

Qualification of manufacturers of special materials

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Annexes B and C are normative, whilst Annex A is for information only.

Introduction

This revision replaces NORSOK M-650, Rev. 2.

The main changes made are related to the following items:

- Validity of the Qualification Test Record (QTR).
- Changes in essential variables of the qualification test.
- Additional extent of testing for section thickness above 60 mm and 120 mm.
- Additional requirements to the content of the Qualification Test Record (QTR).
- Third party witnessing is required for qualification tests, EN 10204 Type 3.1C certificate to be issued.
- Introduction of Qualification Test Record (QTR) front page, see Annex C.

This NORSOK standard is published without marking of changes, compared to Rev. 2, as the modifications are considerable.

1 Scope

This NORSOK standard establishes a set of qualification requirements to verify that the manufacturer has sufficient competence and experience of the relevant material grades, and necessary facilities and equipment to produce these in the required shapes and sizes with acceptable properties.

The following materials grades are included:

- Duplex SS: all grades, product forms and dimensions
- High alloyed austenitic SS: all product forms and dimensions
- Nickel base alloys: castings
- Titanium and its alloys: castings

This NORSOK standard may also be considered for critical components or product forms in other materials) and for special manufacturing/fabrication processes, e.g. induction and cold bending.

Structural steels are not included.

2 Normative references

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

ASTM A 703	Steel Castings, General Requirements, for Pressure-Containing Parts
ASTM A 991	Standard test method for conducting temperature uniformity surveys of furnaces used to heat treat steel products
EN 10204:1991	Metallic products – Types of inspection documents including EN 10204:1991/A1:1995
ISO 9001	Quality Management Systems – Requirements
NORSOK M-630	Material Data Sheet for Piping

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1

can

verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.2

company

operator of a development/project

NOTE: This is normally an oil company.

3.1.3

high alloyed austenitic SS

austenitic SS with $PRE \geq 40$ or $Ni + 2 \times Mo > 30$ ($Mo > 2$)

EXAMPLES: SS type 6Mo, UNS S31266, UNS S32654, UNS S34565, UNS J95370

3.1.4

main contractor

contractor holding an engineering and procurement contract or an engineering, procurement and construction contract

3.1.5**manufacturer**

manufacturer including sub-vendors carrying out the operations affecting the material properties

3.1.6**may**

verbal form used to indicate a course of action permissible within the limits of the standard

3.1.7**pitting resistance equivalent****PRE**

$PRE = \%Cr + 3.3 \times \%Mo + 16 \times \%N$

3.1.8**purchaser**

body that purchase a product from a manufacturer

3.1.9**shall**

verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.10**should**

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.11**SS type 22Cr duplex**

ferritic/austenitic stainless steel alloys with 22 % Cr

EXAMPLES: UNS S31803 and UNS S32205

3.1.12**SS type 25Cr duplex**

ferritic/austenitic stainless steel alloys with 25 % Cr and $PRE \geq 40$

NOTE: Often referred to as "super duplex".

EXAMPLES: UNS S32550, UNS S32750, UNS S32760 and UNS S329274.

3.1.13**SS type 6Mo**

austenitic stainless steel alloys with 6 % Mo and $PRE \geq 40$

EXAMPLES: UNS S31254, UNS N08367 and UNS N08926.

3.2 Abbreviations

HIP	hot isostatic pressed
MDS	material data sheet
NDE	non-destructive examination
PRE	pitting resistance equivalent
QTR	qualification test record
PWHT	post weld heat treatment.
SS	stainless steel
WPQR	welding procedure qualification record
WPS	welding procedure specification

4 Responsibilities

The purchaser is responsible for ensuring that his manufacturers are qualified within the essential variables within this NORSOK standard. Acceptance of a manufacturer is at the discretion and determination of the purchaser.

The qualification exercise itself should be carried out in co-operation with company or its main contractors.

5 Basis for qualification of manufacturers

The basis for qualification of manufacturers shall be

- knowledge and relevant manufacturing experience with the type of material to be qualified (see clause 6),
- acceptable manufacturing facilities and equipment (see clause 6),
- established manufacturing summary (procedure) covering all manufacturing steps from melting or semi product to finished products (see clause 7),
- manufacturers quality system, which shall fulfill the requirements of ISO 9001 or equivalent,
- results of testing in compliance with this NORSOK standard (see clause 8).

Prior to qualification a complete QTR (see clause 9) with information and results of testing as required by this NORSOK standard shall be available for review.

6 General requirements

6.1 Knowledge and relevant experience

The manufacturer shall have knowledge of relevant metallurgical aspects of the applicable alloys including precipitation diagrams, effect of hot forming, welding, and heat treatment parameters, etc. as applicable for his manufacturing process.

The manufacturer shall have relevant experience with manufacture of the type of material to be qualified. Relevant experience should be supported by statistical data or relevant test records from the last 2 years to 3 years production for the product, material and the range of size to be qualified. The material shall have been produced to manufacturing procedures and with equipment intended used for manufacturing to the relevant requirements.

