2010-108-01

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

Progress Meeting No. 1

26 January 2011

MANAGING RISK DNV

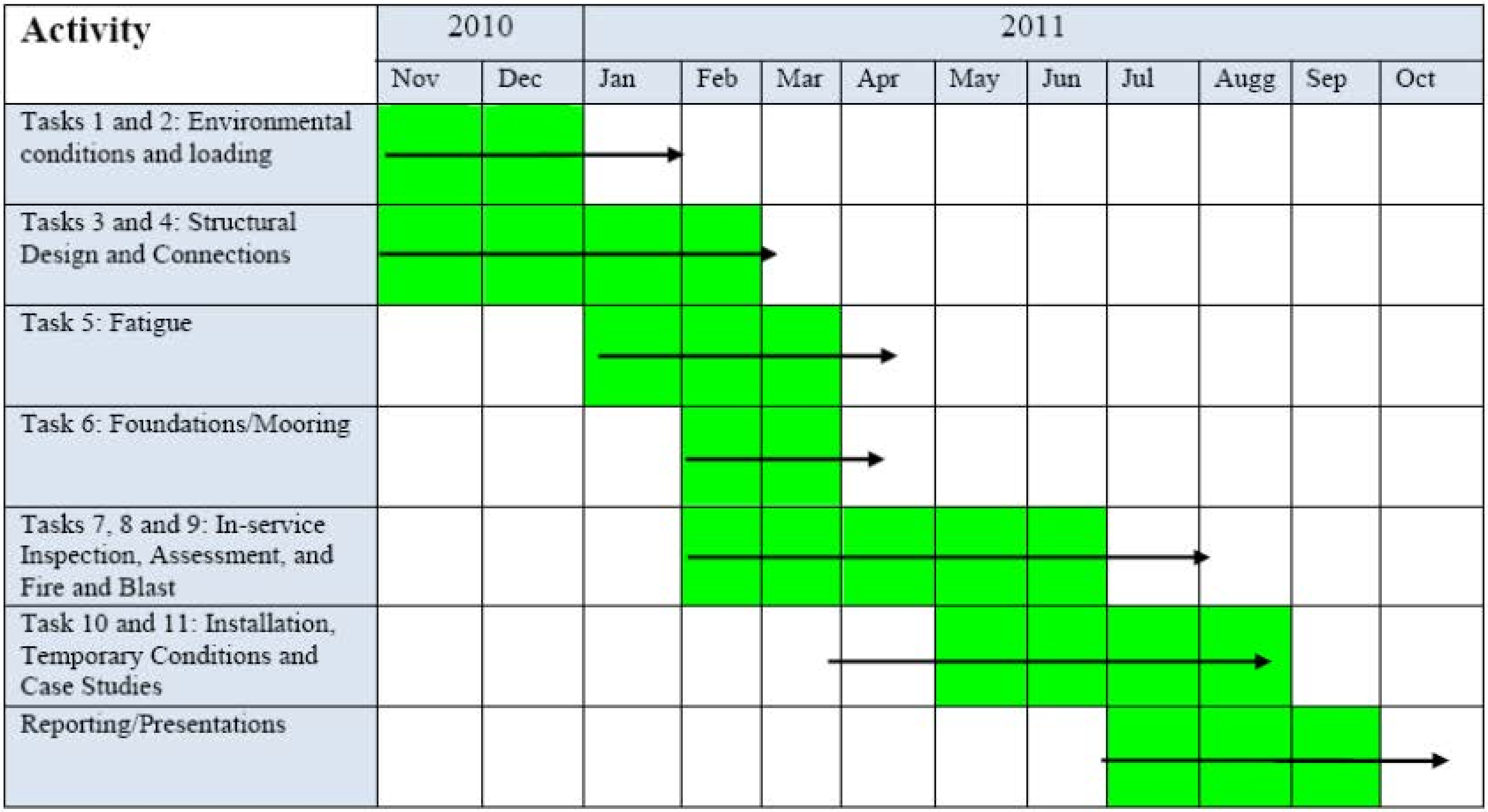
Agenda

- Introductions
- Work To-date
  - Review of standards and TAR reports
  - Jacket and TLP case studies selected
  - Jacket analysis underway
- 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


