

SECTION 5 STEEL PIPES AND FITTINGS

1 General requirements for pipes

1.1 Scope

1.1.1 This sub-section specifies the general requirements for steel pipes to be used in the construction of piping for pressure, cargo, and process systems. Provision is made for carbon and carbon-manganese, alloy, and stainless steels.

1.1.2 Separate requirements for steel piping fittings are given in [6]. Requirements for pipes and fittings of forgings and castings are given in Sec.6 and Sec.8 respectively.

1.1.3 Requirements for pipes and hollow sections intended for structural application are given in Sec.2.

1.1.4 Requirements for individually manufactured and welded pipes for applications not covered by this section shall comply with the relevant design and construction rules.

1.2 Certification requirements

1.2.1 General certification requirements are given in Sec.1 [3.1].

1.2.2 The product shall be delivered with the type of certificate required in the relevant design and construction rules giving at least the following particulars for each test unit which has been accepted:

- purchaser's name, order number and vessel identification, where known
- manufacturer's name
- description of pipes/fittings and material quality
- identification marking of pipes/fittings
- heat number and chemical composition
- results of mechanical tests and technological tests
- results of leak tightness testing
- results of any supplementary and additional test requirements specified.

1.3 Documentation requirements

1.3.1 General documentation requirements are given in Sec.1 [3.2]. Additional manufacturer specific documentation requirements are given in Table 1.

Table 1 Qualification documentation for manufacturer

<i>Item</i>	<i>Documentation type</i>	<i>Additional description</i>
Carbon and carbon-manganese steel pipes	VL or W certificate or TR	<ul style="list-style-type: none"> — unless otherwise required by the standard, suitable grain refining elements may be used at the discretion of the manufacturer. The content of such elements shall be reported — Carbon equivalent shall be reported

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in [Ch.1 Sec.1 \[3.3\]](#). Additional specific requirements are given in [Table 2](#), as further detailed in this section.

Table 2 Additional survey and testing requirements

<i>Survey, inspection and testing item</i>	<i>Description</i>
Chemical composition	Required for all materials
Carbon equivalent	Unless stricter requirements are specified in the standard, carbon and carbon-manganese steel shall conform to a carbon equivalent of maximum 0.50%
Mechanical testing	Required for all grades in accordance with the requirements of the relevant standard
Hot tensile test	Where pipes are designed for use at elevated temperatures on the basis of their high-temperature strength characteristics, a hot tensile test shall be performed on one test specimen per heat and per pipe size
Impact toughness test, all pipes	Where Charpy V-notch impact testing is required, this is applicable for wall thickness 6 mm or greater
Impact toughness test of austenitic steel pipes	For austenitic stainless steel pipes, Charpy V-notch impact testing is required where the design temperature is below -105°C
Hardness test on fittings	Hardness tests on fittings shall be carried out as specified in [6]
NDT of all pipes	Where required by the design principle, pipes shall be subjected to a non-destructive test over their whole length
NDT of welded pipes	For welded pipes, an automatic non-destructive testing of the whole length of the weld is required
Leak tightness test	Each pipe shall be subjected to a hydraulic test or an approved non-destructive test for leak tightness in accordance with the requirements of the relevant standard
Test equipment used for the continuous inspection of pipes	The efficiency of the equipment shall be demonstrated to the surveyor on request
Corrosion test of pipes and fittings	Where pipes/fittings of austenitic stainless steels shall be used in systems where corrosion testing of the pipes is required, testing shall be carried out in accordance with Sec.3 [1.14]
Corrosion test for duplex steels	For ferritic-austenitic (duplex) stainless steel pipes, corrosion testing in accordance with ASTM G48 Method A or an equivalent standard is required
Repair by grinding	<ul style="list-style-type: none"> — defects may be removed by grinding provided that the dimensional tolerances are not exceeded — repair by welding is not permitted except for repair to the weld seam of electric fusion welded pipe

NDT and Leak tightness test after repair	<ul style="list-style-type: none"> – defects removed by grinding shall be re-inspected by NDT – for pipes/fittings repaired by welding, both leak tightness test according to [1.10] and inspection according to [1.11] shall be repeated after repair
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1.5 Materials

1.5.1 Pipes shall be in accordance with recognised standards, as given in [2] to [5], provided that supplementary requirements contained herein and in [2] to [5] also are met. Recognition of other standards is subject to submission to the Society for evaluation, see [Ch.1 Sec.1 \[3.4\]](#).

