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Alloy steel tubes for boiler and heat exchanger

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Contents

Foreword

This translation has been made based on the original Japanese Industrial Standard 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 the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS G 3462**:2011 is replaced with this Standard.

However, **JIS G 3462**:2011 may be applied in the JIS mark certification based on the relevant provisions of Article 19 Clause 1, etc. of the Industrial Standardization Law until May 19, 2015.

Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Alloy steel tubes for boiler and heat exchanger

Introduction

This Japanese Industrial Standard has been prepared based on the first editions of **ISO 9329-2** and **ISO 9330-2** published in 1997 with some modifications of the technical contents.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standards have been modified. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies the alloy steel tubes (hereafter referred to as "tubes") used for exchanging heat between the inside and outside of the tube, such as water tubes, smoke tubes, superheater tubes and air preheater tubes of boilers, and heat exchanger tubes, condenser tubes and catalyst tubes used in chemical and petroleum industries. It is not applicable to the steel tubes for heating furnace and steel heat exchanger tubes for low temperature service.

This Standard applies to tubes with an outside diameter of 15.9 mm to 139.8 mm.

With the previous agreement of the manufacturer, the purchaser may designate the special quality requirements and designate U-bend tubes to be applied, given in Annex JA and Annex JB, respectively in addition to the requirements specified in the text of this Standard.

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

ISO 9329-2 : 1997 *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2 : Unalloyed and alloyed steels with specified elevated temperature properties*

ISO 9330-2 : 1997 *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2 : Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties* (overall evaluation : MOD)

The symbols which denote the degree of correspondence in the contents between the relevant International Standards 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 *Standard test method for heat analysis of steel products*

JIS G 0321 *Product analysis and its tolerance for wrought steel*

JIS G 0404 *Steel and steel products — General technical delivery requirements*

JIS G 0415 *Steel and steel products — Inspection documents*

JIS G 0416 *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

JIS G 0567 *Method of elevated temperature tensile test for steels and heat-resisting alloys*

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 *Guide to the rounding of numbers*

3 Classification and symbols

Tubes shall be classified into eight grades, and the designation of grade and designation of manufacturing method shall be as given in table 1.

Table 1 Designation of grade, designation of manufacturing method and marking

Designation of grade		Designation of manudacturing method		
		Tube manufacturing method	Finishing method	Marking
Molybdenum steel tube	STBA12	Seamless : S Electric resistance welded : E	Hot finished : H Cold finished : C As electric resistance welded : G	Designation of manudacturing method shall be in accordance with **12 b)**.
	STBA13			
Chromium-molybdenum steel tube	STBA20			
	STBA22			
	STBA23			
	STBA24			
	STBA25	Seamless : S	Hot finished : H Cold finished : C	
	STBA26			

4 Manufacturing method

The manufacturing method shall be as follows.

a) Tubes shall be manufactured by a combination of the manufacturing method and finishing method given in table 1.

b) The tubes of STBA 12, STBA 13, STBA 20, STBA 22, STBA 23 and STBA 24 shall be manufactured by a seamless process or by electric resistance welding, and the tubes of STBA 25 and STBA 26 shall be manufactured by a seamless process.

c) Tubes shall be subjected to the heat treatment specified in table 2. Other heat treatments not specified in table 2 shall be agreed between the purchaser and the manufacturer.

d) Plain end finishing shall be applied to the shape of tube end unless otherwise specified.

Table 2 Heat treatment

Designation of grade	Heat treatment [a]
STBA12 STBA13	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering
STBA20 STBA22	Low temperature annealing, isothermal annealing, full annealing or normalizing followed by tempering
STBA23 STBA24 STBA25 STBA26	Isothermal annealing, full annealing or normalizing followed by tempering [b]

Notes [a] Low temperature annealing shall not be applied to the electric resistance welded steel tube.
[b] The tempering temperature for STBA 23, STBA 24, STBA 25 and STBA 26 shall be 650 °C or higher.

5 Chemical composition

Tubes shall be tested in accordance with **10.1** and the heat analysis value shall conform to table 3. As required, alloy elements not included in table 3 may be added. When the product analysis is required by the purchaser, tubes shall be tested in accordance with **10.1** and the product analysis value shall conform to table 3.

