

### JIS G3462 Alloy Steel for Boiler and Heat Exchanger Tubes

#### 1. Scope

This Japanese Industrial Standard specifies the alloy 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 boilers, and heat exchanger industries. However, it is not applicable to the steel tubes for heating furnace and those for heat exchangers for low temperature service.

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. Classifications and symbols

The tube shall be classified into eight classes and their symbols shall be as given in Table 1

Table 1. Symbols of Classes

Classification	Symbol of class
Molybdenum steel tube	STBA 12
	STBA 13
Chromium-molybdenum steel tube	STBA 20
	STBA 22
	STBA 23
	STBA 24
	STBA 25
	STBA 26

World standard comparative table

KS		ASTM		JIS		DIN		BS	
Grade number	GRADE	Grade number	GRADE	Grade number	GRADE	Grade number	GRADE	Grade number	GRADE
D 3572	STHA12	A161 A209	T1 T1	G 3462	STBA12	17175	15Mo 3	-	-

	STHA13	A209	T1a		STBA13	-	-	-	-
	STHA20	A213	T2		STBA20	-	-	-	-
	STHA22	A213	T12		STBA22	17175	13Cr Mo 44	3059	S1 620 S2 620 ERW620 CEW620
	STHA23	A199 A200 A213	T11 T11 T11		STBA23	-	-	-	-
	STHA24	A199 A200 A213	T22 T22 T22		STBA24	17175	10Cr Mo910	3059	S1 622-440 S2 622-440
	STHA25	A199 A200 A210	T5 T5 T5		STBA25	-	-	-	-
	STHA26	A199 A200 A213	T9 T9 T9		STBA26	-	-	-	-

### 3. Method of Manufacture

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

3.2 The tube shall be subjected to heat treatments specified in Table2. However. heat treatments not specified in Table 2 shall be agreed upon by the purchaser and the manufacturer.

Table 2. Heat Treatment

Symbol of class	Heat treatment
STBA 12 STBA 13	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering
STBA 20 STBA 22	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering

STBA 23	Isothermal annealing, full annealing or normalizing followed by tempering
STBA 24	
STBA 25	
STBA 26	

Remark

1. Low temperature annealing shall not be applied to the electric resistance welded steel tube.
2. The tempering temperature for STBA 23, STBA 24, STBA 25 and STBA 26 shall be 650° or higher.

4. Chemical composition

The tube shall be tested in accordance with 9.1 and the resultant ladle analysis values shall conform to Table 3.

Table 3 Chemical Composition

Symbol of class	Chemical Composition						
	C	Si	Mn	P	S	Cr	Mo
STBA 12	0.10~0.20	0.10~0.50	0.30~0.80	0.035max.	0.035max.	-	0.45~0.65
STBA 13	0.15~0.25	0.10~0.50	0.30~0.80	0.035max.	0.035max.	-	0.45~0.65
STBA 20	0.10~0.20	0.10~0.50	0.30~0.60	0.035max.	0.035max.	0.50~0.80	0.45~0.65
STBA 22	0.15 max.	0.50 max.	0.30~0.60	0.035max.	0.035max.	0.80~1.25	0.45~0.65
STBA 23	0.15 max.	0.50~1.00	0.30~0.60	0.030max.	0.030max.	1.00~1.50	0.45~0.65
STBA 24	0.15 max.	0.50 max.	0.30~0.60	0.030max.	0.030max.	1.90~2.60	0.87~1.13
STBA 25	0.15 max.	0.50 max.	0.30~0.60	0.030max.	0.030max.	4.00~6.00	0.45~0.65
STBA 26	0.15 max.	0.25~1.00	0.30~0.60	0.030max.	0.030max.	8.00~10.00	0.90~1.10

Remark

When the purchaser requires product analysis, the chemical composition given in Table 3 shall likewise apply.

4.4 Tensile Strength, Yield Point or Proof Stress and Elongation

The tube shall be tested in accordance with 9.2 and the resultant tensile strength, yield point or proof stress and elongation of the tubes shall comply with Table 3.

Table 3 Mechanical Properties

Symbol of class	Tensile strength kg f/Π {N/mm <sup>2</sup> }	Yield point or proof stress kg f/Π {N/mm <sup>2</sup> }	Elongation %		
			Outside diameter 20 mm and over	Outside diameter 10 mm or over to and excl. 20 mm	Outside diameter up to 10 mm

			No. 11 test piece No. 12 test piece	No. 11 test piece	No. 11 test piece
STBA 12	39{382} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 13	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 20	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 22	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 23	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 24	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 25	42{412} min.	21{206} min.	30 min.	25 min.	22 min.
STBA 26	42{412} min.	21{206} min.	30 min.	25 min.	22 min.

