5

Guidance to use of Annex A and B

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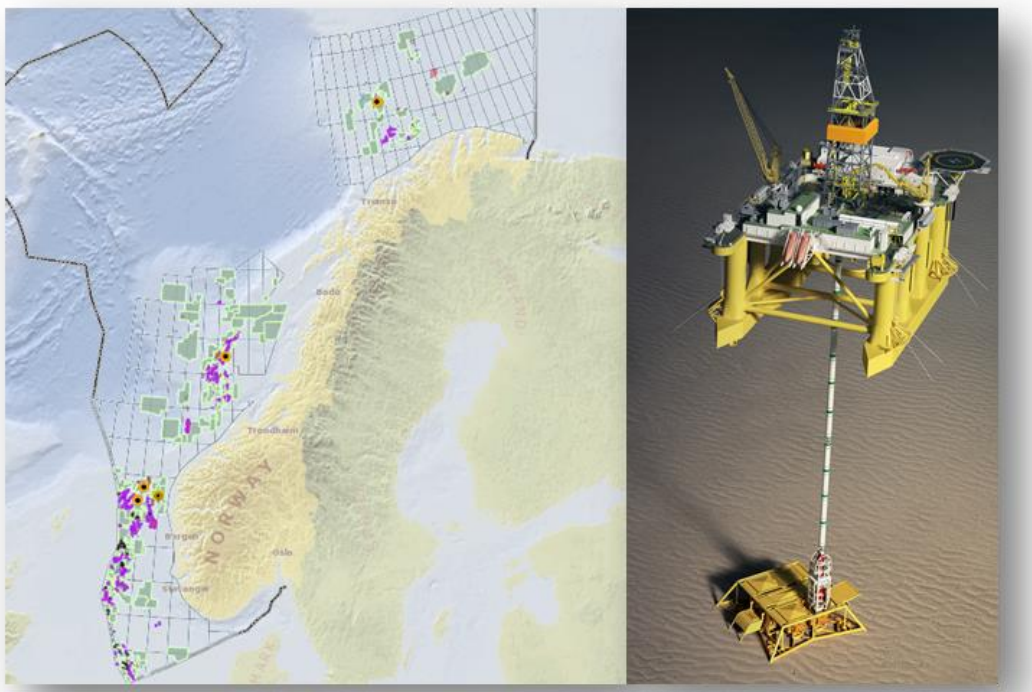
Focus of this presentation



- Subsea wellhead and template drilling loads appliable for NCS
- Structural design and materials for
  - Wellhead systems
  - Subsea tree equipment
  - Completion/workover riser equipment materials

Loads

Design

Materials

Contents

- Introduction
  - Annex A
  - Annex B
- Supplementary requirements and amendments
- Annex A (normative) Template in-place design loads and marine drilling riser loads
- Annex B (normative)
  Structural design, materials, fabrication and testing of subsea wellhead, tree equipment and completion/workover riser systems
- Further reading

Scope of supplementary requirements and amendments in NORSOK U-001 5th edition

NS-EN ISO 13628-1	General requirements and recommendations
NS-EN ISO 13628-4	Subsea wellhead and tree equipment
NS-EN ISO 13628-7	Completion/workover riser systems
NS-EN ISO 13628-8	Remotely Operated Vehicle (ROV) interfaces on subsea production systems
NS-EN ISO 13628-15	Subsea structures and manifolds
API Spec 17E	Specification for Subsea Umbilicals
API Std 17F	Specification for Subsea Production Control Systems

Annex A (normative) Template in-place design loads and marine drilling riser loads

Purpose:

To provide supplementary requirements to NS-EN ISO 13628-4 and NS-EN ISO 13628-15 applicable for Norwegian Continental Shelf (NCS)

Why:

Long lead

- The design of templates is within the scope of NS-EN ISO 13268-15. Annex A provides template in-place design loads and marine drilling riser loads. These standardized design loads allow for time and cost-efficient design, manufacture, and delivery of subsea templates prior to known MODU specific design loads.
- The design of wellheads is within the scope NS-EN ISO 13628-4. The design premise used in NS-EN ISO 13628-4 is limited to pressure-based design. Design loads specified in Annex A extend this design premise to include external load design (extreme, accidental and fatigue) of wellhead systems applicable for the NCS.
- Use of external load ratings (ULS, ALS and FLS) will drive equipment load capacity standardization, like existing pressure and temperature ratings.

Annex A

Annex B (normative) Structural design, materials, fabrication and testing of subsea wellhead, tree equipment and completion/workover riser systems

Purpose:

To provide amendments to NS-EN ISO 13628-4 and NS-EN ISO 13628-7 applicable for Norwegian Continental Shelf (NCS)

Why:

- Structural design methods and qualification testing in NS-EN ISO 13268-4 are limited to rated capacity (i.e. 2/3 of yield).
- Material requirements in NS-EN ISO 13268-4 may not ensure mechanical properties as used in design and may not ensure ductile failure in case of overloading.
- The combination of the above can result in restrictive drilling rig operating limitations.
- NS-EN ISO 13628-7 was published in 2005, design methods, qualification test and material criteria have become outdated.

Overall scope

- Annex B includes design methods, test, material, fabrication and quality control requirements that allow for greater external loading (i.e. extreme, accidental and fatigue). Resulting in increased operating limitations for drilling and C/WO riser operations without reducing structural safety.