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

API, NORSOK, and ISO Main Documents

- API RP 2A Fixed Platforms
- API RP 2T TLP's
- API RP 2FPS Floating Production Systems
- API RP 2INT-MET (Draft)
- API Bulletins 2TD, 2INT-EX and 2INT-DG

- N-001 Integrity
- N-003 Actions and Action Effects
- N-004 Steel Structures
- N-005 Condition Monitoring
- N-006 SIM

- ISO 19901-1 Metocean
- ISO 19901-4 Foundation
- ISO 19902 Fixed Offshore Structures (Steel)
- ISO 19904-1 Floating Offshore Structures

Assumptions

- Case studies will be evaluated during work execution
- Current Edition of standards/RP's
- Development of FEM for platforms/floaters is not anticipated. Use existing models.
- BOEMRE will facilitate input data for case studies
- Available BOEMRE past relevant TA&R Reports and platform specific FEM/results
- Platform/Floating Structure specific data
- No structural optimization or design concept evaluation included
- BOEMRE involvement

Possible Scope for Case Studies

High Level Scope of Case Study for Jacket Platforms:

- Verify the computer model in GeniE to ensure imported model is ready for analysis
- Run in place analysis for extreme (survival) load case
- Run code check using API RP-2A, ISO 19902, NORSOK N-004
- Preliminary foundation design using 3 codes
- Compare the results of code check (members and joints)
- Summarize the results

Assumptions:

- The case study is intended for a 4 legged-jacket platform of category L1 with production deck of small to medium size.
- The case study is intended to be a code check exercise for primary structural members and corresponding key structural joints of a limited number.

High Level Scope of Case Study for TLP:

- 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-2T, ISO 19904, NORSOK N-004
- Compare the results of analyses
- Summarize the results

Assumptions:

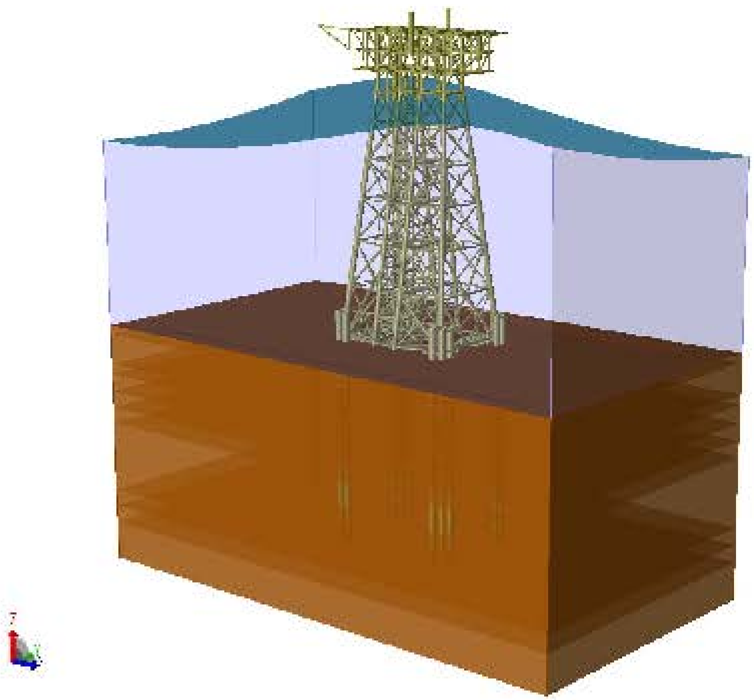
- The case study is intended to be an exercise in acceptance criteria for primary structural members of the hull. Topsides, tendons and foundations are not included as part of this evaluation.

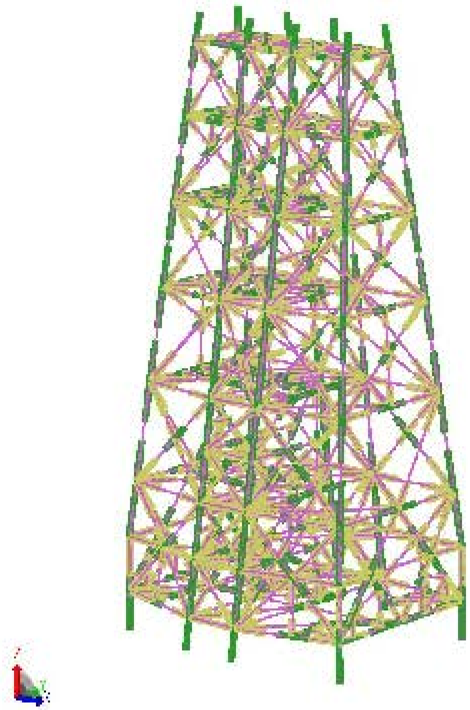
Case Study No. 1 – Fixed Platform in GoM

