

JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS G 3462 : 2019

(JISF)

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

ICS 23.040.10;27.060.30;77.140.75

Reference number : **JIS G 3462 : 2019 (E)**

PROTECTED BY COPYRIGHT

15 S

<https://www.botopsteelpipe.com>

G 3462 : 2019

Date of Establishment: 1962-03-01

Date of Revision: 2019-11-20

Date of Public Notice in Official Gazette: 2019-11-20

Investigated by: Japanese Industrial Standards Committee
Standards Board for ISO area
Technical Committee on Metal and Inorganic
Materials

JIS G 3462:2019, First English edition published in 2020-04

Translated and published by: Japanese Standards Association
Mita MT Building, 3-13-12, Mita, Minato-ku, Tokyo, 108-0073 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2020

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

AT

PROTECTED BY COPYRIGHT

<https://www.botopsteelpipe.com>

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	5
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	20

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 3462:2016**), which has been technically revised.

However, **JIS G 3462:2016** 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.

This **JIS** document is protected by the Copyright Act.

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.

Alloy 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 alloy steel tubes (hereafter referred to as tubes) used for exchanging heat between the inside and outside of the tube, such as water tubes, smoke tubes, superheater tubes and air preheater tubes, 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 0416 *Steel and steel products—Location and preparation of samples and test pieces for mechanical testing*
- JIS G 0567 *Method of elevated temperature tensile test for steels and heat-resisting alloys*
- JIS G 0582 *Automated ultrasonic examination of steel pipes and tubes*
- JIS G 0583 *Automated eddy current examination of steel pipes and tubes*
- JIS Z 2241 *Metallic materials—Tensile testing—Method of test at room temperature*
- JIS Z 2245 *Rockwell hardness test—Test method*
- JIS Z 8401 *Rounding of numbers*

3 Symbol of grade

Tubes shall be classified into 8 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
Molybdenum steel tube	STBA12	Seamless: S Electric resistance welded: E	Hot-finished: H Cold-finished: C As electric resistance welded: G	As given in 13 b).
	STBA13			
Chromium molybdenum steel tube	STBA20			
	STBA22			
	STBA23			
	STBA24			
STBA25	Seamless: S	Hot-finished: H		
		Cold-finished: C		
STBA26				

4 Manufacturing method

The manufacturing method shall be as follows.

- a) Tubes shall be manufactured by a combination of the 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.
- 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 ^{a)}
STBA12 STBA13	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering
STBA20 STBA22	Low temperature annealing, isothermal annealing, full annealing or normalizing followed by tempering
STBA23 STBA24 STBA25 STBA26	Isothermal annealing, full annealing or normalizing followed by tempering ^{b)}
Notes ^{a)} Low temperature annealing shall not be applied to the electric resistance welded steel tube.	
^{b)} The tempering temperature for STBA23, STBA24, STBA25 and STBA26 shall be 650 °C or higher.	

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, and the obtained product analysis values shall satisfy the requirements given in Table 3.

Table 3 Chemical composition

Unit: %

Symbol of grade	C	Si	Mn	P	S	Cr	Mo
STBA12	0.10 to 0.20	0.10 to 0.50	0.30 to 0.80	0.035 max.	0.035 max.	— ^{a)}	0.45 to 0.65
STBA13	0.15 to 0.25	0.10 to 0.50	0.30 to 0.80	0.035 max.	0.035 max.	— ^{a)}	0.45 to 0.65
STBA20	0.10 to 0.20	0.10 to 0.50	0.30 to 0.60	0.035 max.	0.035 max.	0.50 to 0.80	0.40 to 0.65
STBA22	0.15 max.	0.50 max.	0.30 to 0.60	0.035 max.	0.035 max.	0.80 to 1.25	0.45 to 0.65
STBA23	0.15 max.	0.50 to 1.00	0.30 to 0.60	0.030 max.	0.030 max.	1.00 to 1.50	0.45 to 0.65
STBA24	0.15 max.	0.50 max.	0.30 to 0.60	0.030 max.	0.030 max.	1.90 to 2.60	0.87 to 1.13
STBA25	0.15 max.	0.50 max.	0.30 to 0.60	0.030 max.	0.030 max.	4.00 to 6.00	0.45 to 0.65
STBA26	0.15 max.	0.25 to 1.00	0.30 to 0.60	0.030 max.	0.030 max.	8.00 to 10.00	0.90 to 1.10
Alloy elements not specified in this table and the element for which dashes (“—”) are entered in this table may be added as necessary.							
Note ^{a)} Addition of Cr is permitted to a level where chemical composition of the grade concerned remains distinguishable, after the addition of Cr, from those of all other grades.							

