



U.S. Department of Transportation  
Pipeline and Hazardous Materials Safety Administration  
Washington, D.C. 20590

**Hazardous Materials: Liquefied Natural Gas by Rail**  
**Notice of Proposed Rulemaking**  
**Preliminary Regulatory Impact Analysis**

Docket No.: PHMSA-2018-0025 (HM-264)  
RIN 2137-AF40

Office of Hazardous Materials Safety

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## Executive Summary

The Pipeline and Hazardous Materials Safety Administration (PHMSA), in coordination with the Federal Railroad Administration (FRA), is issuing this Notice of Proposed Rulemaking (NPRM) to solicit public comment on potential changes to the Hazardous Materials Regulations (HMR; 49 CFR, parts 171–180), which would permit the bulk transportation of Liquefied Natural Gas (LNG) (also known as Methane, Refrigerated Liquid) in rail tank cars. Specifically, this NPRM proposes to authorize the transport of LNG by rail in a certain tank car specification: United States (U.S.) Department of Transportation (DOT)-113C120W.

Currently, the HMR do not contain the necessary provisions to allow for the bulk transport of LNG in rail tank cars. However, there has recently been increasing interest in the domestic transportation of LNG by rail tank car. On January 17, 2017, PHMSA received a petition for rulemaking (P-1697) from the Association of American Railroads (AAR) requesting a regulatory change to allow Methane, Refrigerated Liquid (commonly referred to as LNG) to be transported in railroad tank cars.<sup>1 2</sup> With a growing U.S. domestic supply and demand for LNG, rail transportation can serve as an alternative to the transport of LNG by highway and a potential new mode of transportation in the LNG export supply chain. PHMSA has identified LNG as an area market sector with opportunities for innovation and infrastructure development while maintaining a high level of safety.

PHMSA and FRA share the responsibility for regulating the transportation of hazardous materials by rail, using a system-wide perspective and a comprehensive approach that focuses on prevention, mitigation, and response. The joint mission of the agencies is to manage, and reduce, the risk posed to people and the environment by the transport of hazardous material by rail. This NPRM does not impose new compliance costs. Rather, it offers numerous potential benefits, business applications and cost savings to regulated entities, shippers and society at large. Rail transportation in the U.S. is recognized as a safe method for moving large quantities of hazardous materials over long distances. The intent of this regulatory impact analysis is to assess the proposed alternative. In this preliminary regulatory impact analysis, PHMSA presents an overview of the derailment history of DOT-113 tank cars as well as the incident history for the transportation of LNG and similar materials by highway. PHMSA and FRA seek public comment on the preliminary regulatory impact analysis of the proposed changes to address the safe transportation of LNG by rail.

This proposed rulemaking does not impose new compliance costs, since it would merely enable the transportation of LNG by an alternative mode. The potential benefits include transportation efficiency; market impacts; emissions reductions; and safety impacts. This proposed rule is expected to expand production opportunities to the industry by allowing LNG transportation by rail. PHMSA evaluated the benefits categories and expected cost savings qualitatively rather

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<sup>1</sup> <https://www.regulations.gov/docket?D=PHMSA-2017-0020>

<sup>2</sup> The AAR petitioned for rulemaking to authorize the transportation of methane, refrigerated liquid (“LNG”), by rail in DOT-113C120W and DOT-113C140W tank cars.

than quantitatively because this is an enabling rule and there is limited information about the potential market for the transportation of LNG by rail.

## **1. INTRODUCTION**

### **1.1 Summary of the Proposed Rule**

The proposed rule would allow for the bulk transportation of LNG in rail tank cars by authorizing the transportation of LNG by rail in the DOT-113C120W specification tank car. The proposed rule would not impose new or additional operating controls. The NPRM relies on the existing HMR requirements for the transportation of cryogenic flammable materials and the existing industry interchange requirements, including, Circular OT-55, which establishes operational controls for “key trains” that transport certain quantities of hazardous materials, including LNG.<sup>3</sup>

### **1.2 Determination of Need**

Federal hazardous materials law authorizes the Secretary of Transportation to “prescribe regulations for the safe transportation, including security, of hazardous materials in intrastate, interstate, and foreign commerce,” 49 U.S.C. 5103(b)(1). The Secretary has delegated this authority to PHMSA in 49 CFR 1.97(b). The HMR are designed to achieve three primary goals: (1) help ensure that hazardous materials are packaged and handled safely and securely during transportation; (2) provide effective communication to transportation workers and emergency responders of the hazards of the materials being transported; and (3) minimize the consequences of an accident or incident should one occur. The hazardous material regulatory system is a risk management system that is prevention-oriented and focused on identifying safety or security hazards and reducing the probability and consequences of a hazardous material release.

The Administrative Procedure Act (APA), 5 U.S.C. 551, *et seq.* requires Federal agencies to give interested persons the right to petition an agency to issue, amend, or repeal a rule. 5 U.S.C. 553(e). In accordance with PHMSA’s rulemaking procedure regulations in 49 CFR 106.95, interested persons may ask PHMSA to add, amend, or repeal a regulation by filing a petition for rulemaking along with information and arguments supporting the requested action. PHMSA has reviewed and responded to P-1697<sup>4</sup> in accordance with § 106.105 and determined that the request merits consideration for a future rulemaking. In addition, this proposed rule would address a comment received to a notification of regulatory review,<sup>5</sup> issued by the Office of the Secretary of Transportation in October 2017 as part of DOT’s implementation of three executive

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<sup>3</sup> Circular OT-55 defines a key train as any train with one tank car load of Poison or Toxic Inhalation Hazard1 (PIH or TIH) (Hazard Zone A, B, C, or D), anhydrous ammonia (UN1005), or ammonia solutions (UN3318); 20 car loads or intermodal portable tank loads of any combination of hazardous material, or; one or more car loads of Spent Nuclear Fuel (SNF), High Level Radioactive Waste (HLRW).

<sup>4</sup> Docket No. PHMSA-2017-0020

<sup>5</sup> Docket No. DOT-OST-2017-0069-0001; 82 FR 45750 (Oct. 2, 2017)

orders targeted at regulatory reform, that further expressed industry support of deregulatory efforts to address the safe transportation of LNG by rail.<sup>6</sup>

Before recommending federal regulatory action, an agency must demonstrate that the proposed action is necessary. Executive Order 12866 states that federal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary by compelling need, such as material failures of private markets to protect or improve the health and safety of the public, the environment, or the well-being of the American people.

In the case of this NPRM, regulatory action is needed to eliminate an unnecessary regulatory burden. This proposed rulemaking is expected to be deregulatory, and is the result of an agency review of existing regulations and petitions to identify opportunities to relax or amend current regulations that are (or have become) obsolete or unduly burdensome. Through this NPRM, PHMSA acts on the petition for rulemaking from AAR by proposing to allow the transportation of LNG by rail in DOT-113 rail tank cars and as such serves the purpose of removing undue restrictions in the safe and efficient transportation of energy products in the U.S.

### **1.2.1 Association of American Railroads Petition for Rulemaking**

On January 17, 2017, AAR submitted a petition for rulemaking to PHMSA titled, “Petition for Rulemaking to Allow Methane, Refrigerated Liquid to be Transported in Rail Tank Cars” [PHMSA-2017-0020 (P-1697)]<sup>7</sup> requesting revisions to 49 CFR 173.319 that would permit the transportation of LNG by rail in DOT-113 tank cars.

In P-1697, AAR requested that PHMSA amend the entry for “UN1972, Methane, refrigerated liquid” in the Hazardous Materials Table (HMT; § 172.101) to add a reference to § 173.319 in Column (8C), thereby authorizing transport of UN1972 in rail tank cars. Additionally, AAR requested that PHMSA amend § 173.319 to include specific requirements for DOT-113 cars used for the transportation of LNG. AAR suggested that the authorized tank car specifications be DOT-113C120W and DOT-113C140W, noting that 120W cars should provide 40 days in transportation before the LNG might vent and 140W cars should provide 45 days. AAR further suggested amending § 173.319(d)(2) to include maximum filling densities comparable to those specified for cargo tanks containing LNG in § 173.318(f)(3).

