84	6.62	7.39	8.15	8.89	9.63	10.3	11.1	12.4	14.4	16.3	18.0
76.2				4.26	4.80	5.33	5.86	6.38	7.24	8.09	8.92	9.75	10.6	11.4	12.1	13.7	15.9	18.0	20.0
82.6							6.88	7.49	8.51	9.52	10.5	11.5	12.5	13.4	14.4	16.2	18.9	21.5	23.9
88.9								8.61	9.79	11.0	12.1	13.3	14.4	15.5	16.6	18.8	21.9	25.0	27.9
101.6									11.1	12.4	13.7	15.0	16.3	17.6	18.8	21.3	25.0	28.5	31.9
114.3									12.3	13.8	15.3	16.8	18.2	19.6	21.1	23.9	28.0	32.0	35.9
127.0												18.5	20.1	21.7	23.3	26.4	31.0	35.5	39.9
139.8																			

**Table 8 Outside diameters, wall thicknesses and unit masses of
SUS821L1TB, SUS323LTB, SUS329J1TB, SUS329J3LTB,
SUS329J4LTB and SUS327L1TB**

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																			
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5	
15.9	0.432	0.561	0.681	0.766	0.847	0.924														
19.0	0.523	0.682	0.833	0.941	1.04	1.14														
21.7	0.603	0.788	0.965	1.09	1.22	1.34	1.45													
25.4	0.711	0.933	1.15	1.30	1.45	1.60	1.74	1.88												
27.2	0.764	1.00	1.23	1.40	1.57	1.73	1.88	2.03	2.27											
31.8	0.900	1.18	1.46	1.66	1.86	2.05	2.24	2.43	2.72	3.01										
34.0		1.27	1.57	1.79	2.00	2.21	2.41	2.62	2.94	3.25	3.55									
38.1		1.43	1.77	2.02	2.26	2.50	2.74	2.97	3.34	3.70	4.05	4.39								
42.7			1.99	2.28	2.55	2.83	3.10	3.36	3.79	4.21	4.62	5.01	5.39							
45.0			2.11	2.41	2.70	2.99	3.28	3.56	4.02	4.47	4.90	5.32	5.73	6.13						
48.6			2.28	2.61	2.93	3.25	3.56	3.87	4.37	4.86	5.34	5.81	6.26	6.70	7.13					
50.8			2.39	2.73	3.07	3.40	3.73	4.06	4.59	5.10	5.61	6.10	6.59	7.05	7.51	8.39	9.61	10.7	11.7	
54.0			2.55	2.91	3.27	3.63	3.98	4.33	4.90	5.46	6.00	6.54	7.06	7.56	8.06	9.02	10.4	11.6	12.7	
57.1			2.70	3.09	3.47	3.85	4.23	4.60	5.20	5.80	6.38	6.95	7.51	8.06	8.59	9.62	11.1	12.4	13.7	
60.3			2.86	3.27	3.68	4.08	4.48	4.87	5.52	6.15	6.77	7.38	7.98	8.57	9.14	10.3	11.8	13.3	14.6	
63.5				3.45	3.88	4.31	4.72	5.13	5.83	6.50	7.17	7.82	8.45	9.08	9.69	10.9	12.6	14.1	15.6	
65.0				3.53	3.97	4.41	4.85	5.27	5.97	6.67	7.35	8.02	8.67	9.32	9.95	11.2	12.9	14.6	16.1	
70.0				3.81	4.29	4.77	5.24	5.70	6.47	7.22	7.96	8.69	9.41	10.1	10.8	12.2	14.1	15.9	17.6	
76.2				4.16	4.69	5.22	5.72	6.23	7.08	7.90	8.72	9.53	10.3	11.1	11.9	13.4	15.5	17.6	19.5	
82.6							6.22	6.78	7.70	8.61	9.51	10.4	11.3	12.1	13.0	14.6	17.0	19.3	21.5	
88.9							6.72	7.32	8.32	9.31	10.3	11.2	12.2	13.1	14.0	15.9	18.5	21.0	23.4	
101.6								8.41	9.56	10.7	11.8	12.9	14.1	15.1	16.2	18.3	21.4	24.4	27.3	
114.3									10.8	12.1	13.4	14.7	15.9	17.2	18.4	20.8	24.4	27.8	31.2	
127.0									12.1	13.5	14.9	16.4	17.8	19.2	20.6	23.3	27.3	31.3	35.1	
139.8												18.1	19.7	21.2	22.8	25.8	30.3	34.7	39.0	

Table 9 Outside diameters, wall thicknesses and unit masses of SUS430TB, SUS430LXTB, SUS430J1LTB, SUS436LTB and SUSXM8TB

