

Section 4 Steel Tubes and Pipes

401. Steel tubes for boilers and heat exchangers

1. Application

- (1) The requirements are mainly to apply to steel tubes intended for heat transfer at inside or outside of the tubes; for example, smoke tubes, water tubes, stay tubes, superheater tubes of boilers, other tubes for high temperature heat exchangers, etc. (hereinafter referred to as "steel tubes").
- (2) Steel tubes other than those specified in (1) are to comply with the requirements in **101. 2.**

2. Kinds

The steel tubes are classified as specified in **Table 2.1.44.**

Table 2.1.44 Kinds

Description	Grade
Carbon steel tubes for boilers and heat exchangers	<i>RSTH 35</i> <i>RSTH 42</i> <i>RSTH 52</i>
Alloy steel tubes for boilers and heat exchangers	<i>RSTH 12</i> <i>RSTH 22</i> <i>RSTH 23</i> <i>RSTH 24</i>

3. Heat treatment

The heat treatment of steel tubes is to comply with the requirements given in **Table 2.1.45.**

Table 2.1.45 Heat treatment [See Guidance]

Grade	Seamless steel tube		Electric-resistance welded steel tube		
	Hot working	Cold working	As weld	Hot working	Cold working
<i>RSTH 35</i>	As drawn	Low temperature annealed, Normalized or full annealed	Normalized	As drawn	Normalized ⁽¹⁾
<i>RSTH 42</i>				Low temperature annealed	
<i>RSTH 52</i>				Normalized	
<i>RSTH 12</i>	Low temperature annealed, Isothermal annealed, Full annealed, Normalized or Normalized and tempered ⁽²⁾				
<i>RSTH 22</i>	Low temperature annealed, Isothermal annealed, Full annealed or Normalized and tempered ⁽²⁾				
<i>RSTH 23</i> <i>RSTH 24</i>	Isothermal annealed, Full annealed or Normalized and tempered at 650°C and over		-		
NOTES					
(1) Steel tubes which are normalized prior to cold working may be finished by annealing					
(2) Low temperature annealing is not to be applied to electric resistance welded steel tube					

4. Chemical composition

The chemical composition of steel tubes is to comply with the requirements given in **Table 2.1.46.**
[See Guidance]

Table 2.1.46 Chemical Composition

Grade	Chemical composition (%)						
	C	Si	Mn	P	S	Cr	Mo
RSTH 35	0.18 max.	0.10~0.35	0.30~0.60	0.035 max.	0.035 max.	-	-
RSTH 42	0.32 max.		0.30~0.80				
RSTH 52	0.25 max.		1.00~1.50				
RSTH 12	0.10~0.20	0.10~0.50	0.30~0.80				
RSTH 22	0.15 max.	0.50 max.	0.30~0.60	0.030 max.	0.030 max.	0.80~1.25	0.45~0.65
RSTH 23		0.50~1.00				1.00~1.50	
RSTH 24		0.50 max.				1.90~2.60	

NOTE:
In case where approved by the Society, RSTH 35 and RSTH 42 may be the killed steel of below 0.10 % Si.

5. Mechanical properties [See Guidance]

The mechanical properties of steel tubes are to comply with the following requirements.

- (1) *Tensile test* : The tensile test of steel tubes is to comply with the requirements given in **Table 2.1.47**.

Table 2.1.47 Mechanical Properties

Grade	Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%) ($L = 5.65\sqrt{A}$)
RSTH 35	175 min.	340 min.	26 (22) min.
RSTH 42	255 min.	410 min.	21 (17) min.
RSTH 52	295 min.	510 min.	
RSTH 12	205 min.	380 min.	
RSTH 22		410 min.	
RSTH 23			
RSTH 24			

NOTES:
1. The values of elongation in parenthesis are applicable to the test specimens taken transversely. In this case, the sampling material is to be heated 600°C to 650°C after flattened and annealed in order to make it free from strain.
2. In case where test specimen of non-tubular section is taken from an electric-resistance welded steel tube, the test specimen is to be taken from the parts that do not include the welded line.

- (2) *Flattening test* : A tubular section which is taken from the end of the steel tube is to stand being flattened cold between parallel plates, without cracking or showing flaw, until the distance between the plates becomes less than the value of H calculated by the following formula. In this case, the length L of steel tube is to be not less than 50 mm, however, not more than 100 mm. For electric-resistance welded steel tubes, however, the welded line is to be placed at right angle to the direction of the applied force as shown in **Fig 2.1.9** (a) For tubes, however, of 15 % of outside diameter and over in thickness, C-type test specimen may be used, having a part of its circumference discarded as shown in **Fig 2.1.9** (b)

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

where:

H = Distance between flattening plates (mm).

t = Thickness of steel tube (mm).

D = Outside diameter of steel tube (mm).

e = Constant given in **Table 2.1.48** which varies according to the grade of steel tubes.

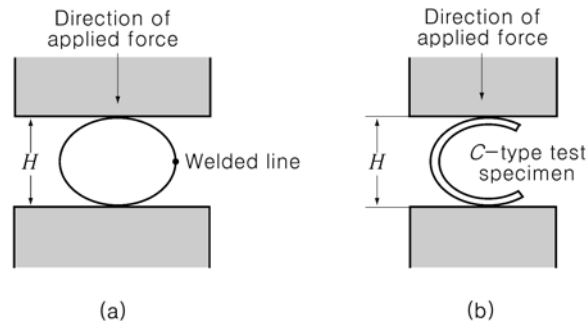


Fig 2.1.9 Flattening test

Table 2.1.48 Value of e

Grade	Value of e
RSTH 35	0.09
RSTH 42, RSTH 12, RSTH 22, RSTH 23, RSTH 24	0.08
RSTH 52	0.07

- (3) *Flaring test* : A section of steel tube which is taken from its end is to stand being flared cold with a tool having an included angle of 60 degrees, until the steel tube at the mouth of the flare is expanded without cracking or showing flaw to the diameter shown in **Table 2.1.49**. The rate of penetration of the mandrel shall not exceed 50 mm/min. In this case, the length of test specimen is to be $1.5 D$, however, not less than 50 mm.

