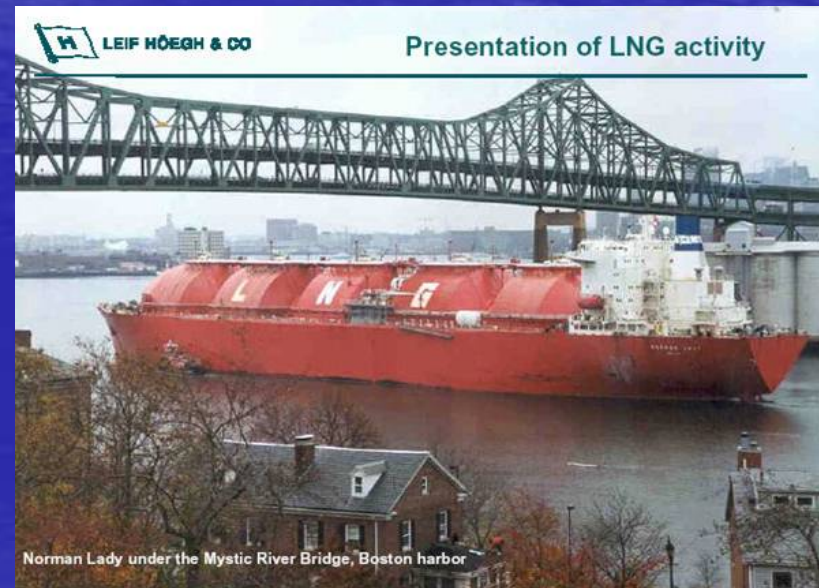


# Safety Exclusion Zones for LNG Import Terminals

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Chemical Hazards Research Center  
University of Arkansas



# LNG Hazards

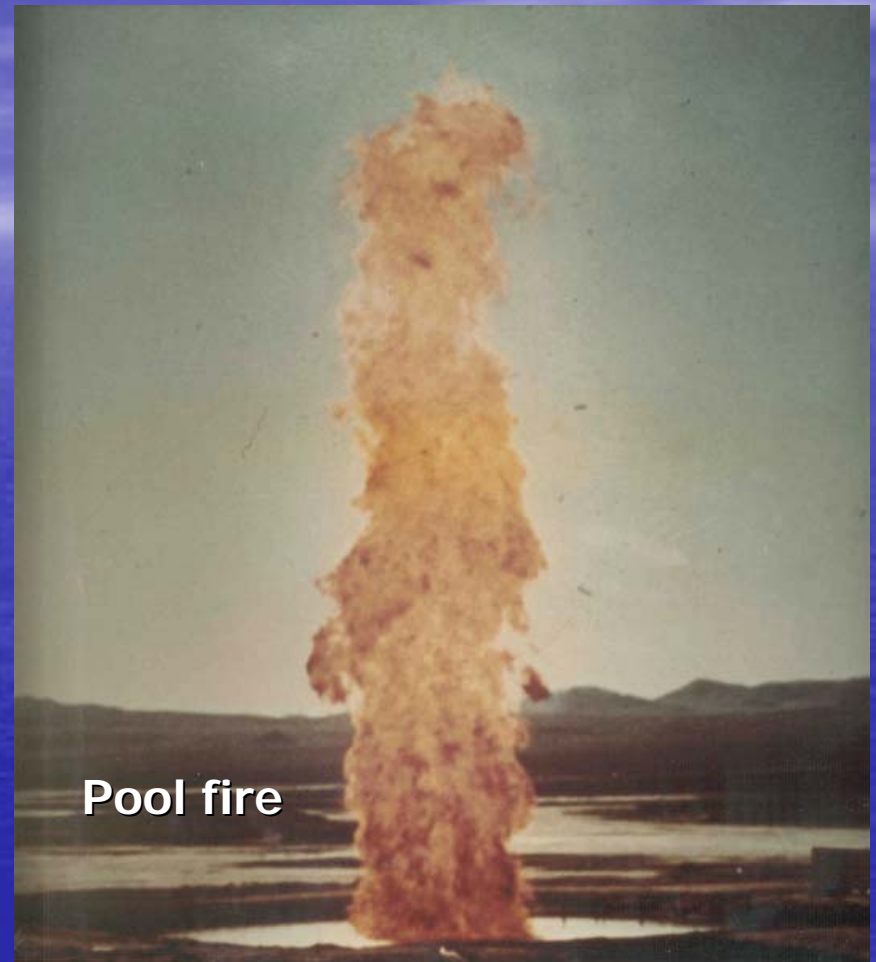
- Toxicity – No acute toxicity (methane) – inhalation hazard due to oxygen deprivation
  - Cryogenic – Potentially severe – But local
  - Rapid Phase Transitions – Secondary Effects?
  - Flammability
    - Minimum ignition energy is low - (easily ignited)
    - Flammability limits - ~ 5% (LFL) to ~ 15% (UFL) (pure methane)
      - LFL methane ~5%
      - LFL propane ~2%
      - gasoline vapors ~1%
    - Minimum explosion/detonation, methane unconfined
    - Principal siting issues
      - vapor cloud fires (vapor dispersion exclusion distances)
      - pool fires (fire radiation exclusion distances)
- ← "Hot Gas" Issue ↓

