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Carbon steel tubes for boiler and heat exchanger

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry based on the provision of Article 14, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act in response to a proposal for revision of Japanese Industrial Standard with a draft being attached, submitted by The Japan Iron and Steel Federation (JISF), an accredited standards development organization. This edition replaces the previous edition (**JIS G 3461** : 2019), which has been technically revised.

However, **JIS G 3461** : 2019 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 December 2024.

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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.

Annex JA and Annex JB are unique to **JIS** and not given in the corresponding International Standards. 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 used for exchanging heat between the inside and outside of the tube (hereafter referred to as tubes), such as water tubes, smoke tubes, superheater tubes, tubes used for air preheater, 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.

NOTE 1 This Standard is generally applicable to tubes of outside diameters 15.9 mm to 139.8 mm.

NOTE 2 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 Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

Part or all of the provisions of the following standards, 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 0201 *Glossary of terms used in iron and steel (Heat treatment)*

JIS G 0202 *Glossary of terms used in iron and steel (Testing)*

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JIS G 0203 *Glossary of terms used in iron and steel (Products and quality)*

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 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS G 0201**, **JIS G 0202** and **JIS G 0203** apply.

4 Symbols of grade

Tubes are classified into 3 grades. The symbols of grade and symbols for manufacturing method are 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 STB410 STB510	Seamless : S Electric resistance welded : E	Hot-finished : H Cold-finished : C As electric resistance welded : G	As given in **15 b**).

5 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 is given in Table 1. Symbols for manufacturing method are as given in Table 1.

b) Tubes shall be subjected to the heat treatment given in Table 2. Other heat treat-

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ments may be applied upon agreement between the purchaser and the manufacturer.

c) Tubes shall be finished with plain ends unless otherwise specified.

d) When tubes are manufactured by electric resistance welding, the weld beads on external and internal surfaces shall be removed to smooth the surfaces along the contour of the tube. The weld beads on internal surface may be left unremoved if so agreed between the purchaser and the manufacturer.

Table 2 Heat treatment

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 [a)]
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 [a)]	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.				

6 Chemical composition

Tubes shall be tested in accordance with **13.1** and the obtained heat analysis values shall satisfy the requirements given in Table 3. When the product analysis is requested by the purchaser, the test shall be carried out in accordance with **13.1**. The obtained product analysis values shall satisfy the requirements in Table 3 within tolerances given below.

a) For seamless steel tubes, tolerances given in Table 3 of **JIS G 0321** shall apply.

b) For electric resistance welded steel tubes, tolerances in Table 2 of **JIS G 0321** shall

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apply.

Table 3 Chemical composition

Unit: %

Symbol of grade	C	Si [a)]	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.
Alloy elements not listed in this table may be added as necessary. Note [a)] Si content may be in a range of 0.10 % to 0.35 %, as specified by the purchaser.					

7 Mechanical properties

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

Tubes shall be tested in accordance with **13.2.1**, **13.2.2** and **13.2.3**, 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 [a)]	Yield point or proof stress [b)]	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 or Test piece No. 12
			Tensile test direction		
	N/mm²	N/mm²	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/mm² = 1 MPa

Note [a)] Exclusively for the heat exchanger tubes, the purchaser may, where necessary, specify the maximum value of tensile strength. In this case, the maximum tensile strength value shall be the value obtained by adding 120 N/mm² to the value in this table.

Note [b)] Unless otherwise specified, the yield point to be determined shall be the upper yield point, R_{eH}, or, wherever this is not pronounced, the 0.2 % proof stress, $R_{p0.2}$.

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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**.						

7.2 Flattening resistance

Tubes shall be tested in accordance with **13.2.1**, **13.2.2** and **13.2.4**. When flattened until the distance between two platens H reaches the value obtained by Formula (1), the test piece shall be free from cracks.

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

where, H: distance between platens (mm)

t : wall thickness of tube (mm)

D: outside diameter of tube (mm)

e : constant for each grade of tube

STB340 : 0.09
STB410 : 0.08
STB510 : 0.07

NOTE For the details of flattening test, see **13.2.4**.

7.3 Flaring property

Tubes shall be tested in accordance with **13.2.1**, **13.2.2** and **13.2.5**. 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 details of flaring test, see **13.2.5**.

