2010-108-01

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

Progress Meeting No. 6

30 June 2011

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Agenda

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

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Work to-date

- Review of standards and TA&R reports
- Comparison - fixed structures:
  - Environmental criteria and loading recipe
  - Member and joint design
  - Foundation design
  - Seismic
  - Fatigue
  - In-service inspection and maintenance
  - Assessment of existing platforms
  - Fire, blast and accidental loadings
  - Installation, temporary conditions
- Comparison - floaters:
  - Environmental criteria and loading recipe
  - Fatigue
  - In-service inspection and maintenance
  - Assessment of existing platforms
  - Fire, blast and accidental loadings
  - Installation, temporary conditions
- Jacket case study final results
- Calculation Sheets Developed for Member and Joint Checks

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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	

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Schedule

Activity	2010		2011									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Augg	Sep	Oct
Tasks 1 and 2: Environmental conditions and loading												
Tasks 3 and 4: Structural Design and Connections												
Task 5: Fatigue												
Task 6: Foundations/Mooring												
Tasks 7, 8 and 9: In-service Inspection, Assessment, and Fire and Blast												
Task 10 and 11: Installation, Temporary Conditions and Case Studies												
Reporting/Presentations												

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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.

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Code Comparison

- Fire, blast and accidental loads

	API RP 2A- WSD Section 18	ISO 19902 Clause 10	NORSOK N-004 Annex A
Assessment Process	**- Implementing preventive measures has historically been, and will continue to be, the most effective approach in minimizing the probability of occurrence of an event and the resultant consequences of the event.** **- In U.S. GOM, considerations of preventative measures coupled with established infrastructure, open facilities and relatively benign environment have resulted in a good safety history. Detailed structural assessement should therefore not be necessary for typical U.S. GOM-type structures and environment.** **- Assessment Process** 1. Initially screen those platforms considered to be at low risk, thereby not requiring detailed structural assessment. 2. Evaluate the structural performance of those platforms considered to be at high risk from a life safety and/or consequences of failure point of view, when subjected to fire, blast, and accidental loading events.	**- In this standard, only designing for hazards for structures of exposure level L1 is quatified.** **- The main hazards that faced by an offshore structure include:** a) vessel collisions b) Dropped objects c) fire and explosions d) abnormal environmental actions, including abnormal seismic actions **- When checking accidental limit states (ALS) for accidental events, all partial action and resistance factors may be set to 1.0**	- The overall goal of the design against accidental actions is to achieve a system where the main safety functions of the installation are not impaired. - The material factor to be used for checks of accidental limit states is γ_M = 1.0
Ship Collisions	**- The platform should survive the initial collision and meet the post-impact criteria.** **- All exposed elements at risk in the collision zone of an installation should be assessed for accidental vessel impact during normal operations.** 1. The collision zone is the area on any side of the platform that a vessel could impact in an accidental situation during normal operations. 2. The vertical height of the collision zone should be determined from the considerations of vessel draft, operational wave height and tidal elevation. 3. Elements carrying substantial dead load, except for platform legs and piles, should not be located in the collision zone. If such elements are located in the collision zone they should be assessed for vessel impact. **- Energy Absorption** An offshore structure will absorb energy primarily from: a. Localized plastic deformation of the tubular wall b. Elastic/platstic bending of the member c. Elastic/platstic elongation of the member d. Fendering device, if fitted e. Global platform deformation (that is, sway) f. Ship deformation and/or rotation **- Damage Assessment** Two cases should be considered: **1. Impact (energy absorption and survival of platform)** Primary framework should be designed and configured to absorb energy during impact, and to control the consequences of damage after impact. Some permanent deformation of members may be allowable in this energy absorption. The kinetic energy of a vessel: $E = 0.5\ a\ m\ v^2$ Where E = the kinetic energy of the vessel a = added mass factor, (1.4 for broadside collision, 1.1 for bow/stern collision) m = vessel mass v = velocity of vessel at impact For platforms in mild environments and reasonably close to their base of supply, the following minimum requirements should be used, unless other criteria can be demonstrated: Vessel Mass = 1100 short tons (1,000 metric tons) Impact Velocity = 1.64 ft/sec (0.5 m/sec) **The 1100-short-ton vessel is chosen to represent a typical 180-200-foot-long supply vessel in the GoM.** **2. Post-impact (platform to meet post-impact criteria)** a)The platform should retain sufficient residual strength after impact to withstand the one-year environmental storm loads in addition to normal operating loads. b) Special attention should be given to defensible representation of actual stiffness of damaged members or joints in the post-impact assessment. Damaged members may be considered totally ineffective providing their wave areas are modeled in the analysis.	**- Vessel impact shall be addressed for the structures with exposure levels L1 and L2.** **- Two energy levels shall be considered:** a) low energy level, representing the most frequent condition, based on the type of vessel that would routinely approach alongside the platform (e.g. a supply boat) and that would have a velocity representing normal manoeuvring of the vessel approaching, leaving, or standing alongside the platform This level is a serviceability limit state to which the owner can set his own requirements based on practical and economical considerations. b) high energy level, representing a rare condition, based on the type of vessel that would operate in the platform vicinity, drifting out of control in the worst sea state in which it would be allowed to operate close to the platform This level represents an ultimate limit state in which the structure is damaged but progressive collapse should not occur. **- The kinetic energy of a vessel:** $E = 0.5\ a\ m\ u^2$ Where E = the kinetic energy of the vessel a = added mass factor, (1.4 for broadside collision, 1.1 for bow/stem collision) m = vessel mass u = velocity of vessel at impact a) The added mass coefficients given above are typical values for large (5000 t displacement) supply vessels. For smaller vessels, a value slightly higher than 1.4 should be applied, e.g. 1.6 for a typical 2500 t supply vessel. b) For the northern North Sea, a vessel mass can be 8000t, whereas in the southern North Sea a mass of around 2500 t is more normal. c) For GoM structures in mild environments and reasonably close their base of supply, a 1000 t vessel represents a typical 55 m to 60 m (180 ft to 200 ft) supply vessel. For deeper and more remote locations in the GoM the vessel mass can be different.The masses of vessels that could collide with the platform when drifting out-of-control should be specifically considered. d) For low energy impacts, a vessel velocity of 0.5 m/s is commonly used, representing a minor accidental "bump" during normal manoeuvring of the vessel while loading or unloading or while standing alongside the platform. e) For high energy conditions, a vessel velocity of 2 m/s is commonly used, representing a vessel drifting out-of-control in a sea state with significant wave height of approximately 4 m.	**- The load bearing function of the installation shall remain intact with the damages imposed by the ship collision action. In addition, the residual strength requirements shall be complied with.** **- Methods used to determine the structural effects from ship collision:** a) non-linear dynamic finite element analysis b) energy considerations combined with simple elastic-plastic methods **- Three levels for the strain energy dissipation consideration:** 1) local cross-section 2) component/sub-structure 3) total system **- Strain energy** Fixed installations $E_s = \frac{1}{2}(m_s + a_s)v_s^2$ Articulated columns $E_s = \frac{1}{2}(m_s + a_s)\frac{\left(1-\frac{v_i}{v_s}\right)^2}{1+\frac{m_s z^2}{J}}$ Compliant installations $E_s = \frac{1}{2}(m_s + a_s)v_s^2\frac{\left(1-\frac{v_i}{v_s}\right)^2}{1+\frac{m_s + a_s}{m_i + a_i}}$ m_s = ship mass a_s = ship added mass v_s = impact speed m_i = mass of installation a_i = added mass of installation v_i = velocity of installation J = mass moment of inertia of installation (including added mass) with respect to effective pivot point Z = distance from pivot point to point of contact Jacket structures can normally be considered as fixed. Floating platforms (semi-submersibles, TLPs, production vessels) can normally be considered as compliant. Jack-ups may be classified as fixed or compliant. **- More details provided in this provision** A.3.5 Ship Collision Forces A.3.6 Force-deformation relationships for denting of tubular members A.3.7 Force-deformation relationships for beams A.3.8 Strength of connections A.3.9 Strength of adjacent structure A.3.10 Ductility limits A.3.11 Resistance of large diameter, stiffened columns A.3.12 Energy dissipation in floating production vessels A.3.13 Global integrity during impact

