

DEP SPECIFICATION

METALLIC MATERIALS – SELECTED STANDARDS

DEP 30.10.02.11-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies appropriate standards for metallic construction materials.

By identifying alternative materials standards, this DEP has two main functions, as follows:

- Where a particular materials standard is specified for certain equipment (e.g., in a DEP), if the Contractor wishes to propose an alternative (equivalent) material, this DEP may be used to select a suitable materials standard which would normally be acceptable to the Principal. Note, however, that such substitution shall not be made automatically and still requires the approval of the Principal.
- In situations where required materials are not explicitly specified, this DEP may be invoked to act as a basis for the Contractor's materials selection.

It should be realised that materials may fail owing to undesirable properties being induced during fabrication and/or service, such as metallurgical changes or corrosion of various types. Such factors shall be taken into account when selecting a material for a given service. Measures which may be required to prevent or limit such risks (e.g., special heat treatment) are outside the scope of this DEP and are not indicated. Attention shall be paid to the suitability of the combined use of different materials listed in this DEP.

The Principal's materials specialist should therefore be consulted regarding selection of materials.

This is a revision of the DEP of the same number dated February 2012; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
bar	Round, square, rectangular, oval, half-round and half-oval products, usually ordered in random lengths.
bolting	Fastening element provided with thread.
nut	Fastening element provided with female thread.
casting	Product obtained by pouring molten metal into a mould.
flanges and fittings	Standard piping components other than tube/pipe, valves, bolting and gaskets.
forging	Metal product, hot worked or hot stamped into a desired shape.
pipe	Tubular product; sizes up to and including DN 300 indicated by a nominal size roughly corresponding to the inside diameter; sizes larger than DN 300 indicated by the outside diameter. Pipe is usually ordered in random lengths.
plate	Flat product, minimum thickness approximately 6 mm (0.236 in) and minimum width approximately 300 mm (11.81 in).
section	A shape that is long in relation to its cross-sectional dimensions, having a cross section other than those of wire, rod, bar, tube, tubing and pipe, such as L, U, I, T, etc.
sheet	Flat product, thickness less than 6 mm (0.236 in) and minimum width approximately 300 mm (11.81 in).
strip	Flat product, maximum width approximately 300 mm (11.81 in) and maximum thickness approximately $\frac{1}{6}$ of the width.
tube	Tubular product, indicated by the outside diameter and usually ordered cut to a specific length.
tubing	Tubular product of small diameter, indicated by the outside diameter and usually ordered in long lengths.
wire	Round product, usually ordered in long lengths.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (5).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2012. The main change in this revision has been the addition of materials from the different piping classes. Cross references had been checked and updated. This version includes dual units.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard form (Other users)	Use DEP Standard form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

1.9 STANDARDS

1. Generally, the tables in (2), (3), and (4) initially specify the ASTM standards for the metallic materials. Thereafter, the tables specify the equivalent CEN, GB (China), and ISO standards. All series of standards rank equally, although individual specifications may not be identical.
2. The choice of standard, therefore, is optional and depends on practical circumstances, such as the location where the plant is to be erected, the acceptability of the standard under the applicable design/construction code and the availability and economy of the material.
3. In order to avoid confusion and to provide a consistent basis for the basic specification of materials, only one series of standards shall be used for any particular piece of equipment (i.e., avoid mixing ASTM standards with CEN standards, etc.). for a deviation from this requirement, agreement shall be obtained from the Principal.
4. The use of trade names for materials shall be avoided whenever an authoritative specification reference is available.
5. Where metric versions of ASTM standards are available (e.g., ASTM A278M) they should be selected. In most cases, ASTM standards and their metric version are issued as a single standard (e.g. ASTM A182/A182M).
6. When a pressure vessels is fabricated and stamped to ASME design codes, the permissible substitute material shall be certified as conforming to the appropriate equivalent SA specification.

For simplicity, Chinese references have been abbreviated and the full material specification number can be found in GB 150 and GB 151. The designations shown in the tables are widely recognised in China. For example, in (2.2.2) carbon steel tube equivalent to ASTM A179 is shown as "10" or "20". By referring to GB 150, the material specification is found to be GB 8163 for thicknesses not greater than 16 mm (0.63 in).

1.10 CATEGORIES OF METALS

1. This DEP specifies standards for the following categories of metallic materials:
 - a. ferrous metals – unalloyed;
 - b. ferrous metals – alloyed;
 - c. non-ferrous metals.
2. Each category of metallic materials is broken out into the following types of products:
 - a. plates, sheets and strip;
 - b. tubes and tubing;
 - c. pipe;
 - d. forgings, flanges and fittings;
 - e. castings;
 - f. bars, sections and wire;
 - g. bolting.

1.11 SEQUENCE OF MATERIALS

1. The sequence of materials in the column "Designation and Application" in (2), (3) and (4) is generally such that the subsequent number indicates a material with an increase in the concentration and/or number of the alloying elements.

