5th International Conference for Fire Brigades in the Oil & Chemical Industry

BP Live LNG Training & Research

Danubius Hotel Budapest 18th November 2009
BP Group Fire Advisor - Kevin Westwood

Misconceptions & Myths

"LNG presents the highest hazard of ALL hydrocarbon fuels"

"LNG fire is highly radiative and can cause 2nd Degree Burns up to 1.5 kilometres"

"The energy content of an LNG Tanker is equivalent to that of several nuclear bombs therefore an LNG explosion will have similar effects"

LNG South Hook - Protestors

LNG South Hook - Tembek

LNG - Properties

- Typical composition -
  - Methane (C1) 80% to 99%
  - Ethane (C2) 1% to 17%
  - Propane (C3) 0.1% to 5%
  - Butane (C4) 0.1% to 2%
  - Pentane (C5) <1%
  - Nitrogen (N2) 0% to 1%
- Specific Gravity (approx) - 0.45
- Flammable Range - 5.3% to 14%
- Auto Ignition - 537 °C
- Flame Temperature - 1330°C

LNG - Characteristics

- Cryogenic Liquid
- Odourless
- Colourless
- Appears like Boiling Water
- Boiling at -162 °C

East Ohio Gas Company

East Ohio Gas Company

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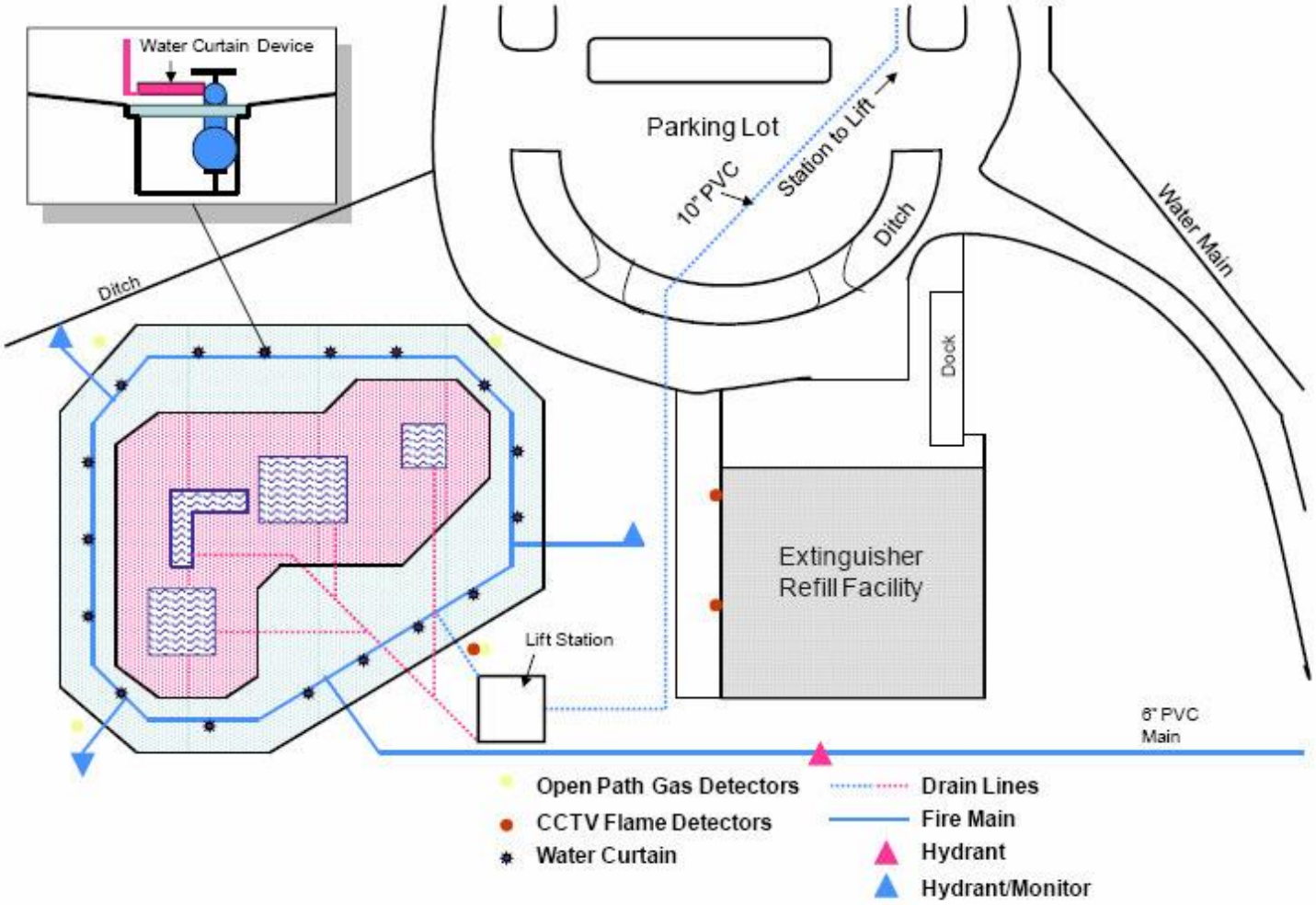
East Ohio Gas Company - Lessons Learned

The lessons learned from this incident are as follows:

- The layout of the site was such that a fire on one tank could easily spread to adjacent tanks
- The tank supports were not protected from flame impingement
- The tanks were not provided with bunds of sufficient capacity to hold the tank contents and allow for overtopping due to catastrophic failure
- The site was too close to an urban conurbation and consequently uncontrolled sources of ignition.
- The drainage system was not designed to prevent the spread of a LNG spill
- The incorrect material was used for the tank construction

BP Live LNG Training & Research Facility

BP LNG Test Facility at Texas A&M



BP LNG Test Facility at Texas A&M

Designed to replicate current facility designs:

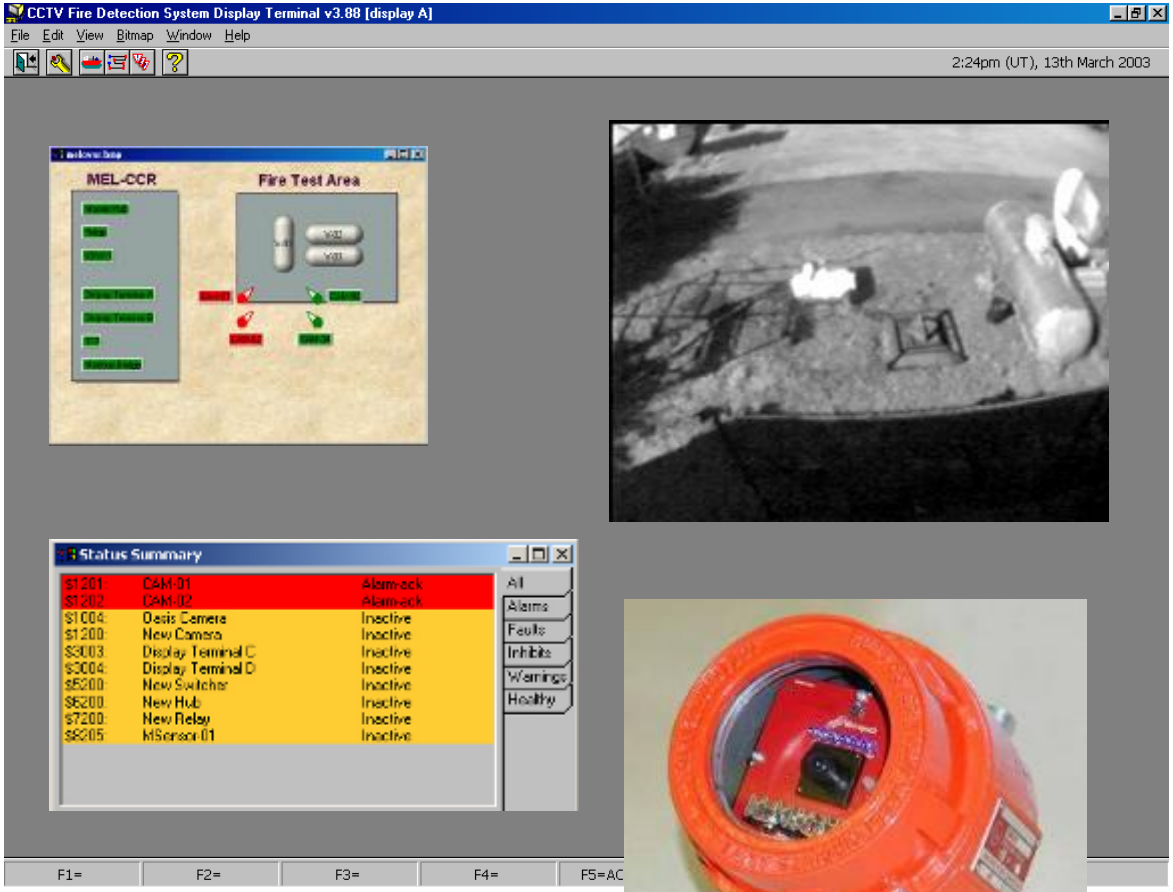
- Stepped "L" Pipe Trench 19m² (200sq. ft)
- Small square pit 9.3m² (100sq.ft) x1.2m
- Big oblong pit 65m² (700 sq.ft).
- Deep 45m² pit (484sq.ft) x 2.4m(8 ft) deep

Vapour Cloud Ignition - Video

Gas Detection

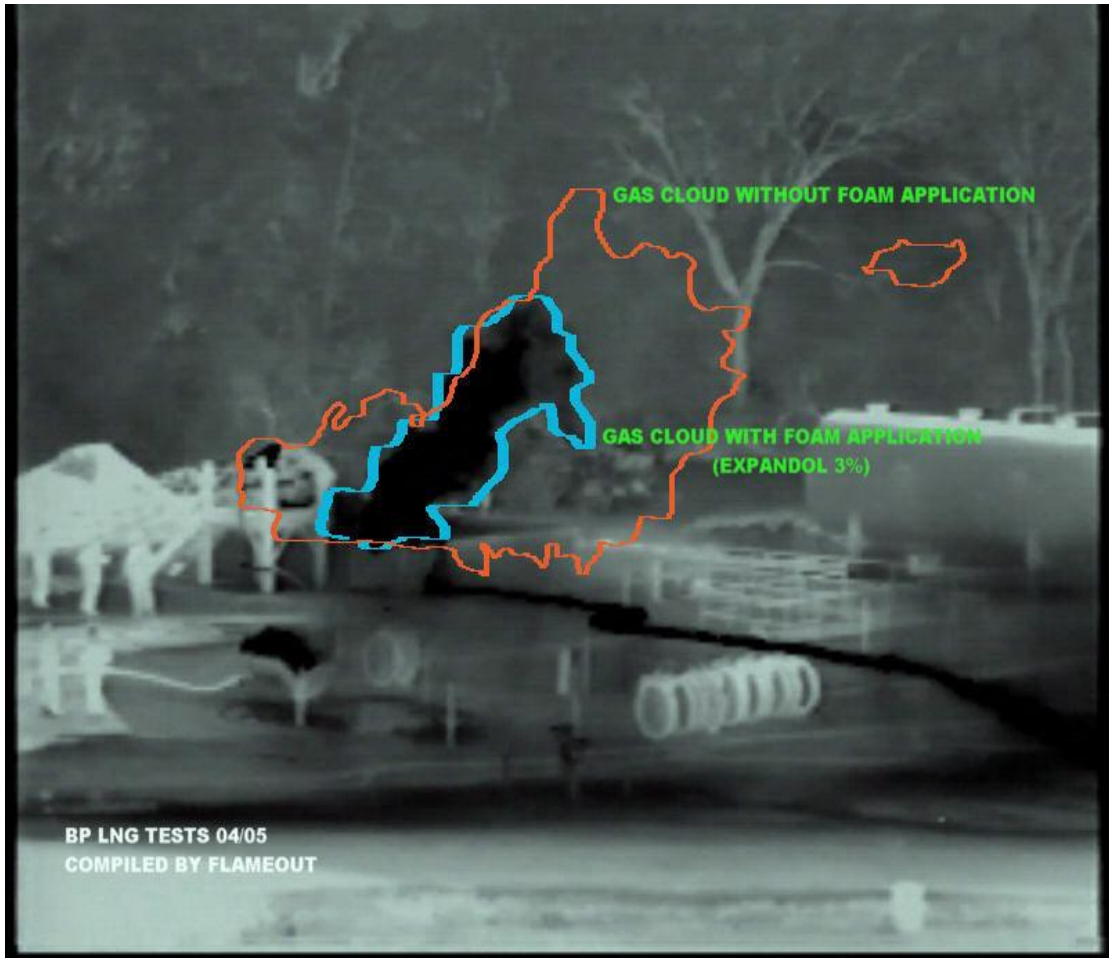
- Open path zone 1 intrinsically safe gas detection system
- Open path superior to point detectors
- Provides protection over large area
- Alarms when gas escapes identified area
- Better at quantifying the severity of release

