

JIS

JAPANESE INDUSTRIAL STANDARD

**Carbon Steel Boiler and
Heat Exchanger Tubes**

㊦ **JIS G 3461**—1988

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by

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**In the event of any doubt arising,
the original Standard in Japanese is to be final authority.**



JAPANESE INDUSTRIAL STANDARD

J I S

Carbon Steel Boiler and Heat
Exchanger Tubes

G 3461-1988

1. Scope

This Japanese Industrial Standard specifies the carbon steel tubes, hereinafter referred to as the "tubes", used for exchanging heat on the inside and outside of the tube, such as water tubes, smoke tubes, superheater tubes, air preheater tubes, etc. of the boiler, and heat exchanger tubes, condenser tubes, catalyser tubes, etc. used in chemical and petroleum industries. However, it is not applicable to the steel tubes for heating furnace and steel heat exchanger tubes for low temperature service.

Remarks 1. The purchaser may designate in addition to the items specified in this text, by prior agreement with the manufacturer, part or all of the items in the supplementary quality requirements Z1, Z2, Z3 and Z4 specified in Appendix 1 and the item of the U-bend tube specified in Appendix 2.

Appendix 1 Z 1 Hardness

Appendix 1 Z 2 Elevated temperature yield point or
proof stress

Appendix 1 Z 3 Ultrasonic examination

Appendix 1 Z 4 Eddy current examination

Appendix 2 U-bend tube

2. The units and numerical values given in { } in this Standard are based on the International System of Units (SI) and are appended for informative reference.

Further, the traditional units accompanied by numerical values in this Standard shall be converted to the SI units and numerical values on Jan. 1, 1991.

2. Classes and Symbols

The tube shall be classified into 3 grades and their class symbols shall be as given in Table 1-1 or Table 1-2.

Table 1-1. Class Symbols
(Applicable till the end of 1990)

Class symbol
STB 35
STB 42
STB 52

Table 1-2. Class Symbols
(Applicable on and after Jan. 1, 1991)

Class symbol	(Informative reference) Traditional symbol
STB 340	STB 35
STB 410	STB 42
STB 510	STB 52

3. Chemical Composition

The tube shall be tested in accordance with 9.1 and the resulting ladle analysis values shall conform to Table 2-1 or Table 2-2.

Table 2-1. Chemical Composition
(Applicable till the end of 1990)

Symbol of class	Unit: %				
	C	Si	Mn	P	S
STB 35	0.18 max.	0.35 max.	0.30 to 0.60	0.035 max.	0.035 max.
STB 42	0.32 max.	0.35 max.	0.30 to 0.80	0.035 max.	0.035 max.
STB 52	0.25 max.	0.35 max.	1.00 to 1.50	0.035 max.	0.035 max.

- Remarks 1. When the purchaser requires product analysis, the permissible deviations for the values given above shall be as specified in Table 2 in JIS G 0321 for the seamless steel tube and likewise in Table 1 for the electric resistance welded steel tube.
2. Where required by the purchaser, Si may be designated as 0.10 to 0.35 %.

Table 2-2. Chemical Composition
(Applicable on and after Jan. 1, 1991)

Symbol of class	Unit: %				
	C	Si	Mn	P	S
STB 340	0.18 max.	0.35 max.	0.30 to 0.60	0.035 max.	0.035 max.
STB 410	0.32 max.	0.35 max.	0.30 to 0.80	0.035 max.	0.035 max.
STB 510	0.25 max.	0.35 max.	1.00 to 1.50	0.035 max.	0.035 max.

- Remarks 1. When the purchaser requires product analysis, the permissible deviations for the values given above shall be as specified in Table 2 in JIS G 0321 for the seamless steel tube and likewise in Table 1 for the electric resistance welded steel tube.

Remarks 2. Where required by the purchaser, Si may be designated as 0.10 to 0.35 %.

4. Mechanical Properties

4.1 The tube shall be tested in accordance with 9.2 and the resulting tensile strength, yield point or proof stress, and elongation of the tube shall comply with Table 3-1 or Table 3-2.