Table 3 Chemical composition

Unit: %

Designation of grade	C	Si	Mn	P	S	Cr	Mo
STBA12	0.10 to 0.20	0.10 to 0.50	0.30 to 0.80	0.035 max.	0.035 max.	—	0.45 to 0.65
STBA13	0.15 to 0.25	0.10 to 0.50	0.30 to 0.80	0.035 max.	0.035 max.	—	0.45 to 0.65
STBA20	0.10 to 0.20	0.10 to 0.50	0.30 to 0.60	0.035 max.	0.035 max.	0.50 to 0.80	0.40 to 0.65
STBA22	0.15 max.	0.50 max.	0.30 to 0.60	0.035 max.	0.035 max.	0.80 to 1.25	0.45 to 0.65
STBA23	0.15 max.	0.50 to 1.00	0.30 to 0.60	0.030 max.	0.030 max.	1.00 to 1.50	0.45 to 0.65
STBA24	0.15 max.	0.50 max.	0.30 to 0.60	0.030 max.	0.030 max.	1.90 to 2.60	0.87 to 1.13
STBA25	0.15 max.	0.50 max.	0.30 to 0.60	0.030 max.	0.030 max.	4.00 to 6.00	0.45 to 0.65
STBA26	0.15 max.	0.25 to 1.00	0.30 to 0.60	0.030 max.	0.030 max.	8.00 to 10.00	0.90 to 1.10

6 Mechanical properties

6.1 Tensile strength, yield point or proof stress, and elongation

Tubes shall be tested in accordance with **10.2.3**, and the tensile strength, yield point or proof stress, and elongation shall conform to table 4. When the tensile test is carried out by using No. 12 test piece for tubes under 8 mm in wall thickness, the minimum value of elongation shall be obtained by reducing 1.5 mm from the elongation value in table 4 at each decrease of 1 mm in wall thickness, and by rounding the result to an integer in accordance with Rule A of **JIS Z 8401**. The obtained value shall conform to table 5.

Table 4 Mechanical properties

Designation of grade	Tensile strength [a)]	Yield point or proof stress	Elongation %				
			Outside diameter				
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over	All diameters	
			Tensile test piece				
			No. 11 test piece	No. 11 test piece	No. 11 test piece or No. 12 test piece	No. 4 test piece	No. 14A test piece
	N/mm²	N/mm²	Tensile test direction				
			Pararell to tube axis	Pararell to tube axis	Pararell to tube axis	Pararell to tube axis	Pararell to tube axis
STBA12	380 min.	205 min.	22 min.	25 min.	30 min.	24 min.	21 min.
STBA13	410 min.						
STBA20							
STBA22							
STBA23							
STBA24							
STBA25							
STBA26							

NOTE : 1 N/mm² = 1 MPa

Note [a)] Exclusively for the heat exchanger tube, the purchaser may, where necessary, designate the maximum value of tensile strength, which shall be obtained by adding 150 N/mm² to the value given in this table.

Table 5 Minimum elongation values for No. 12 test piece taken from tubes under 8 mm in wall thickness (parallel to tube axis)

Unit: %

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
Elongation	21 min.	22 min.	24 min.	26 min.	27 min.	28 min.	30 min.

6.2 Flattening resistance

Tubes shall be tested in accordance with **10.2.4**, and the test piece shall be free from cracks. In this case, the distance H between the two flat plates shall be obtained by formula (1).

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

where, H: distance between flat plates (mm)

t : wall thickness of tube (mm)

D: outside diameter of tube (mm)

e : constant 0.08

NOTE : For flattening test, see **10.2.4**.

6.3 Flaring resistance

Tubes shall be tested in accordance with **10.2.5**, and they shall be free from cracks when flared into a trumpet shape until the outside diameter becomes 1.14 times the original outside diameter. The flaring resistance for tubes over 101.6 mm in outside diameter shall apply only upon the requirement from the purchaser.

NOTE : For flaring test, see **10.2.5**.

6.4 Reverse flattening resistance

The electric resistance welded steel tubes, when tested in accordance with **10.2.6**, shall be free from cracks on the weld.

NOTE : For reverse flattening test, see **10.2.6**.

7 Hydraulic test characteristics or nondestructive test characteristics

Tubes shall be tested in accordance with **10.3**, and the hydraulic test characteristics or nondestructive test characteristics shall be as follows. Which of the characteristics is to be tested shall be as specified by 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 the test pressure is specified by the purchaser, the tube shall withstand the specified minimum hydraulic test pressure without leakage. If the pressure specified by the purchaser exceeds either the test pressure (P) calculated by formula (2) or 10 MPa, the pressure shall be as agreed between the purchaser and the manufacturer. The specified test pressure shall be expressed to the nearest 0.5 MPa for values under 10 MPa, and to the nearest 1 MPa for values of 10 MPa or greater.

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

where, P: test pressure (MPa)

t: wall thickness of tube (mm)

D: outside diameter of tube (mm)

s : 60 % of the lowest value of yield point or proof stress in table 4 (N/mm^2)

2) When the test pressure is not specified by the purchaser, the tube shall withstand the minimum hydraulic test pressure (P) calculated by formula (2) (or 10 MPa in the case where the pressure exceeds 10 MPa) without leakage.

b) **Nondestructive test characteristics** Tubes shall be subjected to either the ultrasonic examination or the eddy current examination, and the nondestructive test characteristics shall be as follows. Instead of these tests, other nondestructive tests in accordance with **JIS** may be performed upon the agreement between the purchaser and the manufacturer, in this case the judgement criteria shall be equivalent to or stricter than that applied to in the ultrasonic examination or the eddy current examination.

