LNG on the Rails

LNG is ideally transported by rail in 30,000 gallon rail tank cars.

LNG / Natural Gas is an excellent solution to reduce costs and improve the environmental foot print of today's diesel locomotives

SCOTT NASON

Chart Industries

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INTRODUCTION

LNG is blossoming as a fuel used in many applications and as such often needs to be transported over land. Highway transportation of LNG in MC-338 Cargo Tanks is well understood and has existed for over 50 years throughout North America.

Rail transportation of LNG is desirable for improved economics, safety and reduced environmental footprint – mirroring rails advantage in shipping a wide, wide variety of liquid chemicals.

Natural gas is also a viable substitute for diesel fuel in high horsepower engines. This has been demonstrated for years in over the road trucking applications, line haul trucks and a host of other high horse power engines. North American railroads took a hard look at LNG / natural gas in the 1990s and are again exploring its use – having done extensive specifications development and pilot projects over the last several years – and one very notable complete fleet overhaul and commitment to dual fuel.

In this paper Chart will discuss the current regulatory framework and activity for transporting LNG by rail in tank cars and in ISO containers; and Chart will discuss the current state of LNG Fuel Tenders used to provide natural gas fuel to duel fuel locomotives.

WHY LNG

Natural gas is well understood by all at this conference to be an abundantly available, domestically produced, very low cost, and very low carbon fuel. It has both cost and environmental advantages over diesel.

While the 'small scale' LNG industry continues to develop and more and more LNG production plants are built, the LNG often must be transported to industrial uses, fueling stations, etc. Dating back to the 1960s, traditional LNG gas peak shaving applications often involve road transport of LNG. And as noted above, highway transportation of LNG in MC-338 Cargo Tanks (Highway Trailers) is well established with payloads of from 10,000 to 11,500 gallons on two axle US sized trailers and about 14,000 gallons on tri-axle Canadian sized trailers.

Railcars can provide an improvement on that transportation in many instances by lowering the cost and environmental footprint required to move the LNG; and by removing LNG trucks from

the nation's highways and into a more robust package, that is the DOT-113 tank car. All the while, carrying 30,000 gallons in a single tank car.

A LOOK AT THE TRANSPORTATION EQUIPMENT FOR LNG

Water and highway transport in 40' UN T75 Portable Tanks (ISO Containers) is also commonly used – particularly when it is truly an intermodal shipment including one leg by water. These containers carry a little over 10,000 gallons in most cases. (A challenge for ISO container shipments is staying within weight and bridge laws on US highways limited to 80,000 lbs. GVWR)

40', UN T75 Portable Tank (ISO Container)

Rail transport of LNG (methane, refrigerated liquid) is envisioned to take place in DOT-113C120W tank cars in the same manner that Liquid Ethylene (Ethylene, Refrigerated Liquid) has been shipped - literally for over 50 years. Rail Tank Cars with 34,500 gallons gross inner tank volume and a little over 30,000 gallons net shipping volume as allowed by shipping density rules have been in service transporting liquid ethylene since the 1960's.

DOT-113C120W Tank Car. ~30,000 gallons net volume

The DOT-113C120W tank cars calls for a stainless steel inner tank to be suspended within a fine grain carbon steel outer tank, with the appropriate inner tank support system, annular piping and insulation. The space between the tanks is evacuated to produce a high-vacuum insulation system. The 'thermos bottle' provides an excellent thermal and structural containment for the LNG – two tanks in one.

The outer tank is a fully butt welded, fine grain carbon steel pressure vessel with 100% xray of its seams and full heat treatment of the welded vessel. The outer tank is a robust rail car in and of itself, but an extra level of protection is provided by the necessity of the thermos bottle – by having the LNG contained 100% in the inner, stainless steel pressure vessel. The inner tank has a prescribed minimum thickness of 3/16" but is typically closer to 5/16" thick; while the outer tank is 7/16" minimum thickness for the shells and ½" minimum for the heads. The space between the tanks is not set, but is typically about 6".

This tank structure of the railcar is considerably heavier than on highway trailers or ISO Containers – appropriately so for the harsh operation environment of freight rail.

Typical piping to load, unload and monitor key metrics are contained in matching piping cabinets on either side of the car. Chart uses virtually all stainless steel components and an all stainless steel cabinet and related hardware.

Typical cryogenic piping. Off-loading liquid ethylene from a DOT-113C120W Tank Car.

Loading and unloading of the LNG is a manual connection process of connecting the appropriate hoses and opening of manual valves on the rail tank car. The supply or receiving side of the system may well include automated features. It is very similar to loading and off-loading highway trailers and ISO containers.

REGULATORY REVIEW

Methane, Refrigerated Liquid (LNG, CH4)) is very similar to Ethylene, Refrigerated Liquid (Liquid Ethylene (C2H4)). LNG is -260 F at its coldest; ethylene is -155F. Their densities are similar as is their flammability. And for another day and another discussion, Ethane, Refrigerated Liquid (liquid ethane, C2H6) is also very similar, with a low temperature of -128F.