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.427	0.553	0.672	0.757	0.836	0.912													
19.0	0.517	0.673	0.822	0.929	1.03	1.13													
21.7	0.595	0.778	0.953	1.08	1.20	1.32	1.43												
25.4	0.702	0.921	1.13	1.29	1.43	1.58	1.72	1.85											
27.2	0.755	0.991	1.22	1.39	1.55	1.70	1.86	2.01	2.24										
31.8	0.888	1.17	1.44	1.64	1.84	2.03	2.21	2.40	2.69	2.97									
34.0		1.25	1.55	1.76	1.97	2.18	2.38	2.58	2.90	3.21	3.51								
38.1		1.41	1.75	1.99	2.23	2.47	2.70	2.93	3.30	3.66	4.00	4.34							
42.7			1.97	2.25	2.52	2.79	3.06	3.32	3.74	4.16	4.56	4.95	5.33						
45.0			2.08	2.38	2.67	2.95	3.24	3.51	3.97	4.41	4.84	5.26	5.66	6.05					
48.6			2.25	2.58	2.89	3.21	3.51	3.82	4.32	4.80	5.27	5.73	6.18	6.62	7.04				
50.8			2.36	2.70	3.03	3.36	3.68	4.00	4.53	5.04	5.54	6.03	6.50	6.97	7.42	8.28	9.49	10.6	11.6
54.0			2.52	2.88	3.23	3.58	3.93	4.28	4.84	5.39	5.93	6.45	6.97	7.47	7.96	8.90	10.2	11.4	12.5
57.1			2.67	3.05	3.43	3.80	4.17	4.54	5.14	5.73	6.28	6.87	7.42	7.96	8.48	9.50	10.9	12.3	13.5
60.3			2.82	3.23	3.63	4.03	4.42	4.81	5.45	6.07	6.69	7.29	7.88	8.46	9.03	10.1	11.7	13.1	14.5
63.5				3.40	3.83	4.25	4.67	5.08	5.76	6.42	7.08	7.72	8.35	8.96	9.57	10.7	12.4	14.0	15.4
65.0				3.49	3.92	4.36	4.78	5.21	5.90	6.59	7.26	7.92	8.56	9.20	9.82	11.0	12.8	14.4	15.9
70.0				3.77	4.24	4.71	5.17	5.63	6.38	7.16	7.86	8.58	9.29	9.98	10.7	12.0	13.9	15.7	17.4
76.2				4.11	4.63	5.14	5.65	6.16	6.99	7.80	8.61	9.41	10.2	11.0	11.7	13.2	15.3	17.3	19.3
82.6							6.15	6.70	7.61	8.50	9.39	10.3	11.1	12.0	12.8	14.4	16.8	19.1	21.2
88.9							6.73	7.23	8.21	9.19	10.1	11.1	12.0	13.0	13.9	15.7	18.2	20.7	23.1
101.6							8.31	9.44	10.6	11.7	12.8	13.9	15.0	16.0	18.1	21.2	24.1	26.9	
114.3									10.7	12.0	13.2	14.5	15.7	16.9	18.2	20.6	24.1	27.5	30.8
127.0									11.9	13.3	14.8	16.2	17.6	18.9	20.3	23.0	27.0	30.9	34.6
139.8												17.9	19.4	21.0	22.5	25.5	29.9	34.3	38.5

Table 10 Outside diameters, wall thicknesses and unit masses of SUS405TB, SUS409TB, SUS409LTB, SUS410TB, SUS410TiTB, SUS444TB and SUSXM15J1TB

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																			
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5	
15.9	0.430	0.557	0.677	0.762	0.842	0.918														
19.0	0.520	0.678	0.828	0.935	1.04	1.14														
21.7	0.599	0.783	0.960	1.09	1.21	1.33	1.44													
25.4	0.707	0.927	1.14	1.29	1.44	1.59	1.73	1.87												
27.2	0.760	0.997	1.23	1.39	1.56	1.72	1.87	2.02	2.26											
31.8	0.894	1.18	1.45	1.65	1.85	2.04	2.23	2.41	2.71	2.99										
34.0		1.26	1.56	1.78	1.99	2.20	2.40	2.60	2.92	3.23	3.53									
38.1		1.42	1.76	2.00	2.25	2.49	2.72	2.95	3.32	3.68	4.03	4.37								
42.7			1.98	2.26	2.54	2.81	3.08	3.34	3.77	4.19	4.59	4.98	5.36							
45.0			2.09	2.39	2.68	2.97	3.26	3.54	3.99	4.44	4.87	5.29	5.70	6.09						
48.6			2.27	2.59	2.91	3.23	3.54	3.84	4.34	4.83	5.31	5.77	6.22	6.66	7.09					
50.8			2.38	2.72	3.05	3.38	3.71	4.03	4.56	5.07	5.56	6.07	6.55	7.01	7.47	8.34	9.55	10.7	11.7	
54.0			2.53	2.90	3.25	3.61	3.96	4.30	4.87	5.42	5.97	6.50	7.01	7.52	8.01	8.96	10.3	11.5	12.6	
57.1			2.68	3.07	3.45	3.83	4.20	4.57	5.17	5.76	6.34	6.91	7.47	8.01	8.54	9.56	11.0	12.3	13.6	
60.3			2.84	3.25	3.65	4.05	4.45	4.84	5.46	6.11	6.73	7.34	7.93	8.52	9.08	10.2	11.8	13.2	14.5	
63.5				3.43	3.86	4.28	4.70	5.11	5.70	6.46	7.12	7.77	8.40	9.02	9.63	10.8	12.5	14.1	15.5	
65.0				3.51	3.95	4.39	4.82	5.24	5.92	6.63	7.31	7.97	8.62	9.26	9.89	11.1	12.8	14.5	16.0	
70.0				3.79	4.27	4.74	5.21	5.67	6.43	7.18	7.91	8.64	9.35	10.1	10.7	12.1	14.0	15.8	17.5	
76.2				4.14	4.66	5.17	5.69	6.20	7.03	7.86	8.67	9.47	10.3	11.0	11.8	13.3	15.4	17.5	19.4	
82.6							6.19	6.74	7.66	8.56	9.45	10.3	11.2	12.0	12.9	14.5	16.9	19.2	21.3	
88.9							6.68	7.28	8.27	9.25	10.2	11.2	12.1	13.0	14.0	15.8	18.4	20.9	23.3	
101.6								8.36	9.51	10.6	11.8	12.9	14.0	15.1	16.1	18.2	21.3	24.3	27.1	
114.3									10.7	12.0	13.3	14.6	15.8	17.1	18.3	20.7	24.2	27.7	31.0	
127.0									12.0	13.4	14.9	16.3	17.7	19.1	20.5	23.2	27.2	31.1	34.9	
139.8													18.0	19.5	21.1	22.6	25.7	30.1	34.5	38.7

