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(JISF)

**Carbon steel tubes for boiler and  
heat exchanger**

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## Contents

	Page
Introduction .....	1
1 Scope .....	1
2 Normative references .....	1
3 Symbol of grade .....	2
4 Manufacturing method .....	2
5 Chemical composition .....	3
6 Mechanical properties .....	4
6.1 Tensile strength, yield point or proof stress, and elongation .....	4
6.2 Flattening resistance .....	4
6.3 Flaring property .....	5
6.4 Reverse flattening resistance .....	5
7 Hydraulic test characteristics or non-destructive test characteristics .....	5
8 Dimensions, unit masses and dimensional tolerances .....	6
8.1 Dimensions and unit masses .....	6
8.2 Dimensional tolerances .....	7
9 Appearance .....	9
10 Supplementary quality requirements and U-bent tubes .....	10
11 Tests .....	10
11.1 Chemical analysis .....	10
11.2 Mechanical tests .....	10
11.3 Hydraulic test or non-destructive test .....	12
12 Inspection and reinspection .....	13
12.1 Inspection .....	13
12.2 Reinspection .....	13
13 Marking .....	13
14 Report .....	14
Annex JA (normative) Supplementary quality requirements .....	15
Annex JB (normative) U-bent tubes .....	17
Annex JC (informative) Comparison table between JIS and corresponding International Standards .....	19

## 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 3461:2012**), which has been technically revised.

However, **JIS G 3461:2012** 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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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, published patent application or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, published patent application or utility model rights.

**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.

# Carbon steel tubes for boiler and heat exchanger

## Introduction

This Japanese Industrial Standard has been prepared based on **ISO 9329-2:1997**, Edition 1, and **ISO 9330-2:1997**, 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 carbon 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, etc. 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 and steel heat exchanger tubes for low temperature service.

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 9329-2:1997 *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)

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 *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 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 *Rounding of numbers*

### 3 Symbol of grade

Tubes shall be classified into 3 grades, and their symbols shall be as given in Table 1.

**Table 1 Symbols of grade and symbols for manufacturing method**

Symbol of grade	Symbol for manufacturing method		
	Tube manufacturing method	Finishing method	Marking
STB340	Seamless: S	Hot-finished: H	As given in <b>13 b)</b> .
STB410	Electric resistance welded: E	Cold-finished: C	
STB510		As electric resistance welded: G	

### 4 Manufacturing method

The manufacturing method shall be as follows.

- a) Tubes shall be manufactured from the killed steel and 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.
- 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.

**Table 2 Heat treatment**

Symbol of grade	Heat treatment				
	Hot-finished seamless steel tube	Cold-finished seamless steel tube	As electric resistance welded steel tube	Hot-finished electric resistance welded steel tube	Cold-finished electric resistance welded steel tube <sup>a)</sup>
STB340	As manufactured. Low temperature annealing or normalizing may be performed as necessary.	Low temperature annealing, normalizing or full annealing	Normalizing	As manufactured. Low temperature annealing or normalizing may be performed as necessary.	Normalizing
STB410	As manufactured. Low temperature annealing or normalizing may be performed as necessary.	Low temperature annealing, normalizing or full annealing	Normalizing	Low temperature annealing	Normalizing
STB510	Normalizing				
Note <sup>a)</sup> The cold-finished electric resistance welded steel tube which has been normalized prior to cold finishing may be finished by low temperature annealing or full annealing.					

- 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.

**5 Chemical composition**

Tubes shall be tested in accordance with 11.1 and the obtained heat analysis values shall satisfy the requirements given in Table 3. Where necessary, other alloy elements than given in Table 3 may be added. When the product analysis is requested by the purchaser, the tube shall be tested in accordance with 11.1. The obtained product analysis values shall satisfy the requirements in Table 3 within the tolerance given in Table 3 of JIS G 0321 for seamless steel tubes and the tolerance given in Table 2 of JIS G 0321 for electric resistance welded steel tubes.