Table 3-1. Mechanical Properties
(Applicable till the end of 1990)

Symbol of class	Tensile strength kgf/mm ² {N/mm ² }	Yield point or proof stress kgf/mm ² {N/mm ² }	Elongation %		
			Outside diameter 20 mm or over	Outside diameter 10 mm or over to and excl. 20 mm	Outside diameter under 10 mm
			No. 11 test piece No. 12 test piece	No. 11 test piece	No. 11 test piece
STB 35	35 {343} min.	18 {177} min.	35 min.	30 min.	27 min.
STB 42	42 {412} min.	26 {255} min.	25 min.	20 min.	17 min.
STB 52	52 {510} min.	30 {294} min.	25 min.	20 min.	17 min.

- Remarks 1. Exclusively for the heat exchanger tube, the purchaser may, where necessary, specify the maximum value of tensile strength, which shall be 12 kgf/mm² {118 N/mm²} added to the value given in Table 3-1.
2. When the tensile test is carried out on No. 12 test piece for the tube under 8 mm in wall thickness, the minimum value of elongation shall be calculated by subtracting 1.5 % from the values of elongation given in Table 3-1 for each 1 mm decrease in wall thickness, and rounding off the result to an integer in compliance with JIS Z 8401. Examples of calculation are given in Reference Table.
3. In the case where the tensile test piece is taken from the electric resistance welded steel tube, No. 12 test piece shall be taken from a seamless portion.

Table 3-2. Mechanical Properties
(Applicable on and after Jan. 1, 1991)

Symbol of class	Tensile strength N/mm ²	Yield point or proof stress N/mm ²	Elongation %		
			Outside diameter 20 mm or over	Outside diam- eter 10 mm or over to and excl. 10 mm	Outside diameter under 10 mm
			No. 11 test piece No. 12 test piece	No. 11 test piece	No. 11 test piece
STB 340	340 min.	175 min.	35 min.	30 min.	27 min.
STB 410	410 min.	255 min.	25 min.	20 min.	17 min.
STB 510	510 min.	295 min.	25 min.	20 min.	17 min.

- Remarks 1. Exclusively for the heat exchanger tube, the purchaser may, where necessary, specify the maximum value of tensile strength, which shall be 120 N/mm² added to the value given in Table 3-2.
2. When the tensile test is carried out on No. 12 test piece for the tube under 8 mm in wall thickness, the minimum value of elongation shall be calculated by subtracting 1.5 % from the values of elongation given in Table 3-2 for each 1 mm decrease in wall thickness, and rounding off the result to an integer in compliance with JIS Z 8401. Examples of calculation are given in Reference Table.
3. In the case where the tensile test piece is taken from the electric resistance welded steel tube, No. 12 test piece shall be taken from a seamless portion.

4.2 Flattening Resistance The tube shall be tested in accordance with 9.3 and shall be free from flaws or cracks on its wall surfaces. The distance between the flattening plates in this test shall be in accordance with the following formula.

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

where (applicable till the end of 1990)

H : distance between flattening plates (mm)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

e : constant individually decided according to the class of tube

0.09 for STB 35

0.08 for STB 42

0.07 for STB 52

where (applicable on and after Jan. 1, 1991)

H : distance between flattening plates (mm)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

e : constant individually decided according to the class of tube

0.09 for STB 340

0.08 for STB 410

0.07 for STB 510

4.3 When in the test of 9.4 the tube is flared into a bell shape 1.2 times the outside diameter, no flaws shall be generated.

4.4 When in the test of 9.5 the electric resistance welded steel tube is subjected to reverse flattening test, flaws, cracks or the like shall not be generated on the weld.

5. Hydrostatic Characteristic or Nondestructive Characteristic

The tube shall be tested in accordance with 9.6 and the resulting hydrostatic characteristic or nondestructive characteristic shall conform to either of the following two. The preference shall be in accordance with the designation made by the purchaser or left to the discretion of the manufacturer.