Video Flame Detection



- The detector analyses the image using advance signal processing
- The on board processing determines if the image contains fire movement and shape
- If a fire is recognised then the detector signals an alarm using relay contacts
- A live video display of the fire is automatically switched to a display.
- gives control room immediate view

Hydrocarbon Imaging



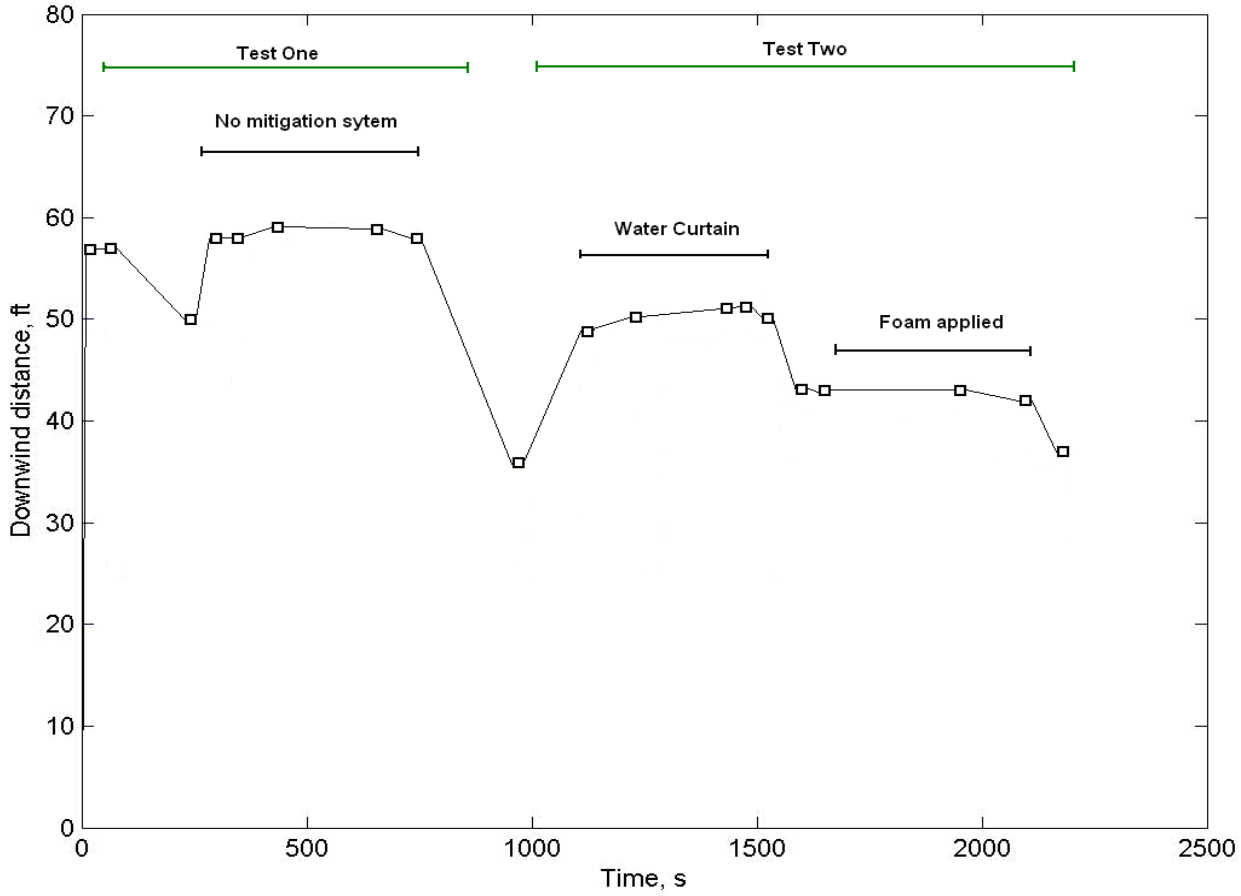
- Hydrocarbon imaging shows foam reducing and controlling LNG vapour release
- Significant vapour reduction with foam

Water Curtains

- Keeps vapours away from ignition sources
- Water curtains need to overlap - use sparingly!
- Avoid water entering pit

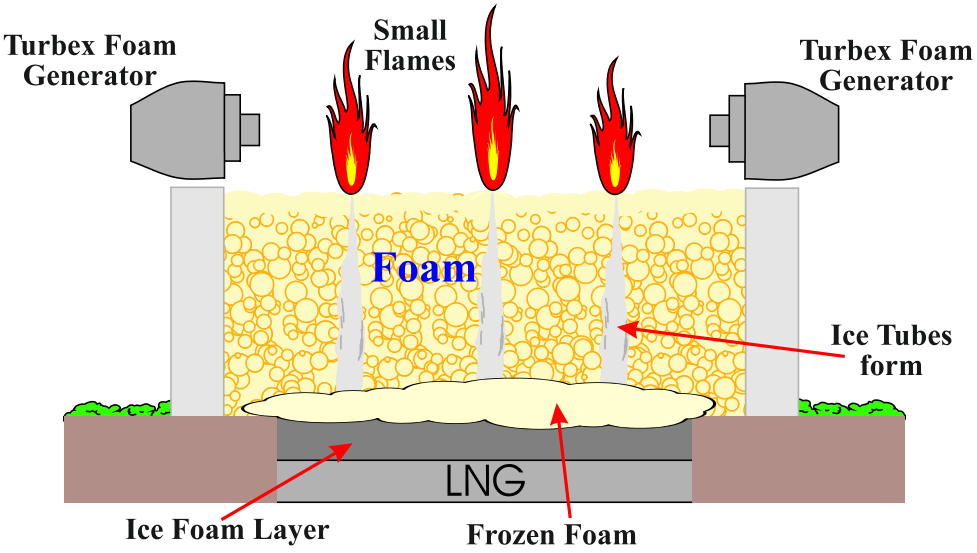
Water Curtain - Video

Downwind Concentrations
Mitigation Effects



Hi Expansion Foam Generators

How Foam Works - Fire Control



- Dynamic situation
- Foam insulates & reduces radiation back to LNG
- Foam allows controlled LNG burn-off
- Pit design affects efficiency
- Fire Intensity decreases
- Regular foam "top-up" to maintain steady state
- Frozen foam also controls fire

