2010-108-01

BOEMRE Comparison of Offshore Standards - M10PC00108 – TA&R Project No. 677

Progress Meeting No. 5

01 June 2011

MANAGING RISK DNV

Agenda

- Introductions
- Work To-date
- Tasks and Schedule
- Summary/Recap

Tasks

1. Environmental Load Recipes	☑
2. Loading Conditions	☑
3. Structural Steel Design	☑
4. Connections	☑
5. Fatigue	☑
6. Foundation Design	☑
7. In-service inspection and maintenance	☑
8. Assessment of existing platforms and floaters	☑
9. Fire, blast and accidental loadings	
10. Installation, Temporary Conditions, and Case Studies	
11. Reporting	
12. Project Management	

Schedule

Scope for Spar Case Study

High Level Scope of Case Study:

- Verify the computer model in SESAM suite of programs to ensure imported model is ready for analysis
- Run in-place analysis for extreme (survival) load case
- Run analysis to verify acceptance with criteria as set in API RP-2FPS, ISO 19904-1, and NORSOK N-004
- Compare the results of the analyses
- Summarize the results

Assumptions:

- The case study is intended to be an exercise in acceptance criteria for primary structural elements of the hull, truss, and soft tank. Topsides, tendons and foundations are not included as part of this evaluation.