Table 11 Outside diameters, wall thicknesses and unit masses of SUSXM27TB

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.425	0.551	0.670	0.754	0.833	0.909													
19.0	0.515	0.671	0.819	0.926	1.03	1.13													
21.7	0.593	0.775	0.950	1.08	1.20	1.31	1.43												
25.4	0.700	0.918	1.13	1.28	1.43	1.57	1.71	1.85											
27.2	0.752	0.987	1.21	1.38	1.54	1.70	1.85	2.00	2.24										
31.8	0.885	1.16	1.44	1.64	1.83	2.02	2.21	2.39	2.68	2.96									
34.0		1.25	1.54	1.76	1.97	2.17	2.38	2.57	2.89	3.20	3.49								
38.1		1.41	1.74	1.98	2.22	2.46	2.69	2.92	3.29	3.64	3.99	4.32							
42.7			1.96	2.24	2.51	2.78	3.05	3.31	3.73	4.14	4.54	4.93	5.31						
45.0			2.07	2.37	2.66	2.94	3.22	3.50	3.95	4.39	4.82	5.24	5.64	6.03					
48.6			2.25	2.57	2.88	3.19	3.50	3.80	4.30	4.78	5.25	5.71	6.16	6.59	7.02				
50.8			2.35	2.69	3.02	3.35	3.67	3.99	4.51	5.02	5.52	6.00	6.48	6.94	7.39	8.25	9.46	10.6	11.5
54.0			2.51	2.87	3.22	3.57	3.92	4.26	4.82	5.37	5.90	6.43	6.94	7.44	7.93	8.87	10.2	11.4	12.5
57.1			2.66	3.04	3.41	3.79	4.16	4.52	5.12	5.70	6.28	6.84	7.39	7.93	8.45	9.47	10.9	12.2	13.4
60.3			2.81	3.21	3.62	4.01	4.40	4.79	5.43	6.05	6.66	7.26	7.85	8.43	8.99	10.1	11.6	13.1	14.4
63.5				3.39	3.82	4.24	4.65	5.06	5.74	6.40	7.05	7.69	8.31	8.93	9.53	10.7	12.4	13.9	15.4
65.0				3.48	3.91	4.34	4.77	5.19	5.88	6.55	7.23	7.89	8.53	9.16	9.78	11.0	12.7	14.3	15.8
70.0				3.75	4.22	4.69	5.15	5.61	6.35	7.10	7.83	8.55	9.25	9.95	10.6	12.0	13.9	15.6	17.3
76.2				4.10	4.61	5.12	5.63	6.13	6.96	7.78	8.58	9.37	10.2	10.9	11.7	13.1	15.3	17.3	19.2
82.6							6.12	6.67	7.58	8.47	9.35	10.2	11.1	11.9	12.8	14.4	16.7	19.0	21.1
88.9							6.71	7.20	8.18	9.15	10.1	11.1	12.0	12.9	13.8	15.6	18.2	20.7	23.0
101.6								8.27	9.41	10.5	11.6	12.7	13.8	14.9	16.0	18.0	21.1	24.0	26.8
114.3									10.6	11.9	13.2	14.4	15.7	16.9	18.1	20.5	24.0	27.4	30.7
127.0									11.9	13.3	14.7	16.1	17.5	18.9	20.2	22.9	26.9	30.8	34.5
139.8												17.8	19.3	20.9	22.4	25.4	29.8	34.1	38.3

**Table 12 Outside diameters, wall thicknesses and unit masses of
SUS836LTB**

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																			
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5	
15.9	0.447	0.579	0.703	0.792	0.876	0.955														
19.0	0.541	0.705	0.861	0.973	1.08	1.18														
21.7	0.623	0.814	0.998	1.13	1.26	1.38	1.50													
25.4	0.735	0.964	1.18	1.35	1.50	1.65	1.80	1.94												
27.2	0.790	1.04	1.28	1.45	1.62	1.78	1.94	2.10	2.35											
31.8	0.922	1.22	1.51	1.72	1.92	2.11	2.32	2.51	2.82	3.11										
34.0		1.31	1.62	1.85	2.07	2.28	2.50	2.70	3.04	3.36	3.67									
38.1		1.48	1.83	2.08	2.34	2.58	2.83	3.07	3.45	3.83	4.19	4.54								
42.7			2.06	2.35	2.64	2.92	3.20	3.47	3.92	4.35	4.77	5.18	5.58							
45.0			2.18	2.49	2.79	3.09	3.39	3.68	4.15	4.61	5.06	5.50	5.92	6.34						
48.6			2.36	2.70	3.03	3.35	3.68	4.00	4.52	5.02	5.52	6.00	6.47	6.93	7.37					
50.8			2.47	2.82	3.17	3.52	3.86	4.19	4.74	5.28	5.80	6.31	6.81	7.29	7.76	8.67	9.93	11.1	12.1	
54.0			2.63	3.01	3.38	3.75	4.12	4.48	5.06	5.64	6.20	6.75	7.29	7.82	8.33	9.32	10.7	12.0	13.1	
57.1			2.79	3.19	3.59	3.98	4.37	4.75	5.38	5.99	6.60	7.19	7.76	8.33	8.88	9.95	11.4	12.8	14.1	
60.3			2.95	3.38	3.80	4.21	4.63	5.03	5.70	6.36	7.00	7.63	8.25	8.85	9.45	10.6	12.2	13.7	15.1	
63.5				3.56	4.01	4.45	4.89	5.32	6.03	6.72	7.41	8.08	8.74	9.38	10.0	11.2	13.0	14.6	16.1	
65.0				3.65	4.11	4.56	5.01	5.45	6.18	6.89	7.60	8.29	8.96	9.63	10.3	11.5	13.3	15.0	16.6	
70.0				3.94	4.44	4.93	5.41	5.89	6.65	7.46	8.23	8.98	9.72	10.5	11.2	12.6	14.6	16.4	18.2	
76.2				4.30	4.85	5.38	5.91	6.44	7.31	8.17	9.01	9.85	10.7	11.5	12.3	13.8	16.0	18.2	20.2	
82.6							6.43	6.94	7.96	8.90	9.82	10.7	11.6	12.5	13.4	15.1	17.6	19.9	22.2	
88.9							6.94	7.57	8.60	9.62	10.6	11.6	12.6	13.6	14.5	16.4	19.1	21.7	24.2	
101.6								8.69	9.88	11.1	12.2	13.4	14.5	15.7	16.7	19.0	22.2	25.2	28.2	
114.3									11.2	12.5	13.8	15.2	16.5	17.7	19.0	21.5	25.2	28.8	32.2	
127.0									12.5	14.0	15.4	16.9	18.4	19.8	21.3	24.1	28.3	32.3	36.2	
139.8												18.7	20.3	21.9	23.5	26.7	31.3	35.9	40.3	

