SECTION 2 STEEL PIPES, TUBES AND FITTINGS

1 General

1.1 Application

1.1.1 General

The requirements of this Section apply to seamless and welded steel pipes, tubes and fittings intended for boilers, pressure vessels and systems operating at ambient, high or low temperature.

Provision is also made for pipes intended for structural applications, at ambient temperature.

Article [1] specifies the requirements common to all the above-mentioned steel pipes, while the appropriate specific requirements are indicated in Articles [2] to [7].

Pipes assigned to Class 3 as defined in Pt C, Ch 1, Sec 10, [1.5] may be manufactured and tested in accordance with recognised national or international standards and, when fabricated by recognised Manufacturers, accepted on the basis of Manufacturer's test certificate (works' certificate W) without testing by the Society.

The general term pipes will be used in the following text to mean pipes and tubes.

1.1.2 Special requirements

Special requirements may be specified in cases of applications intended for dangerous substances or particularly severe service conditions.

In cases of applications involving the storage and transport of liquefied gases, the requirements of Pt E, Ch 9, Sec 6 also apply, as appropriate.

1.1.3 Weldability

Steels in accordance with these rule requirements are weldable subject to the use of suitable welding processes and, where appropriate, to any conditions stated at the time of approval.

1.2 Manufacture

1.2.1 Manufacturing process

The steel used is to be manufactured as detailed in Sec 1, [1.2.1].

Unless a specific method is agreed for individual supplies, or specific requirements are given in the relevant Articles, the pipes may be manufactured by one of the following methods:

a) seamless, hot or cold finished

b) welded, by automatic processes

c) welded, as above hot and/or cold finished.

In the case of welded pipes, the following processes are to be used depending on the grade of steel:

a) electrical resistance (ERW), induction (IW), submerged arc (SAW) welding for carbon and carbon manganese steels

b) electric tungsten arc process (GTAW), plasma (PAW), submerged (SAW) arc welding for austenitic or austenitic-ferritic steels.

The welding process is to be approved according to the applicable requirements of Ch 5, Sec 2 of the Rules.

Nickel steel pipes are to be manufactured seamless.

Unless otherwise specified, the manufacturing process is left to the discretion of the Manufacturer.

1.3 Approval

1.3.1 Welded pipes and fittings and, unless otherwise specified by the Society, seamless pipes and fittings in low alloyed or alloyed steels, intended for high temperature are to be manufactured by approved Manufacturers.

In other cases the Manufacturers are in any event to be recognised by the Society.

The approval procedure is indicated in the "Rules for the approval of Manufacturers of materials".

1.4 Quality of materials

1.4.1 All pipes are to have a workmanlike finish consistent with the method of manufacture and to be free from defects and surface or internal imperfections which may impair their use in subsequent fabrication or service.

1.4.2 All pipes are to be reasonably straight and their ends are to be cut perpendicular to the axis without leaving chips or burrs.

1.5 Visual, dimensional and non-destructive examinations

1.5.1 Each pipe is to be submitted by the Manufacturer to visual examination and verification of dimensions.

All pipes intended for severe conditions, such as super heater tubes, pressure cylinders, pressure systems with working pressure higher than 4,0 N/mm^2, pipes conveying liquefied gases and dangerous media, are to be presented to the Surveyor for visual examination and verification of dimensions.

1.5.2 The dimensional tolerances on the thickness and diameter are to be in accordance with recognised standards.

In welded pipes, the weld reinforcement is to be well faired and within allowable limits.

1.5.3 Welded pipes are to be submitted by the Manufacturer to an appropriate, automatic non-destructive test of welded joints as specified at the approval.

1.6 Rectification of surface defects

1.6.1 Rectification of surface defects by grinding

Small surface defects and imperfections may be removed by grinding, provided that the pipe thickness after repair is within the permissible tolerance and the ground zone is well faired into the adjacent zone.

1.6.2 Rectification of surface defects by welding

Repairs by welding may be accepted at the Surveyor's discretion. The repair procedure is to be submitted for consideration.

The repaired areas are subsequently to be examined by magnetic particle or liquid penetrant methods and/or by other appropriate non-destructive tests.

1.7 Condition of supply

1.7.1 Pipes are to be supplied in the required heat treated or equivalent condition.

Where alternative supply conditions are accepted, the choice of the supply condition, unless otherwise required, is left to the Manufacturer; the condition of supply is always to be mentioned in the testing documentation.

1.7.2 Pipes which are to be expanded after supply are to be annealed at least at their ends.

1.8 Hydrostatic test

1.8.1 With the exception of pipes intended for structural application, each pipe is to be subjected to hydrostatic test at the Manufacturer's works.

