Draft SP 20534
UPDATED Draft Environmental Assessment

July 8, 2019

1 Introduction

Methane refrigerated liquid commonly known as liquefied natural gas (LNG) is currently transported via truck and in United Nations (UN) approved International Organization for Standardization ("ISO") portable tanks by rail under a Federal Rail Administration (FRA) approval in accordance with the Hazardous Material Regulations (HMR; 49 C.F.R. Parts 171-180). Energy Transport Solutions LLC (hereinafter referred to as "ETS" or "Applicant") submitted a special permit application to the Pipeline and Hazardous Materials Safety Administration (PHMSA) for the transportation of LNG in DOT-113C120W rail tank cars. This draft Environmental Assessment (EA) was prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), the President's Council on Economic Quality (CEQ) regulations implementing NEPA, and U.S Department of Transportation (DOT) policy. This draft EA analyzes the potential environmental impacts that could result from PHMSA's issuance of the proposed special permit application. 49 CFR § 107.105(d) requires that PHMSA only grant special permits when the decision "achieves a level of safety at least equal to that required by regulation, or if a required safety level does not exist, is consistent with the public interest."

2 Background and Statement of Purpose and Need

ETS has applied for a special permit asking PHMSA to approve ETS's use of DOT-113C120W tank cars as an appropriate package for the transportation of Methane, refrigerated liquid (LNG) by rail tank car. ETS is a logistics company that provides transportation services to move LNG domestically and internationally. ETS intends to use the special permit to facilitate shipments to customers who are principally exporters of LNG to foreign markets. In most cases, ETS would expect that the ultimate end-users of this LNG will be foreign generators of power for residential, commercial and industrial purposes. Nevertheless, it is possible that there will be some domestic end-users of the LNG—most likely industrial users who would buy LNG from ETS's customers for direct use.

If the proposed special permit were issued to efficiently transport natural gas outside of a pipeline, the natural gas must first be liquefied, reducing its volume at ambient pressures by a ratio of more than 600 to 1 to maximize efficiency in transportation. In the liquefaction process, water and carbon dioxide, along with most hydrocarbons other than methane, are removed. The product is then cooled to -162 ºC (-260 °F) where methane, the predominant component of natural gas, transitions from a vapor to a liquid state. LNG is colorless and odorless and will vaporize (i.e., return to a gaseous state) if released to the atmosphere. As described in more detail below, LNG is like other hazardous materials currently authorized to be transported by rail in DOT-113C120W tank cars, such as Ethylene, refrigerated liquid. Like LNG, cryogenic ethylene is a flammable cryogenic material and has an established history of being transported by rail for over 50 years with very few incidents.

Pursuant to 49 C.F.R. § 172.101, methane in a cryogenic form (otherwise known as LNG) may currently be transported from any origin to any destination in an approved package, like an ISO portable tank or a DOT specification cargo tank motor vehicle (MC-338). However, the DOT-113C120W tank cars that are the subject of the special permit application are not currently approved packaging for transporting LNG by rail. Recently, U.S. production of natural gas has increased dramatically, resulting in an opportunity to replace emissions-intensive energy options, such as coal, with cleaner-burning natural gas for power generation and transportation fuels.

The U.S. Department of Energy (DOE) has acknowledged that natural gas production in the Appalachian region in particular "is expected to increase for decades to come."[1] However, DOE also found that "options for natural gas producers and processors in the Marcellus/Utica region to move [natural gas liquids]," such as propane, "to other markets via pipeline remain limited, and a significant share of production moves by rail." Natural gas that cannot move to market via pipeline must be moved in liquid state (LNG) in MC-338 cargo tanks by truck or in ISO portable tanks via highway or by rail. Transporting LNG in ISO portable tanks by rail requires an approval from FRA. Issuance of a special permit that allows ETS to utilize DOT-113C120W tank cars for LNG transportation could provide advantages over current transportation options for the reasons discussed below.

Other forms of petroleum-based gases are currently authorized to be shipped by rail in tank cars. For example, liquefied petroleum gases (LPGs) are authorized to be shipped via rail in DOT-105 DOT-112, or DOT-114 single-walled, pressurized tank cars. The DOT-113C120W tank cars that are the subject of ETS's special permit application are double-walled tank cars specifically designed for carriage of cryogenic materials, such as LNG. DOT-113C class tank cars are currently authorized under the HMR to move other cryogenic flammable liquids, including Ethylene and Hydrogen. ETS's special permit application requests authorization to move LNG by rail in DOT-113C120W tank cars filled to densities comparable to the maximum filling densities for cargo tanks, which transport LNG via highway, as required in 49 C.F.R. § 173.318(f)(3). In its January 2017 petition for rulemaking, the American Association of Railroads (AAR) also requested that PHMSA authorize the use of DOT-113C tank cars for LNG transportation. PHMSA determined the petition "merits consideration in a future rulemaking.[2] Furthermore, Transport Canada has authorized DOT-113C120W equivalent tank cars (i.e. TC-113C120W) for transport of LNG.[3]

[1] U.S. Department of Energy, Natural Gas Liquids Primer *With a Focus on the Appalachian Region* (June 2018).

[2] U.S. DOT/PHMSA – Acceptance Letter, PHMSA-2017-0020-0005, May 10, 2018.

[3] Section 8.6.3.4 of "Containers for Transport of Dangerous Goods by Rail, a Transport Canada Standard." Accessed via https://www.tc.gc.ca/eng/tdg/containers-transport-dangerous-goods-rail-transport-canada-standard.html#_4.7_Schedule_2 on March 4, 2019.

Statement of Purpose and Need

ETS seeks authorization to ship LNG via rail in DOT-113C120W tank cars in shipment configurations that could range from single to multiple tank cars (blocks) in general manifest trains, and, depending upon demand, up to unit train configurations consisting of up to 100 tank cars. ETS anticipates that at any given time, regardless of the train configuration, tank cars could be loading in preparation for transportation; in transportation to destination; at destination unloading; and/or in transportation as empty/residue shipments on a return trip. If this special permit is approved, shipments of LNG in DOT-113C120W would be subject to requirements that govern all current shipments of that approved packaging—specifically, all applicable provisions of 49 C.F.R Parts 172 and 173, including in particular 49 C.F.R. § 173.319, which regulates tank car shipments of cryogenic liquids.

PHMSA is responding to ETS's request for a special permit to use DOT-113C120W tank cars for the transportation of LNG by rail. Authorizing ETS to transport LNG in DOT-113C120W tank cars by rail as an alternate packaging to MC-338 cargo tanks and UN ISO portable tanks, could provide for a more cost-efficient mode of transport. Therefore, this EA preliminarily finds that rail transportation would reduce the environmental impact of transporting LNG.

In ETS's request for a special permit, it stated that it hoped to transport UN1972, Methane, refrigerated liquid, a Division 2.1 flammable gas material in unit train configurations. Unit train configurations typically consist of 70 or more cars transporting a single material. Based on the projected liquification capabilities of the proposed LNG facility that will originate the shipments for this special permit, the production capabilities of the manufacturers of cryogenic tank cars, and the actual market demands for LNG, it is projected that it will likely take ETS years to reach the liquification capacity to ship LNG at the rates indicated in their application, as well as for the tank car manufacturers to produce the tank cars needed to support such volumes. The special permit will not limit the number of cars in a unit train or the number of daily shipments. Nonetheless, it is important to understand how the quantity of rail tank cars in transportation could change over time as capacity, demand, and production change.