**Table 3 Chemical composition**

Symbol of grade	Unit: %				
	C	Si	Mn	P	S
STB340	0.18 max.	0.35 max.	0.30 to 0.60	0.035 max.	0.035 max.
STB410	0.32 max.	0.35 max.	0.30 to 0.80	0.035 max.	0.035 max.
STB510	0.25 max.	0.35 max.	1.00 to 1.50	0.035 max.	0.035 max.
The purchaser may specify the amount of Si to be in a range of 0.10 % to 0.35 %.					

## 6 Mechanical properties

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

Tubes shall be tested in accordance with 11.2.3, and the tensile strength, yield point or 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, yield point or proof stress, and elongation**

Symbol of grade	Tensile strength <sup>a)</sup>	Yield point or proof stress	Elongation %		
			Outside diameter		
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over
			Test piece		
			Test piece No. 11	Test piece No. 11	Test piece No. 11 Test piece No. 12
			Tensile test direction		
	N/mm <sup>2</sup>	N/mm <sup>2</sup>	Parallel to tube axis	Parallel to tube axis	Parallel to tube axis
STB340	340 min.	175 min.	27 min.	30 min.	35 min.
STB410	410 min.	255 min.	17 min.	20 min.	25 min.
STB510	510 min.	295 min.	17 min.	20 min.	25 min.

NOTE 1 N/mm<sup>2</sup> = 1 MPa  
 Note <sup>a)</sup> 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 120 N/mm<sup>2</sup> 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: %

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
STB340	26 min.	28 min.	29 min.	30 min.	32 min.	34 min.	35 min.
STB410	16 min.	18 min.	19 min.	20 min.	22 min.	24 min.	25 min.
STB510	16 min.	18 min.	19 min.	20 min.	22 min.	24 min.	25 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 11.2.4. When flattened until the distance  $H$  between two platens reaches the value obtained by Formula (1), the test piece shall be free from cracks.



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

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  
           STB340: 0.09  
           STB410: 0.08  
           STB510: 0.07.

NOTE For the detailed procedure for flattening test, see 11.2.4.

**6.3 Flaring property**

Tubes shall be tested in accordance with 11.2.5. When flared into a trumpet shape until the outside diameter is enlarged 1.2 times the original size, 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 11.2.5.

**6.4 Reverse flattening resistance**

Electric resistance welded steel tubes shall be tested in accordance with 11.2.6 and the test piece shall be free from cracks in the weld.

NOTE For the detailed procedure for reverse flattening test, see 11.2.6.

**7 Hydraulic test characteristics or non-destructive test characteristics**

Tubes shall be tested in accordance with 11.3, 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 specified minimum value of yield point or proof stress given in Table 4 (N/mm<sup>2</sup>)

- 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.

NOTE Other non-destructive tests in accordance with JISs include the test specified in JIS G 0586.

- 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.

## 8 Dimensions, unit masses and dimensional tolerances

### 8.1 Dimensions and unit masses

The outside diameters, wall thicknesses and unit masses of tubes shall be as given in Table 6. Dimensions not specified in Table 6 may be used upon agreement between the purchaser and the manufacturer. In this case, the unit mass shall be calculated by Formula (3), assuming 1 cm<sup>3</sup> steel to be 7.85 g, 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.

$$W = 0.024\ 66\ t(D - t) \dots\dots\dots (3)$$

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

0.024 66 : unit conversion factor for obtaining  $W$

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

### 8.2 Dimensional tolerances

The dimensional tolerances for tubes shall be as follows.

- The tolerances on outside diameter of tubes shall be as given in Table 7.
- The tolerances on wall thickness and eccentricity of tubes shall be as given in Table 8.
- The tolerances on length of tubes shall be as given in Table 9.