Annex B Further Reading

Supplementary requirements and amendments to design, manufacture and testing in NS-EN ISO 13628-4, -7 and -15

NORSOK U-001 Clause 8 Subsea wellhead and tree equipment (NS-EN ISO 13628-4)

- Design methods and loads
  - Structural design, loads and testing
  - WH specification
  - WH structural safety strategy
- Materials and manufacture

NORSOK U-001 Clause 13 Subsea structures and manifolds (NS-EN ISO 13628-15)

- 13.4.2 Loads
- 13.6 and 13.7 Materials

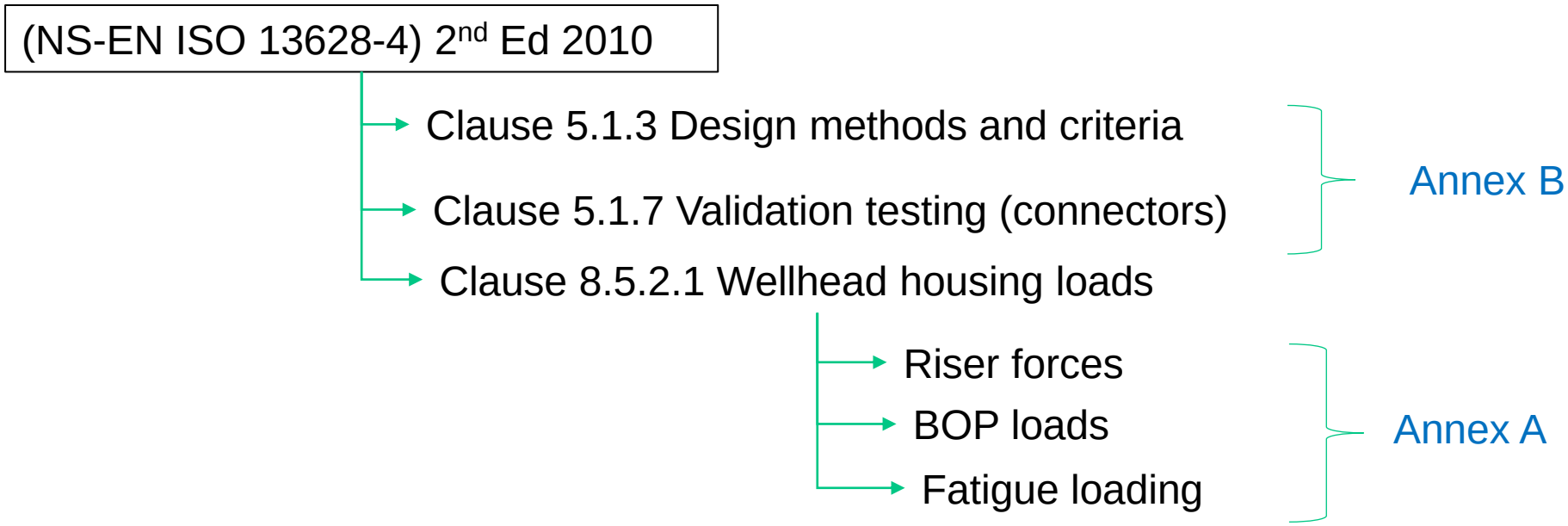
NORSOK U-001 Clause 11 Completion and workover riser systems (NS-EN ISO 13628-7)

- 11.2 Design methods and testing
- 11.2 Materials and manufacture

Clause 8 Subsea wellhead and tree equipment (NS-EN ISO 13628-4)

NORSOK U-001 8.2 General - Design requirements:

- Subsea wellhead and tree equipment shall be designed and tested in accordance with NS-EN ISO 13628-4 and supplementary requirements given in Annex A and Annex B.



Clause 8 Subsea wellhead and tree equipment (NS-EN ISO 13628-4)

NORSOK U-001 8.2 General - Wellhead and tree equipment specification:

- Technical requirements for subsea wellhead and tree equipment shall be given in a written specification(s).
- The wellhead specification shall be based on findings of the structural safety strategy and shall include the following as a minimum:
  - — wellhead type;
  - — wellhead rated working pressure;
  - — wellhead top mandrel diameter size;
  - — wellhead top profile;
  - — water depth class for the marine drilling riser loads specified in Annex A.

NS-EN ISO 13628-4: 2nd Ed 2010

→ Annex M Purchasing guidelines
→ Clause 8.5 Wellheads

} NORSOK U-001 Clause 8.2

Clause 8 Subsea wellhead and tree equipment (NS-EN ISO 13628-4)