AAR noted that the current HMR allow for the transportation of LNG by highway, and expressed the opinion that rail transportation of LNG is a safer mode in comparison. AAR stated that LNG is similar in all relevant properties to some other cryogenic liquids currently authorized for rail transportation. AAR also stated that PHMSA had not previously authorized DOT-113 tank cars for LNG because of a lack of demand and that PHMSA currently authorizes the transportation of some hazardous commodities in the DOT-113 tank cars.

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<sup>6</sup> Executive Orders 13771, “Reducing Regulation and Controlling Regulatory Costs” (82 FR 9339; February 3, 2017); 13777, “Enforcing the Regulatory Reform Agenda” (82 FR 12285; March 1, 2017); and 13783, “Promoting Energy Independence and Economic Growth” (82 FR 16093; March 31, 2017).

<sup>7</sup> PHMSA, <https://www.regulations.gov/docket?D=PHMSA-2017-0020>

AAR's petition P-1697 is consistent with policies of Executive Orders 13771, "Reducing Regulation and Controlling Regulatory Costs"; 13777, "Enforcing the Regulatory Reform Agenda"; 13783, "Promoting Energy Independence and Economic Growth," and 13868, "Promoting Energy Infrastructure and Economic Growth." PHMSA has accepted P-1697 as having merit for consideration for this rulemaking.

## 1.3 Background

### 1.3.1 LNG

LNG is natural gas<sup>8</sup> that has been processed and liquefied through condensation by reducing its temperature to minus 260°F (minus 162°C) at ambient pressure—a process referred to as liquefaction. The liquefaction of natural gas dates back to 1820, when British scientist Michael Faraday first successfully chilled natural gas into a condensed liquefied form. In 1912, the world's first LNG plant was constructed in West Virginia. The first LNG production and regasification facilities in the U.S., referred to as peak shaving plants, started operating in 1941 in Cleveland, OH.<sup>9</sup> There are now over 100 such facilities in the U.S., located primarily near centers of high demand for natural gas. A facility will liquefy gas during periods of low demand, and store it in an adjacent tank. When demand peaks, LNG is withdrawn from the tank, regasified, and put back into the pipeline, thereby enhancing the pipeline system's ability to meet such periods of high demand. Employing the liquefaction process allows the facilities to reduce the volume of natural gas to about 1/600<sup>th</sup> of its vapor state.

LNG is odorless, colorless, non-corrosive and non-toxic. To be consumed, LNG must be vaporized by warming and returning it to its gaseous form – this warming and vaporization process is called regasification. The vaporized natural gas is then injected back into a pipeline system, or used to fuel natural gas operated equipment. Alternatively, LNG can be transported by tanker trucks and in ISO containers on roads and highways or by water.

LNG in the U.S. is often considered an international commodity, whereas natural gas is often viewed as a domestic commodity. Natural gas in the U.S. is obtained largely from domestic sources and is transported via pipelines mainly for domestic consumption;<sup>10</sup> whereas LNG is, presently, largely transported by ocean vessels for exporting to numerous international destinations. International trends in the LNG industry directly impact the domestic trends of natural gas and LNG. LNG is often transported via highway or water to supply regions, both domestic and international, that lack a natural gas source, or that lack the infrastructure needed to receive natural gas via pipeline. Hence, LNG production and consumption trends are sensitive to international prices for alternative fuel sources, mainly crude oil, diesel, and coal. The U.S. LNG market grew considerably between 2010 and 2018. During this period, the number of LNG facilities in the U.S. increased by 28.7 percent, and total storage and vaporization capacities increased by 21 and 23 percent, respectively.<sup>11</sup> Over the same period, total liquefaction capacity

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<sup>8</sup> Natural gas is mixture of hydrocarbons, predominantly composed of methane.

<sup>9</sup> Center for Liquefied Natural Gas, <https://lngfacts.org/about-lng/history-of-lng/>

<sup>10</sup> In 2018, most (70%) of the total U.S. natural gas exports were by pipeline, 67% of which went to Mexico.

<sup>11</sup> Based on PHMSA annual report data from 2010-2018.

increased by 939 percent due to new LNG export terminals.<sup>12</sup> The U.S. is expected to add 6.05 billion cubic feet per day (Bcf/d) of new liquefaction capacity by 2021, in addition to 3.5 Bcf/d already in operation at Sabine Pass, LA and Cove Point, MD. New “LNG trains”<sup>13</sup> at Cameron, Freeport, and Corpus Christi—all along the U.S. Gulf Coast—are expected to be commissioned in the next three years.

The U.S. export market continues to thrive. According to the Energy Information Administration (EIA) projections,<sup>14</sup> U.S. LNG export capacity will reach 8.9 Bcf/d by the end of 2019, making it the third largest in the world behind Australia and Qatar. The EIA’s December 2018 Short-Term Energy Outlook forecasts U.S. LNG exports to average 5.2 Bcf/d in 2019, as the new liquefaction facilities are gradually commissioned and ramp up LNG production to operate at full capacity. As of July 2019, U.S. LNG had been delivered to 35 countries on five continents, and the list of destinations continues to grow. The U.S. also imports some LNG, mostly to states in New England,<sup>15</sup> which are constrained by limited pipeline and storage capacity. More than half (53 percent) of U.S. LNG exports in 2017 were shipped to three countries: Mexico, South Korea, and China. Mexico received the largest amount of U.S. LNG exports. Growing natural gas demand in Mexico, particularly from the power generation sector, and delays in the construction of domestic pipelines connecting to U.S. export pipelines led Mexico to rely on LNG imports to supplement imports of natural gas by pipeline.

### **1.3.2 The U.S. LNG Industry**

The current LNG industry in the U.S. was born in the 1970s, when the first regasification plants were built. Today, the industry is comprised of many entities, of various sizes, meeting different consumer needs, user preferences, locations and distribution channels. Large entities include major energy producers, equipment producers, fueling station companies, and LNG marine carriers. In the U.S., the most common use of LNG is for peak shaving facilities. In addition, there are mobile/temporary facilities, which are portable units that supply natural gas to a pipeline during peak demand or during pipeline repair. Together, peak shaving, satellite, and temporary facilities accounted for 85 percent of the in-service facilities reporting to PHMSA in 2016, as well as 41 percent of storage capacity, 38 percent of vaporization capacity, and 18 percent of liquefaction capacity.<sup>16</sup>

Currently, LNG is typically transported by truck in the U.S. when used for domestic consumption. PHMSA is unaware of any data source that tracks how much LNG is moved by highway. The Federal Motor Carrier Safety Administration (FMCSA) does not have hazardous material-specific data on volume shipped via highways. The information is not captured by PHMSA’s incident reporting and there is no centralized entity, such as EIA, tracking all hazmat being shipped by highway.

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<sup>12</sup> Id.

<sup>13</sup> An “LNG train” in this context is term of art used to describe a liquefaction and purification facility.

<sup>14</sup> <https://www.eia.gov/todayinenergy/detail.php?id=37732>

<sup>15</sup> New England is composed of six states in the northeastern U.S.: Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut.

<sup>16</sup> Profile of the Liquefied Natural Gas Industry, Final Report, Prepared for PHMSA, by Abt Associates, June 2017.