NOTE : Other nondestructive tests in accordance with **JIS** include **JIS G 0586**, etc.

1) For the ultrasonic examination characteristics, no signal shall be equivalent to or greater than the signal from the reference standard of reference sample of category UD specified in **JIS G 0582**.

2) For the eddy current examination characteristics, no signal shall be equivalent to or greater than the signal from the reference standard of reference sample of category EY specified in **JIS G 0583**.

8 Dimensions, mass and dimensional tolerances

8.1 Dimensions and unit mass

The outside diameter, wall thickness and unit mass of tubes shall be as given in table 6. Dimensions not specified in table 6 may be used upon the agreement between the purchaser and the manufacturer. In this case, the unit mass shall be calculated by the following formula assuming 1 cm^3 of steel to be 7.85 g, and be rounded off to three significant figures in accordance with Rule A of **JIS Z 8401**. The value over 1 000 kg/m shall be rounded off to an integer of four significant figures.

$$W = 0.024\,66\,t\,(D - t)$$

where, W: unit mass of tube (kg/m)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

0.024 66 : conversion coefficient of unit to obtain W

NOTE : The unit mass in table 6 is obtained as above.

Table 6 Dimension and unit mass of alloy steel tubes for boiler and heat exchanger

Unit: kg/m

Outside diameter 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	0.435	0.564	0.686	0.771	0.853	0.930													
19.0		0.687	0.838	0.947	1.05	1.15													
21.7			0.972	1.10	1.22	1.34	1.46												
25.4			1.15	1.31	1.46	1.61	1.75	1.89											
27.2			1.24	1.41	1.58	1.74	1.89	2.05	2.29										
31.8				1.67	1.87	2.07	2.26	2.44	2.74	3.03									
34.0					2.01	2.22	2.43	2.63	2.96	3.27	3.58								
38.1					2.28	2.52	2.75	2.99	3.36	3.73	4.08	4.42							
42.7					2.57	2.85	3.12	3.38	3.82	4.24	4.65	5.05	5.43						
45.0					2.72	3.01	3.30	3.58	4.04	4.49	4.93	5.36	5.77	6.17					
48.6					2.95	3.27	3.58	3.89	4.40	4.89	5.38	5.85	6.30	6.75	7.18				
50.8					3.09	3.43	3.76	4.08	4.62	5.14	5.65	6.14	6.63	7.10	7.56	8.44	9.68	10.8	11.8
54.0					3.30	3.65	4.01	4.36	4.93	5.49	6.04	6.58	7.10	7.61	8.11	9.07	10.4	11.7	12.8
57.1						3.88	4.25	4.63	5.24	5.84	6.42	7.00	7.56	8.11	8.65	9.69	11.2	12.5	13.7
60.3						4.10	4.51	4.90	5.55	6.19	6.82	7.43	8.03	8.62	9.20	10.3	11.9	13.4	14.7
63.5						4.33	4.76	5.18	5.87	6.55	7.21	7.87	8.51	9.14	9.75	10.9	12.7	14.2	15.7
65.0						4.44	4.88	5.31	6.02	6.71	7.40	8.07	8.73	9.38	10.0	11.2	13.0	14.6	16.2
70.0						4.80	5.27	5.74	6.51	7.27	8.01	8.75	9.47	10.2	10.9	12.2	14.2	16.0	17.7
76.2							5.76	6.27	7.12	7.96	8.78	9.59	10.4	11.2	11.9	13.5	15.6	17.7	19.6
82.6							6.27	6.83	7.75	8.67	9.57	10.5	11.3	12.2	13.1	14.7	17.1	19.4	21.6
88.9							6.76	7.37	8.37	9.37	10.3	11.3	12.3	13.2	14.1	16.0	18.6	21.1	23.6
101.6								8.47	9.63	10.8	11.9	13.0	14.1	15.2	16.3	18.5	21.6	24.6	27.5
114.3									10.9	12.2	13.5	14.8	16.0	17.3	18.5	21.0	24.6	28.0	31.4
127.0									12.1	13.6	15.0	16.5	17.9	19.3	20.7	23.5	27.5	31.5	35.3
139.8												18.2	19.8	21.4	22.9	26.0	30.5	34.9	39.2

NOTE : On transactions, the unit mass of tube shall be the value given in this table increased by 15 % for the hot finished seamless steel tube, by 10 % for the cold finished seamless steel tube, and by 9 % for the electric resistance welded steel tube.

8.2 Dimensional tolerances

Dimensional tolerances of tubes shall be as follows.

a) The tolerances on the outside diameter of tubes shall be as given in table 7.

b) The tolerances on the wall thickness and wall thickness deviation of tubes shall be as given in table 8.

c) The tolerances on the length of tubes shall be as given in table 9.