## Remark

- Execusively for the heat exchanger tube, the purchaser may, where necessary. designate the maximum value of tensile strength, which shall be 15kgf/Π{147N/Π} added to the value given in the Table 4
- When the tube under 8 mm in thickness is subjected to tensile test by using No. 12 test piece, the minimum value of elongation shall be calculated by subtracting 1.5 % from the value of elongation given in Table4 for decrease of each 1 mm and rounding off the result to a whole number according to JIS Z 8401. Examples of calculation are shown in Reference Table.
- When a tensile test piece is to be taken from the electric resistance welded steel tube. a NO. 12 test piece shall be taken from a seamless portion.

## 4.5 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

H: distance between flat plates (mm)

t: wall thickness of tube (mm)

D: outside diameter of tube (mm)

e: constant 0.08

## 4.6 Flaring Resistance

In the test in accordance with 9.4, the tube shall be flared into a bell shape to 1.14 times the outside diameter and then no flaws shall be generated.

## 4.7 Reverse Flattening Resistance

In accordance with 9.5, the electric resistance welded steel tube shall be subjected to the reverse flattening test and then flaws, cracks and the like shall not be generated on the weld.

4.8 Hydrostatic Characteristic or Nondestructive Characteristic

The tube shall be tested in accordance with 9.6 and the resulting hydrostatic characteristic or nondestructive with 9.6 and the resulting 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.

4.8.1 Hydrostatic Characteristic

When the hydrostatic pressure specified by the purchaser, or in its absence, the hydrostatic pressure P (maximum 100kgf/P{98bar}) calculated from the formula 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 value P.

When a hydrostatic pressure test is made in compliance with the designation of the purchaser and the test pressure exceeds either 100kgf/P {98bar} 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 5kgf/P{4.9bar}

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

$$p = 200st/D$$

where

P : test pressure (kgf/P{10<sup>-1</sup>bar}) (1)

t :wall thickness of tube(mm)

D: outside diameter of tube(mm)

s : 60% of minimum value of yield point or proof stress specified in Table 4 (kgf/Π {N/Π})

Note (1) 1bar = 10<sup>5</sup> Pa

4.8.2 When the hydrostatic pressure specified by the purchaser, or in its absence, the hydrostatic pressure P(maximum 10 MPa) calculated from the formula 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 value P.

5.Dimensions, Mass and Dimensional Tolerance

5.1 Dimensions and Mass

The outside diameter, thickness and mass of the tube shall be as specified in (Attached Table), unless specially designated.

Attached Table Dimensions and Mass of Alloy Steel Boiler and Heat Exchanger Tubes

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
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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

Remarks

1. Calculate the value of mass from the following formula assuming 1X of steel to be 7.58 g and be rounded off the result to 3 significant figures in accordance with JIS Z 8401

$$W=0.2466 t (D-t)$$

where

W: unit mass of tube(kg/m)

t: wall thickness of tube(mm)

D: outside diameter of tube(mm)

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

### 5.2 Dimensions and Mass

The dimensional tolerances of tube shall be as follows:

5.2.1 The tolerance on the outside diameter of the tube shall be specified in Table 5

Table 5 Tolerances on Outside Diameter

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
Up to 25	+0.4 -0.8	【0.10	【0.15	【0.10
25 and over, up to 40		【0.15	【0.20	【0.15
40 and over up to 50		【0.20	【0.25	【0.20
50 and over, up to 60		【0.25	【0.30	【0.25
60 and over, up to 80		【0.30	【0.40	【0.30
80 and over, up to 100		【0.40	+0.40 -0.60	【0.40
100 and over, up to 120	+0.4 -1.2	+0.40 -0.60	+0.40 -0.80	+0.40 -0.60
120 and over, up to 160	+0.4 -1.8	+0.40 -0.80	+0.40 -1.00	+0.40 -0.80
160 and over, up to 200		+0.40 -1.20	+0.40 -1.20	+0.40 -1.20

200 and over	+0.4	+0.40	+0.40	+0.40
	-2.4	-1.60	-1.60	-1.60

Remark

1. For the tolerances on the outside diameter of electric resistance welded steel tube other than cold finished, if specially required by the purchaser, the tolerances on the outside diameter of cold finished steel tube may substitute.