LNG is not typically transported by pipeline. There are only a few hundred feet of LNG pipeline (compared to more than 300,000 miles of natural gas pipelines) in the U.S. which is primarily used to transfer LNG from liquefaction facilities to storage facilities. Additionally, LNG pipelines may be used in loading and unloading LNG tankers. The limited use of LNG pipelines is due to the required design complexity required to accommodate the physio-chemical and safety characteristics of LNG. LNG pipelines require significant insulation and must be capable of handling significant thermal stress in order to maintain the very low temperature needed to prevent vaporization. As a result, LNG pipelines require costly expenditures to prevent damage to frost sensitive materials and equipment in the vicinity of the pipeline. LNG by pipelines are also possible for intermediate distances in specially designed pipelines used for loading and unloading LNG tankers.

Internationally, marine transportation of LNG has seen exponential growth since 2013.<sup>17</sup> However, domestically there is no marine transportation of LNG. Domestic marine transportation is required to be on U.S.-built ships and no U.S.-built LNG carriers currently exist. PHMSA requires incidents involving the release of a hazardous material in transportation to be reported to PHMSA (49 CFR part 171 subpart B). These reporting requirements extend to any vessel operating to, from, or within the United States, to include those of foreign registry. PHMSA reviewed incident data from 2005-2017 and found no incidents related to transportation of LNG by vessel, and only a small number of incidents by highway with no reported deaths or injuries. Our research into additional sources indicates that such accidents are rare and mainly involve problems with machinery and cargo-handling systems and equipment.<sup>18</sup>

### **1.3.3 LNG By Rail in Canada, Europe and Japan<sup>19</sup>**

LNG by rail in tank cars is in its early stages of inception in other countries, as in the U.S. In Canada, LNG is authorized to be transported by rail in tank cars that are equivalent to the DOT-113 specification and UN-T75 ISO containers, but service has been limited.<sup>20</sup> This is likely due to a lack of demand and the considerable cost of required infrastructure. Also, the fact that the US does not currently authorize the movement in DOT-113 prevents the export of the commodity by that means. LNG is permitted to be transported by rail in Europe in specially designed tank cars, but has not yet been utilized<sup>21</sup>. In Japan, LNG has been authorized to be transported by rail since 2000, in specially designed freight railcars and container railcars. The

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<sup>17</sup> According to the EIA, there were 0 MCF of LNG for 2013, but they have grown in each successive reporting year. In 2018, the US exported 1,082,511 MCF of LNG using marine transportation.  
[https://www.eia.gov/dnav/ng/ng\\_move\\_expc\\_s1\\_a.htm](https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm).

<sup>18</sup> Contacts with MARAD, USCG, Society of International Gas Tanker and terminal operators (SIGTTO), and the International Gas Union. See also “LNG Shipping at 50,” at <https://www.sigtto.org/media/2905/lng-shipping-at-50compressed.pdf> and “Carefully to Carry” -- The carriage of liquefied gases in the P&I World, by Thomas Miller stated “The truth is that serious accidents related to gas carrier cargoes have been few”.  
<http://www.mea.szczecin.pl/klaster/Carriage%20of%20liquefied%20gases.pdf>

<sup>19</sup> This overview is intended to be concise, covering only a handful of countries. LNG is present in many other major countries, such as China, Australia, Mexico and Russia.

<sup>20</sup> Containers for Transport of Dangerous Goods by Rail, a Transport Canada Standard,  
<http://www.tc.gc.ca/eng/tdg/containers-transport-dangerous-goods-rail-transport-canada-standard.html>

<sup>21</sup> In 2015, German VTG unveiled Europe’s first LNG tank car, designed jointly with Czech Republic-based Chart Ferro.

country relies on LNG imports for nearly all of its natural gas supply and ranks as the world's largest LNG importer.

### **1.3.4 Hazardous Material Rail Incident/Accident History in the U.S.**

In the context of rail transportation, "accident/incident" is used to describe the entire list of reportable events.<sup>22</sup> These include collisions, derailments, and other events involving the operation of on-track equipment and causing reportable damage above an established threshold; impacts between railroad on-track equipment and highway users at crossings; and all other incidents or exposures that cause a fatality or injury to any person, or an occupational illness to a railroad employee.

Accidents/incidents are divided into three major groups for reporting purposes. These correspond to the following FRA forms: (1) Train accidents -- A safety-related event involving on-track rail equipment (both standing and moving), causing monetary damage to the rail equipment and track above a prescribed amount, reported on Form FRA F 6180.54; (2) Highway-rail grade crossing incidents -- Any impact between a rail and highway user (both motor vehicles and other users of the crossing as a designated crossing site, including walkways, sidewalks, etc., associated with the crossing, reported on Form FRA F 6180.57; and (3) Other incidents -- Any death, injury, or occupational illness of a railroad employee that is not the result of a "train accident" or "highway-rail incident," reported on Form FRA F 6180.55a.

The focus of the accident history overview is on reported derailments incidents. These types train accidents, particularly when occurring outside of switching operations, tend to be the most relevant to the analysis because they have the potential to generate in train forces that can result in an increased probability of death or injury and a larger quantity spilled.

PHMSA requests data from the public on the volume of shipments of cryogenic liquids carried by rail and by truck.

### **1.3.5 An Overview of Derailment and Highway Incidents Involving LNG or Similar Hazardous Materials to LNG**

The purpose of this section is to present an accident history overview of the transportation of LNG. In the U.S., there are no historical records for incidents involving LNG by rail in tank cars, since it has not been shipped in tank cars. LNG by rail in ISO tanks is only permitted by FRA approval. The first example of such permit was granted to the Alaska Railroad Corporation in 2015. Florida East Coast Railroad was also granted a permit in 2017, and is currently transporting LNG by rail. The LNG is permitted to be transported in bulk packaging, ISO-certified tankers atop flatcars. There have been no reported incidents associated with these special permits to date.

Given the absence of data on rail incidents of LNG, this section summarizes the derailment incidents of similar cryogenic liquids transported in DOT-113. The section also presents an overview of highway incidents involving LNG and similar cryogenic liquids. Specifically, the

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<sup>22</sup> 49 CFR 225.5

tables below show the following: (1) Incidents involving derailments of trains transporting ethylene and argon cryogenic liquids in DOT-113 tank cars, (2) Incidents involving the transportation by highway of ethylene and argon cryogenic liquids, and (3) Incidents involving the transportation by highway of LNG. This overview supports the position that the proposed transportation of LNG by rail is as safe, or, in some cases, safer than the transportation of similar hazardous materials.

### **Derailment Incidents Involving Hazardous Materials Similar to LNG, Transported in DOT-113 Tank Cars (2005-2017)**

The AAR Petition identifies four cryogenic liquids (carbon dioxide refrigerated liquid, argon refrigerated liquid, ethylene refrigerated liquid, and refrigerated hydrogen chloride) with similar properties that are currently authorized to be transported by rail. The petition highlights ethylene, in particular, as having insignificant differences from LNG and that it has been safely transported in tank cars for 50 years.

For the purpose of this overview, PHMSA considers two cryogenic liquids that are currently transported by rail in tank cars: ethylene and argon. LNG, or methane refrigerated liquid, is also classified as a Division 2.1 cryogenic liquid, flammable gas (UN1972). Ethylene, refrigerated liquid (UN1038) is also classified as Division 2.1 flammable gas.<sup>23</sup> Argon, refrigerated liquid (UN1951), though a Division 2.2, non-flammable gas and therefore is likely to have different consequences when an accident occurs, is included in this accident overview because it was involved in a derailment incident while being transported in a DOT-113. The other two commodities mentioned in the AAR Petition are not directly comparable to LNG, because Carbon dioxide, refrigerated liquid (UN2187) is a Division 2.2 non-flammable gas and Hydrogen chloride, refrigerated liquid (UN2186) is a Division 2.3 poisonous gas.

