Effective fire-fighting strategies for LNG during bunkering

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A brief outline

• Introduction (Basic Elements of Fire)
• Rapid Phase Transition
• Various Types of Fire
• What to do when a LNG fire does happen
• Best methods to deal with the incident
• Summary and Conclusions (Q&A?)
LNG Fire

- Fire Elements:
  - Fuel
  - Air
  - Source of Ignition

First Commandment Handling LNG
Thou Shall Not Allow CH$_4$ To Mix With Oxygen
Key Points to Remember:

• Methane (CH₄) like any other hydrocarbon is flammable.

• Flammable range 5 to 15% by volume in air.

• **LNG does not burn!!!**
LNG Fire

More Key Points to Remember:

• LNG does not explode???

• LNG vapor does burn

• LNG vapor will explode if enclosed in a confined space
LNG Fire

• Types of LNG Fires:
  ▪ Flash Fire/Vapor Cloud Fire
  ▪ Jet
  ▪ Pool
  ▪ BLEVE
  ▪ Rapid Phase Transition?
LNG Fire

- Rapid Phase Transition:
  - Is not a fire!
  - Occurs when liquid comes in contact with water.
  - LNG vaporizes violently.
  - Rapid phase change from liquid to vapor.
LNG Fire

• Rapid Phase Transition:
  ▪ A physical or cold explosion.
  ▪ No combustion.
  ▪ Hugh amount of energy is transferred in the form of heat from the ambient temperature water to the cold LNG.
LNG Fire

• Rapid Phase Transition

Video: http://www.youtube.com/embed/h-EY82cVKuA
LNG Fire

• (Remaining) types of LNG Fires:
  ▪ Flash Fire/Vapor Cloud Fire
  ▪ Jet
  ▪ Pool
  ▪ BLEVE
LNG Fire

• Flash Fire/Vapor Cloud Fire.

• May happen if a cloud of gas burns without generating significant overpressure.

• Cloud must contain 5 to 15% concentration of methane in air.
LNG Fire

• Flash Fire/Vapor Cloud Fire:
  ▪ Cloud will be ignited at the edge as it disperses and meets source of ignition.
    ▪ Ignition sources include: open flames, sparks, internal combustion engines.
  ▪ Once ignited, a cloud will flash back along the flammable range.
LNG Fire

• Flash Fire/Vapor Cloud Fire:
  ▪ The fire will continue to burn until the hydrocarbon is depleted.
  ▪ Relatively short in duration.
  ▪ Unconfined vapor does not explode.
LNG Fire

• Flash Fire/Vapor Cloud Fire:
  ▪ Fire propagates from ignition to source relatively slowly.
  ▪ Flame height wind dependent.
  ▪ May stabilize as a continuing jet fire for pool fire from the leak origin.
LNG Fire

• Jet Fire:
  ▪ May be caused by vapor leaking from high-pressure sources such as pumps, vent risers, or piping:
    ▪ Vapor must meet an ignition source.
    ▪ Vapor will not ignite spontaneously.
    ▪ RISK – vapor will ignite if it reaches ignition source.
LNG Fire

• Jet Fire:
  ▪ If ignition occurs:
    ▪ In a flash, the flame will burn back to the source of the leak.
    ▪ Fire will continue until source of leak is secured.
LNG Fire

• Pool Fire:
  ▪ Accumulated liquid from spill:
    ▪ Unlikely to occur on deck of ship.
    ▪ On shore, liquid can pool into large quantities.
    ▪ Contain the pool to prevent spreading.
    ▪ If vapor is present, it may ignite and create a pool fire.
LNG Fire

• BLEVE:
  - Boiling Liquid Expanding Vapor Explosion
  - Associated with storage of liquefied gas in pressurized containers (tanks)

Source: Cdang CC BY-SA 3.0 [https://upload.wikimedia.org/wikipedia/commons/2/2a/Bleve_explosion.svg]
LNG Fire

• BLEVE:
  ▪ Heat from fire external to tank:
    ▪ Contents expand.
    ▪ Tank failure, ruptures.
    ▪ Contents vaporize/expand at an extremely high rate
    ▪ Violent explosion.
WHAT to DO: References

International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
LNG Firefighting Procedures

- Best firefighting procedure is:

  **PREVENT A FIRE FROM STARTING**

- To avoid a fire:
  - Prohibit all sources of ignition in the safety zone.
  - Ensure training programs up to date.
  - Train all employees working with LNG.
  - Post NO SMOKING signs.
LNG Firefighting Procedures

• When liquid gas fire is present, follow these procedures:
  ▪ Sound the alarm.
  ▪ Determine source of fire.
  ▪ Execute the emergency plan of action
LNG Firefighting Procedures

• A rough guide:
  - Isolate and contain the source of the fire.
  - Cool surfaces under radiation or encroaching flames with water.
  - Control and extinguish fire with appropriate equipment.
LNG Firefighting Procedures

• Generally accepted fire extinguishing methods, if used appropriately:
  - Water
  - Dry chemical powders
  - Foam
  - Inert Gas and carbon dioxide
LNG Firefighting Procedures

- **Water:**
  - **Do Not** use water on a burning liquefied gas pool.
  - Use of water increases the vaporization of the liquid gas.
  - Use of water increase the rate of burning.
LNG Firefighting Procedures

• Water:
  ▪ Has uses in fighting liquefied gas fires:
    ▪ Usually always available.
    ▪ Can be used to cool surfaces exposed to radiation or affected by fire.
    ▪ A diffused spray – water curtain – may be used to limit the thermal effect of radiation.
    ▪ May be used to extinguish a jet of burning gas – in some instances.
LNG Firefighting Procedures

• Water:

A water curtain is frequently fitted wherever large quantities of cold LNG can leak and damage critical structural components, such as the ship’s side shell directly below the LNG bunker station and bunker hoses and above the waterline.