5.1-1 Hydrostatic Characteristic (Applicable till the end of 1990) When a hydrostatic pressure specified by the purchaser or, unless otherwise specified, the pressure P (100 kgf/cm² {98 bar} at the maximum) calculated from the formula given below is applied, the tube shall withstand it without leakage.

In this case, the purchaser may specify values of pressure lower or higher than the pressure P .

When a hydrostatic pressure test is made in compliance with the designation of the purchaser and the test pressure exceeds either 100 kgf/cm² {98 bar} or the value P calculated from the following formula, the test pressure shall be agreed upon by the purchaser and the manufacturer. The designated hydrostatic test pressure shall be graduated in 5 kgf/cm² {4.9 bar}.

The value P in the following formula shall be obtained by computing to the unit digit and rounding off to the nearest 5 kgf/cm² {4.9 bar}.

$$P = \frac{200st}{D}$$

where

P : test pressure [$\text{kgf/cm}^2\{10^{-1} \text{ bar}\}^{(1)}$]

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

s : 60 % of the minimum value of yield point or proof stress specified in Table 3-1 [$\text{kgf/mm}^2\{\text{N/mm}^2\}$]

Note ⁽¹⁾ 1 bar = 10^5 Pa

5.1-2 Hydrostatic Characteristic (Applicable on and after Jan. 1, 1991)

When a hydrostatic pressure specified by the purchaser or, unless otherwise specified, the pressure P (10 MPa at the maximum) calculated from the formula given below is applied, the tube shall withstand it without leakage.

In this case, the purchaser may specify values of pressure lower or higher than the pressure P .

When a hydrostatic pressure test is made in compliance with the designation of the purchaser and the test pressure exceeds either 10 MPa or the value P calculated from the following formula, the test pressure shall be agreed upon by the purchaser and the manufacturer. The designated hydrostatic test pressure shall be graduated in 0.5 MPa for the pressure values of under 10 MPa and in 1 MPa for the pressure values of 10 MPa or over.

The value P in the following formula shall be obtained by computing to the unit digit and rounding off to the nearest 0.5 MPa or 1 MPa.

$$P = \frac{2st}{D}$$

where

P : test pressure (MPa)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

s : 60 % of the minimum value of yield point or proof stress specified in Table 3-2 (N/mm^2)

5.2 Nondestructive Characteristic Either an ultrasonic examination or an eddy current examination shall be made on the tube, and there shall be no signal greater than those produced by the artificial defects of the reference test block of either the division UD of the working sensitivity specified in JIS G 0582 or of the division EY of the working sensitivity specified in JIS G 0583, respectively.

6. Dimensions, Mass and Dimensional Tolerances

6.1 Dimensions and Mass The outside diameter, wall thickness and mass of the tube shall be as specified in Attached Table, unless otherwise designated.

6.2 Dimensional Tolerances The dimensional tolerances of the tube shall be as follows.

- (1) The tolerances on the outside diameter of the tube shall be as specified in Table 4.

(2) The tolerances on the wall thickness and on the thickness disparity shall be as specified in Table 5.

(3) The tolerances on the length of the tube shall be as specified in Table 6.

Table 4. Tolerances on Outside Diameter

Unit: mm

Division of outside diameter	Tolerances on outside diameter			
	Hot finished seamless steel tube	Cold finished seamless steel tube	Electric resistance welded steel tube other than cold finished	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

Remark: To the tolerances on the outside diameter of the electric resistance welded steel tube other than cold finished, the tolerances for the cold finished steel tube may be applied, as required by the purchaser.

Table 5. Tolerances on Wall Thickness and on Thickness Disparity

Division of method of manufacture		Hot finished seamless steel tube		Cold finished seamless steel tube		Electric resistance welded steel tube	
Division of wall thickness mm	Division of outside diameter mm	Under 100	100 or over	Under 40	40 or over	Under 40	40 or over
		Tolerances	Tolerances	Tolerances	Tolerances	Tolerances	Tolerances
Tolerances on wall thickness %	Under 2	-	-	+0.4 mm 0		+0.3 mm 0	
	2 or over to and excl. 2.4	+40 0	-				
	2.4 or over to or excl. 3.8	+35 0	+35 0	+20	+22	+18 0	+18 0
	3.8 or over to or excl. 4.6	+33 0	+33 0				
	4.6 or over	+28 0	+28 0				
Tolerances on thickness disparity %	-	Within 22.8 of wall thickness		-		-	

Remark: The term "thickness disparity" means the ratio of the difference between the maximum and the minimum of the measured wall thickness in the same section to the ordered wall thickness and this is not applicable to the tube under 5.6 mm in wall thickness.