6.2 Manufacturing facilities and equipment

Facilities and equipment shall be fit for purpose, regularly maintained and calibrated as required.

Foundries shall have heat treatment facilities within their own premises or they shall be located in their close vicinity.

Calibration of the quality heat treatment furnaces shall be made in accordance with ASTM A 991 and additional requirements given in Annex B or equivalent. The calibration shall be carried out with maximum workload, see ASTM A 991 para 6.1.2. This is to demonstrate that the required temperature uniformity and the maximum temperature specified can be reached. The subsequent annual calibrations may be carried out with empty furnace according to the standard.

The equipment shall be capable of transferring materials from heat treatment furnace into quenching bath within maximum 60 s for alloys requiring water quenching unless specifically qualified for the applicable material, product and size.

Quenching baths shall have satisfactory circulation and cooling facilities and shall be capable to keep the water temperature below 50 °C after completion of any quenching operation. The bath should be equipped with temperature monitoring/recording devices.

6.3 Sub-suppliers

If parts of the production are carried out at a sub-supplier, the manufacturer is responsible for ensuring that the sub-supplier meets the requirements of this NORSOK standard for the manufacturing steps that the sub-supplier is performing.

6.4 Evaluation for acceptance

The evaluation for acceptance shall include a visit to the manufacturers and sub-suppliers premises for review of facilities, systems, implementation of procedures and documentation as required by this NORSOK standard. The evaluation for acceptance shall concentrate on facilities and equipment for melting, refining, forming, welding, heat treatment, etc. The review shall be carried out by technical competent personnel and shall be documented, e.g. by a minutes of meeting.

7 Manufacturing summary

7.1 Requirements for manufacturing summary

The manufacturer shall have a manufacturing summary for each production route, type of product and grade of material.

NOTE: Sometimes it may be convenient to combine several production routes, type of products and/or grade of materials into one manufacturing summary, e.g. as shown in the flow chart in Annex B.

The manufacturing summary shall describe, step by step in a logical and correct sequence all important manufacturing activities with reference to detailed procedures. A short description and the main parameters for each activity shall be included. Each production route shall be illustrated with a flow chart. The manufacturing summary is the property of the manufacturer. Distribution is at the manufacturers discretion.

If the manufacturer has different plants or different production routes for a product, separate documentation is required for each of these. If essential parts of the work, such as e.g. heat treatment are subcontracted, this shall be identified in the documentation. The documentation shall then include name and address of each subcontractor and the relevant documentation from the subcontractor's equipment and procedures.

Whenever a change is made in the equipment or procedures, the documentation shall be updated accordingly.

7.2 Content of manufacturing summary

7.2.1 Scope

The scope of the manufacturing summary shall be clearly defined by stating

- name and address of manufacturer,
- grade of material with reference to standard and MDS,
- type and size range of products for which the manufacturing summary applies,
- identification of the manufacturing process.

7.2.2 Content

The manufacturing summary shall include, but not be limited to, the following:

- a) Type and manufacturers requirements (purchasing specification) to start material. Apply especially when semi finished products as ingot, bar, pipe, plate, strip, etc., is used as basis for the manufacture. In such cases also the manufacturer of the start material shall be stated.
- b) Manufacturers receiving inspection of start material.
- c) Melting shop including
 - 1) melting and refining process;
 - 2) casting method, e.g. ingot, continuous cast, etc.
- d) Foundry including
 - 1) melting and refining process;
 - 2) handling of and maximum percentage of return scrap;
 - 3) casting process, e.g. investment, centrifugal, sand castings, etc.;
 - 4) moulding method, type of sand, binding agent and method of casting.
- e) Hot forming including
 - 1) all hot forming processes as forging, pressing and rolling with information about size and thickness range of each hot forming process;
 - 2) maximum and minimum hot forming temperatures and how these temperatures are controlled;
 - 3) possible reheating cycles;

- 4) minimum forging ratio;
 - 5) sketch illustrating each step in the forming process, see Annex A;
 - 6) method of cooling after completion of the hot forming process.
- f) Heat treatment including
- 1) loading temperature, heating rate, holding temperature and time;
 - 2) for continuous and semi continuous furnaces: travel speed as function of size (e.g. thickness, diameter, cross section, etc.) of products to be heat-treated and other relevant parameters.
 - 3) stacking of components in furnace;
 - 4) type and identification of furnace(s);
 - 5) maximum operating temperature for furnace(s);
 - 6) temperature control and calibration of furnace(s);
 - 7) cooling facilities and maximum time from furnace to cooling bath. In addition shall start and maximum end temperature of the bath including how this is controlled shall be stated;
 - 8) sketch of heat treatment facilities/furnace, which also shall show location of pyrometers and/or thermocouples in the furnace. For continuous furnaces the heating zone and the working zone shall be clearly defined.
- g) Blasting/cleaning equipment, inclusive type of grit.
- h) Pickling.
- i) Welding (including weld repair).
- j) PWHT (if applicable).
- k) NDE and inspection.
- l) Production testing including
- 1) type of tests;
 - 2) time of test sampling;
 - 3) sketches showing typical samples with dimensions for production tests with location and orientation of test specimens.
- m) Description of the material traceability system.
- n) A list of applicable procedures.