1.5.2 Pipe grades selected from recognised standards shall be suitable for bending, flanging, and similar forming operations, and for welding.

1.5.3 Where required by the relevant design and construction parts of the rules, pipes shall comply with the requirements of [Ch.1](#) and this section.

1.5.4 Where the use of material with differing requirements is proposed, particulars shall be submitted in connection with the approval of the design for which the material is proposed. As a minimum the following particulars shall be specified:

- manufacturing process
- chemical composition
- heat treatment
- mechanical properties
- leak tightness testing
- non-destructive testing.

Guidance note:

In order for other materials to be considered for approval, a gap analysis report identifying the differences between the proposed material and a corresponding material grade according to one of the standards listed below should be submitted, see [Ch.1 Sec.1 \[3.4\]](#).

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1.6 Manufacture

1.6.1 All pipes delivered with VL or works certificate shall be made by works approved by the Society, see [Ch.1 Sec.2 \[2.2.2\]](#). The steel used shall be made by works approved by the Society.

1.6.2 Pipes shall be manufactured as specified in [2] to [5]. The terms “hot finished” and “cold finished” apply to the condition of the pipe before it is heat-treated.

1.7 Chemical composition

1.7.1 The chemical composition of each heat shall be determined by the steel manufacturer on a sample taken preferably during the pouring of the heat and shall be in accordance with the requirements of the relevant standard. When multiple heats are tapped into a common ladle, the ladle analysis shall apply.

1.7.2 Unless otherwise required by the standard, suitable grain refining elements may be used at the discretion of the manufacturer. The content of such elements shall be reported.

1.7.3 Elements designated as residual elements in the standard shall not be intentionally added to the steel. The content of such elements shall be reported.

1.7.4 Unless stricter requirements are specified in the standard, carbon and carbon-manganese steel shall conform to a carbon equivalent C_{eq} of maximum 0.50% as determined by the formula given in [Ch.1 Sec.2 \[3.2\]](#).

1.8 Condition of supply

1.8.1 The pipes shall be supplied in a condition in accordance with the requirements of the relevant standard and the requirements in [\[2\]](#) to [\[5\]](#). Unless otherwise required, hot finished or as-welded pipes need not be heat-treated.

1.9 Mechanical testing

1.9.1 Pipes shall be sampled and subjected to testing in accordance with the requirements of the relevant standard.

1.9.2 Unless stricter requirements are specified in the standard, the size of a test unit (batch) shall be restricted to maximum:

- 400 pipes for outside diameter < 100 mm
- 100 pipes for outside diameter \leq 500 mm
- 50 pipes for outside diameter > 500 mm.

Further details are given in [\[1.9.3\]](#) and [\[1.9.4\]](#).

1.9.3 Where heat treatment has been carried out, a test unit shall consist of pipes of the same size, same grade of steel, same heat treatment in a continuous furnace or heat-treated in the same furnace charge in a batch furnace, and in case of alloy steel pipes, from the same heat.

1.9.4 Where no heat treatment has been carried out, a test unit shall consist of pipes of the same size, made by the same method, and from the same grade of steel.

1.9.5 Where pipes are designed for use at elevated temperatures on the basis of their high-temperature strength characteristics, a hot tensile test shall be performed on one test specimen per heat and per pipe size. The test is not required if the pipes are made according to a recognized standard where the high-temperature mechanical properties are regarded as proven.

1.9.6 Where Charpy V-notch impact testing is required, this is applicable for wall thickness 6 mm or greater. Unless otherwise specified by the selected recognised standard for the grade in question, transverse Charpy V-notch specimens shall be used for outside diameter of $D \geq 200$ mm. For outside diameter $D < 200$ mm, longitudinal specimens may be used.