Table 2.1.49 Outside Diameter of Steel Tube End after Flaring

Grade	Outside diameter of steel tube end
RSTH 35, RSTH 42, RSTH 52	1.2 times the outside diameter of steel tube
RSTH 12, RSTH 22, RSTH 23, RSTH 24	1.14 times the outside diameter of steel tube

- (4) *Reverse flattening test* : A section of steel tube of 100 mm in length which is taken from the steel tube is to be slotted longitudinally on the opposite side of the welded line, opened and flattened without cracking or showing flaw on the inside of the welded line. There is also to be no misalignment, lack of penetration and overlap. But, this test is applied for electric-resistance welded steel tubes only.

6. Hydraulic test

- (1) Steel tubes are to be hydraulically tested to a satisfactory result by 2 times and over the maximum working pressure at the mill. But the minimum test pressure is to be 7 MPa.
- (2) The test pressure prescribed in (1) need not exceed the pressure calculated by the following formula:

$$P = \frac{2.0St}{D} \text{ (Mpa)}$$

where:

t = Thickness of steel tube (mm)

D = Outside diameter of steel tube (mm)

S = 60 % of the prescribed minimum yield strength (N/mm²)

(3) Where each steel tube is hydraulically tested as a regular procedure during the process of manufacturing at the mill, which makes a number of steel tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(4) A non-destructive inspection deemed appropriate by the Society may be substituted for the hydraulic test specified in (1). **[See Guidance]**

7. Selection of test specimen **[See Guidance]**

The test specimens are to be taken in accordance with the following requirements, from each grade and each size which has been heat treated at the same time in the same heating furnace for heat-treated tubes and from each grade and each size for non-heat-treated steel tubes respectively.

(1) *Seamless steel tubes*

One sampling steel tube is to be selected from each lot of 50 tubes or fraction thereof and each one specimen for tensile test, flattening test and flaring test is to be taken from each sampling steel tube.

(2) *Electric-resistance welded steel tubes*

For electric-resistance welded steel tubes, in addition to the requirements in (1), one sampling steel tube is to be selected from each lot of 100 tubes or fraction thereof, and one reverse flattening test specimen is to be taken from each of the sampling steel tubes.

8. Tolerance for dimensions

The tolerances for the outside diameter and thickness are to comply with the requirements in **Table 2.1.50** and **Table 2.1.51** respectively.

Table 2.1.50 Tolerance for Outside Diameter of steel Tubes

Outside diameter of steel tube D (mm)	Tolerance for Outside Diameter (mm)			
	Seamless steel tube		Electric-resistance welded steel tube	
	Hot finished	Cold working	Other than cold working	Cold working
$D < 25$	+ 0.4 - 0.8	± 0.10	± 0.15	± 0.10
$25 \leq D < 40$		± 0.15	± 0.20	± 0.15
$40 \leq D < 50$		± 0.20	± 0.25	± 0.20
$50 \leq D < 60$		± 0.25	± 0.30	± 0.25
$60 \leq D < 80$		± 0.30	± 0.40	± 0.30
$80 \leq D < 100$	+ 0.4 - 1.2	± 0.40	+ 0.40 - 0.60	± 0.40
$100 \leq D < 120$		+ 0.40 - 0.60	+ 0.40 - 0.80	+ 0.40 - 0.60
$120 \leq D < 160$		+ 0.40 - 0.80	+ 0.40 - 1.00	+ 0.40 - 0.80
$160 \leq D < 200$	+ 0.4 - 1.6	+ 0.40 - 1.20	+ 0.40 - 1.20	+ 0.40 - 1.20
$200 \leq D$	+ 0.4 - 1.8	+ 0.40 - 1.60	+ 0.40 - 1.60	+ 0.40 - 1.60

Table 2.1.51 Tolerance for thickness

Kind	Thickness t (mm)					
	Outside diameter D (mm)	$t < 2$	$2 \leq t < 2.4$	$2.4 \leq t < 3.8$	$3.8 \leq t < 4.6$	$4.6 \leq t$
Hot finished seamless steel tube	$D < 100$	-	+40 % 0 %	+35 % 0 %	+33 % 0 %	+28 % 0 %
	$D \geq 100$		-			
Cold drawn seamless steel tube and Electric-resistance welded steel tube of cold working	$D < 40$	+0.4mm 0 mm	+22 % 0 %			
	$D \geq 40$	+22 %, 0 %				
Electric-resistance welded steel tube of other than cold working	$D < 40$	+0.3mm 0 mm	+18 % 0 %			
	$D \geq 40$	+18 %, 0 %				
NOTE: For hot finished seamless steel tubes, the tolerance for deviation in wall thickness is to be 22.8 % and under of the thickness of the steel tube. But, for steel tubes of less than 5.6 mm in thickness, this note is not applied.						

9. Quality

- (1) Each steel tubes are hydraulically or non-destructively tested as a regular procedure during the process of manufacturing at the mill and are free from leakages or harmful defects.
- (2) The steel tubes are to be of uniform quality. For electric-resistance welded steel tubes, deposit metal projected on outside of tubes is to be removed and finished smooth and that projected on inside of tubes is to be removed to have a height not more than 0.25 mm.

10. Retest procedures

Where the tensile test, *flattening test*, *flaring test* or *reverse flattening test* fails to meet the requirements, additional tests may be conducted according to the requirements given in 109.

