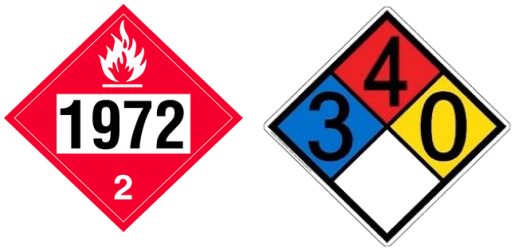
COMMODITY PREPAREDNESS AND INCIDENT MANAGEMENT REFERENCE SHEET

LIQUEFIED NATURAL GAS

CAS NO. 74-82-8
UN 1972
DOT Hazard Class: 2.1
FLAMMABLE GAS
ERG Guide No. 115

HAZARD RATING = HIGH



DOT Hazard Classification and NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response

PURPOSE AND SCOPE

The Commodity Preparedness and Incident Management Reference Sheet (CPIMS) is designed to be used as a resource tool for emergency preparedness personnel in planning, training and responding to rail incidents involving the transportation of Liquefied Natural Gas (LNG).

The CPIMS is not meant to replace Safety Data Sheets (SDS) or local Standard Operation Procedures (SOP) / Standard Operating Guidelines (SOG), but to supplement these documents with guidance and information to facilitate the delivery of a risk-based emergency response capability based upon facts, science, and incident circumstances. Even though the CPIMS is based upon commonly used practices, references, laws, regulations, and consensus standards, it is not meant to establish a standard of operations. Users are directed to develop their own SOP's which follow all system, agency, or employer guidelines for handling hazardous materials.

The CPIMS is divided into the following sub-topics:

- Transportation and Planning Considerations
- LNG Hazard Summary
- LNG Tank Car Design and Construction Summary
- Railroad Safety Procedures
- LNG Emergency Procedures (8 sub sections)
- Reference

TRANSPORTATION AND PLANNING CONSIDERATIONS

- With the recent expansion of U.S. natural gas production, a dramatic increase in the transportation of liquefied natural gas (LNG) by rail from production locations to terminals and users is anticipated. LNG has already been approved for transport by cargo tank truck (MC-338 and its predecessors) for over 50 years in the United States, and for over 60 years by marine vessel internationally.
- In August 2020, the U.S. Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) approved a final rulemaking authorizing the nationwide transportation of LNG by rail (Docket No. PHMSA-2018-0025 (HM-264)). This followed a DOT Special Permit 20534 issued in 2019 to Energy Transport Solutions, LLC, which authorized LNG shipments between Wyalusing, PA and Gibbstown, NJ with no intermediate stops and subject to certain operational controls.
- LNG via rail may be found in an LNG fuel tender, locomotive, tank car, and UN portable tank. A fuel tender will be coupled to a locomotive and may have decals indicating that the tank content is "Liquefied Natural Gas." However, a tender moving to a shop or being repositioned may be found in a regular train service configuration. An LNG tank car or UN portable tank will have a placard with "UN 1972" against a white background and will be marked "Refrigerated Methane Liquid."
- At the present time, LNG is expected to be shipped by rail in limited numbers (1 – 3 tank cars) as part of a general freight (manifest) train that is made up of many different commodities from many different shippers. In these situations, emergency responders need to consider the potential impact that tank cars containing other hazardous commodities may have on tank cars containing LNG if a release occurs, and vice-versa. As the energy infrastructure grows, LNG may eventually be shipped in larger and larger blocks until it is a unit train.
- To determine what specific commodities or hazardous materials may be involved in an accident scenario, responders should obtain a copy of train consist from the train crew or by contacting the rail carrier's emergency contact number. The AskRail® app also provides immediate access to accurate, timely data on the contents of a railroad tank car (askrail.us).
- Responses to an LNG train derailment will require specialized outside resources that may not arrive at the scene for several hours; therefore, it is critical that responders coordinate their activities with the involved railroad and initiate requests for specialized resources as soon as possible.

- Derailment scenarios will likely require mutual aid and a more robust on-scene *Incident Management System* than responders may normally use. Pre-incident planning, preparedness and coordination of response strategies should be considered and made part of response plans, drills, and exercises that include the shippers and rail carriers of this commodity.

LNG HAZARD SUMMARY

- Hazards reflect the physical properties (i.e., how a material behaves) and chemical properties (i.e., how a material harms). LNG by rail presents three main hazards: (1) flammability; (2) dispersion; and (3) cryogenic temperatures.

Hazard	Chemical Behavior	Physical Condition*
Flammability	Flash Point	-306° F (-188° C)
	Boiling Point	-260° F (-160° C)
	Explosive Range	5% (LEL) to 15% (UEL)
	Autoignition Temperature	1,004° F (540° C)
Dispersion	Expansion Ratio	600:1 @ 1 Atmosphere
	Vapor Pressure	258,574 mm Hg @ 100° F (38° C)
	Vapor Density at -166° F (-110° C) relative to Ambient Air	1.0
	Vapor Density at -260° F (-160° C) relative to Ambient Air	1.4
	Liquid Density (Weight per Volume) - Dependent upon methane volume	3.56 - 4 lbs./gallon
Cryogenics	Specific Gravity (Liquid Phase)	0.422@ -260° F (-160° C)
	Solubility in Water	Negligible (below 0.1%)
	Critical Temperature	-232° F (-147° C)
	Heat of Vaporization	220 BTU/lb.

NOTE: * LNG is not a pure substance and consists of multiple components. Physical and chemical properties can cover a range dependent upon the source and components of the LNG.

- LNG is natural gas that has been liquefied through condensation – a process referred to as liquefaction. The resulting LNG takes up about 1/600th of the volume of natural gas in its vapor state. Thus, LNG can be stored and transported in specially designed storage tanks, marine vessels, highway cargo tanks, rail tank cars, or UN portable tanks.

- LNG is a mixture of hydrocarbons in which methane is the primary constituent. LNG is primarily composed of 85% to 96% methane, with other light hydrocarbons such as ethane, propane and butane making up the balance. LNG can also contain about 1% nitrogen. The properties listed in the table on page three (3) can vary depending upon the composition of LNG at the source.

