

DEP SPECIFICATION

TECHNICAL REQUIREMENTS FOR THE SUPPLY OF COMPONENTS IN 6Mo AUSTENITIC, 22Cr DUPLEX AND 25Cr SUPER DUPLEX STAINLESS STEEL

DEP 30.10.02.35-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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All administrative queries should be directed to the DEP Administrator in Shell GSI.

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for supplying 6Mo austenitic, 22Cr duplex and 25Cr super duplex stainless steel components.

General requirements for all components are specified in (1) through (10). Additional requirements for specific product types (flanges, bends and tees) are specified in the relevant appendices in this DEP. Where appropriate, these appendices contain schematics indicating mechanical and corrosion specimen locations and orientations. For components not listed in the appendices, testing shall be carried out as detailed in the main sections of this DEP, taking into account the test specimen location and orientation relative to the finished component shape. In the event of any uncertainty with respect to the testing required or specimen location or orientation, clarification shall be sought from the Principal.

This DEP defines the minimum supplementary requirements for testing and inspection, during manufacture, of components made from the following materials:

- a. 6Mo austenitic stainless steel
- b. 22Cr duplex stainless steel
- c. 25Cr super duplex stainless steel

The components shall include seamless and seam welded pipe; plate; forged bar; flanges; fittings; valves; bends; tees; pumps; well accessories; castings; and other equipment components as advised by the Principal.

This DEP is intended for all components for both pressure containing and non-pressure containing applications, and shall be applied to both process and non-process wetted components.

The requirements of this DEP are primarily intended for finished components rather than raw material, such as plate used to fabricate components. Should components undergo further processing and heat treatment, the requirements of this DEP may not be applicable. Advice should be sought from the Principal in this regard.

In addition, for components to be used for subsea applications where cathodic protection is applied, the requirements of DNV RP F112 and EEMUA 194 shall be adopted.

This DEP shall be used in conjunction with other relevant procurement documents, such as the applicable base codes and specifications and MESC buying descriptions, as identified in the Enquiry or Purchase Requisition.

This DEP does not apply to:

- a. the assembly or fabrication of the components into pipelines, piping systems or vessels either onshore or offshore. Fabrication shall be carried out in accordance with relevant welding and fabrication DEPs.
- b. the manufacture and supply of duplex and super duplex line pipe, which is covered by DEP 31.40.20.34-Gen.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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

This DEP is intended for use in facilities related to oil and gas production. This DEP may also be applied in other similar facilities.

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

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

1.3 DEFINITIONS

1.3.1 General definitions

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

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

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

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.3.2 Abbreviations

Term	Definition
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
Cr	chromium
DAC	distance amplitude correction
DNV	Det Norske Veritas
EEMUA	Engineering Equipment and Materials Users Association
EFA	Enterprise Frame Agreement
FBH	flat bottom hole
HAZ	heat affected zone
HIP	hot isostatic pressing
HISC	hydrogen induced stress cracking
ID	internal diameter
ISO	International Standardisation Organisation
L	longitudinal
LPE	liquid penetrant examination
MESC	Materials and Equipment Standards and Code
MPQ	Manufacturing Procedure Qualification

Term	Definition
Mo	molybdenum
N	nitrogen
NDT	non-destructive testing
OD	outside diameter
PCN	personnel certification scheme
PMI	positive material identification
PRE(N)	pitting resistance equivalent number
RT	radiographic testing
RTJ	ring type joint
SNT	Society of Non-destructive Testing
T	transverse
TA	Technical Authority
UNS	Unified Numbering System
UT	ultrasonic testing
W	tungsten

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Other documents referenced by this DEP are listed in (11).

1.5 SUMMARY OF MAIN CHANGES

This is a new DEP.

1.6 COMMENTS ON THIS DEP

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

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

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

1.7 GUIDANCE FOR USE

The base code or specification will be dependent on the particular product type and will be defined in the enquiry or purchase requisition.

The requirements in this DEP are additional to all requirements specified in the referenced base code or specification.

Where the requirements of this DEP conflict with the requirements of other referenced codes, standards or instructions (including MESC descriptions), this DEP takes precedence.

1.8 DUAL UNITS

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

2. MANUFACTURE

2.1 METHOD

Items shall be manufactured by casting, forging or fabrication from wrought plate or tubular products, as appropriate to the product form and the base code or specification. All components SHALL [PS] be delivered in the solution annealed and water quenched condition, unless otherwise agreed with the Principal.

Forged materials shall be hot worked according to a written procedure and shall have a minimum forging ratio of 4:1.

As far as practically possible, forged and cast components shall be rough machined to near final dimensions prior to heat treatment.

Rolled or forged bar shall only be used in lieu of material forged close to final shape where specific approval from the Principal has been given. Such bars shall only be used provided the Manufacturer can demonstrate satisfactory material properties in the longitudinal and transverse directions, and providing that the starting bar is not greater than 200mm (8 in) in diameter.