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Examples of Code Comparison Table

- Fire, blast and accidental loads (cont'd)

Dropped objects

- Certain locations such as crane loading areas are more subject to dropped or swinging objects.
- The probability of occurrence may be reduced by following safe handling practices.
- The consequnces of damage may be minimized by considering the location and protection of facilities and critical platform areas. Operation procedures should limit the exposure of personnel to overhead material transfer.
-The platform should survive the initial impact and meet the post-impact criteria as defined for vessel collision.

- When evaluating the impact risk from dropped objects, the nature of all crane operations in the platform vicinity shall be taken into account.
- Depending on the consequences for the structural integrity of the structure, the need for a rigorous impact analysis shall be determined.
- Robustness in relation to dropped objects should be incorporated into the design by indirect means such as
a) avoiding weak elements in the structure (particularly at joints)
b) selecting materials with sufficient toughness
c) ensuring that critical components are not placed in vulnerable locations

- Dropped objects are rarely critical to the global integrity of the installation and will mostly cause local damages. The major threat to global integrity is probably puncturing of buoyancy tanks, which could impair the hydrostatic stablility of floating installations.
- The structural effects may either be determined by non-linear dynamic finite element analysis or by energy considerations combined with simple elastic-plastic methods.
- Kinetic energy of a falling object:

$E_{kin} = 0.5\,mv^2$ for objects falling in air

$E_{kin} = 0.5\,(m+a)v^2$ for objects falling in water

a = hydrodynamic added mass for considered motion
For impact in air the velocity is given by
$v = (2gs)^{0.5}$
s = travled distance from drop point
$v = v_0$ at sea surface

