



BSI Standards Publication

Oil and gas industries including lower carbon energy — Piping systems on offshore platforms and onshore plants

Part 2: Materials

National foreword

This British Standard is the UK implementation of EN ISO 13703-2:2023. It is identical to ISO 13703-2:2023.

The UK participation in its preparation was entrusted to Technical Committee PSE/17/-/6, Processing equipment and systems for petroleum and natural gas industries.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Piping systems on offshore platforms and onshore plants -
Part 2: Materials (ISO 13703-2:2023)

Industries du pétrole et du gaz, y compris les énergies
à faible teneur en carbone - Conception et installation
des systèmes de tuyauterie sur les plates-formes de
production en mer et les installations à terre - Partie 2:
Matériels (ISO 13703-2:2023)

Erdöl- und Erdgasindustrie - Rohrleitungssysteme auf
Offshore-Förderplattformen und Onshore-Anlagen -
Teil 2: Rohrleitungswerkstoff (ISO 13703-2:2023)

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN ISO 13703-2:2023) has been prepared by Technical Committee ISO/TC 67 "Oil and gas industries including lower carbon energy" in collaboration with Technical Committee CEN/TC 12 "Oil and gas industries including lower carbon energy" the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2024, and conflicting national standards shall be withdrawn at the latest by April 2024.

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Endorsement notice

The text of ISO 13703-2:2023 has been approved by CEN as EN ISO 13703-2:2023 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 6, *Process equipment, piping, systems, and related safety*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Oil and gas industries including lower carbon energy*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 13703-2, together with ISO 13703-1 and ISO 13703-3, cancels and replaces ISO 13703:2000, which has been technically revised. It also incorporates the Technical Corrigendum ISO 13703:2000/Cor.1:2002.

The main changes compared to the previous edition are as follows:

- deletion of the installation and quality control requirements in Clause 10;
- deletion of former Annex C as requirements are addressed in ASME B31.3;
- addition of material data sheets.

A list of all parts in the ISO 13703 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Requirements are defined in material datasheets and element datasheets, which can be used for the specification and procurement of materials for piping systems. Common fabrication, welding, inspection, examination and testing requirements of piping systems are covered by ISO 13703-3.

Local, national or regional regulations can also affect the specification of piping materials.

Oil and gas industries including lower carbon energy — Piping systems on offshore platforms and onshore plants —

Part 2: Materials

1 Scope

This document provides a set of common supplementary requirements for the most frequently used materials in upstream oil and gas piping systems.

This document is applicable to offshore and onshore production facilities, processing and gas liquefaction plants. The materials covered in this document are intended to be used in the following piping systems services:

- category D, category M, normal and high pressure, according to ASME B31.3;
- sour environments as defined in the ISO 15156 series.

NOTE For the purposes of this document, ANSI/NACE MR0175 is equivalent to the ISO 15156 series, and ANSI/NACE MR0103 is equivalent to ISO 17945.

This document does not provide guidelines for material selection. The selection of suitable materials for a specific service including any necessary additional material requirements remains the responsibility of the end user.

This document does not cover requirements related to:

- sulfide stress cracking (SSC) in corrosive petroleum refining environments included in ISO 17945;
- non-metallic piping systems according to ASME B31.3 or the ISO 14692 series;
- marine piping systems, e.g. ballasting piping system, covered by classification rules;
- subsea production systems;
- downhole equipment;
- transportation pipeline systems, including flowlines, designed in accordance with a recognized pipeline design code.

Common requirements related to manufacture, inspection and procurement of piping and valve parts are included in [Annex A](#) and [Annex B](#), providing material datasheets and element datasheets, respectively. These material and element datasheets can be applied for applications other than piping systems, e.g. pressure vessels and pumps based upon assessment of the end user and conformance with the selected design code for the relevant equipment. This document is not intended to limit the use of alternative materials or grades within a referenced material standard. Where the use of alternative materials/grades are considered appropriate, the end user is responsible for specifying any additional requirements necessary to meet the design code or specification.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3452 (all parts), *Non-destructive testing — Penetrant testing*

ISO 4499-2, *Hardmetals — Metallographic determination of microstructure — Part 2: Measurement of WC grain size*

ISO 4499-4, *Hardmetals — Metallographic determination of microstructure — Part 4: Characterisation of porosity, carbon defects and eta-phase content*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 9606, *Qualification testing of welders — Fusion welding*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 10684, *Fasteners — Hot dip galvanized coatings*

ISO 10893-11, *Non-destructive testing of steel tubes — Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 11970, *Specification and qualification of welding procedures for production welding of steel castings*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 15614-5, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 5: Arc welding of titanium, zirconium and their alloys*

ISO 15614-7, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 7: Overlay welding*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17781, *Petroleum, petrochemical and natural gas industries — Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels*

ISO 17782, *Petroleum, petrochemical and natural gas industries — Scheme for conformity assessment of manufacturers of special materials*

ISO 27509, *Petroleum and natural gas industries — Compact flanged connections with IX seal ring*

ISO 28079, *Hardmetals — Palmqvist toughness test*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ANSI/MSS SP-55, *Quality standard for steel castings for valves, flanges, fittings, and other piping components - visual method for evaluation of surface irregularities*

ANSI/NACE TM0284, *Evaluation of pipeline and pressure vessel steels for resistance to hydrogen-induced cracking*

ANSI/NACE MR0175, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

API RP 934-A, *Materials and fabrication of 2 1/4 Cr-1Mo, 2 1/4 Cr-1Mo 1/4 v, 3Cr-1Mo, and 3Cr-1Mo-1/4 V steel heavy wall pressure vessels for high-temperature, high pressure Hydrogen service*

API RP 934-C, *Materials and fabrication of 1 1/4 Cr-1/2 Mo steel heavy wall pressure vessels for high-pressure Hydrogen service operating at or below 825 degrees F (440 degrees C)*

API Spec 5L, *Specification for line pipe*

API Std 6ACRA, *Age-hardened Nickel-based alloys for oil and gas drilling and production equipment*

ASME B16.20, *Metallic gaskets for pipe flanges*

ASME B16.34, *Valves – Flanged, threaded and welding end*

ASME B31.3, *Process piping*

ASME Boiler and pressure vessel code (BPVC), Section V: *Nondestructive examination*

ASME Boiler and pressure vessel code (BPVC), Section VIII, Division 1: *Rules for construction of pressure vessels*

ASME Boiler and pressure vessel code (BPVC), Section VIII, Division 2: *Alternative rules*

ASME Boiler and pressure vessel code (BPVC), Section VIII, Division 3: *Alternative rules for high pressure vessels*

ASME Boiler and pressure vessel code (BPVC), Section IX: *Welding and brazing qualifications*

ASTM A20/A20M, *Standard specification for general requirements for steel plates for pressure vessels*

ASTM A29/A29M, *Standard specification for general requirements for steel bars, Carbon and alloy, hot-wrought*

ASTM A105/A105M, *Standard specification for Carbon steel forgings for piping applications*

ASTM A106/A106M, *Standard specification for seamless Carbon steel pipe for high-temperature service*

ASTM A182/A182M, *Standard specification for forged or rolled alloy and stainless Steel pipe flanges, forged fittings, and valves and parts for high-temperature service*

ASTM A193/A193M, *Standard specification for alloy-steel and stainless steel bolting for high temperature or high pressure service and other special purpose applications*

ASTM A194/A194M, *Standard specification for Carbon steel, alloy steel, and stainless steel nuts for bolts for high pressure or high temperature service, or both*

ASTM A203/A203M, *Standard specification for pressure vessel plates, alloy steel, Nickel*

ASTM A216/A216M, *Standard specification for steel castings, Carbon, suitable for fusion welding, for high-temperature service*

ASTM A217/217M, *Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service*

ASTM A234/A234M, *Standard specification for piping fittings of wrought Carbon steel and alloy steel for moderate and high temperature service*

ASTM A240/A240M, *Standard specification for Chromium and Chromium-Nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications*

ASTM A269/A269M, *Standard specification for seamless and welded austenitic stainless steel tubing for general service*

ASTM A276/A276M, *Standard specification for stainless steel bars and shapes*

ASTM A312/A312M, *Standard specification for seamless, welded, and heavily cold worked austenitic stainless steel pipes*

ASTM A320/A320M, *Standard specification for alloy-steel and stainless steel bolting for low-temperature service*

ASTM A333/A333M, *Standard specification for seamless and welded steel pipe for low-temperature service and other applications with required notch toughness*

ASTM A334/A334M, *Standard specification for seamless and welded Carbon and alloy-steel tubes for low-temperature service*

ASTM A335/A335M, *Standard specification for seamless Ferritic alloy-steel pipe for high-temperature service*

ASTM A350/A350M, *Standard specification for Carbon and low-alloy steel forgings, requiring notch toughness testing for piping components*

ASTMA351/A351M, *Standard specification for castings, austenitic, for pressure-containing parts*

ASTM A352/A352M, *Standard specification for steel castings, ferritic and martensitic, for pressure-containing parts, suitable for low-temperature service*

ASTM A358/A358M, *Standard specification for electric-fusion-welded austenitic Chromium-Nickel stainless steel pipe for high-temperature service and general applications*

ASTM A363, *Standard specification for Zinc-coated (galvanized) steel overhead ground wire strand*

ASTM A370, *Standard test methods and definitions for mechanical testing of steel products*

ASTM A387/A387M, *Standard specification for pressure vessel plates, alloy steel, Chromium-Molybdenum*

ASTM A388/A388M, *Standard practice for ultrasonic examination of steel forgings*

ASTM A403/A403M, *Standard specification for wrought austenitic stainless steel piping fittings*

ASTM A420/A420M, *Standard specification for piping fittings of wrought Carbon steel and alloy steel for low-temperature service*

ASTM A453/A453M, *Standard specification for high-temperature bolting, with expansion coefficients comparable to austenitic stainless steels*

ASTM A479/A479M, *Standard specification for stainless steel bars and shapes for use in boilers and other pressure vessels*

ASTM A484/A484M, *Standard specification for general requirements for stainless steel bars, billets, and forgings*

ASTM A488/A488M, *Standard practice for steel castings, welding, qualifications of procedures and personnel*

ASTM A494/A494M, *Standard specification for castings, Nickel and Nickel alloy*

ASTM A508/A508M, *Standard specification for quenched and tempered vacuum-treated Carbon and alloy steel forgings for pressure vessels*

ASTM A516/A516M, *Standard specification for pressure vessel plates, Carbon steel, for moderate- and lower-temperature service*

ASTM A564/A564M, *Standard specification for hot-rolled and cold-finished age-hardening stainless steel bars and shapes*

ASTM A578/A578M, *Standard specification for straight-beam ultrasonic examination of rolled steel plates for special applications*

ASTM A671/A671M, *Standard specification for electric-fusion-welded steel pipe for atmospheric and lower temperatures*

ASTM A672/A672M, *Standard specification for electric-fusion-welded steel pipe for high-pressure service at moderate temperatures*

ASTM A691/A691M, *standard specification for Carbon and alloy steel pipe, electric-fusion-welded for high-pressure service at high temperatures*

ASTM A694/A694M, *Standard specification for Carbon and alloy steel forgings for pipe flanges, fittings, valves, and parts for high-pressure transmission service*

