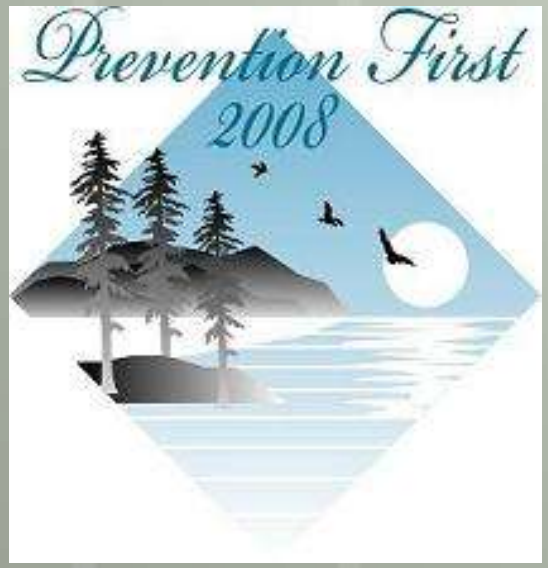
MOTEMS: Critical Issues Resolved and Lessons Learned to Date



Prevention First 2008

September, 2008

Long Beach, CA

Perspective

- First Round of MOTEMS Initial Audit, for “High Risk” Facilities, Completed
- Pier 400, Berth 408 Crude Oil Import Terminal – Putting MOTEMS To The Test
- MOTEMS Has Proven to Be Fairly Robust, But Updates Are Needed

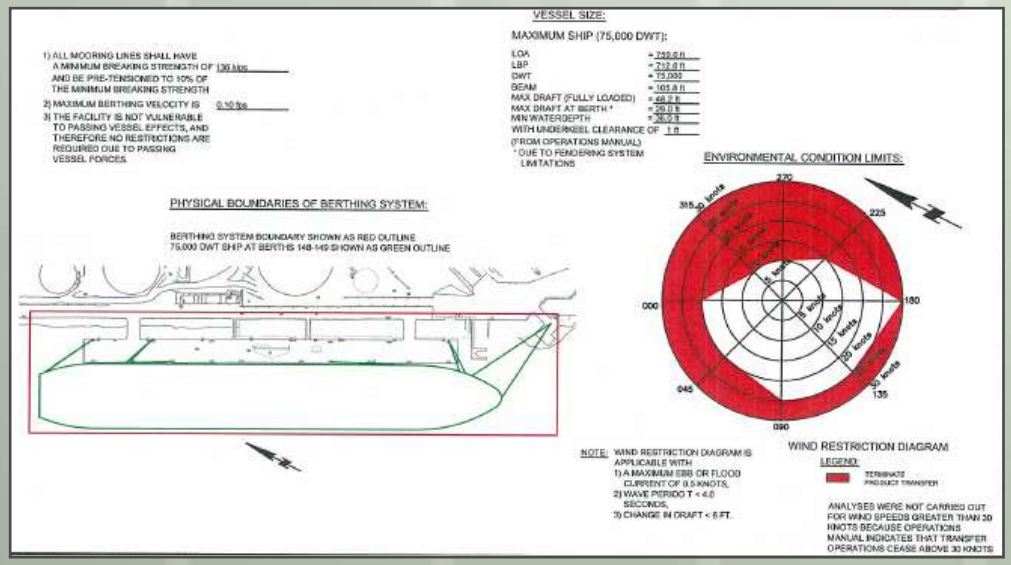
Topics to be Covered

- Audit Submittal Requirements
- Load Factor Updates
- Audit Team Responsibilities, Organization and Qualifications
- Fire Plan Submittal Requirements
- Design of Mooring Hooks and Supporting Structures
- Deck Accelerations for Loading Arm Design
- CARs, AWCARs and UWCARs
- Passing Vessel Analyses and Impact of New Container Ships

Audit Submittal Requirements

Three Primary Elements:

- **Overall Condition Assessment Rating (CAR) for Each Berthing System**
- **Plan for Upgrade Implementation**
  - **“Pre-Conceptual” Design**
  - **Owners Will Likely Require Cost Estimates, But SLC Does Not**
- **Interim Terminal Operating Limits**
  - **Remain in Place Until Improvements Are Implemented**
  - **Can Be Onerous and Controversial**
  - **Limitations May Include:**
    - **Vessel Size**
    - **Draft**
    - **Current Speed**
    - **Wind Speed**
    - **Etc.**



LRFD Load Factor Updates – Division 3

- Driven By Recent Changes to Chapter 6 of ASCE 7 and Corresponding Changes to UFC
- Must Be Aligned With Resistance Factors Which Are Based on ACI 318-05 (Referenced in CBC 2007)
  - Original MOTEMS Document Had Resistance Factors Based on ACI 318-95

ORIGINAL

TABLE 31F-3-12
LRFD LOAD FACTORS FOR LOAD COMBINATIONS [3.13]

Load Type	Vacant Condition	Mooring & Breasting Condition	Berthing Condition	Earthquake Condition
Dead Load (D)	1.4[a]	1.2	1.2	1±k[c]
Live Load (L)	1.7[b]	1.7[b]		
Buoyancy (B)	1.3	1.3	1.3	
Wind on Structure (W)	1.3	1.3	1.0	
Current on Structure (C)	1.3	1.3	1.0	
Earth Pressure on the Structure (H)	1.6	1.6	1.6	1.0
Mooring/Breasting Load (M)		1.3		
Berthing Load (B_e)			1.7	
Earthquake Load (E)				1.0

a. Reduce load factor for dead load (D) to 0.9 to check components for minimum axial load and maximum moment.
b. The load factor for live load (L) may be reduced to 1.3 for the maximum outrigger float load from a truck crane.
c. k = 0.50 (PGA)

