DNV·GL

ISO-NORSOK GAP ANALYSIS TASK 3

Fabrication of jacket structures, Final report

Standard Norge

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Customer:	Standard Norge, Postboks 242	P.O.Box 300
	1326 LYSAKER	1322 Høvik
	Norway	Norway
Contact person:		Tel: +47 67 57 99 00
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Task and objective:

The Gap analysis is carried out in order to determine conseqences of replacing Norsok N-standards with ISO standards for material requirements and fabrication of jacket platforms.

Prepared by:	Verified by:	Approved by:
Gunnar Solland Specialist, Offshore structures	Harald Thorkildsen Group leader topside structures	Frode Kamsvåg Acting Head of Department Marine Structures
Jens Velo Principal engineer, Aker Solutions	[Name] [title]	
[Name] [title]	[Name] [title]	

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0	2014-11-30	First issue, draft report	J.Velo; G.Solland	H. Thorkildsen	F.Kamsvåg
1	2015-03-13	Final report	J.Velo; G.Solland	H. Thorkildsen	F.Kamsvåg

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1 EXECUTIVE SUMMARY

NORSOK expert group on structures (EgN) has initiated a program to review if one or more of NORSOK structural standards may be replaced by reference to ISO standards. This report presents the results of the gap studies for the fabrication of jacket platforms (substructure and topside). A description of the plans for the total gap analyses is presented in Chapter 7.

ISO specifies that fabrication shall be according to a generic specification selected by the owner. It is assumed in this study that the fabrication of the jacket platform is made by use of NORSOK M-101 as fabrication specification and with the various NORSOK M-standards for selection of materials. This assumption is made as it is judged that the NORSOK M-standards will be selected for development projects in Norwegian waters.

In ISO 19902 two methods are presented for determining the particular steel specifications to be used for a specific structure and the accompanying welding, fabrication and inspection requirements. These methods are generally referred to as

a) The material category (MC) approach, and
b) The design class (DC) approach

The MC method has evolved from practices in the Gulf of Mexico. The DC method has evolved from North Sea practices and the NORSOK standards for steel structures. For the present study the DC method is selected.

A summary of the gaps identified are presented in Chapter 4. The main finding is that the use of ISO may increase the fabrication cost. It is also found that NORSOK provides requirements to more of the relevant areas that are needed.

It should be noted that the summary presents a simple summation of the given rates without weighing the various gaps according to their significance.

2 INTRODUCTION

2.1 General

This report is made under contract with NORSOK Standard and is supervised by the NORSOK Expert Group N for structures (EG N). This report covers the work related to Task 3: "Fabrication of jacket platform". Description of the NORSOK EG N Gap analysis project is given in Chapter 7.

The gap analysis is made by comparing requirement found in the NORSOK N and M series of standards with the requirements of ISO 19900 series. The comparison is made by review of the various paragraphs as listed in Chapter 6 and the gaps identified are listed in Chapter 5.

Requirements to materials and fabrication are found in NORSOK M series of standards, but are included in the Gap project as the design and fabrication requirements are closely linked. Furthermore ISO 19902 is covering both design and fabrication aspects and making reference to this code will imply that requirements both to design and to fabrication need to be adhered to.

2.2 Basis of comparison of fabrication requirements

The comparison between NORSOK and ISO is made against the general requirements in ISO 19902.It is also made a more specific comparison between NORSOK and ISO when the design class (DC) approach described in ISO 19902 is selected. This is made as the DC approach described in ISO is based on NORSOK, and is the most relevant method if ISO should be prescribed as the design standard for projects in Norwegian sectors. This will also imply that that the requirements of Annex D (informative – "Design class approach") and Annex F (informative – "Welding and weld inspection requirements – Design class approach") of ISO 19902 is taken into consideration, and not the requirements of Annex C (informative – "Material category approach") and Annex E (informative – "Welding and weld inspection requirements – Material category approach").

ISO specifies that fabrication shall be according to a generic specification selected by the owner. The comparison is done with NORSOK M-101 as the selected generic specification. It will not be meaningful to do a gap analysis against ISO without selecting the fabrication specification to be used. The comparison will otherwise be inconclusive.

ISO has supplementary requirements to the selected generic specification. This document identifies the differences between the additional requirements in ISO with the corresponding requirements in NORSOK. Requirements specified in NORSOK M-101, and which would be identical for both ISO and NORSOK, are not considered. Such topics are establishment of welding procedure specifications, general requirements to qualification of welding procedures, qualification of welders and welding operators, welding coordination, qualification of welding inspectors, preparation for assembly, welding processes, welding consumables, preheating, welding performance, inspection before, during and after welding, weld buttering, straightening of structural members, performance of post weld heat treatment, grinding and peening of welds, weld production tests, qualification of NDT operators, repair of welds containing defects.

The gap analysis is made on the basis of -10°C as the minimum design temperature.

2.3 Method

The gap analysis is made by establishing a list of the topics that should be covered in order to fabricate a jacket structure. For each topic the relevant paragraphs of the two set of standards are listed in Chapter 6. For each topic the requirements are compared and the following are identified:

1. Differences in what is covered by the codes
2. Differences affecting structural integrity
3. Differences affecting fabrication cost

Identified gaps are presented in Chapter 5. For each topic the requirements are rated according to the code presented in Table 2-1.

Table 2-1 Rating code

Type of difference	+2	+1	0	-1	-2
Differences in what is covered by the codes for this topic	ISO covers significant broader scope	ISO covers somewhat broader scope	Similar scope for both standards	NORSOK covers somewhat broader scope	NORSOK covers significant broader scope
Differences affecting structural integrity for this topic	ISO will lead to significant safer structures	ISO will lead to somewhat safer structures	Both standards gives same safety	NORSOK will lead to somewhat safer structures	NORSOK will lead to significant safer structures
Differences affecting fabrication cost for this topic	ISO will lead to significant reduction in cost	ISO will lead to somewhat reduction in cost	Both standards gives same cost	NORSOK will lead to somewhat reduction in cost	NORSOK will lead to significant reduction in cost

3 STANDARDS REVIEWED

3.1 ISO

ISO 19900 Petroleum and natural gas industries — General requirements for offshore structures, Second edition, 2013-12-15

ISO 19901-3, Petroleum and natural gas industries — Specific requirements for offshore structures — Part 3: Topsides structure,
First edition, 2010-12-15

ISO 19902, Petroleum and natural gas industries — Fixed steel offshore structures
First edition 2007-12-01

3.2 NORSOK

NORSOK N-004 Rev. 3	February 2013	Design of steel structures
NORSOK M-001 Edition 5	September 2014	Materials selection
NORSOK M-101 Edition 5,	October 2011	Structural steel fabrication
NORSOK M-120 Edition 5,	November 2008	Material data sheets for structural steel
NORSOK M-121 Rev. 1,	September 1997	Aluminium structural material
NORSOK M-122 Edition 2,	October 2012	Cast structural steel
NORSOK M-123 Edition 2,	October 2012	Forged structural steel
NORSOK M-501, Edition 6	February 2012	Surface preparation and protective coating

4 SUMMARY

In Table 4-1 below a summary of the gaps identified for each group of topics are presented.