- LNG vapors are heavier than air until approximately -160° F. The vapors are odorless, colorless, non-corrosive, and non-toxic. LNG is not odorized, as methyl mercaptan will freeze at -189° F (-123° C) and LNG is shipped at -260° F (-160° C). Although non-toxic, LNG is a simple asphyxiant and will displace air when released in a confined or congested area.

- LNG will float on water, causing the water to look like it is boiling as the LNG transitions back to vapor.

- To be used as a fuel, LNG must be vaporized to return it to its gaseous form (referred to as regasification). The vaporized natural gas is then injected back into a pipeline system or used to fuel natural gas operated equipment.

- While natural gas is lighter than air, initial LNG vapors may be heavier than air due to their cold temperatures. LNG vapors can accumulate in low areas and travel some distance to a source of ignition. If LNG vapors are ignited, they will burn back to the source.

Flammability Hazards

- Under the U.N. Global Harmonized System of Classification and Labeling of Chemicals (GHS), LNG is classified as a Flammable Gas – Category 1 and as a Gas Under Pressure – Refrigerated Liquefied Gas. LNG hazard statements are “Extremely Flammable Gas (H220)” and “Contains Refrigerated Gas: May Cause Cryogenic Burns or Injury (H281).”

- Comparison of LNG flammability hazards to other common flammable materials.

Chemical Property	LNG	Propane	Gasoline
Flash Point	-306° F (-188° C)	-155° F (104° C)	-45° F (-43° C)
LEL	5% - 15%	2.1% - 9.5%	1.3% - 7%
Ignition Temperature	1,000° F (540° C)	850° F (454° C)	495° F (257° C)
Burn Rate	0.36 m/sec.	0.7 – 0.9 m/sec.	0.4 m/sec.

- A vapor cloud may be present due to the operation of a pressure relief device or a breach of containment, which could occur if both the inner tank and jacket shell are breached. This can also lead to auto-refrigeration of the liquid, causing the cryogenic liquid to cool and the pressure to drop within the container.

- Flammable vapors can be present beyond the visible vapor cloud. Once ignited, the fire will burn back to the LNG source.

- Remember that a combustible gas indicator calibrated on methane will alarm at 10% of the lower explosive limit (LEL) of 5,000 ppm of (i.e., 5,000 ppm), well before the oxygen sensor will alarm. Flammability remains a greater hazard than simple asphyxiation.

- Given the high ionization energy (IE) of methane (12. eV), a photoionization detector (PID) is not an effective monitoring technology unless emergency responders have a bulb greater than the IE of methane.

- When working in and around flammable atmospheres, extreme caution must be taken to avoid creating ignition sources. This includes but is not limited to the placement and use of vehicles and equipment, including non-sparking tools and intrinsically safe/explosion-proof equipment.

- When LNG is spilled and its vapors come in contact with an ignition source, the spill will develop into a pool fire and present a thermal radiation hazard. If there is no ignition source, the LNG will vaporize rapidly forming a cold gas cloud that is initially heavier than air, spreading and carrying downwind until it reaches neutral buoyancy as it warms up.

- Responders should wear structural firefighting clothing and self-contained breathing apparatus (SCBA) to avoid potential flash fire exposure. Structural firefighting protective clothing will NOT protect against exposure to the liquid.

Dispersion Hazards

- LNG has an expansion ratio of 1 to 600 when vaporized at 1 atmosphere and warmed to ambient temperature. It is usually stored and transported at very low pressures, typically less than 5 psig, in well insulated containers.

- The density of LNG is 3.56 - 4 lbs./gallon depending upon the source – about half the weight of water (8.3 lbs. per gallon). If spilled on the ground, it will boil rapidly at first and then boil slowly as the ground cools. If spilled on water, it will float on the surface and vaporize rapidly since even at near freezing water temperatures, the water is significantly warmer than the released LNG. The resulting vapor cloud is actually water vapor condensed by the cold LNG vapors and not the LNG vapor itself.

- Initially, the LNG vapor cloud is denser than air. If ignition is delayed, the mixture hugs the ground and spreads laterally. As the cloud mixes with air, the expanding vapor cloud may not be visible. As it continues to disperse, the vapors will eventually become neutrally buoyant (-162° F / -108° C). The size of the vapor cloud will depend on the amount of LNG released, the pressure and direction of the leak source, wind speed and direction, relative humidity and other weather conditions.

- As an LNG release vaporizes back to a gas, it creates hazards similar to a natural gas release. This can include vapor/air explosion hazards indoors, in confined spaces, in congested outdoor areas, or in sewers. Do not flush the product into sewer or drainage systems as it may create an explosion hazard in these confined spaces. Remove sources of heat, sparks, open flames, friction and electricity, including internal combustion engines and power tools. Static electricity may buildup when transferring product; bonding and grounding measures should be taken prior to transfer operations. Use caution when approaching the scene and positioning fire apparatus. Implement air monitoring as soon as possible to detect the presence of combustible gasses.

- A natural gas cloud may ignite but has not been shown to explode if not confined. LNG itself will not burn or explode; it must be vaporized and mixed with air in the right concentrations (5% LEL to 15% UEL) to make combustion possible.

- Methane vapors in open air exhibit a very slow flame spread of approximately 4 mph. If the LNG cloud does not ignite, it can travel some distance under the right conditions. However, as it travels the cloud is also warming up, and will rise and dissipate.

Cryogenic Hazards

- LNG is a cryogenic liquid and is stored and transported at -260° F (-162° C). When cooled to this temperature at atmospheric pressure, natural gas turns into a liquid which provides a practical, safe, and economical method of transportation and storage.

- Contact with cryogenic liquid or vapors can cause severe damage to the skin and eyes. Normal structural firefighting clothing will not provide skin protection against liquid LNG due to its extremely low temperature. Breathing cold vapors can damage lung tissue. LNG contact with ordinary metals such as carbon steel can lead to material embrittlement and fracture, thereby requiring specialized containers and piping. LNG is stored and transported in insulated, thermos-like double walled tanks and containers.

- In marine transportation, when released on water LNG will float and then vaporize. If large volumes of LNG are released on water, it may vaporize too quickly causing a rapid phased transition (RPT). An RPT can only occur if there is mixing between the LNG and water. RPT's may be referred to as a cold explosion without combustion, ranging from small pops to blasts large enough to potentially damage lightweight structures. RPTs may also occur on land or other solid surfaces where LNG collects in a depression.