If the dimensions of the pipe are such that transverse test specimens can be taken without straightening, an additional (transverse) set of specimens shall be taken from fusion-welded pipes so that the notch is located in the middle of the weld metal.

1.10 Leak tightness testing

1.10.1 Each pipe shall be subjected to a hydraulic test or an approved non-destructive test for leak tightness in accordance with the requirements of the relevant standard. Unless stricter requirements are specified in the standard, the testing shall be as given in [\[1.10.2\]](#).

1.10.2 The internal pressure test shall be performed at a standard hydraulic test pressure of 80 bars, except as specified below or unless otherwise approved. Where pipes are intended for an operating pressure of ≤ 25 bars, the test pressure may be reduced to a standard value of 50 bars. In the case of thin-walled pipes with large outside diameters, the test pressure shall be limited so as to ensure that the yield strength or 0.2% proof stress of the pipe material at room temperature is not exceeded. Where, in exceptional cases, testing with water is not possible, another testing medium may be used in agreement with the surveyor.

1.11 Inspection

1.11.1 Pipes shall be subjected to visual inspection and measurements of dimensions by the manufacturer in accordance with the requirements of the relevant standard. Unless stricter requirements are specified in the standard, the pipes shall be inspected at the same frequency as that required for mechanical testing.

1.11.2 The pipes shall have a workmanlike finish consistent with the method of manufacture and shall be free from external and internal defects that can be detected by visual inspection.

1.11.3 For welded pipes, an automatic non-destructive testing of the whole length of the weld is required. Such pipes are considered equivalent to seamless pipes for design purpose.

1.11.4 Where required by the design principle, pipes shall be subjected to a non-destructive test over their whole length in accordance with a recognized standard, e.g. EN ISO 10893.

1.11.5 The test equipment used for the continuous inspection of pipes shall be regularly calibrated using pipes with artificial defects. The efficiency of the equipment shall be demonstrated to the surveyor on request.

1.12 Repair

1.12.1 Defects may be removed by grinding provided that the dimensional tolerances are not exceeded. Repair by welding is not permitted except for repair to the weld seam of electric fusion welded pipe. Defects removed by grinding shall be re-inspected by NDT. For pipes/fittings repaired by welding, both leak tightness test according to [1.10] and inspection according to [1.11] shall be repeated after repair.

1.13 Identification

1.13.1 Pipes shall be legibly marked for identification in accordance with the requirements of the relevant standard with the following minimum information:

- manufacturer's name or trade mark
- material designation
- where applicable, quality level in the case of boiler tubes
- heat number or production code.

2 Pipes for pressure systems

2.1 Scope

2.1.1 These requirements are supplementary to [1] and apply to carbon and carbon-manganese and alloy steel pipes for use in pressure systems.

2.2 Materials

2.2.1 Suitable pipe grades shall be selected from the following recognised standards:

- ISO 9329 Parts 1 and 2, ISO 9330 Parts 1 and 2
- EN 10216 Parts 1 to 3, EN 10217 Parts 1 to 3
- ASTM A53, ASTM A106, ASTM A135, ASTM A335
- JIS G3454, JIS G3455, JIS G3456, JIS G3458.

In addition, those standards given in [4] and [5] may be used.

2.3 Manufacture

2.3.1 Pipes for class I and II pressure systems, as defined in Pt.4 Ch.7, shall be manufactured by any of the following methods:

- hot finished seamless
- cold finished seamless
- electric resistance or induction welded
- cold finished electric resistance or induction welded
- electric fusion welded.

2.4 Mechanical testing

2.4.1 Pipes for class I and II pressure vessels shall satisfy a Charpy V-notch impact toughness requirement of minimum 27 J, unless otherwise approved.

3 Austenitic and ferritic-austenitic steel pipes

3.1 Scope

3.1.1 These requirements are supplementary to [1] and apply to austenitic and ferritic-austenitic stainless steel pipes for corrosive service and to austenitic steel pipes for low-temperature service.