Table 7 Tolerances on outside diameter

Unit: mm

Category of outside diameter	Tolerances on outside diameter			
	Hot finished seamless steel tube	Cold finished seamless steel tube	As electric resistance welded steel tube [a)]	Cold finished electric resistance welded steel tube
under 25	+0.4 −0.8	±0.10	±0.15	±0.10
25 or over to and excl. 40		±0.15	±0.20	±0.15
40 or over to and excl. 50		±0.20	±0.25	±0.20
50 or over to and excl. 60		±0.25	±0.30	±0.25
60 or over to and excl. 80		±0.30	±0.40	±0.30
80 or over to and excl. 100		±0.40	+0.40 −0.60	±0.40
100 or over to and excl. 120	+0.4 −1.2	+0.40 −0.60	+0.40 −0.80	+0.40 −0.60
120 or over to and excl. 160		+0.40 −0.80	+0.40 −1.00	+0.40 −0.80
160 or over to and excl. 200	+0.4 −1.8	+0.40 −1.20	+0.40 −1.20	+0.40 −1.20
200 or over	+0.4 −2.4	+0.40 −1.60	+0.40 −1.60	+0.40 −1.60

Note [a)] For the tolerances on the outside diameter of as electric resistance welded steel tube, the tolerances on the outside diameter of cold finished steel tube may substitute upon the requirement from the purchaser.

Table 8 Tolerances on wall thickness and wall thickness deviation [a)]

Tolerance	Wall thickness mm	Hot finished seamless steel tube		Cold finished seamless 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	—	—	+0.4 mm 0	+20 % 0	+0.3 mm 0	+18 % 0
	2 or over to and excl. 2.4	+40 % 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 wall thickness deviation [b)]	5.6 or over	Within 22.8 % of wall thickness		—		—	

Notes [a)] The tolerance shall be rounded off to one decimal place in accordance with Rule A of **JIS Z 8401**.

[b)] Wall thickness deviation is the ratio of the difference between the maximum and minimum measured thicknesses on the same cross-section to the ordered wall thickness, expressed by percentage. However, this does not apply to tubes under 5.6 mm in wall thickness.

Table 9 Tolerances on length

Category		Tolerance on length
50 mm or under in outside diameter	7 m or under in length	+7 mm 0
	Over 7 m in length	Add 3 mm to the plus side of above tolerance with increase of every 3 m or its fraction in length. However, the maximum value shall be 15 mm.
Over 50 mm in outside diameter	7 m or under in length	+10 mm 0
	Over 7 m in length	Add 3 mm to the plus side of above tolerance with increase of every 3 m or its fraction in length. However, the maximum value shall be 15 mm.
NOTE : The length tolerance may be 0, +30 mm upon the agreement between the purchaser and the manufacturer.		

9 Appearance

The appearance of tubes shall be as follows.

a) The tube shall be practically straight, and the both ends shall be practically perpendicular to the tube axis.

b) The inside and outside surfaces of the tube shall be finished well without defects detrimental to use. In the case of electric resistance welded steel tube, the swelling of inside surface of the weld shall be 0.25 mm or under. The purchaser may specify the inside swelling to be 0.15 mm or less for tubes of 50.8 mm or under in outside diameter and 3.5 mm or under in wall thickness.

c) The surface of the tube may be repaired by grinding, machining or other methods, provided that the wall thickness after repairing still satisfies the specified tolerance on thickness.

d) The surface of repaired part shall be smooth along the contour of the tube.

10 Tests

10.1 Chemical analysis

10.1.1 General matters of chemical analysis and sampling method

General matters of chemical analysis and sampling method of analytical sample shall be in accordance with clause **8** of **JIS G 0404**. The sampling method when the product analysis is required by the purchaser shall be in accordance with clause **4** of **JIS G 0321**.

10.1.2 Analytical method

Heat analysis shall be in accordance with **JIS G 0320**. Product analysis shall be in accordance with **JIS G 0321**.

10.2 Mechanical test

10.2.1 General

General matters of mechanical test shall be in accordance with clauses **7** and **9 of JIS G 0404**. The sampling method for mechanical tests in **7.6** of **JIS G 0404** shall be in accordance with Class A.

10.2.2 Sampling method and number of test pieces

For the sampling method and number of test pieces, one sample shall be taken from each unit of 50 tubes or its fraction of the same dimension and the simultaneous heat treatment. From each sample thus obtained, one tensile test piece, one flattening test piece and one flaring test piece shall be taken. The "same dimension" refers to the same outside diameter and the same wall thickness. The "simultaneous heat treatment" in the case of using continuous furnace refers to a continuous heat treatment performed under same heat treatment conditions. Therefore, if the continuous furnace is stopped, the tubes do not belong to the simultaneous heat treatment. When all tubes of the same dimension to be tested belong to the same heat, the same heat treatment conditions may be applied instead of the simultaneous heat treatment.

In addition, for electric resistance welded steel tubes, one sample shall be taken from each unit of 100 tubes or its fraction of the same dimensions and the simultaneous heat treatment. From each sample thus obtained, one reverse flattening test piece shall be taken.