3 Proposed Action and Alternatives

Transport of LNG in MC-338 cargo tanks is currently authorized by the HMR. Transport of LNG in ISO portable tanks is also authorized by highway and is authorized by rail under approval from the FRA. In responding to the special permit application, PHMSA is considering the following two alternatives:

(1) Proposed alternative: Grant ETS's special permit application to allow ETS to offer LNG for transportation in DOT-113C120W tank cars.

A number of different specifications govern the design and manufacture of DOT-113C120W tank cars.[4] DOT 113 specification rail tank cars are built to a double vessel design with the commodity

[4] *See, e.g.,* 49 C.F.R. Part 179, Subpart F and TC regulation TC14877E, Section 8.6 in addition to industry standards set by the American Association of Railroads.

tank (inner vessel) constructed to withstand a burst pressure of 300 psig and fabricated of ASTM A 240/A 240M, Type 304 or 304L stainless steel; the outer jacket shell (outer vessel) is typically constructed of carbon steel having a tensile strength greater than 70,000 psig. See 49 C.F.R. §§ 179.401-1 and 179.400-8(d), respectively. The inner stainless steel vessel is designed with a minimum plate thickness, after forming, of 3/16 inch, and the outer shell thickness, after forming, may not be less than 7/16 inch. Additionally, the minimum wall thickness, after forming, of the outer jacket heads may not be less than ½ inch and must be made from steel specified in §179.16(c) for tank head puncture resistance. The rail tank car is manufactured with an insulated annular space holding a vacuum between the two pressure vessels. This vacuum area and the insulation on the outer wall of the inner tank significantly reduce the rate of heat transfer from the atmosphere to the liquid inside the tank car, thus minimizing the heating of the cryogenic (i.e., refrigerated) liquid in the tank car while being transported. Other safety features of the tank car include protection systems for the piping between the inner and outer tanks, and multiple pressure relief devices.

Regulations controlling the movement of LNG in the DOT-113C120W packaging would be the same as those that apply to the transportation of other cryogenic liquids, including ethylene. Regulatory requirements governing these operational practices appear in 49 C.F.R Part 174 and 49 C.F.R. § 173.319 which is administered by the FRA. In addition, the AAR has issued Circular OT-55, which sets forth Recommended Railroad Operating Practices for Transportation of Hazardous Materials meeting the AAR's key train definition. Rail hazmat carriers require compliance with the standard through AAR Interchange Rules. The OT-55 operational controls are included in the special permit. The proposed special permit will comply with all applicable provisions in this standard if the special permit is granted.[5] The incorporation of OT-55 into the proposed special permit allows authorized government entities to enforce the provisions therein. The Circular OT-55Q will be included in this docket PHMSA-2019-0100 at www.regulations.gov.

As the AAR explained in a comment to the September 14, 2017 Federal Register notice of ETS's special permit application, AAR Circular OT-55 (currently designated as version Q) calls for operational controls for trains carrying certain quantities of hazardous materials, such as LNG in train configurations containing 20 or more loaded tank cars, which are sufficient to address the risks associated with moving LNG in DOT-113 tank cars. The operational controls in OT-55Q for the transport of hazardous materials address, among other things:

- "Key Trains" are 20 carloads or intermodal portable tank loads of any combination of hazardous materials.

- "Key Trains," including LNG-carrying unit trains, are subject to a maximum speed restriction of 50 mph;

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[5] Fronczak, Robert E. Robert E. Fronczak to Record Center Pipeline and Hazardous Materials Safety Administration Department of Transportation, 2017. Letter. *Re: Special Permit Application Number 20534-N.* October 13, 2017.

- “Key Routes,” which are lengths of track on which either (i) 10,000 car loads or more of hazardous materials or (ii) 4,000 car loadings of flammable gas (such as LNG) will travel over a one-year period and are subject to additional inspection and equipment requirements;

- Separation distance requirements relating to the spacing of loading and operations, loaded tank cars, and other storage tanks at rail facilities; and

- Community awareness and preparations for emergency planning/incident response actions.

Other Safety Control Measures:

Each DOT Specification 113C120W must have:

- Pressure relief devices set to discharge at 75 pounds per square inch gauge (psig);
- A maximum permitted filling density (percent by weight) of 32.5%
- A design service temperature of -162 ºC (-260 °F); and
- A maximum pressure when offered for transportation not to exceed 15 psig

Transport by rail would utilize existing rail infrastructure and implement existing requirements in the HMR for flammable cryogenic liquids. The railroads that ETS would use for transportation are currently subject to the restrictions that have safely moved cryogenic flammable materials for decades, including 49 C.F.R. § 173.319, which is applicable to the transport of cryogenic liquids in tank cars, and AAR Circular OT-55Q, which sets forth operational requirements for hazardous materials including cryogenic flammable liquids.[6] It is also important to note that the proposed special permit does not waive any safety regulations. Instead, the special permit would allow LNG to be transported in the already-approved DOT-113C120W tank car and authorized for use with other cryogenic materials. Any applicable requirements within the HMR, including 49 C.F.R. § 173.319, would apply to the transportation that would take place under the proposed special permit.

(2) No action alternative: Deny ETS’s special permit application for transporting LNG in DOT-113C120W tank cars and continue limiting transport of LNG to the packagings currently authorized by the HMR, including cargo tanks via highway and ISO tanks via rail and highway.

If the special permit is denied, ETS will continue to transport LNG by DOT specification MC-338 cargo tanks or UN ISO portable tanks.

The baseline case for transportation of LNG to be considered is approximately 1200 MC-338 cargo tanks per day using local and state roadways as well as the National Highway System. By issuing the special permit to approve the DOT-113C120W tank cars for transporting LNG by rail, ETS would have the option to transport LNG in DOT-113C120W tank cars.

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6 Fronczak, Robert E. Robert E. Fronczak to Record Center Pipeline and Hazardous Materials Safety Administration Department of Transportation, 2017. Letter. *Re: Special Permit Application Number 20534-N.* October 13, 2017.

The special permit would allow ETS to move LNG by rail in DOT-113C120W tank cars from sources to customers via existing rail corridors. The principal impacts from issuance of the special permit would be associated with moving an additional commodity by rail: fuel efficiency, engine emissions, venting of natural gas, and impacts from possible loss of containment events. What follows will review and assess these impacts.

According to the applicant, using ISO portable tanks to transport LNG for this project is economically infeasible (or undesirable) due to the added infrastructure and operations costs associated with intermodal handling of containers.[7] The use of ISO tanks would require additional facilities for handling the ISO tanks on truck chassis, loading, and unloading at intermodal yards. Additionally, approximately three to four times the number of ISO portable tanks or MC-338 cargo tanks would be required to ship the equivalent volume of LNG in DOT-113C120W tank cars requested by permit. Therefore, this alternative was eliminated from full discussion.

4 Environmental and Human Health Impacts of the Proposed Action and Alternatives

Both the proposed action alternative and the no action alternative could result in impacts to the environment and pose risks to human health and safety. Both the MC-338 and the DOT-113C120W store LNG in specialized insulated containers that have the potential for LNG emissions through venting, although venting is not authorized during normal operation in either case. Impacts from potential loss of containment from both transportation methods are of the utmost concern. This analysis will focus on safety and risk of the transportation of the hazardous material LNG in DOT-113C120W tank cars. This analysis will also discuss the environmental impacts related to fuel efficiency, and engine emissions

Safety and Risk

LNG poses certain potential hazards as a cryogenic liquefied flammable gas. LNG has a shipping identification number of UN1972 for 'Methane, refrigerated liquid.' The liquefaction of natural gas is achieved by cooling it to its normal boiling point, -162º C (-260° F), at atmospheric pressure. At the normal boiling temperature, LNG does not need to be stored under pressure, but it must be insulated to avoid boiling due to heat leakage into the liquid. As the liquid boils at atmospheric pressure, it does so at its constant, boiling temperature of -162º C (-260° F). Heat leakage occurs even in highly insulated vessels and over long periods of storage could amount to substantial vaporization of the liquid. Also, accidents leading to failures in the insulation systems result in rapid heat leak into the liquid. Heat leak into a closed vessel results in an increase in the pressure within the vessel. When the internal tank pressure exceeds the set-to-discharge-pressure of the pressure relief valve, LNG vapors will be released into the atmosphere. No release of LNG vapor to the environment is allowed during the normal transportation of LNG in tank cars.