1.12 SPECIFICATION OF MATERIALS

1. Materials standards identified on drawings, requisition sheets or other documents shall be specified fully in accordance with the information given in (2), (3) and (4), including all additional requirements applicable to the standard. for materials covered by the MESC system, the additional requirements stated therein shall also be met.
2. The latest issue of the selected materials standard shall be used. As this latest issue (including amendments) always prevails, the year of issue of the standard need not be shown.

1.13 METAL TEMPERATURE LIMITS

1. The metal temperatures shown in (2), (3) and (4) are approximate limits allowed for the average temperature through the cross-section of the metallic material during normal operation. The temperatures should be regarded as guidelines only, and do not necessarily apply to cases where corrosion and/or conditions that can affect the structure of the material occur.
2. It should also be recognised that the design code for the equipment may limit the temperature range in which the component can be used.
3. It should be noted that the metal temperature limits shown in (2), (3) and (4) do not necessarily exclude the application of the materials beyond these limits, especially for non-pressure-retaining parts such as internal parts of columns, baffles of heat exchangers, supporting structures, etc.
4. Temperatures shown in brackets, e.g. (+400), are unusual for the indicated application but are allowable from a materials point of view, if so required.

5. Special attention should be given to the specification and application of metals for service at low temperatures (metal temperature 0 °C / 32 °F or lower), for which reference is made to DEP 30.10.02.31-Gen. The Principal's materials specialist should be consulted if there is any doubt on the choice of material for extreme service temperatures.

1.14 CHEMICAL COMPOSITION

1. Chemical composition requirements specified in (2), (3), and (4) relate to product analyses. Percentage compositions are by mass.

1.15 ADDITIONAL REQUIREMENTS FOR STEEL PLATE MANUFACTURED TO PEOPLES' REPUBLIC OF CHINA STANDARDS

1.15.1 General

1. The Rolling Reduction Ratio from cast slab to plate shall be a minimum of 3:1.

1.15.2 Mechanical testing

Tensile Test Specimen orientation

1. Unless otherwise specified, longitudinal axes of tensile test specimens shall be transverse to the direction of the final plate rolling.

Charpy Impact Test Specimens Depth Location for Thicker Plates

2. For plate thickness (T) greater than 30.0 mm (1.18 in) and less than, or equal to, 60.0 mm (2.36 in); Charpy test specimens shall be taken from a plate depth of 0.25 T.
3. For plate thickness (T) greater than 60.0 mm (2.36 in); Charpy test specimens shall be taken from a plate depth of 0.50 T.

1.15.3 Chemical analysis

1. The plate mill certificate shall state the composition of the heat by recording the contents of all of the nominated elements required by that specification. If measured, other trace element contents shall also be recorded on the plate mill certificate.

1.15.4 Third party inspection

1. The steel plate Manufacturer shall grant to nominated third party inspectors free and reasonable access to all steel and plate mills production facilities, test houses and relevant testing and other quality control/quality assurance records.

1.15.5 Stainless steel plate surface finish quality

1. Unless stated otherwise on the purchase order, the minimum standard surface finish quality for stainless steel plate shall be that which has been hot rolled or cold rolled, and annealed or heat treated, and blast cleaned or pickled (equivalent to No. 1 Finish, ASTM A480M).

2. FERROUS METALS – UNALLOYED

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.1 PLATES, SHEETS AND STRIP							
2.1.1	Carbon steel sheets of structural quality, galvanized For general use	+100, +212				4998: Z600-220	
2.1.2	Carbon steel plates of structural quality up to 50 mm (1.97 in) thickness For non-pressure-retaining parts	(+350, +662)	A 283 C 1) C content 0.23 % max.	EN 10025 S275JR 1.0044	Q235-A	630 – E275 (Fe 430B)	1) To be killed or semi-killed.
2.1.3	Carbon steel plates (killed or semi-killed) up to 50 mm (1.97 in) thickness - low strength For pressure-retaining parts	+400, +752	A 285 C 1) C content 0.23 % max.	EN 10028-2 P235GH 1.0345	20R	9328-2 P235	
2.1.4	Carbon steel plates (Si-killed) - low/medium strength For pressure-retaining parts	+400, +752	A 515 60 A 515 65 C content 0.23 % max.	EN 10028-2 P265GH 1.0425 EN 10028-2 P295GH 1.0481	20R 16MnR	9328-2 P265 9328-2 P290	
2.1.5	C-Mn steel plates (Si-killed) – medium strength For pressure-retaining parts. For tube sheets not welded to shell and/or tubes	+400, +752	A 515 70 1)	EN 10028-2 P355GH 1.0473	16MnR	9328-2 P355	1) For tube sheets to be welded to tubes, see (2.1.6). For tube sheets to be welded to shell, see (2.4.3).