The test pressure P, in N/mm^2, is given by the following formula but the maximum pressure may not be higher than 14 N/mm^2 :

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

where :

D : Nominal outside diameter of the pipe, in mm

t : Nominal wall thickness of the pipe, in mm

f : equal to:

0,80 R_{eH} for ferritic steels

0,70 $R_{p0,2}$ for austenitic or austenitic-ferritic steels.

The test pressure is to be maintained for a sufficient time to verify the tightness and at least for 5 seconds.

The test pressure is to be measured by means of a suitable, calibrated pressure gauge.

1.8.2 Unless otherwise agreed, the Manufacturer's certificate of the hydrostatic test is accepted.

The hydrostatic test of pipes intended for boilers, super heaters or pressure systems with working pressure higher than 4,0 N/mm^2, or conveying liquefied gases and dangerous media, may be required to be witnessed by the Surveyor.

1.8.3 Subject to the prior approval of the procedure, a non-destructive test by ultrasonic or eddy current may be accepted as an alternative to the hydrostatic test.

1.9 Sampling and testing

1.9.1 Batch composition

Pipes are to be presented for mechanical and technological tests in the final supply condition and, unless otherwise indicated in the relevant Articles, in batches.

For pipes which are not heat treated, the batch is to consist of pipes of the same size, manufactured by the same procedure, from the same type of steel.

For pipes which are supplied in the heat treated condition, the batches are to consist of pipes of the same size, manufactured from the same type of steel and subjected to the same heat treatment in a continuous furnace or heat treated in the same furnace charge.

For pipes welded by the electric submerged arc welding process, the batch is also to consist of pipes welded with the same welding materials.

For pipes intended for low temperature service, the batch is also to consist of material originating from the same cast.

The size of the batch is to be in accordance with Tab 1.

Table 1 : Number of pipe as made lengths per batch

Outside diameter range (mm)	Maximum number of tubes per batch **(1)**
D ≤ 114,3	200
114,3 < D ≤ 323,9	100
323,9 < D	50
(1) Residual quantities of up to 10 lengths may be allocated to the other batches presented for testing.	

1.9.2 Sampling

The test samples are to be cut from a length selected at random from each batch, for the tests specified in the various Articles.

The specimens for all or part of the following tests, as detailed in the various Articles, are to be obtained from the individual samples.

a) mechanical tests
- tensile test, longitudinal direction
- tensile test transverse to the weld for pipes with D≥ 300 mm
- 3 Charpy V-notch impact tests, longitudinal direction.

  For subsize specimens, reference is to be made to Ch 1, Sec 2, [4.2.2]. For pipes having thickness less than 6 mm, reduced specimens having the maximum thickness are to be used.

b) technological tests
- flattening test

For welded pipes, two tests are to be carried out; in one test the specimen is to be positioned with the welded joint at 0°, in the other at 90°, to the direction of the force.

The distance between plates to be reached during the test is determined by the following formula:

$$Z = \frac{(1 + C)t}{C + \frac{t}{D}}$$

where the value of C is indicated in the tables relevant to the mechanical properties of the various pipes

- a bend test is to be performed in lieu of the flattening test for pipes having D > 400mm or thickness greater than 15% of D.

  For welded pipes, one test is carried out with the outside surface of the pipe in tension and the other with the inside surface of the pipe in tension. The mandrel diameter is indicated in the various Articles and the bend angle is to be equal to 180°.

- flanging or drift expanding test for pipes having D≤150 mm or thickness ≤ 9 mm.

1.9.3 Preparation of test specimens

For the preparation of test specimens and for the testing procedures, reference is to be made to the applicable requirements of Ch 1, Sec 2.

1.9.4 Tensile and technological tests

The results of the test are to comply with the values specified in the appropriate tables.

If during the tensile test there is no marked yield stress R_{eH}, the 0,2% proof stress $R_{p0,2}$ is taken as an alternative.

1.9.5 Impact test

The average value is to comply with the minimum average value required; only one individual value may be less than the average value required, provided that it is not less than 70% of it. The values required for the various products are relevant to standard specimens 10x10 mm^2.

For subsize specimens reference is to be made to Ch 1, Sec 2, [4.2.2].

For reduced specimens obtained from pipes having thickness less than 6 mm, the energy required is proportional to the area of the specimen, referring to the specimen 10x5 mm^2 and to the energy required for this specimen.

1.9.6 Re-test procedure

For re-test procedures reference is to be made to Ch 1, Sec 1, [3.5].

1.10 Identification and marking

1.10.1 The Manufacturer is to adopt a system of identification which enables the material to be traced to its original cast, as appropriate.