LNG TANK CAR DESIGN AND CONSTRUCTION SUMMARY

- Cryogenic materials pose unique challenges for selecting the appropriate transportation packaging / container. The extremely cold temperatures render most types of packaging materials too brittle to maintain during transportation. Therefore, all inner tanks of cryogenic tank cars are required to be constructed from stainless steel packaging that enable them to retain their strength and ductility at extremely low temperatures.

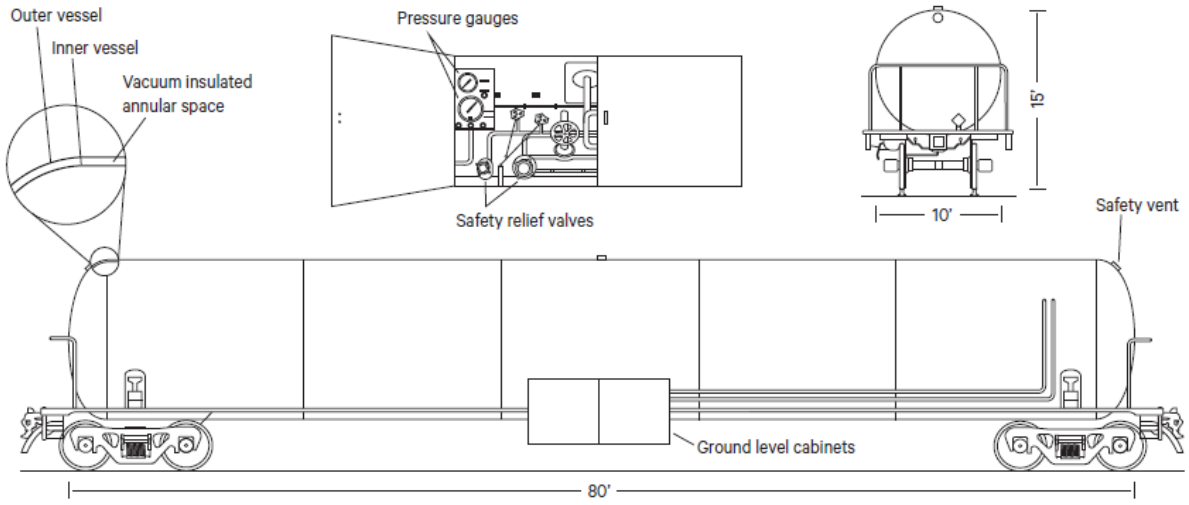
    - Ensuring that the product being transported remains at these cold temperatures during transportation is necessary to prevent product expansion and overpressure conditions, or possible activation of the container's pressure relief device.
    - All bulk containers authorized for the transportation of flammable cryogenic materials (e.g., DOT-113 tank cars, MC-338 cargo tank trucks, and T75 UN portable tanks) are built as a "tank within a tank" design.

- PHMSA has approved the DOT-113C120W9 for the rail transport of LNG. Key construction features of this tank car include the following:

    - This tank car is a vacuum-insulated "tank-within a tank" design similar to a thermos bottle consisting of a stainless steel inner tank supported within a carbon steel jacket, herein after referred to as the outer tank, and specifically designed for the transport of cryogenic materials (e.g., liquid hydrogen, oxygen, ethylene, nitrogen and argon).
    - The delimiter letter "C" indicates that the tank car meets PHMSA's enhanced outer tank shell and thickness requirements and is designed for loading and shipping temperatures as low as -260° F (-162° C).
    - The suffix number "9" indicates that the tank car meets PHMSA's enhanced jacket material and thickness requirements.
    - The inner tank is constructed of an austenitic stainless-steel alloy with a minimum thickness of 3/16th-inch.
    - The outer tank shell is 9/16-inch thickness constructed of normalized carbon steel (AAR TC-128 Grade B). This is the same steel as used for high hazard materials such as the DOT-105 (chlorine) and DOT-117 (crude oil and ethanol) tank cars.
    - The annular space between the inner tank and the outer tank is approximately 6-inches and is under vacuum. The insulated annular space minimizes the rate of heat transfer from the atmosphere to the liquid inside during transport and provides the majority of insulation value.
    - Pressure relief devices include a self-closing pressure relief valve with a start-to-discharge pressure of 75 psig, and a non-reclosing pressure relief device (i.e., burst disc) set to discharge at the tank test pressure. These tank cars may also have regulator valves (aka road valves) that function in transit to reduce the pressure and cool the liquid.

- A protective housing mounted on the side of the tank car surrounds all valves, gauges, closures, and pressure relief devices to protect from environmental exposure.

DOT113 Tank Car



- If an LNG tank car is breached in the liquid phase during a derailment, the LNG will be released as a very cold liquid, creating an LNG pool that could catch on fire. Employing a thicker outer tank will reduce the puncture probability of the inner tank. In a rail accident scenario, a puncture of the inner tank can only occur after the outer tank is breached.

- DOT-113 tank cars have a safety record of over 50 years and over 100,000 rail shipments with no reported fatalities or serious injuries occurring due to a train-accident caused release of product. Also, there are no records of rail incidents involving LNG being shipped in T-75 UN portable tanks. Risk assessment research has shown the following:

  - Ninety-nine percent of the incidents involving DOT-113 or AAR-204W (tank car similar in design to the DOT-113 tank car) involved the non-accidental release of product attributed to defective or improperly secured valves and not a breach of the tank. Two significant rail incidents involving release of cryogenic liquids have occurred – one in Moran, KS and the other in Mer Rouge, LA.
  - Moran, KS Derailment (2011) – Three DOT-113 ethylene tank cars derailed and two of the cars were breached and caught fire. The fire consumed the contents of the #1 ethylene tank car, while the #3 tank car containing ethylene did not breach but began venting through its pressure relief valve. The #2 and #3 tank cars eventually were breached by a controlled vent and burn process employed by tank car specialists to minimize the risks to responders and expedite the clean-up process.
  - Mer Rouge, LA Derailment (2014) – Two tank cars transporting refrigerated liquid argon (DOT-113 and AAR-204W) derailed due to a truck stalled on the tracks and

neither tank car was breached. Approximately 47,000 gallons of liquid argon was released through their pressure relief systems.