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.1.6	Fine-grained C-Mn steels - low strength For pressure-retaining parts also at low temperatures 3) The carbon content shall not exceed 0.23 %.	+400, +752 1)	A 516 60 3) A 662 A 2)	EN 10028-3 P275N 1.0486 EN 10028-3 P275NL1 1.0488 EN 10028-3 P275N 1.0486 EN 10028-3 P275NL1 1.0488	16MnR 16MnDR (low temp. minus 40°C, 40°F)	9328-4 P285TN 9328-4 PL285TN 9328-4 P285TN 9328-4 PL285TN	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) For tube sheets to be welded to shell, see (2.4.3). 3) For sour service, see DEP 31.22.00.31-Gen. and DEP 30.10.02.17-Gen.
2.1.7	Fine-grained C-Mn steels - medium strength For pressure-retaining parts also at low temperatures 3) The carbon content shall not exceed 0.23 %.	+400, +752 1)	A 516 65 70 C content 0.23 % max. 2) 3) SPE 76/220	EN 10028-3 P355N 1.0562 EN 10028-3 P355NH EN 10028-3 P355NL1 1.0566 Only for application <-20°C (-4°F)	16MnR 16MnDR (low temp. minus 40°C, 104°F)	9328-4 P355TN 9328-4 PL355TN	
2.1.8	Fine-grained C-Mn steels – high strength For pressure-retaining parts also at low temperatures (Use subject to specific approval)	+400, +752 1)	A 537 Class 1 (Normalised) 2)	EN 10028-3 P355N 1.0562 EN 10028-3 P355NH EN10028-3 P355NL1 1.0566 Only for application below -20°C (-4°F)	16MnR	9328-4 P355TN 9328-4 PL355TN	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) For tube sheets to be welded to shell, see (2.4.3)
2.1.9	Fine-grained C-Mn steels - very high strength For pressure-retaining parts (Use subject to specific approval.)	+400, +752	A 537 Class 2 (Q/T)	EN 10028-6 P355Q 1.8866			

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.2 TUBES AND TUBING							
2.2.1	Electric-resistance-welded carbon steel tubes For unfired heat transfer equipment	+400, +752	A 214 1) 4)		10 20 1)	2604-3 TW5 1) 4)	1) A non-destructive electric test (in accordance with the materials specification) shall be carried out in addition to the hydrostatic test. 2) For low-temperature applications, see DEP 30.10.02.31-Gen.
2.2.2	Seamless cold-drawn carbon steel tubes For unfired heat transfer equipment	+400, +752 2)	A 179 1) 4) 6) A210 grad A1 7)		10 20	9329-2 PH 23 1)	
2.2.3	Electric-resistance-welded carbon steel tubes For boilers and superheaters	+400, +752	A 178 A 1) 3) 4) 5)		20 1)	2604-3 TW5 1) 3) 4) 5)	
2.2.4	Electric-resistance-welded carbon steel tubes (Si-killed) For boilers and superheaters at high working pressures	+400, +752			20 1)	2604-3 TW5 1) 3) 4) 5)	
2.2.5	Seamless carbon steel tubes (Si-killed) For boilers and superheaters at high working pressures	+400, +752	A 192 1) 5)		20G		3) Electric-resistance-welded tube may be used up to and including 102 mm (4.02 in) external diameter. 4) To be killed or semi-killed. 5) Specify elevated temperature properties. 6) Only for ASME VIII-Div.1 applications. 7) Only for ASME VIII-Div.2 applications
2.2.6	Seamless carbon steel tubes (Si-killed) For unfired heat transfer equipment operating at low service temperatures	+400, +752 2)	A 334 6 C content 0.23 % max. 1)		16Mn 09MnD	9329-3 PL 21 1)	1) A non-destructive electric test (in accordance with the materials specification) shall be carried out in addition to the hydrostatic test. 2) For low-temperature applications, see DEP 30.10.02.31-Gen.

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.3 PIPE							
2.3.1	Electric-fusion-welded carbon steel pipe, sizes larger than DN 400 (NPS 16) For inside plot product lines	+400, +752	A 672 C65 Class 22 C content 0.23 % max. CE shall not exceed 0.43 SPE 74/003				
2.3.2	Seamless C-Mn steel pipe (Si-killed) For inside plot piping, for special services (such as hydrocarbon + hydrogen, hydrocarbon + sulphur compounds, fuel gas). For seamless shells of vessels, for welded-on nozzles, For welded furnace coils and for certain special applications	+400, +752	A 106 B A 106 A 2) C content 0.23 % max. Normalised Sour service S content ≤0.1% 1) SPE 74/002	10208-1 L245GA 1.0459	20	9329-2 PH 26	Seamless usually not obtainable in sizes larger than DN 600 (NPS 24). for larger sizes use ASTM A672 C65 Class 22 (see 2.3.1). 1) CE shall not exceed 0.43% 2) For steam coil and similar applications
2.3.3	Seamless fine-grained C-Mn steel pipe (Si-killed) For process lines at low service temperatures	(+400, +752) 1)	A 333 Grade 6 C content 0.23 % max. CE shall not exceed 0.43% SPE 74/004		16Mn	9329-3 PL 23	1) For low-temperature applications, see DEP 30.10.02.31-Gen. Seamless usually not obtainable >DN600 (NPS 24). for larger sizes use ASTM A671, CC65 Class 22
2.3.4	Electric-fusion-welded fine-grained C-Mn steel pipe (Si-killed), sizes larger than DN 400 (NPS 16) For process lines at moderate or low service temperatures	(+400, +752) 1)	A 671 CC65 Class 22 C content 0.23 % max. CE shall not exceed 0.43 SPE 74/005				1) For low-temperature applications, see DEP 30.10.02.31-Gen.