10.2.3 Tensile test

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

a) **Test piece** Tensile test piece shall be one of No. 11, No. 12 (No. 12A, No. 12B and No. 12C), No. 14A or No. 4 test pieces specified in **JIS Z 2241**, taken in parallel to the tube axis. The sampling position in thickness direction of No. 14A or No. 4 test pieces used for bars shall be in accordance with **A.7** of **JIS G 0416**. No. 4 test piece shall have a diameter of 14 mm (gauge length 50 mm).

In the case of obtaining a tensile test piece from an electric resistance welded steel tube, No. 12 test piece shall be taken from a position without any weld.

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

10.2.4 Flattening test

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

The flattening test of seamless steel tubes may be omitted unless otherwise specified by the purchaser [1)].

Note [1)] This means that the flattening test may be omitted at the discretion of the manufacturer, but only on the precondition that the flattening resistance of the tube satisfies the specification.

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

b) **Test method** The test piece shall be placed at ordinary temperature between two flat plates and flattened by compression until the distance H between the plates is

decreased to the value obtained by formula (1) in **6.2** or less, and then examined for cracks. In the case of electric resistance welded steel tubes, however, the test piece shall be placed, as shown in figure 1, so that the line connecting the centre of the tube and the weld is perpendicular to the direction of compression. A C-shape test piece shall be placed as shown in figure 2.

Direction of compression

Direction of compression

[redacted]

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

The flaring test of seamless steel tubes may be omitted unless otherwise specified by the purchaser [2)].

Note [2)] This means that the flaring test may be omitted at the discretion of the manufacturer, but only on the precondition that the flaring resistance of the tube satisfies the specification.

a) **Test piece** The test piece shall have a length suitable for the test.

b) **Test method** The test piece shall be flared at one of the tube ends at ordinary temperature into a trumpet shape and to at least the size specified in **6.3** with conical tool forming an angle of 60°, and examined for any cracks.

10.2.6 Reverse flattening test

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

When the flaring test is carried out, the reverse flattening test may be omitted unless otherwise specified [3)].

Note [3)] This means that the reverse flattening test may be omitted at the discretion of the manufacturer, but only on the precondition that the reverse flattening resistance of the tube satisfies the specification.

a) **Test piece** A length of 100 mm shall be cut off from one end of the tube to prepare a sample. This sample shall be split in half by cutting at positions that are displaced 90° circumferentially from the weld line to its both sides, and one of the split halves which contains the weld shall be used as a test piece.

b) **Test method** The test piece shall be opened up and flattened by positioning the weld line at the top, and then examined for any cracks in the weld.

10.3 Hydraulic test or nondestructive test

The hydraulic test or nondestructive test shall be as follows.

a) **Frequency of test** The hydraulic test or nondestructive test shall be carried out for each one of tubes.

b) **Test method** The hydraulic test or nondestructive test shall be as follows.

1) **Hydraulic test** The tube shall be held under at least the minimum hydraulic test pressure specified in **7 a)** for at least 5 s, and then examined if it endures the pressure without leakage.

2) **Nondestructive test** The test method shall be as follows. Other nondestructive tests in accordance with **JIS**, when performed, shall be as agreed between the purchaser and the manufacturer.

2.1) The ultrasonic examination shall be in accordance with **JIS G 0582**. The test may be conducted by a category of reference standard stricter than category UD.

2.2) The eddy current examination shall be in accordance with **JIS G 0583**. The test may be conducted by a category of reference standard stricter than category EY.

11 Inspection and re-inspection

11.1 Inspection

The inspection shall be as follows.

a) General matters of inspection shall be in accordance with **JIS G 0404**.

b) The chemical composition shall conform to clause **5**.

c) The mechanical properties shall conform to clause **6**.

d) The hydraulic test characteristics or nondestructive test characteristics shall conform to clause **7**.

e) The dimensions shall conform to clause **8**.

f) The appearance shall conform to clause **9**.

g) In the case where a part or all of the special quality requirements in Annex JA are applied upon the agreement between the purchaser and the manufacturer, and/or in the case where U-bend tubes in Annex JB are specified, the inspection results shall conform to the relevant requirements.

11.2 Re-inspection

Tubes which failed mechanical test may be further evaluated for acceptance by conducting a retest specified in **9.8** of **JIS G 0404**.

12 Marking

Each tube which passed the inspection shall be marked with the following items. Tubes may be bundled together and marked for each bundle by a suitable means, when required by the manufacturer or when the small outside diameter of the tubes is an obstacle to marking on each tube. The arrangement of items is not specified. When approved by the purchaser, part of the items may be omitted to such extent that the product can be identified.

a) Designation of grade

b) Designation of manufacturing method

Designations of manufacturing method shall be as follows. The dash may be omitted.