- Platform Overview

  The platform is located in water depth of 110 m in Central Zone of GoM. The jacket has eight legs with a total of 12 skirt piles installed at the mud line. The piles have 3.41m diameter and are 122 m long.

  The platform topsides has three levels: Drilling Deck, Wellhead Deck and Cellar Deck.





Case Study No. 1 – Fixed Platform in GoM (Contd.)

- In-place Analysis - The structure was modeled as an integrated 3D-space frame including foundation system, using GENIE (Wajac, Sestra, Splice) developed by DNV.
- Basic Load Cases
  - Permanent Loads (G):
    - Structural Self-weight (including modeled and non-modeled members)
    - Equipment loads (Cellar Deck Equipment, Wellhead Equipment, Drilling Deck Equipment)
    - Storage Loads
    - Piping Loads
  - Variable Loads (Q):
    - Area live loads;
    - Crane Loads
    - Rig Loads
  - Environmental Loads (E) :
    - Wind
    - Wave
    - Current
- All three analyses use identical: Permanent and Variable Loads, Marine Growth and Conductor Shielding for one-to-one code check comparison

API Loads and Load Combinations

- API 2INT-MET

Table 4.5.3 1A Independent Extreme Values for Hurricane Winds, Waves, Currents and Surge, Central Gulf of Mexico (89.5°W to 86.5°W)

Return Period (Years)	10	25	50	100	200	1000	2000	10000
Wind (10 m Elevation)								
1-hour Mean Wind Speed (m/s)	33.0	40.1	44.4	48.0	51.0	60.0	62.4	67.2
10-min Mean Wind Speed (m/s)	36.5	44.9	50.1	54.5	58.2	69.5	72.5	78.7
1-min Mean Wind Speed (m/s)	41.0	51.1	57.4	62.8	67.4	81.6	85.6	93.5
3-sec Gust (m/s)	46.9	59.2	66.9	73.7	79.4	97.5	102.5	112.8
Waves, WD >= 1,000 m								
Significant Wave Height (m)	10.0	13.3	14.8	15.8	16.5	19.8	20.5	22.1
Maximum Wave Height (m)	17.7	23.5	26.1	27.9	29.1	34.9	36.3	39.1
Maximum Crest Elevation (m)	11.8	15.7	17.4	18.6	19.4	23.0	23.8	25.6
Peak Spectral Period (s)	13.0	14.4	15.0	15.4	15.7	17.2	17.5	18.2
Period of Maximum Wave (s)	11.7	13.0	13.5	13.9	14.1	15.5	15.8	16.4
Currents, WD >= 150 m								
Surface Speed (m/s)	1.65	2.00	2.22	2.40	2.55	3.00	3.12	3.36
Speed at Mid-Profile (m/s)	1.24	1.50	1.67	1.80	1.91	2.25	2.34	2.52
0-Speed Depth, Bottom of Profile (m)	69.3	84.2	93.2	100.8	107.1	126.0	131.0	141.1
Currents, WD 10 m – 70 m								
Uniform Speed at 10 m Depth (m/s)	1.09	1.61	1.97	2.30	2.60	3.23	3.50	4.05
Uniform Speed at 70 m Depth (m/s)	0.98	1.45	1.77	2.07	2.34	2.91	3.15	3.65
Water Level, WD >= 500 m								
Storm Surge (m)	0.32	0.52	0.66	0.80	0.93	1.13	1.22	1.41
Tidal Amplitude (m)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42

API Loads and Load Combinations

- API 2INT-MET

Table 5-1—Factors for Combining Independent Extremes into Load Cases in Deep Water (WD > = 150 m or 492 ft)