Code Comparison

- Assessment of existing platforms and floaters

	API RP 2A- WSD Section 17 (To be replaced by API RP 2SIM)	ISO 19902	NORSOK N-006
Limitation	Only for the assessment of the following platforms: - designed in accordance with the provisions in the 20th and earlier editions - the platforms designed prior to the first editions	- the assessment of existing fixed steel offshore structures to demonstrate their fitness-for-purpose - also applicable to topsides structures - fit-for-purpose when the risk of structural failure leading to unacceptable consequences is sufficiently low.	- applicable to all types of offshore structures, including bottom founded structures as well as floating structures; As the majority of ageing facilities are fixed structures of the jacket type, the detailed recommendations given are most relevant for this type of structure; - applicable to different types of materials used including steel, concrete, aluminium; - applicable to the assessment of complete structures including substructures, topsides structures, vessel hulls, foundations, marine systems, mooring systems, subsea facilities and mechanical outfitting that contributes to maintain the assumed load conditions of the structure
Assessment Process	1. Platform selection (Section 17.2) 2. Categorization (Section 17.3) 3. Condition assessment (Section 17.4) 4. Design basis check (Sections 17.5 and 17.6) 5. Analysis check (Sections 17.6 and 17.7) 6. Consideration of mitigations (Section 17.8)	24.2 a) assemble data on the structure, its history and exposure level, see 24.3 b) determine if any assessment initiators are triggered, see 24.4 c) determine acceptance criteria, see 24.5 d) assess the condition of the structure, see 24.6 e) assess the actions, see 24.7 f) screen the structure in comparison with similar structures, see 24.8 g) perform a resistance assessment, see 24.9 using 1) design level analysis 2) ultimate strength level analysis 3) prevention and mitigation, see 24.10	4.1 - design, fabrication and installation resume and as-built drawings - documentation of as-is condition - planned changes and modifications of the facility - updated design basis and specifications - calibration of analysis models to measurements of behavior if such measurements exist - the history of degradations and incidents - prediction of future degradations and incidents - the effect of degradation on future performance of the structure - a documentation of technical and operational integrity - planned mitigations - a plan or strategy for the maintenance and inspection
Perform Assessment Initiators	Section 17.2 Definition of Significant: The total of the cumulative changes in greater than 10% - Additional of personnel: life safety level changed to a more restrictive level - Addition of facilities: addition of facilities or the consequence of failure level changed significantly - Increased loading on structure: the new combined environmental/operational loading significantly increased - Inadequate deck height: platforms with inadequate deck height for its exposure category and not designed for the impact of wave loading on the deck - Damage found during inspections: significant damage to primary structural components found during any inspection	24.4 a) Changes from the original design or previous assessment basis, including 1) addition of personnel or facilities 2) modification to the facilities 3) more onerous environmental conditions and/or criteria 4) more onerous component or foundation resistance data and/or criteria 5) physical changes to the structure's design basis, e.g. excessive scour or subsidence 6) inadequate deck height, such that waves associated with previous or new criteria will impact the deck, and provided such action was not previously considered. b) Damage or deterioration of a primary structural component c) Exceedance of design service life - the fatigue life (including safety factors) is less than the required extended service life - degradation of the structure due to corrosion is present, or is likely to occur, within the required extended service life An extension of the design service life can be accepted without a full assessment if inspection of the structure shows that timeb-dependent degradation (i.e. fatigue and corrosion) has not become significant and that there have been no changes to the desi criteria.	4.2 a) changes from the original design or previous assessment basis, including - modification to the facilities, - more onerous environmental conditions and/or criteria, - more onerous component or foundation resistance data - physical changes to the structure's design basis - inadequate deck height b) damage or deterioration of a primary structural component or a mechanical component c) exceedance of design service life, if either - the remaining fatigue life (including design fatigue factors) is less than the required extended service life - degradation of the structure beyond design allowances, or is likely to occur within the required extended service life
Platform Assessment Categories	Section 17.3 Assessment categories based on: Life safety, Consequence of failure Life Safety - Manned-Non-Evacuated - Manned-Evacuated - Unmanned Consequence of failure - A-1 - High Assessment Category: existing major platforms and/or those platforms that have potential for well flow of either oil or sour gas in the event of failure; All platforms in water depths greater than 400 ft are considered A-1 - A-2 - Medium Assessment Category: existing platforms where production would be shut-in during the design event; existing platforms that do not meet the A-1 or A-3 definitions - A-3 - Low Assessment Category: existing platforms where production would be shut-in during the design event	24.3.2 Acceptance criteria for assessment depend on the exposure level of the platform. Table 6.6-1 — Determination of exposure level Life-safety category / Consequence category: C1 High consequence, C2 Medium consequence, C3 Low consequence S1 Manned non-evacuated: L1, L1, L1 S2 Manned evacuated: L1, L2, L2 S3 Unmanned: L1, L2, L3	No categorization given. All platforms are treated same as highest Level L1.
Condition Assessment	Section 17.4 - Topsides - only require the annual Level I survey: topside arrangement and configuration, platform exposure category, structural framing details etc. - Underwater - Level II survey - Soil Data - Available on- or near-site soil borings and geophysical data should be reviewed.	24.6 - Topsides surveys - Underwater and splash zone surveys: Level II inspection as a minimum - Foundation data: available on-site or near-site soil borings shall be reviewed.	See 4.1

Examples of Code Comparison Table

- Assessment of existing platforms and floaters (cont'd)