**Table 13 Outside diameters, wall thicknesses and unit masses of
SUS890LTB**

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.446	0.579	0.703	0.791	0.875	0.953													
19.0	0.540	0.704	0.860	0.971	1.08	1.18													
21.7	0.622	0.813	0.996	1.13	1.26	1.38	1.50												
25.4	0.734	0.963	1.18	1.34	1.50	1.65	1.80	1.94											
27.2	0.789	1.04	1.27	1.45	1.62	1.78	1.94	2.10	2.35										
31.8	0.929	1.22	1.51	1.72	1.92	2.12	2.31	2.50	2.81	3.11									
34.0		1.31	1.62	1.84	2.06	2.28	2.49	2.70	3.03	3.36	3.67								
38.1		1.48	1.83	2.08	2.33	2.58	2.82	3.06	3.45	3.82	4.19	4.53							
42.7			2.06	2.35	2.64	2.92	3.20	3.47	3.91	4.35	4.77	5.17	5.57						
45.0			2.17	2.48	2.79	3.09	3.38	3.67	4.15	4.61	5.06	5.49	5.92	6.33					
48.6			2.36	2.69	3.02	3.35	3.67	3.99	4.51	5.02	5.51	5.99	6.46	6.92	7.36				
50.8			2.47	2.82	3.17	3.51	3.85	4.19	4.73	5.27	5.79	6.30	6.80	7.28	7.75	8.66	9.92	11.1	12.1
54.0			2.63	3.01	3.38	3.75	4.11	4.47	5.06	5.63	6.20	6.75	7.28	7.81	8.32	9.31	10.7	12.0	13.1
57.1			2.79	3.19	3.58	3.98	4.36	4.74	5.37	5.99	6.58	7.15	7.75	8.32	8.87	9.93	11.4	12.8	14.1
60.3			2.95	3.37	3.79	4.21	4.62	5.03	5.70	6.35	6.99	7.62	8.24	8.84	9.44	10.6	12.2	13.7	15.1
63.5				3.56	4.00	4.44	4.88	5.31	6.02	6.71	7.40	8.07	8.73	9.37	10.0	11.2	13.0	14.6	16.1
65.0				3.65	4.10	4.55	5.00	5.44	6.17	6.87	7.59	8.28	8.95	9.62	10.3	11.5	13.3	15.0	16.6
70.0				3.94	4.43	4.92	5.41	5.89	6.68	7.42	8.22	8.97	9.71	10.4	11.2	12.5	14.5	16.4	18.2
76.2				4.30	4.84	5.38	5.91	6.44	7.30	8.16	9.00	9.83	10.7	11.5	12.3	13.8	16.0	18.1	20.1
82.6							6.43	7.00	7.95	8.89	9.81	10.7	11.6	12.5	13.4	15.1	17.6	19.9	22.2
88.9							6.74	7.56	8.59	9.61	10.6	11.6	12.6	13.5	14.5	16.4	19.1	21.7	24.2
101.6								8.68	9.87	11.1	12.2	13.4	14.5	15.6	16.7	18.9	22.1	25.2	28.2
114.3									11.2	12.5	13.8	15.1	16.4	17.7	19.0	21.5	25.2	28.7	32.2
127.0									12.4	13.9	15.4	16.9	18.4	19.8	21.2	24.1	28.2	32.3	36.2
139.8												18.7	20.3	21.9	23.5	26.7	31.3	35.8	40.2