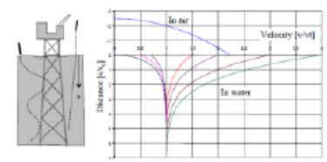

Figure A.4-1 Velocity profile for objects falling in water

$$v_t = \sqrt{\frac{2g(m-\rho_w V)}{\rho_w C_d A_p}}$$ = terminal velocity for the object

$$x_c = \frac{m+a}{\rho_w C_d A_p} = \frac{v_t^2\left(1+\frac{a}{m}\right)}{2g\left(1-\frac{\rho_w V}{m}\right)}$$ = characteristic distance

ρ_w = density of sea water
C_d = hydrodynamic drag coefficient for the object in the considered motion
m = mass of object
A_p = projected cross-sectional area of the object
V = object displacement

Table A.4-1 Terminal velocities for objects falling in water.

Item	Weight [kN]	Terminal velocity [m/s]
Drill collar	28	23 to 24
Winch	250	
Riser pump	100	
BOP annular preventer	50	16
Mud pump	330	7

- Resistance/Energy dissipation
1) Stiffened plates subjected to drill collar impact
The energy dissipated in the plating subjected to drill collar impact is given by:

$$E_{sp} = \frac{R^2}{2K}\left(1+0.48\frac{m_s}{m}\right)^2 \qquad (A.4.6)$$

$$K = \frac{1}{2}\pi f_y t\left(\frac{1+3\frac{d}{r}-6c^2+6.25\left(\frac{d}{2r}\right)^2}{(1+c)^2}\right)$$: stiffness of plate enclosed by hinge circle

f_y = characteristic yield strength
$c = e^{-3.5\left(1-\frac{d}{2r}\right)}$
$R = \pi d\tau t$ = contact force for $\tau \le \tau_{cr}$ see A.4.5.1 for τ_{cr}
$m_s = \rho_p \pi r^2 t$ = mass of plate enclosed by hinge circle
m = mass of dropped object
ρ_p = mass density of steel plate
d = smaller diameter at threaded end of drill collar
r = smaller distance from the point of impact to the plate boundary defined by adjacent stiffeners/girders, see Figure A.4-3.

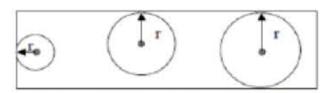

Figure A.4-3 Definition of distance to plate boundary

2) Limits for energy dissipation
a) pipes on plate
The maximum shear stress for plugging of plates due to drill collar impacts may be taken as :

$$\tau_{cr} = f_u\left(0.42+0.41\frac{t}{d}\right) \qquad (A.4.7)$$

f_u = ultimate material tensile strength

b) Blunt objects
For stability of cross-sections and tensile fracture, see A.3.10

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Examples of Code Comparison Table

- Fire, blast and accidental loads (cont'd)

Fire	- If the assessment process identified that a significant risk of **fire** exists, fire should be considered as a load condition; the structural assessment must demonstrate that the escape routes and safe areas are maintained to allow sufficient time for platform evacuation and emergency response procedures to be implemented. - If the assessment process identified that a significant risk of **blast** exists, blast should be considered as a load condition; the blast assessment need to demonstrate that the escape routes and safe areas survive. - The fire and blast analyses should be performed together and the effects of one on the other carefully analyzed. **- Fire as a load condition requires that the following be defined:** 1. Fire scenario: fire type, location geometry and intensity 2. Heat flow charateristics from the fire to unprotetcted and protected steel members - to determine the temperature of the member as a function of time. The amount of radiant heat arriving at the surface of a member is determined using a geometrical "configuration" or "view" factor. For engulfed members, a configuration factor of 1.0 is used. 3. Properties of steel at elevated temperatures and where applicable a) thermal properties - required for the calculation of the steel temperature b) mechanical properties - used to verify that original design still meets the strength and serviceablility requirements. 4. Properties of fire protection systems (active and passive) a) They may be required to ensure that the maximum allowable member temperatures are not exceeded for a designated period when fire occur. b) They may also serve to prevent escalation of the fire. c)The designated period of protection is based on either the fire's expected duration or the required evacuation period. **- Design for fire** **There are the following approaches to be used in the design for fire:** **1. Zone method** a) The zone method of design assigns a maximum allowable temperature that can develop in a steel member without reference to the stress level prior to the fire. b) The assumption of this method is that a member utilization ratio calculated using basic (AISC) allowable stress will remian unchanged for the fire load condition if the allowable stress is increased to yield, but the yield stress itself is subject to a reduction factor of 0.6. This assumption is valid when the nonlinear stress/strain charateristics of the steel may be linearized such that the yield strength reduction factor is matched by the reduction in Young's modulus (as for a 0.2% strain). c) With an unmatched reduction in both yield strength and Young's modulus, the governing design condition may be affected; thus, the zone method may not be applicable. **2. Linear elastic method (e.g. a working stress code check)** a) A maximum allowable temperature in a steel member is assigned based on the stress level in the member prior to the fire, such that as the temperature increases, the member utilization (UR) remains below 1.00 (the member continues to behave elastically) b) With an unmatched reduction in both yield strength and Young's modulus, the governing design condition may be affected; thus, the linear elastic method may not be applicable. **3. Elastic-plastic method (e.g. a progressive collapse analysis)** a) A maximum allowable temperature in a steel member is assigned based on the stress level in the member prior to the fire. A the temperature increases, the member utilization (UR) may go above 1.00 (the member behavior is elastic palstic). b) A nonlinear analysis to be performed to verify that the structure will not collapse and will still meet the serviceablility criteria. **Notes**: 1) Regardless of the design method, the linearization of the nonlinear stress strain relationship of steel at elevated temperatures can be achieved by the selection of a representative value of strain. 2) A value of 0.2% is commonly used and has the benefit of giving a matched reduction in yield strength and Young's modulus, but has the disadvantage of limiting the allowable temperature of the steel to 400°C.	The industry assoications have produced their own more detailed guidance applicable to particular types of operation and circumstances. - API, which can be used for Gulf of Mexico type platforms - UKOOA, which are suited to larger platforms operated in a safety case regime - NORSOK which contains explicit analytical requirements. - ISO 13702 contains requirements and recommendations for fires and explosions	- The assessment of fire load effect and mechanical response shall be based on either a) simple calculation methods applied to individual members - should be based on the provisions given in NS-ENV 1993-1 Eurocode 3: Design of steel structures, Part 1.2. General rules - Structural fire design b) general calculation methods - should be based on the provisions given in NS-ENV 1993 1-1, Part 1.2, Section 4.3 - Assessment of ultimate strength is not needed if the maximum steel temperature is below 400°C., but deformation criteria may have to be checked for impairment of main safety function.