Design Check	- Assessment for Metocean Loading  Notes: 1. RSR - defined as the ratio of a platform's ultimate strength load carrying capacity to its 100-yr L-1 environmental condition strength loading, computed using present API RP 2A criteria for new design as contained in Section 2. 2. The assessment process described herein is applicable for areas outside of the U.S., with the exception of the use of the reduced criteria which are applicable for indicated U.S. areas only. Table 17.6.2-1—U.S. Gulf of Mexico Metocean Criteria Notes: 1. Both hurricanes and winter storms are important to the assessment process. In calculating wave forces based on Section 2.3, a wave kinematics factor of 0.90 should be used for hurricanes, and 1.0 for winter storms. Table C17.1-1—Comparison of Section 2's L-1 Wave Criteria and Section 17 Wave Criteria for 400 ft. Water Depth, Gulf of Mexico A platform owner should take into account the higher risk of platform failure in extreme hurricanes, in comparison to new design, when using the reduced Section 17 criteria.	to have been as severe as, or more severe than, the event that would be considered in the actual ultimate system strength analysis Acceptance criteria may be developed for different exposure levels in terms of - reduced actions to be applied in the assessment, e.g. corresponding to shorter return periods - revised resistance criteria, e.g. reduced RSRs	- the environmental actions will not jeopardize any other main safety function (other than structural integrity) relevant for the facility during the storm, see 6.4 - the risk of significant pollution is found acceptable, see 6.5
		- Metocean parameters and Environmental Actions (24.7.2) The Metocean data required for an assessment are the same as for a new structure design, as are environmental design situations and actions. In some cases, a reduced return period may be considered for assessment, see Clause 24.5. - Deck Elevation and Additional Environmental Actions (24.7.3) If wave inundation of the deck is expected, resistance assessment shall be based on ultimate strength analysis. - Design Level Analysis 1. The assessment of structural members shall comply with the requirements of Clause 13; 2. Assessment of structural connections shall comply with the requirements of Clauses 14 and 15, with the following exceptions: - there is no requirement for joint strength to be limited to its brace member strengths - the strength of ungrouted and grouted joints may be based on experimental or analytical studies 3. Fitness-for-purpose If all components within the structure and foundation are assessed to have utilizations less than or equal to unity, the structure may be considered to be fit-for-purpose, and no further analysis us required. - Ultimate Strength Analysis 1. Local overstress and potential local damage are acceptable, but total collapse or excessive/damaging deformations shall be avoided. 2. Reserve Strength Ratio $R_{RS} = F_{collapse}/F_{100}$ where: $F_{collapse}$ is the unfactored global environmental action which, when co-existing unfactored actions, will cause collapse of the structure; F_{100} is the unfactored 100 year global environmental action calculated in accordance with 3. If the minimum RSR value calculated from the the ultimate strength analysis meets or exceeds the acceptance criteria from 24.5.1, the structure may be considered to be fit-for-purpose, and no further analysis is required. 4. In the absence of specific acceptance criteria, fitness-for-purpose shall be assessed against the RSR value required for a new structure with the same exposure level and in the same location. Table A.9.9-1 — Values of partial action factor γ_{LE} and RSR to achieve target failure rate $P_f < 3 \times 10^{-5}$/yr for new manned installations (exposure level L1) Environment | Partial action factor, γ_{LE} | Mean RSR AUS | 1.50 | 2.15 NS | 1.40 | 1.90	ULS and ALS (section 8) - The same principles for check of ULS and ALS as for design of structures as given in NORSOK N-001, NORSOK N-003 and NORSOK N-004 apply to assessment of existing structures. - Effects of degradation of the structure (e.g. corrosion, wear or damages from inspects) need to be properly monitored and accounted for in the assessments. - Resistance of damaged steel members can be calculated according to NORSOK N-004, Section 10. - The action and material factors according to NORSOK N-001 shall be used for structures that are assessed according to N-006. - Structures that are checked in ULS and ALS by use of linear analyses need normally not to be checked for cyclic failures during a storm. - Further cyclic checks are usually not required in cases where the structural resistance is restricted to all of the following requirements: 1) no structural components will experience local or global buckling determined according to NORSOK N-004 2) tubular joints are not utilized above the capacity in NORSOK N-004 (first crack limit) 3) no plastic mechanism is formed 4) no part of the foundation has reached the ultimate soil capacity 5) joints are, by inspection, proven to be free from fatigue cracks or the calculated fatigue loading is negligible - The cyclic check of the dimensioning storm should be made on low probability characteristic actions and 5% fractile resistance according to NORSOK N-001. - No DFF should be applied when checking the cyclic storm actions. FLS (section 7 and 9) - Existing facilities where structural details do not satisfy the criteria for FLS may continue to be used if requirements in Clause 7 and Clause 9 are fulfilled. - Clause 7: Check of fatigue limit states (FLS) The fatigue life is considered to be acceptable and within normal design criteria if the calculated fatigue life is longer than the total design service life times the DFF. Otherwise a more detailed assessment including results from performed measurements of action effects and/or inspections throughout the prior service life is required. - Clause 9: Requirements to in-service inspection after assessment 1) inspection intervals shall be adjusted to take into account an increased likelihood of fatigue cracks as more fatigue damage is being accumulated.