ASTM A696, *Standard specification for steel bars, Carbon, hot-wrought or cold-finished, special quality, for pressure piping components*

ASTM A703/A703M, *standard specification for steel castings, creep-strength enhanced ferritic alloy, for pressure-containing parts, suitable for high temperature service*

ASTM A705/A705M, *Standard specification for age-hardening stainless steel forgings*

ASTM A739, *Standard specification for steel bars, alloy, hot-wrought, for elevated temperature or pressure-containing parts, or both*

ASTM A781/A781M, *Standard specification for castings, steel and alloy, common requirements, for general industrial use*

ASTM A788/A788M, *Standard specification for steel forgings, general requirements*

ASTM A789/A789M, *Standard specification for seamless and welded ferritic/austenitic stainless steel tubing for general service*

ASTM A790/A790M, *Standard specification for seamless and welded ferritic/austenitic stainless steel pipe*

ASTM A815/A815M, *Standard specification for wrought ferritic, ferritic/austenitic, and martensitic stainless steel piping fittings*

ASTM A860/A860M, *Standard specification for wrought high-strength ferritic steel butt-welding fittings*

ASTM A928/A928M, *Standard specification for ferritic/austenitic (duplex) stainless steel pipe electric fusion welded with addition of filler metal*

ASTM A957/A957M, *Standard specification for investment castings, steel and alloy, common requirements, for general industrial use*

ASTM A960/A960M, *Standard specification for common requirements for wrought steel piping fittings*

ASTM A961/A961M, *Standard specification for common requirements for steel flanges, forged fittings, valves, and parts for piping applications*

ASTM A962/A962M, *Standard specification for common requirements for bolting intended for use at any temperature from cryogenic to the creep range*

ASTM A966/A966M, *Standard practice for magnetic particle examination of steel forgings using alternating current*

ASTM A985/A985M, *Standard specification for steel investment castings general requirements, for pressure-containing parts*

ASTM A988/A988M, *Standard specification for hot isostatically-pressed stainless steel flanges, fittings, valves, and parts for high temperature service*

ASTM A995/995M, *Standard specification for castings, austenitic-ferritic (duplex) stainless steel, for pressure-containing parts*

ASTM A1058, *Standard Test Methods for Mechanical Testing of Steel Products — Metric*

ASTM A1080/A1080M, *Standard practice for hot isostatic pressing of steel, stainless steel, and related alloy castings*

ASTM A1082/A1082M, *Standard specification for high strength precipitation hardening and duplex stainless steel bolting for special purpose applications*

ASTM B124/B124M, *Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes*

ASTM B148, *Standard specification for Aluminum-Bronze sand castings*

ASTM B150/150M, *Standard Specification for Aluminum Bronze Rod, Bar, and Shapes*

ASTM B151/B151M, *Standard specification for Copper-Nickel-Zinc alloy (Nickel Silver) and Copper-Nickel rod and bar*

ASTM B171/B171M, *Standard specification for Copper-alloy plate and sheet for pressure vessels, condensers, and heat exchangers*

ASTM B265, *Standard specification for Titanium and Titanium alloy strip, sheet, and plate*

ASTM B338, *Standard specification for seamless and welded Titanium and Titanium alloy tubes for condensers and heat exchangers*

ASTM B348, *Standard specification for Titanium and Titanium alloy bars and billets*

ASTM B363, *Standard specification for seamless and welded unalloyed Titanium and Titanium alloy welding fittings*

ASTM B366/B366M, *Standard specification for factory-made wrought Nickel and Nickel alloy fittings*

ASTM B367, *Standard specification for Titanium and Titanium alloy castings*

ASTM B381, *Standard specification for Titanium and Titanium alloy forgings*

ASTM B423, *Standard Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloy Seamless Pipe and Tube*

ASTM B424, *Standard Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloys Plate, Sheet, and Strip*

ASTM B425, *Standard Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloys Rod and Bar*

ASTM B443, *Standard specification for Nickel-Chromium-Molybdenum-Columbium alloy and Nickel-Chromium-Molybdenum-Silicon alloy plate, sheet, and strip*

ASTM B444, *Standard specification for Nickel-Chromium-Molybdenum-Columbium alloys (UNS N06625 and UNS N06852) and Nickel-Chromium-Molybdenum-Silicon alloy (UNS N06219) pipe and tube*

ASTM B446, *Standard specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten alloy (UNS N06650) rod and bar*

ASTM B499, *Standard test method for measurement of coating thicknesses by the magnetic method: nonmagnetic coatings on magnetic basis metals*

ASTM B564, *Standard specification for Nickel alloy forgings*

- ASTM B571, *Standard practice for qualitative adhesion testing of metallic coatings*
- ASTM B578, *Standard test method for microhardness of electroplated coatings*
- ASTM B602, *Standard test method for attribute sampling of metallic and inorganic coatings*
- ASTM B637, *Standard specification for precipitation-hardening and cold worked Nickel alloy bars, forgings, and forging stock for moderate or high temperature service*
- ASTM B705, *Standard specification for Nickel-alloy (UNS N06625, N06219 and N08825) welded pipe*
- ASTM B733, *Standard specification for autocatalytic (electroless) Nickel-Phosphorus coatings on metal*
- ASTM B834, *Standard specification for pressure consolidated powder metallurgy Iron-Nickel-Chromium-Molybdenum (UNS N08367), Nickel-Chromium-Molybdenum-Columbium (Nb) (UNS N06625), Nickel-Chromium-Iron alloys (UNS N06600 and N06690), and Nickel-Chromium-Iron-Columbium-Molybdenum (UNS N07718) alloy pipe flanges, fittings, valves, and parts*
- ASTM B861, *Standard specification for Titanium and Titanium alloy seamless pipe*
- ASTM B862, *Standard specification for Titanium and Titanium alloy welded pipe*
- ASTM C633, *Standard test method for adhesion or cohesion strength of thermal spray coatings*
- ASTM E8/E8M, *Standard test methods for tension testing of metallic materials*
- ASTM E94/E94M, *Standard guide for radiographic examination using industrial radiographic film*
- ASTM E112, *Standard test methods for determining average grain size*
- ASTM E165/E165M, *Standard practice for liquid penetrant testing for general industry*
- ASTM E186, *Standard reference radiographs for heavy-walled (2 to 412 in. (50,8 to 114 mm)) steel castings*
- ASTM E280, *Standard reference radiographs for heavy-walled (412 to 12 in. (114 to 305 mm)) steel castings*
- ASTM E446, *Standard reference radiographs for steel castings up to 2 in. (50,8 mm) in thickness*
- ASTM F467/F467M, *Standard specification for nonferrous nuts for general use*
- ASTM F468/F468M, *Standard specification for nonferrous bolts, hex cap screws, socket head cap screws, and studs for general use*
- ASTM F788/F788M, *Standard specification for surface discontinuities of bolts, screws, studs, and rivets, inch and metric series*
- ASTM F812, *Standard specification for surface discontinuities of nuts, inch and metric series*
- ASTM F2329/F2329M, *Standard specification for Zinc coating, hot-dip, requirements for application to Carbon and alloy steel bolts, screws, washers, nuts, and special threaded fasteners*
- ASTM G28, *Standard Test Methods for Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys*
- ASTM G48, *Standard test methods for pitting and crevice corrosion resistance of stainless steels and related alloys by use of ferric chloride solution*
- EEMUA 234, *90/10 Copper nickel alloy piping for offshore applications*
- EN 10204, *Metallic products — Types of inspection documents*
- EN 10228-4:2016, *Non-destructive testing of steel forgings - Part 4: Ultrasonic testing of austenitic and austenitic-ferritic stainless steel forgings*

MSS SP-93-2020, *Quality standard for steel castings and forgings for valves, flanges, fittings, and other piping components — Liquid penetrant examination method*

MSS SP-147, *Quality standard for steel castings used in standard class steel valves — sampling method for evaluating casting quality*

NORSOK M-650, *Qualification of manufacturers of special materials*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

austenitic stainless steel

stainless steel whose microstructure at room temperature consists predominantly of austenite

3.2

carbon steel

alloy of carbon and iron containing up to 2 % mass fraction carbon and up to 1,65 % mass fraction manganese and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminium)

Note 1 to entry: Carbon steels used in the petroleum industry usually contain less than 0,8 % mass fraction carbon.

3.3

end user

organization that is responsible for the operation of an installation/facility and its component (e.g. piping, valve)

Note 1 to entry: In the context of this document, the end user is normally an oil and gas company.

3.4

low alloy steel

steel containing a total alloying element content of less than 5 % mass fraction, or less than 10,5 % mass fraction chromium, but more than that specified for *carbon steel* (3.2)

3.5

manufacturer

organization, including subcontractors, which carries out operations (e.g. forming, heat treatment, welding) that affect the material properties of the finished product

3.6

nickel-based alloys

metallic material in which nickel is the major element

3.7

pilot casting

casting made and tested as part of the initiation and development of the production method such as the first casting from a new or modified pattern produced using identical foundry practices as the production castings it is intended to represent

3.8**purchaser**

organization that purchases a product from a *manufacturer* (3.5)

Note 1 to entry: A purchaser can be an oil and gas company, a contractor or a buyer.

3.9**stainless steel**

steel containing 10,5 % mass fraction or more chromium, possibly with other elements added to secure special properties

3.10**austenitic stainless steel type 304**

austenitic stainless steel (3.1) certified to meet both 304/304L properties

3.11**austenitic stainless steel type 316**

austenitic stainless steel (3.1) certified to meet both 316/316L properties

3.12**austenitic stainless steel type UNS S34565**

highly alloyed *austenitic stainless steel* (3.1) alloys with SMYS ≥ 450 MPa and PREN ≥ 40

3.13**austenitic stainless steel type 6Mo**

highly alloyed *austenitic stainless steel* (3.1) alloys with 6 % Mo and PREN $\geq 40,0$

3.14**ferritic-austenitic stainless steel type 22Cr duplex**

ferritic-austenitic stainless steel alloys with $30,0 \leq \text{PREN} < 40,0$ and Cr ≥ 19 % (by mass)

3.15**ferritic-austenitic stainless steel type 25Cr duplex**

ferritic-austenitic stainless steel alloys with $40,0 \leq \text{PREN} < 48,0$

Note 1 to entry: Stainless steel type 25Cr duplex is often referred to as "super duplex".

3.16**ferritic-austenitic stainless steel type lean duplex**

ferritic-austenitic stainless steel alloys with PREN ≥ 28

Note 1 to entry: In this document, stainless steel type lean duplex concerns UNS numbers S32003, S32304 and S82441.