1.10.2 All pipes and tubes are to be identified and marked with the following indications:

a) Society's brand

b) Manufacturer's name or trade mark

c) identification mark for the type of steel

d) cast number or identification number and/or letters, which will enable the history of the fabrication of the piece or bundle to be traced.

Marking is to be applied by punching. In the case of small wall thickness which may be damaged by punching, alternative methods such as paint, electrical engraving or rubber stamps may be used.

Marking on labels is accepted for small pipes,see Ch 1, Sec 1, [4.1.2].

1.11 Documentation and certification

1.11.1 The testing documentation indicated in Ch 1, Sec 1, [4.2.1] is to be issued and is to include all the required information, as appropriate.

The ladle analysis is to include the content of refining and alloying elements as applicable.

If rimming steel is supplied, this condition is to be stated on the certificate.

1.11.2 When pipes are made from steel produced in a mill other than that where the pipes are manufactured, the Surveyor is to be supplied with a steelmaker's certificate stating the manufacturing process, the grade of steel, the cast number and the relevant ladle analysis.

2 Pipes for pressure systems operating at ambient temperature

2.1 Application

2.1.1 The requirements of this Article apply to seamless and welded carbon and carbon manganese steel pipes, intended for piping systems or pressure vessels operating at ambient temperature or when impact properties at a temperature not lower than -20°C are specified.

2.2 Steel grades

2.2.1 The requirements apply to carbon and carbon manganese steels, which are classed into five groups indicated by the minimum ultimate tensile strength R_m, in N/mm^2: 320, 360, 410, 460 and 510.

Each group is further subdivided into grades HA, HB and HD, based on quality level and impact properties, as applicable.

The letters HA, HB and HD mean impact properties at +20°C, 0°C and -20°C, respectively.

2.3 Condition of supply

2.3.1 Seamless cold finished pipes are to be normalised, while hot finished pipes may be normalised or normalised formed.

Welded pipes are to be supplied in the condition specified at the approval.

At the Manufacturer's discretion, normalising and tempering may be carried out in lieu of normalising; see [1.7].

2.4 Chemical composition

2.4.1 The method of deoxidation and chemical composition on ladle analysis are to comply with the requirements specified in Tab 2.

2.5 Mechanical properties

2.5.1 The mechanical properties are specified in Tab 3.

2.6 Mechanical and technological tests

2.6.1 For pipes intended for pressure cylinders, the tests are to be carried out on each as made length.

Pipes intended for other applications are to be presented in batches, as specified in Tab 1.

One pipe is to be selected from each batch for the required tests as follows:

a) seamless pipes:

- one tensile test, longitudinal direction
- one flattening test or one bend test
- 3 Charpy V-notch impact tests, longitudinal direction, for pipes having thickness ≥ 11mm and, when impact properties are required at -20°C, for thickness ≥ 6 mm

b) welded pipes:

- one tensile test on base metal, longitudinal direction
- one tensile test transverse to the weld for pipes with D ≥ 300 mm
- two flattening tests or two bend tests
- 3 Charpy V-notch impact tests, longitudinal direction, for pipes having thickness ≥ 11 mm and, when impact properties are required at -20°C, for thickness ≥ 6 mm.

3 Pipes for structural applications

3.1 Application

3.1.1 Steel pipes for structural application at ambient temperature are to comply with the requirements specified in Article [2], with the exception of the hydrostatic test which is not required.

3.2 Steel grades

3.2.1 Unless otherwise agreed with the Society, steel grades are to correspond to the types specified in Article [2] with designation 410 HB-HD 460 HB-HD and 510 HB-HD.

The symbol ST is to be added to the steel designation to clearly indicate that pipes are intended for structural application.

4 Pipes for high temperature service

4.1 Application

4.1.1 The requirements of this Article apply to seamless and welded pipes intended for boilers, superheaters and heat exchangers, or pressure parts operating at elevated temperatures.

Table 2 : Chemical composition

Steel grade	Deoxidation	Chemical composition (%) **(1)**					
		C max	Mn	Si max	P max	S max	Al tot. min. **(1)**
320 HA	semi-killed or killed **(2)**	0,16	0,40 - 0,70	0,35	0,040	0,040	
360 HA 360 HB	semi-killed or killed	0,17	0,40 - 1,00	0,35	0,040	0,040	
410 HB	killed	0,21	0,40 - 1,20	0,35	0,040	0,040	
410 HD	killed and fine grained						0,020
460 HB	killed	0,22	0,80 - 1,40	0,35	0,040	0,040	
460 HD	killed and fine grained						0,020
510 HB	killed	0,22	0,60 - 1,80	0,35	0,035	0,035	
510 HD	killed and fine grained						0,020

(1) Nb, V or Ti may be used for grain refining as a complete or partial substitute for Al. The grain refining elements are to be specified at the time of approval; in general Nb and V are not to exceed 0,05 and 0,10%, respectively.