PHMSA conducted a basic comparative analysis of the accident history of similar materials to LNG given the insufficient data on material damages from LNG rail incidents. Based on the 2014, 2015 and 2016 STB waybill data, Argon refrigerated liquid was the only one reported in the 2014, 2015 and 2016 waybill data as shipped in DOT-113 tank cars. Applying a time frame of 2005-2017, PHMSA examined the rail accident history involving cryogenic liquid hazardous material similar to LNG. There were two derailments over 13 years with accidental release of the contents of cryogenic liquids from DOT-113 tank cars. Table 1 (below) shows details on the two derailment incidents involving the transportation of ethylene and argon cryogenic liquids by rail in DOT-113 tank cars. PHMSA records provide details of those derailment incidents: One derailment, in Mer Rouge, LA, (in 2014) involved the accidental release of argon, refrigerated liquid from two tank cars (a DOT-113A90W specification tank car and an AAR204W tank car); one tank car was punctured and released all its content as a result of the derailment. The other derailment in Moran, Kansas, (in 2011) involved the accidental release of ethylene, refrigerated liquid; three DOT-113 specification tank cars containing liquid ethylene derailed. Two of the three tank DOT-113 cars were breached in that incident. A total of 91,539 liquid gallons were released in both incidents, with the total damage valued at \$459,160 in 2017 dollars.

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<sup>23</sup> Ethylene is the only refrigerated liquid classified as a Division 2.1 flammable gas transported by rail. Hydrogen is also authorized for transport, but has not been moved by rail in almost 50 years.

Regarding the count of fatalities and injuries, there were no fatalities or injuries by rail in the transportation of the hazardous materials mentioned above.

**Table 1 - Incidents Involving Derailments of Ethylene and Argon Cryogenic Liquids in DOT-113 Tank Cars (2005-2017)**

Commodity	UN #	Number of Incidents	Death	Injury	Evacuations	Liquid Gallons Released	Total Damages (Original Dollars)	Total Damages (US \$2017)	Avg quantity released per derailment (LGA)	Average damages per derailment (Original \$)	Average damages per derailment (Current \$)	Gas dispersion
ARGON, REFRIGERATED LIQUID	UN1951	1	-		2	47,233	\$218,832	\$227,840	47,233	\$218,832	\$227,840	Yes
ETHYLENE, REFRIGERATED LIQUID	UN1038	1	-		-	44,306	\$210,255	\$231,320	44,306	\$210,255	\$231,320	Yes
Total		2	-		2	91,539	\$429,087	\$459,160	45,769	\$214,544	\$229,580	-

Source: PHMSA data.

Table 2 (below) summarizes incidents involving the transportation of LNG by highway from 2005 to 2017. PHMSA has no data on the volume of shipments by truck and so is unable to calculate an accident rate for truck transport of these materials. There were eight incidents, four of which were crashes and four were non-accident releases. Two of the crashes were single vehicle rollovers. No injuries or fatalities were reported to PHMSA. In addition, the total quantity spilled in those accidents was 11,296 gallons.

**Table 2- Highway Incidents Involving the Transportation of LNG (2005-2017)**

<b>Number of incidents</b>	8
<b>Amount Released (gallons)</b>	11,296
<b>Average Release Volume (gallons)</b>	1,412
<b>Gas Dispersion Events Reported by Carrier</b>	5
<b>Fire</b>	1

Source: PHMSA Data.

Table 3 shows the number of incidents involving the highway transportation of ethylene and argon cryogenic liquids. As shown, there was one incident for ethylene and 37 involving Argon. None of the incidents resulted in hazardous-material-related fatalities, injuries or evacuations.

**Table 3- Highway Incidents Involving the Transportation of Ethylene and Argon Cryogenic Liquids (2005-2017)**

Ethylene and Argon Refrigerated Liquids	Ethylene Refrigerated Liquid	Argon Refrigerated Liquid	Total
Number of Incidents	1	37	38

Amount Released (Gallons)	1	148,796	148,797
Total Damage Value	\$1,010	\$161,784	\$162,794

Source: PHMSA Data.

## 2. LNG SAFETY RESEARCH AND STUDIES

### 2.1 PHMSA Safety Research Studies

PHMSA funds LNG research through PHMSA's Office of Pipeline Safety Research and Development grants.<sup>24</sup> Some of these studies are potentially relevant and beneficial to the safety analysis of LNG by rail as a hazardous liquid commodity. PHMSA sponsored a Review of Vapor Cloud Explosion Incidents report with the primary objective to improve the scientific understanding of vapor cloud development and explosion in order to more reliably assess hazards at large LNG export facilities. Many lessons learned from these events have resulted in safety measures that are required in LNG facilities today. To view all of PHMSA's Pipeline Safety Research and Development projects, visit: <http://primis.phmsa.dot.gov/matrix/>. PHMSA's Office of Hazardous Materials Safety also has several ongoing studies related to LNG transportation and three completed research projects.<sup>25</sup> PHMSA evaluated the completed research projects in the context of this proposed rule, but found them to be either not directly applicable to the economic analysis or of limited relevance to the specific issue of transporting LNG by rail. PHMSA will continue to monitor the ongoing studies for potential consideration in the final rule.

### 2.2 FRA Safety Research Studies and Safety Testing Projects

FRA conducts research on the safe transportation of hazardous material to identify incident trends to find ways to minimize the incident rate of leaks, spills, and damage to the environment due to hazardous materials releases. Also, FRA conducts research in order to lower the potential for loss of lading and reduce the exposure of the environment and populations to hazardous materials releases, and to improve methods of inspection for tank car damage through the investigation of promising non-destructive detection technologies. FRA also conducts research to investigate emerging technologies and take advantage of national and international research programs that would increase the safety and efficiency of rail transportation.

A recent study by FRA was conducted by Sandia National Laboratories, entitled *LNG Safety Assessment Evaluation Methods*.<sup>26</sup> The study evaluated published safety assessment methods across a variety of industries including LNG and hydrogen facilities, highway and marine transportation, as well as protocols from the U.S. Department of Defense. The study also

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<sup>24</sup> Completed Pipeline Safety LNG projects include: [DTRS56-04-T-0005, Modeling and Assessing a Spectrum of Accidental Fires and Risks in a LNG Facility](#), [DTPH5615T00005, Comparison of Exclusion Zone Calculations and Vapor Dispersion Modeling Tools](#), and [DTPH5615T00008, Statistical Review and Gap Analysis of LNG Failure Rate Table](#)

<sup>25</sup> Completed Hazardous Materials Safety LNG studies include: "Risk Assessment of Surface Transport of Bulk Quantities of Liquefied Natural Gas", "Transport Risks Associated with Small Scale LNG Facilities", and "Literature Review: Fire Testing and Thermal Modeling of LNG Bulk Packages."

<sup>26</sup> [www.fra.dot.gov/Elib/Document/16555](http://www.fra.dot.gov/Elib/Document/16555)

reviewed world-wide methodologies for assessing the risks of the transporting of hazardous materials, with emphasis on LNG, by all modes, but with a focus on rail shipments. The primary task of the research was to evaluate the regulatory risk acceptability criteria and to compare the findings with other criteria. All of the methods were evaluated for their potential applicability for use in the LNG railroad application.

FRA is also conducting field experimental research to evaluate the pool fire survivability of a LNG filled portable tank subject to an engulfing pool fire. A new ISO tank is being built for this test, and is expected to be ready before the end of 2019. FRA plans to conduct the full-scale pool fire test of the LNG filled ISO tank before the end in the first quarter of FY2020. FRA is also conducting a full-scale tank car impact testing and analysis of two DOT 113 tanks. The test, which began in March 2019 and is expected to conclude in May 2020, evaluates the performance and crashworthiness of DOT 113 specification tank cars. The test project includes developing puncture models and verifying the models with actual testing data.

Another FRA safety research project underway is an LNG tender crashworthiness assessment that is expected to be concluded in December 2020. This project is a modeling to analyze the performance of an ISO tank (LNG tender) in different accident scenarios: head impact, shell impact, bottom impact and top impact.