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 ^{a)}	Yield point or proof stress	Elongation %					
			Outside diameter					
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over	All outside diameters		
			Tensile test piece					
			Test piece No. 11	Test piece No. 11	Test piece No. 11 Test piece No. 12	Test piece No. 4	Test piece No. 14A	
			Tensile test direction					
	N/mm ²	N/mm ²	Parallel to tube axis	Parallel to tube axis	Parallel to tube axis	Parallel to tube axis	Parallel to tube axis	
STBA12	380 min.							
STBA13	410 min.	205 min.	22 min.	25 min.	30 min.	24 min.	21 min.	
STBA20								
STBA22								
STBA23								
STBA24								
STBA25								
STBA26								
NOTE 1 N/mm ² = 1 MPa								
Note ^{a)} Exclusively for the heat exchanger tubes, the purchaser may, where necessary, specify the maximum value of tensile strength. In this case, the maximum tensile strength value shall be the value obtained by adding 150 N/mm ² to the value in this table.								

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

Unit: %

Wall thickness	Over 1 mm up to and incl. 2 mm	Over 2 mm up to and incl. 3 mm	Over 3 mm up to and incl. 4 mm	Over 4 mm up to and incl. 5 mm	Over 5 mm up to and incl. 6 mm	Over 6 mm up to and incl. 7 mm	Over 7 mm to and excl. 8 mm
Elongation	21 min.	22 min.	24 min.	26 min.	27 min.	28 min.	30 min.
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 0.08

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 1.14 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/mm²)

- 2) When a hydraulic test pressure is specified by the purchaser, the tube shall be subjected to the pressure, which is regarded as the minimum hydraulic test pressure, and shall withstand the pressure without leakage. If the pressure specified by the purchaser is greater than either the test pressure P calculated by Formula (2) or 10 MPa, the test pressure to be applied shall be as agreed between the purchaser and the manufacturer. The test pressure shall be specified in 0.5 MPa increments if lower than 10 MPa, and in 1 MPa increments if 10 MPa or higher.
- b) **Non-destructive test characteristics** Tubes shall be tested by either the ultrasonic examination or the eddy current examination, and their non-destructive test characteristics shall be as follows. Other non-destructive tests specified in relevant Japanese Industrial Standards (JISs) may replace these tests upon agreement between the purchaser and the manufacturer, in which case the judgement criteria shall be at least equal to those applied in the ultrasonic examination or the eddy current examination.

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 cm³ 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.

Table 6 Dimensions and unit masses of alloy steel tubes for boiler and heat exchanger

Unit: kg/m

Out-side diameter (mm)	Wall thickness (mm)																		
	1.2	1.6	2.0	2.3	2.6	2.9	3.2	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.5	11.0	12.5
15.9	0.435	0.564	0.686	0.771	0.853	0.930													
19.0		0.687	0.838	0.947	1.05	1.15													
21.7			0.972	1.10	1.22	1.34	1.46												
25.4			1.15	1.31	1.46	1.61	1.75	1.89											
27.2			1.24	1.41	1.58	1.74	1.89	2.05	2.29										
31.8				1.67	1.87	2.07	2.26	2.44	2.74	3.03									
34.0					2.01	2.22	2.43	2.63	2.96	3.27	3.58								
38.1					2.28	2.52	2.75	2.99	3.36	3.73	4.08	4.42							
42.7					2.57	2.85	3.12	3.38	3.82	4.24	4.65	5.05	5.43						
45.0					2.72	3.01	3.30	3.58	4.04	4.49	4.93	5.36	5.77	6.17					
48.6					2.95	3.27	3.58	3.89	4.40	4.89	5.38	5.85	6.30	6.75	7.18				
50.8					3.09	3.43	3.76	4.08	4.62	5.14	5.65	6.14	6.63	7.10	7.56	8.44	9.68	10.8	11.8
54.0					3.30	3.65	4.01	4.36	4.93	5.49	6.04	6.58	7.10	7.61	8.11	9.07	10.4	11.7	12.8
57.1						3.88	4.25	4.63	5.24	5.84	6.42	7.00	7.56	8.11	8.65	9.69	11.2	12.5	13.7
60.3						4.10	4.51	4.90	5.55	6.19	6.82	7.43	8.03	8.62	9.20	10.3	11.9	13.4	14.7
63.5						4.33	4.76	5.18	5.87	6.55	7.21	7.87	8.51	9.14	9.75	10.9	12.7	14.2	15.7
65.0						4.44	4.88	5.31	6.02	6.71	7.40	8.07	8.73	9.38	10.0	11.2	13.0	14.6	16.2
70.0						4.80	5.27	5.74	6.51	7.27	8.01	8.75	9.47	10.2	10.9	12.2	14.2	16.0	17.7
76.2							5.76	6.27	7.12	7.96	8.78	9.59	10.4	11.2	11.9	13.5	15.6	17.7	19.6
82.6							6.27	6.83	7.75	8.67	9.57	10.5	11.3	12.2	13.1	14.7	17.1	19.4	21.6
88.9							6.76	7.37	8.37	9.37	10.3	11.3	12.3	13.2	14.1	16.0	18.6	21.1	23.6
101.6								8.47	9.63	10.8	11.9	13.0	14.1	15.2	16.3	18.5	21.6	24.6	27.5
114.3									10.9	12.2	13.5	14.8	16.0	17.3	18.5	21.0	24.6	28.0	31.4
127.0									12.1	13.6	15.0	16.5	17.9	19.3	20.7	23.5	27.5	31.5	35.3
139.8												18.2	19.8	21.4	22.9	26.0	30.5	34.9	39.2