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.3.5	Seamless or electric-resistance / arc welded carbon steel pipe	+400, +752	API 5L B (sml/erw/saw) SPE 74/001				For PSL2 non galvanised pipe with WT≤25 mm (1 in) Si≥0.1% SAWpipe thicker than 19 mm (0.75 in), shall be normalised or PWHT after welding Seamless pipe shall be normalised or hot finished.
2.4 FORGINGS, FLANGES AND FITTINGS							
2.4.1	Carbon steel butt-welding pipe fittings for general use Sour service compliant to DEP.30.10.02.17	+400, +752	A 234 WPB or A 234 WPBW C content 0.23 % max. 1)2) SPE 76/200				Sizes up to DN 400(NPS 16) incl. Shall be seamless. Larger sizes may be either seamless or welded. Plate material used for A234 WDP-W shall meet all our sour service requirements per applicable DEP 1) CE shall not exceed 0.43% 2) Normalised or hot finished
2.4.2	Carbon steel butt-welding pipe fittings For low service temperature	(+400, +752) 1)	A 420 WPL6 or A 420 WPL6W C content 0.23 % max. The carbon content shall not exceed 0.43 SPE 76/201				Sizes up to DN 600 (NPS 24) incl. shall be seamless. Larger sizes may be either seamless or welded. 1) For low-temperature applications, see DEP 30.10.02.31-Gen.
2.4.3	Carbon steel forgings For piping components, including flanges, fittings, valves and other pressure-retaining parts and also for tube sheets to be welded to shell	+400, +752	A 105 C content 0.23 % max. Normalise 1) SPE 76/210				1) The carbon content shall not exceed 0.23% and CE shall not exceed 0.43%

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.4.4	Carbon steel forgings For pressure vessel components and associated pressure-retaining equipment, including tube sheets	+400, +752	A 266 Class 2 C content 0.25 % max. Normalised		20 16Mn		
2.4.5	Carbon-manganese steel forgings For standard piping components, including flanges, fittings, valves and other pressure-retaining parts at low service temperatures Tubesheets excluded	(+400, +752) 1)	A 350 LF2 Class 1 C content 0.23 % max. Normalised The carbon equivalent (CE) shall not exceed 0.43%. SPE 76/211	EN 10222-4 P355QH 1.0571	16Mn 16MnD		1) For low-temperature applications, see DEP 30.10.02.31-Gen.
2.4.6	Carbon-manganese steel forgings For pressure vessel components and associated pressure-retaining equipment, including tube sheets, at low service temperatures	+350, +662 1)	A 765 Grade II C content 0.23 % max.	EN 10222-4 P355QH 1.0571			1) For low-temperature applications, see DEP 30.10.02.31-Gen.
2.5 CASTINGS							
2.5.1	Grey iron castings For non-pressure-retaining (internal) parts	+350, +662	A 48 Class 30 A 48 Class 40	EN 1561 EN-GJL-250 EN-JL1040 EN 1561 EN-GJL-300 EN-JL1050		185 Grade 250 185 Grade 300	1) Cast iron not to be used in hazardous service or above 10 bar (145 psi). delete
2.5.2	Grey iron castings For non-pressure-retaining (internal) parts at elevated temperatures	+650, +1202	A 319 Class II				2) Mechanical properties may be improved by the addition of certain elements, such as Cr and Ni (i.e. "pearlitic cast iron").
2.5.3	Grey iron castings For pressure-retaining parts and cooler channels	+350, +662	A 278 Class 40 1)				
2.5.4	Ductile iron castings For pressure-retaining parts including fittings and valves	+400, +752	A 395 1)			1083: 400/18 2)	1) Metallographic examination in accordance with ASTM A395 shall be made additionally to the tensile test. 2) Hardness test and 0.2 % proof test to be included in testing programme.

