

17th INTERNATIONAL CONFERENCE & EXHIBITION ON LIQUEFIED NATURAL GAS (LNG 17)



RISK MITIGATION OF LNG SHIP DAMAGE FROM LARGE SPILLS

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International Organizers



Host Association





DOE LNG Safety Research Program

Focus Areas Based on GAO Research Priorities

Research Priorities (High to Low)	Original Efforts	Expanded Efforts
Large fire phenomena		x
Large scale spill testing		x
Cascading damage testing		x
Comprehensive modeling: interaction of physical processes		x
Risk tolerability assessments	x	Revalidated from previous studies
Vulnerability of cargo tanks (hole sizes in large ships)	x	Revalidated from previous studies
Mitigation techniques		x
Effects of water coming in as LNG flows out		x
Impact of wind, environmental conditions, and waves		x

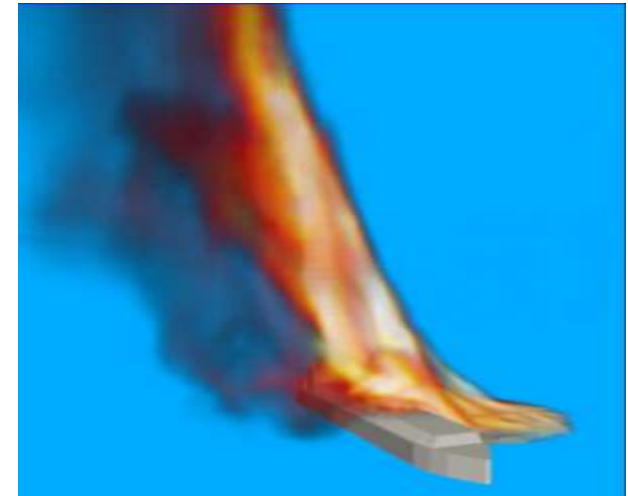
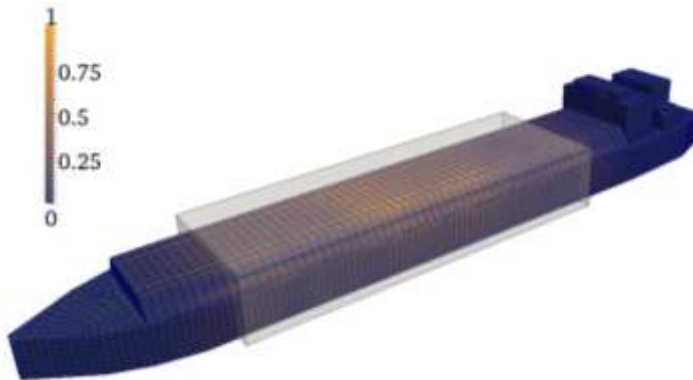
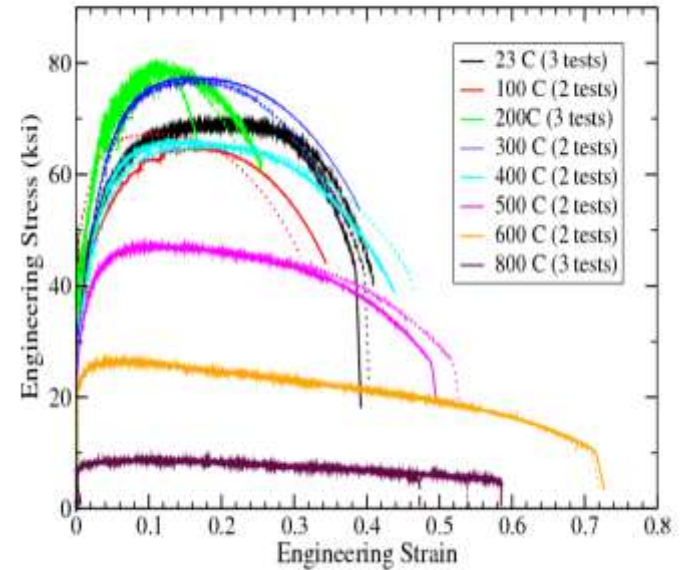