NOTE 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.

8.2 Dimensional tolerances

The dimensional tolerances of tubes shall be as follows.

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

Table 7 Tolerances on outside diameter ^{a)}

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 ^{b)}	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 ^{a)} The tolerances on outside diameter in this table do not apply to local repaired parts.
^{b)} 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	Hot-finished seamless steel tube		Cold-finished seamless steel tube		Electric resistance welded steel tube	
		Outside diameter mm					
		Under 100	100 or over	Under 40	40 or over	Under 40	40 or over
Tolerance on wall thickness	Under 2	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			
	2.4 or over to and excl. 3.8	+ 35 % 0	+ 35 % 0				
	3.8 or over to and excl. 4.6	+ 33 % 0	+ 33 % 0				
	4.6 or over	+ 28 % 0	+ 28 % 0				
Tolerance on eccentricity ^{b)}	5.6 or over	22.8 % max. of wall thickness		—		—	

Notes ^{a)} The plus tolerance is not specified.
^{b)} Eccentricity is expressed by the ratio, in percentage, of the difference between the maximum value and the minimum value of the wall thickness measured on the same cross-section of the tube to the wall thickness value specified in the order. This requirement does not apply to tubes under 5.6 mm in wall thickness.

Table 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

Appearance shall be as follows.

- Tubes shall be straight for practical purposes with both ends at right angles to the tube axis.
- The internal and external surfaces of the tube 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. In this case, 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

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".

In addition, for electric resistance welded steel tubes, one sample shall be taken from each group of 100 tubes or its fraction that are of the same dimensions and of the same

heat treatment batch. From each sample thus obtained, one reverse flattening test piece shall be taken.

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, No. 12 (12A, 12B, or 12C), No. 14A, or No. 4 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. The sampling location of bar-form Test piece No. 14A or No. 4 in thickness direction of section shall be in accordance with **A.7** of **JIS G 0416**. Test piece No. 4 shall be of diameter 14 mm (gauge length 50 mm).

Test piece No. 12 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 purchaser¹⁾.

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

- a) **Test piece** The test piece shall be of at least 50 mm in length. For tubes of wall thickness 15 % or over of the outside diameter, C-shaped test piece prepared by removing a part of the circumference of a ring-shaped test piece may be used.
- b) **Test method** Place the test piece between two platens at ordinary temperature (5 °C to 35 °C), compress to flatten until the distance H between the two platens reaches the value obtained by Formula (1) given 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.

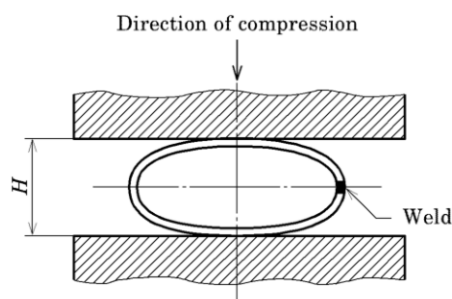


Figure 1 Flattening test (ring-shaped test piece)

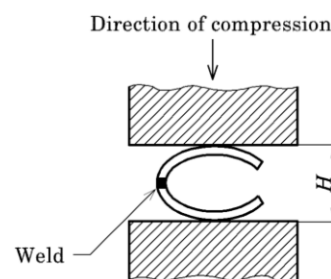


Figure 2 Flattening test (C-shaped test piece)

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 purchaser²⁾.