Additional alloying elements are to be submitted for consideration and approval. Residual elements not intentionally added are not to exceed the following limits (%): Ni ≤ 0,30 ; Cu ≤ 0,25 ; Cr ≤ 0,25 ; Mo ≤ 0,10. Total: Ni + Cu + Cr + Mo ≤ 0,70

(2) For welded pipes, rimmed steel may also be used, as specified at the approval.

Table 3 : Mechanical properties *(1/7/2004)*

Steel grade	Yield stress R_{eH} (N/mm²) min. for thickness t (mm)			Tensile strength R_m (N/mm²)	Elong. A_5 (%) min.	Average impact energy (J) min.		Technological tests		
	t ≤ 16	16<t≤40	40<t≤60			Test temp (C°)	KVL	Flattening test constant C for t/D		Bend test diameter mandrel
								t/D≤0,15	t/D>0,15	
320HA	195			320 - 440	25	+20	27	0,09	0,08	4 t
360HA	235	225	215	360 - 500	24	+20				
360HB						0				
410HB	255	245	235	410 - 550	22	0		0,07	0,06	
410HD						-20				
460HB	285	275	265	460 - 580	21 **(2)**	0				
460HD						-20				
510HB	355	345	**(1)**	510 - 630	19 **(2)**	0	34			
510HD						-20				

(1) To be agreed between Manufacturer and purchaser.

(2) For pipes intended for oleodynamic cylinders manufactured in accordance with recognised standards, a minimum value of elongation of 16% may be accepted.

Table 4 : Chemical composition

Steel grade	Chemical composition (%) **(1)**								
	C max	Mn	Si	P max	S max	Cr	Mo	V	Al tot
320	0,16	0,40-0,70	≤ 0,35	0,030	0,030				
360	0,17	0,40-1,00	≤ 0,35	0,030	0,030				
410	0,21	0,40-1,20	≤ 0,35	0,030	0,030				
460	0,22	0,80-1,40	≤ 0,35	0,030	0,030				
510	0,22	0,60-1,80	≤ 0,35	0,035	0,035				
0,3Mo	0,12-0,20	0,40-0,80	0,10-0,35	0,035	0,035		0,25-0,35		≤0,020
0,5Cr 0,5Mo	0,10-0,18	0,50-0,90	0,10-0,35	0,035	0,035	0,40-0,65	0,45-0,60		≤0,020
1Cr 0,5Mo	0,10-0,18	0,40-0,70	0,10-0,35	0,035	0,035	0,70-1,10	0,45-0,65		≤0,020
2,25Cr 1Mo	0,08-0,15	0,40-0,70	0,10-0,35	0,035	0,035	2,00-2,50	0,90-1,20		≤0,020
0,5Cr 0,5Mo 0,25V	0,10-0,18	0,40-0,70	0,15-0,50	0,035	0,035	0,70-1,10	0,45-0,65	0,22-0,28	≤0,020

(1) Additional alloying elements are to be submitted for consideration and approval. Residual elements are permitted provided they do not impair the properties, subsequent processing or behaviour in service.
For C and C-Mn steels, the following limits (%) apply: Ni ≤ 0,30 ; Cu ≤ 0,25 ; C ≤ 0,25 ; Mo ≤ 0,10 ; Total: Ni+Cu+Cr+Mo ≤ 0,70. For Mo and Cr-Mo alloy steels, the limits are the following (%): Ni ≤ 0,30 ; Cu ≤ 0,25

4.2 Steel grades

4.2.1 The requirements apply to carbon, carbon-manganese steels and low alloy steels (Mo, Cr-Mo and Cr-Mo-V).

4.2.2 Carbon and carbon manganese steels are classed into four groups which are indicated by the minimum ultimate tensile strength R_m (N/mm²): 320, 360, 410, 460 and 510.

4.2.3 Low alloy steels are designated according to the chemical composition into the grades 0,3Mo - 0,5Mo0,5Cr, 1Cr0,5Mo - 2,25Cr1Mo - 0,5Cr0,5Mo0,25V.

The figures mean the nominal percentage content of the main alloying elements.