11. Marking

- (1) The name or brand of the manufacturer, grade of tubes, size and symbol of the method of the manufacture relating to (2) below are to be legibly stamped or stenciled before shipment on each length steel tube in case of 30 mm and above in outside diameter and on each bundle or container of steel tubes in case of less than 30 mm in outside diameter. The Society's brand indicating compliance with the requirements is to be stamped in the vicinity of the foregoing marks.
- (2) The symbols indicating the method of manufacture are to be as specified in the following:
 Hot finished seamless steel tube -S-H
 Cold drawn seamless steel tube -S-C
 Electric-resistance welded steel tube of other than hot and cold working -E-G
 Electric-resistance welded steel tube of hot working -E-H
 Electric-resistance welded steel tube of cold working -E-C

402. Steel pipes for pressure piping

1. Application

- (1) These requirements are mainly to apply to seamless steel pipes and electric-resistance welded steel pipes intended for use in piping which is prescribed in Pt 5, Ch 6 (hereinafter referred to as "steel pipes").
- (2) Steel pipes for general purpose specified in 102. 2 (4) of Pt 5, Ch 6 are to comply with the requirements of KS D 3507(SPP) or equivalent thereto. However, tests in the presence of the Surveyor are not required.
- (3) The steel pipes having characteristics differing from those specified in 402. are to comply with the requirements in 101. 2.

2. Kinds

The steel pipes are classified as specified in **Table 2.1.52**.

Table 2.1.52 Grades of Steel Pipes

Kind	Grade	Schedule applied
Grade 1 Carbon steel pipe for pressure service	RST 138 RST 142	Sch.10~Sch.80
Grade 2 Carbon steel pipe for high pressure service	RST 238 RST 242 RST 249	Sch.40~Sch.160
Grade 3 Carbon steel pipe for high temperature service	RST 338 RST 342 RST 349	Sch.10~Sch.160
Grade 4 Alloy steel pipe	RST 412 RST 422 RST 423 RST 424	

3. Heat treatment

The heat treatment of steel pipes is to comply with the requirements given in **Table 2.1.53**.

Table 2.1.53 Heat treatment

Grade		Seamless steel pipe		Electric-resistance welded steel pipe		
		Hot finished	Cold drawn	As drawn	Hot finished	Cold finished
Grade1	RST 138 RST 142	As drawn	Annealed	As drawn	As drawn	Annealed
Grade2	RST 238		Low temperature annealed or Normalized	-		
	RST 242 RST 249					
Grade3	RST 338 RST 342	As drawn	Low temperature annealed or Normalized	Low temperature annealed or Normalized	As drawn	Low temperature annealed or Normalized
	RST 349			-		
Grade4	RST 412	Low temperature annealed Isothermal annealed, Full annealed, Normalized or Normalized and tempered				
	RST 422	Low temperature annealed , Isothermal annealed, Full annealed or Normalized and tempered				
	RST 423 RST 424	Isothermal annealed, Full annealed or Normalized and tempered at 650℃ and over				

4. Chemical composition

The chemical composition of steel pipes is to comply with the requirements given in **Table 2.1.54**.

Table 2.1.54 Chemical Composition

Grade		Chemical composition (%)								
		<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Cr</i>	<i>Mo</i>		
Grade 1	<i>RST 138</i>	0.25 max.	0.35 max.	0.30~0.90	0.040 max.	0.040 max.	-	-		
	<i>RST 142</i>	0.30 max.		0.30~1.00						
Grade 2	<i>RST 238</i>	0.25 max.	0.10~0.35	0.30~1.10	0.035 max.	0.035 max.				
	<i>RST 242</i>	0.30 max.		0.30~1.40						
	<i>RST 249</i>	0.33 max.		0.30~1.50						
Grade 3	<i>RST 338</i>	0.25 max.	0.10~0.35	0.30~0.90	0.035 max.	0.035 max.				
	<i>RST 342</i>	0.30 max.		0.30~1.00						
	<i>RST 349</i>	0.33 max.								
Grade 4	<i>RST 412</i>	0.10~0.20	0.10~0.50	0.30~0.80	0.030 max.	0.030 max.			0.80~1.25	0.45~0.65
	<i>RST 422</i>	0.15 max.	0.50 max.	0.30~0.60					1.00~1.50	
	<i>RST 423</i>		0.50~1.00				1.90~2.60	0.87~1.13		
	<i>RST 424</i>		0.50 max.							

5. Mechanical properties

The mechanical properties of steel pipes are to comply with the following requirements.

(1) *Tensile test* : The tensile test of steel pipes are to comply with the requirements given in **Table 2.1.55**.

Table 2.1.55 Mechanical Properties

Grade		Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%) ($L = 5.65\sqrt{A}$)
Grade 1 Grade 2 Grade 3	<i>RST 138</i> <i>RST 238</i> <i>RST 338</i>	215 min.	370 min.	24 (20) min.
Grade 1 Grade 2 Grade 3	<i>RST 142</i> <i>RST 242</i> <i>RST 342</i>	245 min.	410 min.	21 (17) min.
Grade 2 Grade 3	<i>RST 249</i> <i>RST 349</i>	275 min.	480 min.	19 (15) min.
Grade 4	<i>RST 412</i>	205 min.	380 min.	21(17) min.
Grade 4	<i>RST 422</i> <i>RST 423</i> <i>RST 424</i>		410 min.	

NOTES:

- The requirements for elongation given in parentheses in the Table are applied for the case where test specimens are taken transversely. In this case, the test sample is to be stress relieved at the temperature of 600°C to 650°C after flattened.
- In case where test specimen of non-tubular section is taken from electric-resistance welded steel pipes, the test specimen is to be taken from the part that does not include a welded line.