An excerpt from a typical manufacturing summary is included in Annex A as an example.

8 Qualification of the manufacturing process

8.1 General

The manufacturing process as described in the manufacturing summary shall be qualified by testing of actual products to

- a) demonstrate that the proposed manufacturing route and production parameters result in products meeting specified requirements;
- b) verify that the proposed production test sampling gives results, which are representative of the properties in the actual components they represent.

In cases where applicable standards and/or specifications do not clearly specify the way production test sampling shall be carried out, the manufacturer shall propose a production test sampling scheme. This may apply to die forged components with weight > 50 kg.

The manufacturer shall update the QTR when necessary and a revision record shall describe all changes made.

8.2 Validity of qualification

8.2.1 General

The validity of a qualification is 5 years from the date of acceptance of the QTR.

The qualification process shall be repeated if any essential changes are made to the production route or the manufacturing procedure.

If production is carried out at different plants/locations, a separate qualification is required for each plant. This applies also for change of subcontractors for essential operations as e.g. heat treatment, etc.

Guidelines for renewal of the qualification after expiring date:

- Manufacturer with regular production as deliveries to actual manufacturing summary is normally requalified by this practice and additional testing is not required.
- A visit shall be made to the manufacturer according to 6.4.
- The manufacturing summary shall be reviewed, updated and a decision made whether retesting is required.
- A minutes of meeting with conclusions for renewal of the qualification shall be implemented in the QTR.
- The QTR front page to be updated.

Qualifications carried out according to revision 2 of this NORSOK standard are generally valid for 5 years. For bars and forgings with section thickness/diameter exceeding 60 mm for highly alloyed austenitic SS and SS type 25Cr duplex, and 120 mm for SS type 22Cr duplex the qualified thickness shall be equal to the tested thickness T only.

8.2.2 Thickness limitations and weight

The maximum qualified weight and thickness shall be according to limits given in Table 1, but shall in any case not exceed the limits specified in the manufacturing summary.

Table 1 - Qualified maximum thickness and weight for applicable products

Type of product	Type of material	Tested thickness (mm)	Qualified thickness (mm)	Weight of tested component (kg)	Qualified weight (kg)
Strip, plate, pipe, tube and wrought fittings	High alloyed austenitic SS + SS type 25Cr duplex	$T \leq 40$	$T + 25 \%$, maximum 40	N/A	N/A
		$T > 40$	T		
	SS type 22Cr duplex	$T \leq 60$	$T + 25 \%$, maximum 60	N/A	N/A
		$T > 60$	T		
Castings, forgings, bars and HIP	High alloyed austenitic SS, Ni-alloys + SS type 25Cr duplex	$T \leq 60$	$T + 10 \%$, maximum 60	$G \leq 250$	$G + 100 \%$
		$T > 60$	T	$G > 250$	All
	SS type 22Cr duplex	$T \leq 120$	$T + 10 \%$, maximum 120	$G \leq 250$	$G + 100 \%$
		$T > 120$	T	$G > 250$	All
	Titanium	T	$T + 25 \%$	$G \leq 150$	$G + 100 \%$
				$G > 150$	All
Investment castings	All	T	$T + 25 \%$	N/A	N/A

8.2.3 Material grade

A change from one material grade to another (e.g. change from one UNS No. to another UNS No.) requires requalification.

8.2.4 Type of melting and refining equipment

A change of the final melting/refining process requires a requalification.

8.2.5 Casting methods

A major change of the casting method requires requalification.

NOTE: A "major change" means e.g. a change between ingot casting and continuous casting for semi-finished products or a change between static casting, centrifugal casting, or vacuum casting for finished products.

8.2.6 Manufacturing equipment

A major change of manufacturing equipment requires requalification, unless the new equipment can be regarded as comparable to the old one with respect to its influence on the product properties. This applies also if the manufacturer has several alternative manufacturing routes for a product.

8.2.7 Forming process

A change from one forming method to another and a change of forging temperature outside the established and qualified tolerances requires requalification. Typical examples are

- from rolling to forging or vice versa,
- from die forging to open die forging or vice versa,
- from hammer forging to press forging or vice versa,
- from hot pressing to extruding or vice versa,
- from hot to cold forming/rolling or vice versa,
- change of cooling method after hot forming from water quenching to any other cooling method.

8.2.8 Heat treatment

The allowable range of heat treatment temperature shall be within $-10\text{ }^{\circ}\text{C}$ to $+30\text{ }^{\circ}\text{C}$ from the temperature used for the component for the qualification testing.

A change of heat treatment method (e.g. a change from furnace heat treatment to induction heat treatment or vice versa, or from batch to continuous heat treatment or vice versa) requires requalification. This also includes PWHT operations, when applicable.