3.2 Materials

3.2.1 Suitable pipe grades shall be selected from the following recognised standards:

- ISO 9329 Part 4, ISO 9330 Part 6
- EN 10216 Part 5, EN 10217 Part 7
- ASTM A269, ASTM A312, ASTM A358, ASTM A789, ASTM A790, ASTM A928
- JIS G3459.

3.3 Manufacture

3.3.1 Pipes shall be manufactured by any of the following methods:

- hot finished seamless
- cold finished seamless
- electric resistance or induction welded

- cold finished electric resistance or induction welded
- electric fusion welded.

3.4 Condition of supply

3.4.1 The pipes shall be supplied in solution treated condition.

Welded austenitic pipes may be delivered in the welded state provided that a test of the procedure has demonstrated that the characteristics of the material are satisfactory and that the strips or plates used for their manufacture are solution annealed.

3.5 Mechanical testing

3.5.1 Where pipes are used at elevated temperatures, the required values for the 0.2% or 1% proof stress prescribed in the relevant standards or recognized specifications shall be met at the corresponding temperature level.

3.5.2 For austenitic stainless steel pipes, Charpy V-notch impact testing is required where the design temperature is below -105°C. Testing shall be carried out at -196°C and the average energy value for standard 10 mm wide test specimens shall be minimum 41 J.

3.6 Corrosion testing

3.6.1 For ferritic-austenitic (duplex) stainless steel pipes, corrosion testing in accordance with ASTM G48 Method A or an equivalent standard is required.

3.6.2 Test specimen surfaces shall have a finish representative of the pipe's delivery condition. The test specimens shall be exposed to the solution at a constant temperature of +20°C for type 22Cr duplex and +50°C for type 25Cr duplex for 24 hours. No pitting on specimen surfaces is allowed when viewed at 20 times magnification. The specimen mass loss shall be less than 4.0 g/m².

4 Pipes for low-temperature service

4.1 Scope

4.1.1 These requirements are supplementary to [1] and apply to carbon and carbon-manganese and alloy steel pipes for use in piping systems for liquefied gases where the design temperature is less than 0°C. These requirements are also applicable for other types of pressure piping systems where the use of steels with guaranteed impact properties at low temperatures is required.

4.2 Materials

4.2.1 Suitable pipe grades shall be selected from the following recognised standards:

- ISO 9329 Part 3, ISO 9330 Part 3
- EN 10216 Part 4, EN 10217 Part 6
- ASTM A333, ASTM A334
- JIS G3460.

4.3 Manufacture

4.3.1 Carbon and carbon-manganese steel pipes shall be manufactured by any of the following methods:

- hot finished seamless
- cold finished seamless
- electric resistance or induction welded
- cold finished electric resistance or induction welded
- electric fusion welded.

4.3.2 Nickel alloy steel pipes shall be manufactured by a seamless process.

4.4 Mechanical testing

4.4.1 Requirements for Charpy V-notch impact testing dependent of steel type and minimum design temperature are given in [Table 3](#).

Table 3 Charpy V-notch impact properties

Steel type	Min. design temperature (°C)	Charpy V-notch impact test	
		Test temperature (°C)	Minimum average energy (J)
C and C-Mn	-55	1)	27
2 ¼ Ni	-65	-70	34
3 ½ Ni	-90	-95	34
9 Ni	-165	-196	41

1) the test temperature shall be 5°C below the design temperature or -20°C whichever is lower

5 Boiler and superheater tubes

5.1 Scope

5.1.1 These requirements are supplementary to [1] and [2] and apply to carbon and carbon-manganese and alloy steel tubes for use in boilers, superheaters and heat exchangers.

5.1.2 Austenitic stainless steels may also be used for this type of service. Where such applications are proposed, see [3.5.1].

5.2 Materials

5.2.1 Suitable pipe grades shall be selected from the following recognised standards:

- ISO 9329 Part 2, ISO 9330 Part 2
- EN 10216 Part 2, EN 10217 Part 2
- ASTM A178, ASTM A209, ASTM A210, ASTM A213
- JIS G3461, JIS G3462, JIS G3463.