4 Abbreviated terms

ANSI	American National Standards Institute
AOD	argon oxygen decarburization
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
ASME	American Society of Mechanical Engineers
BPVC	boiler and pressure vessel code

CE	carbon equivalent, , calculated as follows: $(\% \text{ C} + \% \text{ Mn} / 6 + (\% \text{ Cr} + \% \text{ Mo} + \% \text{ V}) / 5 + (\% \text{ Ni} + \% \text{ Cu}) / 15)$, with chemical element concentration expressed in mass fraction percent
CLR	crack length ratio
CSR	crack sensitivity ratio
CTR	crack thickness ratio
DN	nominal diameter
EBW	electron beam welding
EDS	element data sheet
EEA	European Economic Area
FCAW	flux-cored arc welding
GTAW	gas tungsten arc welding
EEMUA	Engineering Equipment & Materials Users Association
EN	European standard
HAZ	heat-affected zone
HBW	Brinell hardness with Tungsten ball
HFW	high frequency welded
HIC	hydrogen-induced cracking
HIP	hot isostatic pressing
HR	Rockwell hardness
HRB	Rockwell hardness, B scale
HRC	Rockwell hardness, C scale
HV	Vickers hardness
HVAF	high velocity air fuel
HVOF	high velocity oxygen fuel
ISO	International Organization for Standardization
LBW	laser beam welding
MDS	material data sheet
MPCR	manufacturing procedure conformity record
MPS	manufacturing procedure summary
MSS	Manufacturers Standardization Society
MT	magnetic particle testing

NACE	National Association of Corrosion Engineers
NDT	non-destructive testing
NORSOK	the Norwegian shelf's competitive position
NPS	nominal pipe size
OD	outer diameter
PED	Pressure Equipment Directive (European Directive 2014/68/EU)
PREN	pitting resistance equivalent number, calculated as follows: $(\%Cr + 3,3 \times \% (Mo + 0,5W) + 16 \times \%N)$, with chemical element concentration expressed in mass fraction percent
PSL	product specification level
PT	penetrant testing
PTAW	plasma transfer arc welding
PWHT	post weld heat treatment
QL	quality level
QTR	qualification test record
RT	radiographic testing
SAW	submerged arc welding
SAWL	submerged arc longitudinally welded
SMAW	shielded-metal arc welding
SMYS	specified minimum yield strength
SSC	sulfide stress cracking
UNS	unified numbering system
UT	ultrasonic testing
VT	visual testing
WC	Tungsten carbide

5 Material and element datasheets

5.1 General

The material datasheets are collated in [Annex A](#). Each MDS defines the requirements that supplement or amend the referenced material standard or specification. The material shall be delivered in accordance with the standard specification referenced in the MDS including any additional requirements specified therein. Unless otherwise specified in the MDS, all the requirements of the referenced standard specification shall be applied.

MDSs for welded parts specifying acceptance classes give weld joint quality factors ranging from 0,8 to 1,0 according to ASME B31.3. The required class shall be specified on the piping class sheet. The purchase order shall specify acceptable class for each relevant item.

The element datasheets are included in [Annex B](#). Each EDS defines the requirements for special processes and parts used in connection with manufacturing and/or assembly of piping and valves. Processes and parts shall conform with the requirement specified in the EDS in [Annex B](#).

5.2 Numbering system

Each MDS number consists of a one-letter prefix indicating the material type and a three-digit sequential number. The following one-letter prefixes apply:

- C – carbon steels;
- D – ferritic austenitic stainless steels (duplex stainless steels);
- K – copper-nickel alloy 90-10 and other copper alloys including nickel-aluminium bronze;
- L – nickel alloyed steel;
- M – martensitic stainless steel;
- N – nickel-based alloys;
- R – highly alloyed austenitic stainless steels;
- S – austenitic stainless steels;
- T – titanium;
- V – Cr and Cr-Mo alloyed steels;
- X – high strength low alloy steels.

The supplementary suffix “S” is used to designate a material delivered in accordance with the MDS plus the supplementary requirements for sour service but excluding HIC testing.

The supplementary suffix “SH” is used to designate a material conforming with the MDS including the supplementary requirements for sour service plus HIC testing and UT examination, where applicable to the material and product form.

An MDS designated with supplementary suffix “S” or “SH” also satisfies all the MDS requirements for general, non-sour service.

The supplementary suffix “K” is used to designate material suitable for hydrogen service at elevated temperature.

The supplementary suffix “L” is used to designate material with lower impact testing temperature than the original MDS.

The EDS number consists of the three-letter prefix “EDS” and a two-digit sequential number.

5.3 Deviations to ASME B31.3

The use of the MDSs in this document can result in deviations from ASME B31.3. All identified deviations have been carefully considered and are regarded as industry standard. The following deviations are identified:

- the thickness for requiring impact testing is specified to be ≥ 6 mm;
- if sub-size Charpy V-notch impact test specimens are used, the test temperature is not reduced;

NOTE 1 Instead of reduction in test temperature, the specified absorbed energy value is increased compared to ASME B31.3, and the reduction factors for sub-size specimens are modified to be: 7,5 mm - 5/6 and 5 mm - 2/3.

- eddy current testing is accepted as replacement for spot radiography of longitudinal welds in type 6Mo stainless steel pipes for wall thickness less than 4,0 mm;
- thin walled (thickness up to 7,11 mm) longitudinal welded pipes in type 6Mo are accepted in the as welded condition, provided the plate material used is solution annealed.
- HFW pipe according to API Spec 5L is allowed as an equal alternative to SAWL with automated ultrasonic and/or electromagnetic testing of the weld.

In general, the MDSs have supplementary requirements beyond the product standard to ensure a safe use of the material grades.

5.4 High pressure systems according to ASME B31.3

Materials for high pressure systems shall conform to the requirements in ASME B31.3. MDSs for selected piping materials have been included in [Clause A.3](#). The following requirements have been added to the high pressure MDSs:

- a) All pipe and fittings shall be in heat-treated condition, i.e. normalized, normalized and tempered, quenched and tempered, annealed or solution annealed.
- b) Impact test specimens shall be oriented in the transverse direction, where possible, and energy values shall be aligned with ASME B31.3.
- c) Impact testing at -46 °C is included with reduction factors for sub-size specimens: 7,5 mm - 5/6 and 5 mm - 2/3.
- d) Ultrasonic testing of base material of longitudinal welded pipes for longitudinal defects.
- e) Ultrasonic testing of forgings with thickness above 50 mm as described in [5.5](#).
- f) NDT of the pipe base material is carried out according to ASME BPVC VIII Div. 3 instead of according to ASME B31.3.

5.5 Parts designed to ASME BPVC VIII Div. 2

The material test requirements of parts shall be in accordance with BPVC VIII Div. 2 for pressure design even if the part is intended to be used in piping systems assembled according to ASME B31.3 normal service or another code with less stringent requirements than the actual design code for the parts.

ASME BPVC VIII Div. 2 specifies that carbon steel and low alloyed steel must be impact tested and the impact test specimens may be oriented longitudinally and transverse, respectively, provided that the shape and size of part permit the removal of transverse specimens. The minimum absorbed impact energy requirement is made dependent of SMYS and section thickness.

All parts designed to ASME BPVC VIII Div. 2 shall be ultrasonically tested if the section thickness is 50 mm or above in nominal thickness.

The MDSs listed in [Annex A](#) are not considered in conformance with the requirements of ASME BPVC VIII Div. 2.

5.6 Qualification of manufacturers to ISO 17782 or NORSOK M-650

Existing qualifications signed off in conformance with ISO 17782 or NORSOK M-650 with test scope and requirements to other user specifications or standards, such as NORSOK M-630, IOGP S-563, or IOSS P201-1, IOSS P201-2 and IOSS P201-3 are permitted subject to end user's acceptance. Production testing shall be carried out in accordance with the MDSs in this document.

5.7 Machining of valves or valve parts from bar

When allowed by the product standard specification, hollow cylindrically shaped parts, including valve bodies with weld-end or integral flanges, and pressure-controlling parts of valves, may be manufactured from cylindrically shaped bars, provided the requirements in the relevant MDS are met in full.

5.8 NDT of piping and valves

Where MDSs specify NDT requirements, these requirements describe the minimum level of NDT that shall be performed at the material manufacturing stage.

NDT of fabricated piping systems are covered by ISO 13703-3 and not included in the MDSs in this document.

Additional NDT can be required for valve parts when this is specified by the purchaser in the valve data sheet or purchase order documentation. For details of any additional NDT requirements for finished valve parts or piping assembly, reference shall be made to the applicable valve specification or piping fabrication specification.

Where the MDS does not specify additional NDT requirements, the relevant material standard shall apply. At least one item per lot shall be examined if a frequency of inspection less than 100 % is specified. If defects outside the acceptance criteria are detected, two or more items from the same lot shall be tested. If any of these two tests fails, all items in the lot shall be examined.

5.9 Pilot castings

5.9.1 General

The casting foundry/m manufacturer shall produce a pilot casting prior to the production of castings, in accordance with MSS SP-147.

The pilot casting may be taken from the first production order of castings, subject to purchaser approval. Acceptance of a production casting as pilot casting shall require that NDT conforms with the requirements for pilot casting and all testing specified in the MDS for production casting shall be met.

5.9.2 Material qualification ranges for pilot castings

A new pilot casting shall be produced when the casting material is outside the qualification ranges given in [Table 1](#).

Table 1 — Pilot casting material qualification ranges

Pilot casting material type	Qualification range for pilot casting material
Carbon steel	All grades of carbon steel and low alloyed steel
Low-alloy steel	All grades of carbon steel and low alloyed steel
Martensitic stainless steel	All grades of martensitic stainless steel
Austenitic stainless steel	All grades of austenitic stainless steel except super austenitic including 6Mo and Nickel-based alloys
22Cr and 25Cr duplex stainless steel	All grades of 22Cr and 25Cr duplex stainless steel
6Mo or super austenitic stainless steel	All grades of 6Mo and super austenitic stainless steel
Nickel-based alloys	All nickel-based alloys
Titanium (un-alloyed)	All un-alloyed grades of titanium
Nickel-Aluminium bronze	All grades of Nickel-Aluminium bronze

5.9.3 NDT of pilot castings

All pilot castings shall be evaluated by the foundry/manufacturer prior to any weld repairs.

After preparing/dressing the surface, all accessible internal and external surfaces of the pilot casting shall be inspected by VT, RT and PT or MT. Defects that can lead to masking of any possible volumetric defects shall be repaired prior to RT. The repair may involve grinding and welding. If welding is performed, the excavations shall be tested, documented by photographs and mapped with actual dimensions.

The extent of volumetric testing shall be in accordance with the applicable MDS. The acceptance criteria shall be as stated in the applicable MDS, unless agreed otherwise with the end user.

Dimensional inspection shall be in accordance with the casting design drawing.

A pilot casting that fails to conform with the requirements of the MDS shall be rejected or repaired to the extent found acceptable to foundry/manufacturer and end user. Corrective actions shall be implemented by the foundry/manufacturer. If deemed necessary, a new pilot casting shall be made to confirm effectiveness of the corrective actions.

Upon completion of all required testing, the documentation for the pilot casting shall be retained and be available for review at the casting foundry/manufacturer.

5.10 Ferritic-austenitic stainless steels

The compositional and microstructural requirements including ferrite content and acceptance criteria for intermetallic phases and precipitates in parent material and welds are specified in accordance with ISO 17781. Conformance with ISO 17781 is considered fulfilling the microstructural requirements of ISO 15156-3.

NOTE For the purposes of this document, ANSI/NACE MR0175 is equivalent to ISO 15156-3.