- There are currently no reports in the literature of a boiling liquid expanding vapor explosion (BLEVE) of a cryogenic bulk container constructed to current U.S. standards for MC-338 cargo tank trucks, portable tank containers, or rail tank cars. While possible, a BLEVE is viewed as a lower probability event given the following factors:
    - The tank car insulation system, as the double-shell container construction is more robust than non-cryogenic container designs. The annular space of the DOT-113 works in combination with a properly functioning pressure relief system to reduce the likelihood of a high-energy event such as a BLEVE.
    - The requirement for redundant pressure relief systems (i.e., pressure relief valve and burst discs).
    - In 2018 PHMSA conducted a propane pool fire test on a 40-ft. T75 UN portable tank filled with liquid nitrogen. During the 200+ minute fire exposure, pressure relief valves (PRV) opened successfully and relieved the internal pressure to avoid a BLEVE event. Phase 2 tests involved a T75 UN portable tank filled with LNG and exposed to a propane pool fire test were scheduled but are currently delayed due to COVID issues.
- Key operational controls that pertain to the rail transport of LNG include the following:
    - The maximum pressure of an LNG tank car when offered for transportation is 15 psig. Each loaded LNG tank car must be monitored for location and inner tank pressure by the offeror who must notify the carrier if the tank pressure rises by more than 3 psig.
    - The maximum permitted filling density (MPFD) is 37.3%. MPFD is the maximum amount of liquid gas that may be filled into a container as compared to the weight of water a container can hold. For a 34,500 gallon capacity tank car (maximum capacity permitted by regulation), an LNG tank car could hold approximately 29,000 gallons of product.
    - The design service temperature is -260° F (-162° C).
    - Trains with 20 continuous tank cars of LNG, or 35 tank cars of LNG throughout the entire train are required to be equipped with a two-way end-of-train (EOT) device or distributed power. These braking controls are also consistent with the current requirements for High Hazard Flammable Trains (HHFT).
    - LNG shipments must comply with the current 49 CFR 172.820 rail routing requirements, including conducting an annual route analysis. These are consistent with the current HHFT requirements.

LNG TENDER DESIGN AND CONSTRUCTION SUMMARY

- In some locations there currently exist locomotives that are powered by LNG. These liquefied natural gases fueled locomotives are best identified by their connection to natural gas tenders, typically coupled in a locomotive / tender / locomotive configuration. The tender provides pressurized (125 psi) non-odorized gaseous natural gas to the locomotive at 40° F (4.4° C) to 115° F (46.1° C). **LNG is not present on the locomotive(s).**

- Key design and construction features of the tenders include the following:

  - LNG tenders are constructed to DOT-113C120W specification as a minimum.
  - Tenders are equipped with pressure relief devices similar to those found on cryogenic tank cars.
  - Connections between the tender and the natural gas fueled locomotive consist of a gaseous natural gas fuel line and two heat exchange fluid lines (delivery and return) at temperature between 40° F (4.4° C) to 125° F (52° C).
  - Heat exchanger fluid is a 60% propylene glycol / water mixture.
  - Emergency tender cut-offs are designed to stop the flow of gaseous natural gas to its coupled locomotives. Gaseous natural gas may still be present in piping and railroad personnel should be contacted if the pipes need to be vented and/or purged.
  - Some external piping within rectangular protective housings may be cold and frosted due to the presence of LNG in the pipe. All cryogenic piping external to a protective housing that is accessible from ground level and/or adjacent to safety appliances is protected from incidental contact (e.g., jacketed or guarded). Piping used for tender-fill operations is excluded from jacketing or guarding requirements, as this component is free of liquefied natural gas after tender-fill operations. Proper PPE is required when handling these cryogenic components.
  - The natural gas fuel line and the heat exchange fluid line are semi-permanently connected to the tender and are attached to the locomotive by use of dry quick-disconnect couplers. These lines may have manual shut-off valves behind the locomotive end plate and will have manual shut-off valves behind the tender end plate.

RAILROAD SAFETY PROCEDURES

Emergency response personnel should always be aware of the potential for serious injury when working in and around railcars, tracks, and related equipment. The following safe operating practices should be followed when involved in emergency response operations at the scene of an LNG train derailment:

CAUTION: Always expect a train or rail equipment to move on any track from either direction at any time!

- Always contact the railroad to advise them of your presence – they may not know that you are on-scene or that they have a problem. Work with the railroad to be sure the track is "blue flagged" – the railroad's version of "lock-out, tag-out" protection.

- Trains can approach with little or no warning. You may not be able to hear them due to atmospheric conditions, terrain, noisy work equipment, or passing trains on other tracks. Stand a minimum of 25 feet away from the tracks if possible and face the train when rail equipment is passing through.

- Watch for movement in both directions before crossing tracks. If the tracks are clear, walk single file at a right angle to the rails.

- Never stand, walk, or sit on railway tracks, between the rails or on the ends of ties. Never step on the rail - step over it. The rail can be a slip, trip, or fall hazard. Never put your feet on moveable parts of a rail car such as couplers, sliding sills, or uncoupling levers.

- Do not occupy the area between adjacent tracks in multiple track territory when a train is passing. If crossing between two stationary railcars, ensure there is at least 50 feet between them.

- Be especially careful working in rail yards and terminal areas. Rail cars are pushed and moved and can change tracks often. Cars that appear to be stationary or in storage can begin to move without warning. Be sure that any rail equipment is secured against movement (wheels chocked, hand brakes secured, track is blue flagged, etc.) before attempting to work on or near it. Keep at least 25 feet away from the end of a car or locomotive to protect yourself from sudden movement.

- Be aware of the location of structures or obstructions where clearances are close.

- Never move equipment across the tracks unless at an established road crossing or under the supervision of a railroad representative.

- If it is necessary to climb rail equipment, always use three points of contact at all times. The ladders on rail equipment may curve around the car making it difficult to find the rung with your foot. The first step on to rail equipment is typically some distance from the ground. When descending the ladder, step - do not jump from the last step. Normally, there is ballast around the tracks which can be uneven and shift, causing a fall hazard. Locomotive steps are considered ladders. Always face the locomotive going up and coming down.