PROPOSED

TABLE 31F-3-12
LRFD LOAD FACTORS FOR LOAD COMBINATIONS [3.13]

Load Type	Vacant Condition		Mooring & Breasting Condition	Berthing Condition	Earthquake Condition	
Dead Load (D)	1.2	0.9	1.2	1.2	1+k[a]	1-k[a]
Live Load (L)	1.6		1.6[b]	1.0	1.0	
Buoyancy (B)	1.2	0.9	1.2	1.2	1.2	0.9
Wind on Structure (W)	1.6	1.6	1.6	1.6		
Current on Structure (C)	1.2	0.9	1.2	1.2	1.2	0.9
Earth Pressure on the Structure (H)	1.6	1.6	1.6	1.6	1.0	1.0
Mooring/Breasting Load (M)			1.6			
Berthing Load (B_e)				1.6		
Earthquake Load (E)					1.0	1.0

a. k = 0.50 (PGA)
b. The load factor for live load (L) may be reduced to 1.3 for the maximum outrigger float load from a truck crane.

LRFD Load Factor Updates – Division 3

- Driven By Recent Changes to Chapter 6 of ASCE 7 and Corresponding Changes to UFC
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Wind on Structure (W)	1.3	1.3	1.0	
Current on Structure (C)	1.3	1.3	1.0	
Earth Pressure on the Structure (H)	1.6	1.6	1.6	1.0
Mooring/Breasting Load (M)		1.3		
Berthing Load (B_e)			1.7	
Earthquake Load (E)				1.0

a. Reduce load factor for dead load (D) to 0.9 to check components for minimum axial load and maximum moment.
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PROPOSED

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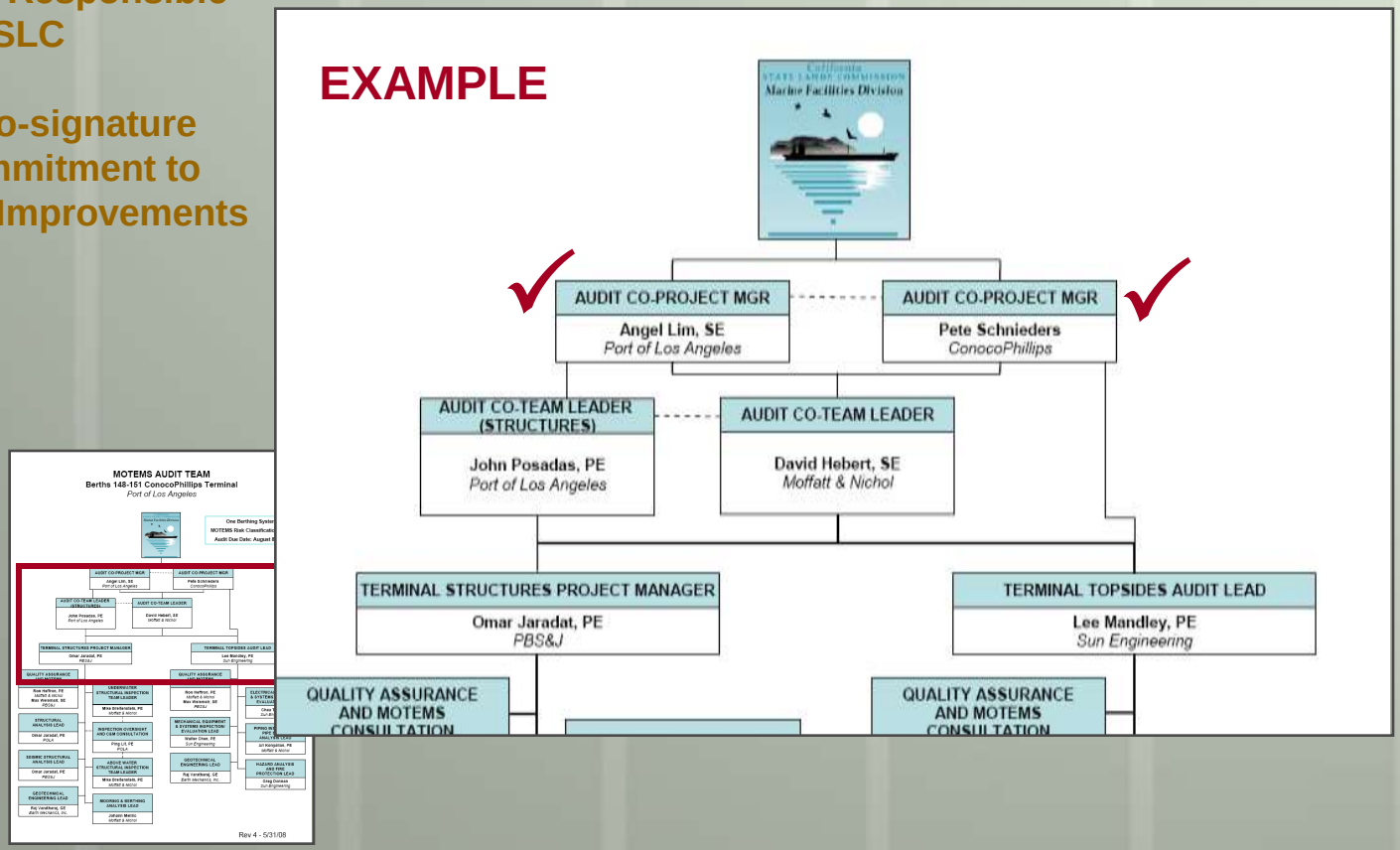
Live Load (L)	1.6		1.6[b]	1.0	1.0	
Buoyancy (B)	1.2	0.9	1.2	1.2	1.2	0.9
Wind on Structure (W)	1.6	1.6	1.6	1.6		
Current on Structure (C)	1.2	0.9	1.2	1.2	1.2	0.9
Earth Pressure on the Structure (H)	1.6	1.6	1.6	1.6	1.0	1.0
Mooring/Breasting Load (M)			1.6			
Berthing Load (B_e)				1.6		
Earthquake Load (E)					1.0	1.0