5.11 Mechanical testing

Tensile testing shall be carried out in accordance with the referenced standard specifications in the respective MDS as included in [Annex A](#). Where testing to ASTM A370 is specified, testing in accordance with ISO 6892-1 is considered equivalent and thereby also acceptable. The elongation shall be measured and reported in accordance with the selected tensile test standard ASTM A370 or ISO 6892-1. For specimens according to ASTM A370, the gauge length shall be 50 mm as far as is practically possible. For specimens according to ISO 6892-1, test specimens with proportional gauge length shall be used. Since ASTM A370 and ISO 6892-1 have different gauge length, the specified minimum required elongation “A” shall apply as relevant for each applicable standard.

Impact testing shall be carried out in accordance with the referenced standard specifications in the respective MDS as included in [Annex A](#). Where testing to ASTM A370 is specified, testing in accordance with ISO 148-1 using a striker radius of 8 mm is considered equivalent and thereby also acceptable.

The impact test temperature for carbon steel and duplex stainless steels is in general specified to be $-46\text{ }^{\circ}\text{C}$. A lower test temperature may be used by applying the specified minimum absorbed energy, unless otherwise agreed with the end user (equipment user).

Hardness testing shall be performed in conformance with the methods described in the MDS in [Annex A](#) and EDS in [Annex B](#), as applicable. The use of alternative methods permitted by the product standard and use of conversion tables or other correlations for individual materials shall be approved by the end user (equipment user). In case of dispute, the hardness scale stated in the MDS or EDS shall prevail. The use of portable hardness testing methods shall be approved by the end user (equipment user).

Annex A (normative)

Material datasheets

A.1 General

This annex lists the material datasheets. [Table A.1](#) provides a list of MDSs for normal pressure service and [Table A.2](#) provides a list of MDSs for high pressure service according to ASME B31.3. The tables include reference to MDS numbers. [Clause A.2](#) contains the MDSs to which reference is made in [Table A.1](#) and [Clause A.3](#) contains the MDSs to which reference is made in [Table A.2](#).

Table A.1 — List of material datasheets for normal pressure service

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
Non-impact tested carbon steel type 235	ASTM A106/A106M grade B	Seamless pipes	C001	1
	API Spec 5L grade B PSL1			
	ASTM A672 grade C60, C65, C70	Welded pipes	C002	1
	API Spec 5L grade B PSL1			
	ASTM A234/A234M grade WPB, WPBW	Wrought fittings	C003	1
	ASTM A105/A105M	Forgings	C004	1
	ASTM A516/A516M grade 60, 65, 70	Plates	C005	1
	ASTM A216/A216M grade WCB, WCC	Castings	C006	1
Impact tested (-46 °C) carbon steel type 235LT, 42KSI, 52KSI, 60KSI and 65KSI	ASTM A696 grade B, C	Bars	C007	1
	ASTM A105/A105M			
	ASTM A333/A333M grade 6	Seamless pipes	C101	1
	ASTM A671/A671M grade CC60, CC65, CC70	Welded pipes	C102	1
	ASTM A420/A420M grade WPL 6, WPL6W	Wrought fittings	C103	1
	ASTM A350/A350M grade LF2 and LF6	Forgings	C104	1
	ASTM A516/A516M grade 60, 65, 70	Plates	C105	1
	ASTM A352/A352M grade LCC	Castings	C106	1
	ASTM A696 grade B, C	Bars	C107	1
	ASTM A350/A350M grade LF2, LF6			
	API Spec 5L grade X42, X52	Seamless pipes	C201	1
	API Spec 5L grade X42, X52 SAWL or HFW	Welded pipes	C202	1
	ASTM A860/A860M WPHY 42, WPHY 52	Wrought fittings	C203	1
	ASTM A694/A694M grade F42, F52	Forgings	C204	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in [5.2](#).

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	API Spec 5L grade X60, X65	Seamless pipes	C211	1
	API Spec 5L grade X60, X65 SAWL or HFW	Welded pipes	C212	1
	ASTM A860/A860M grade WPHY 60, WPHY 65	Wrought fittings	C213	1
	ASTM A694/A694M grade F60, F65	Forgings	C214	1
Ferritic-austenitic stainless steel type lean duplex	ASTM A790/A790M grade UNS S32003, S32304, S82441	Seamless pipes	D101	1
	ASTM A928/A928M grade UNS S32003, S32304, S82441	Welded pipes	D102	1
	ASTM A815/A815M grade UNS S32003, S32304, S82441	Wrought fittings	D103	1
	ASTM A182/A182M grade F68 (S32304)	Forgings	D104	1
	ASTM A240/A240M grade UNS S32003, S32304, S82441	Plates	D105	1
	ASTM A276/A276/A479/A479M grade UNS S32003, S32304, S82441	Bars	D107	1
	ASTM A182/A182M grade F68 (S32304)			
	ASTM A789/A789M grade UNS S32003, S32304, S82441	Tubes	D108	1
Ferritic-austenitic stainless steel type 22Cr Duplex	ASTM A790/A790M grade UNS S31803, UNS S32205	Seamless pipes	D141	1
	ASTM A928/A928M grade UNS S31803, UNS S32205	Welded pipes	D142	1
	ASTM A815/A815M grade UNS S31803, UNS S32205	Wrought fittings	D143	1
	ASTM A182/A182M grade F51 (S31803), F60 (S32205)	Forgings	D144	1
	ASTM A240/A240M grade UNS S31803, UNS S32205	Plates	D145	1
	ASTM A995/A995M grade 4A (UNS J92205)	Castings	D146	1
	ASTM A276/A276M/A479/A479M grade UNS S31803, UNS S32205	Bars	D147	1
	ASTM A182/A182M grade F51 (S31803), F60 (S32205)			
	ASTM A789/A789M grade UNS S31803, UNS S32205	Tubes	D148	1
	ASTM A988/A988M grade UNS S31803, S32205	HIP products	D149	1
Ferritic-austenitic stainless steel type 25Cr Duplex	ASTM A790/A790M grade UNS S32550, S32750, S32760	Seamless pipes	D251	1
	ASTM A928/A928M grade UNS S32550, S32750, S32760	Welded pipes	D252	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	ASTM A815/A815M grade UNS S32550, S32750, S32760	Wrought fittings	D253	1
	ASTM A182/A182M grade F53 (UNS S32750), grade F55 (UNS S32760), grade F61 (UNS S32550)	Forgings	D254	1
	ASTM A240/A240M grade UNS S32550, S32750, S32760	Plates	D255	1
	ASTM A995/A995M grade 6A (UNS J93380), grade 5A (UNS J93404)	Castings	D256	1
	ASTM A276/A276M/A479/A479M grade UNS S32550, S32750 and S32760	Bars	D257	1
	ASTM A182/A182M grade F53 (UNS S32750), grade F55 (UNS S32760), grade F61 (UNS S32550)			
	ASTM A789/A789M grade UNS S32550, S32750, S32760	Tubes	D258	1
	ASTM A1082/A1082M grade UNS S32750, S32760 (strain hardened)	Studs, bolts and nuts	D259	1
	ASTM A1082/A1082M grade UNS S32750, S32760 (solution annealed)	Studs, bolts and nuts	D260	1
Copper-nickel 90-10	ASTM A988/A988M grade UNS S32750, S32750, S32505	HIP products	D269	1
	EEMUA 234 grade 7060X	Seamless pipes and tubes	K101	1
	EEMUA 234 grade 7060X	Welded pipes	K102	1
	EEMUA 234 grade 7060X	Wrought fittings	K103	1
	EEMUA 234 grade 7060X	Flanges	K104	1
	ASTM B171/B171M grade UNS C70600	Plates and sheets	K105	1
	ASTM B151/B151M grade C70600	Bars and rods	K107	1
Aluminium bronze	ASTM B124/B124M grade C63000	Forgings	K114	1
	ASTM B148 UNS grade C95800	Castings	K116	1
	ASTM B150/B150M grade UNS C63200	Bars and rods	K117	1
Nickel alloyed steel, type 3,5 % Nickel	ASTM A333/A333M grade 3	Seamless pipes	L101	1
	ASTM A671/A671M grade CFE 70	Welded pipes	L102	1
	ASTM A420/420M grade WLP3, WLP3W	Wrought fittings	L103	1
	ASTM A350/A350M grade LF3	Forgings	L104	1
	ASTM A203/203M grade D, E	Plates	L105	1
	ASTM A352/A352M grade LC3 (UNS J31550)	Castings	L106	1
	ASTM A334/A334M grade 3	Tubes	L108	1
Martensitic stainless steel	ASTM A182/A182M grade F6A	Forgings	M104	1
	ASTM A217/217M grade CA15 (UNS J91150)	Castings	M106	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	ASTM A276/276M/ASTM A479/479M grade 410 (UNS S41000)	Bars	M107	1
	ASTM A276/276M grade 420 (UNS S42000)	Bars	M127	1
Martensitic precipitation-hardened stainless steel	ASTM A705/705M grade 630 (UNS S17400)	Forgings	M604	1
	ASTM A564/564M grade 630 (UNS S17400)	Bars	M607	1
Nickel-based alloys	ASTM F467/F467M / ASTM F468/F468M grade UNS N06625	Studs, bolt and nuts	N100S	1
	ASTM B444 grade UNS N06625	Seamless pipes and tubes	N101S	1
	ASTM B705 grade UNS N06625 (joint quality factor 0,8/0,85)	Welded pipes	N102S	1
	ASTM B366/B366M grade UNS N06625	Wrought fittings	N103S	1
	ASTM B564 grade UNS N06625	Forgings	N104S	1
	ASTM B443 grade UNS N06625	Plates	N105S	1
	ASTM A494/494M grade CW6MC, CX2MW	Castings	N106S	1
	ASTM B446 grade UNS N06625	Bars	N107S	1
	ASTM B834 grade UNS N06625	HIP products	N109S	1
	ASTM B705 grade UNS N06625 (joint quality factor 1,0)	Welded pipes	N112S	1
	ASTM B423 grade UNS N08825	Seamless pipes and tubes	N141S	1
	ASTM B705 grade UNS N08825	Welded pipes	N142S	1
	ASTM B366/B366M grade UNS N08825	Wrought fittings	N143S	1
	ASTM B564 grade UNS N08825	Forgings	N144S	1
	ASTM B424 grade UNS N08825	Plates	N145S	1
	ASTM A494/A494M grade CU5MCuC	Castings	N146S	1
	ASTM B425 grade UNS N08825	Bars and rods	N147S	1
Nickel-based alloys	API Std 6ACRA UNS N07718 Gr. 120K	Studs, bolts and nuts	N210S	1
	API std 6ACRA grade UNS N07718 Gr. 120K, 140K, 150K	Bars	N217	1
Austenitic stainless steel type 6Mo	ASTM A312/A312M grade UNS S31254, UNS N08367, N08926	Seamless pipes	R111	1
	ASTM A358/A358M grade UNS S31254, UNS N08367, N08926	Welded pipes	R112	1
	ASTM A403/A403M grade UNS S31254, N08367, N08926	Wrought fittings	R113	1
	ASTM A182/A182M grade F44 (UNS S31254), F62 (UNS N08367), UNS N08926	Forgings	R114	1
	B462 Gr. UNS N08926			