FRA is also conducting a full-scale LNG tender rail highway crossing impact test. The project began in 2016 and is expected to conclude in December 2020. The test evaluates the survivability of valves and valve housing on an LNG tender constructed per the AAR proposed standards in a rail crash crossing incident scenario as prescribed on the AAR M-1004 standard.

FRA is commencing another project (fall of 2019) evaluating risk assessment of unit trains versus regular merchandize trains transporting hazardous materials, including LNG. To view FRA safety research studies, visit <https://www.fra.dot.gov/Page/P0505>.

### **2.3 Academic and Other Studies**

Multiple studies have been performed over time regarding the safety and risks of LNG. Many of those focused on the safety of LNG tankers (ocean going ships) since they transport large volumes of LNG and enter ocean ports that may be near populated areas.<sup>27</sup> The “Liquefied Natural Gas (LNG) Import Terminals: Siting, Safety, and Regulation” report (Dec. 14, 2009) from the Congressional Research Service focuses attention on the safety of LNG terminals and infrastructure. These and other reports address the physical hazards of LNG, such as pool fires, flammable vapor clouds,<sup>28</sup> fire, and cryogenic impacts. Some reports also address ship safety, terminal safety, liquefaction facility safety, and security.

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<sup>27</sup> Examples of such a studies include the [DOE Report to Congress in 2012 on Liquefied Natural Gas Safety Research](#) and the [Liquefied Natural Gas \(LNG\) Import Terminals: Siting, Safety, and Regulation](#).

<sup>28</sup> Some cryogenic liquids produce a gas that can burn in air. The most common examples are hydrogen, methane and liquefied natural gas.

### **3. CURRENT DOT REGULATIONS OF LNG**

The transport of LNG is regulated by multiple DOT agencies, including PHMSA, FRA, FMCSA, and the Maritime Administration.<sup>29</sup> The following sections describe PHMSA's and FRA's current regulations.

#### **3.1 PHMSA's Current Regulation of LNG**

PHMSA regulates the surface transportation of LNG, in commerce, moved by highway, rail, and waterway, by specifying authorized packaging and labeling. PHMSA regulates LNG as a hazardous material under 49 CFR part 172, which states that LNG is forbidden on passenger aircraft, cargo aircraft, and passenger rail. Part 172 also specifies safe storage of LNG on vessels. LNG facilities may have to obtain additional permits from federal agencies to operate, such as Clean Water Act, Coastal Zone Management Act, and Clean Air Act permits. The Environmental Protection Agency (EPA) also requires greenhouse gas reporting for certain LNG storage facilities (40 CFR part 98).<sup>30</sup> PHMSA also regulates many LNG facilities under 49 CFR part 193, which sets federal safety standards for LNG facilities that either receive from or deliver to a 49 CFR part 192 pipeline. Facilities regulated under part 193 include baseload, peak shaving, satellite, and import/export terminals, and operators of LNG facilities must submit annual reports to DOT under 49 CFR part 191.17.

#### **3.2 FRA's Current Regulations of Methane, Refrigerated Liquid**

FRA has the enforcement authority and responsibility to ensure the safe transportation of hazardous materials by rail. Movement approvals are required for certain types of hazardous material shipments, such as a one-time shipment of hazardous material carrying tank cars for repair and other non-conforming packaging designed, marked or otherwise represented for the transport of hazardous material. The current HMRs do not contain the necessary provisions to allow for the bulk transport of methane refrigerated liquid (commonly referred to as LNG) in rail tank cars. Bulk methane refrigerated liquid may only be transported via rail in accordance with a PHMSA special permit or an FRA approval.

The proper classification of any hazardous material is required prior to being offered into transportation. In accordance with § 173.115(g), a "cryogenic liquid" means a refrigerated liquefied gas having a boiling point colder than  $-90^{\circ}\text{C}$  ( $-130^{\circ}\text{F}$ ) at 101.3 kPa (14.7 psia). Natural gas has a boiling point of  $-260^{\circ}\text{F}$ . LNG meets the definition of division 2.1, cryogenic liquid and is described by entry "UN1972, Methane, refrigerated liquid (cryogenic liquid), 2.1" on the Hazardous Materials Table (HMT; § 172.101).

The HMR include the design, manufacturing, and maintenance standards for packaging (see parts 178-180). Additionally, the regulations specify which package types may be used for

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<sup>29</sup> Other departments and agencies include the U.S. Coast Guard, the Federal Energy Regulatory Commission (FERC), the Environmental Protection Agency (EPA), the U.S. Department of Energy, the Bureau of Safety and Environmental Enforcement, and the Department of Homeland Security.

<sup>30</sup> For regulation of LNG by other entities, see the following link: <https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/jurisdiction-lng-plants>

specific materials and provide requirements for filling and loading of packages (see part 173). As defined in § 171.8, a “bulk packaging” has a water capacity of greater than 454 kilograms (1,000 pounds) as a receptacle for gases. Per columns (9A) and (9B) of the HMT, bulk packages of LNG are forbidden for transportation by aircraft or passenger rail. Additionally, column (8C) of the HMT provides bulk packaging authorizations for LNG in accordance with § 173.318, Cryogenic liquids in cargo tanks only, and does not include authorization of LNG for tank cars. For cargo rail shipped in ISO containers, a carrier must obtain either a special permit from the Associate Administrator for Hazardous Material Safety, PHMSA (see part 107.105) or a prior approval from the Associate Administrator for Safety, FRA (see part 174.63). FRA has permitted two waivers for shipping LNG by rail in ISO containers to Florida East Coast Railroad and Alaska Railroad.

The DOT-113 rail car has a nominal water capacity of 33,000 gallons, which allows for a payload of approximately 28,500 to 29,000 gallons of cryogenic ethylene. Recently built cars have a gross volume of 34,500 gallons and a net cryogenic ethylene capacity of up to 144,000 pounds (30,380 gallons).<sup>31</sup> The volume capacity of ISO tank portable containers varies by manufacturer between 5,000 gallons and 11,000 gallons of liquid.

### **3.3 PHMSA - Special Permits**

PHMSA’s Approvals and Permits Division has the primary responsibility for the issuance of DOT special permits (SPs). SPs may authorize a regulated entity relief from the requirements in the HMR provided the applicant demonstrates an equivalent or greater level of safety to what’s intended by the regulation. SPs set forth alternative requirements, or a variance to the HMR in a manner that achieves an equivalent level of safety to that required under the regulations, or if a required safety level does not exist, that is consistent with the public interest. Specifically, SPs are issued by PHMSA under 49 CFR part 107, subpart B. LNG has previously been transported in bulk by rail safely in the U.S. under an emergency special permit (DOT-SP 15968).

## **4. BASELINE ANALYSIS**

The baseline for the regulatory analysis represents PHMSA’s and FRA’s best assessment of the current conditions absent the regulatory action. The agencies considered the baseline conditions represented by existing regulations (as discussed in Section 3, above), industry standards, and voluntary measures, determined from the available data as the baseline to estimate the incremental costs and benefits of the proposed rule. The following entities are affected by the proposed rule: rail carriers, LNG operators, LNG shippers, emergency responders, tank car manufacturers, and tank car owners. The following entities are subject to the proposed rule:

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<sup>31</sup> The rail weight limit is 263,000 pounds with a tare weight range of 117,000 to 120,000 pounds. As stated in the HMRs, “except as provided in § 179.13, tank cars, built after November 30, 1970, or any existing tank cars that are converted, may not exceed 34,500 gallons (130,597 L) capacity or 263,000 pounds (119,295 kg) gross weight on rail.” DOT estimates the cost of a single DOT-113 tank car to be \$700,000 to \$725,000 based on informal feedback from manufacturers.

1. Any person transporting any liquefied natural gas in bulk packaging.<sup>32</sup>
2. Any railroad (Class I, II, or III) that transports liquefied natural gas using one or more railroad tank car.