5.2.2 Tolerances on Wall Thickness and on Thickness Deviation

Table 5 Tolerances on Wall Thickness and on Thickness Deviation

Tolerances on wall thickness	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)	Up to 100	100 and over	Up to 40	40 and over	Up to 40	40 and over
Tolerances on wall thickness	Up to 20		-	-	+0.4mm 0	+22 0	+0.3mm 0	+18 0
	2 and over, up to 2.4		+40 0	-	+20 0		+18 0	
	2.4 and over, up to 3.8		+35 0	+35 0				
	3.8 and over, up to 4.6		+33 0	+33 0				
	4.6 and over		+28 0	+28 0				
Tolerances on thickness deviation			Within 22.8 of wall thickness					

Remark

The "thickness deviation" means the ratio of the difference between the maximum and the minimum thickness of the wall measured in the same section to the ordered wall thickness and shall not be applied to the tube under 5.6 mm in wall thickness

5.2.3 The Tolerance on length of the tube shall be specified in Table 7

Table Tolerances on length

Division	Tolerances on length
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Up to and incl. 50 mm in outside diameter	Up to and incl. 7 m in length	+0.7mm 0
	Over 7 m in length	Add 3 mm to the plus side tolerances given above for increase of each 3 m or its fraction in length. However, the maximum value shall be 15 mm.
Over 50 mm in outside diameter	Up to and incl. 7 m in length	+10mm 0
	Over 7 m in length	Add 3 mm to the plus side tolerance given above for increase of each 3 m or its fraction in length. However, the maximum value shall be 15 mm

**Remark**

When accurate length is particularly required, the tolerances on it shall be agreed upon by the purchaser and the manufacturer.

**6. Test****6.1 Chemical Analysis**

6.1.1 Chemical Analysis General matters of chemical analysis and method of sampling analysis samples shall be as specified in 3. of JIS G 0303.

6.1.2 Method of Analysis The method of analysis shall be in accordance with one of the following Standards:

JIS G 1253, JIS G 1256, JIS G 1257, JIS G 1214, JIS G 1215

JIS G 1211, JIS G 1212, JIS G 1213, JIS G 1218

**6.2 Tensile Test****6.2.1 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 cut off from the tube in the longitudinal direction.

**6.2.2 Method of Test**

The test method shall be in accordance with JIS Z 2241

**6.3 Flattening Test****6.3.1 Test Piece**

A test piece 50 mm or over in length shall be cut off from one end of a tube. For the tube whose wall thickness is 15 % or over of the outside diameter, a C0shape test piece made by removing part of the circumference of a whole test piece may be used.

**6.3.2 Test Method**

The test piece shall be placed at ordinary temperature between two flat plates and flattened by compression until the distance occurrence of flaws or cracks on its wall surface.

For the electric resistance of compression as shown in fig. 1, and the C-shape test piece shall be placed as shown in Fig. 2

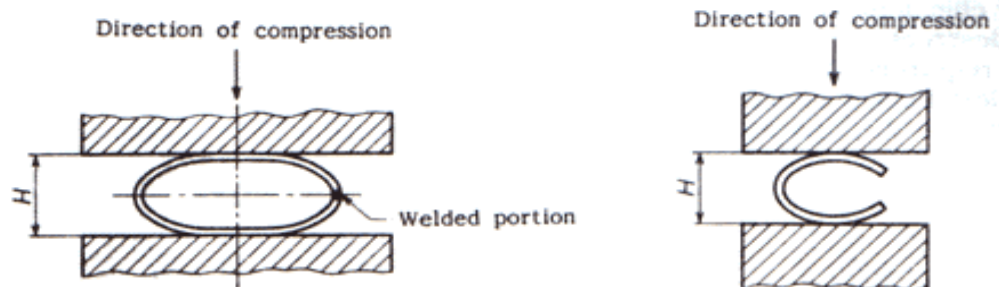


Fig. 1. Flattening Test (For whole Test Piece)

Fig. 2. Flattening Test (For C-shape Test Piece)

## 6.4 Flaring Test

### 6.4.1 Test Piece

An adequate length of tube shall be cut off from one end of the tube to serve as a test piece.

### 6.4.2 Method of Test

The test piece shall be flared at one of the tube ends at ordinary temperature into a bell shape to a specified degree with a conical tool forming angle of  $60^\circ$  and shall then be checked for any flaws or other defects generated.

## 6.5 Reverse Flattening Test

### 6.5.1 Test Piece

A length of 100 mm shall be cut off from one end of the tube to serve as a test piece.