[7] Florida East Coast Railway received an approval from FRA to transport LNG for ETS in ISO tanks from Port Miami, FL to Fort Everglades, FL. ETS does not hold this approval, nor does the approval apply on a nation-wide basis.

The DOT-113C120W design provides an increased crashworthiness when compared to a single vessel-wall design rail tank car of wall thickness equal to the sum of inner and outer tank wall thicknesses of DOT-113C. The tank car insulation is required to be designed to ensure that the heat transfer from the ambient air to LNG in the tank does not result in a pressure rise of over 3 psig/day, on an average. See 49 C.F.R., § 173.319(c). The start-to-discharge-pressure of the pressure relief valve is set at a sufficiently high value (generally 75 psig; 49 C.F.R. § 179.401-1) to ensure, at least, a 20-day transit time from the day of filling the tank car. See 49 C.F.R. § 173.319(a)(3).

The hazardous properties (flammability and pressure build up) of LNG and liquefied ethylene (for comparison of a flammable cryogenic material already authorized in a DOT-113C120W tank car) are virtually identical when the parameters for filling the tank car are adjusted for the specific physical properties of the two materials. The safety profiles of transporting a single tank car of LNG in a DOT-113C120W and single tank car of cryogenic ethylene in a DOT-113 would be very similar except that ethylene vapor burns in both lower and higher concentrations in air. Nonetheless, the applicant states that, depending on demand, it may offer into transportation up to 100 tank cars at a time once its project reaches full capacity. As with any hazardous material offered into rail transportation, each additional tank car containing a hazardous material such as LNG in the train consist, increases the likelihood that a derailment could result in one or more hazardous material releases. LNG poses potential cryogenic temperature exposure hazards as well as fire and explosion hazards. Due to a large difference in temperature, the rapid transfer of heat from an object into the cryogenic liquid can cause burns if direct contact of liquid with skin occurs or if Personal Protective Equipment (PPE) is inadequate to prevent cold-temperature injury during an exposure. Additionally, large spills of the liquid onto metal structures that are not designed to withstand cryogenic temperatures can cause embrittlement and fracturing. Methane is odorless and LNG contains no odorant (unlike odorized residential natural gas supplies), making detection of a release difficult without a detector device. Vapor generated by the evaporation of LNG, comprised primarily of methane, is flammable when mixed with air in vapor concentrations between, approximately, 5% to 15% by volume; outside of this range, the vapor fuel will not burn. By comparison, the flammable ranges in air of ethylene is much broader, at 2.7–36%. Releases of LNG due to venting or to accidents, without immediate ignition, involving either a MC-338 cargo tank, an ISO portable tank, or a DOT-113C120W have the potential to create flammable clouds of natural gas. Large releases of LNG due to the breach of the inner tank of these transport vessels could result in a pool fire, vapor fire, and explosion hazards if methane vapors become confined. These flammability hazards pose the highest potential impacts when compared to localized cryogenic hazards.

In analyzing whether to allow transportation of LNG in DOT-113C12W tank cars, PHMSA is reviewing past performance of DOT-113s in general, which are used for transportation of cryogenic materials. The HMR currently authorizes transportation of "ethylene, refrigerated liquid," a cryogenic flammable gas in DOT-113C120W rail cars.

PHMSA has collected data on the safety history of DOT-113 from its own incident database and from AAR, which compiles data provided by FRA.

PHMSA has analyzed this data regarding DOT-113 damage history.[8] From 1980 to 2017 (a 37-year period), there were 14 instances of damage to DOT-113 tank cars during transportation. Of the 14 instances, there were three instances where a DOT-113 lost lading from breach of both the outer and inner tanks. This is the most serious type of damage. Additionally, there were four instances in which a DOT-113 lost lading from damage or other failure to the valves/fittings. The vast majority of incidents causing damage to the DOT-113s did not result in a loss of hazardous materials.

The first derailment that resulted in the breaching of the inner tank of a DOT-113 took place in May 2011 in Moran, Kansas. Three DOT-113C120 specification tank cars containing "Ethylene, refrigerated liquid" sustained significant damage. Two of the cars were breached in the derailment and initially caught fire. The breach and resulting fire consumed the contents of one of the tank cars. The other two cars were mechanically breached with explosives (i.e., purposely breached) to minimize risk to responders and to expedite the burning and consumption of the entire contents from the two tank cars so that the site could be cleared. The total quantity of refrigerated ethylene spilled was 124,000 gallons. The response cost was estimated at $210,255, and the total damage estimate was calculated at approximately $231,000 in 2017.[9] The other derailment that caused tank failure occurred in October 2014 in Mer Rouge, Louisiana. The rail tank cars were filled with refrigerated liquid argon. One car was a DOT-113A90W specification tank car and the other was an AAR204W tank car (a car equivalent to the concept of a DOT-113 tank car). Both of these tank cars are authorized by special permit. The total quantity of refrigerated argon spilled was 47,233 gallons and the total damage estimate is calculated at approximately $228,000 (in 2017 dollars). No injuries or fatalities were reported as a result of the release of hazardous materials from either incident. Any breach of the inner tank of a rail car carrying cryogenic materials will most likely result in the loss of the entire contents of the tank, meaning that release amounts will typically equal the original lading amount. For safety reasons, a heavily damaged rail tank car filled with cryogenic material would be emptied prior to removal from the site of the incident. Response and mitigation techniques beyond evacuation for breaches in cryogenic tank cars do not exist or are impractical during a derailment scenario. The breach of a cryogenic tank car will typically result in the loss of the entire volume of material in the tank car. Incidents are rare, though rail incidents can be high-consequence events, given the quantity of hazardous materials in transportation.

LNG Characteristics and Hazards

Methane is a non-toxic, flammable and odorless gas. In an accident, when LNG is spilled and its vapors encounter an ignition source, the vapor will ignite only if the vapor concentration in air is between 5% and 15% volume. Immediate ignition with liquid still on the ground could cause the spill to develop into a pool fire and present a radiant heat hazard. If there is no ignition source, the LNG will vaporize rapidly forming a cold gas cloud that is initially heavier than air, mixes with ambient air, spreads and is carried downwind. The dispersion of the cloud due to wind results in the cloud temperature increasing due to mixing with air and contact with other materials and surfaces. The clouds temperature will remain lower than that of air and continue to travel at ground

[8] "RSI-AAR Railroad Tank Car Safety Research and Test Project," RA-19-03, May 3, 2019

[9] Hazardous Materials Incident Report Form (DOT F 5800.1 (01-2004)), May 23, 2011; Moran, Kansas. RSI-AAR Railroad Tank Car Safety Research and Test Project RA-19-03 May 3, 2019.

level until the clouds temperature is greater than that of air and becomes buoyant. Also, the density of the cloud decreases due to continuous mixing with air and contact with other materials and surfaces; however, the cloud density is never lower than that of the ambient air. The result is that the cloud is always heavier than air and disperses hugging the ground (with highest vapor concentrations at ground level). As stated above, the vapor is ignitable only in the 5% to 15% concentration range. Because in the initial stages the dispersing cloud is cold (starting from -260 ^{o}F), the dispersing cloud is visible as a white cloud due to the condensation of water vapor from the atmosphere. However, as the overall cloud temperature increases due to mixing with ambient air, and as the cloud temperature increases to above the "wet bulb" temperature corresponding to the relative humidity of the atmospheric air, the condensed water re-evaporates and the cloud becomes non-visible. The flammable region of the vapor cloud is enclosed within the visible vapor cloud if the ambient relative humidity is greater than or equal to 55%. For regions with relative humidity less than this value, the flammable cloud is outside the visible cloud. An ignition source can ignite the vapor cloud only when it is "on" and the vapor concentration is in the 5% to 15% vapor concentration in air. Once ignited, the vapors will burn back to the LNG source.