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Examples of Code Comparison Table

- Fire, blast and accidental loads (cont'd)

Blast

1. Due to the complexity in predicting blast loads, the pressure-time curves should be generated by an expert in this field.
2. A blast can cause two types of loading:
a) Overpressure - results from increases in pressure due to expanding combustion products It likely to govern the design of structures such as blast walls and floor/roof systems.
b) Drag loading - caused by last-generated wind
Critical piping, equipment, and other items exposed to the blast wind should be designed to resist the predicted drag loads
3. Environmental loads can be neglected in a blast analysis.
4. Structural Resistance
- Strength limit
Failure is defined to occur when the design load or load effects exceed the design strength.
- Deformation limit
1) No part of the structure impinges on critical operational equipment
2) The deformations do not cause collapse of any part of the structure that supports the safe area, escape routes, and embarkation points within the endurance period. A check should be peroformed to ensure that integrity is maintained if subsequent fire occurs.
3) Deformation limits can be based on a maximum allowable strain or an absolute displacement:
a) Strain limit: most types of structural steel used offshore have a minimum strain capacity of approximately 20 percent at low strain rates.

They usually have sufficient toughness against brittle fracture not to limit strain capacity significantly at the high strain rates associated with blast response for nominal U.S. GOM temperature range.
Recommended strain limits for different types of loading are as follows:

Type of Loading	Strain Limit
Tension	5%
Bending or compression	
Plastic sections	5%
Compact sections	2%
Semi-compact sections	1%
Other sections	< yield strain

The strain limits above assume that lateral torsional buckling is prevented.
b) Absolute limits - adopted where there is a risk of a deforming element striking some component, usually process or emergency equipment or key structure
5 Determination of Yield Point
a) Actual yield stress, usually higher than the minimum specific, should be used in the analysis; strain rates and strain hardening effects should be included in determining yield stress and general material behavior.
b) If maximum reaction forces are required, it is necessary to design using an upper bound yield stress. If maximum deflections are required, the design should use a lower bound yield stress.
6 Analysis Methods
a) Static analysis (a long load duration relative to the structure's natural period): The peak pressure should be used to define the loading.
b) Dynamic analysis (load duration is near to the structure's natural period): The actual pressure-time curve can be applied to the structure.
7. Mitigation
The blast effects can generally be minimized by making the vent area as large as possible;
To minimize blast pressure, ven areas should be located as close as possible to likely ignition sources.

The industry assoications have produced their own more detailed guidance applicable to particular types of operation and circumstances.
- API, which can be used for Gulf of Mexico type platforms
- UKOOA, which are suited to larger platforms operated in a safety case regime
- NORSOK which contains explicit analytical requirements.
- ISO 13702 contains requirements and recommendations for fires and explosions

- The reponse to explosion loads may either be determined by
a) non-liear dynamic finite element analysis
b) simple calculation models based on SDOF analogies and elastic-plastic methods of analysis
- Suggested analysis model and reference to applicable resistance function are listed in Table A.6-1