### 6.5.2 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 shall then be checked for any flaws or other defects generated which are injurious to use.

## 6.6 Hydrostatic Test or Nondestructive Examination

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

6.6.1 The tube shall be subjected to a hydrostatic pressure kept at the designated or specified pressure to see if it withstands the pressure without leakage.

6.6.2 The method of nondestructive examination shall be in accordance with either JIS G 0582 or JIS G 0583.

## 7. Inspection

(1) General matters of inspection shall be as specified in JIS G 0303.

(2) The chemical composition, mechanical properties, hydrostatic or nondestructive characteristic, dimensions and appearance shall conform to the requirements specified in 3., 4., 5., 6, and 7.

However, appropriate nondestructive examinations other than those specified in 9.6 (2) may substitute for the said nondestructive examination when agreed upon by the purchaser and the manufacturer.

(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 the purchaser and the manufacturer.

(5) The method of sampling and the number of test pieces for the tensile test, flattening test and flaring 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 of the same dimensions (), and the concurrent heat treatment and then take one flattening test piece from one end of the specimen and one flaring test piece from the other end.

For electric resistance welded steel tubes, in addition to the test pieces given above, take one specimen from each 100 lengths current heat treatment and then take one reverse flattening test piece from this specimen

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

## 8. Reinspection

The tube is entitled to a retest specified in 4.4 of JIS G 0303 for final acceptance.

## 9. Marking

The tubes which have passed the inspection shall be marked with the following items on each tube. 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 by a suitable method on each bundle.

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

(1) Symbol of class

(2) Symbol representing the method of manufacture (<sup>3</sup>)

(3) Dimensions

(4) Manufacturer's name or its abbreviation

(5) Symbol representing the designation of special quality requirements: Z

Note (<sup>2</sup>)

Symbols representing the methods of manufacture shall be as follows:

However, the sign - 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

**10. Report**

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

Reference Table.

Calculation Examples of Elongation Values for No. 12 Test Piece of Tube under 8 mm in Wall Thickness

Symbol of class	Elongation value for each division of wall thickness %						
	Over 7mm Up to 8 mm excl.	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 4 mm up to and incl. 3mm	Over 3 mm up to and incl. 2 mm	Over 1 mm up to and incl. 2 mm
All classes	30	28	27	26	24	22	21

**Appendix 1. Special Quality Requirements**

The special quality requirements shall apply when required by the purchaser, and the manufacturer shall execute the designated items on the straight tube.

**Z1 Hardness**

Z 1.1 The hardness of the tube shall be as given in appendix 1 Table.

**Appendix 1 Table. Hardness**

Symbol of class	Rockwell hardness HRB (Mean of three points)
STBA 12	80 max.
STBA 13	81 max.
STBA 20	85 max.
STBA 22	85 max.
STBA 23	85 max.
STBA 24	85 max.
STBA 25	85 max.

STBA 26	85 max.
	85 max.
	85 max.
	89 max.

Z 1.2 A suitable length shall be cut off from one end of the tube to serve as a test piece.

Z 1.3 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.

Z 1.4 The hardness shall comply with the requirements specified in Appendix 1 Table.

Z 1.5 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.

Z 1.6 Reinspection

The tube is entitled to a retest specified in 4.4 of JIS G 0303 for final acceptance.

Z 2 Elevated Temperature Yield Point or proof Stress

Z 2.1 The value of elevated temperature yield point or proof stress and the testing temperature of the tube shall be agreed upon by the purchaser and the manufacturer.

Z 2.2 The test piece and the test method shall be as specified in JIS G 0567.

Further, when it is difficult to take the test piece of the shape specified in JIS G 0567, the shape of the test piece shall be as agreed upon by the purchaser and the manufacturer.

Z 2.3 The sampling of specimens and the number of test pieces shall be as follows. Take one specimen from each lot of the same heat and from this specimen take one test piece for each test temperature.

Z 3 Ultrasonic Examination

Z 3.1 The standard of working sensitivity in the ultrasonic examination shall be the division UA or UC specified in JIS G 0582 and there shall be no signal equal to or greater than the signal from an artificial flaw of reference test piece.

Z 3.2 The method of the ultrasonic examination shall be in accordance with JIS G 0582.

Z 3.3 The ultrasonic examination shall be performed on each tube and the result shall comply with the requirement specified in (1).

Z 4 Eddy Current Examination

Z 4.1 The standard of 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 equal to or greater than the signal from an artificial flaw in the reference test piece.

Z 4.2 The method of the eddy current examination shall be in accordance with JIS G 0583.