Return Period (Years)	10	25	50	100	200	1000	2000	10000
Peak Wave Case:								
Wind Speed	1.00	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Wave Height	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Current (both speed and depth level)	0.80	0.80	0.75	0.75	0.75	0.75	0.75	0.75
Surge	0.90	0.80	0.70	0.70	0.70	0.70	0.70	0.70
Wind Direction from Wave (deg)	−15	−15	−15	−15	−15	−15	−15	−15
Current Direction from Wave (deg)	−15	+15	+15	+15	+15	+15	+15	+15
Peak Wind Case:								
Wind Speed	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wave Height	1.00	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Current (both speed and depth level)	0.80	0.80	0.75	0.75	0.75	0.75	0.75	0.75
Surge	0.90	0.80	0.70	0.70	0.70	0.70	0.70	0.70
Wind Direction from Wave (deg)	−15	−15	−15	−15	−15	−15	−15	−15
Current Direction from Wave (deg)	15	+15	+15	+15	+15	+15	+15	+15
Peak Current Case:								
Wind Speed	0.75	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Wave Height	0.75	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Current (both speed and depth level)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Surge	0.90	0.80	0.70	0.70	0.70	0.70	0.70	0.70
Wind Direction from Wave (deg)	0	0	0	0	0	0	0	0
Current Direction from Wave (deg)	−50	+50	+50	+50	+50	+50	+50	+50

Note: When factoring surge from Figures 4.5.1 4, 4.5.2 4, 4.5.3 4 and 4.5.4 4, remove the tidal amplitude, factor the surge, then add the tidal amplitude back in.

ISO Loads and Load Combinations

- ISO 19901-1

Table C.21 Indicative independent extreme values for winds, waves, and storm-generated currents — Areas II and III of Gulf of Mexico (see Figure C.14) — Water depths greater than 300 m

Metocean parameter [a]	Return period no. years				
	1 [b]	5 [b]	10 [c]	50 [c]	100 [c]
Wind speed (m/s)					
10 min mean wind speed	17,0	25,5	28,4	40,9	46,1
3 s gust wind speed	22,1	32,0	35,6	51,3	57,8
Waves [d]					
Maximum wave height (m)	9,4	13,0	15,0	22,8	25,0
Significant wave height (m)	4,9	7,3	8,5	12,9	14,6
Spectral peak period [e] (s)	10,3	11,7	12,3	14,3	14,9
Current speed — Storm-generated (m/s) [f]					
Surface	0,4	0,6	1,3	2,0	2,3
20 m depth	0,4	0,6	1,1	1,8	2,0
30 m depth	0,4	0,6	0,8	1,7	1,9
40 m depth	0,4	0,6	0,1	1,4	1,8
50 m depth	0,4	0,6	0,1	0,9	1,4
60 m depth	0,4	0,6	0,1	0,3	0,8
70 m depth	0,4	0,6	0,1	0,1	0,1
90 m depth	0,1	0,1	0,1	0,1	0,1
1 m above sea floor	0,1	0,1	0,1	0,1	0,1

[a] This annex provides some indicative values for metocean parameters which can be suitable for conceptual studies. Site- or project-specific criteria shall be developed for structural design and/or assessment.

[b] Winter storm.

[c] Hurricane.

[d] Wave heights in this table for each return period are identical for all deep water areas of the Gulf of Mexico. This is not necessarily conservative for some areas, and can be overly conservative for some areas in the central Gulf.

[e] Assume that the spectral peak period can vary by ±10 % around these central estimates.

[f] The peak hurricane wind and wave and the peak hurricane current do not generally occur together. To estimate the current associated with the peak hurricane wind and wave, factor the current speed and depth scale by 0,9. To estimate the wind and wave associated with the peak hurricane current, factor the peak wind and wave by 0,8.

ISO Loads and Load Combinations

- ISO 19902

Table 9.10-1 — Partial action factors for in-place situations and exposure level L1

Design situation	Partial action factors [a]					
	$\gamma_{f,G1}$	$\gamma_{f,G2}$	$\gamma_{f,Q1}$	$\gamma_{f,Q2}$	$\gamma_{f,Eo}$	$\gamma_{f,Ee}$
Permanent and variable actions only	1,3	1,3	1,5	1,5	0,0	0,0
Operating situation with corresponding wind, wave, and/or current conditions[b]	1,3	1,3	1,5	1,5	0,9 $\gamma_{f,E}$	0,0
Extreme conditions when the action effects due to permanent and variable actions are additive[c]	1,1	1,1	1,1	0,0	0,0	$\gamma_{f,E}$
Extreme conditions when the action effects due to permanent and variable actions oppose[d]	0,9	0,9	0,8	0,0	0,0	$\gamma_{f,E}$

[a] A value of 0 for a partial action factor means that the action is not applicable to the design situation.