Hot finished seamless steel tube : –S–H

Cold finished seamless steel tube : –S–C

As electric resistance welded steel tube : –E–G

Hot finished electric resistance welded steel tube : –E–H

Cold finished electric resistance welded steel tube : –E–C

c) Dimensions Dimensions shall be marked by "outside diameter × wall thickness".

d) Manufacturer's name or its identifying brand

e) Symbol Z to denominate the special quality requirement (if denominated)

13 Test report

The manufacturer shall submit an inspection document to the purchaser unless otherwise specified. The test report shall be in accordance with clause **13** of **JIS G 0404**. The type of the inspection document shall be the standard designation 3.1 in table 1 of **JIS G 0415**, unless otherwise specified at the time of ordering.

If any alloy elements not specified in table 3 are intentionally added, the content of the added alloy elements shall be appended to the inspection document.

Annex JA (normative)
Special quality requirements

This Annex specifies the special quality requirements. The special quality requirements shall be applied to a part of or all items on straight tubes upon the agreement between the purchaser and the manufacturer.

JA.1 Hardness (Z1) [1)]

The hardness shall be as follows.

a) The hardness of tubes shall be as given in table JA.1.

Table JA.1 Hardness

Designation of grade	Rockwell hardness HRBS or HRBW [a)] (Mean of three points)
STBA12	80 max.
STBA13	81 max.
STBA20	85 max.
STBA22	85 max.
STBA23	85 max.
STBA24	85 max.
STBA25	85 max.
STBA26	89 max.
Note [a)] The measurement may be made by either HRBS or HRBW. In case of any doubt arising, however, HRBS shall be used.	

b) The sampling method and the number of test pieces shall be in accordance with that of the tensile test in **10.2.2**.

c) An adequate length shall be cut off from one end of a tube to prepare a test piece.

d) The test method shall be in accordance with **JIS Z 2245**. The hardness of cross section or inside surface of the test piece shall be measured at three points on each test piece.

Tubes of 2 mm or under in wall thickness shall not be tested. For the electric resistance welded steel tubes, the test shall be conducted in the portion without any weld and heat-affected zone.

e) The hardness of tubes shall conform to table JA.1.

f) Retest Tubes may be further evaluated for acceptance by conducting a retest specified in **9.8** of **JIS G 0404**.

Note [1)] The hardness can be designated as Z1 on transaction of tubes.

JA.2 Yield point or proof stress in elevated temperature tensile test (Z2) [2)]

The yield point or proof stress in elevated temperature tensile test shall be as follows.

a) Yield point or proof stress value and the test temperature in the elevated temperature tensile test of tubes shall be as agreed between the purchaser and the manufacturer.

b) For the sampling method and number of test pieces, one sample shall be taken from each unit of tubes belonging to the same heat. From each sample thus obtained, one test piece shall be taken for each test temperature.

c) Test piece and test method shall be in accordance with **JIS G 0567**.

If taking a test piece as specified in **JIS G 0567** is impracticable, the shape of the test piece shall be as agreed between the purchaser and the manufacturer.

Note [2)] The specification of the yield point or proof stress in elevated temperature tensile test can be designated as Z2 on transaction of tubes.

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

The ultrasonic examination and inspection shall be as follows.

a) The criteria of the working sensitivity in the ultrasonic examination shall be category UA or UC as defined in **JIS G 0582**, and no signal shall be equivalent to or greater than the signal from the reference standard of the reference sample.

b) The method of ultrasonic examination shall be in accordance with **JIS G 0582**.

c) The ultrasonic inspection shall be performed for each tube and the results shall conform to the requirements specified in **a)**.

Note [3)] The specification of the ultrasonic examination can be designated as Z3 on transaction of tubes.

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

The eddy current examination and inspection shall be as follows.

a) The criteria of the working sensitivity in the eddy current examination shall be category EU, EV, EW or EX as defined in **JIS G 0583**, and no signal shall be equivalent to or greater than the signal from the reference standard of the reference sample.

b) The method of the eddy current examination shall be in accordance with **JIS G 0583**.

c) The eddy current examination shall be performed for each tube and the results shall conform to the requirements specified in **a)**.

Note [4)] The specification of the eddy current examination can be designated as Z4 on transaction of tubes.

Annex JB (normative)
U-bend tubes

This Annex specifies the U-bend tubes. When required by the purchaser in addition to the items specified in the text, the requirements given in this Annex shall be applied by the manufacturer.

JB.1 Manufacturing method

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

a) The U-bend tubes shall be made 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 required by the purchaser, the heat treatment may be agreed between the purchaser and the manufacturer.

JB.2 Appearance

The bent portion shall be free from defects detrimental to practical use.