7.4 Reverse flattening resistance

Electric resistance welded steel tubes shall be tested in accordance with **13.2.1**, **13.2.2** and **13.2.6** and the test piece shall be free from cracks in the weld.

NOTE For the test of reverse flattening resistance, see **13.2.6**.

8 Selection of hydraulic test characteristics or non-destructive test characteristics

Tubes shall be subjected to the hydraulic test in accordance with **13.3** or the

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non-destructive test in accordance with **13.4**, and their characteristics shall conform to either of the following. The decision on which characteristics to be tested shall be left to the discretion of the purchaser. If not specified by the purchaser, it shall be left to the discretion of the manufacturer.

a) **Hydraulic test characteristics**, 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.

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

where, P : test pressure (MPa)
t : wall thickness of tube (mm)
D : outside diameter of tube (mm)
s : 60 % of the specified minimum value of yield point or proof stress given in Table 4 (N/mm^2)

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 (**JIS**s) 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 **JIS**s include the test specified in **JIS G 0586** [1].

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.

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9 Dimensions, unit masses and dimensional tolerances

9.1 Dimensions and unit masses

The outside diameters, wall thicknesses and unit masses of tubes shall be as given in Table 6. 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^3 steel to be 7.85 g, and the result shall be rounded 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.

$$W = 0.024\,66\,t\,(D - t) \quad \cdots\cdots (3)$$

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 in Table 6 are the results of the calculation given above.

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Table 6 Outside diameters, wall thicknesses and unit masses of carbon 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	0.527	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 is used in transactions. The standard unit mass 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.

9.2 Dimensional tolerances

The dimensional tolerances for tubes shall be as follows.

a) Tolerances on outside diameter of tubes shall be as given in Table 7.

b) Tolerances on wall thickness and eccentricity of tubes shall be as given in Table 8.

c) Tolerances on length of tubes shall be as given in Table 9.

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Table 7 Tolerances on outside diameter

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 [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

The tolerances on outside diameter in this table do not apply to local repaired parts.

Note [a] 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	+22 % 0	+0.3 mm 0	+18 % 0
	2 or over to and excl. 2.4	+40 % 0	[a] 0	+20 % 0		+18 % 0	
	2.4 or over to and excl. 3.8	+35 % 0	+35 % 0				
	3.8 or over to and excl. 4.6	+33 % 0	+33 % 0				
	4.6 or over	+28 % 0	+28 % 0				
Tolerance on eccentricity [b]	5.6 or over	22.8 % max. of wall thickness		—		—	

Note [a] The plus tolerance is not specified.

Note [b] Eccentricity is expressed by the ratio, in percentage, of the difference between the maximum value and the minimum value of the wall thickness measured on the same cross-section of the tube to the wall thickness value specified in the order. This requirement does not apply to tubes under 5.6 mm in wall thickness.

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Table 9 Tolerances on length

Outside diameter	Length	Tolerance on length
50 mm or under	7 m or under	+7 mm 0
	Over 7 m up to and incl. 10 m	+10 mm 0
	Over 10 m up to and incl. 13 m	+13 mm 0
	Over 13 m	+15 mm 0
Over 50 mm	7 m or under	+10 mm 0
	Over 7 m up to and incl. 10 m	+13 mm 0
	Over 10 m	+15 mm 0
The tolerances on length may be $^{+30}_{0}$ mm upon agreement between the purchaser and the manufacturer.		

10 Appearance

The appearance shall be as follows.

a) Tubes shall be straight for practical purposes with both ends at right angles to the tube axis.

b) The internal and external surfaces of tubes shall be finished smoothly and free from defects detrimental to use. For the electric resistance welded steel tubes, the convex on internal surface of the weld shall be 0.25 mm or under. The purchaser may specify the internal 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.

11 Supplementary quality requirements

The supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer shall be as given in Annex JA.

12 U-bent tubes

U-bent tubes shall be produced upon agreement between the purchaser and the manufacturer. The manufacturing method, appearance, dimensional tolerances on bent portion, measuring method of dimensions and hydraulic test characteristics of U-bent tubes shall be in accordance with Annex JB.

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13 Tests

13.1 Chemical analysis

13.1.1 General requirements and sampling method

General requirements for chemical 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.