4.3 Condition of supply

4.3.1 The products are to be supplied in the conditions indicated in Tab 5.

Table 5 : Mechanical properties - Conditions of supply

Steel grade	Heat Treatment **(1)**	Yield stress R_{eH} (N/mm^2) min for t (mm)		Tensile strength R_m (N/mm^2)	Elong. A_5 (%) min.	Technological tests			
						C **(3)**	Di/D **(4)**		
		t ≤ 40	40 < t ≤ 60				≤ 0,6	0,6<Di/D≤0,8	> 0,8
320	N or NR	195		320 - 440	25	0,09	12	15	19
360	N or NR	225	215	360 - 500	25	0,09	12	15	19
410	N or NR	245	235	410 - 550	22	0,06	10	12	17
460	N or NR	270	260	460 - 580	21	0,06	8	10	15
510	N or NR	345	**(2)**	510 - 640	21	0,06	8	10	15
0,3Mo	N	270	260	450 - 600	22	0,07	8	10	15
0,5Cr 0,5Mo	N+T	270	260	440 - 570	22	0,07	8	10	15
1Cr 0,5Mo	N or N+T	290	280	440 - 590	22	0,07	8	10	15
2,25Cr 1Mo	N+T	280	270	450 - 600	20	0,06	8	10	15
	A	205	205	410 - 560	22	0,06	8	10	15
0,5Cr 0,5Mo 0,25V	N+T	300	290	460 - 610	20	0,06	8	10	15

(1) N : normalising - NR : normalising forming - T: tempering - A : annealing.
(2) To be agreed between Manufacturer and purchaser.
(3) Constant C for flattening test.
(4) Expanding or flanging test; increase of outside diameter D, in %, as a function of Di/D.

4.4 Chemical composition

4.4.1 The chemical composition on ladle analysis is to comply with the requirements specified in Tab 4.

Steels are to be killed with the exception of grades 320 and 360 which may be semi-killed.

4.5 Mechanical properties

4.5.1 The mechanical properties and conditions of supply are specified in Tab 5.

4.6 Mechanical properties at elevated temperatures

4.6.1 The values of the yield stress R_{eH} or 0,2% proof stress $R_{p0,2}$ at temperatures of 100°C and higher are given in Tab 6.

The values are for design purposes only. Their verification is in general not required during the testing, unless figures higher than those shown in Tab 6 and in accordance with recognised standards are proposed by the steel Manufacturer.

In such cases, the verification is required and the procedures detailed in [4.6.2] and [4.6.3] are to be followed.

4.6.2 When the $R_{p0,2}$ is required to be verified, at least one tensile test for each cast is to be carried out at the agreed temperature.

In cases of pipes of different thickness, the sample is to be taken from a pipe selected among those of greatest thickness .

The dimensions of the specimens and the testing procedure are to be in accordance with the requirements of Ch 1, Sec 2, [2.1.7] and Ch 1, Sec 2, [2.2.5] respectively.

The results of tests are to comply with the values specified in Tab 6.

4.6.3 As an alternative to the systematic verification of the required $R_{p0,2}$ as in [4.6.2], it may be agreed with the individual steelmakers to carry out an adequate program of tests on the normal production of each steel, in accordance with an ad hoc procedure.

Subsequent to the satisfactory results of the approval tests, tensile tests at elevated temperatures are not generally required during the routine testing of the material supplied but as a random check for the confirmation.

4.6.4 For design purposes only, the estimated values of the stress to rupture in 100000 hours are given in Tab 7 for groups of steels.

4.7 Mechanical and technological tests

4.7.1 For pipes intended for boiler headers, the tests are to be carried out on each as made length.

Other pipes are to be presented in batches and the number is defined in Tab 1.

Two pipes are to be selected from each batch for the required tests, as follows:

a) seamless pipes and tubes:
- one tensile test, longitudinal direction
- one flattening test or one bend test
- one expanding or flanging test, when required

b) welded pipes:
- one tensile test on base metal, longitudinal direction
- one tensile test transverse to the weld
- two flattening or two bend tests transverse to the weld for pipes with D ≥ 300 mm
- one expanding or flanging test, when required.

When required in [4.6.1], a tensile test at elevated temperature is to be performed on one sample per cast.

5 Ferritic steel pipes for pressure service at low temperature

5.1 Application

5.1.1 The requirements of this Article apply to seamless and welded steel pipes intended for construction of piping systems, pressure vessels and plants, when impact properties at temperatures lower than -20°C are specified.

Provision is made for pipes with wall thickness up to 40mm.

5.2 Steel grades

5.2.1 The requirements apply to carbon and carbon-manganese steels and nickel alloy steels.

5.2.2 The carbon and carbon-manganese steels are classed into four groups which are indicated by the minimum ultimate tensile strength R_m (N/mm^2): 360, 410, 460 and 510.