Methane in vapor state can be an asphyxiant when it displaces oxygen in a confined space. When spilled on the ground, into a confined area such as bound by a dike, the LNG will initially boil-off rapidly forming a vapor cloud, but the boil-off will slow down as the ground cools due to heat being extracted from the ground to provide for the evaporation of LNG. If spilled on water, the LNG will float on top of the water, spread in an unconfined manner, and vaporize very rapidly. This rapid vaporization will occur even at water temperatures near freezing since freezing water is significantly warmer than the spilled LNG.

In either scenario, the vapor cloud will be very cold and visible due to the condensation of water out of the air. Initially, if not ignited, the cloud will be dense and hug the ground. If there is no wind, the cloud will spread laterally from the spill. If there is a breeze, the visible cloud will initially hug the ground as it moves downwind from the spill. The subsequent dispersion behavior of the vapor cloud is as indicated earlier.

The distance over which an LNG vapor cloud remains flammable is difficult to predict. Local weather conditions (wind speed, atmospheric stability or turbulence), terrain, surface cover (i.e., vegetation, trees, and buildings) will influence how a vapor cloud disperses, and how rapidly it dilutes. If an LNG vapor cloud is ignited before the cloud has been dispersed or diluted to below its lower flammability limit, a flash fire may occur. An LNG vapor cloud will not entirely ignite at once. If ignited, the methane in LNG has a flame temperature of about 1,330°C (2,426°F). The resulting ignition leads to a relatively slow (subsonic) burning vapor fire which travels back to the release point producing either a pool fire or a jet fire. Such a slow burning vapor fire will not generate damaging overpressures (i.e., explosions), if propagating in the open with no significant obstructions. To produce an overpressure event, the LNG vapors need to be within the flammability range and ignited, and either be confined within a structure or the travelling flame in the open encounters densely packed structural obstructions (houses, trees, bushes, pip racks, etc.) that can increase the flame turbulence significantly. Other hydrocarbons that are transported by rail and highway, such as propane and butane, are more susceptible to vapor cloud explosions when they become vaporized and are ignited in much less confined conditions.

LNG is stored and transported at -162 °C (-260 °F). Due to this very low temperature, its contact with human skin or eyes will cause severe injury. It will also make ordinary metals subject to embrittlement and fracture when exposed to these temperatures. Transportation of cryogenic materials require specialized double walled tank cars (tank within a tank), with a stainless steel inner tank capable of holding the cryogenic liquid and wrapped with a highly insulating material, an outer carbon steel tank, and the space between the tanks evacuated to a high degree of vacuum to minimize heat leak from the outside to the inner tank.

DOT-113 Tank Car Characteristics

The DOT-113 specification rail tank car is specifically designed for the transport of cryogenic liquids. This tank car design has been in use for over 50 years, and it has a favorable safety record. There are only two documented derailments of DOT-113 specification tank cars where breaches of inner tank holding the cryogenic material occurred. These two derailments have resulted in lading releases due to significant damage sustained during the derailments.

The DOT-113 specification tank car is a double walled, or tank-within-tank, tank car that uses specific grades and thicknesses (3/16-inch minimum) of stainless steel for the inner tank (product tank) that provide high-strength characteristics under cryogenic conditions. The outer jacket shell (outer vessel) tank, or jacket, is made of specific grades and thicknesses (7/16-inch minimum for sidewalls and ½-inch for tank heads) of carbon steel that provides protection to the inner tank and service equipment located in the annular space between tanks, as well as provide the car with a tank-head puncture resistance system, which is required by 49 C.F.R. § 179.16.

Other key safety features of the DOT-113 specification tank car include, but are not limited to, the following:

- Several inches of aluminized Mylar super-insulation surrounding the inner tank.
- A high vacuum environment/annular space between the inner and outer tanks for enhanced product pressure and temperature control
- Specifically, designed loading and unloading equipment (piping, valves, gages, etc.) for use in cryogenic service.
- Safety equipment (pressure relief valves, safety vents, safety shut off valves, and remote monitoring systems) to prevent or limit overpressure issues or non-accident releases.
- Mandated in-transit tracking (time sensitive shipment) and car handling instructions.

DOT-113 Specification Tank Car Survivability

A DOT-113 specification tank car, because of its double walled construction and a thicker outer tank (compared to normal tank car jacket thicknesses), offers better crashworthiness and puncture resistance in derailment accidents when compared to single wall tank cars of wall thickness equal to the sum of the inner and outer tanks of DOT-113 tank car. However, derailments conditions could result in punctures of both the outer and inner tanks leading to a release of the product. As with any tank car, the risk of puncture to a DOT-113 tank car increases with speed and the conditions in the derailment environment.

If in a rail accident only the outer tank is breached, the history of how these cars behave indicates that the outer tank breach will result in the loss of insulating vacuum between the inner and outer tank. This will cause a higher rate of heat transfer to the inner tank from the ambient air and result in LNG vaporization causing a buildup of pressure. The resulting pressure build could eventually lead to the activation of the pressure relief systems on the car and the controlled venting of LNG vapor. While this scenario is concerning, the controlled venting of LNG vapor is minor in comparison to the uncontrolled release of an entire LNG lading as liquid, if the inner tank is punctured below the liquid-vapor interface level. Additionally, in the event the inner tank was damaged and releasing LNG, it is highly unlikely that the derailment would result in an explosion. This is because, if the liquid is released into the annular space between the inner and outer tanks (assuming the outer tank is punctured but not torn apart entirely), the rapid evaporation of the liquid coming in contact with the warm outer tank results in very large volume vapor production; this vapor whose concentration is nearly 100% will occupy the entire annular space and spill over to the outside. Because of its high concentration it will not burn inside the annular confined space, even if there was an ignition source nearby. Therefore, there is no explosion possibility in this type of release. In the case the liquid is released directly to the outside of the outer tank and spills on the ground and evaporates producing a vapor cloud, as we have described before any ignition of this vapor cloud in the open results in only a flash fire and possibly a pool fie, if liquid still pooled on the ground. In this scenario also, there is no likelihood of an explosion.

A boiling liquid expanding vapor explosion (BLEVE)[10] is unlikely to occur from a LNG tank car after derailment, when the inner tank is not punctured and it is exposed to an external pool fire, and the following conditions exist:

(1) The outer tank is intact or has suffered a puncture hole, the pressure relief valves (RPVs) are not damaged and perform as designed.
(2) The insulation on the inner tank is substantially undamaged (at least, in the vapor wetted wall area), the PRVs work as designed but the outer tank is damaged substantially.

No test data or mathematical models exist to predict whether and when a LNG tank car exposed to an external fire would undergo a BLEVE.