Each of these three flammable cryogenic liquids should be allowed to ship in the DOT-113C120W tank car – as ethylene has been for many years. Transport Canada made such an allowance for LNG in 2014. Europe fully approved two Chart / VTG built LNG tank cars in Europe also in 2014. The US DOT has both regulatory activity and a Special Permit application in process to allow LNG to be transported by rail in the US.

Similarly, for UN T75 ISO Containers in the US, special permission is required from the FRA to transport these ISO containers by rail when carrying LNG or flammables. Ref 49 CFR 174.63

Canada has approved the use of UN T75 ISO containers for the rail transport of LNG; as has Europe.

To date at least two railroads have been granted FRA special permission to transport the containers by rail. A modest number of loads have been transported – without incident to my knowledge.

Currently 49 CFR 172.101 – Hazmat Table provides rules and packaging for shipping liquid ethylene by rail in tank cars. It does NOT provide rules and packaging for LNG in tank cars. I understand this NOT to be a specific prohibition against LNG – as many opponents of LNG state, but simply a recognition that prior to a few years ago, there was little to no commercial interest in moving LNG by rail. This is well understood with this audience, but perhaps not as much in the greater public square. The same is true for liquid ethane. There has never been an active prohibition on these liquids – just a lack of commercial demand to publish regulations.

A major advantage for the cryogenic liquids shipping in the DOT-113 tank car is the double wall / tank-within-a-tank design of the car as enumerated above. No other car on the rails today has such a structure. Puncture resistance is considerably enhanced with the two vessel / double wall construction – not to mention that the inner tank has further enhanced puncture resistance properties – being made of stainless steel and operating at low (cryogenic) temperature.

EXECUTIVE ORDER ISSUED APRIL 2019

https://www.whitehouse.gov/presidential-actions/executive-order-promoting-energy-infrastructure-economic-growth/

Section 4(b)

(b) In the United States, LNG may be transported by truck and, with approval by the Federal Railroad Administration, by rail in United Nations portable tanks, but Department of Transportation regulations do not authorize LNG transport in rail tank cars. The Secretary of Transportation shall propose for notice and comment a rule, no later than 100 days after the date of this order, that would treat LNG the same as other cryogenic liquids and permit LNG to be transported in approved rail tank cars. The Secretary shall finalize such rulemaking no later than 13 months after the date of this order.

In addition to the above, The Association of American Railroads (AAR) had petitioned for Rulemaking in January 2017 and PHMSA has acknowledged and accepted / received that petition. Reference P-1697 (PHMSA-2017-0020: https://www.regulations.gov/docket?D=PHMSA-2017-0020

This petition essentially requests that LNG be permitted to be shipped in DOT-113C120W tank cars in the same manner that liquid ethylene has been for over 50 years.

It notes that several other cryogenic liquids and more hazardous liquids have been permitted in rail transportation for many years.

SPECIAL PERMIT APPLICATION

A private company made a Special Permit request to PHMSA to allow LNG to be transported in DOT-113C120W tank cars – again, in the same manner that liquid ethylene and other cryogenic liquids have for many years.

In response to that SP request, The US DOT publicly issued:

> Special Permit - Draft
>
> LNG by Rail SP UPDATED Draft Environmental Assessment
>
> Comment Period; Comment Period Extension; 2,900+ comments received.

https://www.regulations.gov/docketBrowser?rpp=25&so=DESC&sb=commentDueDate&po=0&dct=N%2BO&D=PHMSA-2019-0100

The draft Special Permit essentially would allow the Applicant to ship LNG by rail in DOT-113C120W tank cars in the same manner that liquid ethylene and other cryogenic liquids are shipping today and have been for 50 years.

The draft environmental assessment addressed a number of key items:

- Rail transport is preferably to highway transit of LNG.
    - One railcar carries the same volume of just under three trailers and takes the HAZMAT Liquid off the public highways

    - Rail has notably less incidents per mile, per ton of product shipped, per any measure – as compared to highway transit
    - Rail transportation has a lesser environmental footprint than highway
        - Better fuel efficiencies
        - Reduced engine emissions from locomotive versus trucks
- The EA reviewed past derailments of liquid ethylene and other cryogenic liquid railcars and found no over whelming consequences.
- The EA discussed hazards such as:
    - Properties of LNG / NG
        - LNG / NG as an asphyxiant
        - LNG / NG vapor cloud / vapor dispersion and ignition scenarios
        - Favorable comparison to other hydrocarbons shipped by rail
        - Low temperature hazards
    - Properties / characteristics of the DOT-113C120W tank car
        - Tank-with-in-a-tank / double-walled construction
        - Stainless steel inner tank
        - Vacuum insulation system
        - Safety relief devices; piping, etc.
        - Enhanced puncture resistance due to double wall design
        - Venting / loss of gas
    - BLEVE possibility (unlikely)
    - References recent fire test of an ISO container

Conclusions: (quoted from the Draft Environmental Assessment) (underlines mine)

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.