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	ASTM A240/A240M UNS S31254, N08367, N08926	Plates	R115	1
	ASTM A351/A351M grade CK-3MCuN, CN-3MN	Castings	R116	1
	ASTM A276/A276M/A479/A479M UNS S31254, N08367, N08926	Bars	R117	1
	ASTM182, grade F44 (UNS S31254), grade F62 (UNS N08367)			
	ASTM A269/A269M UNS S31254, N08367, N08926	Tubes	R118	1
	ASTM A988/A988M UNS S31254, N08367	HIP products	R119	1
Austenitic stainless steel type UNS S34565	ASTM A312/A312M UNS S34565	Seamless pipes	R211	1
	ASTM A358/A358M UNS S34565	Welded pipes	R212	1
	ASTM A403/A403M WP UNS S34565	Wrought fittings	R213	1
	ASTM A182/A182M grade F49	Forgings	R214	1
	ASTM A240/A240M UNS S34565	Plates	R215	1
	ASTM A276/A276M/A479/A479M UNS S34565	Bars	R217	1
	ASTM A988/A988M UNS S34565	HIP parts	R219	1
Austenitic precipitation-hardened stainless steels	ASTM A453/A453M grade 660 (UNS S66286)	Studs, bolts and nuts	S100	1
Austenitic stainless steel type 316	ASTM A312/A312M grade TP316	Seamless pipes	S101	1
	ASTM A312/A312M grade TP316	Welded pipes	S102	1
	ASTM A358/A358M grade 316			
	ASTM A403/A403M grade WP316	Wrought fittings	S103	1
	ASTM A182/A182M grade F316	Forgings	S104	1
	ASTM A240/A240M grade 316	Plates	S105	1
	ASTM A351/A351M grade CF3M, CF8M	Castings	S106	1
	ASTM A276/A276M/A479/A479M grade 316	Bars	S107	1
	ASTM A269/A269M grade 316	Tubes	S108	1
	ASTM A194/A194M grade 8M	Nuts	S109	1
Austenitic stainless steel type 304	ASTM A320/A320M grade B8M	Studs, bolts, screws	S109	1
	ASTM A312/A312M grade TP304	Seamless pipes	S201	1
	ASTM A312/A312M grade TP304	Welded pipes	S202	1
	ASTM A358/A358M grade 304			
	ASTM A403/A403M grade WP304	Wrought fittings	S203	1
	ASTM A182/A182M grade F304	Forgings	S204	1
	ASTM A240/A240M grade 304	Plates	S205	1
	ASTM A351/A351M grade CF3, CF8	Castings	S206	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	ASTM A276/A276M/A479/A479M grade 304	Bars	S207	1
	ASTM A269/A269M grade 304	Tubes	S208	1
Austenitic stainless steel, stabilized grade	ASTM A312/A312M grade TP321, TP347	Seamless pipes	S301	1
	ASTM A312/A312M / ASTM A358/A358M grade TP321, TP347	Welded pipes	S302	1
	ASTM A403/A403M grade WP321, WP347	Wrought fittings	S303	1
	ASTM A182/A182M grade F321, F347	Forgings	S304	1
	ASTM A240/A240M grade 321, 347	Plates	S305	1
	ASTM A351/A351M grade CF8C	Castings	S306	1
	ASTM A276/A276M / ASTM A479/A479M grade 321, 347	Bars	S307	1
	ASTM A269/A269M grade TP321, TP347	Tubes	S308	1
	ASTM A312/A312M grade TP321H, TP347H	Seamless pipes	S321	1
	ASTM A312/A312M / ASTM A358/A358M grade TP321H, TP347H	Welded pipes	S322	1
	ASTM A403/A403M grade WP321H, WP347H	Wrought fittings	S323	1
	ASTM A182/A182M grade F347H, F321H	Forgings	S324	1
	ASTM A240/A240M grade 321H, 347H	Plates	S325	1
	ASTM A479/A479M grade 321H, 347H	Bars	S327	1
Austenitic stainless steel, 200-series	ASTM A182/A182M grade F XM-19 (UNS S20910)	Forgings	S404	1
	ASTM A276/A276M / ASTM A479/A479M grade XM-19 (UNS S20910)	Bars	S407	1
Titanium grade 2	ASTM B861 grade 2	Seamless pipes	T101	1
	ASTM B862 grade 2	Welded pipes	T102	1
	ASTM B363 grade WPT2/WPT2W	Wrought fittings	T103	1
	ASTM B381 grade F2	Forgings	T104	1
	ASTM B265 grade 2	Plates	T105	1
	ASTM B367 grade C2	Castings	T106	1
	ASTM B348 grade 2	Bars	T107	1
	ASTM B338 grade 2	Tubes	T108	1
1¼Cr ½Mo alloy steel	ASTM A335/A335M grade P11	Seamless pipes	V101	1
	ASTM A691/A691M grade 1¼ Cr	Welded pipes	V102	1
	ASTM A234/A234M grade WP11	Wrought fittings	V103	1
	ASTM A182/A182M grade F11	Forgings	V104	1
	ASTM A387/A387M grade 11	Plate	V105	1
	ASTM A217/A217M grade WC6	Castings	V106	1
	ASTM A739 grade B11	Bars	V107	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

Table A.1 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
2¼Cr 1Mo alloy steel	ASTM A335/A335M grade P22	Seamless pipes	V201	1
	ASTM A691/A691M grade 2¼ Cr	Welded pipes	V202	1
	ASTM A234/A234M grade WP22	Wrought fittings	V203	1
	ASTM A182/A182M grade F22	Forgings	V204	1
	ASTM A387/A387M grade 22	Plate	V205	1
	ASTM A217/A217M grade WC9	Castings	V206	1
	ASTM A739 grade B22	Bars	V207	1
High strength low alloy steel	ASTM A320/A320M grade L7, L7M, L43 ASTM A194/A194M grade 7, 7M	Studs, bolts and nuts (HDG)	X100	1
	ASTM A320/A320M grade L7, L7M, L43 ASTM A194/A194M grade 7, 7M	Studs, bolts and nuts (black or un-coated)	X109	1
	ASTM A193/A193M grade B7, B7M ASTM A194/A194M grade 2H, 2HM	Studs, bolts and nuts (black or un-coated)	X110	1
	ASTM A193/A193M grade B7, B7M ASTM A194/A194M grade 2H, 2HM	Studs, bolts and nuts (HDG)	X120	1
	ASTM A788/A788M grade AISI 4140	Forged clamp	X124	1
	ASTM A29/A29M grade 4140	Bars	X127	1
	ASTM A508/A508M grade 22	Forged clamp	X134	1
^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2 .				

Table A.2 — List of material datasheets for high pressure service according to ASME B31.3

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
Impact tested (-46 °C) carbon steel type 42KSI, 52KSI, 60KSI and 65KSI	API Spec 5L grade X42, X52	Seamless pipes	C221	1
	ASTM A860/A860M WPHY 42, WPHY 52	Wrought fittings	C223	1
	ASTM A694/A694M grade F42, F52	Forgings	C224	1
	API Spec 5L grade X60, X65	Seamless pipes	C231	1
	ASTM A860/A860M WPHY 60, WPHY 65	Wrought fittings	C233	1
	ASTM A694/A694M grade F60, F65	Forgings	C234	1
Ferritic-austenitic stainless steel type 22Cr Duplex	ASTM A790/A790M grade UNS S31803, UNS S32205	Seamless pipes	D111	1
	ASTM A928/A928M grade UNS S31803, UNS S32205	Welded pipes	D112	1
	ASTM A815/A815M grade UNS S31803, UNS S32205	Wrought fittings	D113	1
	ASTM A182/A182M grade F51 (S31803), F60 (S32205)	Forgings	D114	1
	ASTM A995/A995M grade 4A (UNS J92205)	Castings	D116	1
^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2 .				

Table A.2 (continued)

Type of material	Material standard and grade(s)	Product form	MDS No. ^a	MDS Rev.
	ASTM A276/A276M/A479/A479M grade UNS S31803, UNS S32205	Bars	D117	1
	ASTM A182/A182M grade F51 (S31803), F60 (S32205)			
	ASTM A789/A789M grade UNS S31803, UNS S32205	Tubes	D118	1
	ASTM A988/A988M grade UNS S31803, S32205	HIP products	D119	1
Ferritic-austenitic stainless steel type 25Cr Duplex	ASTM A790/A790M grade UNS S32550, S32750, S32760	Seamless pipes	D211	1
	ASTM A928/A928M grade UNS S32550, S32750, S32760	Welded pipes	D212	1
	ASTM A815/A815M grade UNS S32550, S32750, S32760	Wrought fittings	D213	1
	ASTM A182/A182M grade F53 (UNS S32750), grade F55 (UNS S32760), grade F61 (UNS S32550)	Forgings	D214	1
	ASTM A995/A995M grade 6A (UNS J93380), grade 5A (UNS J93404)	Castings	D216	1
	ASTM A276/A276M/A479/A479M grade UNS S32550, S32750 and S32760	Bars	D217	1
	ASTM A182/A182M grade F53 (UNS S32750), grade F55 (UNS S32760), grade F61 (UNS S32550)			
	ASTM A789/A789M grade UNS S32550, S32750, S32760	Tubes	D218	1
	ASTM A988/A988M grade UNS S32750, S32750, S32505	HIP products	D219	1
Nickel-based alloys	ASTM B444 grade UNS N06625	Seamless pipes and tubes	N121	1
	ASTM B705 grade UNS N06625	Welded pipes	N122	1
	ASTM B366/B366M grade UNS N06625	Wrought fittings	N123	1
	ASTM B564 grade UNS N06625	Forgings	N124	1
	ASTM A494/A494M grade CW-6MC, CX 2MW	Castings	N126	1
	ASTM B446 grade UNS N06625	Bars	N127	1
	ASTM B834 grade UNS N06625	HIP products	N129	1

^a The MDS number may also have a suffix with additional requirements for certain services as described in 5.2.

A.2 Material datasheets for normal pressure service

Material Data Sheet		MDS No. C001 / C001S ^a			Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel					
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT	
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.					

Seamless pipes	ASTM A106/A106M	B	-	ASTM A106/A106M S6
	API Spec 5L	B	PSL1	-
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Metal making	API Spec 5L Gr.B PSL1 pipe steel shall be killed and made according to fine grain practice.			
Manufacturing	Cold-drawn pipes shall be heat treated after cold forming.			
Chemical composition	For ASTM A106/A106M supplementary requirement S6 applies with the following restrictions: C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 % The following restrictions apply to API Spec 5L pipes: C ≤ 0,23 %, CE ≤ 0,43 %			
Repair of defects	Weld repair of base material is not permitted.			
Sour service (additional metallurgical, manufacturing, testing and certification requirements) ^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:			
	<u>Chemical composition</u>			
	S ≤ 0,010 %			
	<u>Hardness testing</u>			
	Hardness testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on one length of pipe per lot. The maximum hardness shall be 22HRC from three readings taken in close proximity.			
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.			
Marking	The pipes shall be marked to ensure full traceability to melt and heat treatment lot.			
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser.			
	The inspection documents shall be issued in accordance with ISO 10474 /EN 10204 type 3.1 and shall confirm compliance with this specification.			
	The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.			