a. k = 0.50 (PGA)
b. The load factor for live load (L) may be reduced to 1.3 for the maximum outrigger float load from a truck crane.

Audit Team Responsibilities

- **Terminal Operator is Ultimately Responsible for Audit Submittal**
  - **Operator is Responsible Directly to SLC**
  - **Landlord Co-signature Shows Commitment to Implement Improvements**

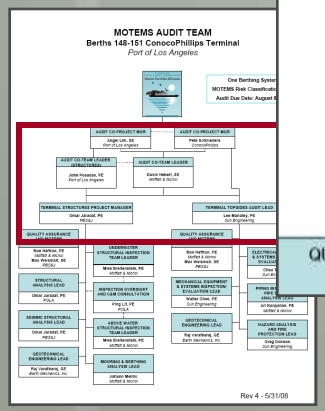


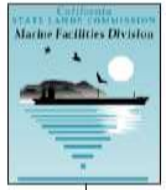
Audit Team Member Roles and Qualifications

- **Terminal Operator Must Provide Audit Project Manager**

3102F.3.4.1 Project Manager. *The Audit shall be conducted by a multi-disciplinary team under the direction of a Project Manager representing the MOT. The Project Manager shall have specific knowledge of the MOT and may serve other roles on the Audit Team.*

EXAMPLE





AUDIT CO-PROJECT MGR
Angel Lim, SE
Port of Los Angeles

AUDIT CO-PROJECT MGR
Pete Schnieders
ConocoPhillips

AUDIT CO-TEAM LEADER (STRUCTURES)
John Posadas, PE
Port of Los Angeles

AUDIT CO-TEAM LEADER
David Hebert, SE
Moffatt & Nichol

TERMINAL STRUCTURES PROJECT MANAGER
Omar Jaradat, PE
PBS&J

TERMINAL TOPSIDES AUDIT LEAD
Lee Mandley, PE
Sun Engineering

QUALITY ASSURANCE AND MOTEMS CONSULTATION

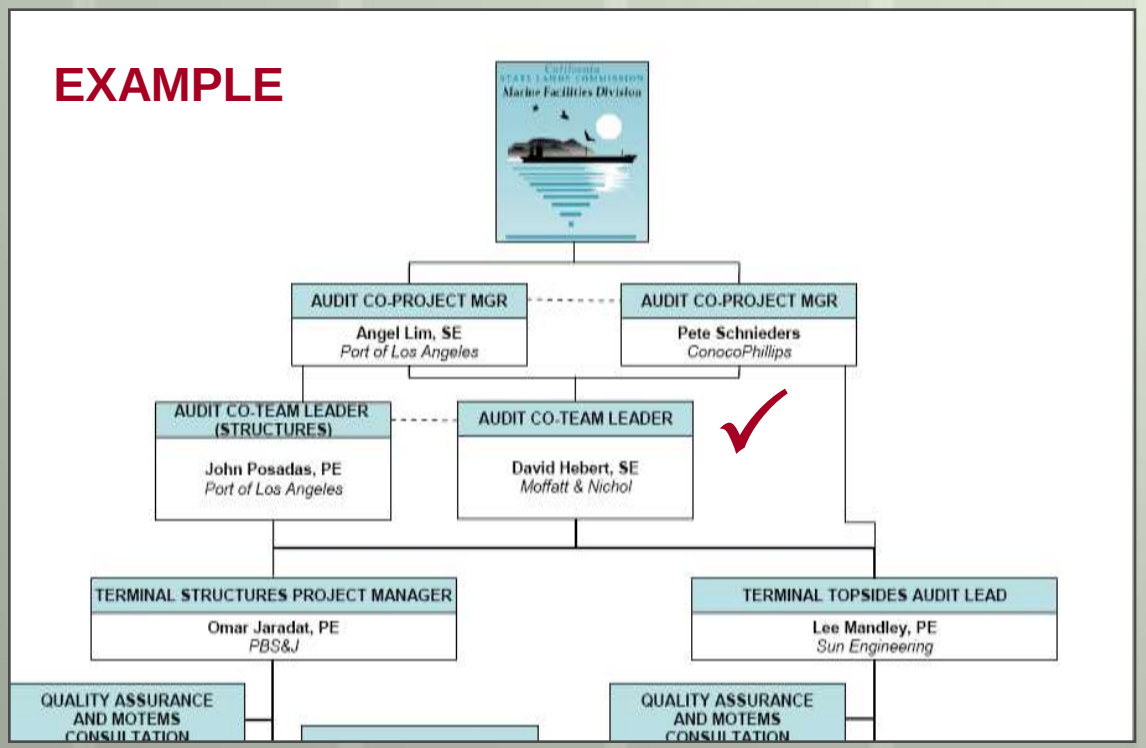
QUALITY ASSURANCE AND MOTEMS CONSULTATION