Each group is further subdivided into two grades LE and LF,based on the quality level and impact properties.

The letters LE and LF mean impact properties at -40°C and -60°C, respectively.

5.2.3 The Ni alloy steels are designated according to the chemical composition into the grades 3,5Ni, 9,0Ni.

The figures mean the Ni nominal percentage content.

5.3 Condition of supply

5.3.1 The pipes are to be supplied in the conditions indicated in Tab 9.

5.4 Chemical composition

5.4.1 The steel is to be killed and fine grained and the chemical composition on ladle analysis is to comply with the requirements specified in Tab 8.

Table 6 : Minimum proof stress ($R_{p0,2}$) values at elevated temperatures

Steel grade	$R_{p0,2}$ (N/mm^2) at a temperature (°C) of **(1)**									
	100	150	200	250	300	350	400	450	500	550
320 HA	170	160	150	125	100	95	90	85		
360 HA	190	175	165	145	120	115	110	105		
410 HA	210	200	190	170	150	140	130	125		
460 HA	235	220	215	195	180	165	160	155		
510 HA	250	240	230	215	195	180	175	170		
0,3Mo	240	235	225	205	175	160	155	150	145	
0,5Cr 0,5Mo **(2)**										
1Cr 0,5Mo	265	250	245	235	190	180	175	165	155	150
2,25Cr 1Mo **(3)**	260	250	245	235	230	215	205	195	180	165
2,25Cr 1Mo **(4)**	110	100	90	85	80	75	70	65	65	70
0,5Cr 0,5Mo 0,25V	260	250	235	215	190	185	175	165	155	145

(1) The values for temperatures <200°C are given for information.
(2) Values to be determined during preliminary approval .
(3) Normalised and tempered condition.
(4) Annealed condition.

Table 7 : Average values for stress to rupture in 100000 hours (N/mm²)

Temperature (°C)	Carbon and carbon manganese steels		Alloy steels				
	360 / 410	460 / 510	0,3Mo	1Cr 0,5Mo	2,25Cr 1Mo		0,5Cr 0,5Mo 0,25V
					N + T **(1) (3)**	A **(2)**	
380	170	225					
390	155	200					
400	140	175					
410	125	155					
420	110	135					
430	100	115					
440	90	100					
450	75	85	240	280	220	195	
460	65	70	205	250	205	180	
470	55	60	175	220	185	165	
480	45	55	140	200	170	155	215
490	35	45	115	170	150	140	190
500		40	95	140	135	125	170
510			75	120	120	115	150
520			60	97	105	100	130
530			45	80	90	90	115
540			35	65	76	76	100
550			30	54	68	68	85
560				43	58	58	70
570				35	50	50	55
580					44	44	45

Note 1: The values shown are estimated average values; the lower limit of the range is approximately 20% less than the average value.

(1) N + T = normalising + tempering.

(2) A = annealing.

(3) When the tempering temperature exceeds 750°C, the values relevant to the annealing heat treatment are to be used.

Table 8 : Chemical composition

Steel grade	Chemical composition (%) **(1)**							
	C max	Mn	Si	P max	S max	Ni	Al tot	Others **(3)**
360 LE-LF	0,17	0,40 - 1,00	≤ 0,35	0,030	0,025	≤ 0,30 **(2)**	≥ 0,020	Cr ≤ 0,25 Cu ≤ 0,30 Mo ≤ 0,10
410 LE-LF	0,18	0,60 - 1,30	≤ 0,35	0,030	0,025	≤ 0,30 **(2)**	≥ 0,020	
460 LE-LF	0,18	0,60 - 1,30	≤ 0,35	0,030	0,025	≤ 0,30 **(2)**	≥ 0,020	
510 LE-LF	0,20	1,00 - 1,60	≤ 0,35	0,030	0,025	≤ 0,30 **(2)**	≥ 0,020	
3,5 Ni	0,15	0,30 - 0,90	0,15 - 0,35	0,025	0,020	3,25 - 3,75	-	
9,0 Ni	0,12	0,30 - 0,90	0,15 - 0,35	0,025	0,020	8,50 - 9,50	-	

(1) With the exception of refining elements, additional alloying elements are to be submitted for consideration and approval; residual elements are permitted provided they do not impair the properties, subsequent processing or behaviour in service.

(2) Higher Ni content up to 0,80 % may be agreed for LF grades.

(3) When the pipes are subjected to hot forming: Cu < 0,25.