The BLEVE event is also highly unlikely due to the mandated requirements for redundant pressure relief systems (valves and safety vents) that are built into each car. In addition, this proposed special permit would require a 15 psig maximum loading pressure when LNG is offered

[10] A BLEVE is not caused by a combustion explosion of a flammable material. As the name implies, it is the explosion caused by rapidly evolving vapor in relatively small space which leads to significant increase in pressure which may violently damage/destroy a damaged or weakened container. When a damaged or weakened container with a liquid in it is exposed to a fire or other heat sources and insufficient pressure relief, the liquid within it can be heated and cause an increase in the tank's internal pressure. If this increase in pressure causes the tank to fail (due to, say, wall metal failure), the rapid depressurization that results leads to an extremely rapid boiling of the liquid, and release of a significant mass of vapor, in microseconds to milliseconds, into the container. This results in very high pressures inside the container leading to its burst, causing an "explosion" (an explosion is the release of energy in an extremely short duration of time).

for transportation in the DOT 113C120W tank car and an average 3 psig/day regulatory allowable pressure gain during transportation. The loading pressure was selected because of the 3 psig regulatory requirement, 20-day travel time, and the 75 psig pressure setting for relief valve operation. These loading conditions are like the requirements for refrigerated ethylene. The loading pressure, along with other safety requirements and operational controls minimize the potential of a BLEVE. Therefore, it is not possible to state with certainty whether a BLEVE is possible in case of a LNG tank car derailment and what conditions need to be there for such an event to occur. However, recent full-scale test with a double walled portable cryogenic tank filled with liquid nitrogen (and whose PRVs operated as designed) and exposed to a > 200-minute engulfing LPG pool fire was neither destroyed nor BLEVE'd. A test was performed with liquid nitrogen in a ISO portable tank on a flatbed rail car and exposed to a propane pool fire underneath the rail car. The results are not conclusive because wind conditions prevented the complete fire engulfment of the tank, and loss of data stream. While the flatbed car was seen to bend due to the heat from the fire, there was no significant damage to the ISO portable tank except for loss of vacuum insulation and melting of small parts of the physical insulation. BLEVE phenomenon did not occur.

LNG Release Scenarios

Based on the review of incident reporting and the 50-year history of transporting cryogenic liquids in DOT-113 specification tank cars, there are three (3) possible release scenarios that could occur during the transport of LNG by rail. Ranked in order of estimated probability, they are:

1. Non-accident release (NAR) from service equipment. Probability – moderate; Consequence – Low

2. Outer tank damage resulting vapor release from pressure relief device (PRD). Probability – Low; Consequence – Low to High

3. Inner tank damage resulting in large release/spill. Probability –Low; Consequence – High

Although Scenario 3 has a low probability, a breached inner tank during a transportation accident could have a high consequence due to a higher probability of a fire due to the formation of a flammable gas vapor/air mixture in the immediate vicinity of the spilled LNG. This probability is based on the likelihood of ignition sources (sparks, hot surfaces, etc.) being generated by other equipment, rail cars, or vehicles involved in a transportation accident that could ignite a flammable vapor cloud.

As with any incident involving a hazardous material in transportation, the actual hazard distance created by a material that is spilled or burning will be influenced by many factors. These factors include, but are not limited to the following:

- Spill Size
- Weather (Wind, Temperature, Humidity, Precipitation)
- Terrain Contours (Hills, Valleys)

- Surface Cover (Vegetation, Structures)
- Soil (Dirt, Clay, Sand)

As stated previously, hazard distance of a vapor cloud dispersion of LNG is difficult to predict. Local weather conditions, terrain, surface cover (i.e., vegetation, trees, and buildings) will influence how a vapor cloud disperses, and how rapidly it diffuses.

Similarly, the actual distance that radiant heat effects from a pool fire of LNG would impact is dependent on the same factors that influence a vapor cloud, including very significantly on the size of the liquid pool formed (topography related) and the volume of LNG spilled. Additionally, the impact of radiant heat effects from a fire on occupied structures will be influenced by local building codes that govern building setback requirements from railroad right-of-way. Depending on the jurisdiction, setbacks for occupied structures could be within fifty (50) feet of either side of a railroad track.

Regardless of the scenario, the recommended protective action distances identified in the PHMSA Emergency Response Guidebook (ERG) for LNG would be appropriate for the initial protection of the public during an incident involving LNG. However, these protective distances may encompass occupied structures along rail tracks, depending on the location of a failure and the proximity of occupied structures to a breached tank car.

Cascading Failure of Multiple DOT-113 Tank Cars

As stated previously, the unique design and materials used to construct DOT-113 specification tank cars used for the transportation of cryogenic liquids provide an inherently more robust tank car when compared to other specification tank cars due to their unique design, and materials of construction, and their specific purpose to transport cryogenic liquids.

In the scenario where multiple DOT-113 specification tank cars are transported in a block or in a unit train configuration, there are two (2) stresses, fire/radiant heat exposure, or cryogenic temperature exposure, that could potentially lead to failure of otherwise undamaged tank cars and consequent release of the material. The DOT-113's double wall design reduces the probability of cascading failures of multiple other undamaged DOT-113 specification tank cars in a consist, either as a block in manifest train or in unit train configuration.

Fire/Radiant Heat Exposure

In a scenario involving fire/radiant heat exposure, an undamaged DOT-113 specification tank car exposed to a radiant heat source would eventually build pressure that would trigger the activation of the tank car's PRD.

As stated previously, this scenario would result in the controlled venting of LNG vapor to the environment. Immediate ignition of these vapors could occur if an ignition source is present. The fire would be relatively small and will be contained to the proximity of the release point of the vapors from the tank car. Additionally, as stated previously, it is highly unlikely that an undamaged DOT-113 tank car involved in a derailment would result in explosion due to a BLEVE. This event is highly unlikely due to the design of the tank car, the loading pressure requirements for cryogenic materials, and the mandated requirements for redundant pressure relief systems (valves and safety vents) that are built into each car. The number of cars that could be impacted by this type of exposure would be dependent on multiple factors. Some of these include, but are not limited to: type of fire, duration of the fire, whether the flames are impinging upon the neighboring cars or whether the exposure is only by radiant heat, defensive actions of responders, etc.

Exposure to heat from an LNG pool fire or ignition of LNG vapors could result in fatalities, serious injuries, and property damage for those within the limited zone of hazard. These risks also exist in the transportation of LNG via highway, existing rail transportation, and pipeline. However, given the safety history of the DOT-113C120W tank cars, it is expected that the risk of a tank car failure and ignition is low.

Cryogenic Temperature Exposure

In a scenario involving cryogenic temperature exposure, the risk to an undamaged DOT-113 specification tank car is the embrittlement of the tank car's outer tank carbon steel due to exposure to the extremely cold temperatures; the inner stainless-steel tank will not be affected. As stated previously, if a DOT-113 specification tank car has its outer tank compromised, it would lose its insulating vacuum and would eventually start to build pressure within the product tank. This pressure build would lead to the activation of the tank car's PRDs and the controlled venting of LNG vapors.

Incident data with (non-LNG) hazard materials may suggest that incidents involving rail tank cars can lead to a larger area of consequence as compared to hazard areas arising from incidents involving MC-338s cargo tank motor vehicles (or ISO portable tanks moved by rail). This is because of the larger volume of LNG in each tank car compared to that in a MC-338 cargo tank. However, the impact on people may be more (depending upon the location of the accident) in the case of a cargo tank because of the highway proximity to densely populated areas compared to the location of rail tracks. It is also noted that highway incidents in general are more common than rail incidents; so PHMSA assumes that this trend applies regardless of the cargo.[11] Therefore, PHMSA believes that from an overall risk to the public perspective rail transportation is a safer option considering the quantity and distance transported.