**Table 14 Outside diameters, wall thicknesses and unit masses of
SUS312LTB**

Unit: kg/m

Out- side diam- eter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.445	0.577	0.701	0.789	0.872	0.951													
19.0	0.539	0.702	0.858	0.969	1.08	1.18													
21.7	0.621	0.811	0.994	1.13	1.25	1.38	1.49												
25.4	0.733	0.961	1.18	1.34	1.50	1.65	1.79	1.93											
27.2	0.787	1.03	1.27	1.44	1.61	1.78	1.94	2.09	2.34										
31.8	0.926	1.22	1.50	1.71	1.92	2.11	2.31	2.50	2.81	3.10									
34.0		1.31	1.61	1.84	2.06	2.28	2.49	2.69	3.03	3.35	3.66								
38.1		1.47	1.82	2.08	2.33	2.58	2.82	3.06	3.44	3.81	4.18	4.52							
42.7			2.05	2.34	2.63	2.91	3.19	3.46	3.91	4.34	4.76	5.16	5.56						
45.0			2.17	2.48	2.78	3.08	3.37	3.66	4.14	4.60	5.05	5.48	5.90	6.31					
48.6			2.35	2.69	3.02	3.34	3.67	3.98	4.50	5.01	5.50	5.98	6.45	6.90	7.35				
50.8			2.46	2.81	3.16	3.50	3.84	4.18	4.72	5.26	5.78	6.29	6.78	7.26	7.74	8.64	9.90	11.0	12.1
54.0			2.62	3.00	3.37	3.74	4.10	4.46	5.05	5.62	6.18	6.73	7.27	7.79	8.30	9.28	10.7	11.9	13.1
57.1			2.78	3.18	3.58	3.97	4.35	4.73	5.36	5.97	6.57	7.16	7.74	8.30	8.85	9.91	11.4	12.8	14.1
60.3			2.94	3.37	3.79	4.20	4.61	5.02	5.68	6.34	6.98	7.60	8.22	8.82	9.41	10.6	12.2	13.7	15.1
63.5				3.55	3.99	4.43	4.87	5.30	6.00	6.70	7.38	8.05	8.70	9.35	9.98	11.2	12.9	14.6	16.1
65.0				3.64	4.09	4.54	4.98	5.41	6.15	6.87	7.57	8.26	8.93	9.59	10.2	11.5	13.3	15.0	16.6
70.0				3.93	4.42	4.91	5.39	5.87	6.65	7.44	8.20	8.95	9.69	10.4	11.1	12.5	14.5	16.4	18.1
76.2				4.29	4.83	5.36	5.89	6.42	7.29	8.14	8.98	9.81	10.6	11.4	12.2	13.8	16.0	18.1	20.1
82.6							6.41	6.98	7.93	8.87	9.79	10.7	11.6	12.5	13.4	15.1	17.5	19.9	22.1
88.9							6.92	7.54	8.57	9.58	10.6	11.6	12.5	13.5	14.5	16.3	19.0	21.6	24.1
101.6								8.66	9.85	11.0	12.2	13.3	14.5	15.6	16.7	18.9	22.1	25.1	28.1
114.3									11.1	12.5	13.8	15.1	16.4	17.7	19.0	21.5	25.1	28.7	32.1
127.0									12.4	13.9	15.4	16.9	18.3	19.8	21.2	24.0	28.2	32.2	36.1
139.8												18.6	20.3	21.9	23.5	26.6	31.2	35.7	40.1

Annex JA (normative)

Supplementary quality requirements

JA.1 Hardness (Z1)¹⁾

The hardness shall be as follows.

- a) The hardness of tube shall be as given in Table JA.1.

Table JA.1 Hardness

Symbol of grade	Rockwell hardness (mean value of three positions)	
	HRBW	HRC
SUS304TB, SUS304HTB, SUS304LTB, SUS309TB, SUS309STB, SUS310TB, SUS310STB, SUS315J1TB, SUS315J2TB, SUS316TB, SUS316HTB, SUS316LTB, SUS316TiTB, SUS317TB, SUS317LTB, SUS321TB, SUS321HTB, SUS347TB, SUS347HTB	90 max.	—
SUS329J1TB	—	29 max.
SUS821L1TB, SUS323LTB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB	—	32 max.
SUS836LTB, SUS409LTB, SUS410TiTB, SUS430TB, SUS430LXTB, SUS430J1LTB, SUSXM8TB, SUSXM27TB	90 max.	—
SUS890LTB, SUS405TB, SUS409TB, SUS410TB, SUS430LTB, SUS444TB, SUSXM15J1TB	95 max.	—
SUS312LTB	96 max.	—

- b) The sampling method and the number of test pieces for tensile test in **12.2.2** shall apply.
- c) A test piece with an appropriate length shall be cut off from the tube to be supplied for the test.
- d) The test method shall be in accordance with **JIS Z 2245**. The hardness of the test piece shall be measured on its cross-section or internal surface at three positions per test piece.

This test shall not be performed on the tubes of wall thickness 2 mm or under. For automatic arc welded steel tubes, laser welded steel tubes and electric resistance welded steel tubes, the test shall be performed in the portion other than the weld or the heat affected zones.

Note ¹⁾ In transaction of tubes, the requirements for hardness may be marked as Z1.

JA.2 Yield point or proof stress in tensile test at elevated temperatures (Z2)²⁾

The yield point or proof stress in the tensile test at elevated temperatures shall be as follows.

- a) The required value of yield point or proof stress and the test temperature in the tensile test of tubes at elevated temperatures shall be as agreed between the purchaser and the manufacturer.
- b) One sample shall be taken from each group of tubes from the same cast. From each sample thus obtained, one test piece shall be taken for each test temperature.
- c) The test piece and the test method shall be in accordance with **JIS G 0567**.

When it is difficult to take a test piece in the shape specified in **JIS G 0567** from the tube, the shape of the test piece shall be as agreed between the purchaser and the manufacturer.

Note ²⁾ In transaction of tubes, the requirements for the yield point or proof stress for the tensile test at elevated temperatures may be marked as Z2.

JA.3 Ultrasonic examination and inspection (Z3) ³⁾

The ultrasonic examination and inspection shall be as follows.

- a) Requirements for the ultrasonic examination and inspection shall be applied to seamless steel tubes.
- b) The standard detection sensitivity for the ultrasonic examination shall be Category UA or UC specified in **JIS G 0582**, and there shall be no signals equivalent to or greater than the signals from the reference sample containing the reference standard of the said category. The category of detection sensitivity to be applied shall be as specified by the purchaser. If not specified, it shall be left to the discretion of the manufacturer.
- c) The ultrasonic examination shall be carried out in accordance with **JIS G 0582**.
- d) The ultrasonic examination shall be performed on each tube, and the results shall conform to the requirements specified in b).

Note ³⁾ In transaction of tubes, the requirements for ultrasonic examination and inspection may be marked as Z3.

JA.4 Eddy current examination and inspection (Z4) ⁴⁾

The eddy current examination and inspection shall be as follows.