Examples of Code Comparison Table

- Assessment of existing platforms and floaters (cont'd)

Design Check		Table A.9.9-2 — Values of partial action factor, $\gamma_{E,S}$ and RSR to achieve target failure rate $P_f < 1 \times 10^{-4}$/yr for new unmanned installations (exposure level L2) [Environment | Partial action factor, $\gamma_{E,S}$ | Mean RSR; Arctic 1.17 1.00; Gulf 1.17 1.00; NS 1.29 1.49] It is emphasized that the results in Table A.9.9-2 relate to new, unmanned (evacuated) structures. For existing structures, the criteria may be relaxed, provided the risk is kept as low as reasonably practicable. Fatigue Limit State - the results of a fatigue assessment in accordance with Clause 16 shows that the fatigue lives of all members and joints are at least equal to the total design service life, and the inspection history shows no fatigue cracks or unexplained damage - a fatigue assessment in accordance with Clause 16 has identified the joints with the lowest fatigue lives and periodic inspection of these joints finds no fatigue cracks or unexplained damage - where fatigue lives of any members and joints are calculated to be less than the total design service life of the structure and fatigue damage has been identified, the structure may be assumed to be fit-for-purpose, provided conservative fracture mechanics predictions of fatigue crack growth demonstrate adequate future life and periodic inspection monitors crack growth of the members or joints concerned.	2) The time interval for inspection shall be planned such that potential fatigue cracks can be detected with a large certainty before they grow so large that the integrity of the structure is endangered. 3) Components where a failure can lead to substantial consequences and have passed their fatigue design life shall be inspected by an appropriate NDT method. These components shall have a maximum inspection interval of 5 years if calculated interval gives a longer period. 4) If there is less than 5 years of corrosion allowance for the components that have experienced significant corrosion, corrosion inspections are required at intervals not exceeding 2 years. 5) Risk based inspection may be recommended for planning of in-service inspection for fatigue cracks. 6) The acceptance criterion when planning in-service inspection for fatigue cracks based on RBI is depending on consequence of failure. The risk of a structural failure due to fatigue cracks should not be larger than risk of other failure modes. - Methodology for low cycle fatigue of joints is given in 8.4.
	- Assessment for Seismic Loading 1. Assessment for seismic loading is not a requirement for seismic zones 0, 1 and 2 2. Assessment for metocean loading should be performed for all seismic zones 3. Perform assessment for ice loading, if applicable. 4. Design basis check - the platforms are acceptable to seismic loading if no significant new faults in the local area have been discovered, or any other information regarding site seismic hazard characterization has been developed that significantly increases the level of seismic loading used in the platform's original design 5. Design level analysis - to be an operator's economic risk decision and not applicable for seismic assessment purposes. 6. Ultimate strength analysis - is requirement if the platform does not pass the design level check or screening; Level A-1 platforms withstand loads associated with a median 1000-yr return period earthquake without system collapse; Level A-3 platforms withstand loads associated with a median 500-yr return period earthquake without system collapse	- Seismic design consideration (24.7.4) The considerations are as given in Clause 11. A two-level seismic design procedure shall be followed: - Ultimate limit state (ULS) for strength and stiffness when subjected to an extreme level earthquake (ELE), from which it should sustain little or no damage. - Abnormal level earthquake (ALE) to ensure that it meets reserve strength and energy dissipation requirements. The structure may sustain considerable damage from ALE, but structural failures causing loss of life and /or major environmental damage shall not be expected to occure.	
	- Assessment for Ice Loading follow API RP 2N for guidance on the selection of appropriate ice criteria and loading	- Ice Conditions and Actions due to Ice (24.7.5) Guidance on ice conditions and actions due to ice is given in ISO 19901-1 for certain areas.	