Audit Team Member Roles and Qualifications

- **Audit Team Leader**
  - Must Lead the On-Site Audit Team and Direct Field Activities
  - Must Lead the Topside Audit Activities Also (Electrical / Mechanical, Fire Protection, Piping)
  - Therefore, Audit Team Leader Must Be Selected By Terminal Operator in Most Cases
  - Orchestrates the Entire Team
  - Responsible for Setting Terminal Operating Limits
  - Stamps Overall Report

3102F.3.4.2 Audit Team Leader. *The Audit Team Leader shall lead the on-site audit team and shall be responsible for directing field activities, including the inspection of all structural, mechanical and electrical systems. The Team Leader shall be a California registered civil or structural engineer and may serve other roles on the audit team.*

EXAMPLE



Audit Team Member Roles and Qualifications

Other Considerations

- Geotechnical
- Structural Lead

EXAMPLE

MOTEMS AUDIT TEAM
Berths 148-151 ConocoPhillips Terminal
Port of Los Angeles

One Berthing System
MOTEMS Risk Classification: High
Audit Due Date: August 8, 2008

- **AUDIT CO-PROJECT MGR** — Angel Lim, SE, *Port of Los Angeles*
- **AUDIT CO-PROJECT MGR** — Pete Schnieders, *ConocoPhillips*
- **AUDIT CO-TEAM LEADER (STRUCTURES)** — John Posadas, PE, *Port of Los Angeles*
- **AUDIT CO-TEAM LEADER** — David Hebert, SE, *Moffatt & Nichol*
- **TERMINAL STRUCTURES PROJECT MANAGER** — Omar Jaradat, PE, *PBS&J*
  - **QUALITY ASSURANCE AND MOTEMS CONSULTATION** — Ron Heffron, PE, *Moffatt & Nichol*; Max Welsmair, SE, *PBS&J*
  - **STRUCTURAL ANALYSIS LEAD** — Omar Jaradat, PE, *POLA*
  - **SEISMIC STRUCTURAL ANALYSIS LEAD** — Omar Jaradat, PE, *PBS&J*
  - **GEOTECHNICAL ENGINEERING LEAD** — Raj Varatharaj, GE, *Earth Mechanics, Inc.*
  - **UNDERWATER STRUCTURAL INSPECTION TEAM LEADER** — Mike Breitenstein, PE, *Moffatt & Nichol*
  - **INSPECTION OVERSIGHT AND C&M CONSULTATION** — Ping Lit, PE, *POLA*
  - **ABOVE WATER STRUCTURAL INSPECTION TEAM LEADER** — Mike Breitenstein, PE, *Moffatt & Nichol*
  - **MOORING & BERTHING ANALYSIS LEAD** — Johann Melilio, *Moffatt & Nichol*
- **TERMINAL TOPSIDES AUDIT LEAD** — Lee Mandley, PE, *Sun Engineering*
  - **QUALITY ASSURANCE AND MOTEMS CONSULTATION** — Ron Heffron, PE, *Moffatt & Nichol*; Max Welsmair, SE, *PBS&J*
  - **MECHANICAL EQUIPMENT & SYSTEMS INSPECTION/ EVALUATION LEAD** — Walter Chen, PE, *Sun Engineering*
  - **GEOTECHNICAL ENGINEERING LEAD** — Raj Varatharaj, GE, *Earth Mechanics, Inc.*
  - **ELECTRICAL EQUIPMENT & SYSTEMS INSPECTION/ EVALUATION LEAD** — Chau Tang, PE, *Sun Engineering*
  - **PIPING INSPECTION & PIPE STRESS ANALYSIS LEAD** — Ari Konyalian, PE, *Moffatt & Nichol*
  - **HAZARD ANALYSIS AND FIRE PROTECTION LEAD** — Greg Donnan, *Sun Engineering*

Rev 4 - 5/31/08

Fire Plan Submittal Requirements

- **MOTEMS-Compliant Fire Plan Must Be Submitted With Audit**
  - Cannot Simply Review Existing and Point Out Deficiencies
  - Must Include a MOTEMS-Compliant Hazard Analysis and Risk Assessment
  - Fire Plan Should be Considered a Draft, Subject to Regulatory Review
- **What to do When Existing Fire Plan is Part of an Integrated Emergency Response Plan**
  - Update the Integrated Emergency Response Plan ✓
  - Prepare New Stand-Alone Fire Plan X
  - Prepare New Stand-Alone Fire Plan and Then Update the Integrated ERP ✓
- **Audit Submittal Requirements if There is an Integrated ERP**
  - Submit Hazard Analysis and Risk Assessment
  - Brief Report Describing Changes Required to be MOTEMS-Compliant
  - Draft Changes to Relevant Sections - Don't Submit the Entire ERP

Design of Mooring Hooks & Supporting Structures

- **Design Procedure:**
  - **Design Using Formula 3-21**
    - Based on Capacity and Number of Lines
    - Use Resistance Factor of 1.0 for Structural Materials
    - Use Resistance Factor of 0.90 for Geotechnical Parameters
  - **Check Using Actual Loads and LRFD Load Combination**