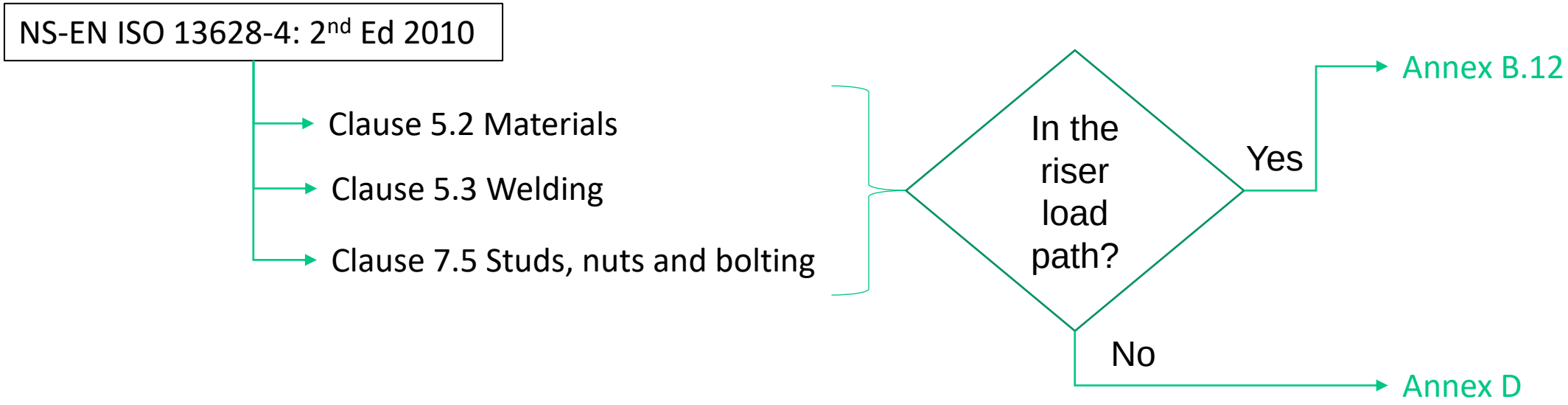
NORSOK U-001 8.3 Wellhead structural safety strategy:

- A wellhead structural safety strategy shall be developed and maintained over the life of the subsea facility.
- The purpose of the safety strategy is to assist in selection of a fit for purpose wellhead system and demonstrate how the structural and functional integrity of the well head system is maintained during drilling, completion, workover ,well intervention operations and plug & abandonment.

Clause 8 Subsea wellhead and tree equipment (NS-EN ISO 13628-4)

NORSOK U-001 8.2 General Material and manufacture requirements:

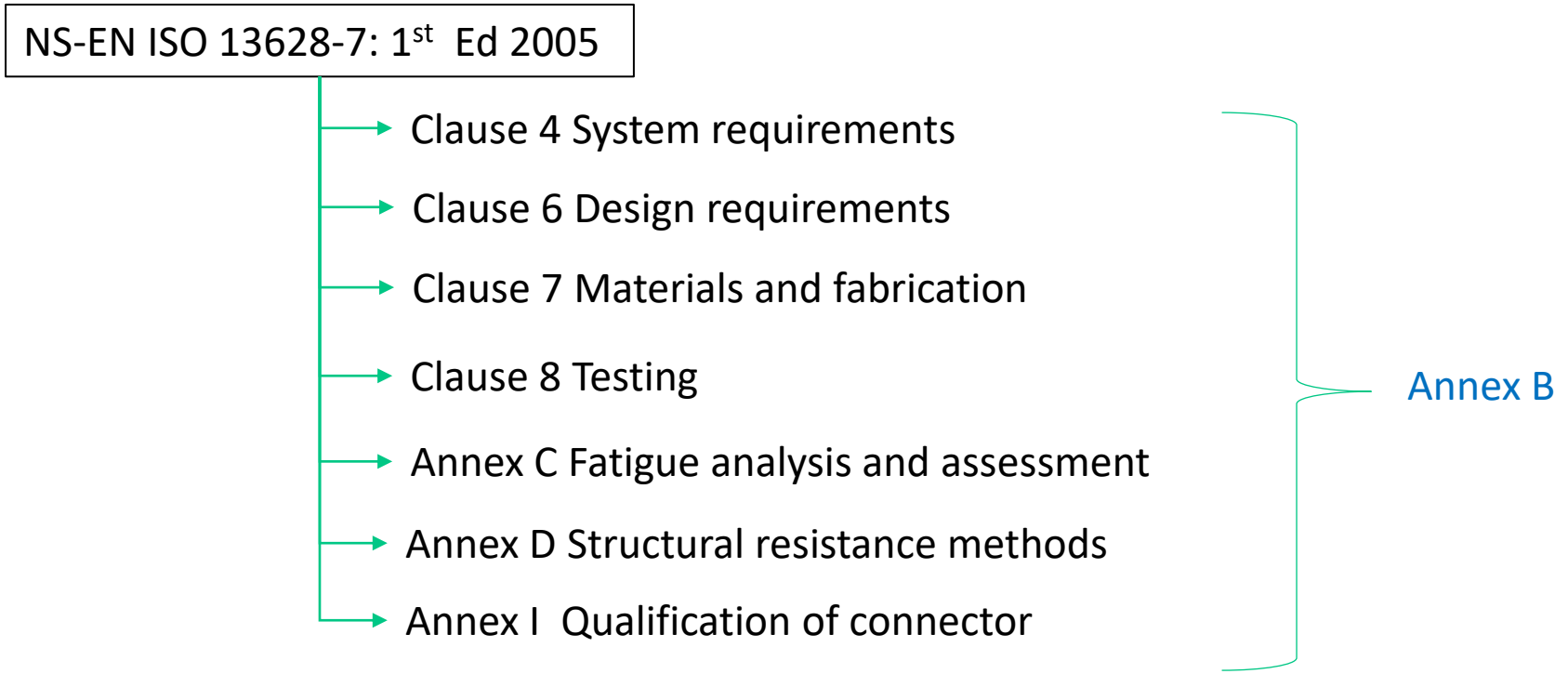
- Subsea wellhead and tree equipment shall be manufactured in accordance with NS-EN ISO 13628-4 and supplementary requirements given in Annex B and Annex D.