JB.3 Dimensional tolerances on U-bend tubes

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

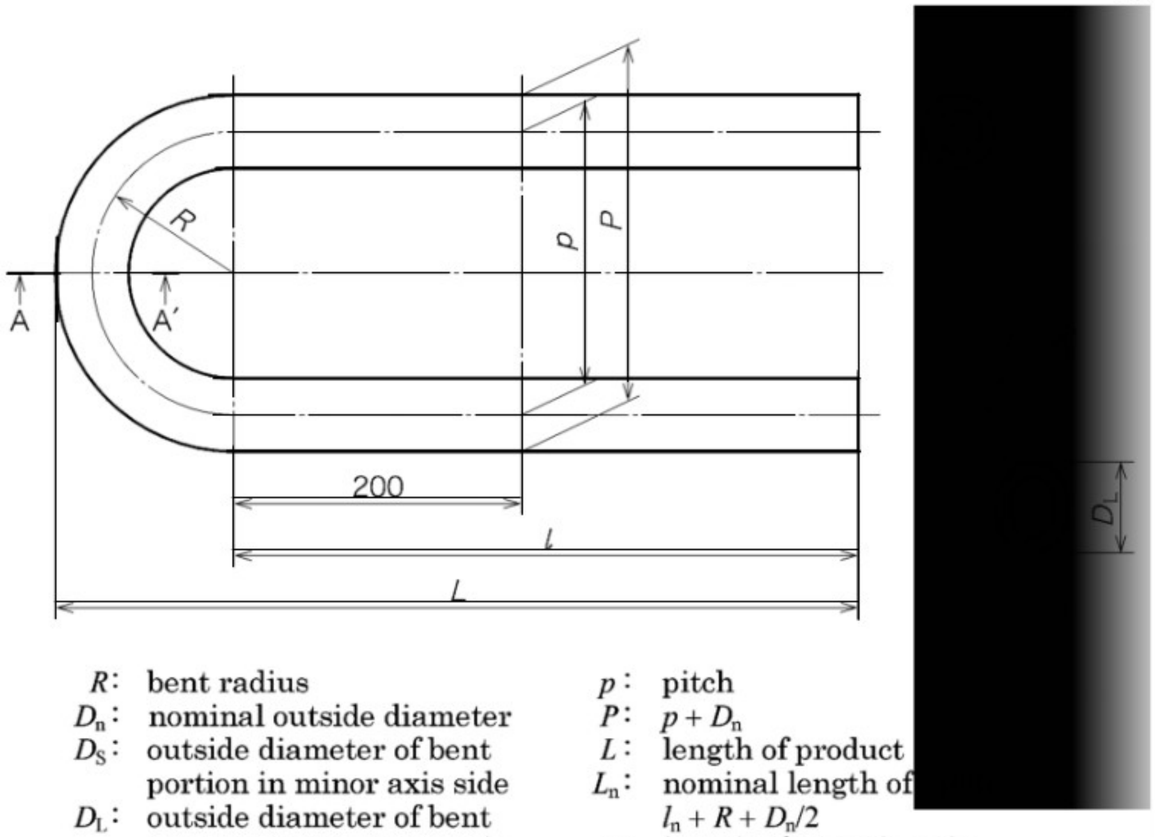
JB.4 Measurement of dimensions of U-bend tubes

From an unit of tubes of the same dimension that have been bent at the same time, one sample product with the smallest bending radius shall be taken. The outside diameters of the tube shall be measured in the two circumferential directions (minor axis side and major axis side) at 90° from the bent portion (dimension D_S in figure JB.1) to determine the variation of the outside diameter. Also, the wall thicknesses of the tube in that position shall be measured at four points on the circumference, to obtain the wall thickness reduction rate as the minimum value of the four measurements.

JB.5 Hydraulic test characteristics

The manufacturer may perform the hydraulic test in **10.3 b) 1)** by using a U-bend tube instead of a straight tube. In this case, the hydraulic test characteristics of the U-bend tube shall conform to **7 a)**.

Unit: mm



R: bent radius
D_n: nominal outside diameter
D_S: outside diameter of bent portion in minor axis side
D_L: outside diameter of bent portion in major axis side
t_n: nominal thickness
t_1: minimum thickness of bent portion
p: pitch
P: $p + D_n$
L: length of product
L_n: nominal length of $l_n + R + D_n/2$
l: length of straight tube portion of product
l_n: nominal length of straight tube portion

Figure JB.1 U-bend tube

Table JB.1 Dimensional tolerances for U-bend tube

Outside diameter variation of bent portion [a] mm		Reduction rate of wall thickness of 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.	$\frac{D_n}{2.5R} \times 100$ max.	±1.5
Note [a] If the calculated value of the variation of the outside diameter is less than 0.5 mm, this specification value shall be 0.5 max.			

Table JB.2 Tolerance on length of U-bend tube

Nominal length of straight tube portion (l_n)	Tolerance on length (l or L) mm
7 m max.	$^{+7}_{0}$
Over 7 m	$^{+10}_{0}$
Length can be assessed by either l or L.	