No Action Alternative

It is important to note that the risks of transporting LNG via rail also apply to the shipment of LNG via highway. As discussed above, the transportation of LNG by cargo tank is already permitted by the HMR. Under the No Action Alternative, ETS would likely opt to transport most of the LNG it wishes to move to market over roadways in MC-338 cargo tank motor vehicles. The risks discussed above, inherent to the transportation of LNG, including, damage to human tissues and container integrity due to -162 ºC (-260 °F) cryogenic materials and the radiant heat from fires that could result from vapor ignition could increase with the selection of the No Action

[11] It appears highway accidents are increasing with the growing economy and the rise in distracted driving, while rail incidents slightly declined in 2018. https://www.statista.com/statistics/204569/rail-accidents-in-the-us/ ; https://www.motus.com/car-accidents-increase-12-3-percent-finds-new-motus-distracted-driving-report/ (last accessed June 3, 2019).

Alternative. The risks that would increase with the selection of the No Action Alternative are increased trips (because of lower volume transported per cargo tank), thereby increasing opportunity for an incident, higher accident rate for highway traffic as compared with rail traffic, and closer proximity to people and inhabited structures on roadways as compared to rail rights of way. On the other hand, a larger quantity LNG loaded into each rail tank car, along with the risks that result from multiple tank cars moving together, could lead to higher consequences. A failure of either an MC-338 or a DOT-113 could cause injury, death, property destruction and environmental harm. The likelihood of failure of MC-338 is higher, but the scope of potential of injury and death, could be greater in a populated area for a DOT-113 failure because of higher volumes of LNG carried in each tank car (by about a factor of 3) compared to that in a MC-338 transport.

Fuel Efficiency

Fuel efficiency for transport of LNG can be calculated by two methods: (1) miles per gallon of fuel and (2) ton-miles per gallon of fuel. Miles per gallon gives the fuel efficiency of the transportation method, nonspecific to the cargo load. For example, a tractor-trailer with 46,000 pounds of payload, which corresponds to approximately 15,000 gallons of LNG,[12] may be expected to have 19.5 gallons diesel consumption per 100 miles.[13] While this method is commonly used with personal cars, it provides no information on how the efficiency is affected by the cargo load. A more standardized and accurate method for comparing the fuel efficiency across all trains and all freight trucks transporting cargo is in the method of ton-miles per gallon of fuel. This method takes the sum of annual ton-miles of freight transported divided by the annual fuel usage to result in ton-miles per gallon (stated as the miles a transportation method can transport 1 ton of freight on a gallon of fuel). An example calculation would be of a heavy-duty diesel truck transporting 19 tons of freight a distance of 500 miles on 71 gallons of diesel fuel. This would result in

$$(19 \text{ tons} * 500 \text{ miles}) / 71 \text{ gallons} = 134 \text{ ton-miles per gallon}$$

for a freight truck. Although the example is of a smaller cargo transportation, the 134 ton-miles per gallon is the value associated with overall freight trucks for their fuel efficiency.[14] For a locomotive, fuel efficiency is 471 ton-miles per gallon[14] resulting in trains having a fuel efficiency around 3.5 times more efficient at hauling freight than trucks.

Denial of the proposed special permit/selection of the No Action Alternative could result in ETS shipping larger quantities of LNG over the highway via cargo tank motor vehicle. A larger reliance on transportation via cargo tank motor vehicle would result in more fuel use and emissions, due to inferior fuel efficiency of highway transportation compared to rail. Issuance of

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[12] Chart ST-16300 LNG Transport Trailer, PN 14722928, 2013.

[13] Accessed via https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812146-commercialmdhd-truckfuelefficiencytechstudy-v2.pdf, pgs. 61-65, on February 20, 2019.

[14] Accessed via https://www.csx.com/index.cfm/about-us/the-csx-advantage/fuel-efficiency/ on February 20, 2019.

the proposed special permit/selection of the Proposed Action Alternative could result in ETS shipping smaller quantities of LNG over the highway in cargo tank motor vehicles and greater quantities of LNG via rail, which would result in less fuel use and less emissions. Moving one ton of freight by train would result in approximately 70% less fuel than moving the same freight by motor vehicle.

Engine Emissions

As shown with the fuel efficiency, trains can transport freight on approximately 30% of the fuel needed for a motor vehicle to transport an equivalent amount. Diesel engines produce a variety of regulated emissions, including: volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter less than 10 microns in diameter (PM_{10}), and sulfur oxides (SO_x). These emissions directly affect air quality which can cause negative health effects such as respiratory and cardiovascular complications.[15] A standardized comparison of the emissions of substances produced from rail and truck transportation methods was calculated by the United States Department of Transportation in their Freight Routing and Emissions Analysis Tool (FREAT).[16] A standardized unit, g/TEU-mi, converted the grams of pollutant produced per twenty-foot equivalent unit (TEU) per mile. A TEU is a commonly defined container unit for shipping cargo with volume of 20' length x 8'6" height x 8' width. The results of the standardized comparison of grams of pollutants produced per TEU per mile for transportation by truck, rail, and ship are shown below in Table 1.

Table 1. Summary of Emission Factors (g/TEU-mi).[16]

	Pollutant				
Mode	VOC	CO	NO_x	PM_{10}	SO_x
Truck	0.34	1.64	6.86	0.12	0.22
Rail	0.14	0.39	2.81	0.07	0.03
Ship	0.30	1.37	7.93	0.23	3.91

Transporting cargo by train results in significant decreases in emissions. Transport by rail substantially decreases the pollutant emissions by a minimum of 1.7 times the particulate matter (PM_{10}) which has direct effects on the quality of air. All other pollutants are within the 1.7 to 7.3x ranges resulting in a significant decrease in pollutants when transporting cargo by rail over truck.

15 Accessed via https://www.epa.gov/particle-pollution-and-your-patients-health/course-outlinekey-points on February 26, 2019.

16 Accessed via https://cms.dot.gov/sites/dot.gov/files/docs/emissions_analysis_of_freight.pdf on February 25, 2019.

Natural Gas Emissions through Venting

According to 49 C.F.R. § 173.318(e), the temperature of LNG in an MC-338 cargo tank should be sufficiently cold at the start of travel that the set pressure for the required pressure relief valve will not be met in less time than the marked rated holding time for LNG. Additionally, 49 C.F.R. § 173.319 provides requirements intended to prevent venting of rail tank cars carrying cryogenic liquids, with reporting requirements for tank cars that are not delivered within 20 days. Thus, no emissions due to warming of the LNG are anticipated during regular transport via rail or motor vehicle.

No emissions are expected during routine transport, as more than 99.99% of hazmat moved by rail reaches its destination and carrier operating restrictions exist which are intended to prevent venting during routine transport.[17,18] However, emissions of LNG can potentially occur if the tank car: (i) is involved in an accident; or (ii) is left unattended for an extended duration in transport, such as a lost tank car. All LNG transport containers are equipped with PRDs for venting of natural gas if such a situation occurs. If a venting event occurs during transport, there are safety mechanisms in place to limit the impacts. For a cryogenically transported DOT-113C120W tank car that has not arrived within 20 days of shipment, the FRA must be immediately notified.[19] The additional safety precaution in place is the design of the tank car. DOT-113C120W tank cars are designed to provide 40 days of transportation without venting. A train carrying cryogenic materials such as LNG is unlikely to require 40 days to reach its destination under normal circumstances because of the notification requirement and the likely follow-up. Thus, the ability of the DOT-113C120W to hold LNG without venting for twice the time necessitated by the regulation for notification to FRA affords extra protections against any environmental impacts associated with venting while in transit.