PROPOSED

3103F.10 Mooring Line Hooks and Support Structure Loading. *All hooks and supporting structures for both new and existing MOTs shall withstand the minimum breaking load (MBL) of the strongest line with a Safety Factor of 1.2 or greater. Only one mooring line shall be placed on each quick release hook. For multiple quick release hooks, the minimum horizontal load for the design of the tie-down shall be:*

$$Fd = 1.2 \times MBL \times [1 + 0.75 (n-1)] \qquad (3\text{-}21)$$

Fd = Minimum horizontal load for assembly tie-down

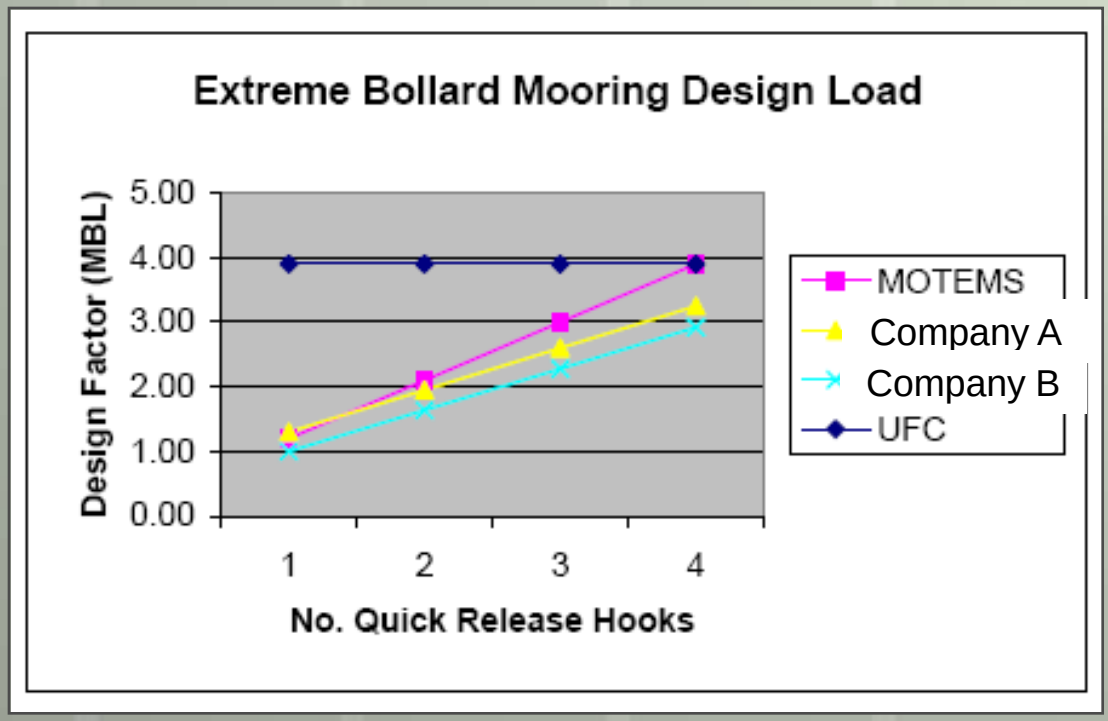
n = Number of hooks on the assembly.

This load shall be applied with a resistance factor of 1.0 on structural materials and 0.9 on geotechnical parameters.

The hooks and supporting structure shall also withstand the LRFD load combinations defined in Table 31F-3-12.

Design of Mooring Hooks & Supporting Structures

- **How Does Proposed New Formula Compare to Current Industry Practice?**



Loading Arm Design Criteria

Three Methods Proposed for Seismic Design of Loading Arms

- **Time History Analysis** — **Most Accurate**
  - Seismic Model of Structure
  - Deck Acceleration RS From Model
- **Response Spectrum Analysis** — **Direct**
  - RS Seismic Model of Structure
  - Peak Deck Acceleration From Model
- **MOTEMS / FEMA Method** — **Indirect**
  - Formula Referenced from MOTEMS
  - Section 3110F.8 References Sect. 6.2 of FEMA 368
  - Now Sect. 6.2 of FEMA 450 (same formula)

Loading Arm Design Criteria

- **MOTEMS / FEMA Method**

$$F_p = \frac{0.4 a_p S_{DS} W_p}{R_p / I_p}\left(1 + 2\frac{z}{h}\right)$$

Where:
- a_p = Component amplification factor (= 2.5 for Cantilever Elements unbraced or braced below their centers of mass)
- S_{DS} = Short period spectral acceleration parameter (used in construction of 2/3*MCE spectra; for site-specific spectra this is equivalent to the peak short period spectral acceleration)
- W_p = Operating weight of a nonstructural component
- R_p = Component response modification factor (=2.5 for Cantilever Elements unbraced or braced below their centers of mass)
- I_p = Component importance factor (=1.5 since failure could impair the continued operation of the facility)
- z = Height above the base of the point of attachment of the component (= 0 for loading arm base)
- h = Average roof height of structure above the base

The value of F_p divided by the operating weight, W_p, gives an equivalent acceleration. This value will be compared to the peak acceleration value from the response spectrum analysis for confirmation of the adequacy of F_p.