**Table 6 Outside diameters, wall thicknesses and unit masses of carbon steel tubes for boiler and heat exchanger**

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	0.435	0.564	0.686	0.771	0.853	0.930													
19.0	0.527	0.687	0.838	0.947	1.05	1.15													
21.7	0.607	0.793	0.972	1.10	1.22	1.34	1.46												
25.4	0.716	0.939	1.15	1.31	1.46	1.61	1.75	1.89											
27.2	0.769	1.01	1.24	1.41	1.58	1.74	1.89	2.05	2.29										
31.8	0.906	1.19	1.47	1.67	1.87	2.07	2.26	2.44	2.74	3.03									
34.0		1.28	1.58	1.80	2.01	2.22	2.43	2.63	2.96	3.27	3.58								
38.1		1.44	1.78	2.03	2.28	2.52	2.75	2.99	3.36	3.73	4.08	4.42							
42.7			2.01	2.29	2.57	2.85	3.12	3.38	3.82	4.24	4.65	5.05	5.43						
45.0			2.12	2.42	2.72	3.01	3.30	3.58	4.04	4.49	4.93	5.36	5.77	6.17					
48.6			2.30	2.63	2.95	3.27	3.58	3.89	4.40	4.89	5.38	5.85	6.30	6.75	7.18				
50.8			2.41	2.75	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			2.56	2.93	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			2.72	3.11	3.49	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			2.88	3.29	3.70	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				3.47	3.90	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				3.56	4.00	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				3.84	4.32	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				4.19	4.72	5.24	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 The standard unit mass used in transaction is to 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.

**Table 7 Tolerances on outside diameter <sup>a)</sup>**

Unit: mm

Outside diameter range	Hot-finished seamless steel tube	Cold-finished seamless steel tube	Hot-finished electric resistance welded steel tube and as electric resistance welded steel tube <sup>b)</sup>	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
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

Notes <sup>a)</sup> The tolerances on outside diameter in this table do not apply to local repaired parts.  
<sup>b)</sup> For the electric resistance welded steel tubes which are finished by methods other than cold finishing, the tolerances on the outside diameter of cold-finished electric resistance welded steel tubes may apply when requested by the purchaser.

**Table 8 Tolerances on wall thickness and eccentricity**

Tolerance	Wall thickness mm	Outside diameter mm					
		Hot-finished seamless steel tube		Cold-finished seamless steel tube		Electric resistance welded steel tube	
		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		+ 0.3 mm 0	
	2 or over to and excl. 2.4	+ 40 % 0	a) 0				
	2.4 or over to and excl. 3.8	+ 35 % 0	+ 35 % 0	+ 20 % 0	+ 22 % 0	+ 18 % 0	+ 18 % 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 <sup>b)</sup>	5.6 or over	22.8 % max. of wall thickness		—		—	
Notes <sup>a)</sup> The plus tolerance is not specified. <sup>b)</sup> 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 9 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 Appearance

The appearance shall be as follows.

- Tubes shall be straight for practical purposes with both ends at right angles to the tube axis.
- The inside and outside surfaces of tubes shall be finished smoothly and free from defects detrimental to use. For the electric resistance welded steel tubes, the convex on inside surface of the weld shall be 0.25 mm or under. The purchaser may specify

the inside convex to be 0.15 mm or under for tubes of outside diameter 50.8 mm or under and of wall thickness 3.5 mm or under.

- 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.

## **10 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.

## **11 Tests**

### **11.1 Chemical analysis**

#### **11.1.1 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.

#### **11.1.2 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.

### **11.2 Mechanical tests**

#### **11.2.1 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.

#### **11.2.2 Sampling method and number of test pieces**

For as-manufactured tubes not subjected to heat treatment, one sample shall be taken from each group of 50 tubes or its fraction that are of the same dimensions, and for heat treated tubes, 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 and one flaring 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".

For the electric resistance welded steel tubes, in addition to the test pieces mentioned above, a test piece for reverse flattening test shall be taken. For as-manufactured tubes not subjected to heat treatment, one sample shall be taken from each group of 100 tubes or its fraction that are of the same dimensions, and for heat treated 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.