[b] For this, check that G_2, Q_1 and Q_2 are the maximum values for each mode of operation.

[c] For this, check that G_1, G_2 and Q_1 include those parts of each mode of operation that can reasonably be present during extreme conditions.

[d] For this, check that G_2 and Q_1 exclude any parts associated with the mode of operation considered that cannot be ensured of being present during extreme conditions.

NORSOK Loads and Load Combinations

- NORSOK N-001

Table 1 – Partial action factor for the limit states

Limit state	Action combinations	Permanent actions (G)	Variable actions (Q)	Environmental actions (E) [d]	Deformation actions (D) [e]
ULS	a [a]	1,3	1,3	0,7	1,0
ULS	b	1,0	1,0	1,3	1,0
SLS		1,0	1,0	1,0	1,0
ALS	Abnormal effect [b]	1,0	1,0	1,0	1,0
ALS	Damaged condition [c]	1,0	1,0	1,0	1,0
FLS		1,0	1,0	1,0	1,0

[a] For permanent actions and/or variable actions, an action factor of 1,0 shall be used where this gives the most unfavourable action effect
[b] Actions with annual probability of exceedance = 10^{-4}
[c] Environmental actions with annual probability of exceedance = 10^{-2}
[d] Earthquake shall be handled as environmental action within the limit state design for ULS and ALS (abnormal effect)
[e] Applicable for concrete structures

NORSOK Loads and Load Combinations

- NORSOK N-003

Table 4 – Combination of environmental actions with expected mean values and annual probability of exceedance 10^{-2} and 10^{-4}

Limit state	Wind	Waves	Current	Ice	Snow	Earthquake	Sea level[a]
Ultimate Limit State	10^{-2}	10^{-2}	10^{-1}	-	-	-	10^{-2}
	10^{-1}	10^{-1}	10^{-2}	-	-	-	10^{-2}
	10^{-1}	10^{-1}	10^{-1}	10^{-2}	-	-	m
	-	-	-	-	10^{-2}	-	m
	-	-	-	-	-	10^{-2}	m
Accidental Limit State	10^{-4}	10^{-2}	10^{-1}	-	-	-	m*
	10^{-2}	10^{-4}	10^{-1}	-	-	-	m*
	10^{-1}	10^{-1}	10^{-4}	-	-	-	m*
	-	-	-	10^{-4}	-	-	m
	-	-	-	-	-	10^{-4}	m

[a] m - mean water level
m* - mean water level, including the effect of possible storm surge
Seismic response analysis should be carried out for the most critical water level.

Case Study No.1 – Fixed Platform in GoM (Contd.)

- **Proposed Results Comparisons for Case Study**
  - High level global loads comparison for Environmental Extreme Condition (Maximum Overturning Moment and Base Shear)
  - Comparison of Tubular Member Design for the jacket structure, for the following Codes (using identical Environmental Loads)
    - API RP 2A Chapter 3
    - NORSOK N-004 Chapter 6
    - ISO 19902 Chapter 13
  - Comparison of equations and formulas used in Codes

Case Study No. 1 – Loads and Load Combinations

- Environmental Loads for Global Loads Comparison

		API	ISO	Norsok *
Water Depth (Including Surge and Tide)	m	110	110	110
Max Wave Height	m	26.0	24.8	26.0
Max Wave Period	s	13.9	13.2	13.9
Wind Direction (Relative to Wave)	deg	-15	0	0
Avg. Wind Speed	m/s	45.6	46.1	48
Current Direction (Relative to Wave)	deg	15	0	0
Current Speed @ Surface	m/s	1.68	2.1	1.32
Current Speed @ Middle of Profile (Elevation)	m/s (m)	1.46 (32)	1.76 (35)	1.11 (35)
Current Speed @ Bottom of Profile (Elevation)	m/s (m)	0.00 (64)	0.09 (70)	0.00 (70)
Current Speed @ Mudline	m/s	0.00	0.09	0.00

