

Welding and inspection of piping

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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 Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.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 for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published supported by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway

NORSOK standards are administered and published by Standard Norway.

Annex A and B are normative. Annex C and D are informative.

Introduction

The intention of this NORSOK standard is to provide additional requirements regarding welding and inspection of piping systems designed to ASME B31.3 for hydrocarbon production and process systems and supporting utility systems.

In this edition the following main changes are introduced:

- requirements to facilitated compliance with PED (EC Pressure Equipment Directive, 97/23/EC) is deleted;
- references to relevant parts of EN 288 is replaced with relevant parts of ISO 15614;
- references to EN 729-2 are replaced with ISO 3834-2;
- requirements are added with respect to weld coordination and weld inspection;
- impact testing of welds in carbon steel Type 235 is deleted;
- location of impact test specimens are changed to comply with ISO 15614-1;
- maximum hardness requirements for Type 22 and 25Cr duplex is deleted;
- for Type 25Cr a change in UNS No is deleted as an essential change;
- a change from 25Cr to 22Cr is deleted as an essential change;
- for carbon steels Type 360 and with higher SMYS without PWHT, an increase in CE (IIW) of more than 0,03 is added as an essential change;
- requirements to welding consumables for carbon steel, Type 6Mo and Type 22/25Cr Duplex is modified;
- maximum inter pass temperature requirement is modified;
- requirement for recording weld repair rates is added;
- radiographic sensitivity requirement is modified;
- acceptance criteria for ultrasonic testing of welds are modified;
- informative annexes for colour coding and welding inspection activities are added;
- normative annex for acceptable oxidation of welds in stainless steels is added.

In addition minor changes and modifications are also made.

1 Scope

This NORSOK standard covers additional and optional technical requirements to ASME B31.3 for welding and weld inspection of piping systems, selected and specified in accordance with to NORSOK L-001, and applies to all piping fabrication including prefabrication, module assembly, package or skid mounted units, site and field installation.

NOTE An option to use ISO 15614 (all parts) for welding procedure qualifications, EN 287-1, and ISO 9606-3 to ISO 9606-5 for welder qualifications, and EN 473 for NDT inspectors, is given as an alternative to ASME Section V and IX.

2 Normative and informative references

The following standards include provisions and guidelines, which through reference in this text, constitute provisions and guidelines 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 the requirements of the referenced standards.

2.1 Normative references

ASME Section II,	Materials Part C – Specifications for Welding Rods, Electrodes and Filler Metals
ASME Section V,	Nondestructive Examination
ASME Section VIII,	Rules for Construction of Pressure Vessels Division 1
ASME Section IX,	Welding and Brazing Qualifications
ASME B31.3,	Process Piping
ASTM E562,	Practice for Determining Volume Fraction by Systematic Manual Point Count
ASTM G48,	Standard Test Method for Pitting and Crevice Corrosion Resistance of Stainless Steel and Related Alloys by the use of Ferric Chloride Solution
EN 287-1,	Qualification test of welders – Fusion welding – Part 1: Steels
EN 473,	Qualification and certification of personnel for non destructive examination
EN 1418,	Welding personnel – Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanised and automatic welding of metallic materials
EN 10204,	Metallic products – Types of inspection documents
ISO 2553,	Welded, brazed and soldered joints – Symbolic representation on drawings
ISO 3690,	Welding and allied processes – Determination of hydrogen content in ferritic arc weld metal
ISO 3834-2,	Quality requirements for fusion welding of metallic materials – Part 2: Comprehensive quality requirements
ISO 6520-1,	Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding
ISO 9606-3,	Approval testing of welders – Fusion welding – Part 3: Copper and copper alloys
ISO 9606-4,	Approval testing of welders – Fusion welding – Part 4: Nickel and nickel alloys
ISO 9606-5,	Approval testing of welders – Fusion welding – Part 5: Titanium and titanium alloys, zirconium and zirconium alloys
ISO 10474,	Steel and steel products -- Inspection documents
ISO 14731,	Welding coordination – Tasks and responsibility
ISO 15609 (all parts),	Specification and qualification of welding procedures for metallic materials
ISO 15156-2,	Petroleum, petrochemical and natural gas industries – Materials for use in H ₂ S-containing environments in oil and gas production – Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons
ISO 15156-3,	Petroleum, petrochemical and natural gas industries – Materials for use in H ₂ S-containing environments in oil and gas production – Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys
ISO 15614 (all parts),	Specification and qualification of welding procedures for metallic materials – Welding procedure test
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 17020,	General criteria for the operation of various types of bodies performing inspection
ISO 17025,	General requirements for the competence of test and calibration laboratories

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NS 477, Rules for approval of welding inspectors

2.2 Informative references

EN 1043-1, Destructive tests on welds in metallic materials – Hardness testing – Part 1:
Hardness test on arc welded joints
ISO 15608, Welding – Guidelines for a metallic materials grouping system

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1

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

3.1.2

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

3.1.3

may

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

3.1.4

can

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

3.1.5

carbon steel type 235

carbon steel with $SMYS \leq 275$ MPa and not impact tested

NOTE ISO/TR 15608 Material group 1.1

3.1.6

carbon steel type 235LT

carbon steel with $SMYS \leq 275$ MPa and impact tested at - 46 °C

NOTE ISO/TR 15608 Material group 1.1

3.1.7

carbon steel type 360LT

carbon steel with $300 \text{ MPa} < SMYS \leq 360 \text{ MPa}$ and impact tested at - 46 °C