The summary is made by simple summation of the score given without any weighing due to the significance of the gaps.

Table 4-1 Summary of rating for the various topics

Group of Topics	Comment	Total score positive and negative					
		Differences in what is covered by the code		Differences affecting structural integrity		Differences affecting fabrication cost	
		+	–	+	–	+	–
5.1.1 Minimum design temperature	Practical limit is -30°C for ISO Limit for NORSOK is -14°C.	1	0	0	0	0	0
5.1.2 Method for determination of steel specifications and accompanying fabrication, welding and inspection requirements.	ISO describes two different systems, NORSOK only one. ISO opens for use of alternative systems which may lead to less reliable structures.	0	-1	0	-1	0	0
5.2 Materials	ISO cover less material types, specifies unnecessary low Charpy impact test temperatures for thin materials and in addition too low Charpy impact energy values.	0	-1	0	-1	0	-2
5.3 Fabrication, welding and weld inspection	ISO does not cover all the aspects as in NORSOK and have some requirements that can lead to increased cost.	0	-3	0	0	0	-5
5.4 Grouting	ISO gives overall requirements for grouting operations.	2	0	0	0	0	0

Group of Topics	Comment	Total score positive and negative					
		Differences in what is covered by the code		Differences affecting structural integrity		Differences affecting fabrication cost	
		+	−	+	−	+	−
5.5 Fabrication of aluminium structures	More details of fabrication of aluminium given in NORSOK, and ISO restrict the use of welded high strength alloys.	0	-2	0	0	0	-2
5.6 Mechanical fasteners	More requirements given in NORSOK. ISO does not restrict yield strength above water.	0	-1	0	-1	0	0
5.75.8 Geometric tolerances	NORSOK gives more requirements relevant for topside structures.	0	-1	0	0	0	0
5.8 Corrosion protection	ISO does not cover coating	0	-1	0	-1	0	0
5.9 Quality assurance	No gap identified	0	0	0	0	0	0
Total		3	-10	0	-4	0	-9

There are noted 3 rating points on topics where ISO is giving requirements where NORSOK is not, but there are 10 cases where the opposite is the case.

No requirements are found where ISO will lead to more reliable structures than NORSOK while there are given 4 rating points where fabrication according to NORSOK will improve the structural integrity.

9 rating points are recorded where fabrication according to ISO will imply increased cost compared with the use of NORSOK.

5 DETAIL REVIEW OF TOPICS

5.1 General

5.1.1 Minimum design temperature

Table 5-1 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	+1	ISO is applicable to temperature below -14°C
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-2 Summary and comments

Summary:

- ISO 19902 has no lower limit for minimum design temperature.
- The minimum design temperature by use of NORSOK is -14°C (ref.N-004, section 5.2, and M-101, section 1).

Comments: (reference to other codes, important information in the Commentary etc.)

- ISO 19902 has no lower limit for minimum design temperature ("LAST" = lowest anticipated service temperature). For the most important parts of the structure, ISO specifies that Charpy impact testing shall be carried out at a temperature 30°C below LAST, both for base materials and for welding procedure qualification tests. In practice this means that ISO can be used down to a LAST of -30°C. This as Charpy impact testing of carbon steel at temperatures lower than -60°C is not realistic.

Table 5-3 Identified gaps

Gaps

- ISO 19902 has no lower limit for minimum design temperature. However, due to the specified Charpy impact test temperatures, the practical minimum design temperature is -30°C.
- The minimum design temperature by use of NORSOK is -14°C (ref. N-004, section 5.2, and M-101, section 1).

5.1.2 Method for determination of steel specifications and accompanying fabrication, welding and inspection requirements.

Table 5-4 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	ISO 19902 (19.5) is not precise in what is covered
Differences affecting structural integrity	-1	ISO 19902 allows for alternative specifications
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-5 Summary and comments

Summary:

- In ISO 19902, section 19.1, two methods are presented for determining the particular steel specifications to be used and the accompanying welding, fabrication and inspection requirements:

  a) the material category (MC) approach, and
  b) the design class (DC) approach

  As these two methods are informative and not normative, other rational procedures may also be considered.

- NORSOK has one system; the design class (DC) system.

Comments: (reference to other codes, important information in the Commentary etc.)

- In ISO 19902, section 19.1, two methods are presented for determining the particular steel specifications to be used for a specific structure and the accompanying welding, fabrication and inspection requirements. These methods, briefly introduced in 19.2.4 and 19.2.5 in the standard and described in detail in Annexes C and D, are generally referred to as

  a) the material category (MC) approach, and

  b) the design class (DC) approach

  The material category (MC) and design class (DC) methods are mutually exclusive. Once the method has been selected it is not interchangeable at any stage with the other.
- In section 19.2.3 of ISO 19902 it is stated that Annex C and D provide normative details concerning the implementation of the procedures applicable to its particular method. In section 19.5 it is indicated that Annexes C and D not are normative, as it is stated that "Annexes C and D list commonly used specifications" for materials. The annexes themselves (Annex C and D) are identified to be "informative". If Annex C and D are normative or informative is then not fully clear.
- In 19.2.3 it is also stated that "as an alternative to the MC and DC approaches, other rational procedures may be considered". This implies that other methods than the MC and DC methods can be applied. This would however require development of detailed specifications for materials and fabrication, and is not considered to be a realistic way in order to satisfy the requirements of this ISO standard.
- NORSOK has one system for material selection; the design class (DC) method.
- Even if the DC method described in ISO is based on the DC method used in NORSOK, the systems in ISO and NORSOK are not identical.

Table 5-6 Identified gaps

Gaps
• ISO 19902 describes two methods for determining the particular steel specifications to be used for a specific structure and the accompanying welding, fabrication and inspection requirements: a) the material category (MC) approach, and b) the design class (DC) approach • As an alternative to the MC and DC approach, it is stated in ISO 19902 that other rational procedures may be considered. • NORSOK has one system for material selection and the accompanying welding, fabrication and inspection requirements; the design class (DC) method. • Even if the DC method described in ISO is based on the DC method used in NORSOK, the systems in ISO and NORSOK are not identical.