- a) The standard detection sensitivity for the eddy current examination shall be Category EU, EV, EW or EX specified in **JIS G 0583**, and there shall be no signals equivalent to or greater than the signals from the reference sample containing the reference standard of the said category. The category of detection sensitivity to be applied shall be as specified by the purchaser. If not specified, it shall be left to the discretion of the manufacturer.
- b) The eddy current examination shall be carried out in accordance with **JIS G 0583**.
- c) The eddy current examination shall be performed on each tube, and the results shall conform to the requirements specified in a).

Note ⁴⁾ In transaction of tubes, the requirements for eddy current examination and inspection may be marked as Z4.

JA.5 Corrosion test (Z6)⁵⁾

JA.5.1 Corrosion test method

The grain boundary corrosion tests shall be in accordance with **b)** to **d)**. Prior to performing these tests, the 10 % oxalic acid etching test (**JIS G 0571**) specified in **a)** may be carried out, upon agreement between the purchaser and the manufacturer, to determine the necessity of the grain boundary corrosion tests in **b)** to **d)** based on the obtained etching structure.

- a) The 10 % oxalic acid etching test shall be carried out in accordance with **JIS G 0571**, and the result shall be evaluated in accordance with Clause 8 of **JIS G 0571**. If a ditch structure and/or end grain pitting II is not detected, the tube is considered to have passed the test. If the etching structure is found to be a ditch structure and/or end grain pitting II, the grain boundary corrosion tests in **b)** to **d)** shall be performed as given in Table JA.2. The decision on which grain boundary corrosion test to perform shall be made upon agreement between the purchaser and the manufacturer.

Table JA.2 Structures by 10 % oxalic acid etching test and corrosion test to be applied

Symbol of grade	Condition	Structure to be tested by ferric sulfate-sulfuric acid corrosion test (JIS G 0572)	Structure to be tested by 65 % nitric acid corrosion test (JIS G 0573)	Structure to be tested by copper sulfate-sulfuric acid corrosion test (JIS G 0575)
SUS304TB	As delivered (solution treatment)	Ditch structure	Ditch structure	Ditch structure
SUS315J1TB			End grain pitting II	
SUS315J2TB			—	
SUS316TB			—	
SUS317TB			—	
SUS304LTB	Sensitized	Ditch structure	Ditch structure	Ditch structure
SUS312LTB			End grain pitting II	
SUS316LTB			—	
SUS317LTB		—	—	
SUS321TB			—	
SUS347TB			—	

- b) The ferric sulfate-sulfuric acid corrosion test shall be in accordance with **JIS G 0572**. The corrosion loss shall be as given in Table JA.3.

Table JA.3 Corrosion loss by ferric sulfate-sulfuric acid corrosion test

Symbol of grade	Condition	Corrosion loss
SUS304TB	As delivered (solution treatment)	As agreed between the purchaser and the manufacturer
SUS315J1TB		
SUS315J2TB		
SUS316TB		
SUS317TB		
SUS304LTB	Sensitized	As agreed between the purchaser and the manufacturer
SUS312LTB		
SUS316LTB		
SUS317LTB		

- c) The 65 % nitric acid corrosion test shall be in accordance with **JIS G 0573**. The corrosion loss shall be as given in Table JA.4.

Table JA.4 Corrosion loss by 65 % nitric acid corrosion test

Symbol of grade	Condition	Corrosion loss
SUS304TB	As delivered (solution treatment)	As agreed between the purchaser and the manufacturer
SUS304LTB	Sensitized	As agreed between the purchaser and the manufacturer

- d) The copper sulfate-sulfuric acid corrosion test shall be in accordance with **JIS G 0575**. The condition of the bent surface shall be as given in Table JA.5.

Table JA.5 Condition of bent surface in copper sulfate-sulfuric acid corrosion test

Symbol of grade	Condition	Condition of bent surface
SUS304TB	As delivered (solution treatment)	No cracks caused by intergranular corrosion
SUS315J1TB		
SUS315J2TB		
SUS316TB		
SUS317TB		
SUS304LTB	Sensitized	No cracks caused by intergranular corrosion
SUS312LTB		
SUS316LTB		
SUS317LTB		
SUS321TB		
SUS347TB		

JA.5.2 Sampling method and number of test pieces

The sampling method and the number of test pieces shall be in accordance with **12.2.2**. If requested by the purchaser, the test piece shall be prepared from a sample tube taken from each group of tubes from the same cast and of the same heat treatment batch.

JA.5.3 Test piece

A test piece with an appropriate length shall be cut off from the sample to be supplied for the test.

Note ⁵⁾ In transaction of tubes, the requirements for corrosion tests may be marked as Z6.

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Annex JB (normative)

U-bent tubes

JB.1 Manufacturing method

The manufacturing method shall be as follows (see Figure JB.1).

- a) U-bent tubes shall be produced by cold-bending process, and the bending radius shall be at least 1.5 times the outside diameter of the tube.
- b) The bent portion of the tube shall not be heat treated, in general. When requested by the purchaser, the application of heat treatment may be agreed upon between the purchaser and the manufacturer.

JB.2 Appearance

The bent portion of the tube shall be free from defects detrimental to use.

JB.3 Dimensional tolerances for U-bent tubes

Change in outside diameter, the reduction rate of wall thickness at the bent portion, and the tolerance on pitch (p) or P ($p + D_n$) shall be as given in Table JB.1. The tolerances on length after bending shall be as given in Table JB.2.

JB.4 Measurement of dimensions of U-bent tubes

From a group of tubes of the same dimensions that have been bent at the same time, one sample with the smallest bending radius shall be taken. The outside diameter of the tube shall be measured in the two circumferential directions (minor axis side and major axis side) at the bent portion forming 90° (dimension D_s in Figure JB.1) to determine the change in outside diameter. At the same position, the wall thickness shall be measured at 4 points on the circumference, and the reduction rate of wall thickness shall be obtained from the minimum value of the four measurements.