Table 6. Tolerances on Length

Division		Tolerances on length
50 mm or under in outside diameter	7 m or under in length	+ 7 mm 0
	Over 7 m in length	Add 3 mm to the plus side permissible deviation given above for each increase of 3 m or its fraction in length. However, the maximum value shall be 15 mm.
Over 50 mm in outside diameter	7 m or under in length	+ 10 mm 0
	Over 7 m in length	Add 3 mm to the plus side permissible deviation given above for each increase of 3 m or its fraction in length. However, the maximum value shall be 15 mm.

Remark: When an accurate length is particularly required, the tolerances shall be agreed upon by the purchaser and the manufacturer.

7. Appearance

- (1) The tube shall be practically straight and its both ends shall be at right angles to its axis.
- (2) The inside and outside surfaces of the tube shall be well-finished and free from defects injurious to use. However, in the case of electric resistance welded tube the swelling of inside surface of the weld shall be 0.25 mm or less. In this case, if necessary, the purchaser may specify the inside swelling as 0.15 mm or less for the tubes 50.8 mm or under in outside diameter and at the same time 3.5 mm or under in wall thickness.

8. Method of Manufacture

- (1) The tube shall be made from killed steel by the seamless process or by the electric resistance welding process.
- (2) The tube shall be subjected to heat treatments specified in Table 7-1 or Table 7-2. The heat treatment not specified in those tables shall be agreed upon by the purchaser and the manufacturer.

Table 7-1. Heat Treatment
(Applicable till the end of 1990)

Heat treatment					
Symbol of class	Hot finished seamless steel tube	Cold finished seamless steel tube	Electric re- sistance welded steel tube other than hot finished or cold finished steel tube	Hot finished electric re- sistance welded steel tube	Cold finished electric re- sistance welded steel tube
STB 35	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Low temperature annealing, normalizing or full annealing.	Normalizing	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Normalizing
STB 42	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Low temperature annealing, normalizing or full annealing.	Normalizing	Low temperature annealing	
STB 52	Normalizing				

Remark: The cold finished electric resistance welded steel tube which has been normalized prior to cold finishing may be finished by annealing.

Table 7-2. Heat Treatment
(Applicable on and after Jan. 1, 1991)

Heat treatment					
Symbol of class	Hot finished seamless steel tube	Cold finished seamless steel tube	Electric re- sistance welded steel tube other than hot finished or cold finished steel tube	Hot finished electric re- sistance welded steel tube	Cold finished electric re- sistance welded steel tube
STB 340	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Low temperature annealing, normalizing or full annealing.	Normalizing	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Normalizing
STB 410	As manufactured. However, as re- quired, low temperature an- nealing or normalizing may be performed.	Low temperature annealing, normalizing or full annealing.	Normalizing	Low temperature annealing	
STB 510	Normalizing				

Remark: The cold finished electric resistance welded steel tube which has been normalized prior to cold finishing may be finished by annealing.

9. Test

9.1. Chemical Analysis

9.1.1 Chemical Analysis General matters of chemical analysis and method of sampling specimens for analysis shall be in accordance with 3. in JIS G 0303.

9.1.2 Analytical Method The analytical method shall be in accordance with one of the following Standards.

JIS G 1211 JIS G 1212 JIS G 1213 JIS G 1214 JIS G 1215
JIS G 1253 JIS G 1256 JIS G 1257

9.2 Tensile Test

9.2.1 Test Piece The test specimen shall be No. 11, No. 12 A, No. 12 B or No. 12 C test piece specified in JIS Z 2201 and shall be cut off from the tube in the longitudinal direction for the tube.