Loading Arm Design Criteria

Three Methods Proposed for Seismic Design of Loading Arms

CHOOSE ONE

- Time History Analysis — Most Accurate
  - Seismic Model of Structure
  - Deck Acceleration RS From Model
- Response Spectrum Analysis — Direct
  - RS Seismic Model of Structure
  - Peak Deck Acceleration From Model

- MOTEMS / FEMA Method — Indirect
  - Formula Referenced from MOTEMS
  - Section 3110F.8 References Sect. 6.2 of FEMA 368
  - Now Sect. 6.2 of FEMA 450 (same formula)

CHECK

CARs, AWCARs and UWCARs

- **Assigning CARs**
  - **Consider Operational Loads Only, Not Seismic**

TABLE 31F-2-5

CONDITION ASSESSMENT RATINGS (CAR) [2.3]

Rating		Description of Structural Systems, Above and Below Water Line
6	Good	No problems or only minor problems noted. Structural elements may show very minor deterioration, but no overstressing observed. The capacity of the structure meets the requirements of this standard. The structure should be considered fit-for-purpose. No repairs or upgrades are required.
5	Satisfactory	Limited minor to moderate defects or deterioration observed, but no overstressing observed. The capacity of the structure meets the requirements of this standard. The structure should be considered fit-for-purpose. No repairs or upgrades are required.
4	Fair	All primary structural elements are sound; but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present, but do not significantly reduce the load bearing capacity of the structure. The capacity of the structure is no more than 15 percent below the structural requirements of this standard, as determined from an engineering evaluation. The structure should be considered as marginal. Repair and/or upgrade measures may be required to remain operational. Facility may remain operational provided a plan and schedule for remedial action is presented to and accepted by the Division.
3	Poor	Advanced deterioration or overstressing observed on widespread portions of the structure, but does not significantly reduce the load bearing capacity of the structure. The capacity of the structure is no more than 25 percent below the structural requirements of this standard, as determined from an engineering evaluation. The structure is not fit-for-purpose. Repair and/or upgrade measures may be required to remain operational. The facility may be allowed to remain operational on a restricted or contingency basis until the deficiencies are corrected, provided a plan and schedule for such work is presented to and accepted by the Division.
2	Serious	Advanced deterioration, overstressing or breakage may have significantly affected the load bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. The capacity of the structure is more than 25 percent below than the structural requirements of this standard, as determined from an engineering evaluation. The structure is not fit-for-purpose. Repairs and/or upgrade measures may be required to remain operational. The facility may be allowed to remain operational on a restricted basis until the deficiencies are corrected, provided a plan and schedule for such work is presented to and accepted by the Division.
1	Critical	Very advanced deterioration, overstressing or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur and load restrictions should be implemented as necessary. The capacity of the structure is critically deficient relative to the structural requirements of this standard. The structure is not fit-for-purpose. The facility shall cease operations until deficiencies are corrected and accepted by the Division.

CARs, AWCARs and UWCARs

- AWCARs and UWCARs
  - Interim Ratings Prior to Structural Evaluation

3102F.3.6.3 Structure

PROPOSED

A structural evaluation, including a seismic analysis, shall be performed in accordance with Sections 3103F through 3107F. Such evaluations shall consider local or global reduction in capacity, as determined from an inspection.

Based on inspection results, structural analyses and engineering judgment, a CAR shall be assigned on a global basis, to the structural portion of the Berthing System. Until seismic upgrades have been implemented following the Initial Audit, only operational loads (no seismic) shall be considered when assigning the overall CAR. The CARs defined in Table 31F-2-5 shall be used for this purpose. The CAR documents the structural fitness-for-purpose. The assigned ratings shall remain in effect until all the significant corrective action has been completed to the satisfaction of the Division, or until completion of the next Audit.

In addition to the global CAR assigned to the structural portion of the berthing system, each independent structural unit (platform, dolphin, wharf, etc.) comprising the berthing system shall be assigned an Above Water Condition Assessment Rating (AWCAR) and an Underwater Condition Assessment Rating (UWCAR). The AWCARs and UWCARs defined in Table 31F-2-5A shall be used for this purpose. The AWCARs and UWCARs shall reflect the condition of the structure relative to its "as-constructed" condition.

TABLE 31F-2-5A
ABOVE WATER CONDITION ASSESSMENT RATINGS (AWCAR) AND UNDERWATER CONDITION ASSESSMENT RATINGS (UWCAR) [2.3]

Rating		Description of Structural Systems Above or Below Water Line
6	Good	No problems or only minor problems noted. Structural elements may show very minor deterioration, but no overstressing observed. The capacity of the structure meets the requirements of this standard. No repairs or upgrades are required.
5	Satisfactory	Limited minor to moderate defects or deterioration observed, but not overstressing observed. The capacity of the structure meets the requirements of this standard. No repairs or upgrades are required in the near-term.
4	Fair	All primary structural elements are sound; but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present, but do not significantly reduce the load bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.
3	Poor	Advanced deterioration or overstressing observed on widespread portions of the structure, but does not significantly reduce the load bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
2	Serious	Advanced deterioration, overstressing or breakage may have significantly affected the load bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high priority basis with urgency.
1	Critical	Very advanced deterioration, overstressing or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high priority basis with strong urgency.