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

Material Data Sheet		MDS No. C002 / C002S ^a / C002SH ^b		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY REQUIREMENT
Welded pipes	ASTM A672/A672M	C60, C65, C70	Cl. 12, Cl. 22, Cl.32 or Cl.42	-
	API Spec 5L	B	PSL1	-
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Metal making	API Spec 5L Gr.B PSL1 pipe steel shall be killed and made according to fine grain practice.			

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.

^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.

Manufacturing	— The longitudinal weld shall be straight and made using the SAW or HFW process. — The weld metal for SAW shall be mild steel analysis A-No.1 per ASME BPVC IX, Table QW-442.
Chemical composition	$C \leq 0,23 \%$, $S \leq 0,020 \%$, $P \leq 0,025 \%$, $CE \leq 0,43 \%$
Heat treatment	For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C. API Spec 5L pipe: Normalized, including weld and HAZ.
Non-destructive testing	Welded pipe to API Spec 5L: According to API Spec 5L, 46th Edition Annex E. OD and ID notches and radially drilled hole shall be used for electromagnetic or ultrasonic testing of weld seam.
Repair of defects	Weld repair of the base material is not permitted. Repairs to weld metal are acceptable in accordance with the standard specification and shall meet the chemistry requirements of the original manufacturing weld.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:
	<u>Chemical composition</u> $S \leq 0,003 \%$ Ni < 1,0 % for the weld metal
	<u>Hardness testing</u> — Welding procedure qualification testing for manufacturing and any repair welding shall meet the requirements of ISO 15156-2 / ANSI/NACE MR0175 using Vickers method, with a maximum hardness of 250HV. — Production testing shall be performed on one length of pipe per lot as follows: Vickers hardness traverse shall be made across the base material, HAZ and weld metal at both ends of the pipe to include the centre of the pipe wall and 1,0 mm – 2,0 mm below the internal and external surfaces, with a maximum hardness of 250HV.
	<u>HIC testing and UT examination</u> When suffix SH applies, one finished pipe per ASTM A672/A672M S14 (lot) shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A. — Acceptance criteria per specimen shall be $CLR \leq 15 \%$, $CTR \leq 5 \%$, $CSR \leq 2 \%$. — Maximum individual crack length shall be reported for each section. — UT examination: — ASTM A672/A672M, S11 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The pipes shall be marked to ensure full traceability to melt and heat treatment lot.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser.
	The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification.
	The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet		MDS No. C003 / C003S ^a / C003SH ^b		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY REQUIREMENT
Wrought fittings	ASTM A234/A234M	WPB, WPBW	-	ASTM A234/A234M S3
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Chemical composition	Supplementary requirement ASTM A234/A234M S3 applies with the following restrictions: C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %			
Heat treatment	Normalized or normalized and tempered or quenched and tempered. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C. All hot formed or forged fittings, including those manufactured by locally heating a portion of the fitting stock, shall be heat treated after manufacture.			
Test sampling	Test sampling shall be made from an actual fitting, from a prolongation thereof, or if not possible, a length of starting material that has been heat treated in the same heat treatment load as the fittings it represents.			
Non-destructive testing	UT is not acceptable in-lieu of RT.			
Repair of defects	Weld repair of the base material is not permitted.			
	Repairs to weld metal are acceptable in accordance with the standard specification and shall meet the chemistry requirements of the original manufacturing weld.			

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.

^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.

Sour service (additional metal-lurgical, manufacturing, testing and certification requirements)^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:
	<u>Chemical composition</u> — $S \leq 0,010$ % for WPB fittings made from seamless pipe — $S \leq 0,003$ % for WPBW fitting made from flat-rolled products — $S \leq 0,020$ % for WPB fitting made from forging
	<u>Hardness testing</u> WPB fittings: hardness testing shall be performed in accordance with the requirements in ASTM A234/A234M. Hardness testing for WPBW fittings: — Production testing shall be performed in accordance with the requirements in ASTM A234/A234M and shall include parent material, weld and HAZ.
	<u>HIC testing and UT examination</u> When suffix SH applies, one finished WPBW fitting made from flat-rolled products per lot shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A. — Acceptance criteria per specimen shall be $CLR \leq 15$ %, $CTR \leq 5$ %, $CSR \leq 2$ %. — Maximum individual crack length shall be reported for each section. — UT testing of flat-rolled product before manufacture: — ASTM A578/A578M, S1, S2.1 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The fittings shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser.
	The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.	
^b The supplementary suffix "SH" shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet		MDS No. C004 / C004S ^a		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY REQUIREMENT
Forgings	ASTM A105/105M	-	-	ASTM A105/A105M S2, S4
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.				

Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.
Metal making	Steel shall be made to fine grain practice according to ASTM A20/A20M.
Chemical composition	Supplementary requirement S4 applies with the following restrictions: $C \leq 0,23 \%$, $S \leq 0,020 \%$, $P \leq 0,025 \%$, $CE \leq 0,43 \%$
Heat treatment	Normalized or normalized and tempered or quenched and tempered. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.
Non-destructive testing	<u>Visual inspection</u> VT shall be carried out on each forging or bar in accordance with the product standard. The testing shall be performed after machining, if applicable, and non-machined surfaces shall be cleaned prior to the testing.
Repair of defects	Weld repair is not permitted.
Sour service (additional metal-lurgical, manufacturing, testing and certification requirements)^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The forgings shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.	

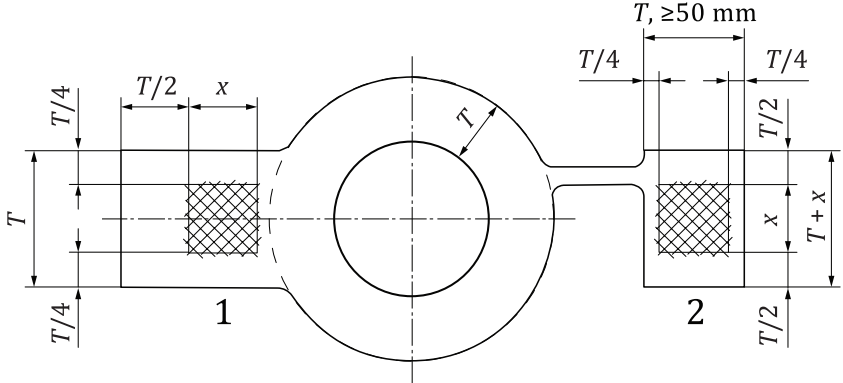
Material Data Sheet		MDS No. C005 / C005S ^a / C005SH ^b		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Plates	ASTM A516/A516M	60, 65, 70	-	-
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Chemical composition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 % For Grade 60 plate 12,5 mm thick and thinner, C ≤ 0,21 %			
Non-destructive testing	<u>Visual inspection</u> VT shall be carried out on each plate in accordance with the product standard. The testing shall be performed after machining, if applicable, and non-machined surfaces shall be cleaned prior to the testing.			
Repair of defects	Weld repair is not permitted.			

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.

^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.

Sour service (additional metallurgical, manufacturing, testing and certification requirements) ^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:
	<u>Chemical composition</u> $S \leq 0,003 \%$
	<u>Hardness testing</u> Production testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on one plate per lot. The maximum hardness shall be 22HRC from three readings taken in close proximity at each location.
	<u>HIC testing and UT examination</u> When suffix SH applies, one plate per lot shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A. — Acceptance criteria per specimen shall be $CLR \leq 15 \%$, $CTR \leq 5 \%$, $CSR \leq 2 \%$. — Maximum individual crack length shall be reported for each section. — UT examination: — ASTM A578/A578M S1, S2.1 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The plates shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.	
^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet		MDS No. C006 / C006S ^a		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Castings	ASTM A216/A216M	WCB, WCC	-	ASTM A216/A216M S4, S5 ASTM A703/A703M S14, S20 ASTM A985/A985M S14, S20
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
	For steel castings produced by the investment casting process, the requirements of ASTM A985/A985M and this MDS shall apply.			
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.				

Metal making	Steel shall be made to fine grain practice according to ASTM A20/A20M.
Chemical composition	Supplementary requirements ASTM A216/A216M S11 and S52 apply with the following restrictions: $C \leq 0,23 \%$, $S \leq 0,020 \%$, $P \leq 0,025 \%$, $CE \leq 0,43 \%$
Heat treatment	For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.
Extent of testing	ASTM A703/A703M S14 or ASTM A985/A985M S14 shall apply.
Test sampling	For castings with weight 250 kg or more, the test blocks shall be integrally cast or gated onto the casting and shall accompany the castings through all heat treatment operations including any post weld stress relieving. Thickness of the test block shall be equal to the thickest part of the casting represented up to a maximum thickness of 100 mm. For flanged components, the largest flange thickness is the ruling section. Dimensions of test blocks and location of test specimens within the test blocks are shown in figure below for integral and gated test block. The test specimens shall be taken within the cross hatched area. Distance from end of test specimen to end of test block shall minimum be $T/4$.  1 integrated test block 2 gated test block For investment casting, test sampling shall be according to ASTM A985/A985M. Test blocks shall accompany the castings through all heat treatment operations including any post weld stress relieving.
Non-destructive testing	<u>General</u> For definition and NDT of pilot castings reference is made to the general part of this document Non-machined surfaces shall be cleaned prior to the testing. <u>Visual inspection</u> The testing shall be carried out after finished machining. Each pilot and production casting shall be tested at all accessible surfaces, including weld ends. Surface testing and acceptance criteria shall be in accordance with ANSI/MSS SP-55. <u>Magnetic particle testing</u> ASTM A216/A216M / ASTM A985/A985M Supplementary requirement S4 shall apply as amended by this MDS: Surface testing and acceptance criteria shall be in accordance with ASME BPVC VIII, Div. 1, Appendix 7. Each pilot and production casting shall be tested after final machining at all accessible external and internal surfaces. <u>Radiographic testing</u>