(2) Flattening test

(a) Pipes other than Grade 1 of electric-resistance welded steel pipe: A tubular section of steel pipe which is taken from the end of the steel pipe, is to stand being flattened between parallel plates, without cracking or showing flaw, until the distance between the plates becomes less than the value of H calculated by the following formula. In this case, the length of test specimen is to comply with the requirements in 401.5 (2). For steel pipes, however, of 15 % of outside diameter and above in thickness, C-type test specimen may be used, having a part of its circumference discarded as shown in Fig 2.1.9 (b)

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

where:

H = Distance between flattening plates (mm).

t = Thickness of steel pipe (mm).

D = Outside diameter of steel pipe (mm).

e = Constant given in Table 2.1.56 which varies according to the grade of steel tubes.

Table 2.1.56 value of e

Grade	RST 142, RST 242, RST 249, RST 342 RST 349	RST 138, RST 238, RST 338, RST 412 RST 422, RST 423, RST 424
e	0.07	0.08

(b) Electric-resistance welded steel pipes Grade 1 :

$$H = \frac{2}{3}D \text{ for welded line,}$$

$$H = \frac{1}{3}D \text{ for elsewhere.}$$

In case of electric-resistance welded steel pipes, the welded line is to be placed at right angle to the direction of the applied force, as in Fig 2.1.10.

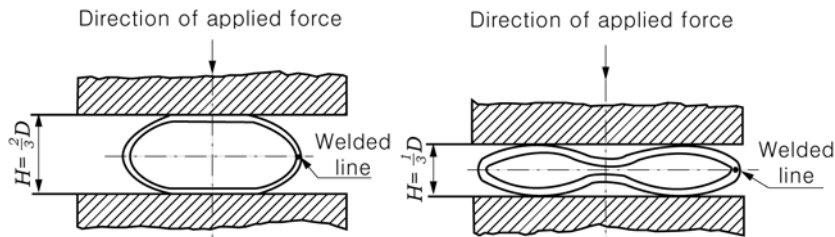


Fig 2.1.10 Flattening test of electric-resistance welded steel pipes Grade 1

(3) Bend test : For steel pipes of 50 mm and under in outside diameter, the specimen for flattening test may be substituted for that for bend test. In this case, a test specimen of tubular section which is taken from the end of the steel pipe and has sufficient length is to stand being bent cold, up to the specified value in Table 2.1.57, without cracking or showing flaw on the wall. But, for Grade 4, this test need not be carried out.

Table 2.1.57 Bend Test

Grade	Angle of bending	Inside bend radius
1, 2 and 3	90°	6 times the outside diameter of steel pipe
NOTE: Electric-resistance welded steel pipes are to be so bent as the welded line is placed widest.		

6. Hydraulic test

- (1) Grade 1 steel pipes are to be hydraulically tested with the pressure specified in **Table 2.1.58**.
- (2) In case where the test pressure higher than prescribed in (1) is specified by the purchaser for Grade 2 through 4 steel pipes, the test is to be carried out with the specified pressure. In this case, test pressure need not exceed the pressure calculated by the following formula:

$$P = \frac{2.0St}{D} (\text{Mpa})$$

where :

P = Hydraulic test pressure (MPa).

D = Outside diameter of steel pipe (mm).

t = Thickness of steel pipe (mm).

S = 60 % of the prescribed minimum yield strength (N/mm²).

- (3) When each steel pipe is hydraulically tested as a regular procedure during the process of manufacturing at the mill which makes a number of steel tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.
- (4) A non-destructive inspection deemed appropriate by the Society may be substituted for the hydraulic inspection specified in (1).

7. Selection of test specimen

- (1) *Grade 1* : Sampling steel pipes are to be selected as following requirements in connection with the nominal diameter of steel pipes specified in **Table 2.1.58** and each one specimen for tensile test, flattening test or bend test is to be taken from each sampling steel pipe.
 - (a) *For steel pipes less than 65A in nominal diameter* : One sampling steel pipe is to be selected from each lot of 1000 pipes or fraction thereof.
 - (b) *For steel pipes which a nominal diameter is 65A or above and less than 150A* : One sampling steel pipe is to be selected from each lot of 500 pipes or fraction thereof.
 - (c) *For steel pipes which a nominal diameter is 150A or above and less than 350A* : One sampling steel pipe is to be selected from each lot of 250 pipes or fraction thereof.
 - (d) *For steel pipes more than 350A in nominal diameter* : One sampling steel pipe is to be selected from each lot of 150 pipes or fraction thereof.
- (2) *Grade 2* : One sampling steel pipe is to be selected from each lot of 50 pipes or fraction thereof, and each one specimen for tensile test and flattening test or bend test is to be taken from each sampling steel pipe.
- (3) *Grade 3*
Selection of test specimen is to comply with the requirements in (2).
- (4) *Grade 4* : One sampling steel pipe is to be selected from each lot of 50 pipes or fraction thereof, and each one specimen for tensile test and flattening test or bend test is to be taken from each sampling steel pipe.