Test specimens shall be extracted from areas that form part of the final component after machining. The Manufacturer shall provide drawings detailing the finished component shape showing the location and orientation of test specimens for approval by the Principal.

Components may be manufactured using the HIP process. Where low temperature properties are required (i.e. -50 °C (-58°F) or below) the use of HIP should be considered.

Fittings for subsea use shall not be manufactured from plate without prior approval from the Principal.

Tees shall be manufactured by forging or forming in one piece. The branch hot forming procedures is an essential feature of the manufacturing procedure qualified in accordance with this DEP. If seam welded pipe is used as the mother material the longitudinal weld shall be located in the body opposite the tee branch.

When welding procedure qualification test rings are required, as advised in the Enquiry or Purchase Requisition, the test rings shall be manufactured using the same procedure as the final components and shall have a minimum length of 400 mm (16 in), unless otherwise agreed with the Principal.

- a. The forging ratio, microstructure and mechanical properties of the test rings shall be as close as practically possible to that achieved for the manufactured components. If this cannot be achieved a sacrificial component(s) shall be supplied.
- b. Test rings shall be subject to testing in accordance with this DEP.
- c. If weld bevelling is required for the test ring both ends shall be machined.

2.2 MANUFACTURING PROCEDURE QUALIFICATION

All manufacturing procedures shall be qualified and appropriately documented. A Manufacturing Procedure Qualification (MPQ) shall be required for each type and size of product unless the Manufacturer has historical qualification test data, acceptable to the Principal, obtained from components of similar size manufactured to an identical procedure and heat treatment, using similar materials of the same UNS number.

Appendix D of this DEP details information to be recorded as part of the MPQ.

In addition to specific approval by the Principal, the essential variables of NORSOK M-650 shall apply to the qualification of manufacturing procedures based on historical qualification data.

2.3 WELDING AND GRINDING

The Manufacturer shall notify the Principal at the time of receipt of the Enquiry or Purchase Requisition if it is proposed to supply any component that will be fabricated from solution annealed sub-components, and where the fabrication weld will not be solution annealed.

All welding necessitated by the manufacturing method, and completed prior to final solution annealing, shall be carried out in accordance with the relevant base code or specification. The testing required by this DEP shall include samples that contain welds made during manufacture.

Bars in barred tees shall be attached using multipass full penetration butt welds.

2.3.1 Repair welding

Weld repairs on base material are not acceptable with the exception of castings. All repairs to castings shall require prior written approval from the Principal. The size and location of all repairs shall be recorded and reported (including a photographic map) to the Principal.

General requirements for all repair welding procedures shall be as follows:

- a. Repair welding procedures shall be submitted to the Principal for approval.
- b. All welding consumables shall be approved by the Principal. Unless otherwise agreed by the Principal, repairs that are subsequently solution annealed shall use nominally matching consumables. Repairs to be left in the as-welded condition shall use consumables over-matching the base material Ni content.
- c. All weld repairs shall be examined by volumetric (RT, UT) and surface (LPE) methods unless otherwise agreed by the Principal.
- d. Where applicable, final examination of repair welds shall be carried after solution annealing.

Repairs to castings by welding shall be in accordance with the relevant base code or specification. All welders and welding operators shall be qualified in accordance with the relevant base code or specification or a suitable alternative approved e.g., EN 287-1 or ASME IX.

The repair welding procedure qualification shall include the following as a minimum:

- a. Qualification on the same grade of material (UNS number)
- b. Specific make of filler metal (brand name)
- c. Charpy V-notch testing in accordance (5.3)
- d. Examination of microstructure of base material and weld zone in accordance with (6)
- e. Macro with hardness measurements in accordance with (5.4)
- f. Bend tests (face and root or side)
- g. Corrosion testing in accordance with (7)

Requirements for minor repairs are as follows:

- a. Minor repair welds are defined as welds required to finish or upgrade the casting which are less than or equal to 20% of the wall thickness of the section to be repaired.
- b. Minor repair welds do not require subsequent solution annealing and water quenching if the Manufacturer has a suitably qualified procedure approved by the Principal.
- c. Three minor repairs separated by less than 25 mm (1 in) shall be considered a major repair

Requirements for major repairs are as follows:

- a. Major repair welds are defined as welds required to finish or upgrade the casting, which exceed 20% of the wall thickness of the section to be repaired.

- b. Major repair welds shall be heat treated in the same manner as the base material and must meet all testing requirements of the base material as stipulated in this DEP.
- c. Major weld repairs shall not exceed $3.28 \times 10^{-4} \text{ m}^3$ (2 in³) in volume.
- d. There shall be no more than two major repair welds per component.