9.2.2 Test Method The test method shall be in accordance with JIS Z 2241.

9.3 Flattening Test

9.3.1 Test Pieces A test piece 50 mm or over in length shall be cut off from the end of a tube. For the tube whose wall thickness is 15 % or over of the outside diameter, a C-shape test piece made by removing part of the circumference of a whole test piece may be used.

9.3.2 Test Method The test piece shall be placed at ordinary temperature between two flat plates and flattened by compression until the distance between the plates comes to the specified value, and checked for the occurrence of flaws or cracks on its wall surface. For the electric resistance welded steel tube, the weld shall be placed at right angles to the direction of compression as shown in Fig. 2., and the C-shape test piece shall be placed as shown in Fig. 3.

Fig. 2. Flattening Test
(for whole Test Piece)

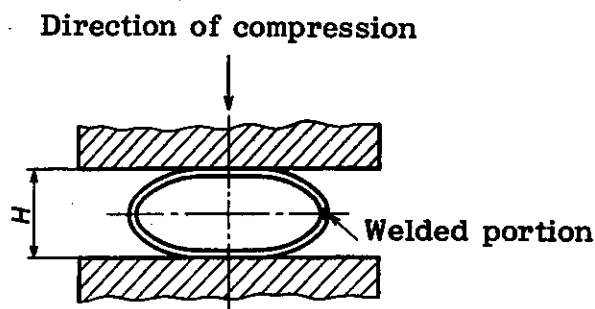
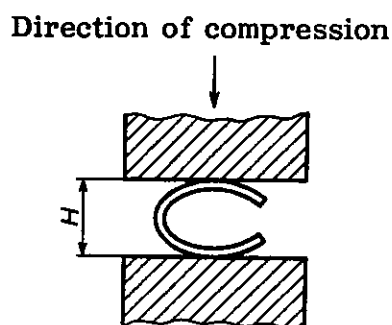


Fig. 3. Flattening Test
(for C-shape Test Piece)



9.4 Flaring Test

9.4.1 Test Pieces An adequate length of tube shall be cut off from one end of the tube as a test piece.

9.4.2 Method of Test The test piece shall be flared at one of the tube ends at ordinary temperature into a bell shape and to the specified size with conical tool forming an angle of 60° and checked for any flaws or other defects.

9.5 Reverse Flattening Test

9.5.1 Test Pieces A length of 100 mm shall be cut off from one end of the tube as a test piece.

9.5.2 Method of Test The test piece shall be split in the direction of tube axis on the opposite side of weld line, opened up, flattened and then checked for any flaws, cracks or other defects injurious to use that may have occurred in the weld.

9.6 Hydrostatic Test or Nondestructive Examination Either a hydrostatic test or a nondestructive examination shall be made in accordance with (1) or (2), respectively.

- (1) The tube shall be subjected to a hydrostatic pressure and kept at the designated or specified pressure to see if it withstands the pressure without leakage.
- (2) The method of nondestructive examination shall be in accordance with either JIS G 0582 or JIS G 0583.

10. Inspection

- (1) General matters of inspection shall be as specified in JIS G 0303.
- (2) The chemical composition, mechanical properties, hydrostatic or non-destructive characteristic, appearance and dimensions shall conform to the requirements specified in 3., 4., 5., 6. and 7. However, appropriate nondestructive examination other than those specified in 9.6 (2) may substitute for the said examination when agreed upon by the purchaser and the manufacturer.

Further, when the supplementary quality requirements given in Appendix 1 or the U-bend test given in Appendix 2 specified by agreement between the purchaser and the manufacturer, the results of inspection shall conform to the relevant requirements specified in Z 1, Z 2, Z 3 and Z 4 of Appendix 1 as well as those specified in Appendix 2.
- (3) Either the hydrostatic test or the nondestructive examination shall be performed for each tube.
- (4) The number of specimens for the product analysis shall be agreed upon by the purchaser and the manufacturer.
- (5) The method of sampling the specimens and the number of test pieces for the tensile test, flattening test and flaring test shall be as follows.