Clause 11 Completion and workover riser systems (NS-EN ISO 13628-7)

NORSOK U-001 11.2 General Design and material requirements:

- Completion and workover riser systems shall be designed, manufactured and tested in accordance with NS-EN ISO 13628-7 and amendments given in Annex B.

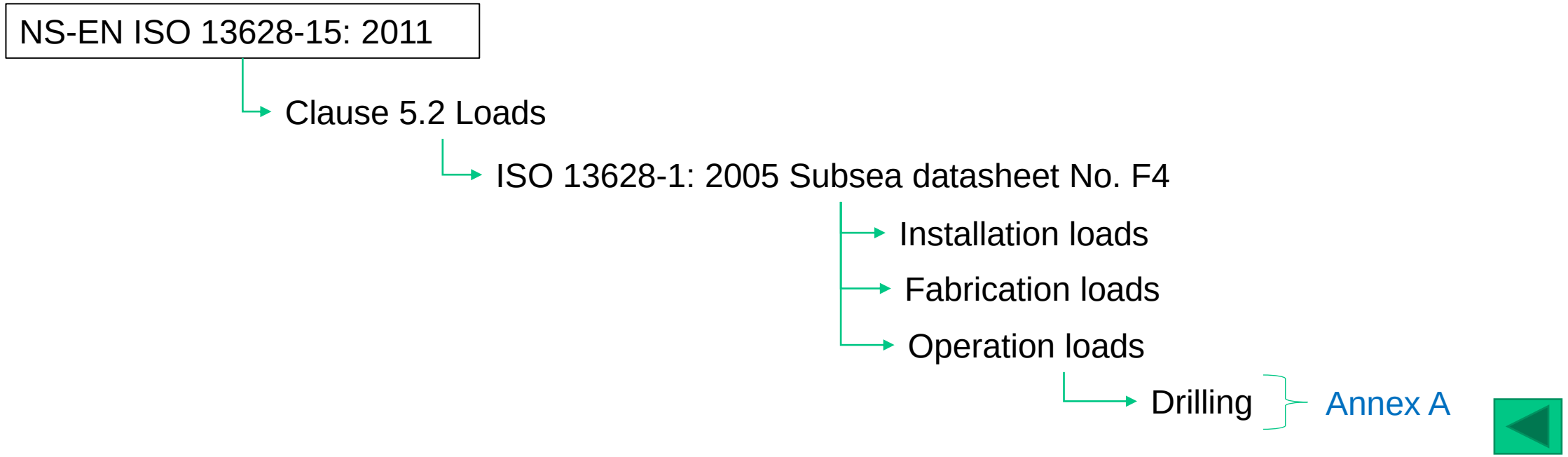


Clause 13 Subsea structures and manifolds (NS-EN ISO 13628-15)

NORSOK U-001 13.4.2 Loads:

- Loads shall follow NS-EN ISO13628-15 clause 5.2. In addition the following applies:

  — Drilling loads, trawl loads and impact loads from dropped objects shall be as defined within 5.3 and in Annex A.



Clause 13 Subsea structures and manifolds (NS-EN ISO 13628-15)

13.6 Material and fabrication of piping systems:

- Material and fabrication requirements of piping systems shall be according to NS-EN ISO13628-15 clause 7 and Annex D.

13.7 Fabrication and manufacturing:

- Fabrication and manufacturing of subsea structures and manifolds shall be according to NS-EN ISO13628-15 clause 8 and Annex D.

Annex A (normative)
Template in-place design loads and marine drilling riser loads

Changes from 4th Edition of NORSOK U-001

Drivers for revision in 5th Edition of NORSOK U-001

A1 Scope

A.2 Template design loads and load conditions

A.3 Marine drilling riser loads

A.3.5 Fatigue design

Annex A (normative)
Changes from 4th Edition of NORSOK U-001

- Conversion to normative requirements

- Normative upper bound marine riser drilling loads for water depth classes (i.e. 80 to 250 m, 251 to 500 m and 501 to 1500 m), rather than BOP weight classes (i.e. 200, 300 and 400 tonnes) as used in the 4th edition