- Never cross over or under rail equipment -- use the ladders, handholds, and crossover platforms or walk around the attached equipment. Remember to block the feet and tie off ladders at the top. When laddering tank cars or box cars, always consider using two points of access - the second being a point of escape should the other become inaccessible for any reason. Plan to use your own ladders.

- To minimize distractions and potential accidents avoid the use of cell phones when within 25 feet of live tracks.

- Stay away from track switches since they can be remotely operated.

LNG EMERGENCY PROCEDURES

- The basic approach for managing an LNG by rail incident will build upon basic Hazardous Materials Operations level skills. Knowledge of the product, its container and the environment will be critical factors in evaluating response options using a risk-based response process. Response challenges will primarily focus on the location of the incident, the type and size of the release, the size of the initial problem, and the amount, type and nature of resources necessary for vapor control, fire control, clean-up and recovery.

- Emergency response organizations should use the following framework and incident management best practices to prepare for, and safely and effectively respond to an LNG rail transportation incident.

1. PRE-INCIDENT PLANNING AND PREPAREDNESS

- Emergency responders should determine the rail carriers of hazardous materials moving through their communities and ascertain if LNG is one of the products being transported. This can be accomplished by contacting the individual rail carrier and requesting a list of the hazardous commodities transported through the community via the Association of American Railroads (AAR) Circular No. OT-55 protocol. This information can assist in preparing emergency response plans and procedures.

NOTE: The latest version of AAR Circular OT-55 and other related hazardous materials reference materials can be downloaded at http://www.boe.aar.com/boe-download.htm.

- Emergency responders should contact and engage the State Emergency Response Commission (SERC) and Local Emergency Planning Committee (LEPC) within their jurisdiction. The SERCs and LEPCs can be a valuable resource in obtaining information

concerning the hazardous commodities being transported through the community, as well as assisting with emergency planning, preparedness, and response activities. LEPCs and emergency responders can seek planning information and commodity-specific training at www.TRANSCAER.com by selecting a state or region to determine the designated contacts.

- Emergency responders should also contact the railroads to identify appropriate points-of-contact and the railroad's hazardous materials response personnel that they are likely to interface with during an emergency. This can help to establish lines of communication and access to information and resources prior to an incident. The railroads can also provide extensive rail specific emergency response training at no cost to emergency responders. Information may be obtained via the railroad's web site or by contacting their media/public relations department.

- Emergency responders should identify the appropriate 24-hour emergency contact numbers for the major (Class I) railroads and ensure they are listed in their emergency operations and response plans. The emergency contact numbers for the Class I railroads are listed below.

Company	Emergency Telephone Number
BNSF Railway	(800) 832-5452
Canadian National (CN) Railway	(800) 465-9239
Canadian Pacific (CP) Railway	(800) 716-9132
CSX Transportation	(800) 232-0144
Kansas City Southern Rail Network	(800) 892-6295
Norfolk Southern Railroad	(800) 453-2530
Union Pacific Railroad	(888) 877-7267

NOTE: Emergency responders should also contact any Short Line or Regional Railroads that service their areas to obtain emergency contact information. These organizations should also be part of any pre-incident planning, preparedness and training/exercise activities.

- Emergency responders should establish contact with their federal, state and local environmental protection agency representative(s) to identify potential air monitoring and environmental control resource capabilities. These resources should be included in the organization's emergency response plan.

- Emergency responders should contact federal agencies such as the U.S. Environmental Protection Agency and Coast Guard to determine the level of assistance that may be provided in the event of a release in navigable waterways located in their jurisdiction. This resource, as well as other federal resources, can be contacted through the National Response Center (NRC) at 1-800-424-8802.

- Organizations should include a railroad annex in their emergency response plan that specifically addresses rail transportation emergency response operations. This annex should include:
  - Hazard analysis that identifies the potential risks to people and property
  - Emergency contact lists
  - Resource listings
  - Equipment inventories
  - Incident management system roles and responsibilities
  - Mutual aid response assets
  - Law enforcement scene security and control operations
  - Support and recovery assets

NOTE: Emergency response plans and procedures should be developed in close coordination with the railroad since they will play a critical role in response and recovery operations. Drills and exercises should be conducted to test the plan at regular intervals to identify any issues that might require corrective action prior to an actual incident.

2. INCIDENT MANAGEMENT PRINCIPLES

- Initial site management and control will be a critical benchmark in managing the problem. Initial incident priorities for an LNG rail incident will be rescue, evacuation, and site management and control.

- Isolate and secure the area. Establish a secure perimeter and entry control points to prevent unauthorized personnel from entering the scene. This can be accomplished with hazard line tape, barricades, traffic cones, or assigned fire service or law enforcement personnel.

- The location of the restricted area / isolation perimeter should be communicated to all impacted personnel operating on the scene. Begin a site assessment from a safe distance, upwind and uphill. An Incident Command Post (ICP) should be established outside the impacted area as soon as possible.

- ERG Guide No. 115 (Flammable Gases) can be used to obtain initial response guidance for LNG incidents. NOTE: The ERG guidance is based upon all flammable gases and is not specific to only LNG.

- Isolate spill or leak area for at least 100 meters (330 feet in all directions).
- Large Spill – consider initial downwind evacuation for at least 800 meters (0.5 miles).
- Fire – If a tank car is involved in a fire, isolate for 1,600 meters (1 mile) in all directions and consider initial evacuation for 1,600 meters (1 mile) in all directions.

NOTE: The AskRail® app, ERG App, and the Areal Locations of Hazardous Atmospheres (ALOHA) plume dispersion model which is part of the CAMEO Suite can also be used to generate plume maps for initial response guidance.

- The *National Incident Management System* (NIMS) should be the framework used to manage all incident operations. Information on NIMS can be obtained at http://www.fema.gov/national-incident-management-system. Unified Command should be established that integrates those agencies and organizations with legal or jurisdictional responsibility including the railroad. Liaisons should be provided at the ICP by assisting or cooperating agencies to ensure effective communication and coordination of resources.

- Due to the size, duration, and complexity of these incidents, Incident Commanders should consider the possibility of additional support from regional or state *All-Hazard Incident Management Teams* (AHIMTs).