U. S. 49 CFR 193 requires estimation of exclusion distances



Vapor cloud fire

Vapor dispersion  
exclusion distance



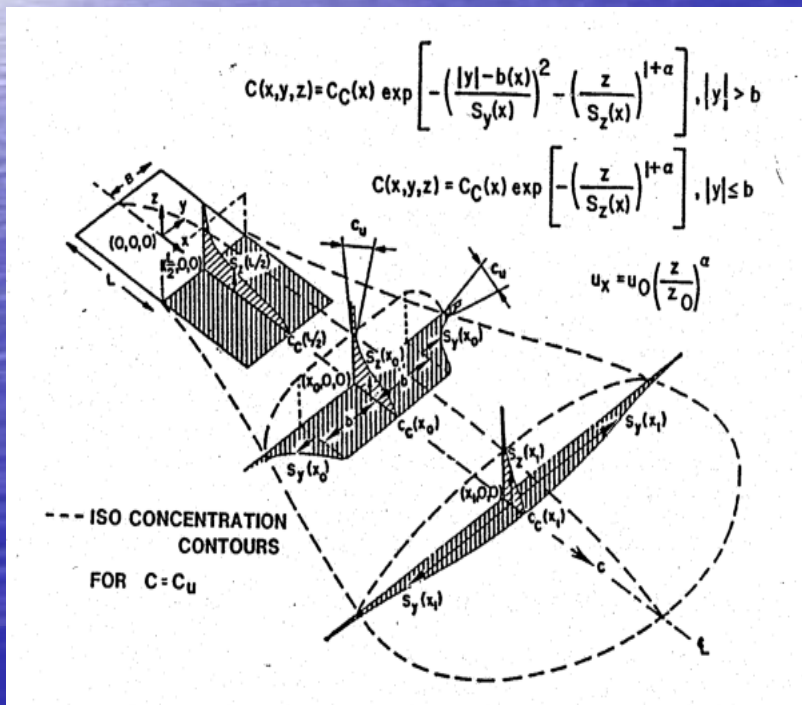
Pool fire

Thermal radiation  
exclusion distance

# Vapor Cloud Exclusion Distances

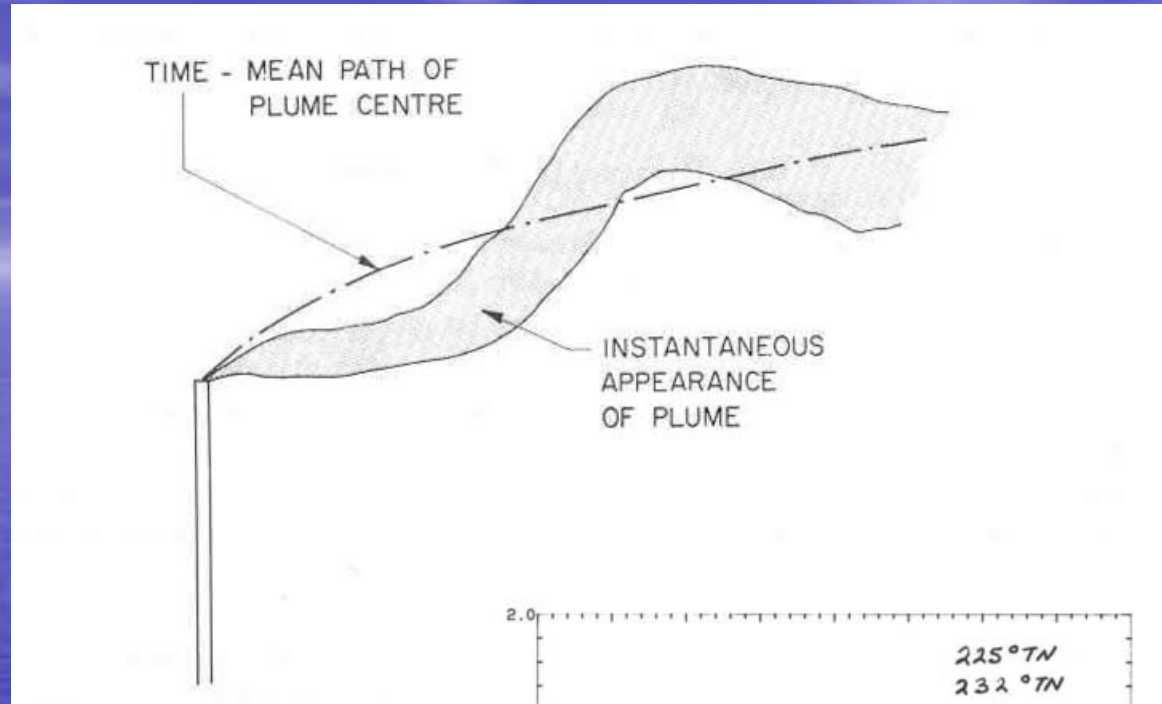
LNG vapor clouds, when formed, are heavier than air (so cold)