Z 4.3 The eddy current examination shall be performed on each tube and the result shall comply with the requirement specified in (1).

Appendix 2. U-Bent Tube

the U-bend tube shall apply when required by the purchaser and shall be executed by the manufacturer.

1. Method of Manufacture

(1) The U-bend tube shall be manufactured 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.

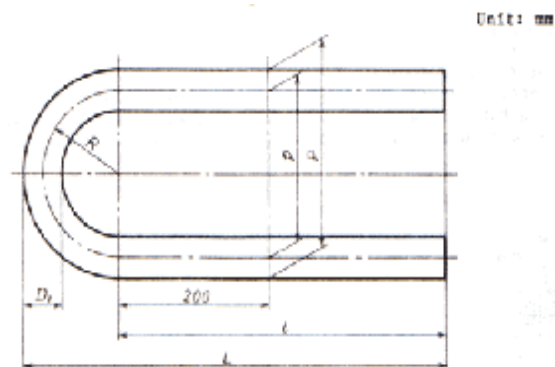
However, when required by the purchaser, a heat treatment may be agreed tube.

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 and the tolerances on the length after bending shall be as specified in Appendix 2 Table

2.

Appendix 2. Figure



R: Bend radius

Dn: Nominal outside diameter

D1: Outside diameter of bent portion

t<sub>n</sub>: Nominal wall thickness

t<sub>1</sub>: Minimum wall thickness of bent portion

p: pitch

P: p + Dn

ラ: Length of straight portion

L: ラ + R + Dn/2

Appendix 2 Table 1. Dimensional Tolerances on Bent Portion

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

Appendix 2 Table 2. Tolerances on Lengths of U-Bent Tube

Division of length	Tolerances on length (l or L)
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 performed as follows.

Take on e specimen from a U-bend tube with the smallest bending radius of the tubes of the same dimension bent concurrently. Measure the outside diameters in the directions at 90X to the 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.

Material Comparison Tables (ASTM, KS, JIS, DIN, BS, NBN, NF, UNI)

ASTM Standard	UNS NO.	KOREA/JAPANES			GERMAN				BRITISH			BELGIAN			FRENCH			ITALIAN		
		KS/JIS Symbol	KS/JIS Number	Remarks	DIN Type	DIN Number	Material Number	Remarks	B.S Number	B.S Grade	Remarks	NBN Type	NBN Grade	Remarks	AFNOR Type	NF Number	Remarks	UNI Type	UNI Number	Remarks
A 199 Seamless Cold Drawn Intermediate Alloy Steel Heat Exchange and Condenser Tubes																				
T5	K41545	STHA 24 / STBA 25	D3572 / G3462	(35)	12CrMo 19 5		1.7362 (3a)	3606	CFS 625	(35)	X12 CrMo 5	837	(35)	Z 12 CD 5.05		(3a)				(3); dalmine 234
T11	K11597	STHA 22 / STBA 23	D3572 / G3462	(35)	13CrMo 44	17175	1.7335 (8)	3606	CFS 621	(35)				10 CD 5.05		(3a)				(3); dalmine 227(10)
T22	K21590	STHA 23 / STBA 24	D3572 / G3462	(35)	10CrMo 9 10	17175	1.7380	3606	CFS 622	(35)	10CrMo 9 10	837	(35)	10 CD 9.10		(3a)	12CrMo 9 10	5462	(10)0	

Material Comparison Tables (ASTM, KS, JIS, DIN, BS, NBN, NF, UNI)

ASTM Standard	UNS NO.	KOREA/JAPANES			GERMAN				BRITISH			BELGIAN			FRENCH			ITALIAN		
		KS/JIS Symbol	KS/JIS Number	Remarks	DIN Type	DIN Number	Material Number	Remarks	B.S Number	B.S Grade	Remarks	NBN Type	NBN Grade	Remarks	AFNOR Type	NF Number	Remarks	UNI Type	UNI Number	Remarks
A 200 Seamless Intermediate Alloy Steel Tubes for Refinery Service																				
T 5	K41545	STHA 24 / STBA 25	D3572 / G3462	(32)	12rMo 19 5		1.7362 (3a)	3604	625	(30)(32)	X12CrMo	837	(32)	TU Z 12 CD	A49-213	(32)				Dalmine 234(3b)
T 11	K11597	STHA 22 / STBA 23	D3572 / G3462	(32)	13CrMo 44	17175	1.7335 (8)	3604	621	(30)(32)				5.05	A49-213	(32)				Dalmine 227(3b)
T 22	K2159	STHA 23 / STBA 24	F3572 / G3462	(32)	10CrMo 9 10	17175	1.7380	3606	622	(30)(32)	10 CrMo 9 10	837	(32)	TU 10 CD 5.05	A49-213	(32)	12CrMo 9 10	5462	(3b)	
														TU 12 CD 9.10						