Take one specimen from each 50 or its fraction of tubes as manufactured of the same dimensions ⁽²⁾, and one specimen from each 50 or its fraction of tubes to be heat-treated of the same dimensions ⁽²⁾ and the concurrent heat treatment and then take one tensile test piece from this specimen. Further, take one flattening test piece from one end of the specimen and one flaring test piece from the other end.

For the electric resistance welded steel tubes, in addition to the test pieces given above, take one specimen from each 100 or its fraction of tubes as manufactured of the same dimensions ⁽²⁾ and likewise one specimen for tubes to be heat-treated of the same dimensions ⁽²⁾ and the concurrent heat treatment and then take one reverse flattening test piece from the specimen.

Note ⁽²⁾ The "same dimensions" means the "same outside diameter combined with the same wall thickness".

10.2 Reinspection The tube may apply for a retest specified in 4.4 of JIS G 0303 for final acceptance.

11. Marking

Each tube having passed the inspection shall be marked with the following items. However, the order of arranging the items is not specified. Further, in the case of either smaller tubes or a request from the purchaser, the tubes may be bundled together and marked for each bundle by a suitable means.

When approved by the purchaser, part of items may be omitted.

- (1) Class symbol
- (2) Letter symbol indicating the manufacturing method ⁽³⁾
- (3) Dimensions
- (4) Manufacturer's name or its abbreviation
- (5) Letter symbol Z indicating the designation of special quality requirements

Note ⁽³⁾ Symbols for indicating the manufacturing method shall be as follows. However, - may be replaced by a blank.

Hot finished seamless steel tube	- S - H
Cold finished seamless steel tube	- S - C
Electric resistance welded steel tube other than hot finished and cold finished	- E - G
Hot finished electric resistance welded steel tube	- E - H
Cold finished electric resistance welded steel tube	- E - C

13. Report

The manufacturer shall, in general, submit to the purchaser a detailed statement of the test results, method of manufacture, ordered dimensions, quantity, work number indicating the history of manufacture, etc.

Reference Table 1-1. Calculation Examples of Values of Elongation for No. 12 Test Piece of Tube under 8 mm in Wall Thickness (Applicable till the end of 1990)

Symbol of class	Value of elongation for each division of wall thickness %						
	Over 7 mm to and excl. 8 mm	Over 6 mm up to and incl. 7 mm	Over 5 mm up to and incl. 6 mm	Over 4 mm up to and incl. 5 mm	Over 3 mm up to and incl. 4 mm	Over 2 mm up to and incl. 3 mm	Over 1 mm up to and incl. 2 mm
STB 35	35	34	32	30	29	28	26
STB 42	25	24	22	20	19	18	16
STB 52	25	24	22	20	19	18	16

Reference Table 1-2. Calculation Examples of Values of Elongation for No. 12 Test Piece of Tube under 8 mm in Wall Thickness (Applicable on and after Jan. 1, 1991)

Symbol of class	Value of elongation for each division of wall thickness %						
	Over 7 mm to and excl. 8 mm	Over 6 mm up to and incl. 7 mm	Over 5 mm up to and incl. 6 mm	Over 4 mm up to and incl. 5 mm	Over 3 mm up to and incl. 4 mm	Over 2 mm up to and incl. 3 mm	Over 1 mm up to and incl. 2 mm
STB 340	35	34	32	30	29	28	26
STB 410	25	24	22	20	19	18	16
STB 510	25	24	22	20	19	18	16

Attached Table. Dimensions and Mass of Carbon Steel
Tubes for Boiler and Heat Exchanger

Unit: kg/m

Wall thickness (mm) Outside diameter (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

Remarks 1. The numerical value of mass shall be obtained by calculating from the following formula assuming 1 cm³ of steel to be 7.85 g and by rounding off the result to 3 significant figures in accordance with JIS Z 8401.

$$W = 0.02466 t (D - t)$$

where w : unit mass of tube (kg/m)

t : wall thickness of tube (mm)

D : outside diameter of tube (mm)

2. In transaction, the unit mass of tube shall be the value given in the above table increased by 15 % for the hot finished seamless steel tube, by 10 % for cold finished seamless steel tube, and by 9 % for electric resistance welded steel tube.