### 11.2.3 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 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**.

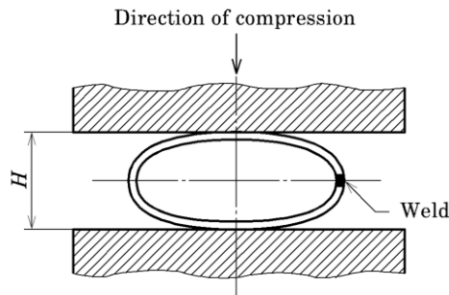
### 11.2.4 Flattening test

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

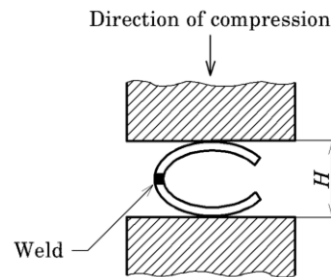
The flattening test for seamless steel tubes may be omitted unless otherwise specified by the purchaser<sup>1)</sup>.

Note <sup>1)</sup> 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 electric resistance welded steel tube, place the test piece, as shown in Figure 1, 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 2.



**Figure 1 Flattening test (ring-shaped test piece)**



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

### 11.2.5 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 purchaser<sup>2)</sup>.

Note<sup>2)</sup> 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** Flare 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.

### 11.2.6 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 purchaser<sup>3)</sup>.

Note<sup>3)</sup> 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.

### 11.3 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 7 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.

## 12 Inspection and reinspection

### 12.1 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 hydraulic test characteristics or non-destructive test characteristics shall conform to the requirements specified in Clause 7.
- e) The dimensions shall conform to the requirements specified in Clause 8.
- f) The appearance shall conform to the requirements specified in Clause 9.
- g) 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 10.

### 12.2 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.

## 13 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

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

#### 14 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.

When other alloy elements than those given in Table 3 are intentionally added, the content rate of the added alloy element(s) shall be reported in the inspection document.

## Annex JA (normative) Supplementary quality requirements

### JA.1 Hardness (Z1) <sup>1)</sup>

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
STB340	77 max.
STB410	79 max.
STB510	92 max.

- b) The sampling method and the number of test pieces for tensile test in **11.2.2** 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 electric resistance welded steel tubes, the test shall be performed in the portion other than the weld or the heat affected zones.

Note <sup>1)</sup> 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) <sup>2)</sup>

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 <sup>2)</sup> 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)<sup>3)</sup>**

The ultrasonic examination and inspection shall be as follows.

- a) 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.
- b) The ultrasonic examination shall be carried out in accordance with **JIS G 0582**.
- c) The ultrasonic examination shall be performed on each tube, and the results shall conform to the requirements specified in **a)**.