Table A.6-1 Analysis models

Failure mode	Simplified analysis model	Resistance models	Comment
Elastic-plastic deformation of plate	SDOF	A.6.8	
Stiffener plastic – plate elastic	SDOF	Stiffener: A.6.9.1and A.6.9.2 Plate: A.6.8.1	Elastic, effective flange of plate
Stiffener plastic – plate plastic	SDOF	Stiffener: A.6.9.1and A.6.9.2 Plate: A.6.8	Effective width of plate at mid span. Elastic, effective flange of plate at ends.
Girder plastic – stiffener and plating elastic	SDOF	Girder: A.6.9.1and A.6.9.2 Plate: A.6.8	Elastic, effective flange of plate with concentrated loads (stiffener reactions). Stiffener mass included
Girder plastic – stiffener elastic – plate plastic	SDOF	Girder: A.6.9.1and A.6.9.2 Plate: A.6.8	Effective width of plate at girder mid span and ends. Stiffener mass included
Girder and stiffener plastic – plate elastic	MDOF	Girder and stiffener: A.6.9.1and A.6.9.2 Plate: Section A.6.8	Dynamic reactions of stiffeners → loading for girders
Girder and stiffener plastic – plate plastic	MDOF	Girder and stiffener: A.6.9.1and A.6.9.2 Plate: A.6.8	Dynamic reactions of stiffeners → loading for girders

By girder/stiffener plastic is understood that the maximum displacement [illegible] exceeds the elastic limit [illegible]

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Examples of Code Comparison Table

- Installation, Temporary Conditions

<table>
<tr><th></th><th>API RP 2A- WSD Section 2.4 & Section 12</th><th>ISO 19902 Clause 8 and 22</th><th>NORSOK N-004 Annex K (ISO 19901-6)</th></tr>
<tr><td>General</td>
<td>- For those installation forces that are experienced only during transportation and launch, and which inlcude environmental effects, basic allowable stresses for member design may be increased by 1/3.</td>
<td>- Internal forces due to factored actions (8.2.4.1)
$$F_d = \gamma_{f,GT} G_T + \gamma_{f,QT} Q_T + \gamma_{f,T} T \qquad (8.2\text{-}1)$$
where
G_T is the action imposed either by the weight of the structure in air, or by the submerged weight of the structure in water, during the transient situation being considered, including any permanent equipment or other objects and any piles or conductors installed on the structure, as well as any ballast installed in or carried by the structure;
Q_T is the action imposed by the weight of the temporary equipment or other objects, including any rigging installed or carried by the structure, during the transient situation being considered;
T represents the actions from the transient situation being considered, including:
a) when appropriate, environmental actions,
b) when appropriate, a suitable representation of dynamic effects (see A.8.1 and 8.2.4.2),
c) for lifting, the effects of fabrication tolerances and variances in sling length as detailed in 8.3.3 and for a dual lift as detailed in 8.3.4,
d) for loadout, allowances for misalignment as detailed in 8.5,
e) for transportation, any hydrostatic and hydrodynamic actions on the structure, including any inertial actions resulting from accelerations of the structure (see 8.6), and
f) for installation, the lifting actions and hydrostatic pressure actions on the structure (see 8.7);
$\gamma_{f,GT}$, $\gamma_{f,QT}$ and $\gamma_{f,T}$ are the partial action factors.
The three design situations in Table 8.2-1 shall all be considered.
Table 8.2-1 — Partial action factors for calculating internal forces
<table>
<tr><th rowspan="2">Situation</th><th colspan="3">Partial action factor</th></tr>
<tr><th>$\gamma_{f,GT}$</th><th>$\gamma_{f,QT}$</th><th>$\gamma_{f,T}$</th></tr>
<tr><td>1</td><td>1,3</td><td>1,3</td><td>1,0</td></tr>
<tr><td>2</td><td>1,1</td><td>1,1</td><td>1,35</td></tr>
<tr><td>3</td><td>0,9</td><td>0,9</td><td>1,35</td></tr>
<tr><td colspan="4">NOTE Situation 1 governs for components in which permanent and variable action effects are dominant. Situation 2 governs for components in which transient action effects are dominant and in which the permanent and variable actions increase the magnitudes of the internal forces. Situation 3 governs for components in which transient action effects are dominant but in which the permanent and variable actions decrease the magnitudes of the internal forces.</td></tr>
</table>
- Internal forces due to unfactored actions (8.2.4.2)
$F_{un} = G_T + Q_T + T$
$S = \gamma_{f,Sun} S_{un}$
Where F_{un} = total action due to the unfactored actions G_T, Q_T and T defined above;
S_{un} = the internal force resulting from F_{un}