Cargo Liquid Hazard Classification

- **Errata**

TABLE 31F-8-1

CARGO LIQUID HAZARD CLASS

Class	Criterion	Reference	Examples
Low (L_c)	Flash Point ≥ 140°F	ISGOTT (Chapter 15, [8.4]) – Non-Volatile	#6 Heavy Fuel Oil, residuals, bunker
High (H_c)	Flash Point <140°F	ISGOTT (Chapter 15, [8.4]) – Volatile	Gasoline, JP4, crude oils

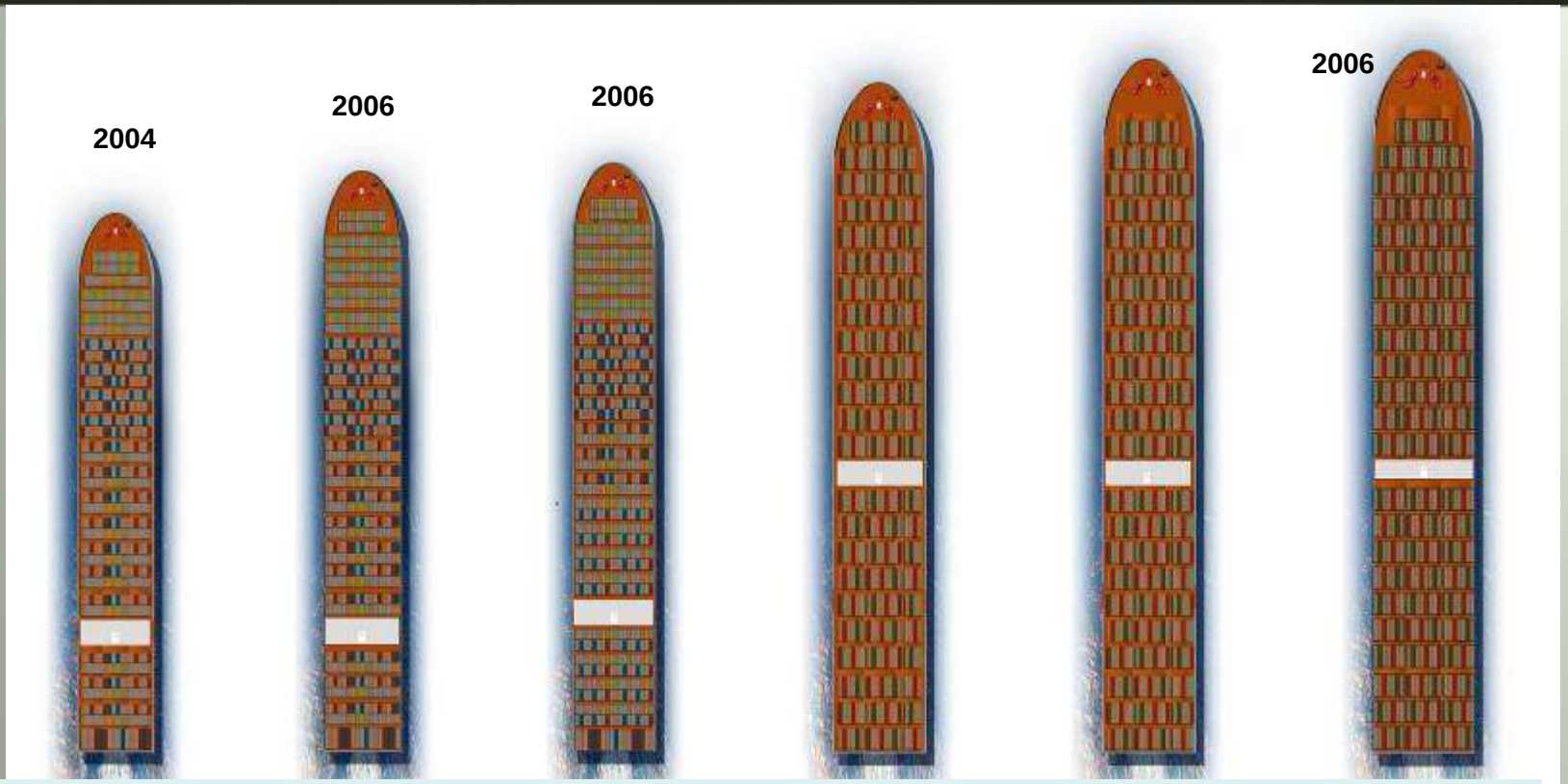
PROPOSED

TABLE 31F-8-1

CARGO LIQUID HAZARD CLASS

Class	Criterion	Reference	Examples
Low (L_c)	Flash Point < 140°F	ISGOTT (Chapter 15, [8.4]) – Non-Volatile	#6 Heavy Fuel Oil, residuals, bunker
High (H_c)	Flash Point ≥ 140°F	ISGOTT (Chapter 15, [8.4]) – Volatile	Gasoline, JP4, crude oils

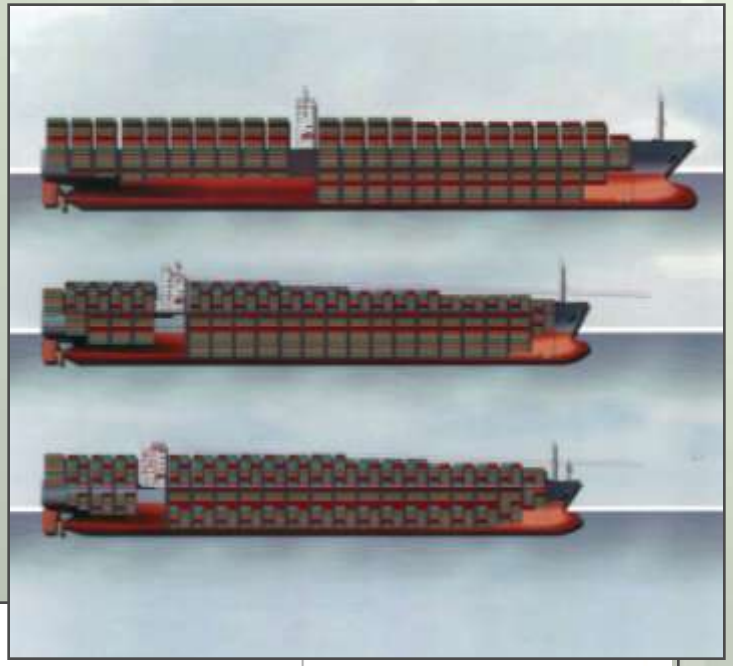
Passing Vessel Analyses and New Container Ships