Appendix 1 Supplementary Quality Requirements

The supplementary quality requirements shall apply only when required by the purchaser and shall be executed by the manufacture 1 for the designated items on the straight tube.

Z 1 Hardness

- (1) The hardness of the tube shall be as given in Appendix 1 Table 1-1 or Table 1-2.

Appendix 1 Table 1-1. Hardness
(Applicable till the end of 1990)

Symbol of class	Rockwell hardness HRB (Mean value of three points)
STB 35	77 max.
STB 42	79 max.
STB 52	92 max.

Appendix 1 Table 1-2. Hardness
(Applicable on and after Jan. 1, 1991)

Symbol of class	Rockwell hardness HRB (Mean value of three points)
STB 340	77 max.
STB 410	79 max.
STB 510	92 max.

- (2) A suitable length shall be cut off from one end of the tube.
- (3) The test method shall be in accordance with JIS Z 2245 and the hardness on the cross section or inside surface of the test piece shall be measured at three points for each test piece.
- Further, a tube under 2 mm in wall thickness shall not be tested. As for the electric resistance welded steel tube, the test shall be performed in the portion other than the weld and the heat-affected zone.
- (4) The hardness shall comply with the requirement specified in Appendix 1 Table 1-1 or Table 1-2.
- (5) The sampling of specimens and the number of test pieces shall be as specified for the tensile test in 10.1(5) of the text.

- (6) Reinspection The tube may be put to a retest specified in 4.4 of JIS G 0303 for final acceptance.

Z 2 Elevated Temperature Yield Point or Proof Stress

- (1) The value of elevated temperature yield point or proof stress and the testing temperature of the pipe shall be agreed upon by the purchaser and the manufacturer.
- (2) The test piece and the test method shall be as specified in JIS G 0567. However, when it is practically difficult to take the test piece of the shape specified in JIS G 0567, the shape of the test piece shall be agreed upon by the purchaser and the manufacturer.
- (3) The method of sampling the test specimens and the number of test pieces shall be as follows. Take one test specimen from each lot of the same heat, and then from one test specimen take one test piece for each lot of the same testing temperature.

Z 3 Ultrasonic Examination

- (1) The criteria of the working sensitivity in the ultrasonic examination shall be the division UA or UC specified in JIS G 0582, and there shall be no signal greater than those produced by the artificial defects of the reference test block.
- (2) The test method of the ultrasonic examination shall be as specified in JIS G 0582.
- (3) The ultrasonic examination shall be performed for each tube and the results shall conform to the requirements specified in (1).

Z 4 Eddy Current Examination

- (1) The criteria of the working sensitivity in the eddy current examination shall be the division EV, EW, or EX specified in JIS G 0583, and there shall be no signal greater than those produced by the artificial defects of the reference test block.
- (2) The test method of the eddy current examination shall be as specified in JIS G 0583.
- (3) The eddy current examination shall be performed for each tube and the results shall conform to the requirements specified in (1).

Appendix 2 U-Bend Tubes

The U-bend tube shall be applied when the purchaser requires it and shall be executed by the manufacturer.

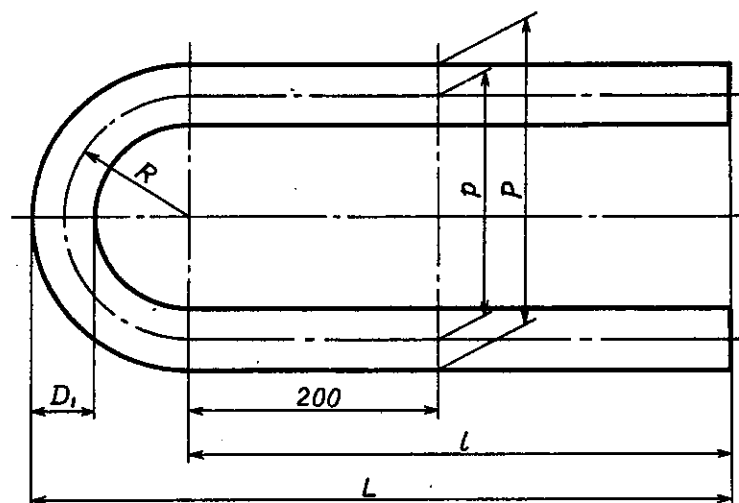
1. Method of Manufacture

The method of manufacture shall be as follows (See Appendix 2 Fig.).