NOTE ISO/TR 15608 Material group 1.2

3.1.8

3.5 Ni steel

low alloyed steel containing 3,5 % Ni

NOTE ISO/TR 15608 Material group 9.2

3.1.9

stainless steel type 316

alloys with approximately 2,5 % Mo of the type UNS S31600 or similar

NOTE ISO/TR 15608 Material group 8.1

3.1.10

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stainless steel type 6Mo,

alloys with 6 % Mo and PREN > 40, e.g. UNS S31254 UNS N08925, UNS N08367

NOTE ISO/TR 15608 Material group 8.2

3.1.11**stainless steel type 22Cr duplex,**

alloys with 22 % Cr according to UNS S31803, UNS 32205 or similar

NOTE ISO/TR 15608 Material group 10.1

3.1.12**stainless steel type 25Cr duplex**

alloys with 25 % Cr and PREN > 40, e.g. UNS S32550, UNS S32750, UNS S32760, UNS S39274

NOTE ISO/TR 15608 Material group 10.2

3.2 Abbreviations

AWS	American Welding Society
DAC	distance amplitude curve
CE	carbon equivalent
EC	European Commission
EN	European Standard
EWf	European Federation for Welding
FCAW	flux core arc welding
FL	fusion line
HAZ	heat affected zone
HV	hardness Vickers
IIW	International Institute of Welding
IW	International welding engineer
IWT	international welding technologist
MAG	metal-arc active gas (135)
MDS	material data sheet
MDT	minimum design temperature
MIG	metal-arc inert gas (131)
MT	magnetic particle testing
NDT	non destructive testing
PN	nominal pressure
PMI	positive material identification
PQR	procedure qualification record
PREN	pitting resistance equivalent number = $Cr + 3,3 (Mo + 0,5W) + 16N$
PT	penetrant testing
RAL	Reichsausschuß für Lieferbedingungen (colour space system)
RT	radiographic testing
PWHT	post weld heat treatment
SMAW	shielded metal arc welding
SMYS	specified minimum yield strength
TIG	tungsten inert gas (141)
UNS	unified numbering system
UT	ultrasonic testing
VT	visual testing
WM	weld metal centre line
WPQR	welding procedure qualification record
WPS	welding procedure specification

4 Welding qualification requirements**4.1 General**

Welding procedures for steels, nickel and titanium based alloys shall be qualified according to ASME Section IX or ISO 15614-1 and ISO 15614-5 as applicable and to this NORSOK standard.

All welding or brazing of copper based alloys shall be qualified according to ASME Section IX.

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The qualification is primarily valid for the workshop performing the welding tests, and other workshops under the same technical and quality management. It may also be transferred to and used by a subcontractor, provided the principles of ISO 3834-2 and ISO 14731 are implemented and documented.

The WPQR/PQR documentation shall include the material certificates for the base and filler materials applied in the weld qualification test.

4.2 Non-destructive testing of test welds

Non-destructive testing shall be according to ISO 15614-1 for all type of materials.

All required post weld heat treatment shall be completed before final non destructive testing.

The NDT acceptance criteria shall be as specified in Clause 6.

4.3 Mechanical testing

4.3.1 General

Test laboratories shall have a quality system in compliance with ISO 17025 or equivalent.

Mechanical testing shall be performed as specified in ASME Section IX or relevant part of ISO 15614 and the additional requirements in this NORSOK standard.

If a specimen fails to meet the test requirements, two sets of retests, for that particular type of test, may be performed with specimens cut from the same procedure qualification test coupon. The results of both retest specimens shall meet the specified requirements.

4.3.2 Impact tests

Impact testing of welds shall be according to Table 1. Full size specimens shall be applied where possible.

If two types of materials are welded together, each side of the weld shall be impact tested and fulfil the requirement for the actual material. The weld metal shall fulfil the requirement for the least stringent of the two.

Table 1 - Impact test requirements ^a

Material	Notch location ^b	Tests temperature	Acceptance Criteria ^{c,d}
Carbon steel Type 235	Not applicable		
Carbon steel Type 235LT and 360LT	WM and HAZ	- 46 °C	27 J for Type 235LT 36 J for Type 360LT
Carbon steel and low alloyed steel with SMYS > 360 MPa	WM and HAZ	MDT or lower	42 J
Type 3.5 Ni steel	WM and HAZ	- 101 °C	27 J
Type 316 and 6Mo and Ni-alloys	WM and HAZ	MDT or lower if MDT is below -101 °C	Lateral expansion min. 0,38 mm
Type 22Cr duplex and Type 25Cr duplex	WM and HAZ	- 46 °C or at MDT.	27 J or lateral expansion min. 0,38 mm

^a No impact test is required for wall thickness < 6 mm.

^b Location of test specimens in HAZ shall be made in compliance with ISO 15614-1.

^c No single values shall be below 70 % of the average requirement.

^d Reduction factors of energy requirements for sub-size specimens shall be 5/6 for 7,5 mm specimen and 2/3 for 5 mm specimen.

4.3.3 Macro-sections

A macro-section shall be taken from all welds and shall be visually examined and meet the acceptance criteria according to ISO 15614-1 and ISO 15614-5.