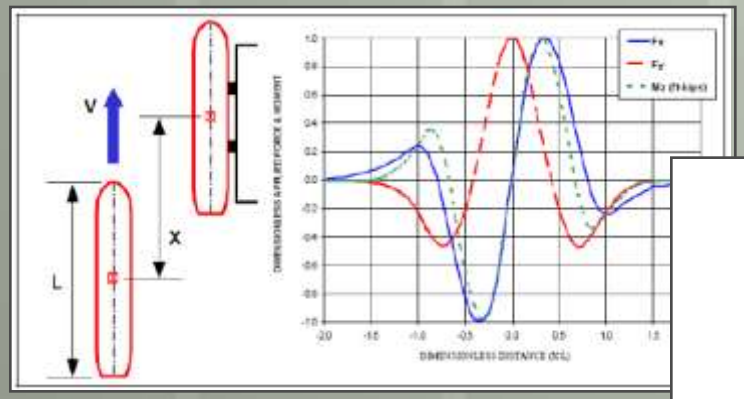


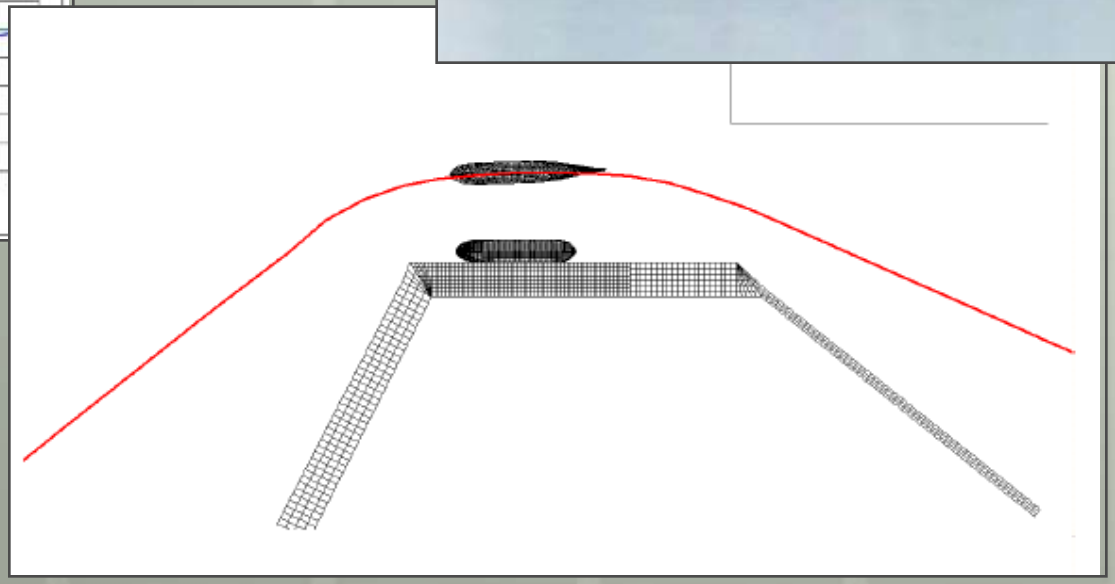
	6,000 TEU	8,000 TEU	10,000 TEU	10,000-12,000 TEU	12,000 TEU	14,000 TEU
AN. SHIP CALLS		>200				
LENGTH	985	1089’	1150’	1265’	??	1302’
BEAM	134	142’	150’	180’	??	184’
BOXES	16	19	18	22	??	22
DRAFT	47’	49’	49’	50’	??	51’
		MSC HEIDI	XIN LOS ANGELES	NEW PANAMAX	SUEZMAX	MAERSK EMMA

Passing Vessel Analyses and New Container Ships

- PassMoor
- DELPass



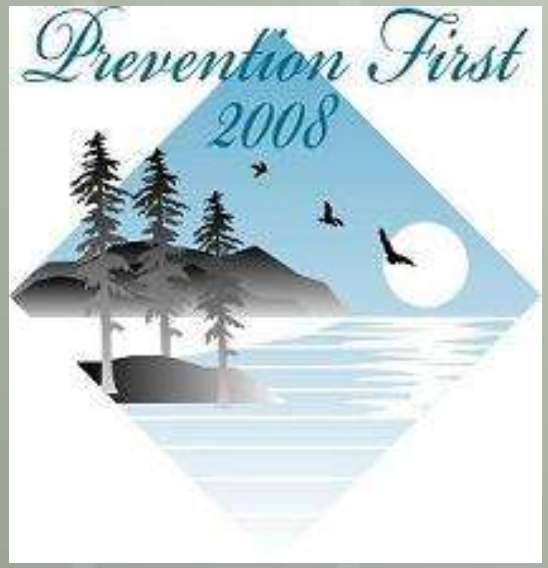




Conclusions

- Ideas Presented Herein Are DRAFTS
- All Proposed Changes Are Welcome
- SLC Intends to Meet Soon to Resolve Issues
- Update to MOTEMS is Pending

MOTEMS: Critical Issues Resolved and Lessons Learned to Date



Questions?

rheffron@moffattnichol.com