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.5.5	Steel castings For pressure-retaining parts	(+400, +752)	A 216 - WCA WCB WCC C content 0.25 % max. CE shall not exceed 0.43% SPE 77/302	EN 10213-2 GP240GH 1.0619 1)		4991 C23-45AH 1)	
2.5.6	Steel castings For pressure-retaining parts at low service temperatures	(+400, +752) 1)	A 352 LCB C content 0.25 % max. A 352 LCC The carbon equivalent (CE) shall not exceed 0.43. SPE 77/302	EN 10213-3 G20Mn5 1.6220 EN 10213-3 G20Mn5 1.6220			1) For low-temperature applications, see DEP 30.10.02.31-Gen.
2.6 BARS, SECTIONS AND WIRE							
2.6.1	Carbon steel bars, sections and raised-tread plates of structural quality For general structural purposes, lifting lugs, sliding bars, etc.	+350, +662	A 36 C content 0.23 % max. 1) 2)	EN 10025 S275JR 1.0044	Q235-A	630 E275 (Fe 430B)	1) For non-welded items, and for items that will not be welded, restriction on C content may be disregarded. 2) To be killed or semi-killed.
2.6.2	Low-carbon steel bars For machined parts	+400, +752	A 576 1022 G10220 1) 2)		20Mn	9327-1	1) To be killed or semi-killed. 2) Where free-machining quality is required, specify Grade 1117.
2.6.3	Medium-carbon steel bars For machined parts	+400, +662	A 576 1035 G10350 A 576 1045 G10450 A 576 1055 G10550 1) 2)	EN 10083-2 C35 1.0501 EN 10083-1 C35E 1.1181 EN 10083-2 C45 1.0503 EN 10083-1 C45E 1.1191 EN 10083-2 C55 1.0535 EN 10083-1 C55E 1.1203	35 45 55	683-1 C35 683-1C45 683-1 C55	1) To be killed or semi-killed. 2) Where free-machining quality is required specify Grade 1137 (G11370).

	Designation and Application	Metal Temp. °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
2.7 BOLTING							
2.7.1	Carbon steel bolts For structural purposes	+230, +446	A 307 B		Q235-A 35	ISO 898-1 4.6	Approved free machining quality acceptable. For bolting to be used beyond limits indicated, see (3.7.1). for nuts see (2.7.2).
2.7.2	Carbon steel nuts For bolts specified under (2.7.1)	+230, +446	A 563 A		Q235-A 20 25		
2.7.3	Medium-carbon steel nuts For bolting specified under (3.7.1)	+450, +842	A 194 2H SPE 81/002	EN 10269 C45E 1.1191	35 40Mn		
2.7.4	Medium-carbon steel nuts For bolting specified under (3.7.2)	+450, +842	A 194 2HM SPE 81/002				

3. FERROUS METALS – ALLOYED

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.1 PLATES, SHEETS AND STRIP							
3.1.1	0.3 Mo steel plates For pressure-retaining parts at high service temperatures	+500, +932		EN 10028-2 16Mo3 1.5415	GB713-1997	9328-216Mo3	NOT for hydrogen service.
3.1.2	0.5 Mo steel plates For pressure-retaining parts at high service temperatures	+500, +932	A 204 A or B				
3.1.3	1 Cr - 0.5 Mo steel plates For high service temperatures and/or resistance to hydrogen attack 1)	+600, +1112	A 387 12 Class 2 2)	EN 10028-2 13CrMo4-5 1.7335	15CrMoR 3)	9328-2 14CrMo4 5	1) For resistance to hydrogen attack, see API 941. 2) To be normalised and tempered or quenched and tempered.
3.1.4	1.25 Cr - 0.5 Mo steel plates For high service temperatures and/or resistance to hydrogen attack 1)	+600, +1112	A 387 11 Class 2 5) SPE 76/221				1) For resistance to hydrogen attack, see API 941. 2) Specify to be normalised and tempered or quenched and tempered. 3) Refer to DEP 30.10.02.32-Gen. 4) Specify P 0.005% max. 5) Specify to be normalised and tempered.
3.1.5	2.25 Cr - 1 Mo steel plates For high service temperatures and/or resistance to hydrogen attack 1)	+625, +1157	A 387 22 Class 2 3)5) SPE 76/221	EN 10028-2 11CrMo9-10 1.7380 3)		9328-2 13CrMo910T 2 3)	
3.1.6	3 Cr - 1 Mo steel plates For high service temperatures requiring optimum creep resistance and/or resistance to hydrogen attack 1)	+625, +1157	A 387 21 Class 2 2) 3)				
3.1.7	5 Cr - 0.5 Mo steel plates For high service temperatures and/or resistance to sulphur corrosion	+650, +1202	A 387 5 Class 2 1) SPE 76/221				1) Specify to be normalised and tempered.
3.1.8	0.5 Ni steel plates For pressure-retaining parts at low service temperatures	(+400, +752) 1)		EN10028-4 13MnNi6-3 1.6217		9328-3 13MnNi6 3	1) For low-temperature applications, see DEP 30.10.02.31-Gen.