Grinding of duplex and super-duplex stainless steel components shall require qualification of the procedure by the Manufacturer, and shall be carried out using iron free grinding discs and stainless steel tools. Qualification shall include metallographic and hardness testing in accordance with (5.4) and (6).

2.4 MATERIAL TESTING – GENERAL REQUIREMENTS

Testing of components shall be performed on material after final heat treatment. Samples for testing shall be taken from one of the following:

- a. Random selection of a component of the same type and form, and from the same heat and heat treatment batch
- b. Prolongation of a component
- c. An integral test coupon that is representative of the size and shape of the component. A separate test coupon should not be used but may be allowed, subject to approval from the Principal, provided that it is same material and dimensionally representative of the actual component, and is heat treated simultaneously with the product.

Testing shall be carried out on material, as defined above, for every lot, where a lot is defined as components of the same type, heat, UNS number, specified dimensions, manufacturing dimensions, manufacturing process, and heat treatment.

Testing shall demonstrate that reasonably uniform and acceptable properties are obtained in longitudinal and transverse directions.

Test samples for downhole well components may be taken from locations that are representative of the final product form. This is typically relevant for components machined from bar.

3. HEAT TREATMENT

Component heat treatment procedures shall be in accordance with the base code or specification and shall form part of the written procedures of the Manufacturer. The heat treatment procedures shall be submitted to the Principal for approval following receipt of the Enquiry or Purchase Requisition.

The heat treatment furnace and its ancillaries should be an integral part of the manufacturing facility. If this is not the case, the Manufacturer shall on receipt of the Enquiry or Purchase Requisition, provide all required procedures required for the control of the heat treatment process and documented evidence of successful use of the proposed facility.

The heat treatment facility shall maintain and operate a quality assurance system in accordance with ISO 9001.

The layout of the components during heating and cooling shall be such as to ensure that the specified soaking temperature, and heating and cooling rates, are achieved for every component within a heat treatment batch.

It shall be ensured that steps taken to minimise distortion of thin-walled components do not prevent the attainment of adequate soaking times at the specified temperature.

Components shall not be placed on furnace floors. Diagrams, or preferably digital photographs, showing the layout of components within furnaces shall be available for review by the Principal.

The heat treatment procedure shall contain, as a minimum, full details of the following:

- a. Facility location
- b. Furnace type and ID
- c. Loading patterns and limitations
- d. Thermocouple locations (see below)
- e. Soaking temperatures and tolerances
- f. Soaking times and tolerances
- g. Heating rates
- h. Cooling conditions including medium and quench bath temperature
- i. Details on how individual components will be separated to ensure a uniform water quench following solution anneal
- j. Furnace work zone dimensions
- k. Time to transfer components from furnace to quench bath
- l. Furnace calibration including temperature ranges
- m. For continuous and semi conducting furnaces, travel speed and heating/working zones

In addition to the furnace recording pyrometry, calibrated thermocouples shall be attached to at least two components in each heat treatment load, or at two locations on a large component heat treated by itself.

- a. The thermocouples shall be located within the furnace at the positions subjected to the lowest and highest anticipated temperatures during heating and soaking.
- b. The temperatures recorded on these two thermocouples shall not differ by more than 15 °C (60 °F) during heating and shall be within the declared temperature tolerance during the soaking period.
- c. A sketch shall be provided that indicates the location of the thermocouples and pyrometers.

- d. A chart record of the temperature measured by these thermocouples shall be available for review by the Principal.

Where the thermocouple placing specified above is considered not feasible in practice, (e.g., where walking beam furnaces are used), the Manufacturer shall clearly demonstrate that adequate control of temperature will be achieved. The details of any alternative arrangements shall be submitted following receipt of the Enquiry or Purchase Requisition, for review and approval by the Principal prior to any manufacture.

All furnaces used for heat treatment shall be calibrated in accordance with ISO 10423:2009 Annex M, API RP 6HT or relevant equivalent.

Transfer of duplex and super-duplex stainless steel components from the furnace to the water quench bath shall be achieved within 60 seconds.

- a. Measurement of the time taken shall commence on start of withdrawal of the load from the furnace and shall be recorded during MPQ and reported in MPQ documentation.
- b. There shall be no delay from opening of the door to the point where the load is taken out.
- c. The quench water shall be agitated, preferably by cross flow, to ensure adequate quenching.
- d. The start and end temperature of the quenching water shall be recorded and shall not exceed 40 °C (104 °F).

4. MATERIALS**4.1 CHEMISTRY REQUIREMENTS**

Component material of manufacture shall be in accordance with a relevant UNS Number, with a nitrogen content and PRE(N) as defined in Table 4.1.