8.2.9 Change of manufacturer of semi-finished products

If the manufacturing is based on the use of semi-finished product from a sub-supplier (e.g. plate, pipe, forgings, billets, bars, etc.), then a change of manufacturer for such products shall require renewal of the qualification. This is not required provided the new sub-supplier is qualified.

8.2.10 Welded products

For manufacture of welded pipe and fittings a change of WPS does not require requalification with except of change from

- double sided to single sided welds,
- change of welding method.

8.3 Qualification testing

8.3.1 Selection of components for testing

Selection of components for testing and test sampling shall be as agreed between purchaser and the manufacturer.

Components for testing shall have a section thickness in the upper thickness range specified by the manufacturing summary and they shall represent the most adverse deformation rate applicable during manufacture. Except for castings and open die forgings the components shall be representative in geometry of what actually shall be manufactured. Castings and open die forgings selected for testing shall be actual products, i.e. not test blocks. For castings qualification should be carried out on a cored component, e.g. valve body.

8.3.2 Testing

All extraction of test samples and testing specifically related to the qualification tests shall be certified in accordance with EN 10204 Type 3.1C.

Testing for qualification shall comprise

- a) production testing with test sampling as specified in NORSOK M-630: MDSs, other applicable standard and/or the manufacturing summary;
- b) additional testing for qualification according to Table 2;

- c) non-destructive testing as specified in NORSOK M-630 and relevant MDSs and/or other relevant material specifications.

Table 2 – Testing required for qualification

Type of product	Sample for production test ^a	Additional tests ^b for qualification ^c
Strip	Cut from strip.	One end on at least two coils shall be tested with three set of tests at each end located in the middle and at each edge.
Plates	Cut from plate.	Both ends on at least two plates shall be tested with three sets of tests at each end located in the middle and at each edge.
Seamless pipe and tube	Cut from over-length of pipe	At least two pipes/tubes shall be tested at one end and in the mid-length position.
Welded pipe and tube	Cut from over-length of pipe or from test plate welded as prolongation of the pipe/tube weld.	Weld and base material shall be tested at one end and in the mid-length position on two pipes.
Wrought fittings - seamless and welded	Cut from sacrificial fitting, over-length of fitting or for welded fittings test plates welded as a prolongation of the fitting weld.	One fitting of each type shall be tested at one end as a minimum. In addition different locations with different deformation ratio should be tested, e.g. inner- and outer radii and neutral zone for elbows. Tees should be tested both in one end and in the crotch area. For welded fittings testing shall comprise base material and weld(s).
Bars	Cut from over-length of bar.	Tests shall be carried out at one end and in the mid-length position of bar. Additional testing according to 8.3.3 apply for SS when section thickness is greater than 60 mm for highly alloyed austenitic SS and SS type 25Cr duplex and 120 mm for SS type 22Cr duplex.
Forgings – closed die. Weight equal to or less than 500 N	Sacrificial forgings.	N/A
Forgings – Closed die weight exceeding 50 kg	Sacrificial forgings.	Additional testing according to 8.3.3 apply for SS when section thickness is greater than 60 mm or 120 mm.
Forgings - open die	Tests from prolongation on actual forging. ^d	Additional testing according to 8.3.3 apply for SS when section thickness is greater than 60 mm for highly alloyed austenitic SS and SS type 25Cr duplex and 120 mm for SS type 22Cr duplex.
HIP components	Integral test blocks.	Testing shall be made from thin and thick sections of a sacrificial product. For sections above 60 mm for SS type 6Mo and SS type 25Cr duplex and 120 mm for SS type 22Cr duplex the tests specified in the respective MDS shall be carried out in the T/4 and the T/2 position. The tests from the T/2 position are for information only.
Ring rolled products	Tests from prolongation on actual forging or separate forged test ring.	Additional testing according to 8.3.3 apply for SS when section thickness is greater than 60 mm or 120 mm.
Castings	Integral test blocks.	Tests from thin and thick sections of a sacrificial casting.
Dished heads	From over-length of the component.	Tests shall be carried out from the over-length and from the deformed area of the component. For dished heads made of plates and welded together prior to forming the tests shall include a weld.
^a Test sampling as specified in the MDS and/or the manufacturing summary. ^b Type and number of tests as specified in the MDS and material specification. ^c A sketch shall be prepared with dimensions of production test samples and tested component for qualification. Location and orientation of test specimens shall be shown. The components used for qualification should in addition be documented with photographs. ^d Use of separate forged test block requires acceptance by purchaser.		

Testing shall be performed on products from regular production or from test production manufactured according to the normal manufacturing route and with regular production equipment.

Type of tests to be performed and minimum requirements shall be as specified in NORSOK M-630 and relevant MDS (or material standard/specification if materials are not covered by a MDS) except that for materials requiring impact testing, the requirement for base material shall be 20 J higher than the production test requirements.