NOTE: AHIMTs are a multi-agency / multi-jurisdictional team for extended incidents formed and managed at the local, state or tribal level. AHIMTs are deployed as a team representing multiple disciplines who manage major and/or complex incidents requiring a significant number of local, state or tribal resources. They do not assume command of the incident; they help local officials manage incidents that extend into multiple operational periods and require a written Incident Action Plan (IAP). These incidents can include weather-related disasters such as a tornado, earthquake, or flood or major hazardous materials incidents such as train derailments.

- Emergency responders should anticipate a large number of liaison agencies operating at the scene (e.g., U.S. Coast Guard, Environmental Protection Agency, National Transportation Safety Board (NTSB), railroad personnel, private contractors). In addition, non-emergency regional and municipal agencies may have a role to play and need to be integrated into the command structure.

- The railroad will integrate its response assets into the public safety NIMS structure. While the exact structure will vary based on the scope and nature of the incident scenario, it will often be integrated as the Railroad Branch within the Operations Section.

- Large-scale incidents may require activation of the jurisdiction's Emergency Operations Center (EOC). The EOC should be fully staffed and the roles and responsibilities of all participating agencies must be clearly defined in the organization's emergency response plan.

3. PROBLEM IDENTIFICATION

- Identify, confirm, and verify the presence of the hazardous material(s) and the extent of the problem. This can be done through either hard copy or electronic format of shipping papers, placards, labels, container shapes, markings/colors and senses (e.g., observable vapor cloud).

NOTE: Shipping papers (either hard copy or electronic format) for shipments in made-up trains include train consists or train lists. For shipments in a rail yard or terminal, a train list or train consist may not be available; the appropriate document is called a track list.

- Identify the rail carrier and locate the train crew. The conductor will have the complete train consist or train list immediately available on the scene. Maintain contact with the conductor and crew until they are relieved by a railroad official(s).

- Determine the incident type: no spill / release; spill / release with no ignition; spill / release with ignition.

- Notify the rail carrier's emergency operations center to have rail traffic stopped to avoid entering the location of the incident to avoid further risk to personnel operating at the scene. Request that a hard copy or electronic format of the train consist, or train list be sent to the ICP.

- Responding railroad officials may also have copies of the train consist or train list. In the absence of shipping papers, emergency responders should use binoculars from a safe distance upwind / uphill and try to locate any 4-digit identification numbers on the placards (or orange panels) displayed on the rail cars. If shipping papers, placards, markings, or labels are destroyed, the reporting marks and number on the railcar can be used to identify the commodities present. In addition, the use of the AskRail® app or directly communicating with CHEMTREC® should be considered.

- When contacting the railroad, provide the following information:
  - Your name, location, organization name and telephone number
  - Location of incident (provide the railroad with the DOT Crossing Number or the railroad milepost so the specific location can be identified)

- Type and number of containers involved
- Presence of markings, labels, reporting marks or placards on tank car
- Presence of smoke, vapors, fire, or spill
- Extent of damage
- Topography
- Weather conditions
- If pictures can be taken from a safe position, do so and send to a railroad representative as quickly as possible

- Be aware of utilities that commonly run next to, across or in the railroad right-of-way. As part of your scene size up, look for downed signal and communication lines, power lines, buried utilities, pipelines and above ground switch heating systems.

4. HAZARD ASSESSMENT AND RISK EVALUATION

- The application and use of a risk-based response (RBR) methodology is critical for hazardous materials incidents. As background, RBR is defined by *NFPA 470 – Hazardous Materials Standards for Responders* as a systematic process, based upon the facts, science and circumstances of the incident, by which responders analyze a problem involving hazardous materials to assess the hazards and potential consequences, develop an incident action plan (IAP), and evaluate the effectiveness of the plan.

- Emergency responders can use a number of reference materials such as the ERG, Safety Data Sheets (SDSs), technical specialists available by contacting the shipper or railroad, or contacting the Chemical Transportation Emergency Center (CHEMTREC®) at 1-800-424-9300, or the 24-hour emergency contact telephone number required to be included on the shipping papers by the federal hazardous materials regulations.

- The level of risk will be influenced by the following factors:
  - Hazardous nature of the material(s) involved
  - Quantity of the material(s) involved
  - Type(s) of stress applied to the container and its breach / release behavior
  - Proximity of exposures and nature of terrain
  - Level and response time of available resources (i.e., water, extinguishing agent)

- The following factors should be considered in estimating the potential impact of the problem:
  - Remember – both tank cars and UN portable tanks being used for the rail transport of LNG have an inner tank and an outer tank.

- How has the container been stressed? It is a mechanical stress due to the energy associated with a derailment scenario, or a thermal stress associated with flame impingement or ambient heating?
- Has the tank car been breached? If so, what is the nature of the breach (e.g., activation of pressure relief devices, breach of the outer tank shell)?
- What type of release is occurring? Is the LNG pooling or is it creating a vapor release?
- What harm will the container and its contents cause?
- What is the proximity of the release to exposures - people, property, environment, critical infrastructure?
- Is the material on fire? Are other tank cars at risk of becoming involved?
- Do you have the capability of successfully controlling vapor or fire spread?

- Based on the results of the risk evaluation process, are there adequate resources available to respond to the scene within a reasonable timeframe so that intervention efforts will be successful?

- Emergency responders should use the information and options selected as the foundation to develop an IAP for the incident.

CAUTION: If your agency is not fully prepared and capable in terms of resources, equipment and properly trained personnel to intervene offensively, defensive or non-intervention strategies will likely be the preferred strategic option.

LNG presents four potential general risk related scenarios: (1) fire; (2) vapor cloud explosion (open air vs. confined); (3) cryogenic effects; and (4) rapid phase transition.

Fire Scenarios

- There are three potential fire risk scenarios: pool fire, jet fire, and vapor cloud fire.

- *Pool Fire Scenario* – An LNG release can form a liquid pool. As the spill forms, some of the liquid evaporates. If an ignition source is encountered, the vapors will ignite and travel back to the origin of the release resulting in the pool fire.
  - If the spill occurs in an unconfined area, the burning pool fire is free to flow based on topography and geometry of the spill.
  - As with any flammable gas fire, the fire should not be extinguished unless the fuel source can be isolated. Fire control options include water, dry chemical and high expansion foam.
  - Water should not be applied directly onto the spill, as it is warmer than LNG and will increase the rate of vaporization and will intensify any fire. Water fog streams can be

used for controlling vapor movement, while water streams can be used for the cooling protection of exposures, including adjoining tank cars or structures.

