Traffic Interactions with Moored Vessels – Best Practices for Safe Operations

Representing SNAME Panel H-10

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Presentation Outline

• Risk Concerns
• How is Mooring Done Now
• Mooring Problem Trends
• Applying Technology to Better Analyze
• Operational Practices
• Developing Best Practices Guideline
• Research to Close Gaps
Are Passing Ship Effects on Mooring Important?

- **NY Harbor Safety Committee Risk Analysis Subcommittee contacts H-10**
  - Experts in ship handling
  - Wanted more technical knowledge

- **CA State Lands – Concern for pollution at terminals in Long Beach & San Francisco Bay**

- **Houston Harbor Safety Committee**
  - RFP to study problem docks
  - Issued warning about larger vessels arriving following project completion - Now it is reality

- **Water’s Study > 50 “Breakaways” (1991-2001) due to passing vessels**
Passing Ship Effects are Important
Vopak Terminal, Houston, TX
Recent Concerns – LNG Terminal Safety

Elba Island LNG Terminal

River is no racetrack
Sunday, December 24, 2006
SavannaNow.com

Cameron LNG Terminal

Part II: Lake Charles Cameron LNG Terminal: Model for Success or Recipe for Disaster?
MAR Ex Newsletter
Moored Ship Breakaways

• The most serious accident led to a tanker fire and total ship loss
Recent Conferences

- Oct. 2002, Interagency Vessel Effects Workshop, Gulfport, Mississippi
- May 2004, ASCE PORTS 2004, Houston, TX
  - Quite a number of papers focused on the effects of passing ships on moored ships
Mooring – the securing of a vessel to shore with lines and anchors to restrain its fore, aft, and rotational movement.
Very Complex Process

- Wind forces
- Current forces
- Tidal forces
- Forces from passing of large ships
- Forces from smaller high speed vessels
Compute Surge, Sway, and Yaw Acting on Moored Ship

- Wind
- Current
- Tide
- Large ship passing
- High speed ship passing
Typical Mooring Systems
How is Mooring Done?

- Ship owner determines size of lines to be used
- Analysis usually done to help determine forces
- Terminals often have their own requirements
- Mariner learns procedures and does the tying up
- Moorings are monitored and adjusted to prevent slack
Science and Technology

- Mooring Force Analyses
- Hydrodynamic Forces from Passing Vessels
- Measurement of Line Forces and Ship motions
- Use of Computational Fluid Dynamics in Advanced Analyses
- Improved Measurement of Hydrodynamic Forces
Hydrodynamics of Passing Ship Effects
Translate Ship Forces and Moments to Mooring Line Forces
Key Factors Influencing Forces
Dynamic Passing Vessel Impacts on Berthed Vessels

Large mass of ship combined with even small motions can result in very large forces.

Berthed Vessel Motion

Mooring Line Loads
Static vs. Dynamic Ship Forces at 1.5xB

Case 5: 4 knots, 5% pretension

Case 6: 4 knots, 10% pretension

Case 7: 8 knots, 5% pretension

Case 8: 8 knots: 10% pretension
Static vs. Dynamic Line Loads at 1.5xB

Case 5: 4 knots, 5% pretension

Case 6: 4 knots, 10% pretension

Case 7: 8 knots, 5% pretension

Case 8: 8 knots, 10% pretension
Models are Available

• **Commercial Analysis Tools**
  – Ship-Generated Hydrodynamics (SGH)-PI Engineering > MOSES
  – OPTIMOOOR - Tension Technology
  – AQWA - WS Atkins
  – Ship-Moorings-Alkyon
  – HYDROPASS/TERMSIM

• **Government Analysis Tools**
  – E-MOOR, FIXMOOR, PASS-MOOR
CFD Research Shows Need for Improved Models on Passing Effects

- Passing effects are not a simple function of speed squared
- Effect of lateral separation distance is not just a Bernoulli effect function
- Modeled multiple ship passings is not just a linear superposition of single ship passing effects
- Effect of crab angle of passing ships is not modeled
Proposed Initial Research Effort

- **Best Practices for Harbor Safety Committees**
  - Work with pilots and ship operators
  - Gather Existing Guidelines and Practices
  - Note experienced guideline shortcomings
  - Identify Responsibilities
  - Needed Measurements to Develop Empirical Guideline
  - Publish “Best Practices” Report
Additional Proposed Research

- Prototype Measurements
- Systematic Test Program
  - Expand Knowledge of all factors including:
    - Line pretensioning
    - Type of Bottom
    - Type of berth
    - Orientation of berth to passing ship traffic
    - Multiple passing events
Conclusions & Summary

- Operational concern about mooring issues
- Need to identify “best practices” for Harbor Safety Committees
- Need better understanding of physical phenomenon & improved models
- Gather prototype measurements to validate models
Discussion/Questions?
Art or Science?

Have come a long way but best operational practices and exploring of gaps is needed