- DEGADIS provides for dense gas effects – Required in U.S.
  - Gravity spreading
  - Decreased vertical mixing

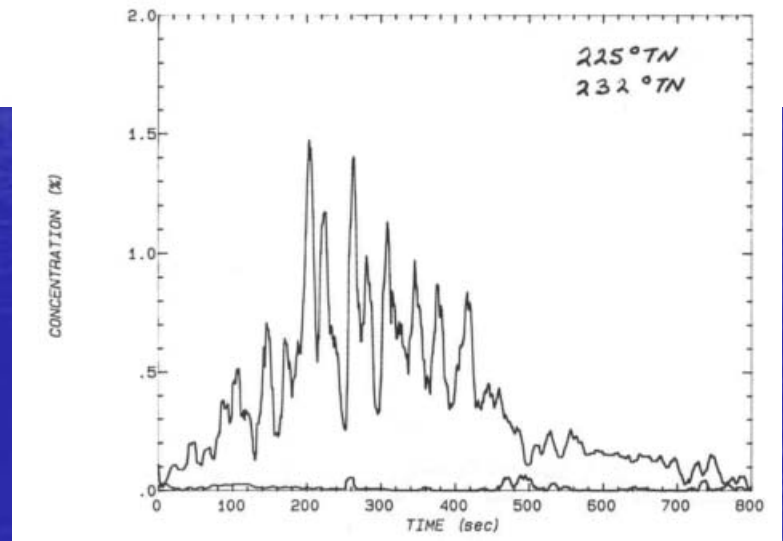


# Vapor Cloud Exclusion Distances

Concept of  
peak-to-mean  
ratio



Federal regulations require  
dispersion distances to 2.5%.



# Vapor Cloud Exclusion Distances

## More LNG vapor dispersion facts that are important - -

LNG vapor is heavy because it is cold – But all adiabatic mixtures of dry air and methane vapor (at BP) are heavier than air. Hence, in absence of heat from ground or water, or absence of humidity, the cloud will remain heavier than air.

If sufficient humidity is present, dilute cloud may become buoyant.

But, principal way that cloud could become buoyant (lighter-than-air) is by heat absorbed from the ground or water.

DEGADIS provides for surface to cloud warming, but it does not allow cloud liftoff.

DEGADIS does not cater for terrain or obstacles (Real World)

# RECENT CHANGES IN LNG FACILITY SITING REQUIREMENTS FOR DETERMINING EXCLUSION ZONES

DOT 49 CFR 193 now incorporates NFPA 59A



- DEGADIS or FEM3A now Allowed
- DEGADIS when level terrain (or water) with no obstacles
  - FEM3A when terrain or obstacles (tank/dike) present



Thermal exclusion zones require  
use of LNGFIRE3

# SHIPSIDE RELEASES

49 CFR 193 does not require determination of exclusion zones beyond the water's edge. The Government is looking at ways to address shipside hazards, particularly important now in view of the terrorist threat (DOE/FERC studies).

- Vapor Dispersion Zones – DEGADIS and FEM3A models are applicable to spills on water. Independent analysis required to specify LNG pool size.
- Thermal Exclusion Zones – LNGFIRE III model is applicable to spills (pool fires) on water. Independent analysis required to specify LNG pool size (thus fire size)

# Estimating the Hazards due to a Terrorist Attack on a LNG Tanker

- Consider attack resulting in loss of containment
  - Multiple ignition sources near release likely
  - Likely that NG will encounter an ignition source before having time to significantly disperse
  - Therefore, likely that a pool fire will follow and damaging overpressures are unlikely
- How big might such a pool fire be?