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

### **JA.4 Eddy current examination and inspection (Z4)<sup>4)</sup>**

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

## **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.

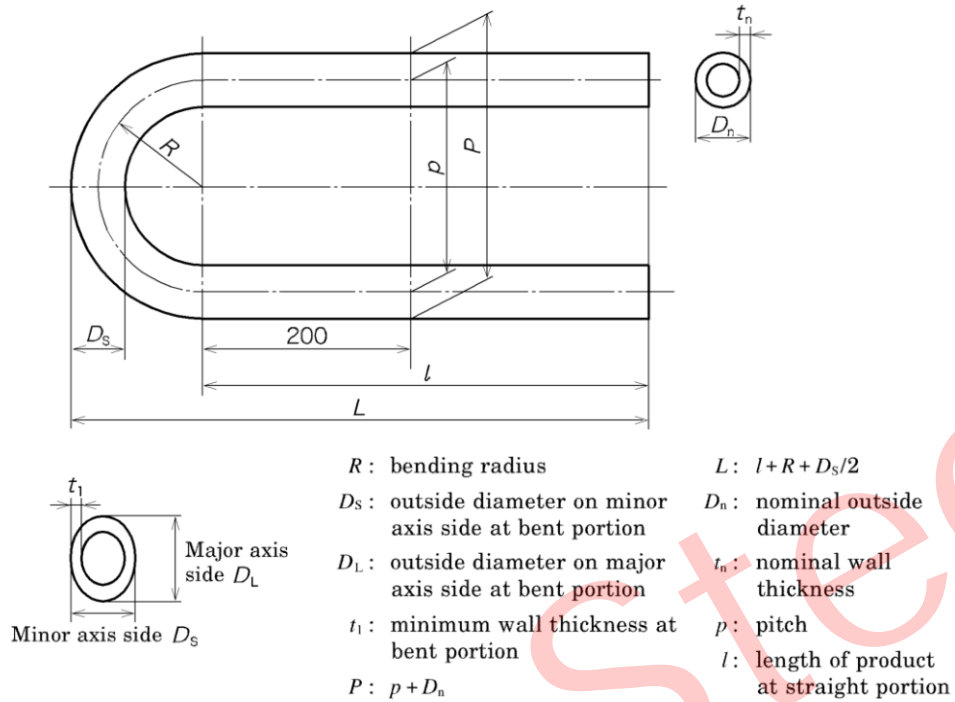
#### **JB.4 Measurement of dimensions of U-bent tubes**

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  $90^\circ$  (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 11.3 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 7 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.	$\frac{D_n}{2.5R} \times 100$ max.	$\pm 1.5$
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.			

**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

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

<b>JIS G 3461 : 2019</b> Carbon steel tubes for boiler and heat exchanger		<b>ISO 9329-2 : 1997</b> Seamless steel tubes for pressure purposes— <i>Technical delivery conditions—Part 2: Unalloyed and alloyed steels with specified elevated temperature properties</i> <b>ISO 9330-2 : 1997</b> Welded steel tubes for pressure purposes— <i>Technical delivery conditions—Part 2: Electric resistance and induction welded unalloyed and alloyed steel tubes with specified elevated temperature properties</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	Carbon steel tubes used for boiler and heat exchanger	1	Tubes made of unalloyed and alloyed steel that are intended for pressure purposes where the material is also subjected to elevated temperatures	Deletion Addition	<b>JIS</b> limits the scope to carbon steel tubes. Alloy steel tubes are specified in other <b>JIS</b> .	1 Harmonization with <b>ISO</b> specifications was difficult due to the difference in standard systems ( <b>JIS</b> standards are systematized according to applications; <b>ISO</b> standards are systematized according to manufacturing methods) and the difference in dimensional system, and also due to the fact that this <b>JIS</b> is cited in mandatory regulations.
2 Normative references						
3 Symbol of grade	3 grades of carbon steel	4.1	<b>ISO 9329-2</b> : 4 grades of unalloyed steel and 14 grades of alloyed steel <b>ISO 9330-2</b> : 4 grades of unalloyed steel and 3 grades of alloyed steel	Deletion Alteration	In <b>JIS</b> , requirements are specified for carbon steel tubes only and chemical compositions are changed.	