9-6-19 UPDATE

PHMSA's LNG rulemaking is under review at OMB and they continue to work with OMB to meet the requirements set out in the Executive Order. The LNG Special Permit Environmental Assessment comment period has closed, and they are organizing, cataloging, reviewing, and preparing responses to the 3000+ comments to determine their next steps.

Also, PHMSA is in the process of engaging with our Emergency response community so that, as LNG transportation increases across any of the modes, our emergency responders will have full awareness and maximum preparedness.

PHMSA and FRA both have various research projects in process.

Of note, The Office of Hazardous material Safety (OHMS) has received a completed "Risk Assessment of Surface Transport of Liquid Natural Gas" report that is publicly available on their website at: https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/research-and-development/hazmat/reports/71651/fr2-phmsa-hmtrns16-oncall-20mar2019-v3.pdf

This report outlines LNG supply and demand in the context of the overall energy market, including new trends for using LNG for propulsion in the motor carrier, maritime, and rail industries. It also explored how natural gas and LNG are transported throughout the United States, and the relationship between peak-shaving facilities, merchant plants, and export facilities. It also includes accident rates for motor carriers transporting LNG and Liquefied Petroleum Gas (LPG), and outlined LNG handling characteristics.

The AAR Tank Car Committee (TCC) also has a Task Force (T79.40) charged with reviewing the DOT-113C120W Tank car for LNG service. That TF met last week and has a number of items under discussion.

LNG / NATURAL GAS AS A FUEL FOR DUAL FUEL (Diesel / natural gas) LOCOMOTIVES

The Florida East Coast Railway has converted its entire fleet of diesel locomotives to dual fuel – diesel and natural gas. Chart designed and built the ISO container style fuel tenders that supply the natural gas to the locomotives.

Two FECR dual fuel locomotives supplied by one Chart LNG Fuel Tender

In this particular design the ISO container holds up to 10,000 gallons of LNG and can dispense natural gas to the locomotives via a submerged pump; via pressure transfer; or via an economizer system. All of this is automatically controlled from a PLC system.

The railroad operates the converted locomotives, the tenders and the overall program via a Letter of Concurrence issued to them by the FRA / DOT. The LOC includes an extensive review of the locomotive conversion, the tender design, the LNG supply, and related monitoring, emergency response preparations, employee training, first responder training, etc.

The Association of American Railroads (AAR) Natural Gas Fuel Tender Technical Advisory Group (NGFT TAG) has developed extensive written standards for the entire spectrum of the LNG as a fuel program. The first release of the documents addressed a tank car style LNG fuel tender – somewhat based on the DOT-113C120W tank car – but that goes well, well beyond tank car requirements.

Two big aspects of the published standards are in the crashworthiness criteria:

- The tender shall absorb the energy of a 45 mph head on collision of two trains
- The tender shall absorb the energy of an 80,000 lb tractor-trailer assembly

  crashing into the side of the tender at 40 mph (the grade crossing accident)

The Specifications are extensive and would take a half a day or more to present on.

The NGFT TAG also added sections to the standard to provide for Compressed Natural Gas (CNG) tenders. There are no CNG tenders in service that I am aware of.

A future revision to the NGFT TAG specifications will include criteria for the ISO container style tender.

"Neither snow nor rain nor heat nor gloom of night stays these couriers from the swift completion of their appointed rounds" (adopted from the unofficial US Postal creed….)

We are delighted to share this short video from MotorWeek's Clean Cities series: https://www.youtube.com/watch?v=nYh98pIAPlI

It demonstrates the environmental and financial benefit of LNG. According to the MotorWeek video, Florida East Coast Railway (FEC) is the first North American railway to operate its entire fleet of locomotives on LNG and in doing so has reduced carbon and sulphur emissions by > 25% and 40% respectively on the Jacksonville to Miami route. Furthermore, FEC are expecting to eventually reduce operating costs by $2 million per annum as a result of switching from diesel.

The economics of converting locomotives from diesel only to diesel / NG dual fuel; acquiring tenders and the associated fuelling facilities are currently not favourable in the US – certainly as measured by the response of the Class I RRs.

But where diesel fuel costs are higher or where environmental regulation is tighter – Chart's LNG fuel Tender technology offers a now proven solution for railroads. This could be a tank car style fuel tender or the ISO container style fuel tender.

The technology is readily available today for both the locomotives and the tenders.

Thank you.

AUTHOR

Nason, Scott |Chart Industries | Application Development Manager, Rail & ISO Markets

D&S West Group | scott.nason@chartindustries.com | +001.603.793.1595

Scott Nason is the Application Development Manager for Chart's Rail Car and ISO Container products. He is concentrating on rail tank cars and LNG fuel tender opportunities as well as opportunities for the use of ISO containers to transport and store LNG and other cryogenic liquids. Prior to this position, Mr. Nason spent several years as a product manager of mobile equipment for Chart, focusing on rail cars, highway trailers, ISO containers, and a variety of cryogenic liquid transportation equipment. He also worked as an engineering manager for Chart's Process Engineering (acquisition), working on bulk tanks and systems for all cryogenic liquids. Mr. Nason has 35 years of experience in design engineering, product management, and business development of cryogenic liquid systems and transportation equipment.