^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

	- Supplementary requirement S5 shall apply as amended by this MDS. Method of radiography and acceptance criteria shall be in accordance with ASME BPVC VIII Div. 1 Appendix 7. - Valve castings shall be examined in the areas as defined by ASME B16.34 for special class valves and other critical areas as defined by designer. In addition, castings shall be examined at abrupt changes in sections and at the junctions of risers, gates or feeders to the castings. - Sketches of the areas to be tested shall be established and agreed with the purchaser. - When random testing (5 %) is specified, minimum one casting of each pattern including feeder and riser system in any purchase order with the foundry shall be examined. - If defect outside acceptance criteria is detected, two more castings shall be tested, and if any of these two fails, all items represented shall be tested. - Pilot castings shall be radiographed to the extent described above. - Frequency of RT of valve castings shall be according to table below.<table><tr><th colspan="6">Extent of RT based on pressure class and nominal outside diameter:</th></tr><tr><th colspan="2">Pressure class:</th><th>≤ 300</th><th>600</th><th>900</th><th>≥ 1 500</th></tr><tr><th rowspan="3">Frequency of RT</th><td>Not re-quired</td><td>< 10"</td><td colspan="3">< 2"</td></tr><tr><td>5 %</td><td>≥ 10"</td><td colspan="3">≥ 2"</td></tr><tr><td>100 %</td><td>Not re-quired</td><td>≥ 20"</td><td>≥ 16"</td><td>≥ 6"</td></tr></table> - Non-valve castings: Each casting shall be examined unless agreed otherwise. Testing shall be at abrupt changes in sections and at the junctions of risers, gates or feeders to the castings and other critical areas as defined by designer. Sketches of the areas to be tested shall be established and agreed.	Extent of RT based on pressure class and nominal outside diameter:						Pressure class:		≤ 300	600	900	≥ 1 500	Frequency of RT	Not re-quired	< 10"	< 2"			5 %	≥ 10"	≥ 2"			100 %	Not re-quired	≥ 20"	≥ 16"	≥ 6"
Extent of RT based on pressure class and nominal outside diameter:																													
Pressure class:		≤ 300	600	900	≥ 1 500																								
Frequency of RT	Not re-quired	< 10"	< 2"																										
	5 %	≥ 10"	≥ 2"																										
	100 %	Not re-quired	≥ 20"	≥ 16"	≥ 6"																								
Repair of defects	ASTM A703/A703M or ASTM A985/A985M, as applicable, supplementary requirement S20 shall apply with the following additional requirements: - Major repairs as defined in ASTM A216/A216M shall be documented in accordance with ASTM A703/A703M or ASTM A985/A985M S20.2. - The repair welding procedure shall be qualified in accordance with ASTM A488/A488M or ISO 11970 and this data sheet using a cast plate. - Weld repairs are not acceptable for castings that leak during pressure testing. - Examination of major repair welds on pressure containing parts shall also include RT. - The post-weld heat treatment temperature or stress relieving temperature for tempered parts shall maximum be equal to the final tempering temperature −15 °C.																												
Sour service (additional metallurgical, manufacturing, testing and certification requirements) ^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: <u>Hardness testing</u> - Production testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on the pilot casting and one casting per lot thereafter. The maximum hardness shall be 22HRC from three readings taken in close proximity. - Welding procedure qualification testing for all repair welding shall meet the requirements of ISO 15156-2 / ANSI/NACE MR0175 using Vickers method, with a maximum hardness of 250HV. The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.																												

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

Marking	The castings shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.	

Material Data Sheet		MDS No. C007 / C007S ^a		Rev. 1
TYPE OF MATERIAL: Non-impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Bars	ASTM A696	B, C	-	
	ASTM A105/A105M	-	-	
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification. This MDS includes additional requirements for valve parts DN 100 (NPS 4) and under man- ufactured from bars, when permitted by the valve specification.			
Manufacturing	Bars shall be manufactured to the following requirements: — bar forgings as defined in ASTM A788/A788M and certified to ASTM A105; or — hot rolled bars manufactured to ASTM A696 Grade B or C to a maximum outside diameter of 250 mm. Cold finishing shall be restricted to turning, grinding or polishing (singly or in combina- tion); cold drawing or cold forming is not permitted.			
Chemical compo- sition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %			
Heat treatment	Normalized or normalized and tempered or quenched and tempered. For products deliv- ered in the tempered condition, the minimum tempering temperature shall be 620 °C.			
Test sampling	<u>Valve parts manufactured from bar</u> Sampling of test specimens for bars intended for machining of valve parts shall conform with the following additional requirements: — The mid-length of the axial tensile test specimen shall be located at a distance equal to the bar outside diameter or minimum of 100 mm, whichever is the greater, from the end of the bar, and the centreline of the specimen shall be located at a minimum distance of OD/4 from the surface. — The centreline of the tangential tensile test specimen shall be located at a minimum distance of OD/4 from the surface and the mid-point of the specimens shall be located at a minimum of 100 mm from the end of the bar. — For bar with outside diameter < 100 mm: tensile test in accordance with the standard. — For bar with outside diameter ≥ 100 mm: in addition to the standard requirement, one tensile test specimen shall be taken in tangential direction of the bar. The specified minimum tensile strength properties of the referenced standard shall be met in both directions.			
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.				

Non-destructive testing	<u>Visual Inspection</u> VT shall be carried out on each bar in accordance with the product standard. The testing shall be performed after machining, if applicable, and non-machined surfaces shall be cleaned prior to the testing. <u>NDT (MT) of valve parts manufactured from bar</u> Inspection shall be according to the applicable valve specification or as specified below. 100 % magnetic particle testing of all accessible internal and external surfaces shall be carried out according to ASME BPVC V, article 7 or ASTM A961/A961M supplementary requirement S55. Acceptance criteria shall be according to ASME BPVC VIII, Div. 1, appendix 6.
Repair of defects	Weld repair is not permitted.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: <u>Chemical composition</u> $S \leq 0,020 \%$, $Ni < 1,0 \%$ <u>Hardness testing</u> Production testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on the end surface of one bar per lot. The maximum hardness shall be 22HRC from three readings taken in close proximity. The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The bars shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.	

Material Data Sheet		MDS No. C101 / C101S ^a			Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel					
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT	
Seamless pipes	ASTM A333/A333M	6	-	-	
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.				
Chemical compo- sition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %				
Heat treatment	During the heat treatment process, pipes shall be placed in such a way as to ensure free circulation around each pipe including any quenching operation. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.				
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.					

Impact testing/ Toughness testing	Impact testing is required for thickness ≥ 6 mm; for pipes with a weld end, the weld end thickness shall govern. The test temperature shall be -46 °C. The minimum absorbed energy for full size specimens shall be 27 J average and 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3.
Repair of defects	Weld repair is not permitted.
Sour service (additional metal-lurgical, manufacturing, testing and certification requirements)^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: <u>Chemical composition</u> $S \leq 0,010$ % <u>Hardness testing</u> Hardness testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on one length of pipe per lot. The maximum hardness shall be 22HRC from three readings taken in close proximity. The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The pipes shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 /EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.	

Material Data Sheet		MDS No. C102 / C102S ^a / C102SH ^b		Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Welded pipes	ASTM A671/A671M	CC60, CC65, CC70	Cl. 12, Cl. 22, Cl.32 or Cl.42	ASTM A671/A671M S2, S7, S11, S14
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Manufacturing	The longitudinal weld shall be straight and made using the SAW process. The weld metal shall be mild steel analysis A-No.1 per ASME BPVC IX, Table QW-442.			
Chemical compo- sition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %			
Heat treatment	For pipes delivered in tempered condition, the minimum tempering temperature shall be 620 °C. During the heat treatment process, pipes shall be placed in such a way as to ensure free circulation around each pipe including any quenching operation.			
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.				
^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.				

Impact testing/ Toughness testing	Impact testing is required for thickness ≥ 6 mm; for pipes with a weld end, the weld end thickness shall govern. The test temperature shall be -46 °C. The minimum absorbed energy for full size specimens shall be 27 J average and 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3.
Extent of testing	For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C. Impact testing per ASTM A671/A671M supplementary requirement S2, as modified by this MDS, shall also be carried out per lot (ASTM A671/A671M supplementary requirement S14 shall apply for lot definition).
Non-destructive testing	ASTM A671/A671M supplementary requirement S7 shall apply.
Repair of defects	Weld repair of the base material is not permitted. Repairs to weld metal are acceptable in accordance with the standard specification and shall meet the chemistry requirements of the original manufacturing weld.
Sour Service (additional metallurgical, manufacturing, testing and certification requirements)^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:
	<u>Chemical composition</u> $S \leq 0,003$ % $Ni < 1,0$ % for the weld metal
	<u>Hardness testing</u> — Welding procedure qualification testing for manufacturing and any repair welding shall meet the requirements of ISO 15156-2 / ANSI/NACE MR0175 using Vickers method, with a maximum hardness of 250HV. — Production testing shall be performed on one length of pipe per lot as follows: — Vickers hardness traverse shall be made across the base material, HAZ and weld metal at both ends of the pipe to include the centre of the pipe wall and 1,0 mm – 2,0 mm below the internal and external surfaces, with a maximum hardness of 250HV.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^{a, b}	<u>HIC testing and UT examination</u> When suffix SH applies, one finished pipe per ASTM A671/A671M S14 (lot) shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A. — Acceptance criteria per specimen shall be $CLR \leq 15$ %, $CTR \leq 5$ %, $CSR \leq 2$ %. — Maximum individual crack length shall be reported for each section. — UT examination: — ASTM A671/A671M, S11 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The pipes shall be marked to ensure full traceability to melt and heat treatment lot.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 /EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet		MDS No. C103 / C103S ^a / C103SH ^b			Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel					
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT	
Wrought fittings	ASTM A420/A420M	WPL6, WPL6W	-	ASTM A960/A960M S51, S53, S57, S69	
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.				
Chemical compo- sition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %				
Heat treatment	During the heat treatment process, fittings shall be placed in such a way as to ensure free circulation around each fitting including any quenching operation. All hot formed or forged fittings, including those manufactured by locally heating a por- tion of the fitting stock, shall be heat treated after manufacture. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.				
Test sampling	Test sampling shall be made from an actual fitting, from a prolongation thereof, or if not possible, a length of starting material that has been heat treated in the same heat treat- ment load as the fittings it represents.				
Tensile testing	ASTM A960/A960M supplementary requirement S51 shall apply as amended by this MDS.				
Impact testing/ Toughness testing	Impact testing is required for thickness ≥ 6 mm; for fittings with a weld end, the weld end thickness shall govern. The impact test specimens shall be taken from mid-thickness position. The test temperature shall be –46 °C. The minimum absorbed energy for full size specimens shall be 27 J average and 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3.				
Hardness testing	ASTM A960/A960M supplementary requirement S57 shall apply with the following re- quirements: hardness testing shall be carried out on a minimum two fittings, including parent material, weld and HAZ, for each test lot, and shall not exceed 197HBW.				
Extent of testing	Tensile, hardness and impact test are required for each melt and heat treatment load.				

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.

^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.