# Pool fire from a terrorist attack

- The largest pool for any loss of containment will occur if the LNG pool spreads on the water.
- Could an attack on a single storage compartment result in a pool fire, or in a succession of other events, that could jeopardize the tanker, possibly resulting in loss and burning of its entire cargo?

The ABS Group Report to FERC was issued May 14, Public comment period ended May 28 – Some of the important results reported are summarized below

The methodology used in the Quest Report to calculate LNG pool spreading was not recommended.

The worst case assumed was release of 12,500m<sup>3</sup> LNG through holes 1m and 5 m diameter; with the results:

	<u>1 m hole</u>	<u>5 m hole</u>
<b>Flammable Cloud Distance (LFL/2)</b>	<b>16,000 ft</b>	<b>18,000 ft</b>
<b>Fire Radiation Distance (to 5 kw/m<sup>2</sup>)</b>	<b>2,800 ft</b>	<b>4,600 ft</b>

# Observations

- There appears to be no significant controversy about estimation of vapor cloud exclusion distances from ship spills (to the  $\frac{1}{2}$  LFL concentration).
- Thermal exclusion distances are the sum of:
  - The distance from the center of the resulting fire to the fire's edge – i.e., the liquid spreading extent
  - The distance from the edge of the pool fire to the location where thermal radiation fluxes exceed prescribed criteria (say second degree burns to unprotected skin in approximately 30 seconds)
  - The radial distance of spreading is controlled by the assumptions about the pool thickness at which spreading ceases.
- If the Quest report methodology is not used to limit the spreading by wave action, there appears to be no important controversy about the estimation of thermal exclusion zones.
- As we have stated in our comments to FERC, it appears that (regarding the estimation of exclusion zones) we are roughly back where we were before 911 and the appearance of the Quest Report.



# Summarizing the Hazards due to a Terrorist Attack on a LNG Tanker

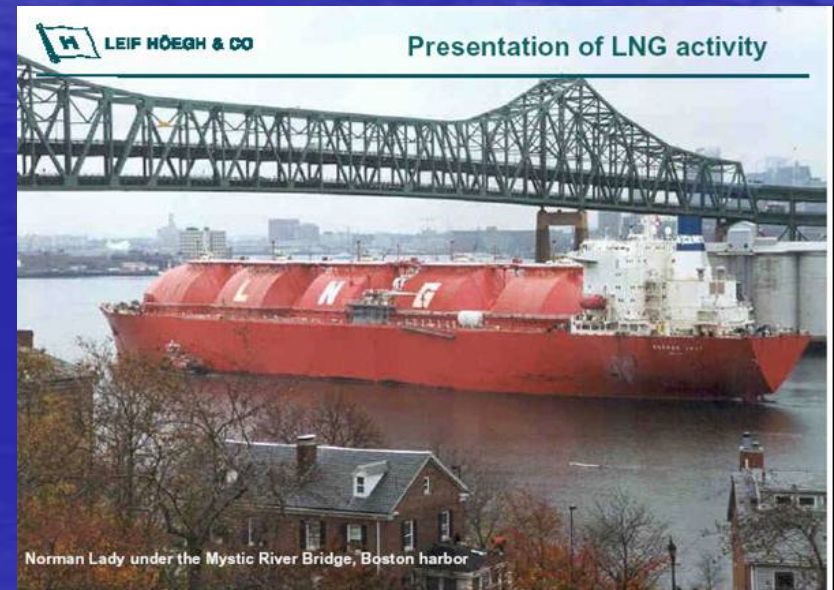
- Damaging overpressures (explosion) are unlikely.
- Pool fire is highly likely due to multiple ignition sources near the rupture.
- Rupture of a ship tank might endanger the ship and its cargo, as the fire could be large enough to essentially envelop the vessel.
- In view of the terrorist threat, serious consideration must be given to the vulnerability of LNG carriers to attack – assessment of the vulnerability is necessary to determine the limits on spill size that have to be anticipated. The possibility of cascade effects that might lead to total loss of the tanker have not been sufficiently addressed.

# Where does that leave Us?

Regulatory decisions under consideration, particularly those addressing shipside hazards, are likely to become determining considerations in future siting decisions

OFFSHORE  
How far?

ONSHORE – What is Remote?





Questions?