Material Comparison Tables (ASTM, KS, JIS, DIN, BS, NBN, NF, UNI)

ASTM Standard	UNS NO.	KOREA/JAPANES			GERMAN				FRENCH			ITALIAN			
		KS/JIS Symbol	KS/JIS Number	Remarks	DIN Type	DIN Number	Material Number	Remarks	AFNOR Type	NF Number	Remarks	UNI Type	UNI Number	Remarks	
A 209 Seamless C-Mo Steel Boiler and Superheater Tubes															
Grade T 1	K11522	STHA 12 / STBA 12	D3572 / G3462	(30)(24)	16Mo5		1.5423 (3a)	18 MD 4.05		(3a)			(3a)	16Mo5 5462	(37)
Grade T 1a	K12023	STHA 13 / STBA 13	D3572 / G3462	(30)(24)	16Mo5		1.5423 (3a)						(3)		(3)

Material Comparison Tables (ASTM, KS, JIS, DIN, BS, NBN, NF, UNI)



ASTM Standard	UNS NO.	KOREA/JAPANESE			GERMAN				BRITISH			FRENCH			ITALIAN		
		KS/JIS Symbol	KS/JIS Number	Remarks	DIN Type	DIN Number	Material Number	Remarks	B.S Number	B.S Grade	Remarks	AFNOR Type	NF Number	Remarks	UNI Type	UNI Number	Remarks
A 213 Seamless Alloy Steel Boiler and Heat Exchanger Tubes																	
Grade T 5	K41545	STHA 24 / STBA 25	D3572 / G3462	(30)(24)	12 CrMo 19 5		1.7362	(3a)	3606	625	(30)	TUZ12C	A49-213	(3a)(32)			Dalmine 234(3b)
Grade T 11	K11597	STHA 22 / STBA 24	D3572 / G3462	(30)(24)	13 CrMo 44	17175	1.7335	(8)(32)	3606	621	(30)	5.05		(3b)(32)			Dalmine 227(3b)
Grade T 12	K11562	STHA 21 / STBA 22	D3572 / G3462	(30)(24)	13 CrMo 44	17175	1.7335	(32)	3606	620	(30)	TU 10 CD 5.05					
Grade T 22	K21590	STHA 23 / STBA 24	D3572 / G3462	(30)(24)	10 CrMo 9 10	17175	1.7380	(32)	3606	622	(30)(32)			(3a)(32)	12 CrMo 9 10	5462	Dalmine 235(3b)
TP 304	S30400	STS 304 TB / SUS 304 TB	D3577 / G3463	(30)(24)	X5 CrNi 18 9	17440	1.4301	(3b)	3606	304S25	(30)	TU 10 CD 9.10	A49-218	(3b)	X5 CrNi 18 10	6904	(3b)
TP 304L	S31403	STS 304LTB / SUS 304LTB	D3577 / G3463	(30)(24)	X2 CrNi 18 9	17440	1.4306	(3b)	3606	304S22	(30)	Z 6 CN 18.09	A49-218	(3b)	X2 CrNi 18 11	6904	(3b)
TP 310	S31000	STS 310STB/SUS 210STB	D3577 / G3463	(30)(24)	X12 CrNi 2528		1.4845	WBL-470(3b)			(3)	Z 2 CN 18.09		(3)	X22CrNi 25 20	6904	(3b)(11)
TP 316	S31600	STS 316TB / SUS 316TB	D3577 / G3463	(30)(24)	X5 CrNiMo 18 10	17440	1.4401	(3b)	3606	316S30	(30)		A49-218	(3b)	X5 CrNiMo 17 12	6904	(3b)
TP 316L	S211603	STS 316LTB / SUS 316LTB	D3577 / G3463	(30)(24)	X2 CrNiMo 18 10	17440	1.4404	(3b)	3606	316S29	(30)	Z 6 CND 17.12	A49-218	(3b)	X2 CrNiMo 17 12	6904	(3b)
TP 321	S32100	STS	D3577 / G3463	(30)(24)	X10	17440	1.4541	(3b)	3606	321S22	(30)	Z2 CND	A49-218	(3b)	X6 CrNiTi 17 12	6904	(3b)