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

JIS G 3462 : 2014 *Alloy steel tubes for boiler and heat exchanger*	**ISO 9329-2** : 1997 *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2 : Unalloyed and alloyed steels with specified elevated temperature properties* **ISO 9330-2** : 1997 *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2 : Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties*

(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	Alloy steel tubes used for boiler, heat exchanger, etc.	**ISO 9329-2** **ISO 9330-2**	1	Unalloyed and alloyed steel tubes with specified elevated temperature properties.	Deletion Addition	In **JIS**, only alloy steel tubes are specified. Carbon steel tubes are specified in other **JIS**.	1 Achieving conformity with **ISO** was challenging because **JIS** and **ISO** are different in structure (**JIS**s are divided according to product application while **ISO**s are divided according to manufacturing method) and in dimensional system, and also because **JIS** is cited in mandatory regulations. 2 To mediate this deviation, the corresponding **ISO**s were translated into Japanese and published as **JIS**s (**JIS G 7220** and **JIS G 7224**). **ISO**-conforming **JIS**s were prepared to achieve conformity with International Standard and to promote **ISO** products.
2 Normative references							
3 Classification and symbols	Eight grades of molybdenum steel tube and chromium-molybdenum steel tube are specified.		4.1	In **ISO 9329-2**, four grades of unalloyed steels and 14 grades of alloyed steels are specified. In **ISO 9330-2**, four grades of unalloyed steels and three grades of alloyed steels are specified.	Deletion Alteration Addition	In **JIS**, Carbon steel is deleted and molybdenum steel is added.	

(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	The manufacturing method, heat treatment and shape of tube end are specified.		5.3, 5.4, 8.2	The manufacturing method, heat treatment and shape of tube end are specified.	Alteration	**JIS** and **ISO** are identical in the specification items but different in the specified contents.	3 Apart from **ISO**, this **JIS** is required as a standard for special purpose. 4 Therefore, this **JIS** adopts most of the contents from the previous edition to stabilize the market. 5 Future task : Harmonization will be enhanced by incorporating as many specification contents of corresponding **ISO** standards into this **JIS** as possible. (Hereafter in this column, justifications for individual deviations are omitted.)
5 Chemical composition	The compositions for eight grades are specified.		6.1	(4 + 4) grades of unalloyed steels, (14 + 3) grades of alloyed steels are specified.	Addition Deletion Alteration	**JIS** and **ISO** are different in the composition of alloyed steel.	
6 Mechanical properties	Tensile strength, flattening resistance, flaring resistance and reverse flattening resistance are specified.		6.2.1 9.10.3 9.10.4	Room temperature (tensile, flattening, drift expanding, impact, etc.) and elevated temperature tensile test are specified.	Deletion Addition	In **JIS**, impact testing is deleted while reverse flattening resistance is added.	
7 Hydraulic test characteristics or nondestructive test characteristics	Either the hydraulic test characteristics or nondestructive test characteristics is applied.		9.5	Either the hydraulic leak-tightness test characteristics or non-destructive test characteristics is applied.	Deletion Addition	In **JIS**, the eddy current examination is added while the electromagnetic testing is deleted.	
8 Dimensions, mass and dimensional tolerances	Dimensions, mass and dimensional tolerances of tubes are specified.		7	Outside diameters, wall thicknesses and mass of tubes are selected from **ISO 4200** and **ISO 1129**.	Alteration	**JIS** and **ISO** have different dimensional systems.	

(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	
9 Appearance	Appearance is specified.		8	Appearance and soundness are specified.	Identical		
10.1 Chemical analysis	Chemical analysis is specified.		9.3	Chemical analysis is specified.	Identical		
10.2 Mechanical test	Tensile test, flattening test, flaring test and reverse flattening test are specified.		9.3 9.4 9.10	Testing of mechanical and technological characteristics.	Alteration	**JIS** and **ISO** are identical in the specification items but different in the frequency of sampling and the shape.	
11 Inspection and re-inspection	Inspection and re-inspection are specified.		9.10, 9.12	Tests and retests are specified.	Addition	In **JIS**, inspections related to Annexes are added.	
12 Marking	Items to be marked are specified.		10	Items to be marked are specified.	Alteration	**JIS** and **ISO** are identical in the specification items but different in the specified contents.	
13 Test report	Test report is specified.		12	Test report is specified.	Alteration	In **JIS**, one inspection document is specified, while in **ISO** four inspection documents are specified.	
Annex JA (normative) Special quality requirements	・Hardness ・Elevated temperature tensile test ・Ultrasonic examination and inspection ・Eddy current examination and inspection		6.2.2 9.8 9.10.5.2	Elevated temperature test Non-destructive test Non-destructive test	Addition	In **JIS**, hardness is added.	

(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 JB (normative) U-bend tube	The manufacturing method of U-bend tube is specified.		—		Addition	In **JIS**, the manufacturing method of U-bend tube is added.	

Overall degree of correspondence between **JIS** and International Standards (**ISO 9329-2**: 1997, **ISO 9330-2**: 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) in 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 Standards in the above table indicates as follows:

— MOD : Modifies International Standards.

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