$\gamma_{f,Sun}$ = partial factor to be applied to S_{un}, usually 1.3
<u>- Guidance is also provided in ISO 19901-6.</u></td>
<td>- NORSOK N-004 Clause K.4.4.6 Installation analysis states that Transport and installation design and operation shall comply with the requirements given in NORSOK J-003. NORSOK J-003 is voided as a consequence of ISO 19901-6 Marine Operations having been issued as DIS.</td></tr>
<tr><td></td>
<td>- Lifting forces on padeyes and on other members of the structure should include both vertical and horizontal components, the latter occurring when lifting slings are other than vertical. Lifting forces on the lift should include buoyancy as well as forces imposed by the lifting equipment.
- To compensate for any side loading on lifting eyes which may occur, in addition to the calculated horizontal and vertical components of the static load for the equilibrium lifting condition, lifting eyes and the connections to the supporting structural members should be designed for a horizontal force of 5% of the static sling load, applied simultaneously with the static sling load. This horizontal force should be applied perpendicular to the padeye at the center of the pinhole.
-Static Loads (2.4.2.b)
a) When suspended, the lift will occupy a position such that the center of gravity of the lift and the centroid of all upward acting forces on the lift are in static equilibrium. The position in this state should be used to determine forces in the structure and in the slings.
b) The movement of the lift as it is picked up and set down should be taken into account in determining critical combinations of vertical and horizontal forces at all points, including those to which lifting slings are attached.
- Dynamic Load Factors (2.4.2.c)
a) For lifts to be made at open, exposed sea , padeyes and other internal members (and both end connections) framing into the joint where the padeye is attached and transmitting lifting forces within the structure should be designed for a minimum load factor of 2.0 applied to the calculated static loads. All other structural members transmitting lifting forces should be designed using a minimum load factor of 1.35.
b) For other marine situations, the selection of load factors should meet the expected local conditions but should not be less than a minimum of 1.5 and 1.15 for the two conditions</td>
<td>-Dynamic Effects (8.3.2)
A dynamic amplication factor (DAF), k_{DAF}, accounting for dynamic effects of the crane taking up the load and for movements of the crane or of the lifted structure, shall be derived from the following:
a) For offshore lifts in air:
1) k_{DAF} = 1.10 for heavy lift by semi-submersible crane vessel
2) k_{DAF} = 1.30 in other cases; the lower DAF vaule may be used based on special investigations, but shall not less than 1.10;
b) For lifts in air, onshore or in sheltered waters,
k_{DAF} = 1.10
c) For lifts partially or fully in water, k_{DAF} shall be specially investigated taking into account factors including the lift arrangement, the orientation of the lifted structure, the ratio of the allowable hook load to the lifted weight, the drag loads on the lifted structure and the motions of the boom tip in the environmental conditions in which the lift is to be made
d) More details see 19901-6 Clause 18.
- Effect of Tolerances (8.3.3)
a) The requirements and partial action factors here are intended to apply to the situations where fabrication misalignments are consistent with the tolerances specified in Annex G and where the variance on the length of slings does not exceed the greater of 0.25% of the nominal sling length or 40 mm.
b) The results sling force should be increased by a factor of not less than 1.25 (1.15 for floating spreader beams) to determine the required safe working load of the sling in 8.3.8.
c) The effectof tolerances in a lift analysis of a standard four-point life may be taken into account by the one of the following methods:</td>
<td>- 19901-6, Clause 18 gives requirements and guidance for the design and execution of listing operations (onshore, inshore and offshore). It covers lifting operations by floating crane vessels, including crane barges, crane ships and semi-submersible crane vessels. Onshore lifts by land-based cranes are also included when they form part of a marine operation such as a loadout.
- Additional information on lifting operations can be found in ISO 19902:2007, Clause 8 and 22.</td></tr>
</table>