Table 4 represents the numbers of impacted entities. They include estimates for Class I, Class II, and Class III railroads that could transport liquefied natural gas.

**Table 4- Number of Railroad Companies**

<b>Railroad Class</b>	<b>Total # of Railroads</b>
Class I	7
Class II	21
Class III	510
<b>Total</b>	<b>538</b>

## **5. ANALYSIS OF COSTS, BENEFITS AND REGULATORY IMPACTS**

This NPRM is a deregulatory action. The preliminary regulatory impact analysis summarizes the potential impacts of the rulemaking, including potential benefits, compliance costs, LNG business applications, and safety.

As stated above, there are no incremental compliance costs attributed to this NPRM. The NPRM merely proposes to accept a petition that would authorize LNG to be shipped by rail in tank cars, as it is by highway and water. It does not propose additional regulatory obligations or new compliance actions. Any and all new costs incurred by the industry to facilitate the transportation of LNG by rail are discretionary business costs. Such costs are not due to new regulatory requirements in the NPRM, and hence are not quantified in this analysis. Future shippers of LNG have the option to continue shipping in cargo tanks, trucks, ocean vessels or to begin (upon implementation of this rulemaking) shipping by rail in tank cars. Installing new rail lines can be as controversial as pipelines. The chosen modal option is at the discretion of the shipper and it depends on many economic and logistical factors.

PHMSA does note that, although it does not propose any operational controls in the NPRM, it does seek comment on the appropriateness of requiring operational controls for the transportation of LNG by rail. The operational controls referenced in the preamble to the NPRM include train length and train composition, speed restrictions and braking requirements, routing requirements, combinations of such controls, and any other operational controls that may be reasonable to

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<sup>32</sup> A bulk packaging is a packaging, other than a vessel or a barge, with (1) a maximum capacity greater than 450 liters (119 gallons) as a receptacle for a liquid; (2) a maximum net mass greater than 400 kilograms (882 pounds) and a maximum capacity greater than 450 liters (119 gallons) as a receptacle for a solid; or (3) a water capacity greater than 454 kilograms (1,000 pounds) as a receptacle for a gas.

apply to movements of LNG by rail. In this RIA, PHMSA also seeks comments on the potential costs and benefits of adding any such operational controls.

## **5.1 Compliance Costs**

None. This NPRM does not impose new compliance costs.

## **5.2 Benefits**

As stated above, there are numerous potential benefits and positive impacts from this proposed rulemaking, including transportation efficiency, expanded fuel usage, including fuel accessibility to remote regions, fuel switching, increased U.S. energy competitiveness, safety impacts, fuel efficiency and fewer emissions.

### **5.2.1 Transportation Efficiency and Expanded Transport**

The proposed rule would be expected to result in transportation efficiencies. Rail and truck transportation of goods compete with, and complement, one another. This could be the case for the transportation of LNG. For heavy loads and long hauls, rail delivery is more efficient than truck. One tank car can replace almost three truck cargo tank trailers. However, rail delivery of LNG has limitations particular to the railway network. Rail delivery operationally takes longer than truck delivery particularly if loads are transported in manifest trains that must be consolidated and sorted onto different trains at rail yards, whereas truck delivery is a direct point-to-point delivery. However, the difference between truck and train delivery times would likely be reduced if unit trains were employed, in which only LNG railcars were transported from origin to destination without railyard sorting. For intermodal deliveries, trucks can complement the rail network by allowing consignees and shippers who are not directly served by rail lines to access rail terminals.

There is also increased efficiency from the fact that trains operate on a fixed schedule and with fixed routes; there is less variability in pick-up and delivery times as compared to trucks. Therefore, the long-distance trips are comparatively quicker. There are also cost savings to be gained from larger capacity and less handling and hence less potential for commodity damage. In addition, since LNG occupies a fraction of the volume of natural gas, and occupies less space, rail transportation (given the potential volume of LNG that could be moved in a single train) is expected to be more economical to transport across long distances and can be stored in larger quantities than trucks.

Rail delivery of LNG could also replace, or supplement, the pipeline delivery of natural gas. If a pipeline were to close due to immediate or planned maintenance work, or due to a pipeline malfunction, railroads could move large supplies of LNG to the demand regions. Railroads are often a substitute for pipelines when the latter is impossible or difficult to construct. Each type of

networks has limitations: pipelines have directional limitations and capacity constraints, while railroads have track safety standards and operational limitations.<sup>33</sup>

The proposed rule likely would allow for expanded production opportunities, including complementary and competitive modal opportunities of transporting LNG by rail in new regions, particularly stranded regions, which lack pipeline service; or emerging regions, such as near chemical plants or feedstock sites, where rail may offer a comparative advantage due to terrain manageability. It is difficult to adequately forecast the future volume of shipments of LNG by rail given the limited quantities that are presently transported and the imperfect information regarding the demand for movement of LNG by rail. Furthermore, the analysis cannot predict the prevalence or car distribution of LNG being transported in tank car blocks (2-25 tank cars together) within manifest trains, or being transported in a unit train (typically 25 or more tank cars being moved as a single commodity train) configuration. It is presumed that LNG would likely be transported first in small blocks as part of manifest trains, and not in a unit train configuration. This presumption is based on the lack of available DOT-113 tank cars to transport this commodity. It is also difficult to adequately forecast the future routes of LNG shipments by rail, due to the lack of details of the specific origin and destinations of interstate rail movements and the connectivity of the current rail network to liquefaction and storage facilities.

PHMSA seeks data and comment from the public proposed rule's likely effect on the expected volume of substitution of LNG transport from other modes of transport (including truck, pipeline, and maritime) and the expected expanded volume of LNG transport.

## **5.2.2 Market Impacts**

Reducing the cost of transporting domestic natural gas by enabling the use of rail tank cars for LNG may also have secondary impacts on the market for LNG. While these would not be additive benefits to be considered in a formal benefit-cost analysis, they represent impacts that would serve important policy goals of promoting domestic energy production and consumption. AAR asserts in its petition that LNG is currently missing from the list of commodities authorized for rail transportation "simply due to the historical lack of interest in transporting LNG by rail," but states that the current and expected future demand for transportation of LNG by rail warrants prompt authorization by PHMSA.

### **5.2.2.1 U.S. International Competitiveness**

The absence of consideration of LNG by rail to date may be, as AAR contends, due to the historical lack of interest in transporting it by rail and the absence of economic incentives. However, there are now many opportunities for LNG by rail, including facilitating the rapidly expanding U.S. LNG export industry. U.S. LNG exports are expected to increase in coming

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<sup>33</sup> Freight rail operations must comply with the applicable speed restrictions in the track safety standards which are established by FRA at 49 CFR § 213.9. This regulation prescribes minimum safety requirements for railroad track that is part of the general railroad system of transportation, Additionally, the railroads are also required to comply with various train operating requirements established in parts 173 and 174 of the HMR, as well as specific industry standards.

years as new U.S. LNG export capacity comes online.<sup>34</sup> As stated above, a recent report by EIA forecasts U.S. liquefied natural gas export capacity to more than double by the end of 2019, making it the third largest in the world following Australia and Qatar. The U.S. also imports some LNG, mostly to New England because states in that region are constrained by limited pipeline and storage capacity. The U.S. also re-exports some natural gas that is originally imported when foreign natural gas prices are favorable.

