RISK MITIGATION OF LNG SHIP DAMAGE FROM LARGE SPILLS

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Fire testing and analysis results

- LNG fires surface emissive powers on water of 280-290 kW/m²
- These temperatures can significantly reduce LNG ship structural steel strength
- Tests show flames will likely anchor to ship structure
- Typical crosswinds can make LNG fire and thermal radiation impact top and large portions of LNG ships
Cryogenic damage testing and analysis results

- LNG known to cause brittle fracture of ship deck plates, testing shows all ship steels vulnerable to fracture
- About 40% of LNG spilled from a large cargo tank breach can stay within the ship
- LNG can flow into many areas between individual cargo tank cofferdams
- Testing shows fractures likely to occur in all structural elements that come in contact with LNG
LNG Safety Research
Cascading Damage Issues and Concerns

- LNG cryogenic and fire cascading damage results
  - Cryogenic fracture and damage will occur as flow progresses and the structural elements cool
  - Fire weakening of the ship structure begins following a spill once the fire stabilizes
  - Damage to an LNG ship from a large spill could be significant
  - Damage identified from large spills would force a ship safety assessment
External Peer Review Panel suggested and identified more detailed and more advanced risk mitigation and safety management procedures for marine LNG operations based on cascading damage testing and analysis results, with suggestions from:

- Chris Zerby, FERC
- John Moorhouse, British Gas (ret.)
- John Dasch, DNV Houston
- Jim Rawers, DOE
- Nick Carron and Charles Rawson, USCG
- Prof. Stan Rolfe, Univ. of Kansas
- Tony Galt, Freeport LNG
- Roger Roue, SIGTTO

SIGTTO Industry Review Panel
Suggested risk management approaches that could be implemented to reduce the likelihood of a large spill:

- Elimination of other than ‘cleared’ marine traffic during marine LNG operations or while at berth,
- Review of the suitability of LNG tanker escorts to improve protection effectiveness and provide active interdiction,
- Enhance operations to improve offshore LNG protection from potential large breach events through enhanced operational awareness, monitoring, and consideration of active and passive protection and interdiction approaches and technologies,
- Provide enhanced standoff systems and protection for LNG ships
  - During transit near populated areas could be problematic
  - Both passive and active systems can be more easily integrated into terminal safety and security capabilities
  - Have to consider safety issues to the ship and crew for any implemented security approaches
Suggested risk management approaches that could be implemented to reduce ship damage and hazards to the public:

- Make sure emergency response plans include procedures for maneuvering the LNG ship to safe anchorage or grounding to monitor, inspect, and assess damage and needs including lightering,

- Utilization of water in ship ballast tanks to minimize ship damage, but availability will be site-specific

- Consider high performance fire fighting capability – either tugs with 7000 m³ to 11000 m³ per hour (30,000 – 50,000 gallons per minute) monitor capacity or similar monitors at terminal jetty - to reduce the thermal and structural damage and protect crews

- Establish lightering procedures and capabilities for marine LNG imports for near-shore terminals and operations,
  - Will be weather and site-specific and require hoses, equipment, etc.
  - Lightering would be a likely requirement for a large spill and capabilities should be developed
Suggested ship risk management approaches that could be implemented through LNG ship crew safety modifications:

- Add lightweight fire insulation on cargo tank covers or fire retardant paint
  - Will require extensive testing and evaluation of ship stability impacts
- Modifications of deluge systems to improve coverage of cargo tanks, lifeboats, and/or crew muster areas,
  - Will require extensive modifications to ship and IGC code
  - Possible options could be in foc’sle space and escape locations - to better protect ship and crew for safe evacuation
- Reduce connectivity of void spaces, etc. to reduce ability of LNG to flow inside the ship
  - Retrofits and new construction options would have to consider the potential safety issues
- Provide breathing systems for crew safety during a large fire – already being considered