Foam 500:1 insulates LNG

Foam Application & Vapour Control

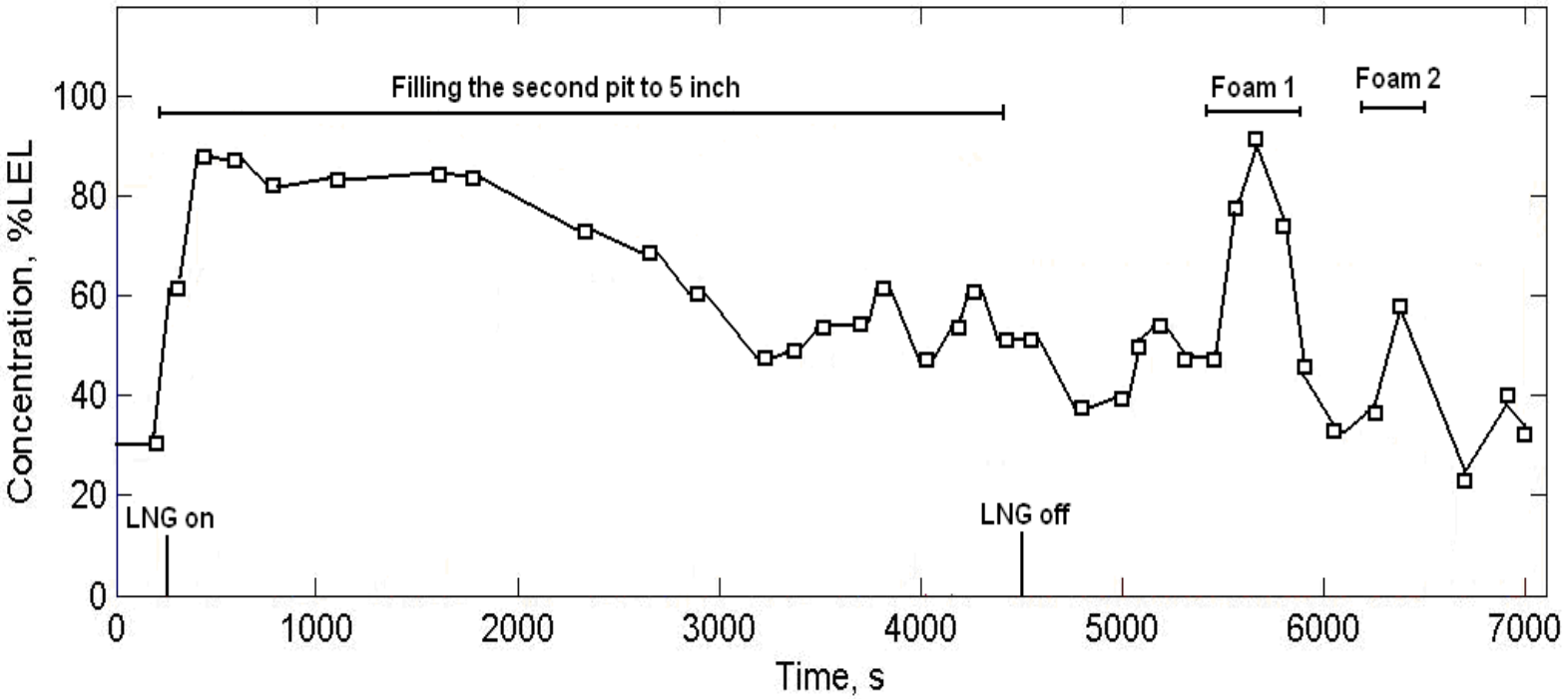
- Vapour in LFL range found 120 -150m from “cloud”
- Frozen foam can lock LNG beneath
- Foam warms vapours so rise & disperse upwards
- Experiments reveal LNG Turbex disperses vapours after 1 min





LNG Foam Generators - Video

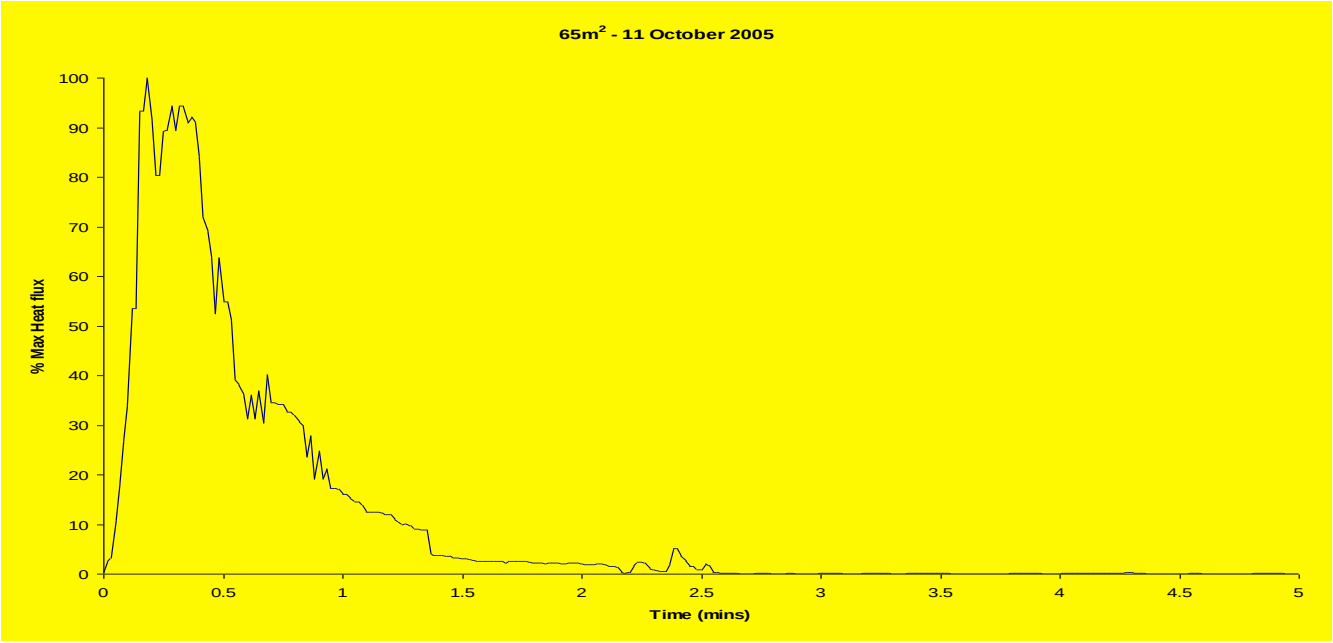
LNG Vapour Reduction During Foam Test



Radiation Reduction:

Recommended rate:10L/min/m²

Pit Area	Foam Application Rate	Maximum Heat Radiation Reduced	Time to reach 90% Heat Reduction	Time to reach Maximum Heat Reduction	Equivalent Pool Diameter	Radiometer (x Pool Diameter)
M2	L/min/m2	%	minutes	minutes	m	
45	7 (2006)	91	3.5	3.6	7.57	4.0
65	3.5 (2005)	94	2.45	4.5	9.10	3.3
65	7 (2006)	95	1.7	2	9.10	3.3
65	10 (2005)	97	1	1.2	9.10	3.3
65	10 (2006)	93	0.95	1.5	9.10	3.0
		75.64	NA	0.79		



Radiation Reduction - Foam Application

Heat output at 30m* ~7.5kW/m²

Heat output at 30m* ~0.7kW/m²

Foam Application Significantly Reduces Radiant Heat Output

** in cross wind direction*

90% Radiation Reduction - Video

Dry Chemical – Powder Application

- Particles split up in the fire for faster free radical capture
- Highly Effective
- Gives ALL personnel best chance of SUCCESS (especially above foam blanket on LNG)
- Can be operated through:
  - hand extinguishers, mobiles, dual agent, powder skids, fixed systems
- Compensates non-fire-fighters for poorer technique.

Dry Chemical Application

Dry Chemical Application

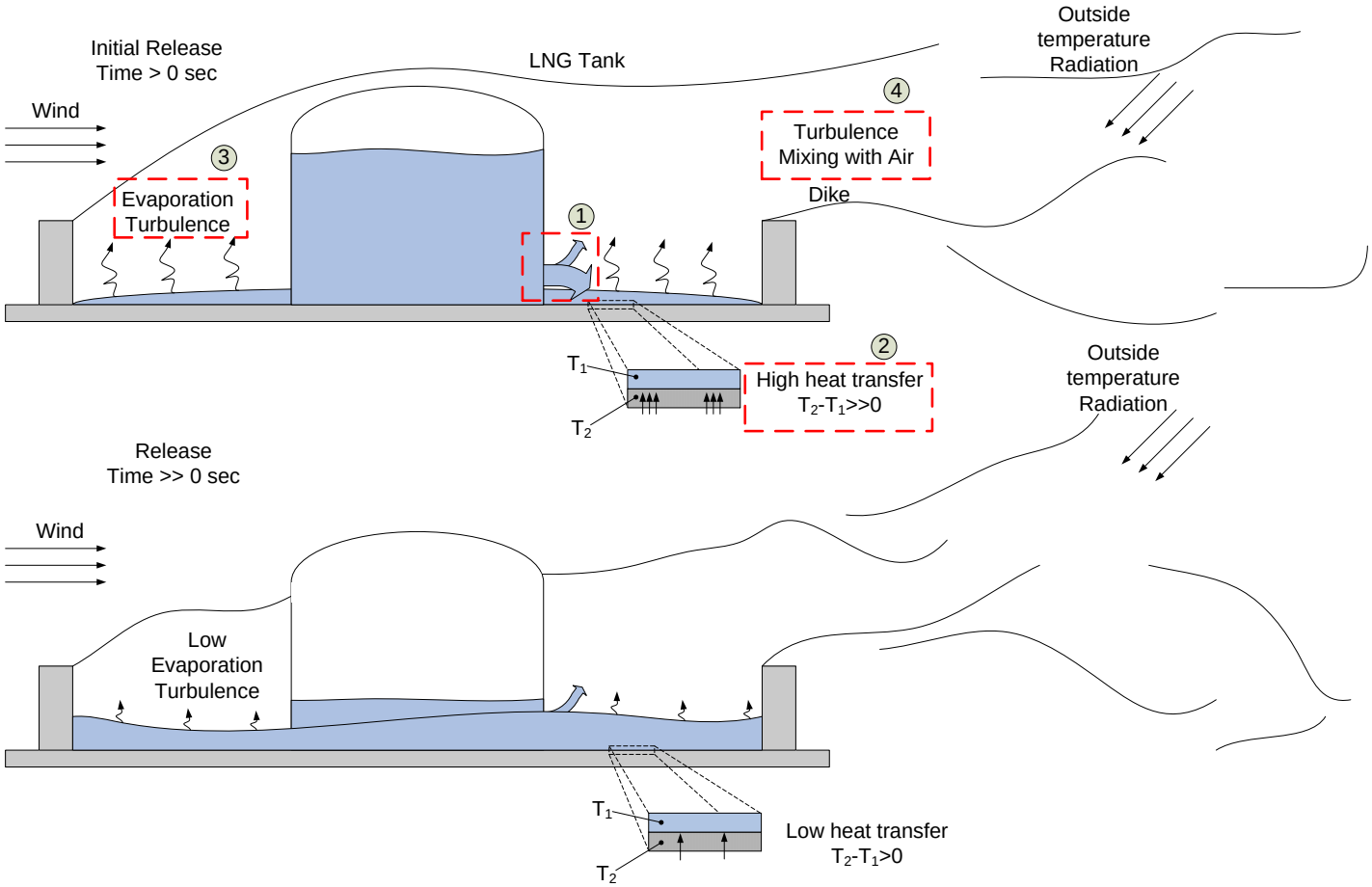
Dry Chemical Application – Video

Mary Kay O'Connor Process Safety Centre

- Mary Kay O'Connor Process Safety Centre Research & Development
  - Understand Vapour Cloud Characteristics
  - Validate Existing Models inc CFD models for LNG Dispersion
  - Measure Effectiveness of Foam and Suitability of Foam Making Equipment
  - Determine Effectiveness of Water Curtains on Dispersion