5.3 Manufacture

5.3.1 Pipes shall be manufactured by any of the following methods:

- hot finished seamless
- cold finished seamless
- electric resistance or induction welded
- cold finished electric resistance or induction welded.

6 Piping fittings

6.1 Scope

6.1.1 This sub-section specifies the requirements for steel piping fittings such as elbows, bends, tees, reducers and caps - for the applications covered in [2] to [5], made from plates, seamless pipes or welded pipes. Detachable pipe couplings and flanges are excluded from these requirements.

Steel pipe fittings made by forging or casting are covered by [Sec.6](#) and [Sec.8](#), respectively.

6.2 Materials

6.2.1 Fittings shall be in accordance with recognised standards, as given in [6.2.2]. Recognition of other standards is subject to submission to the Society for evaluation, see [Ch.1 Sec.1 \[3.4\]](#).

6.2.2 Suitable fitting grades shall be selected from the following recognised standards:

- EN 10253
- ASTM A234, **ASTM A403**, ASTM A420, ASTM A744, **ASTM A815**, ASTM A960, ASTM A961
- JIS B2312, JIS B2313, JIS B2316.

6.2.3 Where required by the relevant design and construction parts of the rules, fittings shall comply with the requirements of [1] and this subsection.

6.2.4 Where the use of material with differing requirements is proposed, particulars shall be submitted in connection with the approval of the design for which the material is proposed. As a minimum the following particulars shall be specified:

- manufacturing process
- chemical composition
- heat treatment
- mechanical properties.

6.3 Manufacture

6.3.1 All fittings delivered with VL or works (W) certificate shall be made by works approved by the Society. See also [Ch.1 Sec.2 \[2.2.2\]](#) and guidance note.

Guidance note:

Exceptions may be accepted in a transition period as decided by the Society, in which fittings for VL or W certification may be accepted from non-approved manufacturers. Such manufacturers should apply for approval. Manufacturers in which approval certificate is suspended or withdrawn are not covered by this exception.

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6.3.2 The starting materials for fabrication of fittings (covered by this section) shall consist of plates, seamless pipes or welded pipes and shall be sourced from works approved by the Society.

6.3.3 Fittings shall be manufactured by **hot or cold forming operations** such as pressing, bending or fusion welding according to recognized standards.

6.4 Chemical composition

6.4.1 Chemical composition of the starting materials shall fulfil [1.7].

6.5 Condition of supply

6.5.1 All fittings shall be in the heat-treated or hot worked state specified for the material in the relevant standard or material specification.

6.5.2 Heat treatment after cold bending shall be carried out as specified in Pt.4 Ch.6 Sec.10 [3].

6.6 Mechanical testing

6.6.1 Fittings shall be tested in accordance with the requirements of the relevant standard. For stainless steel fittings and fittings for low-temperature service, supplementary requirements for testing in [3] and [4] also apply.

6.6.2 Unless stricter requirements are specified in the standard, the size of a test unit shall be restricted to the maximum size given in Table 4 and as given in [6.6.3] and [6.6.4].

Table 4 Test units for fittings

Size d_a (mm) ¹⁾	No. of fittings per test unit ²⁾
< 100	≤ 200
100 ≤ d_a < 225	≤ 100
225 ≤ d_a < 350	≤ 50
d_a ≥ 350	≤ 25

1) d_a = outer diameter
 2) for elbows; the test unit size apply to 90° elbows. The number of elbows in each test unit is halved in the case of 180° elbows and doubled in the case of 45° elbows

6.6.3 Where heat treatment has been carried out, a test unit shall consist of fittings of **the same size, made from the same grade of steel, the same heat treatment in a continuous furnace or heat-treated in the same furnace charge in a batch furnace**, and in the case of alloy steel fittings with an outer diameter $d_a > 100$ mm, originating from the same heat.

6.6.4 Where no heat treatment has been carried out, a test unit shall consist of fittings of the same size, made by the same forming process, and from the same grade of steel.