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.1.9	1.5 Ni steel plates For pressure-retaining parts at low service temperatures	(+400, +752) 1)		EN 10028-4 15NiMn6 1.6228		9328-3 15NiMn6	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) Specify C 0.10 % max. Si 0.30 % max. P 0.002 % max. S 0.005 % max.
3.1.10	3.5 Ni steel plates For pressure-retaining parts at low service temperatures	(+400, +752) 1)	A 203 D	EN 10028-4 12Ni14 1.5637		9328-3 12Ni14G2	
3.1.11	9 Ni steel plates For pressure-retaining parts at low service temperatures	+400,+752 1)	A 353 2) max 25 mm (0.98 in) A 553 Type I 2)	EN 10028-4 X8Ni9 1.5662 2) EN 10028-4 X8Ni9 1.5662 2)		9328-3 X8Ni9 2) 9328-3 X8Ni9 2)	
3.1.12	13 Cr steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions	+540, +1004	A 240 Type 410S S41008 1) A 240 Type 405 S40500 1) 2)	EN 10088-2 X6Cr13 1.4000 EN 10088-2 X6CrAl13 1.4002	0Cr13 1) 2) 0Cr13Al 1) 2)		1) For cladding purposes only. 2) Type 405 shall not be used above 400 °C (752 °F).
3.1.13	18 Cr-8 Ni steel plates, sheets and strip For pressure-retaining parts at low service temperatures or to prevent product contamination Plate shall be solution heat-treated	(+400, +752) 1)	A 240 Type 304 S30400 2) A 240 Type 304N S30451 2) SPE 76/222	EN 10088-2 X5CrNi18-10 1.4301 2)	0Cr18Ni9 2)	9328-5 X5CrNi18 9 2)	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2 Method A.
3.1.14	18 Cr-8 Ni steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or low and moderate service temperatures	+500, +932 1)	A 240 Type 304L S30403 2)	EN 10088-2 X2CrNi19-11 1.4306 2)	00Cr19Ni10 2)	9328-5 X2CrNi18 10 2)	

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.1.15	18 Cr-8 Ni steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or low and moderate service temperatures with increased strength	+500, +932 1)	A 240 Type 304LN S30453 2)	EN 10088-2 X2CrNiN18-10 1.4311 2)	GB 3280-92	9328-5 X2CrNiN18 10 2)	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2 Method A. 3) For optimum resistance to intergranular corrosion, specify a stabilisation heat treatment at 900 °C (1652°F), for 4 hrs, subsequent to solution heat treatment.
3.1.16	18 Cr-8 Ni stabilised steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or high service temperatures	+600, +1112	A 240 Type 321 S32100 2) 3) A 240 Type 347 S34700 2) 3) SPE 76/222	EN 10088-2 X6CrNiTi18-10 1.4541 2) 3) EN 10088-2 X6CrNiNb18-10 1.4550 2) 3)	0Cr18Ni10Ti 2) 3)	9328-5 X6CrNiTi18 10 2) 3) 9328-5 X6CrNiNb18 10 2) 3)	
3.1.17	18 Cr-10 Ni-2 Mo steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or high service temperatures Plate shall be solution heat-treated	+500, +932 1)	A 240 Type 316 S31600 2) SPE 76/200 A 240 Type 316L S31603 2)	EN 10088-2 X3CrNiMo17-13-3 1.4436 2)	0Cr17Ni12-Mo2 2) 00Cr17Ni14-Mo2 2)	9328-5 X5CrNiMo17 13 2) 9328-5 X2CrNiMo17 12 2)	
				EN 10088-2 X5CrNiMo17-12-2 1.4401 2)		9328-5 X2CrNiMo17 12 2)	
				EN 10088-2 X2CrNiMo17-12-2 1.4404 2) EN 10088-2 X2CrNiMo18-14-3 1.4435 2)		9328-5 X2CrNiMo17 3 2) 9328-5 X5CrNiMo17 12 2)	
3.1.18	18 Cr-8 Ni-2 Mo steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or low and moderate service temperatures with increased strength	+500, +932 1)	A 240 Type 316LN S31653 2)	EN 10088-2 X2CrNiMoN17-11-2 1.4406 2) EN 10088-2 X2CrNiMoN17-13-3 1.4429 2)		9328-5 X2CrNiMoN17 12 2) 9328-5 X2CrNiMoN17 13 2)	

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.1.19	18 Cr-10 Ni-2 Mo stabilised steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or high service temperatures	+500, +932	A 240 Type 316Ti S31635 1) 2) A 240 Type 316Cb S31640 1) 2)	EN 10088-2 X6CrNiMoTi17-12-2 1.4571 1) 2) EN 10088-2 X6CrNiMoNb17-12-2 1.4580 1) 2)	0Cr18Ni12-Mo2ti 1) 2)	9328-5 X6CrNiMoTi17 12 1) 2) 9328-5 X6CrNiMoNb17 12 1) 2)	1) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2 Method A. 2) For optimum resistance to intergranular corrosion, specify a stabilisation heat treatment at 900 °C (1652 °F), for 4 hrs, subsequent to solution heat treatment.
3.1.20	18 Cr-10 Ni-3 Mo steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or high service temperatures	+500, +932	A 240 Type 317 S31700 1) A 240 - Type 317L S31703 1)	EN 10088-2 X2CrNiMo18-15-4 1.4438 1)	0Cr19Ni13-Mo3 1) 00Cr19Ni13-Mo3 1)	9328-5 X3CrNiMo 18 16 4 1)	
3.1.21	25 Cr-20 Ni steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions and/or extreme service temperatures	+1000, +1832	A 240 Type 310S S31008	EN 10095 X8CrNi25-21 1.4845	GB 3280-92		
3.1.22	18 Cr-8 Ni steel plates, sheets and strip For pressure-retaining parts at extreme service temperatures under certain corrosive conditions	+700, +1292	A 240 Type 304H S30409	EN 10028-7 X6CrNi18-10 1.4948			
3.1.23	22 Cr-5 Ni-Mo-N steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions	+300, +572 1)	A 240 S31803 2) SPE 76/222	EN 10088-2 X2CrNiMoN22-5-3 1.4462			1) For low temperature applications, see DEP 30.10.02.31-Gen. 2) N 0.15 % min. 3) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2, Method A 4) Shall be subjected to ASTM G48, Method A