  - Water may have limited effectiveness in cooling exposed LNG or cryogenic tank cars that have maintained their integrity due to the tank within a tank design. The indiscriminate use of water on the surface of containers and piping may lead to increased icing and the possible failure of valves, instrumentation and other control devices. Air monitoring should be conducted to determine the effectiveness of water streams in dispersing flammable vapors.
  - For a small LNG fire, the preferred extinguishing agent is dry chemical (potassium bicarbonate or Purple K). However, re-ignition is a distinct possibility.
  - High expansion foams are not considered to be effective LNG fire extinguishing agents but can be effective in dike and impoundment areas at LNG storage and transfer locations where the foam blanket reduces the radiant heat generated by the fire. They may also prove valuable in vapor control of unignited LNG vapors.
  - When high expansion foam is initially applied to a spill, there is some initial warming and an increase in vaporization, but the rate of vaporization eventually stabilizes and slows down the escaping LNG vapor so that the flammable area of the release is much smaller.
  - Aqueous Film-Forming Foam (AFFF) and Alcohol Resistant Aqueous Film-Forming Foam (AR-AFFF) foams are not effective in controlling vapor production or extinguishing an LNG fire.

- *Jet Fire Scenario* – A jet fire could occur during unloading or transfer operations when pressures are increased by pumping. It could also occur with the ignition of vapors from the pressure relief valve discharge.
  - In this scenario, LNG vapors discharging through a breach will form a gas jet that entrains and mixes with air. If the mixture finds an ignition source while in the flammable range, a jet fire may occur.
  - In a derailment scenario, a jet fire from the pressure relief valve discharge could impinge upon an adjoining tank car and increase the potential for a cascading scenario.
  - A jet fire scenario can only be controlled by isolating the source or product flow, while protecting exposures (as possible).
- *Vapor Cloud Fire Scenario* – When LNG is released into the atmosphere a vapor cloud forms and disperses by mixing with air. If the vapor cloud ignites before the vapor cloud is diluted below the LEL, a flash fire may occur. Ignition can only occur in the portion of the vapor cloud that is within the flammable range; the entire vapor cloud does not ignite at once.
  - A flash fire may burn back to the release point producing either a pool fire or a jet fire (or both), but it will not generate damaging over-pressures if it is unconfined.

Vapor Cloud Explosion (Open Air vs. Confined)

- If an LNG vapor cloud with concentrations in the flammable range is confined inside a structure and ignited, damaging overpressures may occur. Outdoor areas congested with equipment and structures can also help confine LNG vapor and may facilitate an overpressure upon ignition.
    - Pure methane has not been known to generate damaging overpressures if ignited in an unconfined or uncongested area.
    - Liquefied gases such as propane and butane are more susceptible to vapor cloud explosions.

Cryogenic Effects

- LNG containers are manufactured from high quality metals intended for cryogenic storage and transport. The inner tank is designed for contact with the LNG, while the outer tank is to contain the insulating vacuum and provide mechanical stress protection in the event of an accident scenario.

- Exposure to cryogenic liquid can cause embrittlement of steel, rubber and plastics. Skin contact with LNG will result in thermal burns. Never walk into an LNG spill.

- If the tank car is not damaged but is leaking, the following might be the source / cause:
    - Fittings in Cabinet – valves and caps are a potential source of leaks and may need to be closed or tightened.
    - Vapors releasing from vent stack
    - Pressure relief valve or rupture (frangible) disc is releasing

Rapid Phase Transition (RPT)

- RPT has been observed in some LNG spill experiments on water focused on the marine transportation of LNG. It involves the nearly simultaneous transition from the liquid to vapor phase with an associated rapid pressure increase.

- RPT may result in two types of effects: (1) a localized overpressure resulting from rapid phase change, and (2) dispersion of the “puff” of LNG expelled to the atmosphere. The RPT energy comes from a physical phase change and is much less than the energy available from a chemical combustion reaction.

- While RPT changes have been observed in a few LNG spill experiments on water, they have not resulted in any known incidents involving LNG surface transport.

5. SELECT PROPER PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

- Assure that emergency responders are using the proper personal protective equipment (PPE) and clothing equal to the hazards present (i.e., fire scenario vs. liquid / vapor release). Contact with a cryogenic can cause severe damage to the skin and eyes. Breathing cold vapors can damage lung tissue. **Structural firefighting protective clothing (SFPC) and positive-pressure SCBA should be the initial level of PPE selected when dealing with potential fire scenarios**.

- Any changes in the level of PPE should be based on the associated hazards and risks, and the results of air monitoring operations. Continuous monitoring with a combustible gas indicator and instruments capable of detecting LNG vapors are important in ensuring site safety.

CAUTION: SFPC will provide thermal protection for LNG fires; however, SFPC is porous and can absorb LNG liquid and vapors and will not provide substantial protection against cryogenic liquids. Ensure that the protective clothing and equipment is rated for the temperature of the material to be handled (i.e., fire vs. liquid / vapor release). Exposure to LNG liquid can cause embrittlement of rubber and related PPE materials.

6. LOGISTICS AND RESOURCE MANAGEMENT

- Order specialized equipment and technical resources early in the incident. If you are unsure of your initial resource requirements, always call for the highest level of assistance available. **Do not wait to call for additional resources or activate mutual aid agreements.** Also consider both response times and incident scene access when requesting resources.
- Establishing a Logistics Section early in the incident will be critical in providing the necessary support, resources, and services to meet operational objectives. **The size, scope, and resources needed to successfully manage a hazardous materials derailment scenario will overwhelm the capability of most emergency response agencies.**

- Emergency planning and response agencies must identify their logistical needs, identify agencies or organizations that can meet those requirements, and effectively manage the resources available from those identified sources within the NIMS framework.

- The rail carrier will be the primary providers of logistical support and resources at a derailment scenario. Rail carriers can provide emergency response resources, air monitoring and environmental management capabilities, product and container specialists and contractors to safely manage the consequences of a train derailment. For example, rail carriers may use the services of private contractors to provide air monitoring and environmental assessments.