Table 2.1.58 Schedule and Hydraulic Test Pressure

Nominal diameter (A)	Outside diameter (mm)	Nominal thickness (mm)									
		Sch.10 (10S)	Sch.20 (20S)	Sch.30	Sch.40	Sch.60	Sch.80	Sch.100	Sch.120	Sch.140	Sch.160
6	10.5	(1.2)	(1.5)	-	1.7	2.2	2.4	-	-	-	-
8	13.8	(1.65)	(2.0)	-	2.2	2.4	3.0	-	-	-	-
10	17.3	(1.65)	(2.0)	-	2.3	2.8	3.2	-	-	-	-
15	21.7	(2.1)	(2.5)	-	2.8	3.2	3.7	-	-	-	4.7
20	27.2	(2.1)	(2.5)	-	2.9	3.4	3.9	-	-	-	5.5
25	34.0	(2.8)	(3.0)	-	3.4	3.9	4.5	-	-	-	6.4
32	42.7	(2.8)	(3.0)	-	3.6	4.5	4.9	-	-	-	6.4
40	48.6	(2.8)	(3.0)	-	3.7	4.5	5.1	-	-	-	7.1
50	60.5	(2.8)	3.2(3.5)	-	3.9	4.9	5.5	-	-	-	8.7
65	76.3	(3.0)	4.5(3.5)	-	5.2	6.0	7.0	-	-	-	9.5
80	89.1	(3.0)	4.5(4.0)	-	5.5	6.6	7.6	-	-	-	11.1
90	101.6	(3.0)	4.5(4.0)	-	5.7	7.0	8.1	-	-	-	12.7
100	114.3	(3.0)	4.9(4.0)	-	6.0	7.1	8.6	-	11.1	-	13.5
125	139.8	(3.4)	5.1(5.0)	-	6.6	8.1	9.5	-	12.7	-	15.9
150	165.2	(3.4)	5.5(5.0)	-	7.1	9.3	11.0	-	14.3	-	18.2
200	216.3	(4.0)	6.4(6.5)	7.0	8.2	10.3	12.7	15.1	18.2	20.6	23.0
250	267.5	(4.0)	6.4(6.5)	7.8	9.3	12.7	15.1	18.1	21.4	25.4	28.6
300	318.5	(4.5)	6.4(6.5)	8.4	10.3	14.3	17.4	21.4	25.4	28.6	33.3
350	355.6	6.4	7.9	9.5	11.1	15.1	19.0	23.8	27.8	31.8	35.7
400	406.4	6.4	7.9	9.5	12.7	16.7	21.4	26.2	30.9	36.5	40.5
450	457.2	6.4	7.9	11.1	14.3	19.0	23.8	29.4	34.9	39.7	45.2
500	508.0	6.4	9.5	12.7	15.1	20.6	26.2	32.5	38.1	44.4	50.0
550	558.8	6.4	9.5	12.7	15.9	22.2	28.6	34.9	41.3	47.6	54.0
600	609.4	6.4	9.5	14.3	17.5	24.6	31.0	38.9	46.0	52.4	59.5
650	660.4	7.9	12.7	-	18.9	26.4	34.0	41.6	49.1	56.6	64.2
Hydraulic test pressure (MPa)	Grade 1	2.0	3.5	5.0	6.0	9.0	12.0	-	-	-	-
	Grade 2	-	-	-	6.0	9.0	12.0	15.0	18.0	20.0	20.0
	Grade 3 and Grade 4	2.0	3.5	5.0	6.0	9.0	12.0	15.0	18.0	20.0	20.0

NOTE:
The values of nominal thickness in parentheses are applicable to stainless steel pipes.

8. Tolerance for dimensions

Tolerances for the outside diameter and the thickness are to comply with the requirements in **Table 2.1.59**.

Table 2.1.59 Tolerance for Dimensions

Kind	Outside diameter of steel pipe D (mm)	Tolerance for outside diameter	Tolerance for wall thickness			
			Grade 1		Grade 2, 3 and 4	
Hot finished seamless steel pipe	D < 50	± 0.5 mm	Thickness of steel pipe: Less than 4 mm	+ 0.6 mm - 0.5 mm	Thickness of steel pipe: Less than 4 mm	± 0.5 mm
	D ≥ 50	± 1 %	Thickness of steel pipe: 4 mm and over	+ 15 % - 12.5 %	Thickness of steel pipe: 4 mm and over	± 12.5 %
Cold drawn seamless steel pipe and electric-resistance welded steel pipe	D < 40	± 0.3 mm	Thickness of steel pipe: Less than 3 mm	± 0.3 mm	Thickness of steel pipe: Less than 2 mm	± 0.2 mm
	D ≥ 40	± 0.80 mm	Thickness of steel pipe: 3 mm and over	± 10 %	Thickness of steel pipe: 2 mm and over	± 10 %
<p>NOTE: For hot finished seamless steel pipes Grades 2, 3 and 4, the tolerance for deviation in wall thickness is to be 20 % and under of the thickness of the pipes. But, for steel pipes less than 5.6 mm in thickness, this note is not applied.</p>						

9. Quality

- (1) Each steel pipes are hydraulically or non-destructively tested and are free from leakages or harmful defects.
- (2) The steel pipes are to be of uniform quality and free from harmful defects.

10. Retest procedures

Where the tensile test, *flattening test* or *bend test* fails to meet the requirements, additional tests may be conducted according to the requirements given in **109**.

11. Marking

- (1) The name or brand of the manufacturer, grade of steel tubes, size and symbol of the method of the manufacture relating to (2) below are to be legibly stamped or stenciled before shipment on each length steel tube in case of 60 mm and above in outside diameter and on each bundle or container of steel tubes in case of less than 60 mm in outside diameter. The Society's brand indicating compliance with the requirements is to be in the vicinity of the foregoing marks.
- (2) The symbols indicating the method of manufacture are to comply with the requirement in **401. 10 (2)**.

403. Stainless steel pipes

1. Application

- (1) The requirements are to apply to the stainless steel pipes for low temperature service or corrosion-resistance service (hereinafter referred to as "stainless steel pipes").
- (2) Stainless steel pipes having characteristics differing from those specified in **403**, are to comply with the requirements in **101. 2**.

2. Kinds

The stainless steel pipes are classified as specified in **Table 2.1.60**.