LNG Safety Research

LNG Ship Damage Concerns from Fires

➤ 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

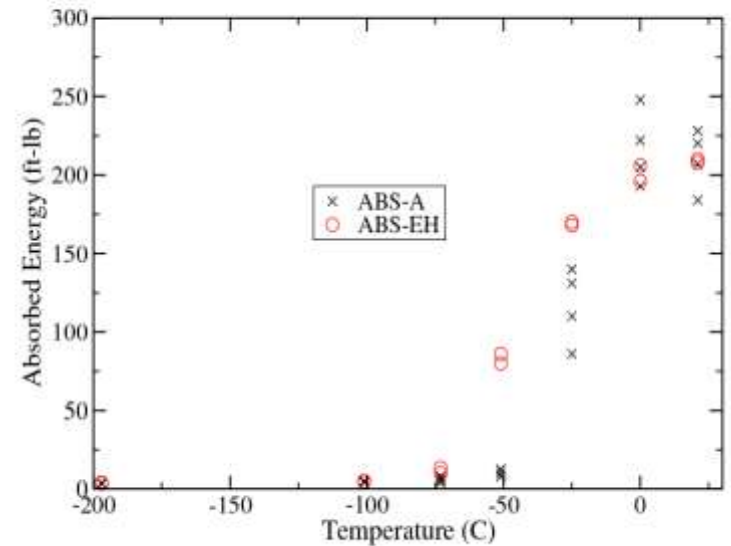
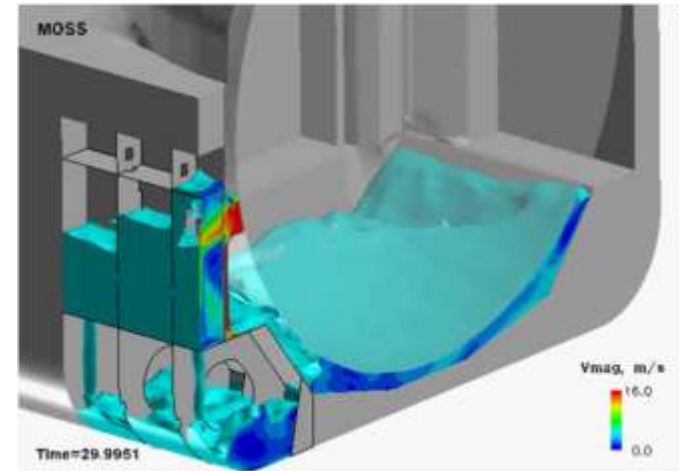




LNG Safety Research

LNG Ship Cryogenic Damage Concerns from Spills

- **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



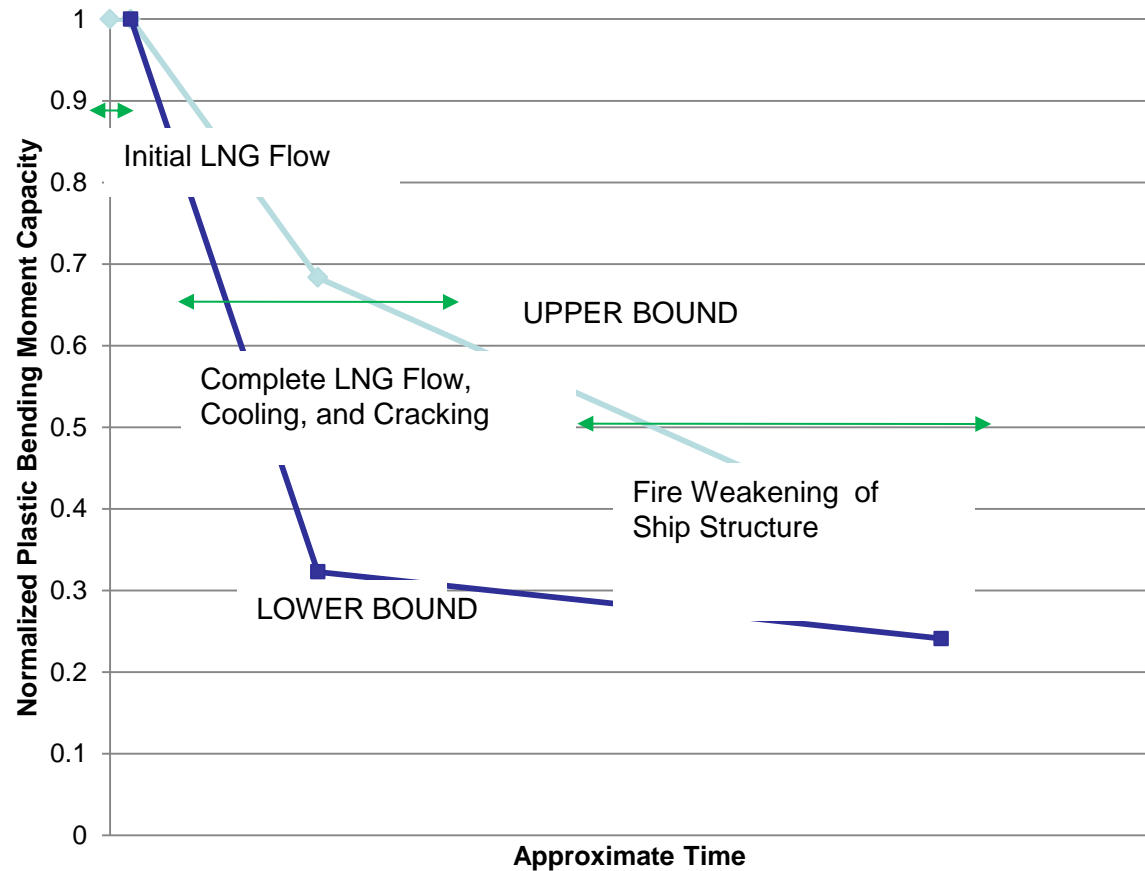


LNG Safety Research

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





Risk Mitigation and Risk Management Discussions

- **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:**
- **External Peer Review Panel:**
 - 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**



Risk Mitigation and Risk Management to Reduce Likelihood of Large Spills

- **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**



Risk Mitigation and Risk Management to Reduce Damage and Hazards from Spills

- **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**



Risk Mitigation and Risk Management LNG Ship and Crew Safety Modifications

- **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**