(I) Requirements in <b>JIS</b>		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between <b>JIS</b> 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	<b>ISO 9329-2</b> <b>ISO 9330-2</b>	5	Tube manufacturing process and heat treatment	Addition Alteration	Add requirements for tube end shape to <b>JIS</b> , and specify type of heat treatment only.	2 As a measure for the above, the corresponding <b>ISO</b> standards have been translated into Japanese and published as <b>JIS G 7220</b> , <b>JIS G 7224</b> so that <b>ISO</b> -equivalent <b>JIS</b> s are in place to improve harmonization with International Standards, and to promote widespread use of the <b>ISO</b> -conforming products.
5 Chemical composition	Chemical compositions of 3 carbon steel grades		6.1	<b>ISO 9329-2</b> : Chemical compositions of 4 grades of unalloyed steel and 14 grades of alloyed steel <b>ISO 9330-2</b> : Chemical compositions of 4 grades of unalloyed steel and 3 grades of alloyed steel	Deletion Alteration	Chemical compositions and tolerances for product analysis of carbon steel differ between <b>JIS</b> and <b>ISO</b> standards.	3 Necessity of this <b>JIS</b> , independent from <b>ISO</b> standards, as a standard for special applications remains distinct. 4 Specifications in the previous edition of <b>JIS</b> are maintained in this current edition in order not to disturb the market stability.
6 Mechanical properties	Tensile properties, flattening resistance, flaring property and reverse flattening resistance		6.2	Tests at room temperature (tensile, flattening, drift or ring expanding, and impact tests) and tests at elevated temperatures	Deletion Addition Alteration	In <b>JIS</b> , delete requirements for 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 Hydraulic test characteristics or non-destructive test characteristics	Hydraulic test characteristics or non-destructive test characteristics	<b>ISO 9329-2</b> <b>ISO 9330-2</b>	9.5 Hydraulic leak-tightness test or non-destructive test	Alteration	Hydraulic test pressure value in <b>JIS</b> is lower than that specified in <b>ISO</b> standards.	5 Future tasks: • Incorporate specifications of corresponding <b>ISO</b> standards (or translated <b>JIS</b> ) into this <b>JIS</b> as far as possible to improve harmonization with <b>ISO</b> standards. • Make a proposal for additions of specifications in this <b>JIS</b> that are currently not part of the <b>ISO</b> standards as required by the market to improve harmonization with <b>ISO</b> standards.	
8 Dimensions, unit masses and dimensional tolerances	Dimensions, unit masses and dimensional tolerances		7.1 The outside diameters, wall thicknesses and masses of the tubes shall be selected from those in <b>ISO 4200</b> and <b>ISO 1129</b> .	Deletion Addition Alteration	The dimensional system differs between <b>JIS</b> and <b>ISO</b> standards.		
9 Appearance	Appearance		8.1 Appearance and soundness	Alteration	Alter requirements for the weld of electric resistance welded steel tubes.		
10 Supplementary 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 <b>JIS</b>		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between <b>JIS</b> 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	
11 Tests	Methods of chemical analysis, mechanical tests, hydraulic test and non-destructive test	<b>ISO 9329-2</b> <b>ISO 9330-2</b>	9.3 9.4 9.5 9.8 9.10	Methods of chemical analysis, mechanical tests, and hydraulic test or non-destructive test	Deletion Addition Alteration	In <b>JIS</b> , delete requirements for tensile test at elevated temperatures, ring expanding test, etc., add those for reverse flattening test, and alter those for sampling method for analysis, analysis method, mechanical test piece sampling frequency and mechanical test piece shape.	
12 Inspection and reinspection	Inspection and reinspection		9.10 9.12	Inspection and reinspection	Addition Alteration	Add inspection items to <b>JIS</b> , and alter general requirements for inspection and requirements to be applied when the tube fails in the mechanical test.	
13 Marking	Marking		10	Marking	Alteration	<b>JIS</b> and <b>ISO</b> are identical in specification items but different in specified contents.	
14 Report	Report		12	Report	Alteration	<b>JIS</b> specifies 1 type of inspection documents, while <b>ISO</b> 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, and eddy current examination and inspection	ISO 9329-2 ISO 9330-2	6.2.2 9.8 9.10.5.2	Properties at elevated temperatures, non-destructive 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 9329-2:1997, ISO 9330-2:1997): MOD
NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows: — 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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For inquiry, please contact:

**Publication and Information Unit, Japanese Standards Association Group**

Mita MT Building, 3-13-12, Mita, Minato-ku, Tokyo, 108-0073 JAPAN

TEL. 03-4231-8550 FAX. 03-4231-8665

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