- The time required for assets to arrive on scene and initiate operations must be considered since long delays can diminish operational effectiveness. Logistics for access, staging, positioning and movement should be considered, including the need for escorts to facilitate prompt access to the scene.

- Technical specialists and contractor support can also be made available from the shipper and can be obtained by contacting the 24-hour emergency telephone number provided on shipping papers or by contacting CHEMTREC at 1-800-424-9300.

- Emergency responders may also obtain assistance from the NRC by calling 1-800-424-8802. For example, the NRC can provide 24-hour access to federal government agency resources and technical assistance. The NRC also serves as the EPA's *Hazardous Materials Hotline* and the USCG *Oil Spill Hotline*.

7. SELECT AND IMPLEMENT RESPONSE OBJECTIVES

- The initial stage of a rail incident involving LNG should include an analysis of appropriate site-specific response procedures and potential effects that an incident would have on nearby life, property, critical systems and the environment.

- ERG Guide No. 115 (Flammable Gases) should be used by emergency responders to obtain initial response guidance for LNG incidents. Rescue operations should be performed from an uphill and upwind location, if possible.

- **Traditional firefighting strategies and tactics may not be effective in these situations.** LNG incidents also need to be approached and managed as a hazardous materials problem to ensure that proper and appropriate technical assistance and the support of outside resources are notified and requested as soon as possible.

- Use the railroad's emergency telephone number to establish communication with the railroad and stay in constant communication with the railroad. If the train crew is disabled or unavailable, the train consist is available from the Railroad Emergency Telephone Number point-of-contact and can be sent to the scene via e-mail or fax.

- Confirm your location with the Railroad Emergency Telephone Number point-of-contact by observing mile posts or the individual grade crossing identification numbers at or near the scene.

- Coordinate operations with the railroad, chemical shippers and manufacturers, CHEMTREC and/or the shipper's 24-hour emergency contact to ensure that you have access to all the information available concerning the commodity and tank car(s) involved in the accident.

- Utilize the railroads' hazardous materials personnel when they arrive on scene. They can assist with size-up and damage assessment. These personnel have been specifically trained to respond to railroad emergencies and derailments.

CAUTION: Based on the collection, evaluation and verification of response information, emergency responders need to determine whether an offensive, defensive or non-intervention mode should be employed.

Remember that offensive operations normally require operating in close proximity to the problem and can significantly increase the risks to emergency responders.

- The following factors should be considered as part of developing the initial response strategy:

QUESTION	RESPONSE CONSIDERATIONS
Are there any life safety exposures in danger that responders must address right now? Can responders safely evacuate or protect in place?	Number of people to be protected, ability of public to move, available time, resources needed, adequate facilities to shelter evacuees.
Can responders safely approach the incident?	Location of the incident, access and terrain, number of tank car(s) involved, extent of damage, size of release or fire involved, and radiant heat levels.
Do responders fully understand the nature and scope of the problem?	Risk evaluation must be completed, and the results shared with Technical Specialists from the railroad and/or shipper, and response agencies.

QUESTION	RESPONSE CONSIDERATIONS
If a fire is involved, do responders have immediate access to sufficient water supplies that are required for effective exposure protection or fire control operations?	Most fire departments will be challenged to provide an adequate water supply for an initial attack on a flammable gas derailment scenario. Defensive operations will likely be required until water supply can be sustained.
Can cooling water be effectively applied to any exposures impacted by direct flame impingement?	Cooling water must be able to reach their intended targets to be effective. If access, supply or equipment is limited, the ability of cooling water to reach the affected areas will be diminished. Cooling water will have limited effect upon an intact DOT-113 tank car due to the double shell / insulation design. Cooling water can be applied at the point of impingement from a jet fire scenario.
If the LNG release is not on fire, can potential ignition sources be removed and/or eliminated?	Vehicle traffic may need to be curtailed. Automatic switching systems (i.e., industrial air conditioning units, traffic signals) need to be switched off, etc.
Will extinguishment improve or worsen the incident and what are the impacts of doing so?	When dealing with flammable gas fires, the best option is to eliminate the fuel source. If the source cannot be controlled and the fire is extinguished, an unignited vapor cloud scenario will be created. In many situations, the best and safest response option for a train derailment scenario may be defensive or non-intervention tactics to allow the fire to burn itself out.
If the LNG release is not on fire and involves transfer operations at a fixed facility, can the product transfer be isolated and controlled?	Transfer operations at a loading / unloading facility may involve the use of transfer pumps and the control of isolation valves at the transfer facility. Depending upon facility layout and operations, these valves may be either manually or remotely actuated to control the release. Emergency responders should not isolate any valves without coordination with facility operations personnel.

QUESTION	RESPONSE CONSIDERATIONS
Have appropriate notifications been made or has the organization's emergency response plan been activated?	"Working" train derailment scenarios cannot be safely and effectively managed alone. Additional technical support and resources must be requested immediately in accordance with the agency's emergency response plan. The railroads, shippers and their emergency response contractors will be the primary means of technical support and resources and are an integral component of the organization's emergency response plans, procedures and operations.

CAUTION: The strategy for an LNG by rail incident that provides the highest level of safety to responders is either defensive to protect exposures or non-intervention.

If rescue, evacuation and exposure protection requirements have been met and there is no immediate or increasing risk to either emergency responders or critical structures and exposures, a strategy which allows an ignited release to burn off (controlled burn) and cool adjacent exposures can be effective.

8. CLEAN-UP AND POST-EMERGENCY OPERATIONS

- Based upon the scenario (e.g., manifest train vs. unit train derailment) and the potential for emergency responder exposures, establish a decontamination corridor in the warm zone away from the contaminated area.

CAUTION: Contact with cryogenic liquid or vapors can cause severe damage to the skin and eyes. Consider normal medical protocols for skin exposure to cold temperatures, including exposure to liquefied and cryogenic materials.

- Forced air ventilation may be used for decontamination of the outer shell of protective clothing. Maintain appropriate respiratory protection throughout the decontamination process.

- Based upon the scenario assess and control off-site runoff impacts since it may contain harmful contaminants. Properly dispose of in accordance with applicable federal, state and local environmental regulations.

- Conduct a post-incident analysis to properly document the incident and identify follow-up activities.

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