Examples of Code Comparison Table

- Inspections

TABLE 1

API RP 2A WSD/LRFD 14. SURVEY	ISO 19902	NORSOK N-005
14.3 SURVEY LEVELS LEVEL I Below water verification of performance of the cathodic protection system (i.e. dropped cell) and an above water visual survey to determine the effectiveness of corrosion protection system, detect debris (e.g. netting, cables, excessive corrosion and load), missing and damaged members. General examination of all structural members in splash zone and above water, concentrating on condition of the corrosion protection system (e.g. coating, grating, handrail, etc.) Survey should identify indications of obvious overloading, design deficiencies and use inconsistent with the platform's original purpose. If above water damage is detected, NDT should be used when visual inspection can not fully determine the extent of damage. Should Level I survey indicate that underwater damage could have occured, a Level II inspection LEVEL II General underwater visual inspection by divers or ROV to detect presence of excessive corrosion, accidental or environmental overloading, scour and seafloor instability, fatigue damage, design or construction deficiencies, presence of debris, and excessive marine growth. The survey should include measurement of cathodic potentials of pre-selected critical areas. Detection of significant structural damage during Level II survey should become the basis for initiation of Level III survey, which should be carried out at maximum practical time interval. LEVEL III An underwater visual inspection of pre-selected areas and/or, based on results of Level II survey, areas known or suspected damage. Such areas should be efficiently cleaned of marine growth to permit thorough inspection. EVD can provide an acceptable alternative to close visual inspection (CVI). CVI for corrosion monitoring should be included as part of Level III survey. Detection of significant structural damage during Level III survey should become the basis for initiation of Level IV survey, where CVI alone and/or determine the extent of damage. Level IV survey if required, should be conducted as soon as conditions permit. LEVEL IV An underwater NDT of preselected areas and/or, based on results of Level III survey, areas known or suspected damage. Level IV survey should also include detailed inspection and measurements of damaged areas. A Level II and/or Level IV survey of fatigue-sensitive joints and/or areas susceptible to cracking could be necessary to determine if damage has occured. Monitoring fatigue-sensitive and/or reported crack-like indications, can be an acceptable alternative to an in-situ verification.	23 IN-SERVICE INSPECTION AND SIM LEVEL I Below water verification of performance of the cathodic protection system (i.e. dropped cell) and an above water visual survey to determine the effectiveness of corrosion protection system, detect debris (e.g. netting, cables, excessive corrosion and load), missing and damaged members. General examination of all structural members in splash zone and above water, concentrating on condition of the corrosion protection system (e.g. coating, grating, handrail, etc.) Survey should identify indications of obvious overloading, design deficiencies and use inconsistent with the platform's original purpose. If above water damage is detected, NDT should be used when visual inspection can not fully determine the extent of damage. Should Level I survey indicate that underwater damage could have occured, a Level II inspection LEVEL II General underwater visual inspection by divers or ROV to detect presence of excessive corrosion, accidental or environmental overloading, scour and seafloor instability, fatigue damage, design or construction deficiencies, presence of debris, and excessive marine growth. The survey should include measurement of cathodic potentials of pre-selected critical areas. Detection of significant structural damage during Level II survey should become the basis for initiation of Level III survey, which should be carried out at maximum practical time interval. LEVEL III An underwater visual inspection of pre-selected areas and/or, based on results of Level II survey, areas known or suspected damage. Such areas should be efficiently cleaned of marine growth to permit thorough inspection. EVD can provide an acceptable alternative to close visual inspection (CVI). 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14.4 SURVEY FREQUENCY Frequency of surveys are dependent upon the exposure categories of the platform for both life safety and consequence of failure considerations Survey Intervals Exposure Category / Survey Level Level I II III IV L-1 1 yr 3-5 yrs 5-10 yrs * L-2 1 yr 5-10 yrs 11-15 yrs * L-3 1 yr 5-10 yrs * * * survey should be performed if required based on lower inspection findings Time interval between surveys for fixed platforms should not exceed the intervals shown in table above, unless a rationale can be given to justify longer intervals. Justification should be documented and retained by operator. Following factors, which either increase or decrease survey intervals, should be taken into account:	23.7 DEFAULT PERIODIC INSPECTION REQUIREMENTS In absence of a risk or reliability based inspection strategy, following default requirements shall apply. These requirements address only the concerns of safeguarding life and protecting the environment. Additional inspections may be needed to meet reliability requirements, owner's corporate policy or industry standard/practices. Compliance with default requirements does not guarantee structural reliability or fitness-for-purpose. Survey Intervals Exposure Level / Inspection Level I II III IV L-1 Annual 3 yrs 5 yrs * L-2 Annual 1 yrs 1 yrs * L-3 Annual 1 yrs 3 yrs * or special * determined from Level III inspection results	4.3 CONDITION MONITORING PRINCIPLES Operators shall monitor the condition of operated offshore installations in a systematic manner. This may include development of an overall philosophy and strategy for condition monitoring, establishing of service specific systems and inspection programs, etc.