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

- a) **Test piece** The test piece shall be of the proper length for the flaring test.
- b) **Test method** 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 purchaser³⁾.

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

- a) **Test piece** Cut off a sample having a length of 100 mm from one end of the tube. Cut this sample into half at a position circumferentially displaced by 90° from the weld line to both sides, and take one of the split halves which contains the weld as a test piece.
- b) **Test method** Flatten the test piece out into a plate shape at ordinary temperature (5 °C to 35 °C) with the weld line at the top and examine if any cracks are present in the weld of the test piece.

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 alloy elements not specified in Table 3 and the alloy element for which dashes (“–”) are entered 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) ¹⁾

The hardness shall be as follows.

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

Table JA.1 Hardness

Symbol of grade	Rockwell hardness (mean value of three positions)
	HRBW
STBA12	80 max.
STBA13	81 max.
STBA20	85 max.
STBA22	85 max.
STBA23	85 max.
STBA24	85 max.
STBA25	85 max.
STBA26	89 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 ¹⁾ In transaction of tubes, the requirements for hardness may be marked as Z1.

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

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

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

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

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

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

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

The ultrasonic examination and inspection shall be as follows.

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

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

The eddy current examination and inspection shall be as follows.

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

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

Annex JB (normative)

U-bent tubes

JB.1 Manufacturing method

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

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

JB.2 Appearance

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

JB.3 Dimensional tolerances for U-bent tubes

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

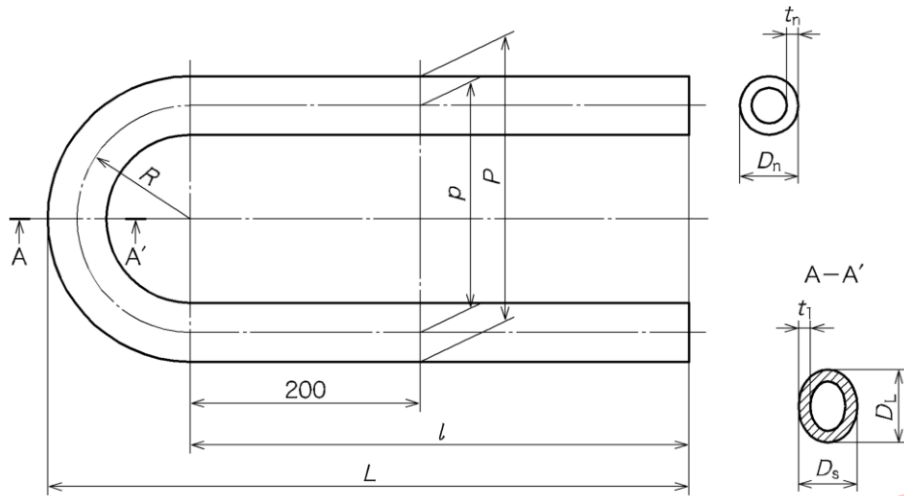
JB.4 Measurement of dimensions of U-bent tubes

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

JB.5 Hydraulic test characteristics

The manufacturer may perform the hydraulic test specified in 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



- 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 : length of product
- L_n : nominal length of product
 $l_n + R + D_n/2$
- l : length of product at straight portion
- l_n : nominal length of product 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 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 or under.			

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

Tube nominal length at straight portion (l_n)	Tolerance on length (l or L) mm
7 m max.	+7 0
Over 7 m	+10 0
Length in the right column of this table may be either l or L .	