There are also many new potential economic gains for the U.S. energy industry, including export opportunities to Europe, Japan, Caribbean, Central American and South American countries. European efforts to import more LNG in the coming years could create another potential opportunity for U.S. producers, as the increased adoption of LNG in smaller economies—such as Poland, Greece, Italy and Lithuania—has opened up new opportunities of U.S. exporters. Japan, being the largest LNG importer in the world, is an additional potential trade partner of the U.S. Industry analysts believe there are commercial opportunities for the U.S. through exports by major Japanese electric and gas utilities and Japanese investment in U.S. LNG infrastructure, mainly U.S. power plants and gas liquefaction export facilities.<sup>35</sup>

#### **5.2.2.2 LNG as Fuel**

The AAR Petition cites a “commercial interest” in LNG by rail. The Petition states that “[a]uthorizing transportation of LNG by rail likely would stimulate more interest. In addition, several railroads are actively exploring LNG as a locomotive fuel. If railroads are to use LNG-powered locomotives, they would need to supply LNG along their networks. Transporting LNG in tank cars would be an optimal, if not essential, way to transport LNG to those locations.”

There are many potential uses of LNG as fuel. LNG is an ideal fuel for long-haul trucks, railroad locomotives, ships and tug boats, heavy construction, mining equipment, forestry, and agriculture. The rail industry suggests that allowing LNG to be transported by rail would substantially increase the economic benefits for companies shifting locomotive fuel from diesel to LNG. The use of LNG as locomotive fuel is not a new idea; it dates back to the 1980s. Recent attention has been given to dual-fuel locomotive engines, which can burn natural gas as the primary fuel using diesel fuel only as a pilot fuel for gas ignition. However, becoming an effective large-scale system requires several conditions- fuel source, locomotive, refueling and storage on board. If any component is lagging or is improperly developed, the entire LNG-based system may be unsuitable.

The EIA reported that U.S. natural gas production grew by 10 billion cubic feet per day (Bcf/d) in 2018, an 11 percent increase from the previous year. The increase was the largest annual volumetric growth on record and reached a record high for the second consecutive year.<sup>36</sup> From the consumption side, the EIA stated in its Annual Energy Outlook 2018 that it expects a 40 percent increase in natural gas consumption in the U.S. industrial sector by 2050.<sup>37</sup> The U.S.

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<sup>34</sup> See a list of existing and under-construction large-scale U.S. liquefaction facilities

[https://www.eia.gov/energyexplained/index.php?page=natural\\_gas\\_lng](https://www.eia.gov/energyexplained/index.php?page=natural_gas_lng)

<sup>35</sup> <https://www.export.gov/article?id=Japan-Liquefied-Natural-Gas-LNG>

<sup>36</sup> <https://www.eia.gov/todayinenergy/detail.php?id=38692>

<sup>37</sup> [Annual Energy Outlook 2018](#)

industrial sector consumes more natural gas than any other sector, surpassing electric power in 2017 and the combined residential and commercial sectors in 2010. In 2017, about two-thirds of total industrial natural gas consumption was consumed for heat or power applications—either for industrial processes, such as in furnaces, or for onsite electricity generation. Several industries including bulk chemicals, food, glass, and metal-based durables used natural gas for 40 percent or more of their heat or power applications in 2017. EIA expects that these industries would continue to use about the same proportion of natural gas for heat or power applications through 2050 because of the cost associated with fuel switching. Industrial fuel switching often involves changing manufacturing processes, which requires substantial capital investment in new equipment. The EIA’s Annual Energy Outlook 2018 projects that U.S. dry natural gas production will increase through 2050 across a wide variety of alternative assumptions about the future.<sup>38</sup>

### **5.2.2.3 Home Heating Fuel Switching**

There are also potential economic benefits to be gained from switching fuel usage to natural gas (LNG). The potential to switch depends on differences in the relative prices of alternative fuels and the costs of application technologies. Oil furnaces are cheaper than natural-gas options, but gas models are slightly more efficient on average. Natural gas is a common energy source for home central heating systems. However, for rural and mountainous areas with limited access to natural gas, oil-fired boilers and furnaces are often an alternative. While the U.S. natural gas pipeline network extends to most of the lower 48 States, there are areas in the U.S. that are isolated from this network, or that have more demand for natural gas than the pipeline network can supply. A notable example is New England, which is a “stranded” gas market that currently is served by truck delivery of LNG or by waterborne imports. New England could be a candidate for LNG delivery by rail. It is a market with high demand and limited access to the pipeline network. In New England, LNG provides about 8 percent of its total annual gas supply. The nearby states of Pennsylvania, Ohio, and West Virginia currently account for 30 percent of U.S. gas production, which could be more efficiently transported to New England by rail until the pipeline network connects the two regions.

### **5.2.3 Emissions**

According to the 2018 Transportation Statistics Annual Report of the Bureau of Transportation Statistics,<sup>39</sup> greenhouse gases and the six other most common air pollutant emissions from transportation, with the exception of particulate matter (PM-10), are below their 2000 levels and continued to decline from 2009 to 2016. Reductions in transportation’s air emissions have contributed to improved air quality in urban areas within the U.S. On average, air quality was good for 247 days in 2015 compared to 192 days in 2000.

As far as rail transportation, a recent FRA commissioned study<sup>40</sup> found that rail is on average more fuel efficient than trucks. Rail fuel efficiency varies from 156 to 512 ton-miles per gallon,

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<sup>38</sup> [Annual Energy Outlook 2018](#)

<sup>39</sup> <https://www.bts.gov/TSAR>

<sup>40</sup> Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors (2009). The study is dated; trucks have improved but the turn-over in locomotives is much slower.

truck fuel efficiency ranges from 68 to 133 ton-miles per gallon, and rail-truck fuel efficiency ratios range from 1.9 to 5.5<sup>41</sup>. The study found that there is a strong correlation between rail-truck fuel efficiency ratio and equipment type. Tank car movement resulted in the highest ratio (Min-Max: 5.3- 5.3).

A study by the AAR states that U.S. freight railroads can, on average, move one ton of freight 479 miles per gallon of fuel, making rail the most environmentally friendly way to move freight over land. Additionally, the study states that moving freight by rail instead of by truck lowers greenhouse gas emissions by 75 percent. EPA data, cited in the study, finds that despite the large volume of freight moved, U.S. freight railroads only account for 0.5 percent of total U.S. greenhouse gas emissions and 2 percent of emissions from transportation-related sources.

#### 5.2.4 Safety Impacts

Safety risk is a consideration of every hazardous material in transportation. PHMSA's Technical Evaluation and Recommendation in response to the AAR Petition states that "[f]rom a material risk point of view, LNG should be authorized for bulk shipments by rail, because the hazards are no greater than materials already authorized." PHMSA's technical evaluation also states that "there is nothing from a chemical perspective that shows any different hazard from other currently authorized cryogenic liquids."<sup>42</sup> While there may be safety impacts due to a large increase in the number of tank cars transporting cryogenic liquids, this should not change the hazard analysis of authorizing the use of the DOT-113 tank car for LNG. There is currently no quantity limitation to the number of cars within a single consist for any cryogenic materials.<sup>43</sup> Therefore, when applying an equivalent level of safety, LNG should be authorized. Any limitation to handle large conveyances of cryogenic tank cars within a single consist should be handled under a separate petition/rulemaking as that same concern is present for many other cryogenic liquids and should be considered outside the scope of this particular request." FRA stated in its Response Letter<sup>44</sup> to Florida East Coast Railway that "[m]oving hazardous materials by rail is not new, and is one of the safest ways to move dangerous products. In fact, FRA believes it is safer to transport LNG by rail than it would be to transport the product by an alternative method."

In addition, as stated in the accompanying NPRM, the DOT 113C120W specification rail tank cars are constructed to a double pressure vessel design. The commodity tank (inner vessel) is constructed of ASTM A 240/A 240M, Type 304 or 304L stainless steel. The outer jacket (outer

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<sup>41</sup> Rail-truck fuel efficiency ratio is calculated as the ratio between rail and truck fuel efficiency, both measured in lading ton-miles per gallon. The study analyzed several types of rail equipment. The tank car movement resulted in the highest ratio, followed by double-stack, covered hopper, and gondola movements. Auto rack movements resulted in the lowest ratios (minimum 1.9 to maximum of 2.2).