5.2 Materials

5.2.1 Material selection

The material selection process by use of the DC approach in ISO 19902 is described in section 5.6 in Task 2, Design of jacket structures /2/.

Section 5.2, Materials, in this document describes the requirements to the selected materials in some more detail.

5.2.2 Material specifications

Table 5-7 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	Castings and forgings not covered by ISO
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-8 Summary and comments

Summary:

- Material specifications for the following product forms are given in ISO 19902 (Annex D): Plates, rolled sections, hollow sections. References to specifications for cast and forged structural steel are not given.
- NORSOK has material specifications for the following product forms: plates, rolled sections, hollow sections, cast steel, forged steel.

Comments: (reference to other codes, important information in the Commentary etc.)

- Material specifications for the following product forms are given in ISO 19902 (Annex D): Plates, rolled sections, hollow sections. ISO have no references to specifications for cast and forged structural steel.
- Material specifications for the following product forms are given in NORSOK:
    - NORSOK standard M-120: Plates, rolled sections, hollow sections.
    - NORSOK standard M-122: Cast structural steel.
    - NORSOK standard M-123: Forged structural steel.

Table 5-9 Identified gaps

Gaps
• ISO has references to material specifications for plates, rolled sections and hollow sections. ISO have no references to specifications for cast and forged structural steel. • NORSOK has material specifications for all relevant product forms, i.e. plates, rolled sections, hollow sections, cast steel and forged steel.

5.2.3 Charpy Impact test temperatures for base materials

Table 5-10 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	Stricter requirements for small thicknesses in ISO 19902

1) For definition of rating codes see Table 2-1

Table 5-11 Summary and comments

Summary:
• In ISO 19902, Table 19.4-1 (normative), it is specified that steels belonging to a certain toughness class shall be Charpy impact tested at the same temperature for all thicknesses.
Comments: (reference to other codes, important information in the Commentary etc.)
• Charpy impact testing at the same temperature for all thicknesses is more stringent than required in the fabrication part of ISO 19902, and also more stringent than required by NORSOK (both for base materials and fabrication), which accept higher impact test temperatures for materials up to a certain thickness.

Table 5-12 Identified gaps

Gaps
• In ISO 19902, Table 19.4-1 (normative), it is specified that steels belonging to a certain toughness class shall be Charpy impact tested at the same temperature for all thicknesses. • Other standards, including NORSOK, accept higher test temperatures for thin materials.

5.2.4 Charpy Impact energy values for base materials

Table 5-13 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	-1	Risk that welded connection may get too low toughness
Differences affecting fabrication cost	-1	Possible toughness problems will have cost impact.

1) For definition of rating codes see Table 2-1

Table 5-14 Summary and comments

Summary:

- The Charpy impact energy values specified for the base materials in ISO 19902, (Table 19.4-1 (normative), are too low.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-15 Identified gaps

Gaps

- The Charpy impact energy values specified for the base materials in ISO 19902, Table 19.4-1 (normative), are lower than specified by NORSOK, and are too low in order to guarantee compliance with the minimum Charpy energy values specified in HAZ after welding (ref. Table F.1 in ISO 19902).

5.3 Fabrication, welding and weld inspection

5.3.1 Welding and fabrication standard

Table 5-16 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	ISO does not have a specification for fabrication, welding and inspection.
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	Complicated to work to ISO plus a separate generic specification.

1) For definition of rating codes see Table 2-1

Table 5-17 Summary and comments

Summary:

- ISO 19902 has just a few specific requirements to welding, fabrication and NDT. The requirements specified in ISO 19902 shall be used in conjunction with owner specifications, selected international, national or regulatory standards for welding, fabrication and inspection.
- In the NORSOK system for steel structures, NORSOK M-101 is an independent and "stand alone" specification for fabrication, welding and inspection.

Comments: (reference to other codes, important information in the Commentary etc.)

- ISO 19902 has just a few specific requirements to fabrication, welding and NDT. In section 20.1 and 20.2.1 of the standard it is stated that fabrication, welding and weld inspection of fixed offshore structures shall be performed in accordance with a selected generic specification or standard (owner specifications, international, national or regulatory standards). The additional requirements that shall supplement the requirements of the selected generic specification are described in section 20 of ISO 19902. The most important complementary provisions are specific requirements to weld metal and HAZ toughness (Charpy impact and CTOD test temperatures and energy values). The toughness requirements are further detailed in section 5.3.2.1 and 5.3.2.2 below. The toughness requirements specified in ISO 19902 shall overrule the corresponding toughness requirements specified in the selected generic standard.
- Annex A of the standard, which is informative, contains additional information and guidance to the normative parts of the standard. In section A.20.2.1 of ISO19902 it is stated that NORSOK M-101 is a generic standard that is generally compatible with the DC method. Further comparisons between ISO and NORSOK with regard to fabrication, welding and inspection are based on NORSOK M-101 to be the selected generic fabrication standard.

Table 5-18 Identified gaps

Gaps

- ISO 19902 has just a few specific requirements to welding, fabrication and NDT. In section 20.1 and 20.2.1 of the standard, it is stated that fabrication, welding and weld inspection of fixed offshore structures shall be performed in accordance with a selected generic specification or standard (owner specifications, international, national or regulatory standards).
- In the NORSOK system for steel structures, NORSOK M-101 includes all aspects of fabrication, welding and inspection.

5.3.2 Qualification of welding procedures

5.3.2.1 Weld metal and HAZ Charpy toughness requirements

Table 5-19 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	For some cases ISO specifies lower test temperatures than NORSOK.

1) For definition of rating codes see Table 2-1

Table 5-20 Summary and comments

Summary:

- There are differences in the requirements to weld metal and HAZ Charpy toughness, both for test temperatures and energy values.
- The main differences being that for some cases ISO specifies lower test temperatures than NORSOK.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-21 Identified gaps

Gaps
• By use of the DC method, the minimum Charpy V-notch toughness requirements for weld metal and HAZ are defined in Annex F of ISO 19902. For a minimum design temperature of -10°C, the Charpy impact test temperature specified by ISO are lower than specified by NORSOK for some strength groups, toughness classes and thicknesses. ISO specifies the same test temperature for SQL II as for SQL I, while NORSOK specifies higher test temperatures for SQL II than for SQL I. Examples of differences in test temperatures between ISO and NORSOK are shown in the table below.