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Examples of Code Comparison Table

- Installation, Temporary Conditions (Cont'd)

Lifting	previously listed. c) For typical fabrication yard operations where both the lifting derrick and the structure or components to be lifted are land-based, dynamic load factors are not required. For special procedures where unusual dynamic loads are possible, appropriate load factors may be considered. **- Allowable stresses (2.4.2.d)** a) basic allowable stresses as specified in Section 3.1 b) The AISC increase in allowable stresses for short-term loads should not be used. c) All critical structural connections and primary members should be designed to have adequate reserve strength to ensure structural integrity during lifting. **- Effect of Tolerances (2.4.2.e)** a) The load factors recommened in 2.4.2c are intended to apply to situations where fabrication tolerances do not exceed the requirements of 11.5, and where the variation in length of slings does not exceed plus or minus 1/4 of 1% of nominal sling strength, or 1.5 inches. b) The total variation from the longest to the shortest sling should not be greater than 1/2 of 1% of the sling length or 3 inches. c) If either fabrication tolerance or sling length tolerance exceeds these limits, a detailed analysis taking into account these tolerances should performed to determine the redistribution of forces on both slings and structural members. The same type analysis should also be performed when unusual deflections of particularly stiff structural systems may also affect load distribution. **- Slings, Shackles and Fittings (2.4.2.f)** a) For normal offshore conditions, slings should be selected to have a factor of safety of 4 for the manufacturer's rated minimum breaking strength of the cable compared to static sling load. b) The static sling load should be the maximum load on any individual sling, as calculated in 2.4.2a, b, and e, by taking into account all components of loading and the equilibrium position of the lift. c) This factor of safety should be increased when usually severe conditions are anticipated, and may be reduced to a minimum of 3 for carefully controlled conditions. d) Shackles and fittings should be selected so that the manufacturer's rated working load is equal to or greater than the static sling load, provided the manufaturer's specifications include a minimum factor of safety of 3 compared to the minimum breaking strength.	[illegible] 1) an analysis with one pair of opposite slings assumed to carry 75% and the other pair of 25% of the hook force, and vice versa 2) an analysis with modifying sling lengths, e.g. two diagonally opposite slingd with increased length, each by an amount corresponding to the total tolerance, fo each diagonal in turn. **- Member and joint strength (8.3.6)** $F_d = k_{DAF} \gamma_{f,d} \gamma_{f,f} (\gamma_{f,GT} G_T + \gamma_{f,QT} Q_T + \gamma_{f,T} T)$ $S = k_{DAF} \gamma_{f,d} \gamma_{f,f} \gamma_{f,Sm} S_m$ Where $\gamma_{f,d}$ = rigging factor, specified in 8.3.4; 1.10 for dual lift, and 1.00 for single crane lifts gf,lf = local factor, specified in 8.3.5; a) For lifting attachments (padeyes, trunnions, padears), spreader beams, and internal members (including both end connections) framing into the joint where the lifting attachment is attached and transmitting lift forces: = 1.25 (for a lift in open waters) = 1.15 (for a lift onshore or in sheltered waters) b) For other structural members = 1.00 **- Lifting attachments (8.3.7)** a) Lifting attachments and the connections to the supporting structural members shall be designed for a lateral force of 5% of the sling force, in addition to the calculated horizontal and vertical components of the sling force (including DAF, rigging factor, local factor and partial action factors) for equilibium lifting condition. b) This lateral forces acts simultaneously with the static sling force and shall be applied perpendicular to the lifting attachment at the centre of the pinhole or tubular. Where a spreader bar is directly connected to the padeyes, a lateral force of 8% shall be used. c) Where two slings are connected to one padeye, or where a sling is doubled over a trunnion, the padeye or trunnion should be designed for a 45:55% split of the lift point force between the two slings. **- Slings, Shackles and fitting (8.3.8)** a) For normal offshore conditions, slings should have a total resistance factor of 4.0 on the manufacturer's rated minimum breaking strength of the cable compared to the calculated sling force. b) The total resistance factor should be increased when unusually severe conditions are anticipated. Conversely, the total resistance factor may be reduced to a minimum of 3.0 for carefully controlled conditions. c) Where two slings are connected to one padeye, or where a sling is doubled over a trunnion, the padeye or trunnion should be designed for a 45:55% split of the lift point force between the two slings. d) Shackles and fittings should be such that the manufacturer's rated working load is greater than or equal to the calculated sling force, provided the manufacturer's specifications include a minimum resistance factor of 1.0 on minimum breaking strength.	
Loadout	**- Direct Lift (2.4.3.a)** Lifting forces for a structure loaded out by direct lift onto the transportation barge should be evaluated only if the lifting arrangement differs from that to be used in the installation, since lifting in open water will impose more severe conditions. **- Horizontal Movement Onto Barge(2.4.3.b)** Structures skidded onto transportation barges are subject to load conditions resulting from movement of the barge due to tidal fluctuations, nearby marine traffic and/or change in draft, load conditions imposed by location, slope and/or settlement of supports at all stages of the skiding operation. Since movement is normally slow, impact need not be considered.	**- Direct Lift (8.5.1)** Action on a structure that is lifted onto the transportation barge shall be evaluated in accordance with 8.3. If the lifting arrangement is the same as that used to offload the structure from the transportation barge at sea, it will suffice to check the latter load cases only. **- Horizontal movement onto barge (8.5.2)** Structures skidded onto transportation barges are subject to actions resulting from movement of the barge due to tidal fluctuations, nearby marine traffic and/or change in draft, load conditions imposed by location, slope and/or settlement of supports at all stages of the skiding operation. Since movement is normally slow, impact need not be considered. **- Self-floating structures (8.5.3)** Self-floating structures skidde directly into the water at the fabrication yard shall be analysed to determine the actions on the structures as they move down the slipways and into the floating position. Consideration should be given to local enviromental conditions and dynamically induced forces.	- 19901-6, Clause 11 applied to the loadout of various types of structure, including, but not limited to, steel and concrete structures, TLPs, spars, FPSs, modules, components and bridges onto floating or grounded barges ans ships. Additional information can be found in ISO 19902:2007, Clauses 8 and 22. - 19901-6, Clause 11 applied particularly to skidded and trailer-transported floating loadouts in tidal waters. Recommendations for grounded loadouts or loadouts accomplished by lifting are also included.
	- Environmental Criteria (2.4.4.b) The selection of environemntal conditions to be used should consider the following: 1. Previous experience along the tow route 2. Exposure time and reliability of predicted "weather windows" 3. Accessibility of safe havens	- For long ocean tows where the structure and barge are unmanned, the extreme enviornmental conditions are typically selected to have a probability of exceedance during the tow duration in the range of 1% to 10%. The specific value will depend on an evaluation of acceptable risks and consequences. - For short duration tows, the environmental conditions should generally have a return period	- ISO 19906-1, Clause 12 applies to offshore transportation, inshore transportation and transportation in sheltered areas, using either wet tow or dry tow. Additional information can be found in ISO 19902:2007, Clause 8 and 22, and ISO 19903:2006, Clause 11.