Table 9 : Mechanical properties and condition of supply

Steel grade	Heat treatment (1)	Yield stress R_{eH} (N/mm^2) min. for t (mm)		Tensile strength R_m (N/mm^2)	Elong. A_5 (%) min.	Average impact energy (J) min.		Technological tests		
						Test temp (°C)	KVL	Flattening test constant C for t/D		Bend test diameter mandrel
		≤ 25	25 < t ≤ 40					t/D≤0,15	t/D>0,15	
360 LE	N	225	215	360-500	22	-40	27	0,09	0,08	4 t
360 LF						-60				
410 LE	N	255	245	410-550	20	-40	27	0,07	0,06	
410 LF						-60				
460 LE	N	275	265	460-580	20	-40	27			
460 LF						-60				
510 LE	N	345	335	510-630	19	-40	34			
510 LF						-60				
3,5 Ni	N or N+T or Q+T	255	245	450-640	19	-100	34			
9,0 Ni	N+N+T	470	460	640-840	16	-196	41			
9,0 Ni	Q+T	570	560	690-840						

(1) N: Normalising ; N+T: normalising and tempering ; N+N+T: double normalising and tempering ; Q+T: quenching and tempering.

5.5 Mechanical properties

5.5.1 The mechanical properties and conditions of supply are specified in Tab 9.

5.6 Mechanical and technological tests

5.6.1 The pipes are to be presented in batches and the number of pipes per batch is defined in Tab 1.

Two pipes are to be selected from each batch for the required tests, as follows:

a) seamless pipes and tubes:
- one tensile test, longitudinal direction
- one flattening test or one bend test
- 3 Charpy V-notch impact tests, longitudinal direction, for thickness ≥ 3 mm

b) welded pipes:
- one tensile test on base metal, longitudinal direction
- one tensile test transverse to the weld
- two flattening tests or two bend tests transverse to the weld for pipes with D ≥ 300 mm
- 3 Charpy V-notch impact tests, longitudinal direction, for thickness ≥ 3 mm.

6 Austenitic and austenitic-ferritic stainless steel pipes

6.1 Application

6.1.1 The requirements of this Article apply to seamless and welded austenitic and austenitic-ferritic stainless steel pipes intended for use in the construction of piping systems conveying chemicals or liquefied gases.

6.1.2 Austenitic stainless steels are suitable for use at both elevated and low temperatures.

When austenitic stainless steels are proposed for use at elevated temperatures, details of chemical composition, heat treatment and mechanical properties are to be submitted for consideration and approval.

Ferritic austenitic (duplex) steels are suitable for use for service temperatures between -20°C and +275°C.

6.2 Steel grades

6.2.1 The requirements apply to Cr-Ni stainless steels.

Steels are designated according to AISI grades; the corresponding ISO grades are also indicated in Tab 10.

6.3 Condition of supply

6.3.1 The pipes are to be supplied in the solution treated condition.

6.4 Chemical composition

6.4.1 The chemical composition on ladle analysis is to comply with the requirements specified in Tab 10.

6.5 Mechanical properties

6.5.1 The mechanical properties are specified in Tab 11.

Table 10 : Chemical composition

ISO grade designation	AISI grade designation	Chemical composition (%) **(1)**								
		C max	Mn max	Si max	P max	S max	Cr	Ni	Mo	Others
X2CrNi1810	304L	0,03	2,00	1,00	0,045	0,035	17,0-19,0	9,0-13,0	-	
X5 CrNi1810	304	0,07	2,00	1,00	0,045	0,035	17,0-19,0	9,0-13,0	-	
X2CrNiMo1713	316L	0,03	2,00	1,00	0,045	0,035	16,0-18,5	11,0-14,0	2,0-2,5	
X5CrNiMo1713	316	0,07	2,00	1,00	0,045	0,035	16,0-18,5	11,0-14,0	2,0-2,5	
X6CrNiTi1810	321	0,08	2,00	1,00	0,045	0,035	17,0-19,0	9,0-13,0	-	5xC≤Ti≤0,80
X6CrNiNb1810	347	0,08	2,00	1,00	0,045	0,035	17,0-19,0	9,0-13,0	-	10xC≤Nb≤1,0
X2CrNiMoN2253	UNS31803	0,03	2,00	1,00	0,030	0,020	21,0-23,0	4,50-6,50	2,5-3,5	0,08≤N≤0,20

(1) Additional alloying elements are to be submitted for consideration and approval.
Residual elements are permitted provided they do not impair the properties, subsequent processing or behaviour in service of the material.