*) Based on API 2INT-MET

Case Study No.1 – Preliminary Comparison Results

- Global loads (Peak Wave Case)

		Max Base Shear		Max Overturning Mom.	
		MN	Phase	MNm	Phase
API	1	97.9	350	2578	340
	2	88.1	350	2132	340
	3	92.8	350	1902	340
	4	88.7	350	2294	340
	5	95.5	0	2793	340
	6	86.5	350	2396	340
	7	93.0	350	2551	340
	8	90.5	350	2574	340
	MAX	**97.9**	-	**2793**	-
ISO	1	100.1	340	2592	340
	2	91.4	350	2067	340
	3	96.4	350	1808	340
	4	89.7	0	2178	340
	5	97.6	0	2665	340
	6	89.9	0	2596	340
	7	96.6	350	2470	340
	8	91.6	350	2521	340
	MAX	**100.1**	-	**2665**	-
Norsok	1	93.0	340	2530	340
	2	84.9	350	2004	340
	3	90.0	350	1894	120
	4	83.5	350	2119	340
	5	90.6	0	2608	340
	6	83.5	350	2533	340
	7	90.1	350	2388	340
	8	85.1	350	2456	340
	MAX	**93.0**	-	**2608**	-

Case Study – Preliminary Comparison Results

- Maximum Member Utilization for API Code Check

		API		Utilization for Corresponding Members			
				ISO		NORSOK	
	Member	UF	Formula	UF	Formula	UF	Formula
1	513	1.33	3.3.4-3	0.93	13.2-31	0.80	6.15
2	505	1.32	3.3.4-3	0.93	13.2-31	0.79	6.15
3	1651	1.31	3.3.4-3	0.90	13.2-31	0.80	6.15
4	1622	1.3	3.3.4-3	0.90	13.2-31	0.80	6.15
5	96	1.26	3.3.3-1	0.81	13.2-31	0.65	6.15
6	158	1.15	3.3.1-4	0.92	13.4-20	0.88	6.50
7	2707	1.14	3.3.3-1	0.62	13.4-12	0.60	6.42
8	350	1.14	3.3.3-1	0.60	13.4-12	0.58	6.42
9	448	1.13	3.3.3-1	0.65	13.4-12	0.64	6.42
10	138	1.13	3.3.1-4	0.91	13.4-20	0.88	6.50
11	662	1.13	3.3.1-4	0.99	13.4-20	0.95	6.50
12	161	1.13	3.3.1-4	0.90	13.4-20	0.86	6.50
13	134	1.12	3.3.1-4	0.89	13.4-20	0.85	6.50
14	55	1.12	3.3.3-1	0.90	13.4-20	0.86	6.50
15	154	1.12	3.3.1-4	0.88	13.4-20	0.84	6.50

Case Study – Preliminary Comparison Results

- Maximum Member Utilization for ISO and Norsok Code Checks

	ISO				NORSOK		
	Member	UF	Formula		Member	UF	Formula
1	740	1.8	13.6-21		740	1.67	6.71
2	462	1.78	13.6-21		462	1.65	6.71
3	1690	1.66	13.6-21		1690	1.54	6.71
4	461	1.63	13.6-21		461	1.51	6.71
5	41	1.36	13.6-21		41	1.23	6.71
6	749	1.28	13.6-21		749	1.19	6.71
7	36	1.24	13.6-21		647	1.14	6.71
8	31	1.24	13.6-21		31	1.13	6.71
9	647	1.23	13.6-21		36	1.13	6.71
10	748	1.19	13.6-21		748	1.1	6.71
11	646	1.18	13.6-21		646	1.09	6.71
12	21	1.14	13.6-21		21	1.05	6.71
13	10	1.12	13.6-21		10	1.02	6.71
14	432	1.05	13.6-21		432	0.97	6.71
15	751	1.04	13.6-21		751	0.96	6.71

Summary

- Reviewed project status
- Case studies selected
- API, NORSOK, and ISO Standards applied to Jacket Case Study Preliminary results presented
- Future tasks
- Next deliverable
- Next Progress GoToMeeting

Further comments

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