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.1.24	25 Cr-7 Ni-Mo-N steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions Plate shall be solution –heat treated	+300, +572 1)	A 240 S32750 2)3) SPE 76/222	EN 10088-2 X2CrNiMoN25-7-4 1.4410			1) For low temperature applications, see DEP 30.10.02.31-Gen. 2) N 0.15 % min. 3) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2, Method A 4) Shall be subjected to ASTM G48, Method A
3.1.25	20 Cr-18 Ni-6 Mo-Cu-N steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions Plate shall be solution heat-treated and water cooled	(+400, +752) 1)	A 240 S31254 4) SPE 76/222	EN 10088-2 X1CrNiMoCuN 20-18-7 1.4547			
3.1.26	Carbon steel or low-alloy steel plates with ferritic stainless steel cladding For high service temperatures and/or certain corrosive conditions	+400,+ 752	A 263 1)		GB8165 JB4733 1)		1) Specify base metal and cladding
3.1.26	22 Cr-25 Ni-6 Mo-Cu-N steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions	+400,+ 752	ASTM B688 UNS N08367 SPE 76/227	76/227			The finished items furnished to Grades UNS N08367 shall be annealed and water cooled Pickled in accordance with ASTM A380 The material shall be capable of passing the ferric chloride test in accordance of ASTM G48 Method A 1) Specify base metal and cladding
3.1.27	Carbon steel or low-alloy steel plates with austenitic stainless steel cladding For high service temperatures and/or certain corrosive conditions	+400,+ 752	A 264 1)		GB8165 JB4733 1)		
3.1.28	25 Cr-7 Ni-Mo-N steel plates, sheets and strip For pressure-retaining parts under certain corrosive conditions Plate shall be solution –heat treated	+300,+ 572	ASTM A240 uns32760 SPE 76/222				N 0.15% min Plate shall be solution heat treated Material should be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2 Method A

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.2 TUBES AND TUBING							
3.2.1	Seamless 0.5 Mo steel tubes For boilers, superheaters and unfired heat transfer equipment at high service temperatures	+500, +932	A 209 T1 1)		20MoG 1)		NOT for hydrogen service. 1) Specify total Al content 0.012 % max.
3.2.2	Seamless 1 Cr-0.5 Mo steel tubes For boilers, superheaters and unfired heat transfer equipment at high service temperatures and/or requiring resistance to hydrogen attack 1)	+600, +1112	A 213 T12 2)		15CrMo	9329-2 8CrMo4-5 2)	1) For resistance to hydrogen attack, see API 941. 2) Specify to be normalised and tempered or quenched and tempered. 3) Specify P 0.01% max.
3.2.3	Seamless 1.25 Cr-0.5 Mo steel tubes For boilers, superheaters and unfired heat transfer equipment at high service temperatures and/or requiring resistance to hydrogen attack 1)	+600, +1112	A 213 T11 2) 3)			9329-2 8CrMo5-5 2)	
3.2.4	Seamless 2.25 Cr-1 Mo steel tubes For boilers, furnaces, superheaters and unfired heat transfer equipment at high service temperatures requiring optimum creep resistance and/or resistance to hydrogen attack 1)	+625, +1157	A 213 T22 2) 3)		12Cr2Mo 3)	9329-2 11CrMo9-10 2) 3)	
3.2.5	Seamless 5 Cr-0.5 Mo steel tubes For high service temperatures and/or resistance to sulphur corrosion, e.g. furnace tubes	+650, +1202	A 213 T5 2)			9329-2 X11CrMo5 2)	
3.2.6	Seamless 9 Cr-1 Mo steel tubes For high service temperatures and/or resistance to sulphur corrosion, e.g. furnace tubes	+650, +1202	A 213 T9 1)			9329-2 X11CrMo9-1 1)	1) Specify to be normalised and tempered or quenched and tempered.