- (1) The U-bend tube shall be made by cold bending process and the bending radius shall be at least 1.5 times the outside diameter of the tube.
 - (2) The bent portion of the tube shall, in general, not be heat-treated. However, when required by the purchaser, the heat treatment may be agreed upon.
2. The bent portion shall be free from defects injurious to use.
 3. The dimensional tolerances on the bent portion shall be as specified in Appendix 2 Table 1 and the tolerances on length after bending shall be as specified in Appendix 2 Table 2.

Appendix 2 Figure

Unit: mm



R : Bend radius

D_n : Nominal outside diameter

D_1 : Outside diameter of bent portion

t_n : Nominal wall thickness

t : Minimum wall thickness of bent portion

p : Pitch

l : Length of straight portion

$P : p + D_n$

$L : l + R + \frac{D_n}{2}$

Appendix 2 Table 1. Dimensional Tolerances on Bent Portion

Variation of outside diameter		$\frac{D_1 - D_n}{D_n} \times 100 \%$	Reduction rate of wall thickness	Tolerances on pitch (p) or P
Short radius side	Long radius side		$\frac{t_n - t_1}{t_n} \times 100 \%$	mm
$\frac{D_n}{4R} \times 100$ max. However, minimum value 0.5 mm	$\frac{D_n}{8R} \times 100$ max. However, minimum value 0.5 mm		$\frac{D_n}{2.5R} \times 100$ max.	± 1.5

Appendix 2 Table 2. Tolerances on Length of U-Bend Tube

Division of length	Tolerances on length (l or L) mm
7 m or under in length of straight portion after bending	+ 7 0
Over 7 m in length of straight portion after bending	+ 10 0

4. The measurement of dimensions of bent portion shall be carried out as follows. Take one specimen from U-bend tube with the smallest bending radius of the tubes of the same dimensions bent concurrently. Measure the outside diameters in two directions at 90° to bent portion and the wall thickness at four locations on the circumference and then obtain the variation rate of outside diameter and the reduction rate of wall thickness.

Applicable Standards:

- JIS G 0303-General Rules for Inspection of Steel
- JIS G 0321-Product Analysis and its Tolerance for Wrought Steel
- JIS G 0567-Method of High Temperature Tensile Test for Steels and Heat-Resisting Alloys
- JIS G 0582-Ultrasonic Examination of Steel Pipes and Tubes
- JIS G 0583-Eddy Current Examination of Steel Pipes and Tubes
- JIS G 1211-Methods for Determination of Carbon in Iron and Steel
- JIS G 1212-Methods for Determination of Silicon in Iron and Steel
- JIS G 1213-Methods for Determination of Manganese in Iron and Steel
- JIS G 1214-Methods for Determination of Phosphorus in Iron and Steel
- JIS G 1215-Methods for Determination of Sulfur in Iron and Steel
- JIS G 1253-Method for Photoelectric Emission Spectrochemical Analysis of Iron and Steel
- JIS G 1256-Method for X-Ray Fluorescence Spectrometric Analysis of Iron and Steel
- JIS G 1257-Methods for Atomic Absorption Spectrochemical Analysis of Iron and Steel
- JIS Z 2201-Test Pieces for Tensile Test for Metallic Materials
- JIS Z 2241-Method of Tensile Test for Metallic Materials
- JIS Z 2245-Method of Rockwell and Rockwell Superficial Hardness Test
- JIS Z 8401-Rules for Rounding off of Numerical Values

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