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Piping system layout, design and structural analysis

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Standards Norway
P.O. Box 242, 1326 Lysaker
NORWAY
Visiting address
Mustads vei 1, 0283 Oslo
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Telephone: + 47 67 83 86 00
Fax: + 47 67 83 86 01
Email: petroleum@standard.no
Website: www.standard.no/petroleum

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Foreword

NORSOK L-002:2016 was adopted as NORSOK Standard in July 2016.

NORSOK L-002:2016 supersedes NORSOK L-002 Rev. 3, July 2009.

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, added value 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 recognized 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 Subject to development and publication of international standards, the relevant NORSOK standards will be withdrawn.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-001N.

The NORSOK standards are prepared and published with support by the Norwegian Oil and Gas Association, the Federation of Norwegian Industries, Norwegian Shipowners' Association and The Petroleum Safety Authority (PSA) Norway.

NORSOK standards are administered and published by Standards Norway.

Annex A and B are informative.

Revision information, 4th edition updates:

The latest edition of this standard have focused on development of a standard that result in cost reductions within topsides layout and piping. The new version have been given a general update that clarifies and simplifies requirements and remove non-relevant requirements. Equipment specific material handling requirements have been removed, as they now can be found in the NORSOK R-002 standard. Guidance for use of hoses are included and the update highlight that reduction in engineering man-hours can be obtained by use of manual calculations.

1 Scope

This NORSOK standard covers the basis for layout, design and structural analysis of process, drilling, utility and instrument piping and tubing for offshore oil and/or gas production facilities, upper part of riser, barred tee and pig trap/launchers. Relevant parts of this NORSOK standard may also be used for control room, laboratory, helideck and other facilities around the platform.

This NORSOK standard does not cover risers, sub-sea pipework, sanitary piping systems, marine systems in hulls of vessels and floating platforms and land based plants.

2 Normative 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

ASME B31.3, *Process Piping (Main design standard)*

API TR 6AF2, *Technical Report on Capabilities of API Integral Flanges under Combination of Loading-Phase II, Fifth Edition*

EN 1993 (all parts), *Design of steel structures*

EN 13480 (all parts), *Metallic industrial piping*

EN ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

EN ISO 14692 (all parts), *Petroleum and natural gas industries – Glass reinforced plastics (GRP) piping*

G-OMO, *Guidelines for Offshore Marine Operations*

NORSOK L-001, *Piping and valves*

NORSOK L-CR-003 (L-003), *Piping details*

NORSOK L-004, *Piping fabrication, installation, flushing and testing*

NORSOK L-005, *Compact flanged connections*

NORSOK M-001, *Material selection*

NORSOK M-601, *Welding and inspection of piping*

NORSOK M-622, *Fabrication and installation of GRP piping systems*

NORSOK N-001, *Integrity of offshore structures*

NORSOK N-004, *Design of steel structures*

NORSOK P-002, *Process system design*

NORSOK R-001, *Mechanical equipment*

NORSOK R-002, *Lifting equipment*

NORSOK R-004, *Piping and equipment insulation*

NORSOK S-001, *Technical safety*

NORSOK S-002, *Working environment*

NORSOK Z-DP-002, *Coding system*

NORSOK Z-015, *Temporary equipment – forms*

PED 97/23/EC, *Pressure Equipment Directive*

PED 2014/68/EU, *Pressure Equipment Directive*

PSA, *Framework regulations*

3 Terms and definitions

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

3.1

can

expression in the content of a document conveying expected or conceivable material, physical or causal outcome

3.2

Company

owner or operator of the installation

3.3

Contractor

party which carries out all or part of the design, engineering, procurement, construction and commissioning for a project or operation of a facility

3.4

DIB

double isolation and bleed valve according to ISO 14313^[10] / API SPEC 6D

3.5

isolation valve

valve that is used to shut off a piece of equipment or system for maintenance purpose only

3.6

may

expression in the content of a document conveying consent or liberty (or opportunity) to do something

Note 1 to entry: Permissions are expressed using the verbal forms specified in ISO/IEC Directives Part 2 clause 7.4 Table 5.

3.7

shall

expression in the content of a document conveying objectively verifiable criteria to be fulfilled and from which no deviation is permitted if compliance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.2 Table 3.

3.8

should

expression in the content of a document conveying a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.3 Table 4.

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but it is not prohibited.