Table 2.1.60 Grades and Chemical Composition

Grade	solid solution treatment(°C)	Chemical Composition (%)									
		C	Si	Mn	P	S	Ni	Cr	Mo	Others	
RSTS 304TP	1010 and over, quenching	0.080 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00~11.00	18.00~20.00	-	-	
RSTS 304LTP	1010 and over, quenching	0.030 max.					9.00~13.00				
RSTS 309STP	1030 and over, quenching	0.080 max.					12.00~15.00	22.00~24.00			
RSTS 310STP	1030 and over, quenching		1.50 max.				19.00~22.00	24.00~26.00			
RSTS 316TP	1010 and over, quenching	0.030 max.	1.00 max.				10.00~14.00	16.00~18.00			2.00~3.00
RSTS 316LTP	1010 and over, quenching						12.00~16.00				
RSTS 317TP	1010 and over, quenching	0.080 max.	1.00 max.				11.00~15.00	18.00~20.00			3.00~4.00
RSTS 317LTP	1010 and over, quenching	0.030 max.									
RSTS 321TP	920 and over, quenching	0.080 max.	1.00 max.				9.00~13.00	17.00~19.00			-
RSTS 347TP	980 and over, quenching			Nb ≥ 10×C							

3. Heat treatment

The stainless steel pipes are generally to receive a solid solution treatment. For RSTS 321TP and RSTS 347TP, stabilizing treatment may be required. In this case, heat treatment temperature is to be of 850~930°C.

4. Chemical composition

The chemical composition of stainless steel pipes is to comply with the requirements given in **Table 2.1.60**.

5. Mechanical properties

(1) The mechanical properties of stainless steel pipes are to comply with the following requirements.

(a) *Tensile test*

The tensile test of stainless steel pipes is to comply with the requirements given in **Table 2.1.61**.

(b) *Flattening test*

Flattening tests are to be carried out in accordance with the requirements in **402. 5 (2)**. However, where the requirements are applied, the value of e is to be taken as 0.09.

(2) The Society may require the impact test or corrosion resistance test according to purposes of stainless steel pipes.

Table 2.1.61 Tensile Test

Grade	Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%) ($L = 5.65 \sqrt{A}$)	
			L	T
<i>RSTS 304TP</i>	205 min.	520 min.	26 min.	22 min.
<i>RSTS 304LTP</i>	175 min.	480 min.		
<i>RSTS 309STP</i>	205 min.	520 min.		
<i>RSTS 310STP</i>				
<i>RSTS 316TP</i>				
<i>RSTS 316LTP</i>	175 min.	480 min.		
<i>RSTS 317TP</i>	205 min.	520 min.		
<i>RSTS 317LTP</i>	175 min.	480 min.		
<i>RSTS 321TP</i>	205 min.	520 min.		
<i>RSTS 347TP</i>				

NOTES:

1. *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.
2. Where the nominal diameter of stainless steel pipes is 200 mm and over, tensile test specimens may be taken transversely.
3. Where test specimens of non-tubular section are taken from welded pipes, the test specimens are to be taken from the part that does not include the welded line.

6. Hydraulic test

(1) Stainless steel pipes are to be hydraulically tested with the pressure specified in **Table 2.1.62**.

Table 2.1.62 Hydraulic Test Pressure

Schedule No.	Sch.10S	Sch.20S	Sch.40	Sch.80	Sch.120	Sch.160
Test pressure (MPa)	2.0	3.5	6.0	12.0	18.0	20.0

(2) In case where the test pressure higher than prescribed in (1) is specified by the purchaser, the test is to be carried out with the specified pressure. In this case, the test pressure need not exceed the pressure calculated by the following formula:

$$P = \frac{2.0St}{D} (\text{Mpa})$$

where:

P = Hydraulic test pressure (MPa).

t = Thickness of stainless steel pipe (mm).

D = Outside diameter of stainless steel pipe (mm).

S = 60 % of the prescribed minimum yield strength (N/mm²).

(3) When each pipe is hydraulically tested as a regular during the process of manufacturing at the mill which makes a number of tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(4) A non-destructive inspection deemed appropriate by the Society may be substituted for the hydraulic test specified in (1).

7. Selection of test specimens

One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof which are of the same charge, size and kind and are simultaneously heat treated, and each one specimen for tensile test and flattening test is to be taken from each sample pipe.

8. Tolerance for dimensions

Tolerances for the outside diameter and the thickness are to comply with the requirements in **Table 2.1.63**.

Table 2.1.63 Tolerance for Dimensions

Kind	Outside diameter of stainless steel pipe		Tolerance for wall thickness	
	Hot-finished seamless stainless steel pipe	Less than 50	± 0.5 mm	Thickness of pipe: Less than 4 mm
50 and over		± 1 %	Thickness of pipe: 4 mm and over	± 12.5 %
Cold drawn seamless stainless pipe, automatic arc welded stainless steel pipe and electric-resistance welded stainless steel pipe	Less than 30	± 0.3 mm	Thickness of pipe: Less than 2 mm	± 0.2 mm
	30mm and over	± 1 %	Thickness of pipe: 2 mm and over	± 10 %
<p>NOTE: For hot finished seamless stainless steel pipes, the tolerance for deviation in wall thickness is to be 20 % and under of the thickness of the pipes. But, for stainless steel pipes less than 5.6 mm in thickness, this note is not applied.</p>				

9. Quality

- (1) Each steel pipes are hydraulically or non-destructively tested and are free from leakages or harmful defects.
- (2) The stainless steel pipes are to be of uniform quality and free from harmful defects.

10. Retest procedures

Where the tensile test or *flattening test* fails to meet the requirements, additional tests may be conducted according to the requirements given in **109**.