Fighting LNG fires is not a simple task. Completely extinguishing an LNG fire could leave a pool of LNG which will continue to release gas that could reignite in a much more intensive fire. The most important first step is to cool any surrounding tanks or pipes that contain LNG, natural gas or other flammable substances, and to cool spaces that contain critical machinery and accommodations. This will help prevent the spread of the fire and reduce its consequential damage. Intensive heating of LNG tanks by an outside fire impinging on the tank can lead to excessive venting of the tanks. Spraying large quantities of water by a deluge system or from hoses or monitors is generally the recommended method of cooling. Medium or high-expansion foam sprayed on a liquid pool LNG fire also can reduce the intensity of the flames, reducing the potential for damage to surrounding areas, but will not stop the release of gas.
LNG Firefighting Procedures

• Fixed water deluge systems:
  ▪ Used when a quick application of large quantities of water are required.
  ▪ Provide cooling or fire intensity control.
  ▪ Used to cool surfaces and equipment:
    ▪ Valves, critical structural components, plants and jetties, etc.
  ▪ Designed to supply a layer of water over exposed surfaces.
LNG Firefighting Procedures

- Fixed monitors or hand held nozzles:
  - Used to provide cooling water spray or foam for radiation protection during firefighting.
  - Used to deliver dry chemicals to more effectively suppress the fire.
  - Used to divert the vapor cloud away from the source of ignition.
LNG Firefighting Procedures

• Dry Chemicals:
  ▪ Very effective in suppressing small gas fires:
    ▪ Sodium bicarbonate
    ▪ Potassium bicarbonate
    ▪ Urea potassium bicarbonate

Source: Firefighting - Dry Chemicals – D. Jones, Gaston College
LNG Firefighting Procedures

• Dry Chemicals:
  ▪ Bring the fire under control by vapor dispersion then use dry chemicals to extinguish the flames.
  ▪ LNG carriers are required by the IGC to have fixed dry powder systems.
  ▪ The system should reach above-deck exposed cargo areas using hand hose lines or combination monitor/hand hoses.
LNG Firefighting Procedures

The International Maritime Organization (IMO) sets the requirements for firefighting equipment aboard LNG ships. The IMO requires:

- Fixed dry chemical powder is fitted for firefighting in the exposed cargo area with at least two hoses or monitors capable of reaching the manifold area.

- Monitors have a discharge rate of not less than 10 Kg/sec and a range of 10 to 40 meters depending on capacity.

- Hoses have a discharge rate of at least 3Kg/sec with the rate designed so one man can operate.

- Consists of two independent systems with remote control monitor to cover manifold area and sufficient powder storage for a minimum discharge time of 45 sec.

Dry chemicals also will work to extinguish LNG fires, but with the caution that extinguishing the flame without cutting off the source of the gas can be dangerous. It is important to stop the spread of released gas into confined spaces and other parts of the vessel to prevent an explosion due to the confined space. Firefighting should be one of the major sections of the bunkering operation emergency response plans and personnel involved with bunkering should have training on what to do if a fire is encountered.
LNG Firefighting Procedures

• Dry Chemicals:
  - Adjacent hot surfaces should be cooled with water before extinguishing the flame with dry chemicals.
  - After extinguishing the fire, cool the adjacent surfaces with water.
  - Customarily, jetty manifold spaces are protected by portable or fixed powder systems.
LNG Firefighting Procedures

• Foam:
  - Foam systems suppress fire by separating the fuel from the air.
  - Use high expansion foam to flood the surface of the burning pool (confined area) to suppress radiation and reduce rate of vaporization.
  - After vapor is dispersed, use dry chemicals to extinguish flames.
LNG Firefighting Procedures

• Foam:
  ▪ Can reduce the horizontal range of the gas clouds of a confined pool.
  ▪ Increases the vapor’s buoyancy due to heat input from the foam.
  ▪ May increase the vaporization rate as it diffuses into the liquid.
LNG Firefighting Procedures

• Foam:
  - Foam will not extinguish a liquefied gas fire.
  - For liquefied gases, foam should only be used in confined areas.
  - Usually only found at terminals and is generally not provided on gas carriers.
LNG Firefighting Procedures

• Inert gas is a non-reactive gas under particular conditions used on gas carriers and in terminals to prevent explosions:
  ▪ Inter-barrier spaces
  ▪ Cargo spaces:
    ▪ Ships’ holds
    ▪ Onshore plant areas in which flammable gas may be detected.
LNG Firefighting Procedures

- Inert gas and CO₂ safety measures:
  - Electrostatic charging can be produced when CO₂ is injected – can be the ignition source in a flammable space.
  - Once initial pressure flow has subsided, injecting an inert gas into a safety relief valve is an effective means of suppressing a vapor fire at a vent riser.
  - Keep the space sealed until it is sufficiently cooled and won’t reignite when oxygen is introduced back into the space.
Summary and Conclusions

- Cases of fire, especially those based on LNG, are obviously dangerous.

- Any type of incident can be successfully managed/resolved if the basic principles are well understood.

- Prevention is crucial, with measures such as using the proper/right type of equipment and training in all available scenarios holding a pivotal role.
LNG Firefighting Procedures

• Display firefighting plans and muster lists:
  ▪ Training program should ensure that employees understand these procedures.
LNG Firefighting Training
Effective fire-fighting strategies for LNG during bunkering

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