3.9

SN curve

cyclical stress (S) against the logarithmic scale of cycles to failure (N) curve

4 Abbreviations

For the purposes of this NORSOK standard, the following abbreviations apply:

AIV	Acoustic Induced Vibrations
API	The American Petroleum Institute

ASME	The American Society of Mechanical Engineers
DNV	Det Norske Veritas (now: DNV GL Det Norske Veritas Germanischer Lloyd)
EN	European Standard
FABIG	Fire and Blast Information Group
GRP	glass reinforced plastic
HSE	health and safety executive
ISO	International Organization for Standardization
MOB	man over board
NPS	nominal pipe size
P&ID	piping and instrument diagram
PSA	Petroleum Safety Authority Norway
PSV	pressure safety valve
3D CAD	three dimensional computer aided design (CAD) model

5 Layout

5.1 General

The layout shall be based on the following requirements:

- a) ensure that the arrangement and functionality provided by the layout satisfies all safety, construction, operations and maintenance requirements with minimum impact on space, weight and cost;
- b) the location and spacing of equipment, piping and structures shall take into consideration ventilation aspects in order to avoid accumulation of possible gas and vapour releases and to reduce explosion pressure;
- c) deck elevations in different areas of the installation shall to the extent possible correspond in order to ease material handling and operation;
- d) equipment and systems shall be arranged such that the amount of onshore completion is maximized and offshore work minimized;
- e) all equipment shall to the extent possible be positioned to satisfy both the process flow sequence and gravitational requirements;
- f) all piping and tubing shall be arranged to facilitate supporting, and shall be planned for ease of removal of equipment for inspection and servicing;
- g) space shall be allocated at an early stage for primary and secondary escape routes, access ways, main pipe/cable racks/trunks and main ductwork as well as main penetration areas;
- h) piping above open sea exposed to waves shall be avoided;
- i) in order to get a neat layout, top and bottom entry compressors should be evaluated;
- j) compact type equipment should be evaluated to get a neat layout;
- k) the distance between the well slots on fixed offshore installations shall be minimum 2,5 m. On floating units, a greater minimum distance may be required to avoid interference between the risers.

5.2 Miscellaneous requirements

The flare tip shall be located over open sea.

Provisions for loading and unloading of liquids and dry bulk should be installed on two sides. For platforms, where requirements for drilling by separate jack-up rigs prevents the use of two loading stations, compensating measures shall be evaluated (e.g. increased storage capacity).

Operation and replacement of loading hoses shall be possible by means of the offshore cranes. Hose reels shall be used for all loading hoses to provide a safe working environment for the operators.

Deck area with sufficient load capacity shall be allocated for temporary equipment, e.g. pull-in winches, coiled tubing, containers, testing equipment etc.

All workshops (e.g. electrical, instrument, mechanical, welding, insulation, paint), storage and laboratories, shall be located close to each other, and all unnecessary traffic through any of the rooms shall be avoided.

Over-pressurized ventilated rooms (e.g. local electrical room) in classified areas shall be avoided.

In cases where two or more process trains are required, both piping symmetry and easy segregation of the equipment and piping shall be aimed at.

If a bridge-landing platform shall be provided, it shall have easy access to main escape ways. The landing platform shall be located in such a way that emergency release of the bridge is not obstructed by structures in the vicinity of the landing. In cases where the bridge landing is within the reach of the main crane, it shall be designed and equipped for use as a lay down area.

Reference is made to NORSOK S-001 for requirements to location of exhaust and to NORSOK S-002 for location of exhaust with respect to exposure of personnel and air inlets.

Space should be provided in the wellbay area for X-mas tree lubrication devices.

5.3 Material handling requirements

5.3.1 General

Material handling requirements shall conform to NORSOK R-002.

5.3.2 Offshore cranes

The offshore cranes shall be located in positions giving the best combination of crane coverage and free sight from the crane cabins to the handling areas and supply boats. The location shall be optimized such that unnecessary long crane booms are avoided.

The offshore cranes shall cover the deck area and lay down/storage and handling areas including the entire pipe deck (installations with drilling or well intervention facilities only).

The offshore cranes shall not be used with crane boom or load over non-protected, pressurized process equipment or for direct mounting/dismounting of equipment.

The need for dropped object and swinging load protection shall be evaluated.

The offshore cranes, including the crane hooks, should not be used as hang off point for other material handling equipment.

Crane boom rests shall be provided.

A dedicated area for replacement of crane hooks with an arrangement for storage of main load and whip line hook shall be provided. The need for a separate working platform for this purpose to be considered.

5.3.3 Lay down/storage and other crane handling areas

Lay down and handling areas shall as a main rule be placed in locations visible from the crane cabins. As a minimum, one lay down area per deck level shall be visible from the crane cabin, provided that all items to be handled by the crane within the area can be transported to the actual lay down area.

For installations with more than one crane, common lay down areas reachable by two cranes shall be provided.

Lay down areas shall to the largest possible extent be located at the periphery of the installation in order to optimize crane operations.

Lay down areas shall be provided with heavy duty barriers. The barriers shall have sufficient height to protect equipment and other structures located next to the lay down area.

Hose loading stations and the MOB boat shall be visible from the crane cabins. For MOB boat launching arrangement requirements, reference is made to NORSOK S-001.

5.3.4 Transportation routes

Transportation routes shall be sized to allow transportation of the largest/heaviest item from its position to the actual lay down area. Reference is also made to requirements in NORSOK S-002.

Transportation routes shall, where required, be designed for specific transportation solutions, such as heavy lifts and/or forklift trucks, air film transporters, etc. Transportation routes shall not contain steps or thresholds.

The need for protection barriers along transportation routes intended for transportation of large/heavy equipment, and in locations where forklift trucks are used, shall be evaluated. The protection barriers shall not obstruct access to equipment, valves, etc.