LNG may be transported on the highway through MC-338 cargo tanks with gross capacities up to 16,300 gallons,[20] subject to applicable restrictions on vehicle weight. If the requested special permit is granted, then LNG may be transported via rail in DOT-113C120W rail tank cars with a gross capacity of 30,680 gallons,[21] around twice the capacity of the cargo tanks. In the event of an accident or insulation system failure or extended duration in transport, with no puncture of the tank, pressure in the container may rise slowly as the LNG warms due to heat leakage into the container. A spring-loaded and self-resetting PRD may temporarily open and vent some natural gas, which will reduce the pressure back to an acceptable level. The device will then reclose and prohibit the emission of additional natural gas unless experiencing pressure build-up again. The short duration of venting also provides some cooling to the LNG. This cycle will repeat until the

[17] Fronczak, Robert E. Robert E. Fronczak to Record Center Pipeline and Hazardous Materials Safety Administration Department of Transportation, 2017. Letter. *Re: Special Permit Application Number 20534-N.* October 13, 2017.

[18] Fronczak, Robert E. Associate of American Railroads to Pipeline and Hazardous Materials Safety Administration. Petition for Rulemaking to allow methane, refrigerated liquid to be transported in rail car. P-1697. January 17, 2017.

[19] 49 CFR § 173.319(a)(3).

[20] Chart ST-16300 LNG Transport Trailer, PN 14722928, 2013.

[21] Chart SR-603 LNG Tank Car, PN 14722936, 2013.

container reaches its destination or is otherwise addressed. If a venting event should occur, tank cars would be expected to release more natural gas relative to a cargo tank (due to the higher volume of a tank car). However, a DOT-113C120W tank car has a lower boil-off rate because the surface area is less per unit volume and thus will vent with a lower frequency than an MC-338 cargo tank.

Tank Car and Commodity Comparison

Many pressurized tank cars can transport flammable liquids on the rail: DOT-105, 109, 112, 114, and 120. DOT-113C120W tank cars are specifically authorized to transport cryogenic liquids under the HMR that address both safety and insulated design.[22] Rail tank cars are authorized to transport methane in liquefied form in other countries including Canada.[23] In the U.S., DOT-113C120W tank cars are authorized to transport refrigerated ethylene but not LNG. Other similar specification cryogenic tank cars are authorized for transporting hydrogen, nitrogen, oxygen, and argon. DOT-113C120W tanks are designed specifically for cryogenic cargo transportation and are equipped with additional safety features compared to pressurized tank cars. An important safety aspect of cryogenically transported liquids is the regulated maximum filling density for the container. In its petition for rulemaking, the AAR has proposed the pressure control settings summarized in Table 2 below for the transport of LNG in rail tank cars.

Table 2. Pressure control valve setting or relied valve setting.[24]

	Maximum permitted filling density (percent by weight)				
Maximum Set-to-Discharge Pressure (psig)	**Ethylene**	**Ethylene**	**Ethylene**	**Hydrogen**	**Methane (LNG)**
17				6.60	
45	52.8				
70					
75		51.1	51.1		32.5
Maximum pressure when offered for transportation	10 psig	20 psig	20 psig		15 psig
Design service temperature	-260°F	-260°F	-155°F	-423°F	-260°F

22 49 CFR § 173.319

23 Accessed via https://www.tc.gc.ca/media/documents/tdg-eng/tp14877_en.pdf on February 25, 2019;

24 Fronczak, Robert E. Associate of American Railroads to Pipeline and Hazardous Materials Safety Administration. Petition for Rulemaking to allow methane, refrigerated liquid to be transported in rail car. P-1697. January 17, 2017.

Specifications (see 180.507(b)(3) of this subchapter	113D60W 223C60W	113C120W	113S120W	113A175W 113A60W	113C120W 113C140W

Values for maximum permitted filling density for LNG were extracted from 49 C.F.R. § 173.318(f)(3) and adjusted for a 15% outage for consistency across standards for cryogenic flammable gases currently transported by both motor vehicle and rail in the U.S. The differences between the cryogenic tank cars specified above are due to gross volume and pressure. As shown by Table 2, the temperature of LNG is between the values for ethylene and hydrogen. LNG is also between the maximum set-to discharge pressures and the maximum permitted filling densities compared to ethylene and hydrogen. These parameters make the transport of LNG comparable to other cryogenic flammable liquids transported in DOT-113C120W tank cars. Transport of LNG by DOT-113C120W tank cars will be within current specifications of other cryogenic flammable liquids transported by DOT-113C120W tank cars posing no additional risks associated with the design specifications to accommodate temperature and pressure of LNG.

Vegetation and Waterways

The behavior of LNG during a loss of containment (LOC) event is typical of any cryogenic liquid. A spill of LNG will vaporize when it contacts ambient air and when in contact with warm solids such as the ground, and leaves behind little to no residue. The cold vapors may condense humid air, causing fog formation and decreased visibility. After vaporization, the cold vapors are denser than ambient air and they will tend to stay close to the ground as they disperse, getting pushed by prevailing winds. The dense vapors can travel significant distances without complete dilution, as the mixing with ambient air is limited near the ground. Due to a large difference in temperature, the rapid transfer of heat from an object into the cryogenic liquid can cause burns if direct contact with skin occurs or if PPE is inadequate to prevent cold-temperature injury due to an exposure.

For small releases, such as a hole in the tank due to a damaged appurtenance or other accident, there will be insignificant difference in the extent of cryogenic damages for either tank cars or cargo tanks. The release will increase in proportion to the hole size in the container, not the volume of container. For catastrophic leaks, the pool size can grow proportionally to the tank volume. If the volume of the cargo tank is 1/3 of the volume of the tank car, for example, the area of the resulting pool spills will be proportional to the volumes. Maximum pool size is dependent upon the rate of release, the ground temperature, the ambient temperature, and the nature of the ground (brush, roadway, drainage ditches, etc.). Negative effects observed in the environment due to pooling of LNG may be expected to be similar to frost damage observed on plants after the first hard freeze of the year, in the area immediately adjacent to the pool.

Other liquefied gases behave similarly to LNG upon accidental discharge into the environment. For example, the U.S. Department of Homeland Security's Chemical Security Analysis Center has conducted experiments to study liquefied chlorine gas releases at the Dugway Proving Ground. Those tests observed that an accidental release of liquefied chlorine gas resulted in a pool of chlorine on the ground. After evaporation of the chlorine pool, there was "no appreciable contamination on or in common urban surfaces."[25] LOC of LNG is expected to have a similar negligible impact on soil or groundwater quality following evaporation. Due to their nature, cryogenic liquefied gas spills have much less impact to the environment compared to other flammable materials such as gasoline or crude oil with respect to leaching into the soil or waterways.

When considering a potential LOC event involving LNG, any LNG released would behave similarly regardless of whether the release event involved LNG from MC-338 cargo tanks or from a DOT-113C120W tank car. DOT-113C120W tank cars have a larger capacity than MC-338 cargo tanks and a unit train will transport multiple DOT-113C120W tank cars.

Indirect Effects and Cumulative Impacts

The longevity of locomotives versus motor vehicles plays an impact in the environment due to the lifespan of the equipment associated with each transportation mode. A locomotive has a lifespan of approximately 30 years with freight cars having a lifespan of 50–65 years.[26] Motor vehicles have a lifespan of 2–7 years, and their trailers have around 8 years of life. The lifecycle of multiple vehicles transporting the same amount of LNG would have a larger environmental impact due to the longevity of the different transport methods.