Examples of Code Comparison Table

- Inspections (cont'd)

1. Original design assumptions 2. Present structural condition 3. Service history of platform 4. Platform structural redundancy 5. Criticalness of platform to other operations 6. Platform location 7. Damage 8. Fatigue sensitivity **Special Surveys** Level I survey should be conducted after direct exposure to a design environmental event. Level II survey should be conducted after severe accidental loading that could lead to structural [illegible] and which exceeds design assessment criteria. Areas of limited structural integrity of the platform, which have undergone structural repair, should be subjected to a Level II survey approximately one year following completion of the repair. A Level II survey should be performed at successive inspection intervals to monitor the repaired areas. Level II scour surveys in scour prone areas should take account of local experience, and are usually [illegible]	Inspection requirements less than default can be justified when an inspection strategy is developed and maintained. **Special Inspections** Special inspections shall be undertaken to assess performance of repairs undertaken to ensure the fitness for purpose of structure, and to be specifically [illegible] to monitor known defects, damage, local corrosion, scour, or other conditions which could potentially affect the fitness for purpose of the structure. **Unscheduled Inspections** An inspection shall be conducted as soon as practical after the occurrence of an environmental event exceeding that for which structure was designed or assessed, or of a significant accidental action. The [illegible] provides full coverage from sea floor to top of structure, conductors, risers and various appurtenances, and which includes checking the marine conditions of corrosion protection and looking for debris and damage.	
14.5 PREFERRED SURVEY AREAS During initial platform design and any subsequent reanalysis, critical members and joints should be identified to assist in defining requirements for future platform surveys. Selection of critical areas should [illegible] redundancy, and fatigue lives determined during platform design/assessment.	**20.3 DATA COLLECTION AND UPDATE** Records of [illegible] original design analyses, fabrication, [illegible] installation and in-service inspections, engineering evaluations, reports, and incidents shall be retained by the owner for the life of the structure and transferred to new owners as necessary.	**6.4 INSPECTION RECORD** Owner shall establish a [illegible] for the [illegible] from condition monitoring programme throughout the lifetime of the [illegible]. The data may include video tape, inspection log, first hand inspection report, [illegible] and [illegible]. Such data records should also include [illegible], date and actual scope of work and description of findings and any anomalies discovered.
14.6 RECORDS Records of all surveys should be retained by the operator for the life of the platform. Such records should contain detailed accounts of survey findings, including video tapes, photographs, measurements, and other pertinent survey results. Records should also identify the survey crews performed. Description of detected damage should be thoroughly documented and tied to with survey results. Any resulting repairs and engineering evaluations of the platform's condition should be documented and retained.		

Summary

- Comparison progress to date
- Case studies status
- API, ISO, and NORSOK Standards applied to a Jacket platform case study results finalized
- Tasks 9 and 10 Underway
- Next deliverable: Monthly Progress Report
- Next Progress GoToMeeting – July 5th, 2011.

Further comments

Safeguarding life, property and the environment

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