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

(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. of clause	Content	Classification by clause	Detail of technical deviation	
JIS G 3462:2019 Alloy steel tubes for boiler and heat exchanger		ISO 9329-2:1997 Seamless steel tubes for pressure purposes— <i>Technical delivery conditions—Part 2: Unalloyed and alloyed steels with specified elevated temperature properties</i> ISO 9330-2:1997 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>					
1	Scope	ISO 9329-2 ISO 9330-2	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	JIS limits the scope to alloyed steel tubes. Unalloyed steel tubes are specified in other JISs .	1 Harmonization with ISO specifications was difficult due to the difference in standard systems (JIS standards are systematized according to applications; ISO standards are systematized according to manufacturing methods) and the difference in dimensional system, and also due to the fact that this JIS is cited in mandatory regulations.
2	Normative references						
3	Symbol of grade	8 grades of molybdenum steel and chromium molybdenum steel	4.1	ISO 9329-2 : 4 grades of unalloyed steel and 14 grades of alloyed steel ISO 9330-2 : 4 grades of unalloyed steel and 3 grades of alloyed steel	Deletion Alteration Addition	In JIS , delete requirements for unalloyed steel tubes, and add requirements for molybdenum steel tubes.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
4 Manufacturing method	Manufacturing method, heat treatment and tube end shape	ISO 9329-2 ISO 9330-2	5.3, 5.4, 8.2	Tube manufacturing process, heat treatment and tube end shape	Alteration	While the specification items for manufacturing method and heat treatment are identical between JIS and ISO , the specified contents differ.	2 As a measure for the above, the corresponding ISO standards have been translated into Japanese and published as JIS (JIS G 7220 , JIS G 7224) so that ISO -equivalent JIS s are in place to improve harmonization with International Standards, and to promote widespread use of the ISO -conforming products.
5 Chemical composition	Chemical compositions of 8 alloy steel grades		6.1	Chemical compositions of unalloyed steel (4+4) and alloyed steel (14+3)	Addition Deletion Alteration	Chemical compositions of alloy steel differ between JIS and ISO standards.	3 Necessity of this JIS , independent from ISO standards, as a standard for special applications remains distinct.
6 Mechanical properties	Tensile properties, flattening resistance, flaring property and reverse flattening resistance		6.2.1 9.10.3 9.10.4	Tests at room temperature (tensile, flattening, drift or ring expanding, and impact tests) and tensile tests at elevated temperatures	Deletion Addition Alteration	In JIS , delete requirements for the impact test etc., add requirements for reverse flattening resistance, and alter the specified value of mechanical properties and applicable dimensions of flaring property.	4 Specifications in the previous edition of JIS are maintained in this current edition in order not to disturb the market stability.
7 Hydraulic test characteristics or non-destructive test characteristics	Application of either hydraulic test characteristics or non-destructive test characteristics		9.5	Application of either hydraulic leak-tightness test or non-destructive test	Deletion Addition Alteration	In JIS , add requirements for the eddy current examination, delete those for the magnetic particle test and specify the hydraulic test pressure value lower than that specified in ISO standards.	

(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	
8	Dimensions, unit masses and dimensional tolerances	ISO 9329-2 ISO 9330-2	7	The outside diameters, wall thicknesses and masses of the tubes shall be selected from those in ISO 4200 and ISO 1129 .	Alteration	The dimensional system differs between JIS and ISO standards.	5 Future tasks: Incorporate specifications of corresponding ISO standards into this JIS as far as possible in order to continue to improve harmonization with ISO standards.
9	Appearance		8	Appearance and soundness	Alteration	Alter requirements for the weld of electric resistance welded steel tubes.	
10	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.	
11.1	Chemical analysis		9.3	Chemical analysis	Alteration	Alter the sampling method for analysis and the analysis method in JIS .	
11.2	Mechanical tests		9.3 9.4 9.10	Testing of mechanical and technological characteristics	Alteration	JIS and ISO are identical in specification items but different in the sampling frequency and shape of test piece.	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
12 Inspection and reinspection	Inspection and reinspection	ISO 9329-2 ISO 9330-2	9.10 9.12	Inspection and reinspection	Addition Alteration	Add inspection items to JIS, and alter general requirements for inspection and requirements to be applied when the tube fails in the mechanical test.	
13 Marking	Marking		10	Marking items	Alteration	JIS and ISO are identical in specification items but different in specified contents.	
14 Report	Report		12	Report	Alteration	JIS specifies 1 type of inspection documents, while ISO specifies 4 types.	
Annex JA (normative) Supplementary quality requirements	Hardness, tensile test at elevated temperatures, ultrasonic examination and eddy inspection, and eddy current examination and inspection		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, ISO 9330-2:1997): MOD
NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows: <ul style="list-style-type: none">— 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: <ul style="list-style-type: none">— MOD: Modifies International Standard(s).

Botop Steel

Errata for JIS (English edition) can be downloaded in PDF format at Webdesk (purchase information page) of our website (<https://www.jisa.or.jp/>).

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

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

PROTECTED BY COPYRIGHT

<https://www.botopsteelpipe.com>