8.3.3 Additional testing

For section thickness/diameter exceeding 60 mm for highly alloyed austenitic SS and SS type 25Cr duplex, and 120 mm for SS type 22Cr duplex, the additional tests listed below shall be carried out. The test results shall be for information only.

- a) Impact (for duplex SS only) and tensile testing in both the longitudinal and transverse direction in the 1/4T x T location.
- b) Impact (for duplex SS only) and tensile tests from the mid-thickness location, T/2 x T, in both longitudinal and transverse direction.
- c) From the mid thickness location, T/2 x T, hardness, corrosion and micro-examination shall be carried out according to conditions as specified by applicable MDS.

8.4 Welding procedure qualifications

The qualification exercise shall include the supporting WPQR for the WPS for the following:

- Welded products according to applicable MDS.
- Repair welding of welds according to applicable MDS.
- Minor and major repair welding as defined in ASTM A 703 for castings.

9 Qualification test record (QTR)

Prior to being accepted the manufacturer shall establish a QTR. The QTR shall be issued with document and revision numbers. The document shall be prepared with a front page with relevant information, see Annex C, and a following page including table of content. For being accepted it is essential that all documentation is accurate and specific.

Content of QTR shall include the following:

- a) Name and address of manufacturer, see Annex C QTR front page.
- b) Manufacturing summary, see clause 7.
- c) Description of samples used for production testing and component(s) tested for qualification. Sketch(es) shall be prepared with dimensions of production test samples and tested components for qualification. Location and orientation of test specimens shall be shown, see 8.3.
- d) Heat treatment chart(s) from the heat treatments of the components used for the qualification testing, see 8.2.8.
- e) Test reports from qualification testing as required in 8.3.2.
- f) WPS and WPQR, see 8.4.
- g) Specific reference list from the last two years manufacture of the grade of material and type of components as included in the manufacturing summary, e.g. see clause 7:
 - 1) grade of material;
 - 2) type of products;
 - 3) size/weight of products manufactured;
 - 4) tonnage produced per year of subject grade of material;
 - 5) project/customer references;
 - 6) production statistics (test results) from regular production.
- h) Record of furnace temperature uniformity survey according to Annex B.
- i) Description of quality assurance system.
- j) Minutes of meeting(s) from visit(s) to manufacturer by purchaser as required in 6.4.

Annex A (Informative) Manufacturing summary front page and example

Example of information, which shall be included on the front page:

Plant(s) and location(s): *Actual plants, locations and equipment facilities where this procedure is relevant.*

Product(s): *e.g. CLOSED DIE FORGINGS*

Specification(s): *e.g. NORSOK M-630, MDS D44 Rev. 3*

Limitations in the procedure:

- Weight:**
- Length:**
- Thickness:**
- Other:**

Qualification documentation: *Ref. to the relevant document(s)/reports/test result(s) which confirm that manufacturing of materials in accordance with this procedure will ensure satisfactory results per the actual specification.*

Other relevant information:

Revision:	Date:	Made by:	Checked by:	Approved by:

Manufacturing Summary No.:

EXAMPLE OF MANUFACTURING SUMMARY (4 pages)Doc. No: MS-03
Page 1 of 4

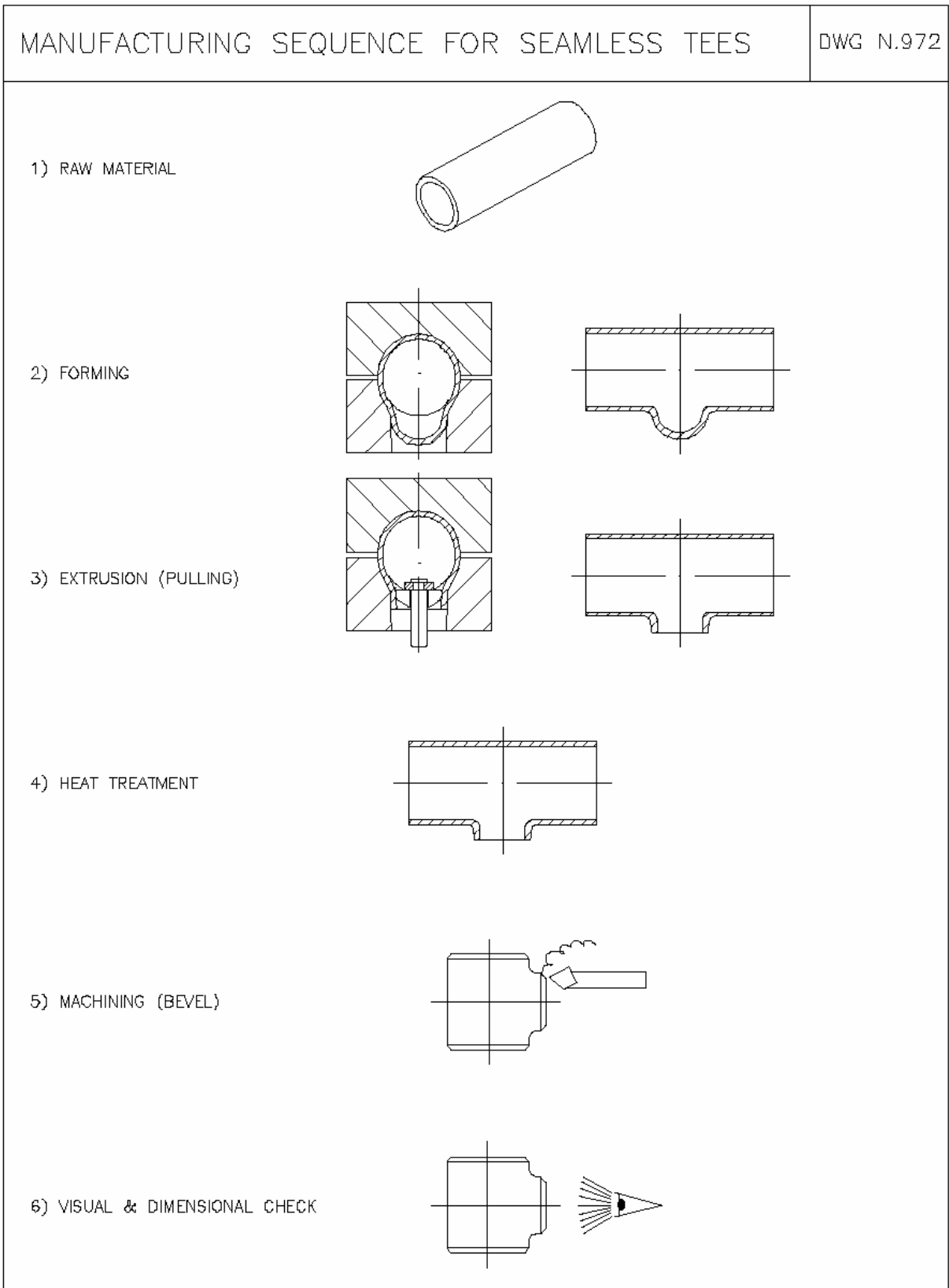
MANUFACTURING SUMMARY
TEE MADE BY FORGING
Seamless Pipe
Size 1" to 24" / Thickness 10 mm to 31,25 mm
ASTM A 815 UNS S31803 – MDS D43 REV. 2
(Prototype Tee 6" sch. 160)

N°	PHASE	DESCRIPTION	PROCEDURE
1	Identification of base material	Pipe to ASTM A 790 S31803 MDS D41 Rev. 2 N = 0,14 % to 0,20 % Manufacturer:	POQ-05
2	PMI	100 % raw material.	PMI-01 Rev.0
3	Cutting	Cutting to required length by saws.	POQ-09
4	Identification marking	Hard stamping of last two number of heat number.	POQ-05
5	Heating	Heating at xxxx °C - xxxx 0 °C holding time minimum 1 min for each mm thickness. Temperature controlled by opt. pyrometer. Equipment = furnace bloss N° 3 furnace gibbon N° 2	POQ-09 I.O. 13 Rev.2
6	Ovalization	Ovalization of pipe by pressing Equipment = 60 t; 100 t; 150 t; 200 t; 250 t; 300 t; 400 t; 900 t; 1200 t.	POQ-09 I.O. 13 Rev. 2
7	Re-heating	Reheating at xxxx °C - xxxx °C holding time minimum 1 min for each mm thickness. Temperature controlled by opt. pyrometer.	POQ-09 I.O. 13 Rev.2
8	Forming	Forging by presses Start forming temperature xxxx°C – xxxx°C Equipment = 60 t; 100 t; 150 t; 200 t; 250 t; 300 t; 400 t; 900 t; 1200 t. After forming the temperature shall not be less than 950 °C.	POQ-09 I.O. 13 Rev.2
9	Cooling	Quenching in cold water.	
10	Cutting hole	Cutting of bulge.	
11	Re-heating	Re-heating at xxxx °C – xxxx °C holding time minimum 1 min for each mm thickness. Temperature controlled by opt. pyrometer.	POQ-09 I.O. 13 Rev.2
12	Extrusion	Extrusion of branch by press After extrusion the temperature shall not be less than xxx °C. Re-heating at xxxx °C if more than one step is necessary.	POQ-09 I.O. 13 Rev.2
13	Cooling	Quenching in cold water.	
14	Cutting	Cutting to final dimensions by plasma, except section Connecting test samples to body of tee	

**MANUFACTURING SUMMARY TEE
MADE BY FORGING
Seamless Pipe
Size 1" to 24" / Thickness 10 mm to 31,25 mm
ASTM A 815 UNS S31803 – MDS D43 REV. 2
(Prototype Tee 6" sch. 160)**