The frequency of highway cargo tanks transporting LNG will be 2 to 4 times that of a rail tank car for a given capacity of LNG; thus, the mileage for highway cargo tanks will be considerably higher than that of rail tank cars. The higher number of trips results in a higher baseline representative risk to the public for the highway transport of LNG when compared to rail transport of an equal quantity of LNG along a similar route. In addition to the increased trips resulting in increased risk, motor vehicle transport could increase the congestion on the highway. Conversely, a unit train may have impacts on highway congestion in areas in which the rail tracks cross the highway at grade, therefore halting traffic in certain areas for the duration of the train crossing. Given the baseline case of LNG movement presented here—700 motor vehicles or 2–4 unit trains per day—the impact on traffic for rail transport could be significantly lower on the local, state, and national road systems.

Greenhouse gas (GHG) emissions from diesel engines are directly related to fuel consumption, and as such a shift from highway to rail transportation of freight can decrease the GHG emissions per ton-mile by more than 85%.[27] While trains may not be able to get from door to door, a combined effort is underway by the EPA to increase the use of rail freight transportation in order to decrease GHG emissions. The EPA SmartWay Transport Partnership encourages intermodal

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25 Whitmire, M. & Schneider, J. *Evaluation of portable x-ray fluorescence for the determination of chlorine in the environment after chlorine releases at jack rabbit II*. US Department of Homeland Security, Chemical Safety Analysis Center. CSAC-16-004. February 2016.

26 Accessed via http://railtec.illinois.edu/wp/wp-content/uploads/pdf-archive/9.1.pdf on February 25, 2019.

27 Frey, Christopher, and P. Kuo. "Assessment of potential reduction in greenhouse gas (GHG) emissions in freight transportation." *Proceedings, International Emission Inventory Conference, US Environmental Protection Agency, Raleigh, NC*. Vol. 15. 2007.

ground freight transportation which combines motor vehicle and rail systems where freight trains will transport the cargo over long distance, high volume rail corridors where motor vehicles will then transport the cargo from the rail terminal to its final destination.

Transport Partnership encourages shippers to use locomotives for the bulk of their transportation due to the 65% decrease in GHG emission from the combined effort of locomotives and motor vehicles.[28] A comparison between GHG emissions is provided in Table 3. Motor vehicle transportation generates 6.9 times the amount of carbon dioxide compared to the rail transportation mode.

Table 3. GHG Emission Factors for Transportation Modalities (g/TEU-mi).[29]

Mode	**CO_2**
Truck	1001.00
Rail	144.97
Ship	292.83

It is conceivable that granting this special permit application may result in additional business opportunities to be realized as a result of the efficiencies of transporting LNG by rail and thereby further incentivize domestic production. Such business opportunities could include end-use applications (such as power plants), export facilities, and the associated loading/unloading facilities that would accommodate such developments. The significant increase in the domestic production and export/use of LNG already underway is independent of this special permit application, making it hard to pinpoint that authorizing DOT-113C120W tank cars as an appropriate packaging to move LNG by rail would be the relevant cause of any continued increase in the production or utilization of natural gas.[30] Similarly, it is too speculative to reach any conclusions about whether approving this special permit would result in the development of new end-use projects, let alone the extent of any such projects' natural gas utilization or any increased production they might entail. The rail lines on which LNG-carrying DOT-113C120W tank cars would travel have largely been built already.

Additional possible indirect effects that may occur in connection with the two alternatives discussed in this draft EA are discussed in Table 4, assuming the transportation of the same quantity of LNG under each alternative.

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[28] Accessed via www.epa.gov/smartway on February 20, 2019.

[29] Accessed via https://cms.dot.gov/sites/dot.gov/files/docs/emissions_analysis_of_freight.pdf on February 25, 2019.

[30] Clements, Jude. "U.S. Liquefied Natural Gas Poised For 'Biggest Year Ever.'" Wall Street Journal, November 23, 2018.

Table 4. Overview of indirect impacts from transport of LNG by rail or truck.

Effect	Alternative 1: LNG by Motor Vehicle	Alternative 2: LNG by Rail
Methane Production	Viable delivery options facilitates marketing and incentivizes production	Less costly/more efficient rail facilitates marketing and further incentivizes production
Manufacture	Fabrication by existing manufacturing plants of new MC-338s (3x more needed than DOT-113s); operational impacts of existing plants would be regulated by permits or existing laws	Fabrication by existing manufacturing plants of new DOT-113s; operational impacts of existing plants would be regulated by permits or existing laws
Quantity of tanks	3x more cargo tanks to transport LNG	Fewer tanks to transport LNG
Wear of highway	Increased wear on highway and roads (cost to taxpayers)	n/a
Wear of rails	n/a	Increased wear on rails (cost to railroads)
Congestion	Increased road congestion due to increased quantity of vehicle	Possible increased road congestion at railroad crossings with grade crossings
Noise/Vibration	Increased noise and vibration along route	Increased noise and vibration along rail right of way with increased rail traffic[31]
Construction of road/rail	Construction of new access roads or reconstruction of existing roads to tolerate increased loads/traffic	Construction of new spur lines to facilities (impacts to be addressed by existing regulatory approval requirements)

Although indirect effects and cumulative impacts associated with the approval of this special permit may present themselves (e.g., construction of ancillary loading and unloading equipment), these activities are generally driven by numerous market forces and regulated by local/state/federal entities which may require environmental assessments and permitting. Because this special permit would allow ETS to add a new use to an existing set of infrastructure (rail lines) and may require minor modifications to existing or new infrastructure to accommodate new rail loading or receiving facilities, it is hard to identify any reasonably foreseeable future actions that might result in cumulative impacts from the issuance of the special permit. The special permit would only approve an additional packaging for the transport of LNG, thereby providing an additional option of transport.

[31] Wolfe, Steven L. "Rail Transit Noise and Vibration Impacts–Why Environmental Planning Doesn't Always Work." Proceedings of ACOUSTICS 2011, November 2-4, 2011.

6 Agencies and Persons Consulted

FRA-Office of Safety and Hazardous Materials Division

PHMSA-Office of Hazardous Materials Safety, Office of Chief Counsel

Applicant-Energy Transport Solutions, LLC

7 Conclusions

ETS has applied for a special permit requesting PHMSA to authorize ETS's use of DOT-113C120W tank cars as a packaging for the transportation of LNG by rail, subject to the constraints discussed in this draft EA. This EA was prepared to analyze the impacts to the environment of using DOT-113C120W tank cars as an appropriate packaging for transporting LNG by rail. PHMSA proposes that transportation of LNG by a DOT-113C120W rail tank car, as an alternative to the transport of LNG in MC-338 cargo tanks on the road, could provide a more cost-efficient mode of transport and reduce the environmental impact of transporting LNG. Moreover, the existing regulatory requirements that govern the movement of cryogenic flammable materials similar to LNG are expected to provide adequate safety measures for LNG shipped in DOT-113C120W tank cars.

This analysis did not identify any significant environmental impacts from granting this special permit. The LNG-carrying DOT-113C120W tank cars would travel on existing main rail lines. The addition of an authorization to transport another flammable, cryogenic material by rail using the same tank car and operating restrictions as other similar cryogenic flammables materials is not expected to introduce new, unaddressed risks. Furthermore, issuance of a special permit is expected to decrease the risks to the public and the environmental impacts associated with transporting LNG. Similarly, less wear-and-tear on public roadways would be expected. While it would be difficult to attribute any future LNG infrastructure construction (e.g., ancillary loading and unloading equipment) to PHMSA granting this special permit, any such construction that may arise would be subject to relevant existing regulations at the local, state and federal levels to address potential impacts.

8 Public Comment and Proposed Finding of No Significant Impact (FONSI)

PHMSA welcomes public comment on the proposed special permit and any related environmental impacts or safety risks. PHMSA proposes to find that the issuance of the proposed special permit would not result in significant impacts to the human environment.