11. Marking

Stainless steel pipes which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in **402. 10**. However, the symbols indicating the manufacturing method of automatic arc welded steel pipes are to be as specified in the following:

- Automatic arc welded steel pipe : -A
- Automatic arc welded and cold finished steel pipe : -A-C
- Automatic arc welded and machined steel pipe : -A-B

404. Steel pipes for low temperature service

1. Application

- (1) These requirements are to apply to the seamless steel pipes and electric resistance welded steel pipes not exceeding 25 mm in thickness, intended to be used at the design temperature lower than 0°C in liquefied gas carriers (hereinafter referred to as "steel pipes").

- (2) Any requirement regarding the steel pipes over 25 mm in thickness is left to the discretion of the Society. **[See Guidance]**
- (3) Steel pipes having characteristics differing from those specified in **404**, are to comply with the requirements in **101. 2**.

2. Kinds

The steel pipes are classified as given in **Table 2.1.64**.

3. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.64**.

Table 2.1.64 Grades and Chemical Composition (%)

Grade	Deoxidation	C	Si	Mn	P	S	Ni
RLPA	Fully killed fine grain	0.23 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	-
RLPB		0.18 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	-
RLPC		0.18 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	-
RLP 2		0.19 max.	0.10~0.35	0.90 max.	0.035 max.	0.035 max.	2.00~2.60
RLP 3		0.16 max.	0.10~0.35	0.90 max.	0.030 max.	0.030 max.	3.20~3.80
RLP 9		0.10 max.	0.10~0.35	0.90 max.	0.030 max.	0.030 max.	8.40~9.50

4. Heat treatment

The heat treatment of steel pipes is to comply with the requirements given in **Table 2.1.65**.

5. Mechanical properties

- (1) The mechanical properties of steel pipes are to comply with the following (a) to (d).

(a) *Tensile test*

The tensile test of steel pipes is to comply with the requirements given in **Table 2.1.65**.

(b) *Impact test*

The impact test of steel pipes is to comply with the requirements given in **Table 2.1.65**.

(c) *Flattening test*

Flattening test is to be carried out in accordance with the requirements given in **402. 5 (2)**. Where this requirement is applied, the value of *e* is to be taken as 0.08. For steel pipes of 50 mm and under in outside diameter, the specimen for flattening test may be substituted for that for bend test. In this case, a test specimen of tubular section which is taken from the end of the steel pipe and has sufficient length is to stand being bent cold, up to the specified value in **Table 2.1.65**, without flaw and cracking on the outside of bent portion. Electric resistance welded steel pipes are to be bent at the place where the welded line is on the outside of bent portion.

- (2) Where deemed necessary by the Society, other tests may be required in addition to the tests specified in (1)

6. Hydraulic test

All steel pipes are to be subjected to hydraulic test in accordance with the requirements given in **402. 6**.

7. Selection of test specimens

- (1) One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof which are of the same charge, size and kind and are simultaneously heat treated. Each one specimen for tensile test and flattening test is to be taken from each sample pipe.

- (2) One set of three specimens for impact test is to be taken from each sample pipe in accordance with **Fig 2.1.11**. Moreover, for electric resistance welded steel pipes, another set of three specimens is to be taken from the welded zone in accordance with **Fig 2.1.12**.

Table 2.1.65 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test ⁽¹⁾⁽²⁾⁽³⁾				Bend test		Impact test	
		Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%) ($L = 5.65 \sqrt{A}$)		Inside radius of bend	Angle of bend (°)	Test temp. (°C)	Average absorbed energy (J) ⁽⁴⁾
				L	T				
RLPA	Normalized, Normalized and tempered or Quenched and tempered	205 min.	380 min.	26 min.	19 min.	6 times the outside diameter of steel pipe	90	-40 ⁽⁵⁾	27 min.
RLPB								-50 ⁽⁵⁾	
RLPC								-60 ⁽⁵⁾	
RLP 2		245 min.	450 min.	20 min.	14 min.			-70	34 min.
RLP 3								-95	
RLP 9	Double normalized and tempered or Quenched and tempered	520 min.	690 min.	15 min.	11 min.	-196	41 min.		

NOTES:

- (1) L (or T) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.
- (2) Where the nominal diameter of steel pipes is 200 mm and over, the tensile test specimen may be taken transversely.
- (3) Where test specimen of non-tubular section is taken from electric resistance welded pipes, the test specimen is to be taken from the portion that does not include the welded line.
- (4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
- (5) Impact test temperature for steel pipes specified in **Pt 7, Ch 5** is to be 5°C below the design temperature or -20°C, whichever is the lower.

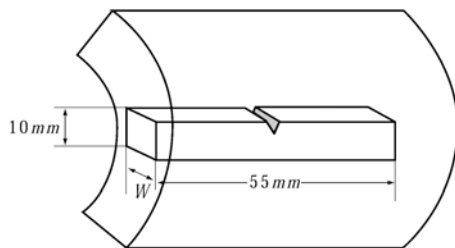


Fig. 2.1.11 The position of selection for impact test specimen taken from the seamless steel pipes and other portions than weld zone of electric-resistance welded steel pipes

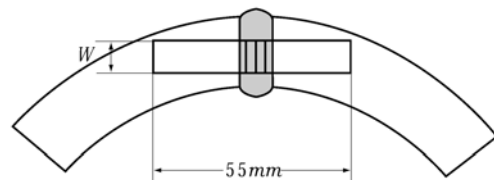


Fig. 2.1.12 The position of selection for impact test specimen taken from the weld zone of electric-resistance welded steel pipes

8. Tolerance for dimensions

The tolerances for outside diameter and wall thickness of steel pipes are to be in accordance with the requirements given in **Table 2.1.66**.