SQL (NORSOK)	SMYS (MPa)	Thickness (mm)	Test temp. (°C) NORSOK	Test temp. (°C) ISO
I	≤ 400	25	-20	-40
II	≤ 400	12< t <25	0	-20
II	≤ 400	25	0	-40
II	≤ 400	25< t ≤50	-20	-40
II	>400, ≤ 500	≤ 12	0	-20
II	>400, ≤ 500	12< t ≤25	-20	-40
III	≤ 400	25	0	-20
III	≤ 400	50	-20	-40

• For steels with SMYS ≤ 500 MPa, the minimum Charpy impact energy values specified by ISO are a few Joules lower than specified by NORSOK (except for SQL II with SMYS ≤ 400 MPa, where ISO specifies higher values than NORSOK).

5.3.2.2 Weld metal and HAZ CTOD toughness requirements

Table 5-22 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	The requirements to CTOD testing are better defined in NORSOK than in ISO.
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	ISO requires higher CTOD values than NORSOK. When CTOD testing is not required by ISO, PWHT shall be carried out.

1) For definition of rating codes see Table 2-1

Table 5-23 Summary and comments

Summary:

- There are differences in the requirements to weld metal and HAZ CTOD toughness, both regarding extent of testing and CTOD values. The requirements for CTOD testing are better defined in NORSOK than in ISO.

Comments: (reference to other codes, important information in the Commentary etc.)

- For the comparison, steel with SMYS ≤ 500 MPa is considered.

Table 5-24 Identified gaps

Gaps

- NORSOK M-101specifies CTOD testing for thicknesses > 50 mm for all strength levels for SQL I and II and when SMYS > 400 MPa for SQL III, both with and without PWHT. The requirement for minimum CTOD value shall be prescribed by the designer. If not specified by the designer, the requirement for minimum CTOD value shall be as for the steel purchase order. This means that minimum acceptable values shall be as specified by the NORSOK MDS's; 0,25 mm without PWHT and 0,20 mm with PWHT.
- In NORSOK maximum qualified thickness when CTOD testing is required is 10% higher than the actual thickness tested.
- In ISO 19902, requirements to CTOD testing are described in section 20.2.2.5 (normative) and Annex F (informative). For which applications CTOD testing is required is not as clearly defined in ISO as it is in NORSOK. ISO requires CTOD testing for steel of toughness classes CV2X and CV2ZX. This means that when ISO is applied, welded connections in DC 2 and 3 can be accepted without CTOD testing at all. This as steel of toughness classes not requiring CTOD testing can be used in DC 2 and 3. By use of NORSOK, CTOD testing is always required in DC 2 and 3. ISO specifies higher acceptance level than NORSOK, minimum 0.38 mm when the minimum design temperature is -10°C.
- In Annex F, applicable for the design class approach, it is stated that "Where the drawings give no indication, all welds with a minimum design throat thickness exceeding 40 mm on nodes and 50 mm elsewhere shall be post weld heat treated, or subjected to a full fracture mechanics assessment of welds under consideration. The interpretation of this is that if PWHT is carried out, CTOD testing is not required at all.
- In ISO the maximum qualified thickness when CTOD testing is required, is the actual thickness tested.

5.3.2.3 Maximum hardness

Table 5-25 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	Difficulties meeting hardness requirements can lead to increased cost

1) For definition of rating codes see Table 2-1

Table 5-26 Summary and comments

Summary:

- Maximum hardness below water with cathodic protection is 325 HV10 in ISO and 345 HV10 in NORSOK.
- NORSOK accepts higher hardness values above water than ISO (when PWHT is not required).

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-27 Identified gaps

Gaps

- Maximum hardness below water with cathodic protection:
  - ISO: 325 HV10
  - NORSOK: 345 HV10
- Maximum hardness above water:
  - ISO: 350 HV10 for all strength classes and delivery conditions.
  - NORSOK (refers to ISO 15614-1):
    - 380 HV10 without PWHT (320 HV10 with PWHT) for normalized steel with SMYS ≤ 460 MPa, all strength classes of TMCP steel, all strength classes and delivery conditions of cast steel, and QT steel with SMYS ≤ 360 MPa.
    - For QT steel with SMYS > 360 MPa, maximum acceptable hardness is 450 HV10 without PWHT and 380 HV10 with PWHT.

5.3.2.4 Essential variables

Table 5-28 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	Somewhat more stringent requirements in ISO can lead to higher fabrication cost.

1) For definition of rating codes see Table 2-1

Table 5-29 Summary and comments

Summary:

- ISO has a few more essential variables than NORSOK.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-30 Identified gaps

Gaps

- For welding procedures that are Charpy tested there are some minor differences in essential variables between ISO and NORSOK with regard to:
  - Chemical composition (CE and Pcm)
  - Interpass temperature
  - Heat input
  - Welding consumables
- For welding procedures that are CTOD tested there are a few more additional requirements (of less importance) to essential variables in ISO compared to NORSOK with regard to:
  - Maximum qualified thickness
  - Depth and width of back-gouging
  - Weld layer thickness

5.3.3 Cold forming

Table 5-31 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	NORSOK has more specific requirements than ISO
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-32 Summary and comments

Summary:

- NORSOK has more specific requirements to cold forming than ISO.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-33 Identified gaps

Gaps

- Both ISO and NORSOK accept cold forming up to a deformation ratio of 5% without documentation of mechanical properties.
- If cold deformation exceeds 5%, NORSOK have specific requirements to either heat treatment or strain ageing tests. ISO have no specific requirements.

5.3.4 Post weld heat treatment (PWHT)

Table 5-34 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-1	More PWHT may be required according to ISO

1) For definition of rating codes see Table 2-1

Table 5-35 Summary and comments

Summary:

- By use of NORSOK, PWHT is not required. This as fracture mechanics testing is required for all situations where PWHT could be relevant.
- By use of ISO, PWHT is required if fracture mechanics testing is not carried out. Fracture mechanics testing is not required for all situations where PWHT could be relevant.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-36 Identified gaps

Gaps
• In ISO 19902, Annex F, it is stated that if no information is given in drawings, all welds with throat thickness exceeding 40 mm on nodes and 50 mm elsewhere shall be post weld heat treated, or subjected to a full fracture mechanics assessment of the welds under consideration. • In NORSOK M-101, section 6.13, it is stated that PWHT shall be required for structural welds in steel quality level I and II, and steel quality level III with yield strength Re > 400 MPa, when the nominal thickness as defined in ISO 15614-1, exceeds 50 mm, unless adequate fracture toughness can be documented in the as welded condition. As fracture mechanics testing is required for all these conditions, both with and without PWHT, this means that in practice PWHT is not required.

5.3.5 Non-destructive testing (NDT)

Table 5-37 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-38 Summary and comments

Summary:
• By use of the Design Class approach as described in ISO 19902, and NORSOK M-101 as the selected generic fabrication specification, the requirements to NDT of welds will be the same in ISO as in NORSOK.

Comments: (reference to other codes, important information in the Commentary etc.)

- By use of the Design Class approach as described in ISO 19902, and NORSOK M-101 as the selected generic fabrication specification, the requirements to NDT of welds as per ISO 19902 will be as follows:
    - Non-destructive inspection categories shall be determined in accordance with Annex D of ISO 19902. This is exactly the same system as specified in NORSOK N-004, section 5.
    - In ISO 19902, section 20.3, it is stated that "the inspection requirements for the DC methodology are described in Annex F". In ISO 19902, section 21.1, it is stated that "the extent of NDT of welds shall be in compliance with the inspection category. The selection of an inspection category for each weld should be in accordance with Annex F". The type and extent of NDT as specified in Annex F is exactly the same as specified in NORSOK M-101 (with the exception of some minor changes made in Edition 5 of M-101 issued in October 2011).
    - Requirements to NDT procedures and acceptance criteria are not given in ISO 19902. However, by use of NORSOK M-101 as the selected generic fabrication standard, NDT procedures and acceptance criteria shall be in accordance with the NORSOK standard.

Table 5-39 Identified gaps

Gaps

- By use of the Design Class approach as described in ISO 19902, and NORSOK M-101 as the selected generic fabrication specification, the requirements to weld inspection are the same in ISO 19902 as in NORSOK.

5.4 Grouting

Table 5-40 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	+2	NORSOK does not address grout operations
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-41 Summary and comments

Summary:

- NORSOK does not address grout operations

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-42 Identified gaps

Gaps
• NORSOK does not address grout operations while requirements to this is given in ISO 19902

5.5 Fabrication of aluminium structures

Table 5-43 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-2	Material and fabrication requirements given in NORSOK but lacks in ISO
Differences affecting structural integrity	0	
Differences affecting fabrication cost	-2	ISO does not allow welded high strength aluminum structures.

1) For definition of rating codes see Table 2-1

Table 5-44 Summary and comments

Summary:
• Fabrication of aluminium structures are better covered in NORSOK than in ISO. • ISO restrict the use of welded high strength aluminium.
Comments: (reference to other codes, important information in the Commentary etc.)
•

Table 5-45 Identified gaps

Gaps
• ISO 19902 does not allow for use of welded aluminium structures with higher yield stress than 130 MPa. • NORSOK N-001 gives requirements to inspection of aluminium structures • NORSOK M-121 gives detail specification of aluminium material, while ISO is missing similar detailed specifications.

5.6 Mechanical fasteners

Table 5-46 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	NORSOK have more specific requirements to structural fasteners than ISO.
Differences affecting structural integrity	-1	ISO has no restrictions to use of high strength bolting above water.
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-47 Summary and comments

Summary:

- NORSOK standard M-001 includes requirements to fastener materials for structural use, both above and below water.
- In ISO 19902 has a recommendation to maximum yield strength of carbon steel fasteners when exposed to cathodic protection.

Comments: (reference to other codes, important information in the Commentary etc.)

-

Table 5-48 Identified gaps

Gaps

- NORSOK has requirements to fasteners for structural use. NORSOK M-001, Ed. 5, section 5.11.1 and 5.11.2, specific requirements to fastener materials to be used above water, and section 5.11.3 to fastener materials to be used below water.
- The only specific requirement found in ISO is in ISO 19902, section 15.2.8.2, where it is given a recommendation to maximum yield strength of carbon steel threaded fasteners exposed to cathodic protection.

5.7 Geometric tolerances

Table 5-49 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	NORSOK M-101 covers more details relevant for topside structures.
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-50 Summary and comments

Summary:

- NORSOK covers more requirements relevant for topside structures. In case NORSOK M-101 is selected as the fabrication specification in a project that is designed and fabricated according to ISO 19902 it need to be decided which standard that should be governing.

Comments: (reference to other codes, important information in the Commentary etc.)

- ISO 19902 specifies that the fabrication should be made according to a selected standard for fabrication (20.1) and for the comparison in the present document NORSOK M-101 is selected as the fabrication standard. As both NORSOK M-101 and ISO 19902 in the normative Annex G states requirements to tolerances it is not clear what will govern in case of conflicting requirements. For the purpose of this comparison it is assumed that as NORSOK M-101 is selected as the fabrication standard to be used with ISO standards also the tolerance requirements of NORSOK M-101 will be governing.

Table 5-51 Identified gaps

Gaps

- Both ISO 19902 (Annex G) and NORSOK M-101 gives detailed requirements to geometric tolerances. Both standards provide requirements for fabrication of jackets while NORSOK also provide details more relevant for topside structures. ISO 19901-3 refer to ISO 19902 for fabrication issues.

5.8 Corrosion protection

Table 5-52 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	-1	ISO does not have specific requirements to corrosion protection by use of coating.
Differences affecting structural integrity	-1	ISO does not have specific requirements to corrosion protection by use of coating.
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-53 Summary and comments

Summary:

- Both ISO and NORSOK have specific requirements to corrosion protection by cathodic protection.
- NORSOK has, ISO has not, specific requirements to corrosion protection by use of coating.

Comments: (reference to other codes, important information in the Commentary etc.)

- ISO 19902, section 18.4.4, includes requirements to cathodic protection, both by use of sacrificial anodes and by use of impressed current. In the NORSOK system, requirements to cathodic protection are covered by M-503 "Cathodic protection", covering both use of sacrificial anodes and impressed current.
- ISO 19902 does not contain specific requirements to corrosion protection by use of coating. In section 18.5.2 of ISO 19902 it is stated that "recommendations for surface preparation, materials, coating application, inspection, and repairs are given in applicable standards and practices". In the NORSOK system, corrosion protection by coating is covered by M-501 "Surface preparation and protective coating".

Table 5-54 Identified gaps

Gaps

- Both ISO and NORSOK have specific requirements to corrosion protection by cathodic protection.
- NORSOK has, ISO has not, specific requirements to corrosion protection by use of coating.

5.9 Quality assurance

Table 5-55 Difference rating for the topic

Type of difference	Difference rating 1)	Comment
Differences in what is covered by the codes	0	
Differences affecting structural integrity	0	
Differences affecting fabrication cost	0	

1) For definition of rating codes see Table 2-1

Table 5-56 Summary and comments

Summary:

- By use of the design class approach and NORSOK M-101 as the generic standard for fabrication, welding and inspection, the quality assurance requirements will in principle be the same.

Comments: (reference to other codes, important information in the Commentary etc.)

- By use of the design class approach and NORSOK M-101 as the generic standard for fabrication, welding and inspection, the requirements to quality assurance, quality control and documentation will in principle be the same. This includes quality management system to ISO 9001, quality system for welding acc. to ISO 3834-2, quality control plans, inspection and test plans, procedures for fabrication, welding, inspection and testing, and in addition reporting and documentation to verify compliance with the requirement of the specifications (e.g. NDT, dimensional control).

Table 5-57 Identified gaps

Gaps
• By use of the design class approach and NORSOK M-101 as the generic standard for fabrication, welding and inspection, the quality assurance requirements will in principle be the same.

6 PARAGRAPHS FOR TOPICS RELATED TO FABRICATION

6.1 General

6.1.1 Minimum design temperature

ISO:

ISO 19902:

19.2.2.4 Lowest anticipated service temperature

NORSOK:

N-004:

5.2 Steel quality level

M-101:

1 Scope

6.1.2 Method for determination of steel specifications and accompanying fabrication, welding and inspection requirements.

ISO:

ISO 19902:

19.1	General (Materials)
19.2	Design philosophy
19.2.1	Material characterization
19.2.2	Material selection criteria
19.2.2.1	Yield strength requirements
19.2.2.2	Structure exposure level
19.2.2.3	Component criticality
19.2.2.4	Lowest anticipated service temperature
19.2.2.5	Other considerations

19.2.3	Selection process
19.2.4	Material category approach
19.2.5	Design class approach
19.3	Strength groups
19.4	Toughness classes
19.5	Applicable steels
D.1	General (Annex D - Design class approach)
D.2	Specific steel selection NORSOK:

N-004:

5.1 Design class

5.2 Steel quality level

5.3 Welding and non-destructive testing (NDT)

6.2 Materials

6.2.1 Material selection

Reference is made to Task 2, Design of jacket structures. See DNV report 2014-1424 /2/.

6.2.2 Material specifications

ISO:

ISO 19902:

19.4	Toughness classes
19.5	Applicable steels
D.1	General (Annex D – Design class approach)
D.2	Specific steel selection

NORSOK:

M-120:

The whole document

M-122:

The whole document

M-123:

The whole document

6.2.3 Charpy Impact test temperatures for base materials

ISO:

ISO 19902:

19.4 Toughness classes

19.5 Applicable steels

D.2 Specific steel selection

NORSOK:

M-120:

The whole document and international standards referred to in each MDS

M-122:

5.4 Mechanical testing

M-123:

6 Mechanical testing

6.2.4 Charpy Impact energy values for base materials

ISO:

ISO 19902:

19.4 Toughness classes

19.5 Applicable steels

D.2 Specific steel selection

NORSOK:

M-120:

The whole document, and international standards referred to in each MDS

M-122:

5.4 Mechanical testing

M-123:

6 Mechanical testing

6.3 Fabrication, welding and weld inspection

6.3.1 Welding and fabrication standard

ISO:

ISO 19902:

20.1 General (Welding, fabrication and weld inspection)

20.2.1 Selected generic welding and fabrication standards

A.20.2.1 Selected generic welding and fabrication standards

NORSOK:

M-101:

The whole document

6.3.2 Qualification of welding procedures

6.3.2.1 Weld metal and HAZ Charpy toughness requirements

ISO:

ISO 19902:

20.2.2.4	Charpy V-notch (CVN) toughness
20.2.2.4.1	Testing
A.20.2.2.4	Charpy V-notch (CVN) toughness
F.1	General (Annex F – Welding and weld inspection requirements – Design class approach)
F.2	Toughness of weld and heat affected zone (HAZ)
F.2.1	General

NORSOK:

M-101:

5.4.2 Charpy V-notch testing

6.3.2.2 Weld metal and HAZ CTOD toughness requirements

ISO 19902:

20.2.2.5.1	General (CTOD toughness)
20.2.2.5.2	Pre-production qualification
20.2.2.5.3	CTOD fracture toughness requirements
A.20.2.2.5	CTOD toughness
B.1	Testing procedure requirements (Annex B – CTOD testing procedures)
B.2	Test-assembly welding
B.3	Number and location of CTOD specimens
B.4	Specimen preparation
B.5	Pre-compression
B.6	Sectioninmg
F.1	General (Annex F - Welding and weld inspection requirements – Design class approach
F.2	Toughness of weld and heat affected zone (HAZ)
F.2.2	CTOD testing
F.2.3	PWHT alternative to CTOD testing

NORSOK:

M-101:

5.3	Welding procedure qualification record (WPQR) – Range of approval
5.3.1	For welding of steels in all strength classes
5.4.1	General (Examination of the test weld)
5.4.4	Crack tip opening displacement (CTOD) testing

M-120:

Relevant Material data Sheets (MDS)

6.3.2.3 Maximum hardness

ISO:

ISO 19902:

20.2.2.6 Hardness testing

NORSOK:

M-101:

5.4.1 General (Examination of the test weld)

M-001:

6 Design limitations for candidate materials

6.3.2.4 Essential variables

ISO:

ISO 19902:

20.2.2.4.2	Additional essential variables (when Charpy V-notch testing is required)
20.2.2.5.4	Additional essential variables (when CTOD testing is required)
20.2.2.5.5	Qualification range (when CTOD testing is required)

NORSOK:

M-101:

5.3 Welding procedure qualification record (WPQR) – Range of approval

6.3.3 Cold forming

ISO:

ISO 19902:

20.4.3 Forming

NORSOK:

M-101:

6.5 Forming

6.3.4 Post weld heat treatment (PWHT)

ISO:

ISO 19902:

F.2.3 PWHT alternative to CTOD testing

NORSOK:

M-101:

6.13 Post weld heat treatment (PWHT)

6.3.5 Non-destructive testing (NDT)

ISO:

ISO 19902:

20.3 Inspection

21.1 General (Quality control, quality assurance and documentation)

21.3.6 Inspection of welding

D.3 Welding and non-destructive inspection categories

F.3 Extent of NDT for structural welds

NORSOK:

N-004:

5.3 Welding and non-destructive testing (NDT)

M-101:

9.1 General (Non-destructive testing (NDT))

9.2 Qualification of non-destructive testing (NDT) operators

9.3 Extent of visual examination and non-destructive testing (NDT)

9.4 Visual examination and finish of welds

9.5 Radiographic testing

9.6 Ultrasonic testing

9.7 Magnetic particle and penetrant testing

9.8 Acceptance criteria

6.4 Grouting

ISO 19902:

19.6.1 Grout materials

19.6.2 Onshore grout trial

19.6.3 Offshore grout trial

19.6.4 Offshore quality control

NORSOK:

No requirements given

6.5 Fabrication of aluminium structures

ISO:

ISO 19901-3:

10.4.1 General (Aluminium alloys)

10.4.2 Types of aluminium

10.4.3 Material properties

NORSOK:

N-001:

7.7.2 Selection of aluminium materials

7.7.3 Fabrication of aluminium structures

M-121 Whole document

6.6 Mechanical fasteners

ISO:

ISO 19901-3:

11.1.1 General (Assembly)

ISO 19902:

15.2.8.2 Threaded fastener materials and manufacturing

A.15.2.8.2 Threaded fastener materials and manufacturing

NORSOK:

M-001:

5.11.1 General (Fastener materials for pressure equipment and structural use)

5.11.2 Marine atmosphere

5.11.3 Fasteners for subsea applications

6.7 Geometric tolerances

ISO:

ISO 19901-3:

11.1.1 General (Assembly)

ISO 19902:

20.4.4 Fabrication tolerances

G.1 Measurements

G.2 Launch rails

G.3 Global horizontal tolerances

G.4 Global vertical tolerances

G.5 Roundness of tubular members

G.6 Circumference of tubular members

G.7 Straightness and circumferential weld locations of tubular members

G.8 Joint mismatch for tubular members

G.9 Leg alignment and straightness tolerances

G.10 Tubular joint tolerances

G.11 Cruciform joints

G.12.1 Stiffener location

G.12.2 Stiffener cross-section

G.13 Conductor, pile guide, pile sleeve and appurtenance support tolerances

NORSOK:

M-101:

E.1 Scope and objectives

E.2 Codes, standards and specifications

E.3 Definitions

E.4.1 Implementation policy of requirements

E.4.2 Procedures and documents

E.4.3 Qualification of inspectors

E.4.4 Instrument reliability

E.4.5 Reference temperature

E.4.6.1 Reference system

E.4.6.2 Marking criteria

E.4.6.3 Accuracy

E.4.7 Interface criteria

E.4.8 Alignment requirement

E.5.1 I/H-girders (Fabrication tolerances for structural components)

E.5.2 Box girders

E.5.3 Tubulars

E.5.4 Panels

E.5.5 Girder nodes

E.5.6 Box nodes

E.5.7 Tubular nodes

E.5.8 Cast and forged elements

E.5.9 Curved and cylindrical shell subject to external pressure

E.5.10 Conical transitions

E.6.1 Topsides and modules (Assembly tolerances)

E.6.2.1 Assembly tolerances (Jacket and other tubular frame structures)

E.6.2.2 Final tolerances for jacket, interface jacket/MSF

E.6.2.3 Guides, sleeves, piles and clamps

E.6.2.4 Piles

E.6.2.5 Conductor guides

E.6.2.6 Appurtenances

E.7.1 Crane pedestal

E.7.2 Skid beams

E.7.3 Outfitting structure

E.7.4 Installation aids

E.7.5 Grillages

E.7.6 Cranes

6.8 Corrosion protection

ISO:

ISO 19902:

18.1	General (Corrosion control)
18.2	Corrosion zones and environmental parameters affecting corrosivity
18.3	Forms of corrosion, associated corrosion rates and corrosion damage
18.4.1	General (Design of corrosion control)
18.4.2	Considerations in design of corrosion control
18.4.3	Coatings, linings and wrappings
18.4.4.1	Cathodic protection systems
18.4.4.2	Galvanic anode system
18.4.4.4	Impressed current systems
18.5.2	Coatings and linings
18.5.3	Cathodic protection

ISO 19901-3:

12.1	General (Corrosion control)
12.2	Forms of corrosion, associated corrosion rates and corrosion damage
12.3.1	General (Design of corrosion control)
12.3.2	Considerations in design of corrosion control
12.3.3	Coatings, linings and wrappings
12.4.2	Coatings and linings

NORSOK:

M-501:

The whole standard.

M-503:

The whole standard

6.9 Quality assurance

ISO:

ISO 19902:

21.1	General (Quality control, quality assurance and documentation
21.2	Quality management system
21.3.1	General (Quality control plan)
21.3.2	Inspector qualifications
21.3.3	NDT personnel qualifications
21.3.4	Inspection of materials
21.3.5	Inspection of fabrication
21.3.6	Inspection of welding

ISO 19901-3:

11.1.1	General (Assembly)
11.3	Fabrication inspection
11.4	Quality control, quality assurance and documentation

NORSOK:

M-101:

6.1	General (Fabrication and welding requirements)

7 DESCRIPTION OF THE GAP ANALYSIS PROJECT

7.1 Background

Several standards in the ISO 19900 series are during the last years formally issued that then can be referenced from the NORSOK standards in the N-series. This will make it possible to withdraw entire standards or remove parts of the current NORSOK standards. Before the decision of withdrawal of entire standards or omission of parts of a standard by reference to ISO it is necessary to closely investigate the consequences. NORSOK Expert Group on structures (EG N) decided to carry out this project in order to conclude about the future of the NORSOK N-series of standards.

NORSOK standards build upon 40 years of experience from the North Sea developed in accordance with Norwegian (European) principles for structural design and fabrication. ISO is developed for World wide application and with integration of several traditions of structural design and fabrication. This yields not only between different regions but also between different types of objects. ISO standards are developed on a consensus bases which make them often offering alternative methods which may lead to different results. It seems therefore necessary to do a thorough review of the differences in the standard before the NORSOK N-series of standards refer to ISO.

7.2 Purpose

The purpose of the gap analysis is to fade out the various NORSOK standards with exception of N-001.

The primary goal is to show that an adequate safety level can be achieved by reference to ISO and that parts of or entire NORSOK standards can be withdrawn.

A secondary goal is to collect comments to future revisions for the ISO 19900 series standards.

A tertiary goal is to establish a basis for making specifications as an addition to the ISO requirements for platform owners used to work according to NORSOK standards, but will refer to ISO when working outside the Norwegian shelf in order to maintain their company standards for structures.

7.3 Method

Because the document structure is different in ISO and NORSOK it is not possible to compare them standard by standard. Instead it is proposed to work according to the following procedure where three different activities are defined:

1) For each platform type that the standards is intended to cover (jacket, semi, FPSO, etc.) establish a list of topics that the standards as a minimum should treat.
2) For each item on the list of topics it will be noted which parts of the ISO and NORSOK standards that gives recommendations. In addition the standards will be checked if there are relevant recommendations that is not covered by the list of topics
3) For each topic it will be made a comparison of the requirements between ISO and NORSOK and the gap will be identified.

7.4 Scope of work

The work is intended to be carried out as separate part projects denoted Task 1, Task 2 etc. Each task is intended to be completed within 6 months. Each task will deal with a subset of the various types of structures or phases in the life of the structure. Each task will be documented in a separate report. The following tasks are proposed:

Task 1 Design of jacket platform (Activity 1 and 2, see 7.3)

Task 2 Design of jacket platform (Activity 3, see 7.3)

Task 3 Fabrication and installation of jacket platform

Task 4 Design, installation and fabrication of ship shaped FPSO structure

Task 5 Design, installation and fabrication of semi and tension leg platforms

Task 6 Assessment of existing structures

8 CONCLUSIONS

8.1 General

In the following the resulting gaps are presented when the requirements of the ISO 19900 series of standards and NORSOK N-series of standards are compared for the case of fabrication of a jacket platform (substructure and topside).

The comparison is made by assuming that in ISO 19902 the DC method is applied.

ISO 19902 require the use of a generic fabrication specification and in this study it is assumed that NORSOK M-101 are selected.

8.2 Basis of comparison of fabrication requirements

ISO 19902 has just a few specific requirements to fabrication, welding and NDT. ISO specifies that fabrication shall be according to a generic specification selected by the owner.

8.3 Minimum design temperature

- ISO 19902 has no lower limit for minimum design temperature. However, due to the specified Charpy impact test temperatures, the practical minimum design temperature is -30°C.
- The minimum design temperature by use of NORSOK is -10°C (can be used down to -14°C).

8.4 Method for determination of steel specifications and accompanying fabrication, welding and inspection requirements

- ISO 19902 describes two methods for determining the particular steel specifications to be used for a specific structure and the accompanying welding, fabrication and inspection requirements:

  a) the material category (MC) approach, and

  b) the design class (DC) approach

- As an alternative to the MC and DC approach, it is stated in ISO 19902 that other rational procedures may be considered.
- NORSOK has one system for material selection and the accompanying welding, fabrication and inspection requirements; the design class (DC) method.
- Even if the DC method described in ISO is based on the DC method used in NORSOK, the systems in ISO and NORSOK are not identical.

8.5 Material specifications

- ISO has references to material specifications for plates, rolled sections and hollow sections. ISO have no references to specifications for cast and forged structural steel.
- NORSOK has material specifications for all relevant product forms, i.e. plates, rolled sections, hollow sections, cast steel and forged steel.

8.6 Charpy Impact test temperatures for base materials

- ISO 19902 specifies that steels belonging to a certain toughness class shall be Charpy impact tested at the same temperature independent of thicknesses.

- Other standards, including NORSOK, accept higher test temperatures for materials up to a certain thickness.
- The test temperatures specified for the base materials in ISO 19902 are also for many cases unnecessary more stringent than what is required to meet the specified requirements in the fabrication part of the ISO standard.

8.7 Charpy Impact energy values for base materials

- The Charpy impact energy values specified for the base materials in ISO 19902 are lower than specified by NORSOK, and are too low in order to guarantee compliance with the minimum Charpy energy values specified in HAZ in connection with welding procedure qualification testing.

8.8 Welding and fabrication standard

- ISO 19902 has just a few specific requirements to welding, fabrication and NDT. In ISO it is stated that fabrication, welding and weld inspection of fixed offshore structures shall be performed in accordance with a selected generic specification or standard (owner specifications, international, national or regulatory standards).
- In the NORSOK system for steel structures, NORSOK M-101 includes all aspects of fabrication, welding and inspection.

8.9 Weld metal and HAZ Charpy toughness requirements in connection with welding procedure qualification testing

- The Charpy impact test temperature specified by ISO is lower than specified by NORSOK for some strength groups, toughness classes and thicknesses.

8.10 Weld metal and HAZ CTOD toughness requirements in connection with welding procedure qualification testing

- There are differences in the requirements to weld metal and HAZ CTOD toughness, both regarding extent of testing, and CTOD values. For which applications CTOD testing is required is not as clearly defined in ISO as in NORSOK. ISO specifies higher CTOD values than NORSOK.

8.11 Maximum hardness

- NORSOK accepts higher hardness than ISO in connection with welding procedure qualification testing, both for structures below water with cathodic protection, and above water.

8.12 Essential variables in connection with qualification of welding procedures.

- When Charpy impact and/or CTOD testing is required as part of the welding procedure qualification testing, ISO has some more essential variables than NORSOK (chemical composition of base materials, interpass temperature, heat input, welding consumables, qualified thickness, depth and with of back-gouging, weld layer thickness).

8.13 Cold forming

- NORSOK has more specific requirements to cold forming than ISO.

8.14 Post weld heat treatment (PWHT)

- By use of NORSOK, PWHT is not required. This as fracture mechanics testing is required for all situations where PWHT could be relevant.
- By use of ISO, PWHT is required if fracture mechanics testing is not carried out. Fracture mechanics testing is not required for all situations where PWHT could be relevant.

8.15 Non-destructive testing (NDT)

- By use of the design class approach as described in ISO 19902, and NORSOK M-101 as the selected generic fabrication specification, the requirements to NDT of welds will be the same in ISO as in NORSOK.

8.16 Grouting

- NORSOK does not address grout operations, while requirements to this are given in ISO 19902.

8.17 Fabrication of Aluminium structures

- Fabrication of aluminium structures are better covered in NORSOK than in ISO.
- ISO restricts the use of welded high strength aluminium.

8.18 Mechanical fasteners

- NORSOK standard M-001 includes requirements to fastener materials for structural use, both for use above and below water.
- The only specific requirement included in ISO 19902, is a recommendation to maximum yield strength of carbon steel threaded fasteners exposed to cathodic protection.

8.19 Geometric tolerances

- NORSOK covers more requirements relevant for topside structures. In case NORSOK M-101 is selected as the fabrication specification in a project that is designed and fabricated according to ISO 19902, it needs to be decided which standard that should be governing.

8.20 Corrosion protection

- NORSOK has, ISO has not, specific requirements to corrosion protection by use of coating.
- Both ISO and NORSOK have specific requirements to corrosion protection by cathodic protection.

8.21 Quality assurance

- By use of the design class approach, and NORSOK M-101 as the generic standard for fabrication, welding and inspection, the quality assurance requirements will in principle be the same by use of ISO as by use of NORSOK.

9 REFERENCES

/1/ DNV report 2013-0406 rev.0 Gap analysis between Norosk N- and ISO 19900 series of standards; Task 1: Requirement for Fixed Platforms

/2/ DNV report 2014-1424 rev.0 ISO-NORSOK Gap analysis Task 2; Design of jacket structures. Draft report dated 2014-11-30.

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