JB.5 Hydraulic test characteristics

The manufacturer may perform the hydraulic test specified in 12.4 b) 1) by using a U-bent tube instead of a straight tube. In this case, the hydraulic test characteristics of U-bent tube shall conform to the requirements specified in Clause 8 a).

Unit: mm

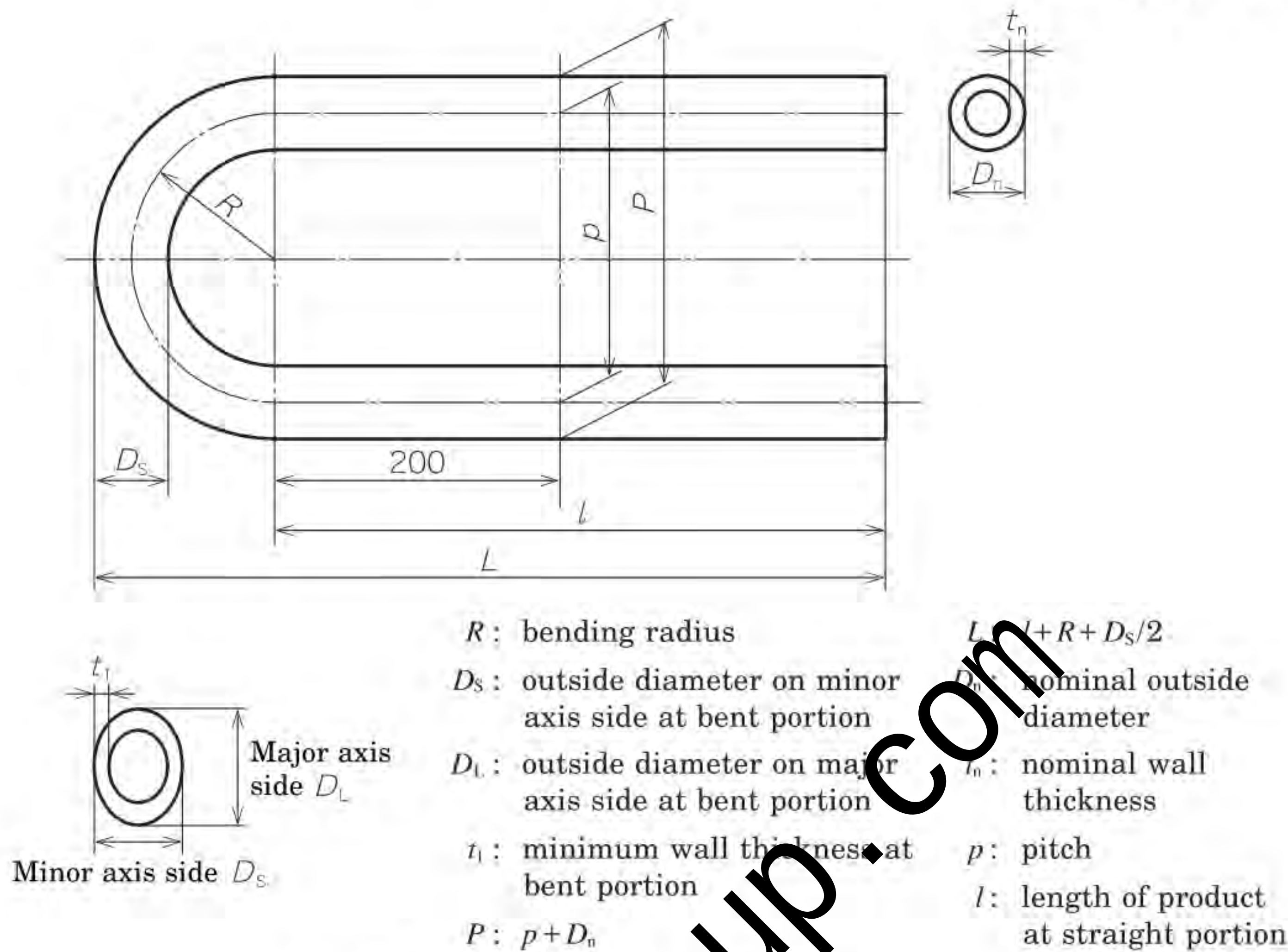


Figure JB.1 U-bent tube

Table JB.1 Dimensional tolerances for U-bent tubes

Change in outside diameter at bent portion mm		Reduction rate of wall thickness at bent portion $\frac{t_n - t_1}{t_n} \times 100$ %	Tolerance on pitch (p) or P mm
Minor axis side $D_n - D_s$	Major axis side $D_L - D_n$		
$(D_n/4R) \times D_n$ max.	$(D_n/8R) \times D_n$ max.		
If the calculated value of the change in outside diameter is under 0.5 mm, this specification value shall be 0.5 mm or under.		$\frac{D_n}{2.5R} \times 100$ max.	± 1.5

Table JB.2 Tolerances on length of U-bent tubes

Tube length at straight portion after bending	Tolerance on length (l or L) mm
7 m or under	+7 0
Over 7 m	+10 0

Annex JC (informative)
Comparison table between JIS and corresponding International Standards