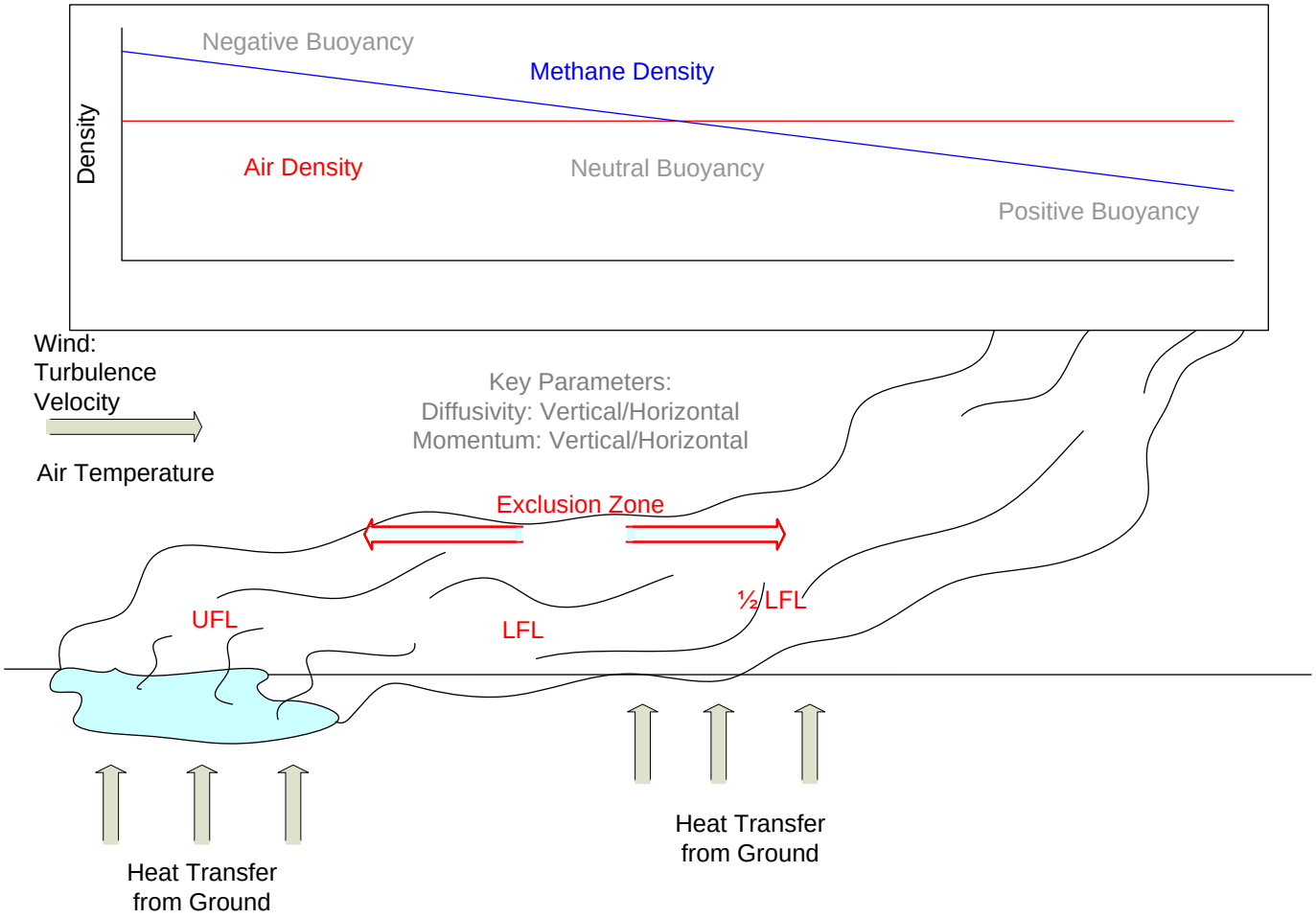
Data Collection

LNG Dispersion Phenomenon



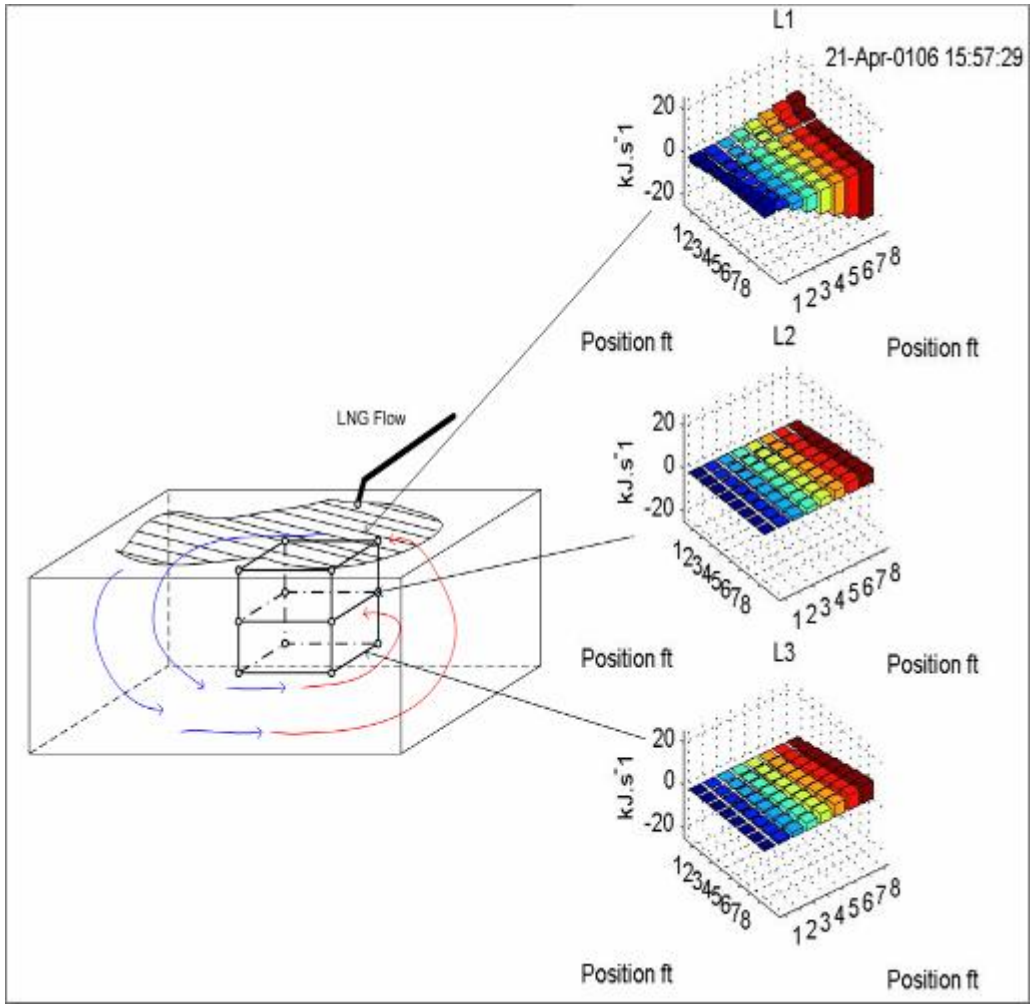
Source - Benjamin Cormier

Buoyancy Effects



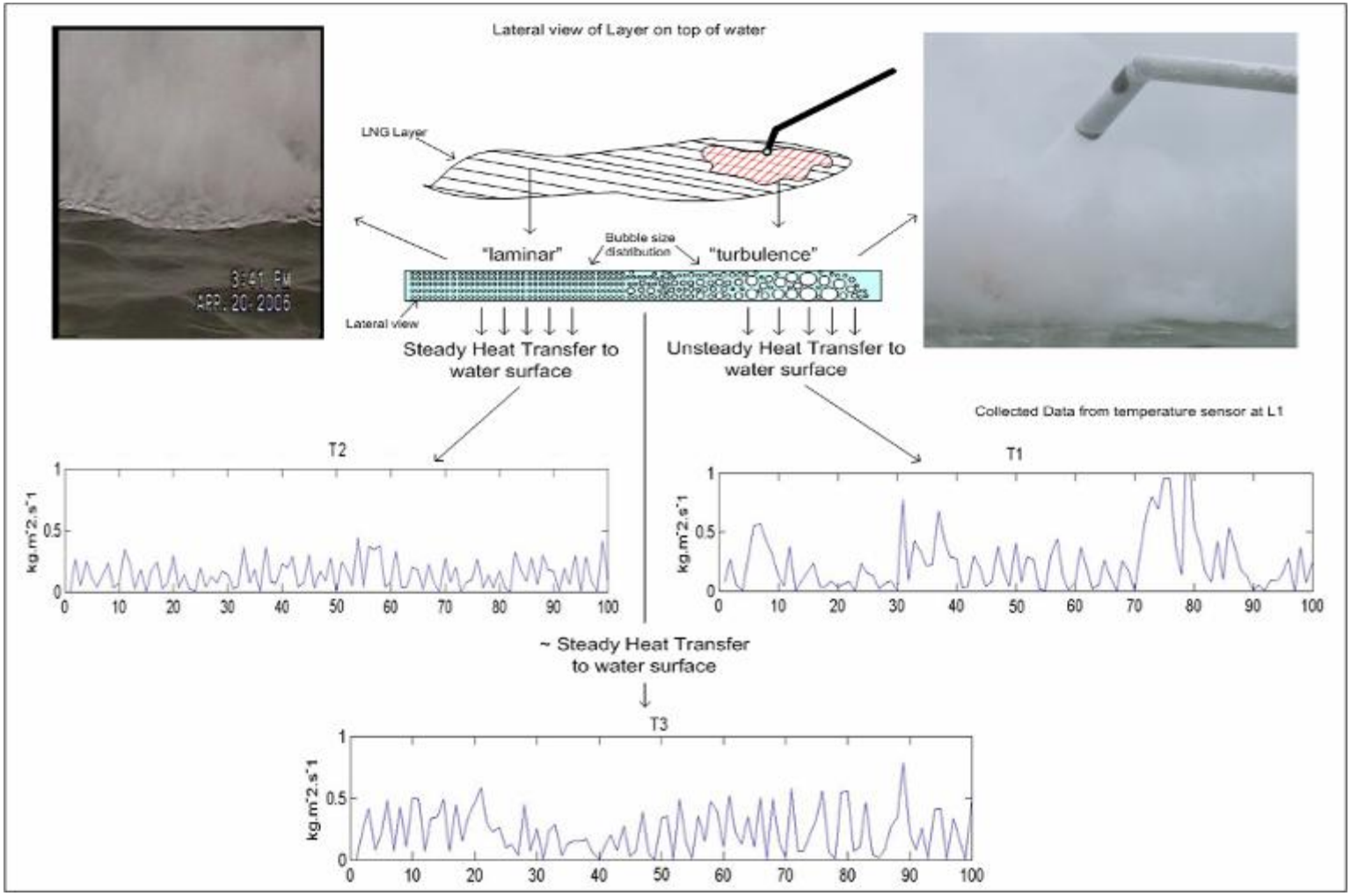
Source - Benjamin Cormier

LNG Spill on Water - Convective

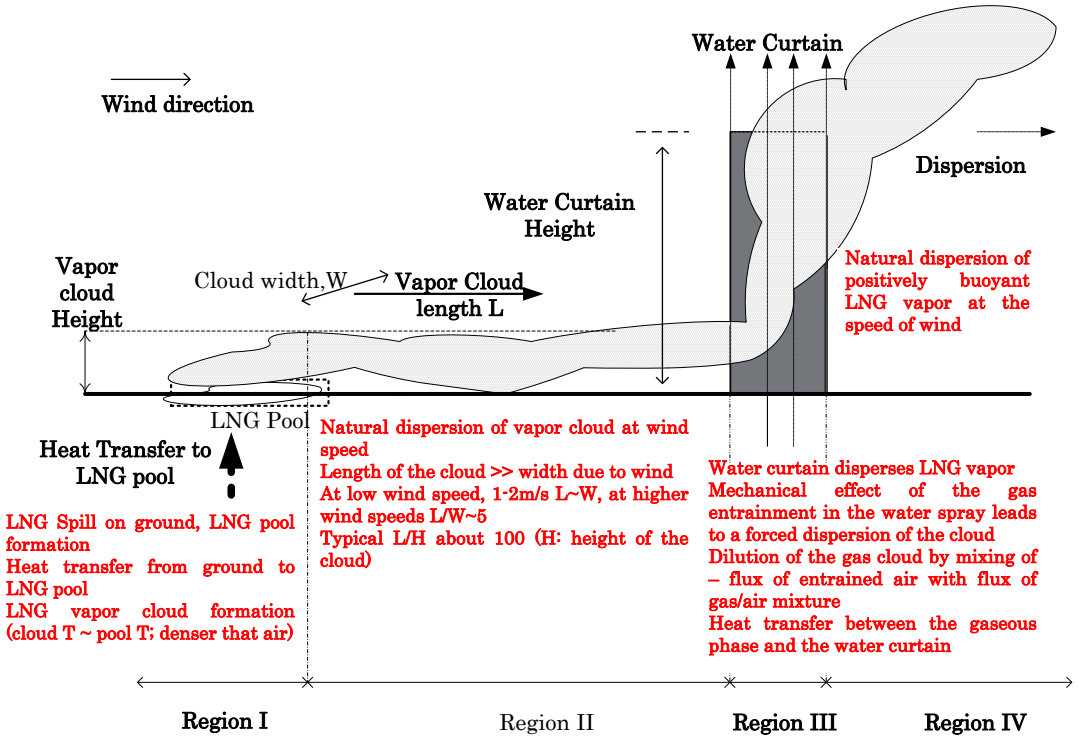


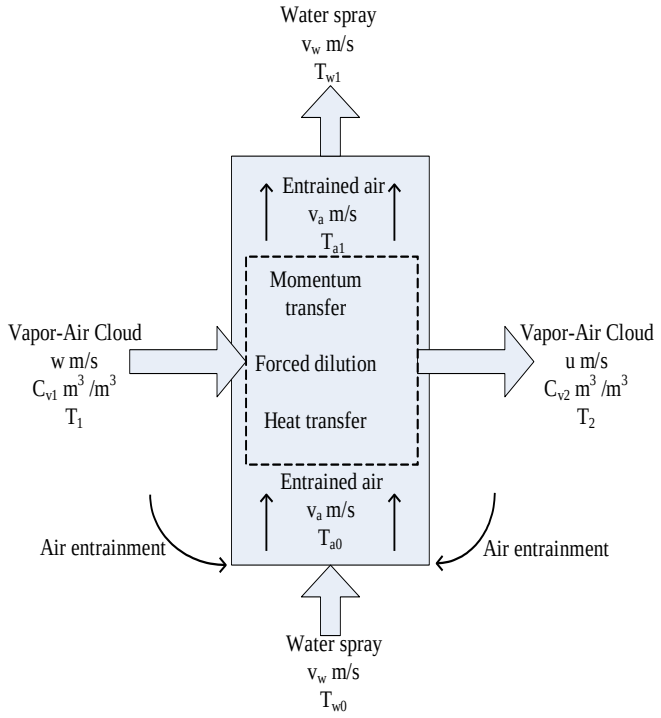
- Change of temperature of the water:
  - Cold water sink and warm water raise
- This effect avoid the formation ice underneath the LNG layer