<sup>42</sup> All hydrocarbon materials - from methane to diesel - burn in fires producing about the same temperature within +/- 100 F. A large (30 m diameter and greater) LNG liquid pool fire on land is no worse than any similarly sized gasoline or other hydrocarbon fire. For a good description of potential safety hazards of LNG, see LNG Safety Assessment Evaluation Methods, <https://prod.sandia.gov/techlib-noauth/access-control.cgi/2015/153859r.pdf>

<sup>43</sup> To date, volumes of cryogenic materials shipped by rail have been small. To PHMSA's knowledge there have not been any unit trains of any cryogenic materials moved by rail because demand from shippers/receivers is insufficient to require shipments approaching unit train volumes. However, should such demand materialize, there would be no regulatory barrier preventing shipment of this material in a unit train configuration.

<sup>44</sup> <http://www.saveourfl.com/images/uploads/pages/102317---march-3-2017.pdf>

vessel) is typically constructed of carbon steel. This design provides an increased crashworthiness when compared to a single vessel design rail tank car. The rail tank car is manufactured with a vacuum and insulated area between the two pressure vessels. This vacuum area and the insulation significantly reduce the rate of heat leak from the atmosphere to the liquid inside the tank car thus minimizing the heating of the cryogenic material while being transported. Due to its unique design requirements, the DOT-113 specification tank car is inherently more robust than other tank cars transporting other flammable liquids or liquefied gasses, and is safer from the perspective of material releases resulting from a tank rupture during a derailment. If a DOT-113 is involved in a derailment, the most likely scenario would involve the breach of the outer tank. This breach would cause the loss of the insulating vacuum between the inner and outer tank, and would allow the inner tank and material to warm and build pressure. The resulting pressure build would eventually lead to the activation of the pressure relief systems on the car and the controlled venting of LNG vapor.<sup>45</sup> While this scenario may result in safety impacts, the controlled venting of LNG vapor is minor in comparison to the uncontrolled release of an entire LNG shipment. Additionally, it is highly unlikely that damage to DOT-113 involved in a derailment would result in explosion due to a boiling liquid expanding vapor explosion. This event is highly unlikely due to specific loading requirements for cryogenic materials, and due to the mandated requirements for redundant pressure relief systems (valves and safety vents) that are built into each car.

From an accident history standpoint, as discussed above, rail transportation of hazardous materials in the U.S. are considered a safe method of transporting large quantities of chemicals over long distances. Rail transportation is also not as adversely influenced by weather conditions as trucks, and can traverse through heavy rain, fog, and snow. Further, rail transportation is well structured and less susceptible to human error. According to the AAR, the rate of rail accidents caused by defective track and by human error were the lowest in 2017. On the other hand, rail accidents in comparison to highway accidents are potentially more catastrophic in size and impact, due to the higher volume of hazardous materials per shipment.

Rail and truck accident rates are not equally comparable due to inherent variations in risk factors associated with each mode of transportation. Variables such as fleet configuration, package type, transportation routing, operational requirements, among others, impact how accidents are compared. Accident studies, therefore, apply different evaluation methods based on the specific mode of transportation of the commodity.

A recent study by Exponent (Hart, et al)<sup>46</sup> evaluated the risks of the transportation of bulk LNG vs. bulk liquefied petroleum gas (LPG) by truck and rail. The study evaluated the potential risk profiles for the transportation of LNG in bulk packages versus the transportation of LPG which

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<sup>45</sup> DOT-113 tank cars have redundant pressure relief systems. Each car has a total of four pressure relief devices (PRDs) consisting of two pressure relief valves and two pressure relief vents. A combination of each of these devices are mounted on opposite ends of the car to minimize the chances of both sets of devices being damaged in a derailment. In the case of a PRD failure to open, the redundant PRD(s) would vent any over-pressure. Theoretically, if all redundant PRD's failed, and the insulation was compromised, slow over pressurization would lead to an eventual container rupture and release of gas and liquid LNG. A BLEVE would require the compromised tank car with the failed redundant PRD valves to be additionally engulfed in a pool fire.

<sup>46</sup><https://www.exponent.com/knowledge/alerts/2015/08/bulktransportation/~media/03b73782ec76446798c70f6ac403ef84.ashx>

is currently shipped in bulk via road tanker truck and rail tank car. In general, the study found that the transportation risk profile for the transportation of LNG in a bulk package would be similar to the risk profile of LPG currently in transportation by highway and rail. However, the study suggested that the safety risk for the rail transportation of these materials may be slightly higher than highway transportation due to the larger volume of material transported in a rail car relative to the volume of material transported in a highway tanker.

Currently, as stated above, LNG is not permitted to be transported by rail without a waiver from the FRA, and only in UN ISO tanks. Cryogenic liquefied gases (e.g., ethylene, argon, nitrogen, etc.) are shipped in double-walled vacuum insulated DOT-113 cars with a capacity of 30,000 gallons. Tanker trucks for LPG are single-walled pressure vessels, whereas LNG trucks use double-walled cryogenic tankers.<sup>47</sup> The Exponent study found that, similar to road tankers, the annual accident rate for all rail pressure tank cars was found to be identical to that for the smaller subset of LPG pressure tank cars; thus, PHMSA reasonably assumes a common accident rate of  $6 \times 10^{-7}$  accidents per mile per year for both LNG and LPG tanker trucks.

## **6. Analysis of Regulatory Alternatives**

### **Alternative 1: No Action**

This alternative effectively denies the AAR's petition and maintains the status quo.

Taking no action would limit the transportation of LNG to highway cargo tanks or ISO portable tanks, which could increase the safety risk as volumes transported would increase. The increase in risk is not only due to the increased number of shipments placed into the public transportation system, but also from the increase in handling cycles (i.e. loading, unloading, etc.) of those shipments.

### **Alternative 2- Authorize DOT-113C120W and DOT-113C140W**

This alternative would adopt the AAR petition in its entirety, including the authorization of the DOT-113C140W specification tank car into the HMR for the transportation of LNG. As discussed in the accompanying NPRM, the intended advantage to the DOT-113C140W tank car is that it would have a similar design and construction to the DOT-113C120W specification, but would potentially allow for 5 days of additional transportation time because the tank car would use a thicker inner tank material that would allow for a higher inner tank test pressure (140 psig) and higher pressure relief device settings. PHMSA and FRA believe that a complete engineering review of this specification is warranted, and that more research and supporting data are needed to demonstrate that this additional transportation timeframe benefits safety or justifies the addition of a new tank car specification to the HMR. While PHMSA is not opposed to considering this request for future action, it does not wish to delay action on the DOT-113C120W tank car. Accordingly, this alternative was eliminated from full consideration in this rulemaking.

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<sup>47</sup> Mileage data were not available for the subset of cryogenic pressure tankers but were available for the larger set of all pressurized tanker trucks.

**Alternative 3:** Authorize transportation of LNG by Rail in DOT-113C120W Tank Cars and Rely on Existing Operational Controls under DOT Regulations and AAR’s Circular OT-55 (Preferred alternative)

Under this alternative, operational controls specified in AAR’s Circular OT-55 would be required for any key train transporting LNG in DOT-113 tank cars. Specifically, Circular OT-55 defines a “Key Train” and outlines operational controls such as speed restrictions for trains meeting the “Key Train” definition. PHMSA estimates there would be approximately five railroads (1 Class I, 2 Class II, and 2 Class III) to 14 railroads (2 Class I, 2 Class II, 10 Class III) that would be impacted under this alternative. This alternative would not impose any additional costs to the industry because the railroads in practice follow the industry standards and operational controls specified in AAR’s Circular OT-55 to ensure safe transportation of all hazardous materials, including LNG. This alternative reflects PHMSA’s deregulatory effort of authorizing the transportation on LNG by rail and does not impose any costs on the industry. Alternative 3 relies on existing operational controls under DOT regulations and OT-55.