JIS G 3463:2019 <i>Stainless steel tubes for boiler and heat exchanger</i>					ISO 9329-4:1997 <i>Seamless steel tubes for pressure purposes—Technical delivery conditions—Part 4: Austenitic stainless steels</i> ISO 9330-6:1997 <i>Welded steel tubes for pressure purposes—Technical delivery conditions—Part 6: Longitudinally welded austenitic stainless steel tubes</i>		
(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
1 Scope	Stainless steel tubes for boiler and heat exchanger	ISO 9329-4 ISO 9330-6	1	Austenitic stainless steel tubes used for pressure and corrosion resisting purposes at room temperature, low temperatures and elevated temperatures	Addition Deletion	In JIS , requirements for stainless steels other than austenitic series are added, and the scope is limited.	1 Harmonization with ISO specifications was difficult due to the difference in standard systems (JIS standards are systematized according to applications; ISO standards are systematized according to manufacturing methods) and the difference in dimensional system, and also due to the fact that this JIS is cited in mandatory regulations.
2 Normative references							
3 Symbol of grade	41 grades in total, consisting of 23 austenitic series, 6 austenitic-ferritic series, and 12 ferritic series		6.1	ISO 9329-4: 17 grades of austenitic steel ISO 9330-6: 12 grades of austenitic steel	Addition Alteration	In JIS , add requirements for austenitic-ferritic series and ferritic series, and alter elements of austenitic series.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
4 Manufacturing method	Tube manufacturing method, heat treatment and tube end shape	ISO 9329-4 ISO 9330-6	5	Tube manufacturing process and heat treatment.	Alteration	In JIS , specify the lower limit temperature for heat treatment only, and add heat treatment conditions for austenitic-ferritic series and ferritic series.	2 As a measure for the above, the corresponding ISO standards have been translated into Japanese and published as JISs (JIS G 7222, JIS G 7226) so that ISO-equivalent JISs are in place to improve harmonization with International Standards, and to promote widespread use of the ISO-conforming products. 3 Necessity of this JIS, independent from ISO standards, as a standard for special applications remains distinct. 4 Specifications in the previous edition of JIS are maintained in this current edition in order not to disturb the market stability.
5 Chemical composition	Chemical compositions of 41 grades of stainless steel		8.2	Tube end shape.	Addition		
6 Mechanical properties	Tensile properties, flattening resistance, flaring property and reverse flattening resistance		6.1	ISO 9329-4 : chemical compositions of 17 grades of austenitic steel ISO 9330-6 : chemical compositions of 12 grades of austenitic steel	Addition Alteration	Chemical compositions differ between JIS and ISO standards.	
			6.2	Mechanical and technological properties at room temperature (tensile, flattening, drift or ring expanding, and impact tests) and proof-stress values at elevated temperatures	Deletion Addition Alteration	In JIS , delete requirements for the impact values and the property values at elevated temperatures, add requirements for reverse flattening resistance, and alter the specified value of mechanical properties and applicable dimensions of flaring property.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
7 Austenitic grain size	Austenitic grain size for SUS321HTB tubes	ISO 9329-4 ISO 9330-6	—	—	Addition	This item is not specified in ISO standards.	5 Future tasks: • Incorporate specifications of corresponding ISO standards (or translated JIS) into this JIS as far as possible to improve harmonization with ISO standards. • Make a proposal for additions of specifications in this JIS that are currently not part of the ISO standards as required by the market to improve harmonization with ISO standards.
8 Hydraulic test characteristics or non-destructive test characteristics	Hydraulic test characteristics or non-destructive test characteristics		9.5	Hydraulic leak-tightness test or non-destructive test	Alteration	Hydraulic test pressure value in JIS is lower than that specified in ISO standards.	
9 Dimensions, unit masses and dimensional tolerances	Outside diameters, wall thicknesses, unit masses and dimensional tolerances		7	The outside diameters, wall thicknesses and masses of the tubes shall be selected from those in ISO 4200 and ISO 1107 . Lengths and tolerances are specified.	Addition Deletion Alteration	The dimensional system differs between JIS and ISO standards.	
10 Appearance	Appearance		8.1	Appearance and soundness	Identical	—	
11 Supplementary quality requirements and U-bent tubes	Supplementary quality requirements and U-bent tubes		—	—	Addition	Add the supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer, and the requirements for U-bent tubes to be applied when specified by the purchaser.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
12 Tests	Methods of chemical analysis, mechanical tests, austenitic grain size test, hydraulic test and non-destructive test	ISO 9329-4 ISO 9330-6	9.3 9.4 9.5 9.9	Analysis, tensile properties, flattening resistance, leak-tightness test and non-destructive test	Deletion Alteration	In JIS , delete requirements for tensile test at elevated temperatures, ring expanding test, etc., and alter requirements for sampling method for analysis, analysis method, mechanical test piece sampling frequency and mechanical test piece shape.	
13 Inspection and reinspection	Inspection and reinspection		9.10 9.11	Inspection and reinspection	Addition Alteration	Add inspection items to JIS , and alter general requirements for inspection and requirements to be applied when the tube fails in the mechanical test.	
14 Marking	Marking		10	Marking	Alteration	JIS and ISO are identical in specification items but different in specified contents.	
15 Report	Report		11	Report	Alteration	JIS specifies 1 type of inspection documents, while ISO specifies 4 types.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex JA (normative) Supplementary quality requirements	Hardness, tensile test at elevated temperatures, ultrasonic examination and inspection, eddy current examination and inspection and corrosion test	ISO 9329-4 ISO 9330-6	6.2 6.4 9.8 9.10.5.2	Properties at elevated temperatures, non-destructive test, corrosion test and inspection	Addition	Add requirements for hardness to JIS .	
Annex JB (normative) U-bent tubes	U-bent tubes		—	—	Addition	Add requirements for U-bent tubes to JIS .	

Overall degree of correspondence between **JIS** and International Standard(s) (**ISO 9329-4:1997**, **ISO 9330-6:1997**): MOD

NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows:

- Identical: Identical in technical contents.
- Deletion: Deletes the specification item(s) or content(s) of International Standard.
- Addition: Adds the specification item(s) or content(s) which are not included in International Standard.
- Alteration: Alters the specification content(s) which are included in International Standard.

NOTE 2 Symbol in column of overall degree of correspondence between **JIS** and International Standard(s) in the above table indicates as follows:

- MOD: Modifies International Standard(s).

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In addition, printed errata are available in our journal *Standardization and Quality Control*, and also in *Monthly Information* that is distributed to the subscribers of JIS (English edition).

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