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.2.7	Seamless 3.5 Ni steel tubes For low service temperatures	(+400, +752) 1)				9329-3 12Ni14	1) For low-temperature applications, see DEP 30.10.02.31-Gen.
3.2.8	Seamless 9 Ni steel tubes	+400, +752 1)				9329-3 X10Ni9	
3.2.9	Seamless 12 Cr steel tubes For unfired heat transfer equipment under certain corrosive conditions	+540, +1004	A 268 TP 405 S40500 1) or A 268 TP 410S S41008 2)		0Cr13		1) TP 405 not to be used above 400°C (752°F). 2) Composition in accordance with ASTM A240 Type 410S. All requirements of A268 shall be fulfilled.
3.2.10	Seamless and welded 18 Cr-10 N-2 Mo steel tubes For certain general applications	+500, +932	A 269 TP 316 S31600 1) or A 269 TP 316L S31603 1)		0Cr17Ni12-Mo2 0Cr17Ni14-Mo2	9329-4 X5CrNiMo17 12 1) 9329-4 X2CrNiMo17 12 1)	1) For tubes intended for use with compression fittings, hardness shall not exceed 90 HRB.
3.2.11	Welded 18 Cr-8 Ni steel tubes For superheaters and unfired heat transfer equipment to prevent product contamination or for low service temperatures	(+400, +752) 1)	A 249 TP 304 S30400 2) 3) 4) A 249 TP 304L S30403 2) 3) 4)		0Cr18Ni9 00Cr19Ni10	2604 - 5 TW 47 - LWHT 3) 4) 2604-5 TW46-LWHT 3) 4)	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) The tubes are welded without the addition of filler metal, so the inside diameter and wall thickness of the tubes are restricted to DN100 (NPS 4) max. and 5.5 mm (0.22 in) max., respectively. 3) A non-destructive electric test (in accordance with the materials specification) shall be carried out in addition to the hydrostatic test. 4) The material shall be capable of passing intergranular corrosion test ASTM A262 Practice E or ISO 3651-2 Method A.
3.2.12	Welded 18 Cr-8 Ni stabilised steel tubes For superheaters and unfired heat transfer equipment under certain corrosive conditions	+600, +1112	A 249 TP 321 S32100 2) 3) 4) A 249 TP 347 S34700 2) 3) 4)		0Cr18Ni10Ti 0Cr18Ni11Nb	2604-5 TW53-LWHT 3) 4) 2604-5 TW50-LWHT 3) 4)	
3.2.13	Welded 18 Cr-10 Ni-2 Mo steel tubes For superheaters and unfired heat transfer equipment under certain corrosive conditions	+500, +932 1)	A 249 TP 316 S31600 2) 3) 4) A 249 TP 316L S31603 2) 3) 4)		0Cr17Ni12-Mo2 00Cr17Ni14-Mo2	2604-5 TW60-LWHT 3) 4) 2604-5 TW57-LWHT 3) 4)	
3.2.14	Welded 20 Cr-18 Ni-6 Mo Cu-N steel tubes For superheaters and unfired heat transfer equipment under certain corrosive conditions	(+400, +752)	A 249 S 31254 2) 3)				

	Designation and Application	Metal Temp., °C, °F (See 1.10)	ASTM	CEN	GB (CHINA)	ISO	Remarks
3.2.15	Seamless 18 Cr-8 Ni steel tubes For unfired heat transfer equipment to prevent product contamination or for low service temperatures	+400, +752 1)	A 213 TP 304 S30400 2) A 213 TP 304L S30403 2)		0Cr18Ni9 2) 00Cr19Ni10 2)	9329-4 X5CrNi18 9 2) 9329-4 X2CrNi18 10 2)	1) For low-temperature applications, see DEP 30.10.02.31-Gen. 2) The material shall be capable of passing intergranular corrosion test
3.2.16	Seamless 18 Cr-8 Ni stabilised steel tubes For superheaters and unfired heat transfer equipment under certain corrosive conditions and/or at high service temperatures	+600, +1112	A 213 TP 321 S32100 2) 3) 4) A 213 TP 347 S34700 2) 3) 4)		0Cr18Ni10Ti 3) 0Cr18Ni11Nb 3)	9329-4 X6CrNiTi18 10 2) 3) 9329-4 X6CrNiNb18 10 2) 3)	3) For optimum resistance to intergranular corrosion, specify a stabilisation heat treatment at 900°C (1652°F), for 4 hrs, subsequent to solution heat treatment. 4) For solution heat treatment and stabilization heat treatment of U-bends on SS 321 and SS 347 tubes, please contact Principal. (applicable to all SS 321, 347 tubes)
3.2.17	Seamless 18 Cr-8 Ni steel tubes For boilers, superheaters and unfired heat transfer equipment at extreme service temperatures under certain corrosive conditions	+815, +1499	A 213 TP 304H S30409				2) The use of this grade is subject to agreement of the Principal.
3.2.18	Seamless 18 Cr-8 Ni stabilised steel tubes For boilers, superheaters and unfired heat transfer equipment at extreme service temperatures under certain corrosive conditions	+815, +1499	A 213 TP 321H S32109 2) A 213 TP 347H S34709 2)		321S51 2)		