13.1.2 Analytical method

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

13.2 Mechanical tests

13.2.1 General

General requirements for mechanical tests shall be in accordance with Clause 7 and Clause 9 of JIS G 0404. The sampling shall be in accordance with Class A specified in 7.6 of JIS G 0404.

13.2.2 Sampling method and number of test pieces

The sampling method for mechanical tests and the number of test pieces shall be as follows.

a) **Tensile test, flattening test and flaring test**

1) For as-manufactured tubes, one sample shall be taken from each group of 50 tubes or its fraction that are of the same dimensions. 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.

2) For tubes 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 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 “same heat treatment batch” of continuous furnace refers to a group of tubes from continuous furnace operation under the same heat treatment 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”.

b) **Reverse flattening test** For electric resistance welded steel tubes, a reverse flattening test piece shall be taken in addition to the test pieces of **a**).

1) For as electric resistance welded tubes, one sample shall be taken from each group of 100 tubes or its fraction that are of the same dimensions. From each sample thus obtained, one reverse flattening test piece shall be taken.

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2) For tubes 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 of the same heat treatment batch. From each sample thus obtained, one reverse flattening test piece shall be taken.

13.2.3 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 the 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, No. 12B or No. 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**.

13.2.4 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 [1].

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

a) **Test piece** The length of the test piece shall be 50 mm or over. For tubes of wall thickness 15 % or over of the outside diameter, C-shaped test piece prepared by removing 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 between the two platens H reaches the value obtained by Formula (1) given in **7.2**, 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.

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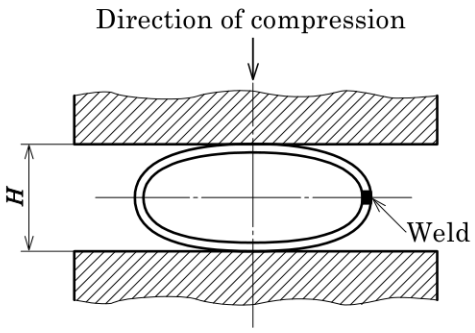

Figure 1 Flattening test (ring-shaped test piece)

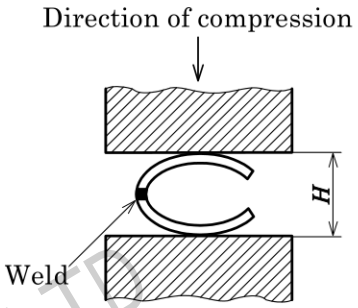

Figure 2 Flattening test (C-shaped test piece)

13.2.5 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 [2].

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

a) **Test piece** The test piece shall be of the proper length for the flaring test.

b) **Test method** 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 **7.3**, and examine for cracks.

13.2.6 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 [3].

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

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

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

13.3 Hydraulic test

The hydraulic test frequencies and the test method shall be as follows.

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a) **Frequency of test** The hydraulic test shall be carried out on each tube.

b) **Test method** Apply to the tube the pressure not less than the minimum hydraulic test pressure specified in **8 a)**, hold for at least 5 s, and then examine if the tube withstands the pressure without leakage.

13.4 Non-destructive test

The non-destructive test frequencies and the test method shall be as follows.

a) **Frequency of test** The non-destructive test shall be carried out on each tube.

b) **Test method** The test method shall be as follows. When other non-destructive tests specified in relevant **JIS**s are carried out upon agreement between the purchaser and the manufacturer, the test method shall be in accordance with the **JIS** to be applied.

1) The ultrasonic examination shall be in accordance with the method specified in **JIS G 0582**. The test may be carried out by category of reference standard stricter (shallower) than Category UD at the discretion of the manufacturer. The alarm level may be set lower (stricter) than signals from the reference standard at the discretion of the manufacturer.

2) The eddy current examination shall be in accordance with the method specified in **JIS G 0583**. The test may be conducted by a category of reference standard stricter (smaller in diameter in the case of drill hole, and shallower in the case of square notch or recess) than Category EY at the discretion of the manufacturer. The alarm level may be set lower (stricter) than signals from the reference standard at the discretion of the manufacturer.