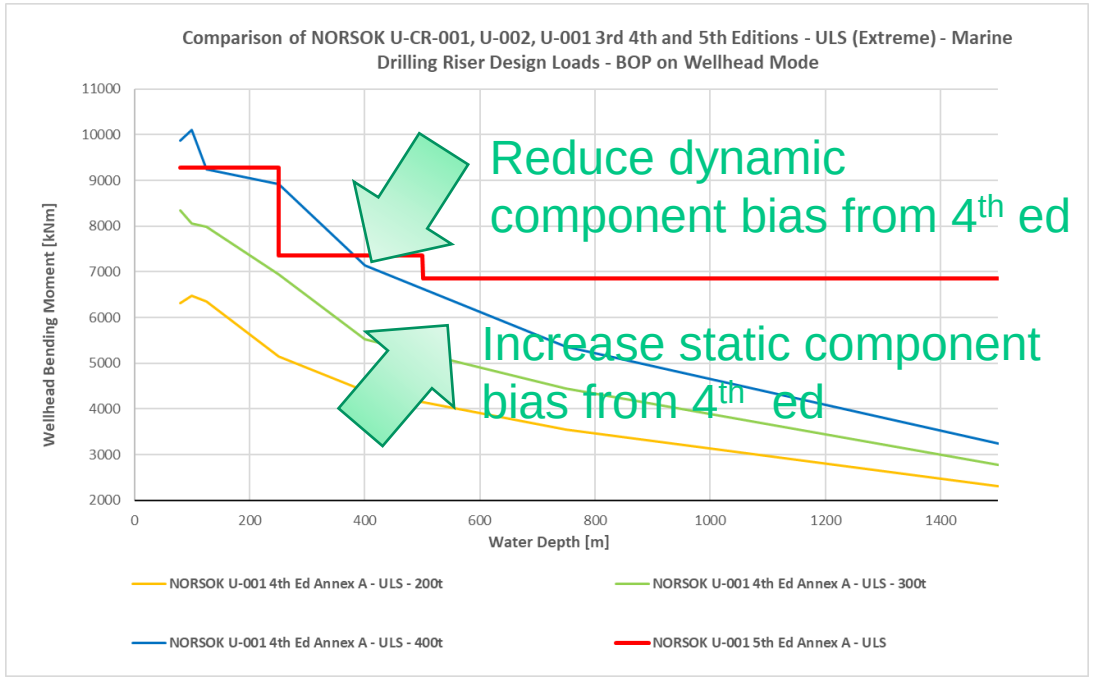
- Marine riser drilling loads are now based on a representative selection drilling rigs in operation on the NCS for future operations, rather than a design rig approach as used in 4th edition.

- Normative fatigue design loads for wellhead systems and for templates (limited to region of riser load transfer between the wellhead system and template well slot)

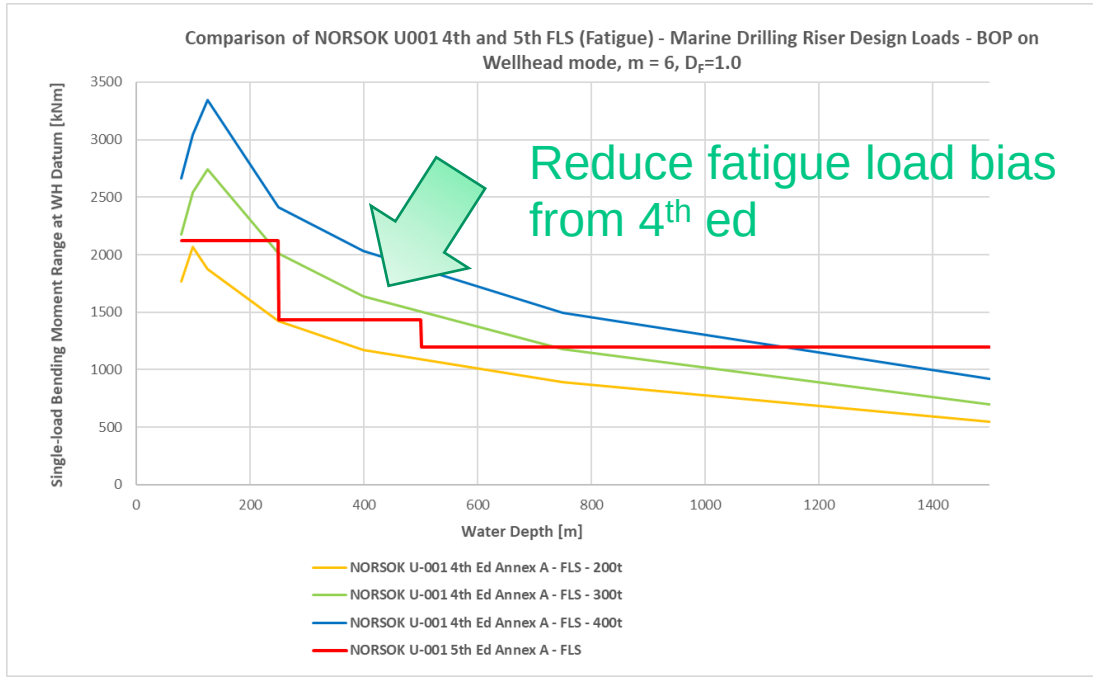
Annex A (normative)

Drivers for revision in 5th Edition of NORSOK U-001

Wellhead ULS and ALS Design Loads



Wellhead Fatigue Design Loads



Annex A (normative)
A.1 Scope

- Annex A includes in-place template design loads and marine drilling loads.
- Default design loads for templates when project site-specific loads are not known
- Used for design or selection of well head systems.
- Limited to operations from semisubmersible mobile drilling units (MODUs).
- Limited to Norwegian Continental Shelf (NCS).