LNG Spill on Water – Vapour rate effects

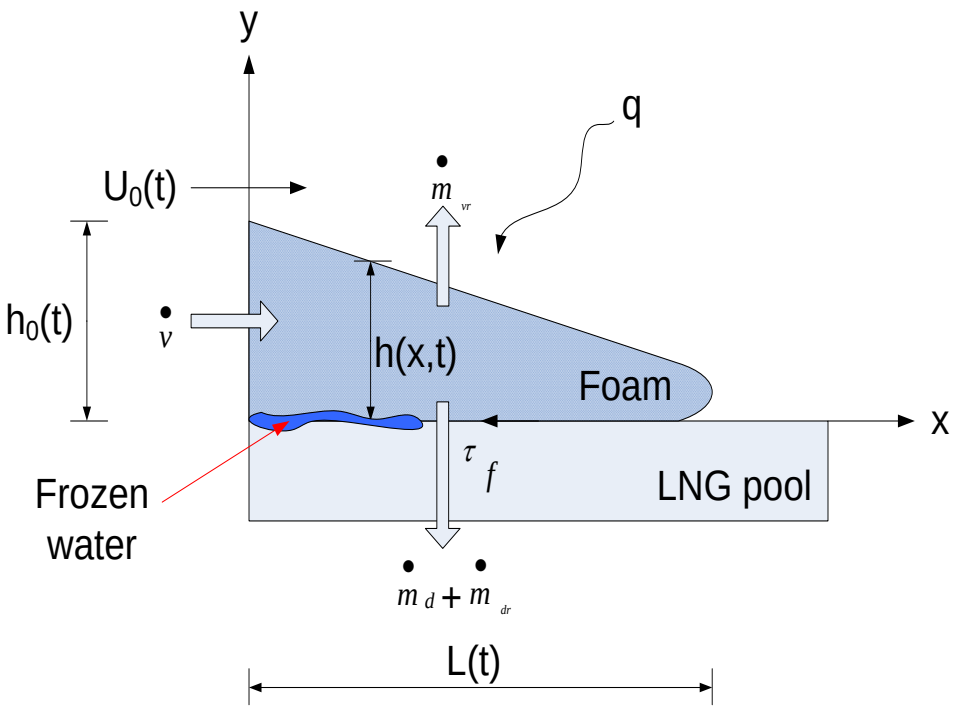


Water Curtain Desired Application





Hi Ex Foam & LNG Interaction



Foam spreading on LNG liquid pool surface. Foam is applied from the left with constant volume rate and the spread is opposed by a friction shear stress. The foam is exposed to heat radiation from fire causing an evaporation mass loss and a radiation-induces drainage in addition to the conventional drainage. Drained water will form ice due to cryogenic temperature of LNG liquid pool (adapted from FOAMSPEX report)