14 Inspection and reinspection

14.1 Inspection

The inspection shall be as follows.

a) General requirements for inspection shall be as specified in **JIS G 0404**.

b) The chemical composition shall conform to the requirements specified in Clause **6**.

c) The mechanical properties shall conform to the requirements specified in Clause **7**.

d) The hydraulic test characteristics shall conform to the requirements specified in **8 a)**.

e) The non-destructive test characteristics shall conform to the requirements specified in **8 b)**.

f) The dimensions shall conform to the requirements specified in Clause **9**.

g) The appearance shall conform to the requirements specified in Clause **10**.

h) When part or all of the supplementary quality requirements are applied according to Clause **11**, the inspection results shall conform to the relevant requirements specified in Annex JA.

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i) U-bent tubes manufactured in accordance with Clause **12** shall conform to the requirements specified in Annex JB.

14.2 Reinspection

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.

15 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. 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

The symbols for manufacturing method shall be as follows. The dash ("–") may be replaced with a blank.

1) Hot-finished seamless steel tube –S–H

2) Cold-finished seamless steel tube –S–C

3) As electric resistance welded steel tube –E–G

4) Hot-finished electric resistance welded steel tube –E–H

5) 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 requirement (if specified)

16 Information to be supplied by the purchaser

The purchaser shall provide the manufacturer, processor or intermediary with at least the following information at the time of ordering in order to properly specify the requirements in this Standard.

a) Symbol of grade (Table 1)

b) Manufacturing method and finishing method (Clause **5**)

c) Product dimensions (Clause **9**)

17 Report

Unless otherwise specified, the manufacturer shall submit the inspection document 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

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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.

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Annex JA (normative)
Supplementary quality requirements

JA.1 Hardness (Z1) [4)]

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 **13.2.2** 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 [4)] In transactions 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) [5)]

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

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the tube, the shape of the test piece shall be as agreed between the purchaser and the manufacturer.

Note [5] In transactions 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 (Z3) [6]

The ultrasonic examination shall be as follows.

a) The ultrasonic examination shall be carried out in accordance with **JIS G 0582**.

b) The standard detection sensitivity for the ultrasonic examination shall be Category UA or UC reference standard specified in **JIS G 0582**. The signals from the reference sample containing the reference standard of the said category shall be regarded as alarm level, and there shall be no signals equivalent to or greater than the alarm level. Which of the reference standard categories applies shall be specified by the purchaser. If not specified, it shall be left to the discretion of the manufacturer.

c) The ultrasonic examination shall be performed on each tube, and the results shall conform to the requirements specified in **b)**.

Note [6] In transactions of tubes, the requirements for ultrasonic examination may be marked as Z3.

JA.4 Eddy current examination (Z4) [7]

The eddy current examination shall be as follows.

a) The eddy current examination shall be carried out in accordance with **JIS G 0583**.

b) The standard detection sensitivity for the eddy current examination shall be Category EU, EV, EW or EX reference standard specified in **JIS G 0583**. The signals from the reference sample containing the reference standard of the said category shall be regarded as alarm level, and there shall be no signals equivalent to or greater than the alarm level. Which of the reference standard categories applies shall be specified by the purchaser. If not specified, it shall be left to the discretion of the manufacturer.

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

Note [7] In transactions of tubes, the requirements for eddy current examination may be marked as Z4.

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Annex JB (normative)
U-bent tubes

JB.1 Manufacturing method

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

a) U-bent tubes shall be produced by cold-bending process, and the bending radius shall be at least 1.5 times the outside diameter of the tube.

b) The bent portion of the tube shall not be heat treated, in general. When requested by the purchaser, the application of heat treatment may be agreed 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 and 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 product with the smallest bending radius shall be taken. The outside diameter of the tube shall be measured in the two circumferential directions (minor axis side and major axis side) at the bent portion forming 90° (dimension D_S in Figure JB.1) to determine the change in outside diameter. At the same position, the wall thickness shall be measured at 4 points on the circumference, and the reduction rate of wall thickness shall be obtained from the minimum value of the four measurements.

JB.5 Hydraulic test characteristics

The manufacturer may carry out the hydraulic test specified **13.3** 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 **8 a**).