Annex A (normative)
A.2 Template design loads and load conditions

Table A.1 – Default template in-place design load cases

Phase/ activity	Load case ID	Load case	Template loads and displacements
Installation of conductor	1.1	Weight of 100 m of 36" x2.0" conductor, submerged in seawater, temporary hung-off at template (TGB)	Down force on template: 923 kN Temporary load, ULS
	1.2	Weight of 100m of 36" x 2.0" conductor, submerged in 1,56SG cement, permanently hung-off at template (TGB) NOTE After cementing, this load will be a fixed preload on the template, which grants load factor 1.0. The conductor can be assumed vertically fixed to soil at 30m soil depth.	Down force on template: 578 kN Permanent load, ULS
Installation of surface casing	2.1	Weight of wellhead and 1000 m of 20" x 0.64" surface casing hung off in conductor housing. Submerged weight in seawater: 1700 kN	Down force on template: 158 kN Temporary load, ULS
	2.2	Submerged weight of wellhead and 1000 m of 20"X0.64" surface casing, submerged in 1.56 specific gravity cement, seawater-filled: 620 kN NOTE After cementing, this load will be a fixed preload on the template, which grants load factor 1.0. The conductor can be assumed vertically fixed to soil at 30m soil depth.	Down force on template: 58 kN Permanent load, ULS

Table A.2 – Template in-place combined load conditions

Load case ID	Load case description	Combined load cases and LRFD load factors [a, b]												
		A ULS	B ULS	C ULS	D ULS	E ALS	F ULS	G ULS	H ULS	I ULS	J ULS	K ULS	L ALS	M FLS
1.1	Conductor, temporary	1.3												
1.2 [c]	Conductor, cemented (deformation load)		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2.1	Surface casing, temporary			1.3										
2.2 [c]	Surface casing, cemented (deformation load)				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.1	BOP impact (vertical and horizontal separately)					1.0								
3.2	BOP weight						1.3	1.3	1.3	1.3	1.3	1.3	1.0	1.0
4.1	Guide-wires (if used)						1.3	1.3	1.3	1.3	1.3	1.3	1.0	1.0
4.2	Intermediate and production casings and tubing							1.3	1.3	1.3	1.3	1.3	1.0	1.0
5.1	HXT weight (if applicable)								1.3	1.3	1.3	1.3	1.0	1.0

Template loads for site specific conditions can be calculated by spreadsheet which is available at this link, NORSOK U-001:2021 - Input data Annex A Table A.1. Excel spread sheet Revision 1F (2020-10-30)

Annex A (normative)
A.3 Marine drilling riser loads

Table A.4 – ULS and ALS wellhead design loads- BOP on wellhead mode

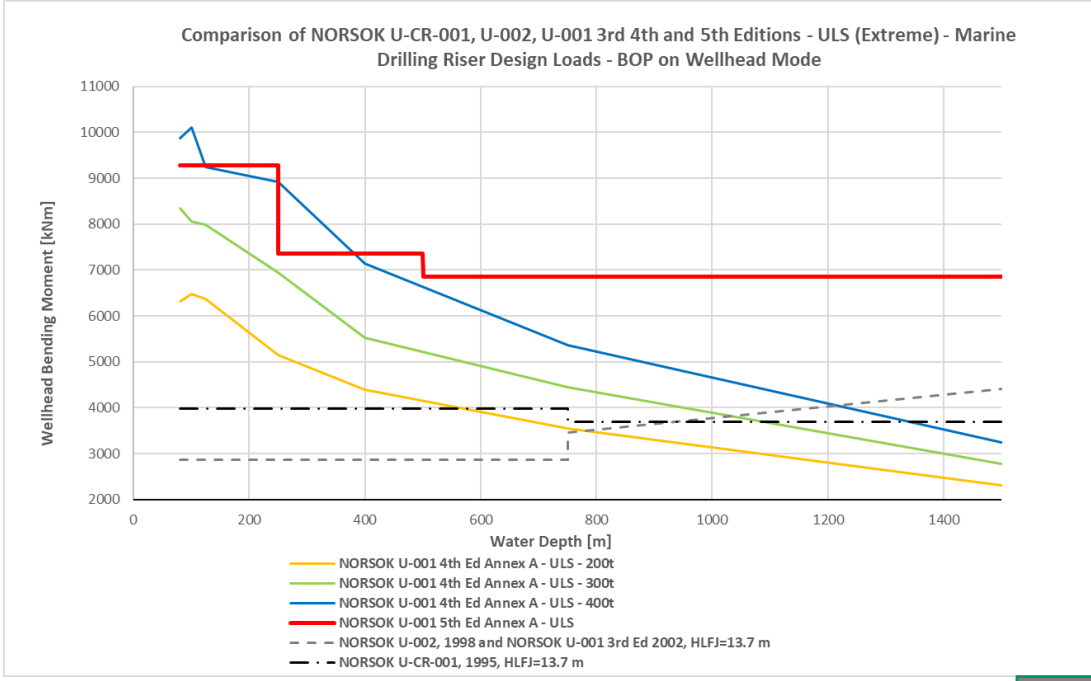
Water depth ranges [m]	ULS			ALS		
	Bending moment M_W [kNm)	Shear force Q_W [a] [kNm	Tension [b] [kN]	Bending moment M_W [kNm)	Shear force Q_W [a] [kNm	Tension [c] [kN]
From 80 to 250	9 289	678	-1 472	13 382	977	3 424
From 251 to 500	7 354	537	-1 472	12 217	892	3 424
From 501 to 1500	6 862	501	-1 472	11 467	837	3 424

[a] Shear force, $Q_w = \frac{M_w}{H_{LFJ}}$. Standard design case value of H_{LFJ} is given in Table A.3.

[b] Negative tension values means weight acting downwards. Based on worst case down weight (i.e. effective tension at lower flex-joint minus weight of BOP and LMRP).

[c] Positive tension values means a vertical force acting upwards. Based on effective tension at lower flex-joint minus weight of BOP and LMRP plus 450 tonnes drill pipe tension. For vertical and horizontal well completions it is assumed the drill pipe tension is reacted by the BOP stack (i.e. via a closed pipe ram on the landing string).