Non-destructive testing	UT is not acceptable in-lieu of RT.
	<u>Magnetic particle testing</u> ASTM A960/A960M supplementary requirement S53 and S69 shall apply as amended by this MDS: Magnetic particle testing, in accordance with ASME BPVC V, Article 7 shall apply to 10 % of all fittings with wall thickness < 12,7 mm per lot or a minimum of one item per lot in any purchase order. All fittings with wall thickness ≥ 12,7 mm shall be 100 % tested. Testing shall be carried out as follows: — Non-machined surfaces shall be cleaned prior to testing. — The testing shall be carried out after final machining and cover 100 % of accessible surface of the test item. — The acceptance criteria shall be to ASME BPVC VIII Div. 1, Appendix 6.
Repair of defects	Weld repair of the base material is not permitted. Repairs to weld metal are acceptable in accordance with the standard specification and shall meet the chemistry requirements of the original manufacturing weld.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: <u>Chemical composition</u> — $S \leq 0,010$ % for WPL6 fittings made from seamless pipe — $S \leq 0,003$ % for WPL6W fitting made from flat-rolled products — $S \leq 0,020$ % for WPL6 fitting made from forging or hot rolled/wrought bar — $Ni < 1,0$ % for the weld metal of WPL6W fittings
	<u>Hardness testing</u> For WPL6W fittings, in addition to the hardness testing requirement in the MDS, welding procedure qualification testing for manufacturing and any repair welding shall meet the requirements of ISO 15156-2 / ANSI/NACE MR0175 using Vickers method, with a maximum hardness of 250HV.
	<u>HIC testing and UT examination</u> When suffix SH applies, one finished WPL6W fitting made from flat-rolled products per lot shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A. — Acceptance criteria per specimen shall be $CLR \leq 15$ %, $CTR \leq 5$ %, $CSR \leq 2$ %. — Maximum individual crack length shall be reported for each section. — UT examination of flat-rolled product before manufacture: — ASTM A578/A578M S1, S2.1 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The fittings shall be marked to ensure full traceability to melt and heat treatment lot.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 /EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet		MDS No. C104 / C104S ^a		Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel				
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Forgings	ASTM A350/A350M	LF2	Class 1	ASTM A350/A350M S6 ASTM A961/A961M S55
	ASTM A350/A350M	LF6	Class 1 or 2	ASTM A350/A350M S6 ASTM A961/A961M S55
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Chemical compo- sition	Supplementary requirement ASTM A350/A350M S6 applies with the following restric- tions: C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %			
Heat treatment	During the heat treatment process, forgings shall be placed in such a way as to ensure free circulation around each forging including any quenching operation. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.			
Impact testing/ Toughness testing	Impact testing is required for thickness ≥ 6 mm; for forgings with a weld end, the weld end thickness shall govern. The test temperature shall be –46 °C for grade LF2 and –51 °C for grade LF6. The minimum absorbed energy for full size specimens shall be 27 J average and 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3.			
Extent of testing	One set of tensile, impact and hardness testing shall be carried out for each heat and heat treatment load. A test lot shall not exceed 2 000 kg for forgings with as forged weight up to 50 kg, and 5 000 kg for forgings with as forged weight > 50 kg.			

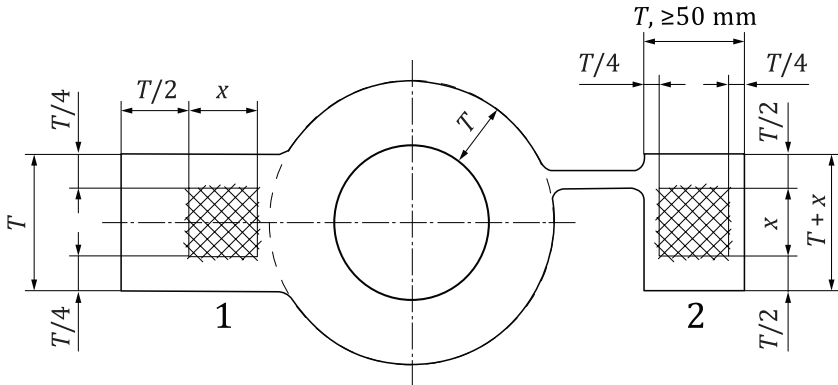
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

Non-destructive testing	<u>Visual inspection</u> VT shall be carried out on each forging in accordance with the product standard. The testing shall be performed after machining, if applicable, and non-machined surfaces shall be cleaned prior to the testing. <u>Magnetic particle testing</u> 10 % of all forgings per lot or a minimum of one item per lot in any purchase order shall be examined with magnetic particle testing. All accessible internal and external surfaces shall be examined according to ASME BPVC V, article 7 or ASTM A961/A961M supplementary requirement S55. Acceptance criteria shall be according to ASME BPVC VIII, Div. 1, appendix 6.
Repair of defects	Weld repair is not permitted.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^a	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements: <u>Hardness testing</u> Hardness testing shall be performed in accordance with the requirements in ASTM A350/A350M. The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The forgings shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.	

Material Data Sheet		MDS No. C105 / C105S ^a / C105SH ^b			Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel					
PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY REQUIREMENT	
Plates	ASTM A516/A516M	60, 65, 70	-	ASTM A516/A516M S5	
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.				
Chemical composition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 % For Grade 60 plate 12,5 mm (1/2 in) thick and thinner, C ≤ 0,21 %				
Heat treatment	During the heat treatment process, components shall be placed in such a way as to ensure free circulation around each plate including any quenching operation.				
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination.					
^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.					

Impact testing/ Toughness testing	Impact testing is required for thickness ≥ 6 mm. The test temperature shall be minus 46 °C. The minimum absorbed energy for full size specimens shall be 27 J average and 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3. The test specimen shall be taken in the longitudinal orientation to the final direction of rolling.
Non-destructive testing	<u>Visual inspection</u> VT shall be carried out on each plate in accordance with the product standard. The testing shall be performed after machining, if applicable, and non-machined surfaces shall be cleaned prior to the testing.
Repair of defects	Weld repair is not permitted.
Sour service (additional metallurgical, manufacturing, testing and certification requirements)^{a, b}	When sour service requirements are specified by the purchaser, the material shall conform to the requirements of the ISO 15156 series / ANSI/NACE MR0175 and the following additional requirements:
	<u>Chemical composition</u> $S \leq 0,003 \%$
	<u>Hardness testing</u> Production testing shall be performed in accordance with the requirements in ASTM A370 / ASTM A1058 on one plate per lot. The maximum hardness shall be 22HRC from three readings taken in close proximity at each location.
	<u>HIC testing and UT examination</u> When suffix SH applies, one plate per lot shall be tested as follows: — HIC testing: — HIC testing in accordance with NACE TM0284, using Test Solution A; — Acceptance criteria per specimen shall be $CLR \leq 15 \%$, $CTR \leq 5 \%$, $CSR \leq 2 \%$. — Maximum individual crack length shall be reported for each section. — UT examination: — ASTM A578/A578M S1; S2.1 shall apply.
	The material shall be traceable in accordance with ISO 15156-2 / ANSI/NACE MR0175 and this MDS.
Marking	The plates shall be marked to ensure full traceability to melt and heat treatment lot.
Certification	The material manufacturer shall have a quality system in place (e.g. ISO 9001) accepted by the purchaser. The inspection documents shall be issued in accordance with ISO 10474 / EN 10204 type 3.1 and shall confirm compliance with this specification. The inspection documents shall include the following information: — Heat treatment condition. For tempered condition, tempering temperature shall be stated.
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service, but excluding HIC testing and UT examination. ^b The supplementary suffix “SH” shall be used to designate a material delivered in accordance with the MDS including the additional supplementary requirements for sour service plus HIC testing and UT examination.	

Material Data Sheet	MDS No. C106 / C106S ^a	Rev. 1
TYPE OF MATERIAL: Impact tested carbon steel		
^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.		

PRODUCT FORM	STANDARD	GRADE	ACCEPTANCE CLASS	SUPPLEMENTARY RE- QUIREMENT
Castings	ASTM A352/A352M	LCC	-	ASTM A352/A352M S4, S5 ASTM A703/A703M S8, S14, S20
Scope	This MDS defines applicable options and/or requirements that supplement or amend the referenced standard specification.			
Chemical compo- sition	C ≤ 0,23 %, S ≤ 0,020 %, P ≤ 0,025 %, CE ≤ 0,43 %			
Heat treatment	During the heat treatment process, castings shall be placed in such a way as to ensure free circulation around each casting including possible quenching operation. For products delivered in the tempered condition, the minimum tempering temperature shall be 620 °C.			
Impact testing/ Toughness testing	ASTM A703/A703M supplementary requirement S8 shall apply. Impact testing shall be performed at a minimum temperature of –46 °C. Acceptance criteria shall be 27 J average, 20 J single. Reduction factors for sub-size specimens shall be: 7,5 mm – 5/6 and 5 mm – 2/3.			
Extent of testing	One set of tensile and impact test is required for each melt and heat treatment load. A test lot shall not exceed 5 000 kg.			
Test sampling	Test blocks shall be integrally cast or gated onto the casting and shall accompany the castings through all heat treatment operations including any post weld stress relieving. Thickness of the test block shall be equal to the thickest part of the casting represented up to a maximum thickness of 100 mm. For flanged components, the largest flange thickness is the ruling section. Dimensions of test blocks and location of test specimens within the test blocks are shown in the figure below for integral and gated test block. The test specimens shall be taken within the cross hatched area. Distance from end of test specimen to end of test block shall minimum be T/4.  1 integrated test block 2 gated test block			
Non-destructive testing	<u>General</u> For definition and NDT of pilot castings reference is made to the general part of this document. Non-machined surfaces shall be cleaned prior to the testing. <u>Visual inspection</u> The testing shall be carried out after finished machining.			

^a The supplementary suffix “S” shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.

Each pilot and production casting shall be tested at all accessible surfaces, including weld ends. Surface testing and acceptance criteria shall be in accordance with ANSI/MSS SP-55.

Magnetic particle testing

ASTM A352/352M supplementary requirement S4 shall apply as amended by this MDS:

Surface testing and acceptance criteria shall be in accordance with ASME BPVC VIII, Div. 1, Appendix 7.

Each pilot and production casting shall be tested after final machining at all accessible external and internal surfaces.

Radiographic testing

- Supplementary requirement S5 shall apply as amended by this MDS. Method of radiography and acceptance criteria shall be in accordance with ASME BPVC VIII Div. 1 Appendix 7.
- Valve castings shall be examined in the areas as defined by ASME B16.34 for special class valves and other critical areas as defined by designer. In addition, castings shall be examined at abrupt changes in sections and at the junctions of risers, gates or feeders to the castings.
- Sketches of the areas to be tested shall be established and agreed with the purchaser.
- When random testing (5 %) is specified, minimum one casting of each pattern including feeder and riser system in any purchase order with the foundry shall be examined.
- If defect outside acceptance criteria is detected, two more castings shall be tested, and if any of these two fails, all items represented shall be tested.
- Pilot castings shall be radiographed to the extent described above.
- Frequency of RT of valve castings shall be according to table below.

<i>Extent of RT based on pressure class and nominal outside diameter:</i>					
<i>Pressure class:</i>		<i>≤ 300</i>	<i>600</i>	<i>900</i>	<i>≥ 1 500</i>
<i>Frequency of RT</i>	Not re-quired	< 10"	< 2"		
	5 %	≥ 10"	≥ 2"		
	100 %	Not re-quired	≥ 20"	≥ 16"	≥ 6"

- Non-valve castings: Each casting shall be examined unless agreed otherwise. Testing shall be at abrupt changes in sections and at the junctions of risers, gates or feeders to the castings and other critical areas as defined by designer. Sketches of the areas to be tested shall be established and agreed.

Repair of defects

ASTM A703/A703M supplementary requirement S20 shall apply with the following additional requirements:

- Major repairs as defined in ASTM A352/A352M shall be documented in accordance with A703 S20.2.
- The repair welding procedure shall be qualified in accordance with ASTM A488/A488M or ISO 11970 and this data sheet using a cast plate.
- Weld repairs are not acceptable for castings that leak during pressure testing.
- Examination of major repair welds on pressure containing parts shall also include RT.
- The post-weld heat treatment temperature or stress relieving temperature for tempered parts shall maximum be equal to the final tempering temperature –15 °C.

^a The supplementary suffix "S" shall be used to designate a material delivered in accordance with the MDS plus the additional supplementary requirements for sour service.