Qatar - BP $3m LNG Research Sponsorship

Officials from BP, Qatar Petroleum and Texas A&M at Qatar, along with three undergraduate student researchers, participated in the signing ceremony

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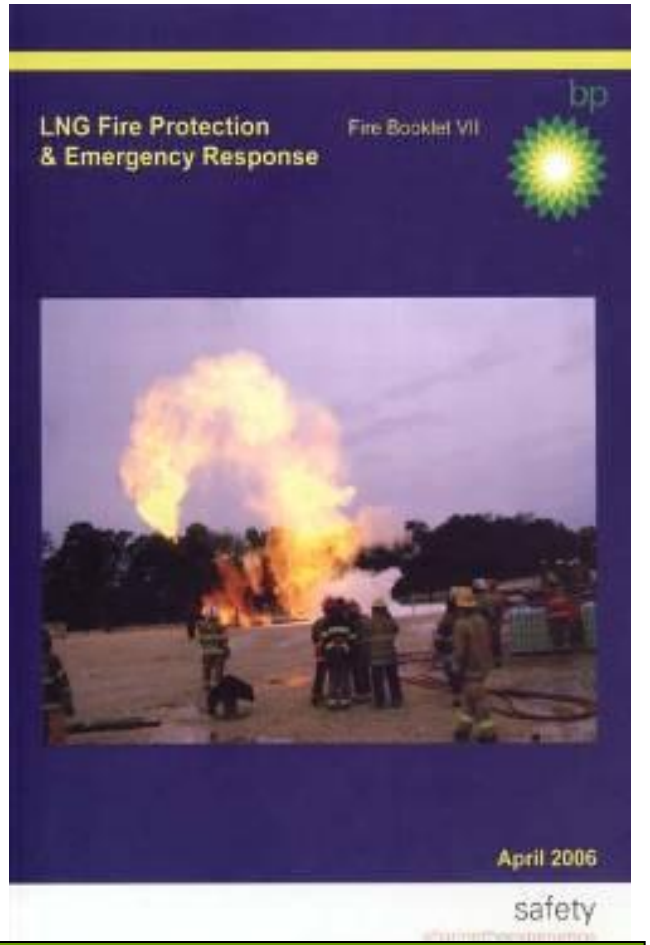
FoamGlas - Application

FoamGlas - Application

Foamglas Application

BP LNG Fire Protection & Emergency Response



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Thank You - Video