Risk Assessment/Hazards for Deep Water Port LNG Receiving Terminals

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Presentation Overview

- Overview of general hazards and risk analysis for large LNG spills over water
- Guidance on site-specific hazards and risk management approach
- Considerations and scale of results for
  - near-shore and off-shore systems
  - large LNG vessels, Deep Water Port storage and regasification systems
Use of Guidance
Information and Results

• The information and results presented are intended to be used as guidance for conducting site-specific hazard and risk analyses.

• The results are not intended to be used prescriptively, but rather as a guide for using performance-based approaches to analyze and responsibly manage risks to the public and property from potential LNG spills over water.
Key Features Impacting Possible LNG Carrier Spills

If Ignition Occurs

- Wind Tilts Fire
- Thermal Damage Due to Fire
- Other possible hazards
  - Fireball
  - Late ignition and vapor cloud fire

Analysis Requires Adequate Representation of Key Features
• Identify “scale” of hazards from an LNG spill over water

• Provide direction on use of hazard analysis techniques

• Provide direction on use of risk management to improve public safety

• Provide process for site-specific evaluations
Risk-based Assessment Approach for LNG Spills over Water

Risk = \( P_A \times (1-P_E) \times C \)

- Characterize Facilities
- Define Threats \( P_A \)
- Determine Consequences
- Define Safeguards \( P_E \)
- Analyze System \( R \)
- Sufficient Protection? Y/N

Make Changes & Reassess

End Until Change
Chapter 6 of the report provides guidance on assessing LNG terminal safety and security concerns:

- Site-specific conditions to consider
  - location, environmental conditions, proximity to infrastructures or residential or commercial areas, and available resources

- Site-specific threats to evaluate

- Cooperating with stakeholders, public safety, and public officials to identify site-specific “protection goals”

- Appropriate modeling and analysis approaches for a given site, conditions, and operations

- System safeguards and protective measures to consider

- Identification of approaches to manage risks, through prevention and mitigation, enhancing energy reliability and the safety of people and property
Common Deep Water Port Concepts

Off-shore floating buoy, with LNG carrier-based LNG regasification into pipeline

Off-shore terminal-based storage and LNG regasification into pipeline
## Growing size of LNG Vessels and Terminals

<table>
<thead>
<tr>
<th>Class</th>
<th>145,000m³</th>
<th>155,000m³</th>
<th>215,000m³</th>
<th>260,000m³</th>
<th>300,000m³ Terminal</th>
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<td>5</td>
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<td>2-3</td>
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<td>12 m</td>
<td>12.5 m</td>
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Differences in Facilities Impact Hazards and Energy Delivery Issues

- **Near-shore, On-shore**
  - Traffic control, safety zones, escorts to enforce
  - Smaller threats but closer to people, infrastructure
  - Smaller LNG ships – smaller LNG tanks, less standoff, older designs and safety features
  - Allows LNG storage

- **Off-shore – Deep Water Ports**
  - Limited traffic control or enforcement
  - Larger threats but further from public
  - Larger ships – more LNG, more standoff, new designs and safety features
  - Deliver to public as natural gas

- **Combinations**
  - Large vessels near-shore, small regasification vessels off-shore
Behavior of LNG Pool Fires

- Burn rate controls pool area and flame height
- Flame height decreases as pool diameter increases, with transition at very large diameters
- Hydrocarbons produce smoke, but production unknown for LNG pool fires >35 m diameter
- Lower flame height and smoke shielding combine to reduce the radiative heat flux levels for large spills
# Potential Thermal Hazards for Spills from Common LNG Vessels

<table>
<thead>
<tr>
<th>HOLE SIZE (m²)</th>
<th>TANKS BREACHED</th>
<th>DISCHARGE COEFFICIENT</th>
<th>BURN RATE (m/s)</th>
<th>SURFACE EMISSIVE POWER (kW/m²)</th>
<th>POOL DIAMETER (m)</th>
<th>BURN TIME (min)</th>
<th>DISTANCE TO 37.5 kW/m² (m)</th>
<th>DISTANCE TO 5 kW/m² (m)</th>
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<tbody>
<tr>
<td><strong>ACCIDENTAL EVENTS</strong></td>
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<tr>
<td>1</td>
<td>1</td>
<td>3x10⁻⁴</td>
<td>220</td>
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<tr>
<td><strong>INTENTIONAL EVENTS</strong></td>
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<td>3</td>
<td>6</td>
<td>3 x 10⁻⁴</td>
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<td>572</td>
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<td>6</td>
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<td>512</td>
<td>3.4</td>
<td>602</td>
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</table>

*Nominal case: Expected outcomes of a potential breach and thermal hazards based on credible threats, best available experimental data, and nominal environmental conditions for a common LNG vessel.*
Potential Dispersion Hazards for Spills from Common LNG Vessels

<table>
<thead>
<tr>
<th>HOLE SIZE (m²)</th>
<th>TANKS BREACHED</th>
<th>POOL DIAMETER (m)</th>
<th>SPILL DURATION (min)</th>
<th>DISTANCE TO LFL (m)</th>
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</thead>
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<tr>
<td><strong>Accidental Events</strong></td>
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<td><strong>Intentional Events</strong></td>
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Dispersion distances are limited by closest ignition source.

Wind direction

Vapor cloud

LNG pool

Heat transfer from water to LNG pool

Qualitative gas concentration contours

Water

Side View

Top View

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Use of Risk and Safety Guidance to Evaluate LNG DWP Terminals

Assessing LNG DWP terminal safety and security concerns:

• Site-specific conditions to consider
  • location, environmental conditions, proximity to shipping lanes, fishing areas and recreation areas, and available protection resources

• Site-specific threats — large maritime ships, ease of access

• Identify “protection goals” — on-shore public, shipping, fishing, boating and recreation

• Appropriate modeling and analysis approaches for a given site, conditions, and operations

• System safeguards and protective measures available or can be incorporated

• Identification of approaches to manage risks to enhance energy reliability and safety of people and property
Potential Thermal Hazards From Large LNG Vessels or DWP– 200,000m$^3$ spill
Potential Dispersion Distances From Large LNG Vessels or DWP– 200,000m³ spill

Lower Flammability Limit for methane is 5%
LNG DWP Large Spill
Risk and Hazard Conclusions

- Site-specific analysis of threats, conditions, and protection goals are always needed
- Existing consequence analysis methods are generally conservative for large spills
  - Use for screening, coordination of risk management approaches
  - Use to look at possible range of hazards
- The scale of the hazards to the public from a large LNG DWP spill is ~ 2 miles for fire and ~ 3-4 miles for a vapor dispersion
- Risk management approaches should be used to balance hazards and public protection