Table 2.1.66 Tolerance for Outside Diameter and Wall Thickness

Kind	Tolerance for outside diameter	Tolerance for wall thickness
Hot-finished seamless steel pipe	D < 50 : ± 0.5 mm 50 ≤ D < 250 : ± 1 % (maximum value 2.0 mm) 250 ≤ D : ± 0.8 %	t < 4 : ± 0.5 mm t ≥ 4 : ± 12.5 %
Cold-drawn seamless steel pipe and Electric-resistance welded steel pipe	± 0.8 % (max. value 0.3 mm)	t < 2 : ± 0.2 mm t ≥ 2 : ± 10 %
NOTE: For hot-finished seamless steel pipes, the tolerance for deviation in wall thickness is to be 20 % or less of wall thickness, but it shall not be applied to the pipes less than 5.6 mm in wall thickness.		

9. Quality

The steel pipes are to be of uniform quality and free from harmful defects.

10. Retest procedures

- (1) Where other mechanical tests than impact tests fail to meet the requirements, additional tests may be carried out according to the requirements given in **109**.
- (2) Regarding the impact tests, additional tests are to be carried out according to the requirements given in **301. 10** (3).

11. Marking

Marking for steel pipes is generally to comply with the requirements given in **402. 10**. and in case the requirement in Note (5) of **Table 2.1.65** has been applied, "impact test temperature T" is to be suffixed to the marking. (e.g. *RLPA-25T*)

405. Header

1. Application

- (1) These requirements are to apply to the headers to be used for boilers.
- (2) The headers having characteristics differing from those specified in **405**. are to comply with the requirements in **101. 2**.

2. Kinds

The headers are classified as specified in **Table 2.1.67**.

Table 2.1.67 Grades of Headers

Grade	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
	<i>RBH 1</i>	<i>RBH 2</i>	<i>RBH 3</i>	<i>RBH 4</i>	<i>RBH 5</i>	<i>RBH 6</i>

3. Heat treatment

Headers are to be heat treated by annealing or normalizing.

4. Chemical composition

The chemical composition of headers is to comply with the requirements given in **Table 2.1.68**.

Table 2.1.68 Chemical Composition

Grade	Chemical composition (%)						
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Cr</i>	<i>Mo</i>
<i>RBH 1</i>	0.25 max.	0.10~0.35	0.30~0.80	0.040 max.	0.040 max.	-	-
<i>RBH 2</i>	0.30 max.						
<i>RBH 3</i>	0.10~0.20	0.10~0.50	0.30~0.60	0.030 max.	0.030 max.	0.80~1.20	0.45~0.65
<i>RBH 4</i>							0.20~0.45
<i>RBH 5</i>	0.15 max.						0.45~0.65
<i>RBH 6</i>							2.00~2.50

5. Mechanical properties

(1) **Tensile test:** The tensile test of headers is to comply with the requirements given in **Table 2.1.69**.

Table 2.1.69 Mechanical Properties

Grade	Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation(%) ($L = 5.65 \sqrt{A}$)	Reduction of area (%)
<i>RBH 1</i>	205 min.	410 min.	24 min.	38 min.
<i>RBH 2</i>	225 min.	450 min.	23 min.	40 min.
<i>RBH 3</i>	205 min.	380 min.	22 min.	
<i>RBH 4</i>		410 min.	21 min.	
<i>RBH 5</i>				
<i>RBH 6</i>				
NOTE: When test specimens are taken crosswise to the rolled direction, the values of yield strength and tensile strength are to be as given in this Table and the elongation is to take the value reduced by 5 % from the percentage given in this Table. The value of reduction of area may be only remained on records for reference.				

(2) **Bend test:** The test specimen is to stand being bent cold through 180° without flaw and cracking on the outside of bent portion to an inside radius of 20 mm. Where the test specimen of 20 mm in thickness can not be taken, the test specimen may be as original in thickness, in which case, however, the width of test specimen is not to be less than 1.5 times the thickness and the inside radius of bend is to be equal to the thickness.

6. Selection of test specimens

- (1) Tensile test specimens are to be taken lengthwise or crosswise to the rolled direction and bend test specimens to be taken crosswise to the rolled direction each from the open ends of headers.
- (2) For the headers of the same size made from the same melt and subjected to the heat treatment simultaneously in the same furnace, tensile and bend test specimens are to be selected in accordance with the requirements given in **Table 2.1.70**.

Table 2.1.70 Number of Test Specimens

Grade	Length of test specimens l (mm)	Number of test specimens
<i>RBH 1</i> <i>RBH 2</i>	$3000 \leq l$	1 set for each one length
	$2000 \leq l < 3000$	1 set for each three lengths
	$2000 > l$	1 set for each five lengths
<i>RBH 3 RBH 4</i> <i>RBH 5 RBH 6</i>	$3000 \leq l$	1 set from each end for each one lengths
	$3000 > l$	1 set for each one length

- (3) Where the both ends of header are closed by reforging, the test samples of proper size may be cut from the open ends before reforging.
- (4) Where test samples cut from circular headers, etc. are necessary to be flattened, the test samples are to be taken from the body before being subjected to the heat treatment and after flattening the test samples are to be heat treated simultaneously with the body in the same furnace, or the test samples are to be cut from the structures after being subjected to the heat treatment and after flattened cold, they are to be heated to the temperature of 600°C to 650°C for the purpose of removing the distortion due to the flattening, and the required test specimens are to be cut from the test samples.

7. Tolerance for thickness

The tolerance for thickness is to be $\pm 12.5\%$. The tolerance, however, may not apply to the closed portions of circular or square headers, the side corners of square headers and the corrugated headers.

8. Quality

Headers are to be of uniform quality and free from harmful defects.

9. Marking

Headers which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **401. 10**.