Comparison of 3rd, 4th and 5th editions, wellhead ULS design loads



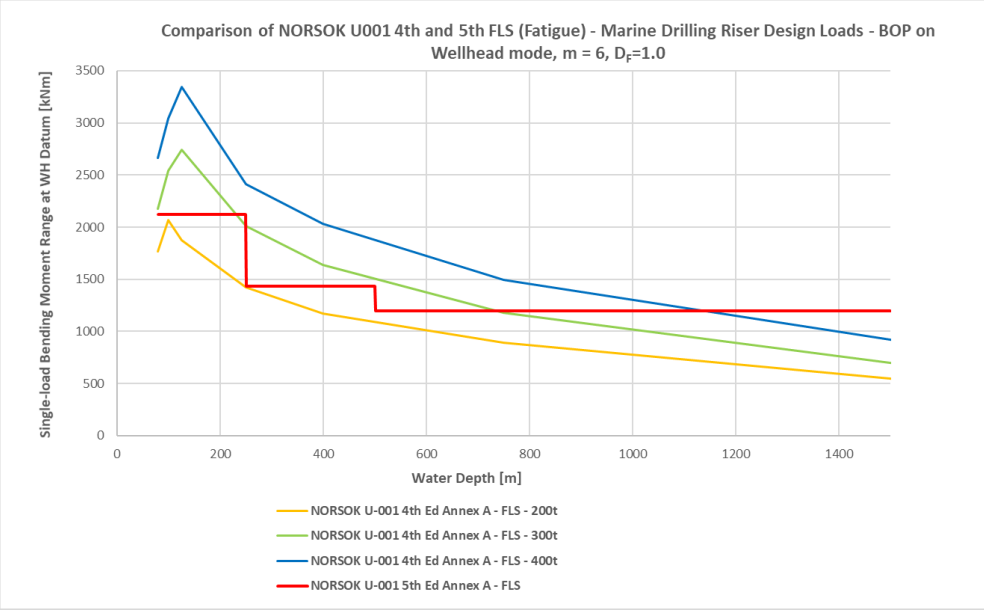
Annex A (normative)
A.3.5 Fatigue design

Table A.7 – Annual WH single-load bending moment range ΔMo

Water Depth ranges [m]	BOP on wellhead mode	BOP on HXT mode
	Single-load bending moment range ΔM_o (note) at WH datum [kNm]	Single-load bending moment range (note) at WH datum [kNm]
From 80 to 250	2124	2466
From 251 to 500	1436	1766
From 501 to 1500	1194	1452

NOTE For definition of single-load bending moment range, see B.6.4. The single-load bending moment range includes a fatigue design factor D_F= 1.

Comparison of 4th and 5th edition, wellhead fatigue design loads



Fatigue unit load

Bending moment range [kNm]	Number of cycles
0.1	3948892
0.2	826087
0.3	698721
0.4	550639
0.5	416070
0.6	309974
0.7	223998
0.8	166948
0.9	111824
1	78218
1.1	52813
1.2	34385
1.3	21874
1.4	13388
1.5	8007
1.6	4921
1.7	2673
1.8	1574
1.9	847
2	471
2.1	230
2.2	110
2.3	55
2.4	27
2.5	13
2.6	7
2.7	3
2.8	1
2.9	1

Multiply

Water Depth ranges [m]	BOP on wellhead mode	BOP on HXT mode
	Single-load bending moment range ΔM_o (note) at WH datum [kNm]	Single-load bending moment range (note) at WH datum [kNm]
m 80 to 250	2124	2466
m 251 to 500	1436	1766
From 501 to 1500	1194	1452

NOTE For definition of single-load bending moment range, see B.6.4. The single-load bending moment range includes a fatigue design factor D_F= 1.

Load histogram, one year of operation

Annex B (normative)
Structural design, materials, fabrication and testing of subsea wellhead, tree equipment and completion/workover riser systems

Changes from 4th Edition of NORSOK U-001

Table of contents

B.2 Scope

Annex B (normative)
Changes from 4th Edition of NORSOK U-001

- Conversion to normative requirements
- Revised applicable equipment list.
- Amendment cross references to applicable NS-EN ISO 13628-4 and -7 clauses.
- Amendment to weak link design criteria
- Amendment to elastic-plastic analysis criteria
- Direct reference to DNV-RP-C203 for fatigue analysis of connectors
- Running string, landing string and C/WO riser product requirements
- Inclusion of riser pipe structural capacities
- Update of material and fabrication requirements in B.12