Where the fittings are delivered without heat treatment, and have been subject to theoretical cold forming of less than 5% for ferritic steels and less than 10% for austenitic and ferritic-austenitic steels, testing of the starting material is sufficient. Theoretical cold forming may be calculated in accordance with Ch.4 Sec.6 [5.2.6]. See also the requirements given in Pt.4 Ch.6 Sec.10 [3].

6.6.5 Testing shall be carried out on selected fitting from the unit to be covered. Provided the length of the fitting is not sufficient for testing, fittings of excess length shall be manufactured using the same or a similar process, and shall follow the test unit as described in [6.6.3] and [6.6.4].

The test samples shall be prepared from the **hardest and softest fittings** determined in the hardness test, see [6.6.6].

6.6.6 Hardness tests shall be carried out on 10% of the fittings per test unit, except for austenitic and austenitic-ferritic steels subject to tensile testing on the fitting. Where the number of fittings per test unit is less than 30 fittings a minimum of three fittings shall be tested.

Hardness test shall be performed on each individual fitting for the following:

- outer diameter $D \geq 225$ mm for unalloyed steel with tensile strength $R_m \geq 500$ MPa
- outer diameter $D \geq 200$ mm for alloyed steel, except for 0.3% Mo and Cr-Mo steel, which shall follow the requirement for unalloyed steel.

6.6.7 One tensile test shall be carried out for each test unit unless stricter requirements are specified. For outer diameter $D \geq 100$ mm, two tensile tests shall be carried out (where the test unit is less than 10 fittings, one set of specimens is acceptable). Sample product shall be selected as the hardest and the softest fitting found in hardness tests according to [6.6.6]. Fittings having an outer diameter $D < 100$ mm may be tensile tested on the starting material.

6.6.8 Where Charpy V-notch impact testing is required, this is applicable for wall thickness 6 mm or greater. Two sets of specimen shall be tested for each test unit unless test unit is less than 10 fittings, where one set of specimen is acceptable.

Where the fittings are delivered without heat treatment and have been subject to theoretical cold forming of more than 5% for ferritic steels and more than 10% for austenitic and ferritic-austenitic steels, the area with the highest cold forming shall be tested. Where sampling of the representative area is not possible, testing of same material in artificially cold formed condition is accepted. For ferritic steels, the material shall additionally be tested in the strain-aged condition, see Ch.1 Sec.3 [3.8], Ch.4 Sec.6 [5.2] and Pt.4 Ch.6 Sec.10 [3].

6.7 Corrosion testing

6.7.1 Where fittings of austenitic stainless steels shall be used in systems where corrosion testing of the pipes is required, testing shall be carried out in accordance with Table 2.

6.7.2 For ferritic-austenitic (duplex) stainless steel pipes fittings, corrosion testing in accordance with ASTM G48 Method A or an equivalent standard is required.

6.7.3 Test specimen surfaces shall have a finish representative of the fitting's delivery condition. The test temperature shall be +20°C for type 22Cr duplex and +50°C for type 25Cr duplex, respectively. No pitting on specimen surfaces is allowed when viewed at 20 times magnification. The specimen mass loss shall be less than 4.0 g/m^2 .

6.8 Inspection

6.8.1 Fittings shall be subject to visual inspection and measurements of dimensions by the manufacturer. Surface quality and dimensions shall be in accordance with the requirements of the relevant standard.

The fittings shall have a workmanlike finish consistent with the method of manufacture and shall be free from external and internal defects that can be detected by visual inspection.

6.8.2 Unless stricter requirements are specified in the standard, welded alloy steel fittings with nominal bores > 75 mm shall be subject to random radiographic inspection of the welds. These shall be selected in such a way that every size of fittings is included.

6.9 Identification

6.9.1 Fitting with outer diameter $D \geq 225$ mm shall be marked in accordance with [1.13]. Smaller fittings may alternatively be marked with the manufacturer's symbol and a unique identification number ensuring traceability to the test unit and certificate.

The level of documentation shall be in accordance with [1.3].