5.3.5 Lifts and hatches

If the installation consists of more than one deck elevation, and is permanently manned, it shall be equipped with a sufficient number of personnel and goods lifts. The size and capacity of these lifts shall be adjusted to the size/weight of the largest/heaviest items to be transported by the lift. The goods lift shall give access to all main deck levels, and the access to main workshop/stores shall be emphasized.

Floating installations shall in addition be provided with lifts with sufficient capacity to handle equipment located in the substructure.

Pedestal cranes on floating installations should not be used to lift loads through hatches. Suitable guiding systems shall be evaluated.

Special attention shall be given to installation and/or maintenance in the wellhead area. Hatches shall be designed and secured in such a way that they cannot fall through the opening.

5.3.6 Miscellaneous

A forklift truck garage/charging station (approximately 8 m²) should be located adjacent to the main workshop. A sea fastening arrangement shall be provided on floating installations.

Flush mounted deck lugs for skidding of heavy equipment shall be installed in the main workshop.

5.4 Safety and working environment

Ergonomic consideration shall be taken in design regarding

- tools, valves and control devices, including emergency controls devices, which shall be accessible
- provision for cleaning, maintenance and repair shall be taken into consideration.

Requirements related to safety and working environment shall conform to NORSOK S-001 and S-002.

Provision shall be made to protect piping and equipment from falling objects in accordance with NORSOK S-001 and R-002.

Discharge to sea shall be located such that any hazard to supply vessel personnel is avoided.

6 Piping design

6.1 General

The design of piping and tubing systems shall conform to ASME B31.3 except where the requirements of this NORSOK standard or Company requirements are more stringent. GRP piping shall be designed in conformance with ISO 14692 and NORSOK M-622.

The Company shall decide the need for, and eventual extent of independent verification of the piping and tubing design documents with supports and construction work, in order to comply with § 19 in the PSA Framework regulations.

Piping design shall comply with The Pressure Equipment Directive (PED). Compliance with PED does not normally eliminate the need for independent design verification.

The Company decided verification shall be carried out by independent personnel, not involved in design, fabrication, installation or testing. A third party company is normally needed for the verification work in

order to obtain sufficient independency. The third party company shall be under direct contract with the Company.

NOTE: The verification can be performed in conformance with DNV-RP-D101 [5].

6.2 Numbering systems

Numbering systems for piping, piping items, valves and tubing shall be in accordance with NORSOK Z-DP-002 or the project coding manual.

6.3 Arrangement

All piping shall be routed to provide a simple, neat and economical layout, allowing for easy support and adequate flexibility.

Piping should be arranged on horizontal racks at specific elevations. Care shall be taken to avoid pockets.

No piping shall be located inside instrument, electrical or telecommunication control/switchgear rooms, except fire fighting, cooling medium piping serving these rooms and open drain lines as described below. Piping for liquid flow shall be all welded and contain no valves inside such rooms. Exceptions are subject to Company approval. Pipe connections to equipment located in these rooms (e.g. coolers for transformers, etc.), shall be provided with protection covers to avoid damaging leakages.

NOTE: Open drain piping in the roof of EIT rooms to drain the deck above the room should be avoided, but where layout restrictions dictate the need, the piping shall be boxed in to contain leakages.

Bridge piping shall be designed with expansion loops capable of handling relative movement of platforms in design storm conditions.

All hydrocarbon gas piping including bypasses (e.g. equalizing lines), shall be arranged to minimize the possibility of trapping or collecting liquid.

Dead ends shall to the greatest extent possible be avoided for all piping and tubing systems.

Reducers in conjunction with control and pressure release valves shall be located directly upstream/downstream the valve, however space for bolt removal shall be provided.

Routing of piping in areas which are not accessible for inspection and maintenance without extensive use of scaffolding (e.g. below cellar deck, outside columns, etc.), shall be avoided. However, if this is inevitable, special attention shall be paid to material selection in order to minimize the need for maintenance.

Effects of wave slamming and wave run-up along columns on piping and supports, as well as possible negative effects on the integrity of the unit, shall be investigated.

Piping shall not be routed in transit through manned areas such as workshops, offices, etc.

When allocating space for future installation of piping, possible extra space requirement in conjunction with offshore installation shall be evaluated to facilitate the installation work and avoid inappropriate short pipe spools (and a large number of field welds).

Minimum distance between extremities of piping/valves and/or insulation in operating conditions shall be 25 mm. Greater distance might be required to achieve access for installation of e.g. insulation.

6.4 Tubing as substitute for piping

The use of tubing as substitute for piping shall be kept to a minimum.

In cases where the Company has permitted use of tubing as a substitute for piping, reference is made to the project piping and valve material specification. The following applies:

- a) tubing shall not be used behind walls or within enclosed compartments without access for inspection;
- b) tube fittings and flanges shall not be used for nitrogen services in rooms or other enclosed areas due to the potential risk in case of leakage;
- c) if tubing is used for drainage of instrument equipment in hydrocarbon service, the piping block valve shall be easily accessible.