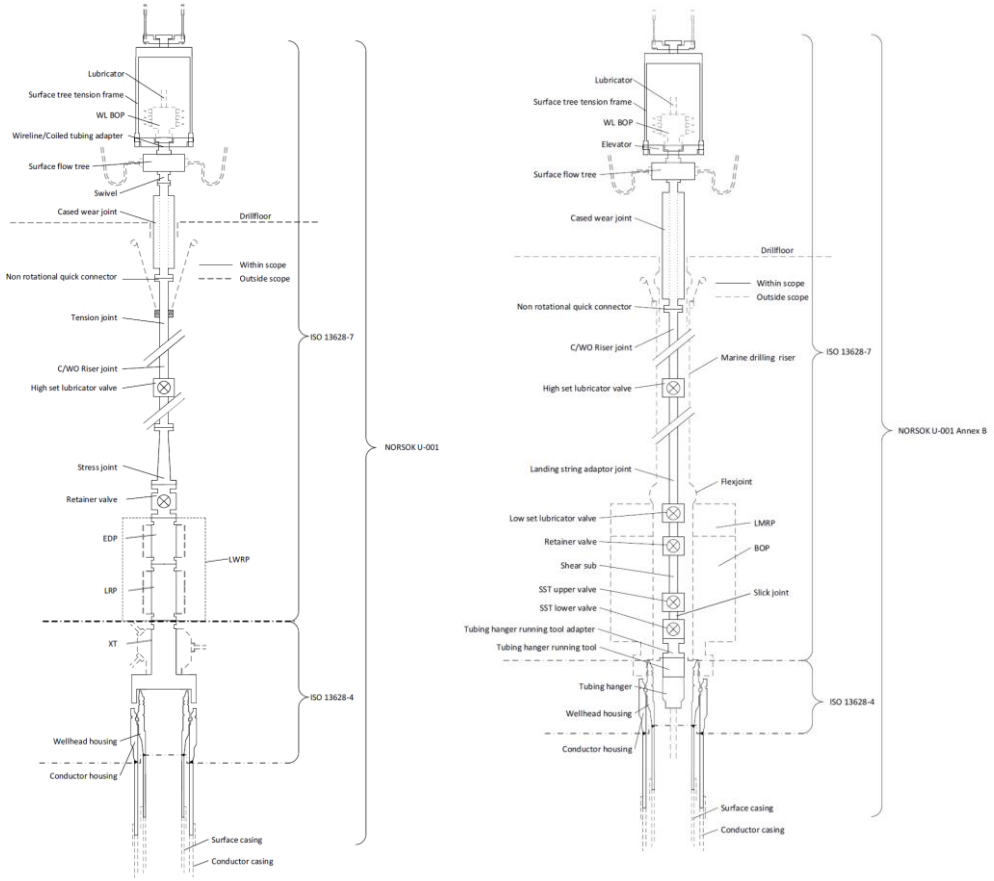
Annex B (normative)
Table of contents

Annex B (normative)
B.2 Scope

Table B. 1 – Components and equipment within the scope of Annex B

IS0 13628-4 Subsea wellhead and tree equipment	ISO 13628-7 C/WO workover riser system equipment	Extensions joints
Components and equipment in the riser load path		
Tubing hangers	Tubing hanger orientation systems	Extension of wellhead housing to the top of the first casing or conductor string [d]
Casing hangers	Subsea test trees	Extension of conductor housing to the top of the first conductor string [e]
Tubing hanger running tools [a]	Shear subs	
Tree cap running tool (horizontal trees) [a]	Retainer valves	
Tree running tools	Lubricator valves	
Tree connectors	Lower workover riser packages	
Tree cap connectors	Subsea WCT-BOP's	
Tubing heads	Emergency disconnect package connectors	
Tubing head connectors	Riser connectors	
Tree valve blocks	Stress joints	
Conductor housing	Riser joints	
Subsea wellhead housings	Tension joints	
Pressure containing bolting (closure bolting)	Surface tree adapter joints	
Primary structural bolting	Swivels	
Pressure containing seal rings	Surface trees	
End and outlet connectors	Wireline/coiled tubing adapters	
Other structural equipment	Primary structural bolting	
Other pressure containing equipment	Pressure containing seal rings	
Load shoulders and rings [c]	Other structural equipment	
	Other pressure containing equipment	
Components and equipment not in the riser load path [b]		
Bonnets		
Valve blocks (production and annulus valve wing blocks)		

Figures B.1 and B.2



Further reading – Annex A

Marine drilling riser loads on subsea wells on the Norwegian continental shelf using semisubmersible drilling rigs: 4Subsea Report 26583U-1762362461-2 Revision 2.0 (2020-11-03) 1685 NORSOK annex A revision

4Subsea Technical Note regarding reducing wellhead loads from marine drilling operations can be used for guidance, 4Subsea Technical Note: Reducing wellhead loads from marine drilling operations

OMAE 2022- 81380 Rationale for NORSOK U-001 5th Edition Revision of Static and Cyclic Subsea Wellhead Loads". This paper will be available June 2022 thru https://asmedigitalcollection.asme.org/OMAE.

Further reading – Annex B

ISOPE-2001-JSC-249A	Burst and gross plastic deformation limit state equations for pipes Part 1 - Theory
ISOPE-2001-JSC-249A	Burst and gross plastic deformation limit state equations for pipes Part 2 - Application
PVP2014-28665	Fatigue capacity of steel cylindrical bodies and conduits subjected to internal pressure
PVP2014-28712	Structural design of metallic components in ISO 13628-7
PVP2014-28719	Fasteners – Strength and quality control requirements
PVP2016-63525	Tensile testing and analysis of notched low allow steel specimens
PVP2016-63554	New edition (4th) of NORSOK U-001 for subsea production systems
OMAE 2017-61364	Best practice guidance for establishing the design fatigue capacity of subsea well intervention system connectors
International journal of fatigue 96 (2017) 43-66	Fatigue analysis of low alloy steel forgings used in the subsea industry
PVP2018-85088	Structural capacities of flanged joints
OMAE2021-62880	Use of DNV-RP-C203 for determining the fatigue capacity of connectors