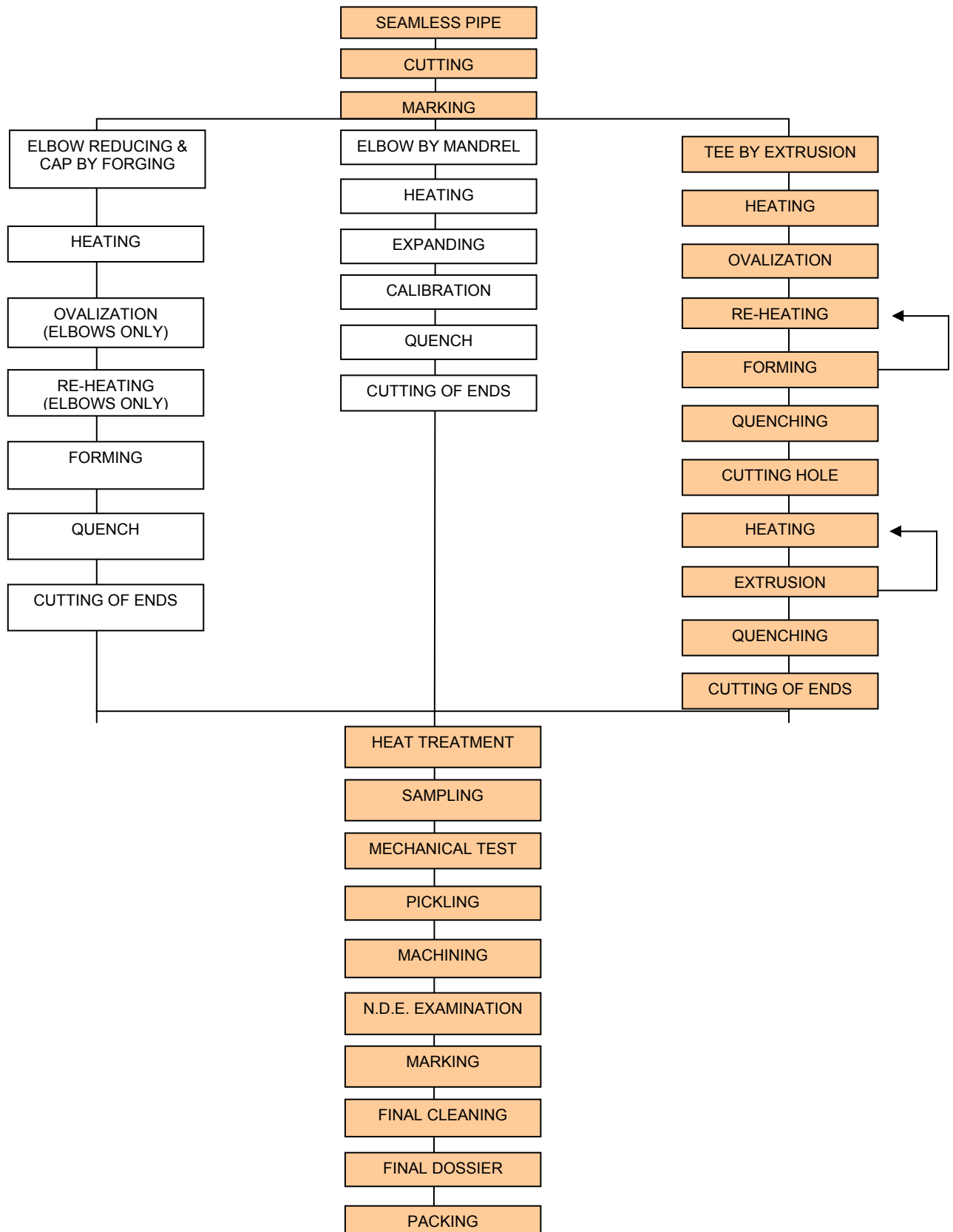
N°	PHASE	DESCRIPTION	PROCEDURE
15	Heat treatment	<i>Heat treatment:</i> Solution annealing in gas heating furnace <i>Equipment:</i> Sottri truck-hearth with dimension of <i>Furnace loading temperature:</i> room temperature <i>Heating rate:</i> xxx°C/h (above xxx°C) <i>Holding temperature:</i> xxxx°C <i>Holding time:</i> 1h/1" wall thickness or minimum 15 min <i>Quenching:</i> In cold water max xx °C within 60 s.	HT-01 Rev.3
16	Shot blasting	Stainless steel grit.	
17	Sampling	Removal of material for test samples.	MDS D43 Rev. 2 Test sample plan N° SP-01 Rev.1
18	Mechanical test	According to NORSOK MDS D43 Rev.2	MDS D43 Rev. 2 Test sample plan N° SP-01 Rev.1
19	Pickling	Immersion in acid solution at temperature of xx °C Equipment: N° 2 pickling vat 900 mm x 1600 mm x 1000 mm	PK-01 Rev.0
20	Machining	Working of the ends as per purchase order.	
21	Dye penetrant test	According to ASTM A 815 Supplementary Requirement S7 Accept criteria: ASME VIII Div.1 100 % of the fittings.	ASME VIII Div.1 App.8
22	PMI	100 % of the fittings.	PMI-01 Rev.0
23	Marking	Marking by low stress stamping according P.O.	MDS D43 Rev.2
24	Visual and dimensional	By calibrated equipment.	POQ-05 Drw. No. 972
25	Pickling	Re-immersion in acid solution for final cleaning and passivation.	PK-01 Rev.0
26	Final dossier	Inspection certificate plus NDE certificates.	EN 10204 3.1B
27	Packing	According order requirements.	ASTM E 700

Revision No.	Date	Made by	Approved by	Note Flow chart is shown at page 4 of 4 shaded route.