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Examples of Code Comparison Table

- Installation, Temporary Conditions (Cont'd)

Transportation	4. Seasonal weather system 5. Appropriateness of the recurrence interval used to determine maximum design wind, wave and current conditions and consider the characteristics of the tow, such as size, structure, sensitivity, and cost **- Determination of Forces (2.4.4.c)** a) Beam, head and quartering wind and seas should be considered to determine maximum transportation forces in the tow structural elements. b) Tows may be analyzed based on gravitational and inertial forces resulting from the tow's rigid body motions using appropriate period and amplitude by combining roll with heave and pitch with heave. c) Submerged members should be investigated for slamming, buoyancy and collapse force. d) Large buoyant overhanging members also may affect motions and should be considered. e) The effects on long slender members of wind-induced vertex shedding vibrations should be investigated. f) For long transocean tows, repetitive member stresses may become significant to the fatigue life of certain member connections or details and should be investigated.	of not less than 1 year for season in which the tow takes place. **- Environmental Criteria (8.6.2)** The selection of environemntal conditions to be used should consider the following: 1. Previous experience along the tow route 2. Exposure time and reliability of predicted "weather windows" 3. Accessibility of safe havens 4. Seasonal weather system 5. Appropriateness of the recurrence interval used to determine maximum design wind, wave and current conditions and consider the characteristics of the tow, such as size, structure, sensitivity, and cost. **- Determination of Forces (8.6.3)** a) Beam, head and quartering wind and seas should be considered to determine maximum transportation responses due to the environmental actions on the overall system. In case of large barge- transported structures, the stiffness of both the structures and the barge shall be included in the structural analysis. b) Tows may be analyzed based on a combination of permanent and inertia actions resulting from the tow's rigid body motions using appropriate period and amplitude by combining roll with heave and pitch with heave. c) Large buoyant overhanging members also may affect motions and should be considered. d) The effects on long slender members of wind-induced vertex shedding vibrations should be investigated.	
Launching Forces and Uprighting Forces	**- Guyed Tower and Template Type (2.4.5.a)** a) Forces supporting the jacket on the ways should be evaluated for the full travel of the jacket. b) Deflection of the rocker beam and the effect on loads throughout the jackets should be considered. C) Horizontal forces required to initiate movement of the jacket should be evaluated. d) Consideration should be given to wind, wave, current and dy namic forces expected on the structure and barge during launching and uprighting. **- Tower Type (2.4.5.b)** Forces should be evaluated for the full travel of the tower down the ways. **- Hook Load (2.4.5.c)** Floating jackets for which lifting equipment is employed for turning to a vertical position should be designed to resist the gravitational and internal forces required to upright the jacket.	**- Launched structures (8.7.2)** a) A structure shall not be lauched from a barge if the significant wave height exceeds 2.0 m or if it is expected to exceed 2.0 m before sufficient on-bottom stability is achieved. 'b) Barge-launched structures shall be analysed to determine the actions on the structure throughout the launch. Consideration shall be given to hydrostatic pressure, wind and current actions, and the development of dynamically induced actions resulting from the launch. c) Horizontal actions required to initiate movement of the structure should also be evaluated. Expected actions o both the structure and the barge during launching should be considered. **- Crane assisted uprighting of structures (8.7.3)** The requirements of 8.3 apply to this situation.	- ISO 19901-1, Clause 9.9.3 and Clause 17.5
On-Bottom Stability	- The factors of safety against bearing capacity failure recommended are 2.0 for on bottom gravity loads alone and 1.5 for the design environmental condition applicable for the installation period. - At the operators discretion, with supporting analyses an alternative of limiting penetration criteria may be used. - Allowable steel stresses may be increased by one-third when wave loading is included. - In the event of rough seas or if the installation equipment must leave the site for other reasons before the jacket has been adequately secured with piles, the effective weight on bottom may require adjustment to minimize the possibility of jacket movement due to skidding, overturning, or soil failure.	The design shall ensure the followings: a) the footings or mudmats have adequate capacity against sliding and bearing failure, and that pin-piles, if any, have adequate strength to avoid being damaged b) the footings, mudmats, or other bearing components and structural members supporting these, have adequate strength to avoid being damaged c) the safety margins against overturning of the structure are adequate, with the recommendation that the structure be checked in a piled condition but without the permanent action of the topsides if placement of the topsides does not follow shortly after structure installation.	**NORSOK N-004, K.6.4** The foundation system for the jacket temporary on-bottom condition prior to installation of the permanent foundation system shall be documented to have the required foundation stability for the governing environmental conditions as specified, and for all relevant limit states.

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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 Completed (except case study for SPAR)
- Next deliverable: Monthly Progress Report
- Next Progress GoToMeeting – August 1st, 2011.

Further comments

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