Table 4.1 PRE(N) and nitrogen requirements

Alloy²	Nitrogen Content %	PRE(N) or PRE(W)¹ (min)
6Mo	0.18 min	40
22Cr Duplex	0.14 min	34
25Cr Super Duplex	0.20 min	40

NOTES: 1. $PRE(N) = \%Cr + 3.3 \times \%Mo + 16 \times \%N$ or $PRE(W) = \%Cr + 3.3 \times (\%Mo + 0.5 \times \%W) + 16 \times \%N$
 2. The maximum sulphur level shall be 0.010 % for all material types and grades.

4.2 SURFACE CONDITION

All components shall be supplied white pickled (de-scaled and acid cleaned) and passivated unless subsequently machined to final shape, or where the manufacturing process does not result in a scaled surface. The procedure for pickling shall be submitted for review.

The surface of all finished components shall be completely free of debris, dirt, weld splatter etc.

The final surface condition shall at least meet a maximum roughness of $Ra = 35$ micrometers.

4.3 SUPPLY ROUTE AND QUALITY ASSURANCE/ CERTIFICATION REQUIREMENTS

The Manufacturer and Supplier shall maintain and operate a quality assurance system in accordance with ISO 9001. In addition, the guidance given for manufacturing quality requirements by EEMUA 218 shall be implemented as far as possible.

Manufacturer's test reports are required for all components supplied according to this DEP. Test reports shall include details of country of manufacture, heat treatment, chemical analysis obtained from one component from each cast supplied (analysis carried out by the Manufacturer), mechanical test results as required by the product specification, and the metallurgical examination as required by (6) of this standard. All heat treatment charts and records, as defined in (3) of this DEP, shall also be supplied. All documentation, including charts and photos, shall be legible and in English.

For supply of materials where the Pressure Equipment Directive (PED) is applicable, the manufacturing procedures shall have undergone a specific assessment for materials in accordance with the requirements of this DEP (Ref. PED 97/23/EC, Annex I, 4.3). The Certification shall be accompanied by a valid test and inspection plan signed by a Notified Body.

In the case of supply of piping components; flanges, pipe, fittings, these materials shall be sourced from Manufacturers/Suppliers that are on the Principal's technically approved manufacturer's list.

Principal approved Manufacturers shall be selected for the manufacture and supply of other products made from materials as specified in this DEP.

A Manufacturer shall, as a minimum, provide test reports with inspection certificates in accordance with ISO 10474, type 3.1B or 3.2 that are representative for the manufacture of the required products.

When a Manufacturer is not qualified as stated above, a specific Inspection & Test Plan (ITP) shall be prepared and approved with the requirement that the test reports with inspection certificates shall be provided in accordance with ISO 10474, type 3.2.

A Manufacturer holding a valid NORSOK M-650 qualification shall, as a minimum, provide test reports with inspection certificates in accordance with ISO 10474, type 3.1B or 3.2 that are representative for the manufacture of the required products.

4.3.1 Stock components

6Mo materials may be supplied from stock when 3.1B certification is provided, the material supplied from a qualified manufacturer and the requirements of this DEP are met.

22Cr duplex and 25Cr super duplex stainless steel components supplied from stock, and certified to ISO 10474, type 3.1 certification, may be accepted subject to approval from the Principal. Full traceability for these components shall be proven and material certificates available.

Typically the following will be required in order to accept stock components with 3.1B certification:

- a. Full review of all certification and confirmation that all requirements of this DEP are met
- b. Original testing witnessed by an accredited third party or carried out in a laboratory accredited to ISO 17011.

and

- c. Sacrificial testing of component from same heat treatment batch.

or

- d. Additional NDT testing on the components to be purchased. Testing shall be defined by the Principal based on (1) and (2) above, but shall typically include 100 % PMI, ferrite scope checks and surface replica metallography.

The Principal shall confirm any additional testing requirements after documentation has been submitted.

4.4 POSITIVE MATERIAL IDENTIFICATION

Positive material identification (PMI) shall be performed in accordance with DEP 31.10.00.10-Gen.

The percentage of components tested may be defined following a risk based assessment.

The metal grade shall be identified. The measured values shall be specified, as a minimum, for the main alloy elements Cr, Ni, Mo per the material base code or specification.

4.5 MARKING

All marking shall be carried out using low-stress die-stamping, electronic etching or by the vibro-etching method. The maximum depth shall be 0.5 mm (0.02 in) and the minimum height 8 mm (0.3 in).

4.6 PROTECTION AND HANDLING

Components shall not be oiled for preservation nor any other coating applied, unless otherwise specified. All components shall be cleaned, dried, packed, handled and transported so as to arrive at their destination dry and without distortion or damage.

Nylon slings or rubber-coated hooks/supports shall be used for all handling operations. Components shall not come in to contact with carbon steel bearers or any carbon steel swarf, debris or tools. If wire brushes are used for any operation they shall be made from stainless steel wire and be dedicated for use on stainless steel. All grinding shall be carried out using consumables that are dedicated for use on stainless steel.