EXAMPLE OF MANUFACTURING FLOW CHART

Manufacture flow chart for elbow and tee manufacture



Annex B (Normative)

Additional requirements to ASTM A 991 "Standard test method for conducting temperature uniformity surveys of furnaces used to heat treat steel products"

B.1 General

Temperature uniformity survey of quality heat treatment furnaces shall be performed according to ASTM A 991 with the following additional requirements:

1. The alternative of attaching thermocouples to the extremities of each load, see ASTM A 991 Para 1.4, is not acceptable as an alternative to the specified temperature uniformity survey.
2. The temperature uniformity survey shall be carried out at the maximum set point temperature for the actual materials to be processed in the furnace. The maximum limit of 1100 °C stated in ASTM A 991 Para 6.1.1.2 shall not apply.
3. The documentation of the temperature uniformity survey shall include sketch of the furnace with working zone of furnace and number and location of thermocouples used for the survey, see ASTM A 991 Para 8.2.7 and 8.2.8.

B.2 Batch type furnaces

The following additional requirements apply:

1. For furnaces with set point temperature in the working zone above 800 °C the temperature at any point shall not vary by more than ± 14 °C from the furnace set point temperature after the furnace working zone has been brought up to temperature.
2. For furnaces with set point temperature in the working zone below 800 °C shall not vary by more than ± 8 °C from the furnace set point temperature after the furnace working zone has been brought up to temperature.
3. Once the furnace temperature has reached the set point temperature, the temperature of all test locations shall be recorded at 2 min intervals maximum, for at least 10 min. Then readings shall be taken at 5 min intervals, maximum, for sufficient time to determine the recurrent temperature pattern of the furnace-working zone for at least 30 min.

B.3 Continuous conveyance and semi continuous conveyance furnaces

The following additional requirements apply:

1. The objective of the survey is to verify that:
 - The specified heat treatment temperature for a material can be kept uniform within the tolerances specified below through the working zone of the furnace as defined in the heat treatment procedure.
 - The defined travel speeds in the heat treatment procedure results in specified holding time being achieved.
2. The temperature survey shall be carried out on actual products. Minimum two surveys shall be carried out with products representing the smallest (thinnest) and largest size (thickness) respectively to be heat-treated.
3. The manufacturer shall establish a procedure for how to carry out the temperature survey.
4. The temperature of the products heat treated in furnace with set point temperature in the working zone above 800 °C shall not vary by more than ± 14 °C from the furnace nominal set point temperature in the working zone.
5. The temperature of the product heat treated in furnaces with set point temperature in the working zone below 800 °C shall not vary by more than ± 8 °C from the furnace nominal set point temperature in the working zone.

Annex C
(Normative)
Form for qualification test record front page

This form is available as a word file at the NORSOK home page <http://www.standard.no/>.

At the attached form examples of how to fill in the form is given.

Manufacturer logo	QTR Qualification Test Record NORSOK M-650		QTR. No.:
			Rev. No.:
Manufacturer name/address/ Web page:			
Reference standard	NORSOK M-650 Rev. 3		
Material designation and MDS No.:	Example: ASTM A182 Gr. F55; MDS D54, Rev. 3.		
Manufacturing summary doc. No.:			Rev. No.:
Products and manufacturing process(es):	Example: Die forged flanges, Production route No. xx Forged discs, Production route No. xx Rolled rings, Production route No. xx		
Mandatory conditions and sub-contractors:	Example: <ul style="list-style-type: none"> Heat treatment by: XXXXXXXX Forgings shall be machined as close as possible to final shape prior to quality heat treatment. 		
Other information:	Example: <ul style="list-style-type: none"> Pickling by XXXXXXXX. 		

Tested and Qualified Thickness and Weight

Products and manufacturing process(es):	Test record No.	Tested thickness mm	Qualified thickness mm	Test piece weight kg	Qualified weight kg
Die forged flanges	Abs 56	170	170	250	All
Forged discs	Abs 57	55	60	70	140
Rolled rings	Abs 58	130	130	300	All

Qualification/Acceptance signatures

Manufacturer:	Prepared by/Date:	Checked by/Date:
<p>The manufacturer and this QTR are evaluated and found to be in compliance with the requirements of NORSOK M-650 for supply of the above listed products and materials. <i>This acceptance does not exempt any purchaser from his responsibility to ensure that this qualification is valid for his products within the essential variables of NORSOK M-650.</i></p>		
Qualified/Accepted by (company name/address):		Signature/Date:

