POSEIDON

POSEIDON INTERNATIONAL LTD

Salvesen Tower, Blaikies Quay,

ABERDEEN AB11 5PW

Purchase order:
Doc. Id: POS-DK07-136-R01

Specialist Support on Structural Integrity Issues

PETROLEUMSTILSYNET
PETROLEUM SAFETY AUTHORITY NORWAY

Author(s)

David Galbraith, John Sharp

Summary
Poseidon have undertaken a number of small pieces of work for PSA in 2007 relating to Structural Integrity. The results of these tasks are compiled in this report.

01	11.12.2007	DNG	JVS	DNG	Issue to PSA
Rev.	*Date*	*Originator*	*Check*	*Approve*	*Description*

INDEX

1. Introduction

Poseidon have undertaken a number of small pieces of work for PSA in 2007 relating to Structural Integrity. The results of these tasks are compiled in this report.

2. PSA workshop – May 25th 2007

The following notes are from a meeting on "Ageing Installations & Life Extension – Decommissioned structures" held at PSA's Offices on May 25th 2007

2.1. OLF Project –Life extension (Lars Bjorheim, Statoil)

Scope:

a) State of art

b) Document of "as is " condition – SIM

c) Reanalysis of life extension (reassess acceptance criteria different from design criteria)

d) Mitigating actions (shortcomings related to original acceptance criteria)

e) Maintenance & surveillance barriers (including human and organisational factors)

Timescale: Draft version 15.12.07, Hearing deadline 15.2.08, Final proposal for national standard 15.4.08

2.2. Patrick Decosemaker (Total). Decommission Frigg installation.

Available 2 nodes from DP1, Parts of QP and DP2 platforms, Some repairs performed and available, flooded members, grouted clamps available.

Results presented from post removal inspection of DP1, mainly visual;, corrosion, CP anodes

2.3. Michael Hall (Conoco-Phillips)

Seven platforms shut down in 1998 – mainly 3 leg steel jackets. Looked at piles from Edda. Welded section in mud-zone recovered.

2.4. Inge Lotsberg (DnV). Pile fatigue reassessment post removal.

Concern about usage of fatigue life during pile driving. Edda pile specimens tested. Results indicate using reduced factor to cover pile driving.

2.5. Tor Gunnar Eggen (SINTEF)

Outlined SINTEF facilities and methods for improving welds (Haagenson) .

2.6. Marc Lefranc. Force Technology.

Outlined capabilities in NDE mainly

2.7. Peter Tubby, TWI

Listed TWI capabilities. Retained 12 nodes from Brent Flare (30 years in N.Sea). Phase 1 tests completed in 2007 – phase 2 to be decided. Phase 1 included NDE and thickness, dimensions, weld quality, material properties, remaining fatigue life, comparison with design calculations.

2.8. Inge Lotsberg – DnV.

What can be learnt from decommissioned components? Current condition versus design assumptions?

- Material – stress-strain unlikely to change. Possible concerns about strain ageing – risk for brittle materials (early 1970's local brittle zones occurred).
- Corrosion –thickness measurements
- Marine growth – profile, accurate measurement, implications for fatigue analysis and loading.
- Comparison with Norsok profile.
- Ultimate capacity ; limited t can be learnt from structure if maximum loading in situ not known. No proof that design loading not occurred. Some recent codes/standards have less ultimate capacity for some joint types (X joints).
- Inspection of fatigue cracks; CVI and MPI. Specimens in splash zone – difficult to inspect in service. If no cracks found provide back-up to fatigue analyses done
- Fatigue analysis – significant changes over last 20-30 years. Reanalyse using modern criteria.
- Question: What should be done before decommissioning undertaken to maximise benefits from testing.

2.9. Conoco-Phillips

Outlined procedure for analysis of Ekofisk 2/4 B platform, installed in 1972 (12 legs). Seabed subsidence of 5.2m. PSA requested application for platform to >20 years. Procedures developed for this including a gap analysis.

2.10. Gerhard Ersdal PSA

Summary: How can we use decommissioned platforms to provide information for life extension? Not possible in all cases – knowledge may not be easily transferable. However can do verification and updating of models via benchmarking – benefit for life extension.

Concerns about quality of materials used in 1960/70's (both concrete ands steel) . Also weld quality. These relied on when doing life extension assessment.

Models of degradation can be verified.

Testing only useful when background information available.

Tests on grouted connections (e.g. piles) useful as NDE not possible at installation stage.

Useful steps: Collate what has been done to date and draw general conclusions. Identify what should be looked at before decommissioning. Prepare guidelines on testing.

PSA ould introduce requirements in PSA regulations for testing (currently following installation of a type of structure PSA require testing for first few years). Possibly more difficult for decommissioned structures as need to share data.

An alternative is for industry to lead, to identify what is needed for life extension. Research Institutes have opportunity to come up with good ideas for testing.

2.11. Collation of Steelwork/Components tested following decommissioning

Platform	Age on decommissioning	Tests undertaken
1. West Sole WE (BP)	Installed in 1967-removed in 1978 (11 years)	• Before removal (vibration monitoring, marine life, CP survey, weld inspection)
		• During removal (marine fouling, CP system, paintwork)
		• After removal to shore (marine growth, cleaning, CP and anode survey, structural inspection, dimensions, grout survey
2. Viking AD (Conoco)	Installed in 1970, removed in 1998 (28 years)	• Grouted repair clamp;
		• compilation of a visual record of the clamp and its dimensions at the end of service;
		• assessment of marine growth, in terms of thickness, density and distribution; corrosion survey;
		• non-destructive assessment of the grout layer between the clamp shell and the jacket tubulars;
		• crack detection of all welds and measurement of residual stress in the vicinity of the welds of the tubulars;
		• disassembly of one half of the clamp and measurement of stress in the studbolts
3. DP1 (Total)	Jacket damaged during installation	• Post removal inspection of DP1, mainly visual;, corrosion, CP anodes
4. Edda (Conoco)	Installed 1978	• Piles: visual, sections tested for remaining fatigue life
5. Brent Flare (Shell)	Installed 1975	• Nodes from Brent Flare: tests included NDE and thickness, dimensions, weld quality, material properties, remaining fatigue life, comparison with design calculations.

3. Possible learnings from decommissioned structures

The following table compiles the possible learnings that could be made from examination of decommissioned structures.

	Component/steelwork	**Reasons for testing**	**Test requirements**
1	Grouted piles	Significant lack of data on the condition of grouted piles after installation, lack of NDE data. Performance of piles a key element in demonstrating life extension.	How well grouted, corrosion of steelwork, condition of circumferential welds (any cracking), evidence of effect of pile driving.
2	Repairs to joints/members	Significant lack of data on the condition of such repairs after installation. Lack of NDE data. Continuing good performance of repairs necessary for life extension.	Overall condition of repair, extent of grouting (if any), bond to steelwork, cracking at welds, if repair neoprene lined condition of liner.
3	Materials/welding	Lack of knowledge of the specification and performance of steels used in early platforms and of the quality of welding. Steel quality and properties necessary input for life extension.	Fracture toughness of early steels, weld quality and any cracking evident, residual stresses
4	Ring stiffened joints	NDE very difficult during life for inner ring sections. Ring stiffeners key component for confirming joint strength and fatigue performance in life extension.	Condition of inner ring stiffeners, cracking at welds between stiffeners and joint,
5	Flooded members	Flooded member inspection is now the leading tool, for underwater inspection. Its performance is not fully demonstrated, particularly for partially filled members. Missed flooded members could be significant for demonstrating acceptable performance during life extension, given limited life beyond through thickness cracking.	Flooded member detection prior to decommissioning. Repeated inspection on land and comparison with underwater results. Useful also to identify causes of flooded members during an on-land inspection. Presence of through thickness cracking without member flooding (assuming cracking not caused during decommissioning)
6	Closure welds	Welds made under difficult conditions in the yard, with limited NDE. Possible sites for fatigue cracking in life extension.	Weld quality, any cracking present etc

	Component/steelwork	Reasons for testing	Test requirements
7	Cast Joints	Early cast materials had limited performance data (may also be relevant to jack-ups)	Condition of casting, fracture toughness, quality of any repair welding and any associated cracking
8	Verification of underwater inspection capability	In-service inspection underwater is difficult and limited because of cost and diver time	Detailed inspection of low life joints before decommissioning; comparison with results from detailed inspection on-land

4. Protocol for testing of decommissioned components

The following table contains a protocol for the testing of decommissioned components that would maximise the learnings from the components .

Event	**Activities**	**Notes**
1. Before removal (1) –on-shore	DFI information, previous inspection histories, assess knowledge available on fatigue life, , original material specifications etc	This will determine the usefulness of follow-up analyses and tests after removal
2. Before removal (2) - offshore	Visual survey of state of marine growth, steelwork condition (visual), presence of damage (visual), fatigue cracking (visual), flooded members	
3. During Removal	Assess and note any damage during decommissioning to steel tubulars, piles etc	
4. Immediately after removal	Visual survey of marine growth, condition of anodes, evidence for corrosion on steelwork, state of coatings/paintwork, flooded members	
5. After removal (later)	Accidental damage to tubulars, fatigue cracking at welds (visual), weld quality, condition of grout in piles and any repairs, detailed analysis of coatings/paint for evidence of any deterioration	Steelwork/ components to be stored to avoid damage, corrosion
6. Detailed NDE	MPI for cracks at welds, steel thickness in splash zone, pitting in splash zone,	
7. Dimensional analysis	Comparison of member sizes and thicknesses with original drawings.	
8. Materials	Detailed analysis of steel to compare with original specifications e.g. fracture toughness, materials quality etc	
9. Testing of components - fatigue	Tubular joints for remaining fatigue life	Need fatigue history from offshore. Joint to be stored to avoid any corrosion.
10. Testing of components - piles	State of grout, cracking at circumferential welds etc	Piles are normally uninspectable – information from recovered piles very valuable
11. Testing of components - repairs	State of grout in repair, bond to steelwork, strength of bolts,	Repairs are undertaken offshore, with minimal NDE. Hence information from recovered repairs valuable.

5. Published papers and conferences on ageing and life extension

The following tables compile a selection . of papers and workshops in which ageineg or lifew extension was specifically mentioned in the title. There are a number of other papers which are not included here in which life extension was inherent, such as when an installation was analysed and modified as part of a change in the platform's function.

	Title	Authors	Source
1	Changing Approaches to Design & Inspection for Life Cycle Safety of Offshore Installations	A. Stacey & M. Birkinshaw, J. V. Sharp	Proceedings of ETCE/OMAE2000 February 14 – 17, 2000 New Orleans, LA, OMAE - 2070
2	Fatigue reliability of old semi-submersibles	Det Norske Veritas	OTO report 2000 052, HSE
3	Fatigue reliability of old semi-submersibles	G. Sigurdsson, I. Lotsberg, T. Myhre and K. Orbeck-Nilssen, Det Norske Veritas	OTC 11950, 2000
4	Reassessment issues in Life Cycle Structural Integrity Management of Fixed Steel Installations,	A.Stacey, M.Birkinshaw, J.V.Sharp,	OMAE Conference, Oslo, OMAE 2002-28610
5	On Assessment of Existing Offshore Structures	Gerhard Ersdahl, Ivar Langen, PSA	Paper No. 2002-JSC-379
6	Beyond lifetime criteria for offshore cranes	BAE Systems (Land & Sea Systems)	OTO report 2001/088, 2002, HSE
7	Ageing rigs, review of major accidents – causes and barriers	COWI	Report to PSA, 2003
8	Application of Structural Integrity Monitoring to Life Extension of Ageing Offshore Installations,	A.Stacey, J.V.Sharp	ERA Conference London 2004
9	Managing life extension in ageing offshore Installations,	D. N. Galbraith, J. V. Sharp, E. Terry	Offshore Europe Conference, Aberdeen 2005, SPE 96702
10	Assessment of existing offshore structures for life extension	G. Ersdal	Doctoral thesis, University of Stavanger, 2005

	Title	**Organisation and date**
1	Workshop on ageing installations and life extension	PSA, Sept. 28th, 2006
2	Workshop on the lifetime extension of fixed steel offshore platforms	OGP, Structures committee, Paris, June 11 and 12th, 2007

6. Presentation on Flooded Member Detection

The following presentation on Flooded Member Detection is given by Professor Sharp as part of his MSc teaching.

Flooded Member Detection

by

Prof. J.V.Sharp

November 06

Flooded Member Detection

Introduction

- **Ageing platforms** offshore (many 25-30 years old)
- **Cracking** in joints observed and repaired
- **Inspection** important for maintaining structural integrity
- **Current practice** to rely on techniques which detect member flooding (crack progressed to through thickness stage)
- **FMD** replacing inspection by MPI, eddy current
- **FMD** very cost effective - use ROV
- **Structural integrity management** with through thickness cracks present in the structure?
- **Static capacity** of joints with large cracks, under extreme wave loading?

Flooded Member Detection

Offshore NDE methods

- **Magnetic particle inspection (MPI)**
  - small surface breaking cracks
  - wide experience offshore
- **Electromagnetic methods -eddy current methods (ACFM)**
  - surface breaking and shallow flaws
  - can size cracks
- **Flooded member detection**
  - through thickness cracks
  - ultrasonic/gamma ray
  - but short remaining life

Flooded Member Detection

Gross In-service Inspection

- Gross visual inspection (GVI) using ROV. Major cracks, lost members
- Flooded member detection (FMD)
- Benefits
  - cheap, fast (ROV)
  - good coverage of platform
- Limitations
  - through thickness cracks only, limited fatigue life remaining
  - Static strength of joints reduced
  - Missed crack serious?
  - Repairs expensive, time consuming
  - Redundancy key issue

Inspection Techniques

INSPECTION TECHNIQUES USED ON UKCS

	Techniques used offshore					
Operator	GVI	FMD	MPI	ACPD	UT	Other
1	Y	Y	Y			
2	Y	Y	Y		Y	EC, R
3	Y	Y	Y	Y		
4	Y	Y	Y			EC
5	Y	Y	Y			
6	Y	Y		Y		
7	Y	Y	Y		Y	
8	Y	Y				
9	Y	Y	Y	Y	Y	EC
10	Y	Y				

Flooded Member Detection

- **Causes of Flooded members**
  - through thickness fatigue cracks
  - cracks from root defects
  - accidental damage
  - anode bracket failures
- **Detection**
  - ultrasonic
  - gamma-ray
- **Structural implications**
- **Planning of inspections (frequency, type)**

Flooded Member Detection

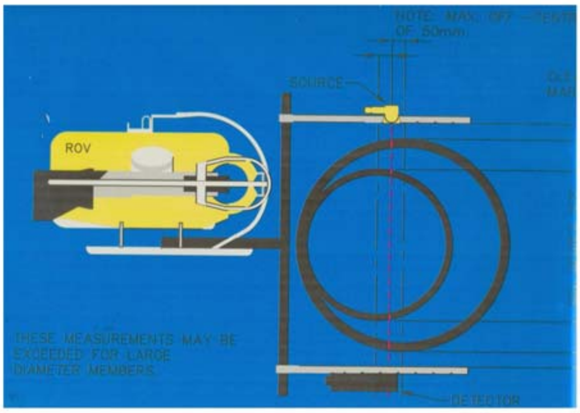
Tracerco – FMD

Source: www.tracerco.com

- Gamma source - Co^{60}
- Deployed from ROV
- Used by number of subsea operators
- 2000 members examined p.a.
- 10-15 members per hour, with no prior surface preparation

Tracerco FMI System from www.tracerco.com

- No need to remove marine growth prior to measurement
- Speed of measurement – it only takes a few seconds per member
- Instant diagnosis of flooded or practically flooded members
- Adaptable to a wide range of ROV's
- Can be used to water depths of 10,000 ft.
- Diver operated version available
- 20 years of operational experience has proved the system very reliable
- Purpose designed computer software used to generate and present results
- All handling and operation carried out by Tracerco engineers

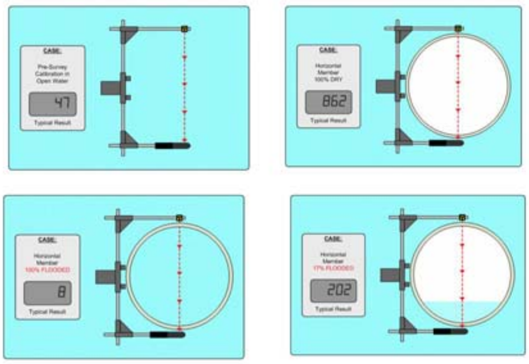


ROV used for flooded member detection, using radioactive source

Flooded Member Detection

Prosub Services Ltd

- deployed from ROV
- radioactive source (Cs 137) + gamma scintillation counter
- adjustable support frame for variable diameter members
- horizontal and vertical members
- detailed procedure for calibration
- safety implication for using radioactive source



Prosub Services Ltd – count rate for external diameter of **1000mm** and a nominal steel wall-thickness of **32mm**

Flooded Member Detection

Calibration - Gamma Systems

- Count rate in air (3900 counts)
- Count rate via water path only (47 counts)
- Typical count rates
  - 862 counts dry member
  - 8 counts flooded member
  - 202 counts - partial flooding (uncertain?)

Flooded Member Detection

Gamma Detection System

- Need to know members size and wall thickness - calculate amount of water present (if any) from count rate
- Need to do checks 6 to 12 and 3 to 9 positions (source & detector)
- Accuracy approx. 10mm
- Fixed yoke mode, range of diameters - accuracy 50mm water depth
- Fail safe in measurement
  - decreased count rate - either counter/source off diameter or water present

Flooded Member Detection

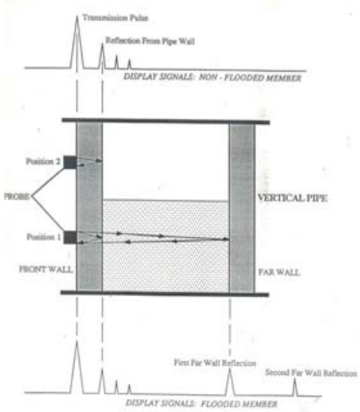
Radiation Safety

- Use of FMD via ROV
- Main responsibility is manufacturer/operator
- Transfer of gamma source to or from ROV (dose rate not to exceed 7.5 microsieverts
- Simultaneous diver activities, need for safe working distance
- Few operators avoid use of gamma ray technique due to concerns from radiation safety
- Need for operators to be trained as Radiation Protection Supervisors

Flooded Member Detection

Ultrasonic System

- Non-radioactive method
- Depends on receiving signal from back surface, when water present
- non-flooded members, not fail safe
- no signal at back surface
  - transducer misalignment
  - Corrosion or other debris, scattering ultrasound
- Horizontal members?
  - 10% filling not being found.



Flooded member detection using UT system

Flooded Member Detection

TRIALS

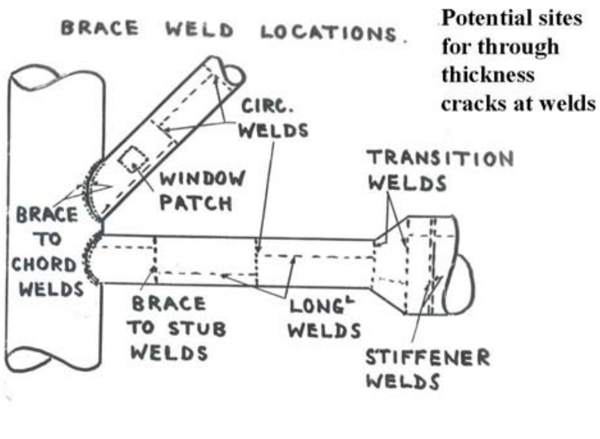
- ICON Project (Validate several NDE methods for use offshore)
  - trials in tank (ultrasonic system)
  - diver trials, by ROV, gamma-ray
  - 0,10,50,100% filling
  - horizontal, vertical, diagonal trials
  - repeat trials
  - inclusion of debris
  - 50, 100% trials fully successful

Planning Flooded Member Detection Inspections

- Member diameters to be known
- Member access identified
- Location of anodes, grout pipes - affect readings
- Any members designed to be flooded
- Presence of debris, marine growth, drill cuttings, affect access & readings
- Need contingency plan for lost gamma source

Follow-up to location of Flooded Members

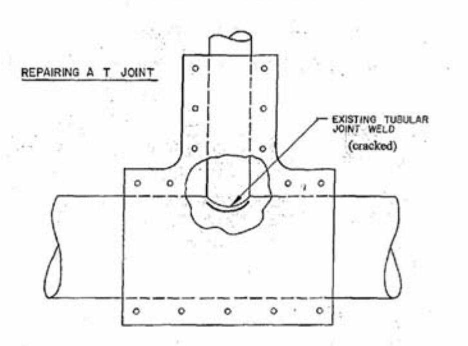
- Need to locate source of water ingress
- Need to detect cracking or other problem
- Check any visible cracking (GVI,CVI)
- If necessary pressurise system and locate egress of gas
- Having identified problem/crack - need to assess need for repair
- Repair of crack with several options available



Repair Options

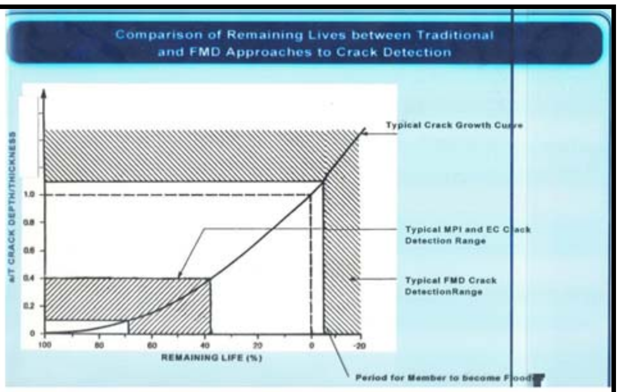
- Small cracks -
  - grinding (up to 60% of wall thickness)
  - welding
- Through wall thickness cracks (TTC)
  - assess effect on overall structure
  - hyperbaric welding
  - grouted or mechanical clamps
  - repair methods for TTC expensive and time consuming

Repair using clamp



Flooding with Through Thickness Crack Present?

- Differential pressure between inside/outside member?
- Tight crack - residual stresses present?
- Water ingress via crack affected by:
  - Presence of coatings?
  - Marine growth?
  - Corrosion products?
- Cyclic loading - is crack opening? Help water ingress?



Compare range of a/T for MPI and EC crack detection with range for FMD detection as a function of remaining life

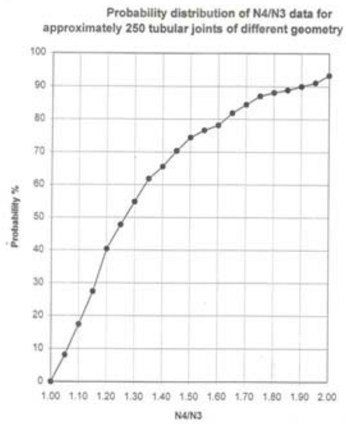
Structural Implications of Through Thickness Crack?

- No detection until 'Through thickness crack'(TTC)
- Remaining life limited, both fatigue and static
- Selection of inspection intervals important. Growth between intervals limited to ensure structural integrity not compromised. Problem of any missed defects?
- Completeness of survey?
  - already flooded members
  - chord side leg joints
  - no access to member
  - stiffened joints (internal stiffeners)
- Redundancy of components?
- Static strength of a cracked joint?

Remaining Fatigue Life

Four stages in Fatigue Life

- N_1 - number of cycles to first detectable crack
- N_2 - number of cycles to first visible crack
- N_3 - number of cycles to through thickness crack
- N_4 - number of cycles to end of test: extensive through thickness cracking leading to loss of stiffness, and loads offset to near members
- NOTE: N_3 is the 'design point' in designing for fatigue. Hence presence of TTC indicates welded component has reached 'design point'



Probability distribution of N4/N3 for a set of tubular joints tested in fatigue

Static Strength of Joints with TTC's

- Presence of cracks reduces static strength of a welded joint
- Current design formulae for welded joints do not allow for any cracking
- Reduction in strength proportional to the cracked area in the joint
- Through thickness cracks may reduce strength by up to 40% ($1.2N_3$)
- Cracked joints may not be able to resist extreme wave loading (winter storms)
- Factor in re-assessment and inspection planning

Risk Control of Through Thickness Cracking

- Need high probability of detection of cracks - limited life left
- Inspection intervals need to be sufficient that cracks found before significant loss of strength of the welded joint occurs
- Need to establish redundancy of particular joints in structure. Some joints (high beta K and X joints) more vulnerable to to through thickness cracks
- At initial design stage - many aspects can be taken to control integrity by using FMD as main inspection tool, increasing effectiveness in practice e.g. good access, good redundancy, ensure safe limit in static strength, built in monitors?

Flooded Member Detection

ISO Offshore Code "In-service inspection and structural management"

- Level III - minimum requirements
  - baseline inspection plus: FMD of the following:
    - all primary structural members, that should not be flooded
    - key support members for risers, conductors and other appurtenances
    - Marine growth measurement

Competence Requirements - FMD

- **CSWIP Certification**
  - Underwater diver inspector (3.1U, 3.2U)
  - ROV inspector (3.3U)
  - Underwater Inspector Controller (3.4U)
- **3.2 U includes:**
  - MPI, UT, Radiography, eddy current, weld toe profiling
- **FMD not included**
- **Query over demonstration of competence**
- Competence provided by FMD operator

Conclusions

- FMD has many advantages as offshore inspection tool, quick, less cost, use from ROV
- Through thickness cracks found only - limited remaining life
- Need to demonstrate sufficient 'redundancy', static strength of cracked joints etc
- Need to plan for efficient use of FMD
- Knowledge of members, access, previous history etc. important
- Reliability of FMD in practice is key factor i.e. no failures in finding through thickness cracks

Conclusions

- There is much reliance on the use of **general inspection methods, e.g. GVI / FMD,** and an assumption that component failure will not lead to overall system failure
- There is a need for a fuller justification of the use of **global inspection techniques** to demonstrate structural integrity
- This on the grounds that **significant redundancy** is available and that failure of a single joint will not lead to structural collapse
- **Widespread fatigue cracking** has occurred in ageing aircraft – such cracking could cause problems offshore if the sole inspection method is FMD

7. Review of OLF "state of the art" document on ageing

Number	Originato r	Item	Comment	Action
1	BP	General	This state of the art report meets the project objective	No action
2	BP	General	I believed that the scope was limited to fixed platforms but there was some discussion on floaters. Need to clarify/confirm the scope of the proposed standard. Personally I would rather focus on fixed platforms for now.	The agreement so far is that the standard should cover all type of structures. Propose to keep this decision. But, as the most frequent type of platforms that will be subjected to reassessment is jackets the detailing is expected to reflect this.
3	BP	General	Also clarify in scope if document only covers platform life extension or does the document intend to cover reassessment in general, e.g. other changes in use such as increased loads?	Yes, the scope should describe the area the standard covers. But it should cover increased loads as this can be seen as life extension.
4	BP	General	Table of contents should have a dedicated section on repair and mitigation methods - preferred/not allowed/ limitations/allowable benefits/etc..	Should be discussed in the task group meeting.
5	BP	Section 1.7.	One of the biggest problems is lack of information, poor quality drawings, etc. Maybe need to state the need for clarity in assumptions and need for sensitivity check to assess criticality of assumptions made?	Should be discussed in the task group meeting.
6	BP	Section 1.8.6	We would welcome detailed provisions on underwater repair (e.g. use of wet welding) and potential (or lack of potential) for inspection/repair etc in splash zone.	Should be discussed in the task group meeting
7	BP	Section 3.1.2	API RP SIM is an important input for this study - a well advanced draft should be available now. I may be able to help obtain one if you cannot.	So far a copy has not been available. Help is welcome.
8	BP	Section 3.1.4	ISO 19904-1 (Floaters) is now formally issued - Clause 14 covers reuse and Clause 18 covers SIM - may be useful a reference?	Will be used as reference.

Number	Originator	Item	Comment	Action
9	BP	Section 3.2.	Need to be clear on the tubular section thickness to be used for different parts of the analysis, e.g. hydrodynamic loads vs. strength check vs. fatigue check. Nominal thickness vs. measured thickness where available (given uncertainty in measurement)? What corrosion allowance in future, etc.?	Recommendation on modelling of tubulars will be considered included in the standard.
10	BP	Section 4.2.4.3	Not sure about the paragraph on grinding - does this only apply to life extension where no defect has been found pre-grinding? If so the smoother transition justifies resetting the fatigue damage to zero. If a crack is found, 1mm depth is probably not enough if you are then relying on rather uncertain MPI, etc to 'prove' all crack removed and justify resetting fatigue damage...	Will be considered.
11	BP	Section 4.4.4.1	Should always avoid loadpath definition based on static strength approach, i.e. %T, %X, %K, etc, as it is a non-linear problem, unless SCF formula is based on carry-over functions. I have a fairly recent paper on this that I can make available if requested. This describes SCFs for all node configurations (except the effect of members in other planes overlapping where there is almost no data).	We will like to review this paper and consider any impact it may have on the standard.
12	BP	Section 4.4.4.1	The biggest error (conservatism) is for T/Y joints where the SCF formulae are usually applied including the beam bending term to crudely estimate this load which is actually a 'known' within the FEA. We often see joints reported as failing where the SCF has been based on a very long chord length and simple beam bending theory. In reality the joint concerned is usually one connection in a complex node where there will be minimal bending.	It will be considered if there will be reasonable to include such recommendation in the standard.
13	BP	Section 4.4.7	Fatigue may not be only factor, e.g. potential wear/corrosion may be more important. Also regarding fatigue I noted in some work in the early 1990s that the factor of safety varied considerably between SCF formulae by the same author, e.g. T joint under axial load vs.. K joint under IPB. This could give a bias towards certain configurations in the inspection hierarchy. I therefore tried to produce 'mean' SCF formulae for inspection planning to avoid this anomaly.	Corrosion will be addressed in the standard. The proposal for using mean SCF is seen as a good idea and will be considered.

Number	Originator	Item	Comment	Action
14	BP	Section 4.8.	Has fatigue in subsea piles been a real problem or just insufficient analytical life? If so how do you rectify once installed?	It is not known to us any failure due to pile fatigue. The rectification will need to be made on installation records.
15	BP	Proposed table of content	To include FE model maintenance and updates.	To be discussed.
16	BP	Proposed table of content	What do you do in areas that are non-inspectable/repairable when the notional fatigue life / SF = 10 is exceeded?	Will be discussed in the meeting.
17	BP	Proposed table of content	After Section 9. Add section covering mitigation and repair methods.	To be discussed in the meeting
18	Statoil	General	The general impression of the report is good, and it leaves a feeling that we are on the right track	No
19	Statoil	General	One of the principal conclusions in the report is that available standards (API RP2A and ISO 19900) are regarded to be not enough detailed to ensure a consistent safety level for life extension. To my mind, this highlights the need for concrete guidance on reassessment for life extension for all limit states on: • Accept criteria for reassessment for life extension • Conditions for modified accept criteria • Analysis methods Concrete guidance on these issues will enable predictable life extension processes where platforms may achieve the desired safety level through a combination of structural assessments, inspection, operational actions, etc.	If agreed by the task group this will form guidance for which parts of the standard that should be given priority.
20	PSA	General	The document includes little on how to manage life extension. Would expect “these are the things that you have to take into account in a life extension” list. Although some previous work outside DNV on life extension has been mentioned in the reference list, little is included in the report.	The focus in the state of the art report has been current standards that cover these issues. We agree that a list of “things to considered when doing life extensions” may be useful to include in the standard. It will be helpful if we are given specific references to the work outside DNV that is missing.

Number	Originator	Item	Comment	Action
21	PSA	General	The document is mostly a collation of information, and there is not really much new information in the document. It focuses too much on areas of interest and work in DNV, and needs to be updated with respect to what is being done in other organizations on SIM, life extensions and ageing.	Please give specific references and we will review and check if the "State-of-the-art" document needs to be expanded on this.
22	PSA	General	Heavy on fatigue and improved methods. Not enough attention is given to corrosion issues and loss of wall thickness, particularly in the splash zone and on topsides, and the effect of this on the static strength. Integrity of ageing PFP can be a major challenge. This is not addressed.	This was not addressed in the documents selected for the "State-of-the-art" study, but needs to be covered in the standard.
23	PSA	General	Discussions about API, ISO and NORSOK do not conclude what are the differences and possibly the way forward.	Some aspects of the difference in API/ISO and Norsok is given in Chapter 5. The way forward is implicit given in the proposal for the table of content in the standard. Details to be discussed in the meeting.
24	PSA	General	The document needs to cover also concrete platforms, ship shaped installations and semi submersibles.	Yes. But so far, it is assumed that jackets will be given the most detailed recommendations. Need to be discussed.
25	PSA	General	The proposed table of contents (chapter 7) should include a section on mitigation and risk reduction	Content of such a section should be discussed in the meeting.
26	PSA	General	The proposed table of contents could also include a section on criteria for de-manning of installations, and possibly a section on mooring lines (the cause of most incidents in structures in PSA's data base).	A section on de-manning is assumed to be included in Chapter 6. It will be considered to include recommendations to mooring lines for existing platforms if there are aspects that are not covered by ordinary standards.
27	PSA	3	Chapter 3 of this report is missing a section on Accidental limit state.	To be discussed in the meeting.
28	PSA	General	The full scale measurements mentioned in section 4.4.3 are incomplete. It could also include concrete structures, jack-up's, semi submersible installations and FPSO's. Measurements are also performed at Ekofisk W, Draupner, Ekofisk 2/4 H, Tern and Gorm.	The measurements referred are those that are having relevance for fatigue calculations on jackets. If other published measurements dealing with this topic exist, they should be reviewed.

Number	Originato r	Item	Comment	Action
29	PSA		The intention for PSA is that the resulting standard should eliminate the need for a guideline in this as part of the PSA regulations. To meet this objective the basic elements in the PSA guidelines need to be addressed in the standard, and I would expect a discussion of how these could be included in the present work. This includes: • The barrier concept and damage tolerance • The need for identification of new failure modes in life extension. This view is also addressed in DNV's own RP on New Technology (we would say that using an offshore structure in a life extension stage where you have little or no data points would at least be a class 2 challenge in the RP on Qualification of New Technology method). However, most important it is a part of the present PSA reg.	To be discussed in the meeting
30	PSA		How to do decisions when the installation does not meet the regulations, e.g. low fatigue life but no occurrence of cracks, or long fatigue life but with occurrence of cracks. How such information should be presented to the decision makers in the operating company and regulator. E.g. table over joints that don't fulfill regulation requirements as it has been used by several rig owners.	The standard should include recommendations in the cases mentioned. It should be discussed if the standard should give requirements for information management.
31	PSA		Increase focus on the elements that can not be inspected.	To be discussed.

Number	Originato r	Item	Comment	Action
32	PSA		What should the required maintenance program be when original design codes are used for life extension? I'm not sure that we can force the operators into using this document for their assessment of structures for life extension, so some will possibly continue to use the original design code. What should the maintenance program then be? The uncertainties that this introduce are important.	If the maintenance programme in the original design codes is not satisfactory then maybe the original design codes should be changed? Should be discussed.
33	PSA		Some parts of this document needs to be updated at some stage as the ISO 19902 will be issued by the time this document is finalized.	The "State-of-the-art" report is not assumed to be updated due to changes in the reference documents. It shall reflect the situation at the time it was made.
34	PSA		Reference to API RP 2A should indicate whether it is referring to the WSD or LRFD document.	Agree. It is WSD ref/4/.
35	PSA	1.5	We do not regard RSR's to be a safety format. The RSR concept can be applied to both the WSD and partial safety factors (LRFD) format.	RSR is stated to be a *safety parameter* that is used by API and ISO. The resulting safety format is neither a WSD nor a LRFD format.
36	PSA	1.8.4	Details of acceptance criteria for fatigue crack size are not given in this text.	Not covered by the reviewed documents.
37	PSA	1.8.4	An assessment of fatigue cracks can not be a fatigue issue alone. This report is not taking into account the effect of cracks on static capacity. Missing reference to the work performed by HSE on the effect of cracks on the static strength of nodes (performed by TWI – information found in OMAE papers).	The HSE work (and OMAE papers) are limited to simple tubular joints and recommendations ofn this basis are given in Norsok N-004. Here we look at all types of joints.
38	PSA	1.8.4	We do not design for actual yielding of significant areas once safety factors are taken into account. There are other limitations of FMD that are not addressed here (e.g. brace in compression not letting water in).	Need to be clarified in the meeting.

Number	Originato r	Item	Comment	Action
39	PSA	1.8.5	Care must be taken to the quality and completeness of the pile driving record. If there are insufficient data, it is not possible to draw meaningful conclusions. AKv comment: Do not agree.	To be discussed in the meeting.
40	PSA	1.8.5	Does this mean that the soil is worse than assumed in the design? DFF for pile driving only to be changed	The driving records provide more information so uncertainties are reduced.
41	PSA	1.8.6	Quality control is important. Ref ISO 19902 16.16.6, but ISO 19902 are dealing with fatigue improvements methods for relatively new structures. In this document we need to deal with ageing structures.	Should be discussed in the meeting as the comment is not clear to us.
42	PSA	3.1.1.1	Does not take into account how API RP 2A was used in the North Sea. Particular aspects were applied differently like return periods, fatigue. DNV guidelines and DEn guidelines used in addition	This is correct. How API RP 2A was applied in the North Sea is not intended to be covered.
43	PSA	3.2	Static capacity of cracked joints should be included.	It is intended to cover this in the standard.
44	PSA	3.2	Is this about high stress low cycle fatigue?	Yes.
45	PSA	4.2.2	The RP 2A and ISO 19902 default inspection program is intended for use when the company is not bothered to do it properly. This fact needs to be taken into account in the report.	This comment is not fully understood. The standard will assume that companies are doing their inspection properly.
46	PSA	4.2.3	Strongly agree that a clearer description for NS structures is needed.	To be included in the standard.
47	PSA	4.2.4.2	The concept of FUI is mostly relevant to drilling rigs, not so much for stationary installations.	It is included in the “State-of-the-art-study” as similar recommendations for stationary installations have not been available.
48	PSA	4.2.4.2	It should be noted that these req’s are not according to PSA regulation for drill rigs or for installations. PSA require increased inspection when FUI is above 1, and mainly for damage tolerant members.	Will be included.

Number	Originato r	Item	Comment	Action
49	PSA	4.2.4.2	What does FUI say about risk of corrosion?	Corrosion need to be controlled by potential readings, check of anodes, thickness measurements and general inspection.
50	PSA	4.5	Could be broader than just measurement of load effect. Could include dynamic motions, tilt, wave height, etc.	Ok. Consider reformulation.
51	PSA	4.6	Needs to cover recommended inspection tools, intervals, etc in the life extension phase. This is a major omission	Should be discussed in the meeting.
52	PSA	4.7	Needs to cover also acceptance criteria for crack growth wrt static strength. Time to through thickness crack growth is important, and the examples are too specific to cover the whole problem area.	The examples will only be given in the commentary. Otherwise engineering assessment to be performed.
53	PSA	4.8	A very critical area for life extension. Hence, an important problem area. More data from these tests are needed before comments can be given.	To be discussed in meeting.
54	PSA	4.10	Care should be taken when using probabilistic based inspection planning in life extension. The Ageing Plant report from HSE does not recommend the use of RBI methods when a plant is approaching the ageing phase. Work by John Dalsgaard Sørensen performed for PSA indicated that system effects needs to be taken into account, and acceptance levels for PoF should be adjusted according to the number of critical joints in the structure, e.. the number of nodes that have exceeded the design life.	This depends on assumptions made. It is important that structural engineers are involved in the assessment and not only people working with reliability analyses. RBI is an efficient tool when used properly.
55	PSA	5	I'm not sure I prefer the safety level of API. The comparison is of interest, but should not necessarily be used to alter the safety level in Norwegian regulations and standards. An alternative approach to reducing the safety factors is to use the relevant loading that is anticipated when personnel is on board, and to use the same partial safety factors.	The document is not proposing to adopt the API safety level. See Conclusive Summary. Still it should be discussed what is reasonable requirements to existing structures.

Number	Originato r	Item	Comment	Action
56	PSA	7.1	I do not agree. The N-001 will still describe the fundamentals for e.g. load factors and quality assurance, competence etc also for life extension analysis. This has to be reviewed carefully, and to take into account the new changes to N-001. N-004 can still be used for life extension, but this document will probably give alternatives to N-004.	The meaning was that all the fundamentals are given in N-001, N-003 and N-004, but specific requirements for existing platforms are given in the new standard. The intention is that such requirements should not be used at the design stage. Wording to be improved.
57	PSA	Proposed table of content	RSR format and probabilistic format analysis has to be defined differently. New description of how to do non-linear analysis is necessary. Is a probabilistic level (level 4 in ISO 19902) to be included at all?	Need to review which part of 19902 that is relevant. It is so far not seen as feasible to give detailed recommendation for probabilistic methods in this standard.
58	PSA	Proposed table of content	Need to add effect of not having the necessary information mentioned in ISO 19902. Probably by indicating higher safety factors for taking into account the increased uncertainty	Yes. Will be considered.
59	PSA	Proposed table of content	Use safety factors rather than target safety levels. Target safety levels indicates the use of risk and reliability analysis	Yes. The target safety level is not intended to be explicitly stated, but given by requirements of e.g. safety factors
60	PSA	Proposed table of content	Need to include SLS, ULS and ALS.	Yes. Will be considered. Detailed recommendations will only be given when there should be given other requirements to existing structures compared to the design stage.
61	PSA	Proposed table of content	If more detailed analysis than expected in the design regulation are used, can the safety factors be reduced to account for the reduced uncertainty?	Yes, to be included.
62	PSA	Proposed table of content	The chapter should include advices on using the most advanced and accurate analysis methods and their limitations. In life extension the engineering hours are likely to be “cheap” compared to the consequence of having to modify or replace the structure. Hence, advanced analysis must be expected, and guidelines for using them are needed.	Will be included as far as possible.

Number	Originator	Item	Comment	Action
63	PSA	Proposed table of content	Not only a plan for tomorrow are needed. A plan for the whole period the structure is planned to be used is needed, and a plan for how to change this plan if unexpected ageing effects are at a later stage proven to be important. From a regulators view this has to be written in a format that is indicating the agreement between operator and regulator to keep the integrity of the structure intact.	Yes, to be included.
64	BP	Proposed table of content	One thought in addition to my previous comments concerns metocean variations from initial design - both updates in data and updates in analysis techniques, leading to overutilisation of previously OK elements. Maybe a brief section on metocean/seismic data, etc is required in the table of contents (unless it is a subsection under data collection?	Will be considered.

8. Comparison of SIM requirements

A comparison of the requirements of 3 standards covering inspection has been undertaken. The standards are:

- NORSOK N-005 Condition monitoring of loadbearing structures
- ISO 19902 Petroleum and natural gas industries — Fixed steel offshore structures
- API RP2 SIM Recommended Practice for the Structural Integrity Management of Fixed Offshore Structures

The purpose of the review was to determine which, if any, clauses of N-005 can be deleted once ISO 19902 is published at the end of 2007, and whether there is additional material contained within API RP2 SIM that should be incorporated into either a Norwegian application of ISO 19902 or into Norwegian regulations.

A summary of the review is:

- NORSOK N-005 Essentially limited to inspection albeit that reference is made to condition monitoring as having a wider scope – does address all types of structure (fixed steel / concrete / floating), but gives relatively little detail on each.
- ISO 19902 Clauses 23 and 24 together cover Structural Integrity Management and Assessment as a whole and addresses them holistically, involving inspection as necessary. Focuses on fixed steel structures (other ISOs cover the other forms (19903 , 19904 1), but general requirements similar between the ISO documents. ISO 19900 (general requirements) gives the high level requirements.
- API RP2 SIM Similar in scope to the ISOs – i.e. inspection is part of overall structural integrity management. Current text (draft) is more focused on fixed steel but API's intent is to develop API RP2 SIM to cover all structural forms.

It is noted that over the next few years the ISOs and the APIs are intended to converge, leading to the transfer of the SIM text out of ISO 19902/19903/19904 into ISO 19901 xx – when done API RP2 SIM will be a "wrapper" to the ISO document.

The most significant inclusion in N-005 that is not included in either ISO 19902 or in API RP2 SIM is specific requirements for the safety of the inspection itself, as the latter two documents are focused on the structure's requirements. ISO 19902 does however contain a description of the hazards of different methods of deploying inspection including air diving, saturation diving, atmospheric diving suits and ROVs.

It is considered that the Norwegian regulations already contain the requirements for operator safety, these should perhaps be reviewed to ensure the inspector safety requirements are adequately covered before any withdrawal of N-005.

The full review follows:

Items	NORSOK N-005	ISO 19902	API RP SIM
General comments	Essentially limited to inspection albeit that reference is made to condition monitoring as having a wider scope – does address all types of structure (fixed steel / concrete / floating), but gives relatively little detail on each.	Clauses 23 and 24 together cover Structural Integrity Management and Assessment as a whole and addresses them holistically, involving inspection as necessary. Focuses on fixed steel structures (other ISOs cover the other forms (19903 , 19904-1), but general requirements similar between the ISO documents. ISO 19900 (general requirements) gives the high level requirements.	Similar in scope to the ISOs – i.e. inspection is part of overall structural integrity management. Current text (draft) is more focused on fixed steel but API's intent is to develop API RP2 SIM to cover all structural forms.
		Over the next few years the ISOs and the APIs will converge, leading to the transfer of the SIM text out of ISO 19902/19903/19904 into ISO 19901-xx – when done API RP2 SIM will be a "wrapper" to the ISO document.	
Scope	1 to 3: Self explanatory	1 to 4 Self explanatory but covers whole of 19902 scope in ~150 words	1 to 3 Self explanatory
References			
Definitions & Abbreviations			
Objectives	4.1 Very brief statement	ISO 19900 9.4 More detail than in N-005	1.3 Covers purpose of SIM as a whole – not just inspection
Regulations, Standards and Premises	4.2 Background and reference to ISO 19900 (as 13819-1)	ISO 19900 But regulations are not explicitly covered (they are local documents) ISO 19902 Annex H notes local regulatory requirements	US document – at present US industry is largely self-regulating
Condition monitoring (CM) principles	4.3 Much the same as ISO, but includes reference to safety of the inspection operation	23.1.2 Focused on the structure rather than the safety of the inspectors – however this is noted in A.23.4	4.4.2 Similar, but as part of inspection planning – allows 2 fundamental approaches to allow for large fleets of similar GoM installations

Items	NORSOK N-005	ISO 19902	API RP SIM
Technical documentation	4.4 / 4.4.1, 4.4.2, 4.4.3 Covers DFI resume and IMR design brief and requirements (note – in the audits we have seen no evidence of such a document having been developed in line with N-005	23.2 & A.23.2 – also in 24 Details are given in informative annex – scope of the data expected to be assembled to meet SIM requirements	4.2 Similar approach to ISO 19902
Periodic framework programme	4.4.4 Basic requirement for a programme including assembly of a condition summary	23.5 and also parts of 24. ISO allows 2 different ways to create a programme – a financially punitive one for those who don't want to think about their platforms and one based on an understanding of the installation and its limitations.	4.4.2 Allows two different approaches – one requiring design and fabrication to give high tolerance to defects, the other being intensive on inspection and repair requirements
Inspection related to SIM	Not explicitly covered in N-005	23.1.3 Puts inspection into context as part of "Structural Integrity Management"	4.5 As ISO
Condition monitoring philosophy Requirements for a programme of CM	5.1 5.2 Not really a philosophy – includes a list of the major activities required	23.4.1 & 23.4.2 Covers same material as N-005 5.1	4.4 But not so well covered as in either N-005 or 19902
Intervals for CM	5.3 Describes basic need for initial and periodic inspections	23.4.3 to 23.6 Similar but N-005 "initial" is called "baseline" – also includes a special inspection for repairs and remediation	5.3/5.4/ 5.5 5.3 is above water (annual and includes monitoring of CP system from above water (drop cell)), 5.4 baseline underwater, 5.5 is periodic underwater

Items	NORSOK N-005	ISO 19902	API RP SIM
Unscheduled inspections on special occasions	5.4 Very basic requirement (no detail of scope) can include "ISO special inspection" No mention of decommissioning or reuse	23.6.3 23.6.4 23.6.3 is the special – but is a scheduled (i.e. planned) inspection. 23.6.4 is a unscheduled inspection following an extreme environmental event or damage – both contain more detail than N-005 Requirements given for inspections for reuse in 23.6.3 and 25	5.6.1 covers special inspecations a la ISO 5.6.2 is the unscheduled inspection "post event inspections" Requirements for inspection for reuse and decommissioning in 5.6.4 and 5.6.5
Updating of program for CM	5.5 Very basic	23.1.3 23.2, 23.3 Explicit requirements as part of SIM cycle	4.1 As part of SIM cycle
Default requirements	Not applicable for North Sea	23.7 Included to cover areas such as GOM with very large numbers of similar structures	5.5.3 Similar to ISO
Safety for inspection personnel	6.1 Basic statement of safety considerations Explicitly says diving should be avoided where possible PSA "activities" regulations also cover safety	A.23.4.5 Safety is not a specific heading as it is part of the operation considerations. ISO 19902 is focused on the needs of the structure but includes considerations of different ways to deploy inspection, covers air diving, sat. diving, ADS and ROV – talks about particular hazards of each of these.	- Nothing seems to be said on safety of the inspection personnel
Qualification of inspection personnel	6.2 General requirement to EN473	23.8 Personnel qualification requirements given for a range of tasks – wider than N-005. Cites CSWIP and EN 473.	5.2, C5.3 Parallels ISO but doesn't give formal qualification requirements

Items	**NORSOK N-005**	**ISO 19902**	**API RP SIM**
Detailed inspection planning	6.3 Includes a list of items that can lead to degradation at different platform zones (atmospheric / splash / submerged)	23.6 part Done in a different way –to look for presence of damage or deterioration due to different causes as part of different types of inspection	5.3 to 5.6 Similar approach to ISO 19902, but presented differently
Inspection record keeping	6.4 Basic requirement for keeping data with preference for electronic data base	23.2, A.23.2 Basic requirement in 23.2 as part of SIM – data collection and update – recommendations and examples of good practice given in A.23.2	5.10 Basic statement of requirement
Condition assessment	6.5 High level requirement for evaluation of inspections and of the structure	23.3 and 24 23.3 gives requirement for evaluation including structural considerations and input from inspections. Assessment triggers in 24.4 have to be addressed. Clause 24 goes into detail on formal assessments including analysis when appropriate	6, 7 6 is damage evaluation and 7 is structural assessment which includes (7.3) using information from inspections
Damage evaluation	Not covered	24	6.1/6.2
Component evaluation	Not covered	24	6.3
Structural assessment	Not covered	24	7.1 – 7.13
Assessment criteria & loads	Not covered	24	8.1- 8.5
Mitigation & risk reduction	Not covered	24	9.1-9.7
Annex – inspection methods	Annex A Includes selection of methods for above and below water. Annex A is not called up from the main text though is referenced from Annex F	A.23.4.5 More information than is given in N-005, giving capabilities and limitations of different techniques and discussion on deployment methods	5.8 Discussion on survey requirements not to same detail as ISO

Items	NORSOK N-005	ISO 19902	API RP SIM
Annex – safety procedures for in service inspection	Annex B Specific safety requirements given	ISO 19902 focused on need of the structure so no consideration of specific safety requirements for personnel	As for ISO
Annex – Jacket structures	Annex C Specific issues for fixed steel structures	ISO 19902 ISO 19902 specifically addresses fixed steel structures, so these aspects are covered throughout main text	Current text focused on fixed steel.
Annex – Column stabilised units	Annex D Specific issues for Column stabilised units	Not currently covered in any ISO document. Mobile units are intended to be covered by class rules	Not currently addressed in API – Class rules apply
Annex – Ship-shaped units	Annex E Specific issues for Ship shaped units	ISO 19904 Is covered by ISO 19904, but this document has not been reviewed in this exercise	API RP2FPS? This document has not been reviewed as part of this exercise
Annex – Concrete structures	Annex F Specific requirements for Concrete structures	ISO 19903 Is covered by ISO 19903, but this document has not been reviewed in this exercise	No API document as yet for concrete structures

9. Review of draft Norsok N-006

Poseidon assisted PSA in the review and collation of comments on a proposed new Norsok N-006. The summary below is the compiled comments.

Clause	**Comment**
General comments	The document seems to be developed from an analysis point of view rather than an assessment point of view, meaning that the recommendations often jump to performing an analysis where other steps may be valid options first. This basis could be discussed – analysis should normally not be performed without a good reason.
	Parts of this document are copied from ISO 19902. Reference to this document in normative or informative should be evaluated, or at least this copying should be mentioned in the foreword.
	The purpose of the document could be stated clearer.
	The document is biased towards fatigue. All others concerns are afterthoughts. We are not sure this is a sufficient balance between the relevant challenges.
	The document seems to assume that all inspection planning are based on probabilistic methods. That may not be so in all cases.
	The question of if a reduced acceptance criteria for safety of structures in life extension was discussed at last meeting. The stand of PSA is clearly that it is not. If the working group should decide that it is, this needs a convincing argument and the how this can be used and in which cases, which limitations there is to the use of such needs to be addressed. Possibly also numerical examples are needed.
	System effects needs to be included when it comes to evaluating ageing structures. If a structure contains several critical components (e.g. several components that are beyond their design service life) the safety level used to determine e.g. inspection intervals and structural system safety. JCSS / RILEM publication 2001: Probabilistic Assessment of Existing Structures may be a relevant refeference if the neccessary limitations are covered.
	Platform is often used. Normal NORSOK language is “Facility”, or “structure” if relevant.
Page 8:	The general basic requirements for safety of existing offshore load-bearing structures should be discussed – e.g. same safety level as new, permanent structures, or if not how a reduced safety level should be selected.
	Methods for assessment may need to be discussed. It is likely that operators will evaluate the use of a probabilistic assessment. Recommendations to the use of a deterministic method rather than a probabilistic could be included.
	The inspection planning will however normally be performed by probabilistic methods. General requirements with respect to acceptance criteria’s in such analysis may need to be discussed. General requirement should include both the system reliability level, and the component reliability level, especially in situations where more components become critical for ageing structures due to e.g. the effect of inspections.

Clause	**Comment**
Page 9, Figure1:	Can triggers be initiated without a collection and assessment of data? I think the order of the three first boxes needs to be reviewed.
	Could you add reference to clauses in the different boxes? Would make it possible to give more detailed information and make the figure easier to understand.
	What does it mean that “sufficient safety is documented”?
	The arrow from “is mitigation feasible/cost effective” should go to a new box “Do mitigation”, not “Perform analysis …”.
	The two bottom boxes should be “Structure satisfactory” and “Structure not satisfactory”. More relevant for the purpose than weather the assessment is a success or not.
Page 9&10, 4.2	The text in 4.2 is close to the text in ISO 19902 24.4, but with some items deleted. Why are these items deleted?
	More onerous are mentioned several times. Is any onerous change included, or is a 1% change acceptable. Do we need guidance?
	A note should be added if this is to be a NORSOK standard, stating:
	Note: On the NCS the design life will be limited to the planned design life in plan for development and operation and the DFI résumé, as defined in the information duty regulation.
Page 10, 5.2 Collection of data	I would recommend that shall is used instead of should in first sentence. If these data are not available, what should be done? Add “In absence of such data …”. I would say that the safety factors then should be increased to cover for the increased uncertainty. Recommendations are needed.
Page 11, 5.3.2	Is replacement of anodes possible? Should that be added as an option?
Page 11, 5.3.3	ISO 19902 is not in the reference list.
Page 11, 5.3.4 and 5.3.5	I am not fully familiar with the content of ISO 19903 and ISO 19904-1. I need to check the relevance. Based on my information ISO 19904-1 is based on the assumption that class rules are applied, which is not always the case on the Norwegian Continental Shelf.
Page 11, 6.1:	Does ‘The requirements to existing structures should in general meet the requirements of NORSOK N-001.’ imply same reliability level as for new structures?
	“faultless structural behaviour” needs to be clarified. How much inspection is needed to come to such a conclusion? We have seen many examples of “due to no inspection, we have no findings”.
Page 11, 6.2:	The first sentence (and paragraph) is rather difficult to understand. Consider rewriting, possibly into more than one sentence.
Page 12, 6.3	Use “safety functions” rather that “life” in second sentence. “The criterion should be determined … loss of safety functions due to [facility] failure is …”.
Page 12, 6.4	Deck elevation is probably a better term than “air gap”.
	The check described here is not in accordance with NORSOK N-001, and not in general accordance with PSA regulation. This part needs to be rewritten to be in accordance with the mentioned standard and regulation.

Clause	**Comment**
Page 12&13, 7.1	Unsure if we agree on all these items. Need to read them closely. Two specific comments:
	3): The uncertainty related to measurements has to be dealt with. Recommendations needed?
	10): The acceptance criterion should depend on the number of critical components when component/element based checks are performed.
	The actual number of conductors and risers may also be mentioned. Maybe even inactive conductors can be removed to reduce loads and hence fatigue damage.
	Eddy current and Magnetic particle inspection is rather diver intensive. Is this a good recommendation?
	This section does not reflect the redundancy / criticality of the elements evaluated.
Page 14, figure 2	What does “Are calculated fatigue life short” mean? Shorter than the design service life and the extended service life?
	The box “Perform revised fatigue life analysis” should point to “Compare calculated lives with inspection history” rather than “plan inspection …”.
	We do not feel comfortable with the “plan inspection for the life extension period that fulfils the target safety level for the structure” box. Several options are possible here. Guidance is needed. E.g. there is a large difference between a joint with low fatigue life and high criticality and no cracks detected (this was the case on one of the welds on Veslefrikk B, and inspection intervals based on deterministic crack growth analysis from a as large as likely crack that was missed during inspection was found to be recommended with adjustments for the FDF) and a non-critical joint with low fatigue life (where probabilistic inspection planning may be more relevant). I will try to prepare more information on practice on the Norwegian Continental Shelf on this issue.
Page 15, 7.3.1	Interesting and difficult issue. We need to review carefully. Not sure that we do agree.
	6): ‘The calculated life fatigue of the considered non-inspected detail should be at least 3 times longer than the fatigue life of the hot spot that is inspected’: With red is suggested some additional text.
	Correlation should be used with care.
Page 15, 7.3.2	What is the basis for the factor 3? Reference and justification should be included at least in the commentary.
Page 16, figure 3	The figure needs clarification.
Page 18, 8.2.1:	There should be a reference to how characteristic values should be determined (5% fractiles, etc.)
	There should be a reference for how to update characteristic values (and coefficients of variances) in case of more data – very relevant for existing structures
	The reduced partial safety factors clearly indicate a lower reliability level for existing structures!
Page 18, 8.2.2:	There should be a reference to how characteristic values for strength should be determined (5% fractiles?) also in ALS

Clause	Comment
Page 24:	The section 'Fatigue design …' is unclear – which two approaches are referred to?
Page 29:	More text is needed around eq. (5).
Page 34:	Reference to /65/ could be added for 'Ultiguide'
Page 37, Comm. 9:	More references than to Norwegian authors could be relevant for reliability-based inspection planning!
	The section starting with 'One may ..' is unclear.
Page 38:	What is the basis for eq (9) and (10)? They will in many cases be un-conservative. At least a reference to work supporting the application of (9) and (10) should be given.
Page 38-40:	Why not describe principles in reliability-based inspection planning?
Page 40, Table 2:	What is the basis for the numbers in Table 2. A reference to work supporting the numbers should be given.
Page 40:	'The cost of increasing the safety level for an existing platform will in general be more expensive than at the design stage and consequently it seems sensible to differentiate the required level of safety for check of platforms at the design stage and when performing assessment of existing platforms.' Is this OK? is the statement based on cost-benefit and LQI considerations?
Page 41:	Why is the basic annual reliability level chosen to 10-3 ? could it be 10-4 or 10-5 ?
Page 41, Table 3:	Should the distributions for XR and XL be LogNormal?
Page 42:	It is not described which characteristic values associated with RSR = 1.6.
Page 42, Table 4:	Which assumptions are different from the base case when obtaining the other annual PoF in Table 4?
	The background and basic requirements used should be described.
7.3	We agreed that fig. 3 is misleading. The corrosion and fatigue parts should be separate and the title to the figure needs changing.
7.4	An interval of one years for monitoring is stated – why? I assume this is intended to include a winter's weather.
7.5	Fatigue assessment of GBS is a difficult area – not sure what 19903 says on this?
7.7	It is stated that an inspection method with sufficient probability to detect fatigue cracks should be used. Lower down it states that FMD is not considered reliable for certain types of connection or where cracks may occur in the chord with insert pile etc. FMD is not suitable for any location if detection of fatigue cracks is the requirement.
8.1	Statement again about "faultless structural behaviour" – whatever that means!
8.4	Resistance to cyclic storm loading: This is an unusual clause in a standard, particularly the section (8.4.5) on checking low cycle fatigue. The detal suely belongs to the commentary. The S-N curve in figure 25 is new to me and reference (Boge et al, 2007) is not listed in the reference list.
8.6	Removal of conductors or other non-functional steelwork is a mitigation not listed. Also why no mention of fatigue improvement methods to improve fatigue lives.

Clause	**Comment**
9	This section on probabilistic inspection planning is very wordy and not very useful. Fig. 6 is not very clear, 100mm crack length is seen as “detectable” with 300mm as the allowable size – why?. The conclusions from fig. 6 are very unclear – suggest delete this figure or move to the commentary with better explanation.
10.	A very short list of the required documentation – very limited in value!

10.Structural KPIs

:	Original design	Current understanding	Analysis	Inspection
General				
1. Identification and documentation of significant structural limitations weaknesses and vulnerabilities, and relevance of these to emergency response planning (how can this be best measured) [drawdown]	✓	✓	✓	
2. Degree of compliance with ISO assessment "triggers" in most recent assessment of structure.		✓	✓	✓
3. Condition of structural PFP (e.g. percentage requiring remedial action)				✓
4. RSR – value of and appropriateness of compared to experience with structural form (i.e. 1.85 for traditionally framed steel jacket)	✓	✓	✓	
5. Weight management – comparison of current weight and design maximum (or minimum {significant for concrete platforms}) weights – note weight distribution can be significant.	✓			✓
6. Inspection –compliance with ISO 19902 default and specific inspection programmes – also Backlog and assessment of identified anomalies.				✓
Fatigue				
1. Number of welded connections with fatigue life less than "design life", taking into account modern DFFs, SCFs and platform specific FEAs (in accordance with ISO 19902).	✓	✓	✓	
2. Number of cracks identified during in-service inspection.				✓
Corrosion:				
1. Number of CP readings outside acceptable range		✓		✓
2. Percentage usage of anodes (maximum usage and average usage) compared with design life				✓

:	Original design	Current understanding	Analysis	Inspection
3. Splash zone corrosion allowance deterioration				✓
4. Condition of painting / coatings of topsides steelwork (e.g. percentage requiring remedial action)				✓
Other hazards				
1. Extreme weather – probability of wave impact (lack of air gap) on topsides structure or equipment (not explicitly design for wave impact) – relevant for bottom supported installations and TLPs.	✓	✓	✓	
2. Extreme weather – DO WE NEED SOMETHING FOR FLOATING STRUCTURES? – e.g. wave steepness				
3. Ship impact – Impact absorbance capacity for both elastic and plastic (low energy and high energy impacts) and comparison with potential energy levels resulting from impacts with vessels common in the vicinity of the installation.	✓	✓	✓	
4. Dropped objects?				
5. Fire – Fire resistance (e.g. H30, J120) and comparison with potential incidents on the installation determined from risk analyses	✓	✓	✓	
6. Explosion - Energy absorbance capacity for both elastic and plastic (low energy and high energy explosions) and comparison with potential energy levels resulting from potential incidents on the installation determined from risk analyses.	✓	✓	✓	
7. Seismic - Energy absorbance capacity for both elastic and plastic (low energy and high energy events) and comparison with probability of different levels of seismic event (Note for low risk areas compliance with ISO 19900 series assessment criteria is acceptable).	✓	✓	✓	
8. Subsidence				✓
9. Scour				✓