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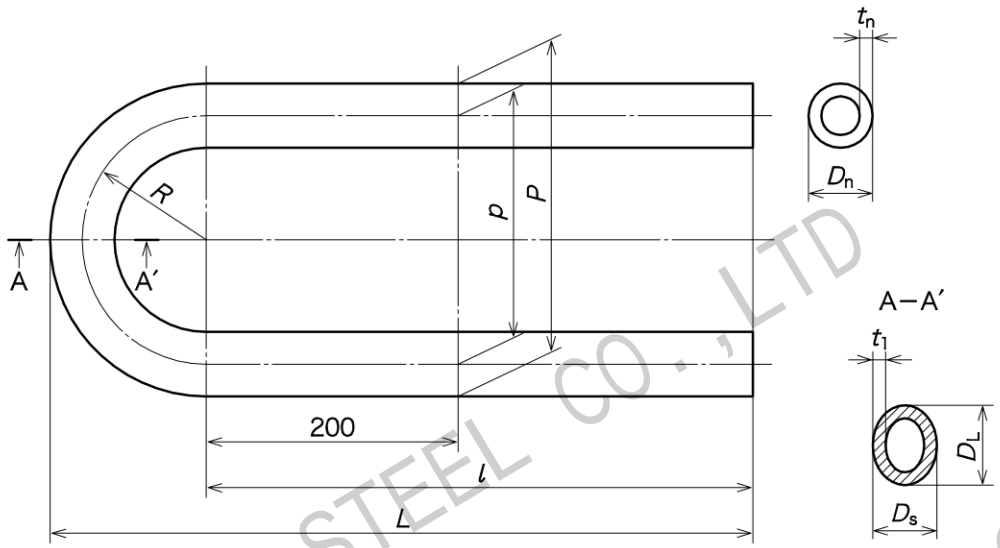
Unit: mm



Key
- R : bending radius
- D_n : nominal outside diameter
- D_S : outside diameter on minor axis side at bent portion
- D_L : outside diameter on major axis side at bent portion
- t_n : nominal wall thickness
- t_1 : minimum wall thickness at bent portion
- p : pitch
- P : $p + D_n$
- L : $l + R + D_S/2$
- l : length of tube at straight portion

Figure JB.1 U-bent tube

Table JB.1 Dimensional tolerances for U-bent tubes

Change in outside diameter at bent portion [a] 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.	±1.5
Note [a] If the calculated value of the change in outside diameter is under 0.5 mm, this specification value shall be 0.5 mm max.			

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

Length of straight portion of tube after bending	Tolerance on length (l or L) [a] mm
7 m or under	$^{+7}_{0}$
Over 7 m	$^{+10}_{0}$
Note [a] The indicated tolerance may be applied to either l or L.	

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Bibliography

[1] JIS G 0586 *Automated flux leakage examination of steel pipes and tubes*

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Annex JC (informative)

Comparison table between JIS and corresponding International Standards

JIS G 3461		**ISO 9329-2** : 1997, **ISO 9330-2** : 1997, (MOD)		
a) No. of clause (**JIS**)	b) No. of clause (corresponding International Standard)	c) Classification by clause	d) Detail and justification of technical deviation	e) Future measures for the technical deviation
1	1	Alteration	**JIS** covers carbon steel tubes used for the boiler and heat exchanger and alloy steel tubes are covered by another **JIS**. **ISO** covers tubes made of unalloyed and alloyed steel that are intended for pressure purposes where the material is also subjected to elevated temperatures. The dimensional systems differ between **JIS** and **ISO**.	Although the standard systems differ (**JIS**s are systematized according to applications; **ISO** standards according to manufacturing methods), the requirements between **JIS** and **ISO** are almost the same when other **JIS**s are included. Harmonization of dimensional systems is difficult due to the fact that the **JIS** specification is cited in mandatory regulations in Japan. The **JIS** specification is maintained without change.
3	—	Addition	Add a clause for terms and definitions, where **JIS G 0201**, **JIS G 0202** and **JIS G 0203** are added.	As required for **JIS**. The **JIS** specification is maintained without change.
4	4.1	Deletion	**JIS** specifies 3 grades of carbon steel, whereas **ISO 9329-2** specifies 4 grades of carbon steel and 14 grades of alloy steel and **ISO 9330-2** specifies 4 grades of carbon steel and 3 grades of alloy steel.	In **JIS**, requirements are specified for carbon steel tubes only and chemical compositions are changed. The requirements between **JIS** and **ISO** are almost the same when other **JIS**s are included. The **JIS** specification is maintained without change.