Table 11 : Mechanical properties

Steel grade	Yield strength (N/mm²) min. **(1)**		Tensile strength R_m (N/mm²)	Elong. A_5 (%) min	Average impact energy KVL (J) at		Technological tests			
							C **(2)**	Di/D **(3)**		
	$R_{p0,2}$	R_{p1}			-196°C	-20°C		≤ 0,6	0,6<Di/D≤0,8	> 0,8
304L	175	205	460 - 690	30	41			9	15	17
304	195	235	460 - 690	30	41					
316L	185	215	460 - 690	30	41					
316	205	245	460 - 690	30	41		0,09			
321	195	325	510 - 710	30	41					
347	205	245	510 - 710		41					
UNS 31803	450		620	25		27				

(1) Conventional proof stress; the 0,2% proof stress values are given for information and, unless otherwise agreed, are not required to be verified during the test.
(2) Constant C for flattening test.
(3) Expanding or flanging test; increase of outside diameter D, in %, as a function of Di/D.

6.6 Mechanical and technological tests

6.6.1 *(1/4/2009)*

Unless they are required to be tested on each length, pipes are to be presented in batches, as specified in Tab 1.

Two pipes are to be selected from each batch for the required tests, as follows:

a) seamless pipes:

- one tensile test, longitudinal direction
- one flattening test or one bend test with mandrel diameter of 3 t
- 3 Charpy V-notch impact tests, longitudinal direction
- one expansion or flanging test, when required

b) welded pipes:

- one tensile test on base metal, longitudinal direction
- one tensile test transverse to the weld for pipes with D ≥ 300 mm
- two flattening or two bend tests transverse to the weld with mandrel diameter of 3 t
- 3 Charpy V-notch impact tests, longitudinal direction, when required
- one expansion or flanging test when required.

When required, one tensile test at elevated temperature is to be performed on one sample per cast.

Unless otherwise required, impact tests on the austenitic grades are to be performed for design temperature lower than -105°C and are to be carried out at -196°C.

6.7 Corrosion tests

6.7.1 For materials used for piping systems for chemicals, the corrosion tests, ASTM A262 Practice E (Copper- copper sulphate sulphuric) or ASTM A262 Practice C (Nitric acid test), as appropriate, may be required to be carried out on two pipes per batch.

Tests in accordance with other recognised standards are accepted, subject to the agreement of the Society.

7 Fittings

7.1 Application

7.1.1 The requirements of this Article apply to seamless and welded carbon, carbon manganese, low alloy and alloy steel fittings, fabricated from pipes or plates and intended for piping systems or pressure plants.

7.2 Steel grades and relevant properties

7.2.1 Fittings fabricated from pipes are to meet the requirements of Articles [1] to [6], depending on the applications, with respect to manufacture, chemical composition and mechanical properties. Fittings may be hot or cold formed from sections of pipes.

Fittings fabricated from plates are to meet the requirements of the Articles from Sec 1, [1] to Sec 1, [7], depending on the applications, with respect to manufacture, chemical composition and mechanical properties.

Fittings may be made from sections of plates formed in one or more shells and welded together. The relevant welding process is to be approved.

7.2.2 Unless otherwise required, the material used for the fabrication of the fittings is to be covered by a works' certificate (W).

7.3 Condition of supply

7.3.1 All fittings are to be in the heat treated or hot working condition specified in the various Articles for the corresponding material.

Fittings in ferritic steel manufactured by hot forming may be delivered in the normalised forming condition in lieu of normalising, provided that evidence is given of the equivalence of such condition; see [1.7.1].

Fittings manufactured by cold forming are in general to be submitted to heat treatment after forming.

A proposal to deliver fittings in the cold formed condition may be considered by the Society; to this end, the Manufacturer is to submit detailed information relevant to forming procedure, mechanical properties after forming and destination of the products.

The heat treatment procedure of welded fittings is to be defined during the approval tests.

7.4 Mechanical properties

7.4.1 The mechanical properties of the finished fittings are to comply with the values specified for the starting materials (plate or pipe).

7.5 Mechanical and technological tests

7.5.1 The fittings are to be presented for testing in batches homogeneous for cast and in the number indicated in Tab 1.

A Brinell hardness test HB is to be performed on 10% of the fittings, with a minimum of 3 units, to verify the homogeneity of the batch. The difference in the hardness value may not be greater than 30 units.

Two fittings per batch are to be selected for the mechanical and technological tests specified in Articles [2] to [6] depending on the application.

The tensile tests are to be performed on the hardest and softest fittings.

7.6 Non-destructive examination

7.6.1 Unless otherwise specified during the approval procedure or in the order, checks with radiographic examination are in general to be performed on welded fittings with outside diameter higher than 75 mm, at the Surveyor's discretion.

7.7 Marking and certification

7.7.1 The requirements specified in Article [1] relevant to marking in [1.10] and certification in [1.11] are to be complied with, as appropriate.