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a) No. of clause (**JIS**)	b) No. of clause (corresponding International Standard)	c) Classification by clause	d) Detail and justification of technical deviation	e) Future measures for the technical deviation
6	6.1	Alteration	**JIS** specifies 3 grades of carbon steel, whereas **ISO 9329-2** specifies 4 grades of carbon steel and 14 grades of alloyed steel and **ISO 9330-2** specifies 4 grades of carbon steel and 3 grades of alloyed steel.	In **JIS**, requirements are specified for carbon steel tubes only and chemical compositions are changed. The requirements between **JIS** and **ISO** are almost the same when other **JIS**s are included. The **JIS** specification is maintained without change.
7	6.2	Deletion	**JIS** specifies tensile characteristics, flattening resistance, flaring property and reverse flattening resistance, whereas **ISO** specifies tests at room temperature (tensile, flattening, drift or ring expanding, and impact tests) and tests at elevated temperatures.	The tests at elevated temperatures are deleted to maintain requirements in the previous edition of **JIS** for the market stability.
		Addition	Add the reverse flattening resistance.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
		Alteration	Change the specified values of mechanical properties and applicable dimensions of flaring property.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
8	9.5	Alteration	The hydraulic test pressure value in **JIS** is lower than that specified in **ISO** standards.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
			Add the eddy current examination as an alternative test to the hydraulic test, and delete the electromagnetic examination.	Necessary specifications for **JIS**. The **JIS** specification is maintained without change.

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a) No. of clause (**JIS**)	b) No. of clause (corresponding International Standard)	c) Classification by clause	d) Detail and justification of technical deviation	e) Future measures for the technical deviation
9	7.1	Alteration	The dimensional systems differ between **JIS** and **ISO** standards.	The **JIS** specification is cited in mandatory regulations in Japan. The **JIS** specification is maintained without change.
10	8.1	Alteration	Alter requirements for the weld of electric resistance welded steel tubes.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
11	—	Addition	Add a statement that the supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer shall be as given in Annex JA.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
12	—	Addition	Add a statement that the U-bent tubes to be manufactured upon agreement between the purchaser and the manufacturer shall be as given in Annex JB.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
13	9.3 9.4 9.5 9.8 9.10	Deletion	Delete the tensile test at elevated temperatures.	Deletion was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
		Addition	Add the reverse flattening test.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
		Alteration	Change requirements for sampling method and analytical method for chemical analysis, mechanical test piece sampling frequency and mechanical test piece shape.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.

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a) No. of clause (**JIS**)	b) No. of clause (corresponding International Standard)	c) Classification by clause	d) Detail and justification of technical deviation	e) Future measures for the technical deviation
13	9.10.5.2	Alteration	Add the eddy current examination, and delete the electromagnetic examination.	Necessary specifications for **JIS**. The **JIS** specification is maintained without change.
14	9.10 9.12	Alteration	Add inspection items, and change general requirements for inspection and requirements to be applied when the tube fails in the mechanical test.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
15	10	Alteration	Marking items differ between **JIS** and **ISO** standards. Specify that part of items may be omitted upon agreement between the purchaser and the manufacturer as far as the product can still be identified.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
16	4	Alteration	Specify that the purchaser shall provide the manufacturer, processor or intermediary with information.	**JIS** specifically states to whom information is presented in accordance with the commercial practice in Japan. The **JIS** specification is maintained without change.
17	12	Alteration	**JIS** specifies 1 type of inspection documents, whereas **ISO** specifies 4 types.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
Annex JA	6.2.2 9.8 9.10.5.2	Addition	**ISO** specifies properties at elevated temperatures and non-destructive test. In **JIS**, requirements for hardness are added.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.
		Alteration	Specify supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer.	Alteration was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.

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a) No. of clause (**JIS**)	b) No. of clause (corresponding International Standard)	c) Classification by clause	d) Detail and justification of technical deviation	e) Future measures for the technical deviation
Annex JB	—	Addition	Add requirements for U-bent tubes.	Addition was made to maintain requirements in the previous edition of **JIS** for the market stability. The **JIS** specification is maintained without change.

NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows :
— Deletion : Delete the specification item(s) or content(s) of International Standard(s).
— Addition : Add the specification item(s) or content(s) which are not included in International Standard(s).
— Alteration : Alter the specification content(s) or structure of International Standard(s).

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

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