LNG use as a locomotive fuel and associated safety issues

Presented at the

TRB Workshop on Natural Gas as a Fuel for Freight Transport

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by

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DISCLAIMER

- **The information and conclusions presented in this talk are that of the author only and do not represent FRA policy or endorsement.**

Presentation Sequence

1) What is FRA? What is its role in natural gas(NG) use as a locomotive fuel?
2) Why is CNG/LNG attractive as locomotive fuel?
3) How is CNG/LNG proposed to be used by Rail Roads (RRs)?
4) What are the potential safety issues?
5) What are FRA's current actions relative to NG use in locomotives?

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RAIL– *Moving America Forward*

Who We Are

The Federal Railroad Administration (FRA) enables the safe, reliable, and efficient movement of people and goods for a strong America, now and in the future.

- Safety is our number one priority
- We are laying a foundation for higher performing rail
- Promulgating and enforcing rail safety regulations
- Investing in America's rail corridors
- Research and development to advance rail safety

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RAIL
Moving America Forward

Federal Railroad Administration (FRA)

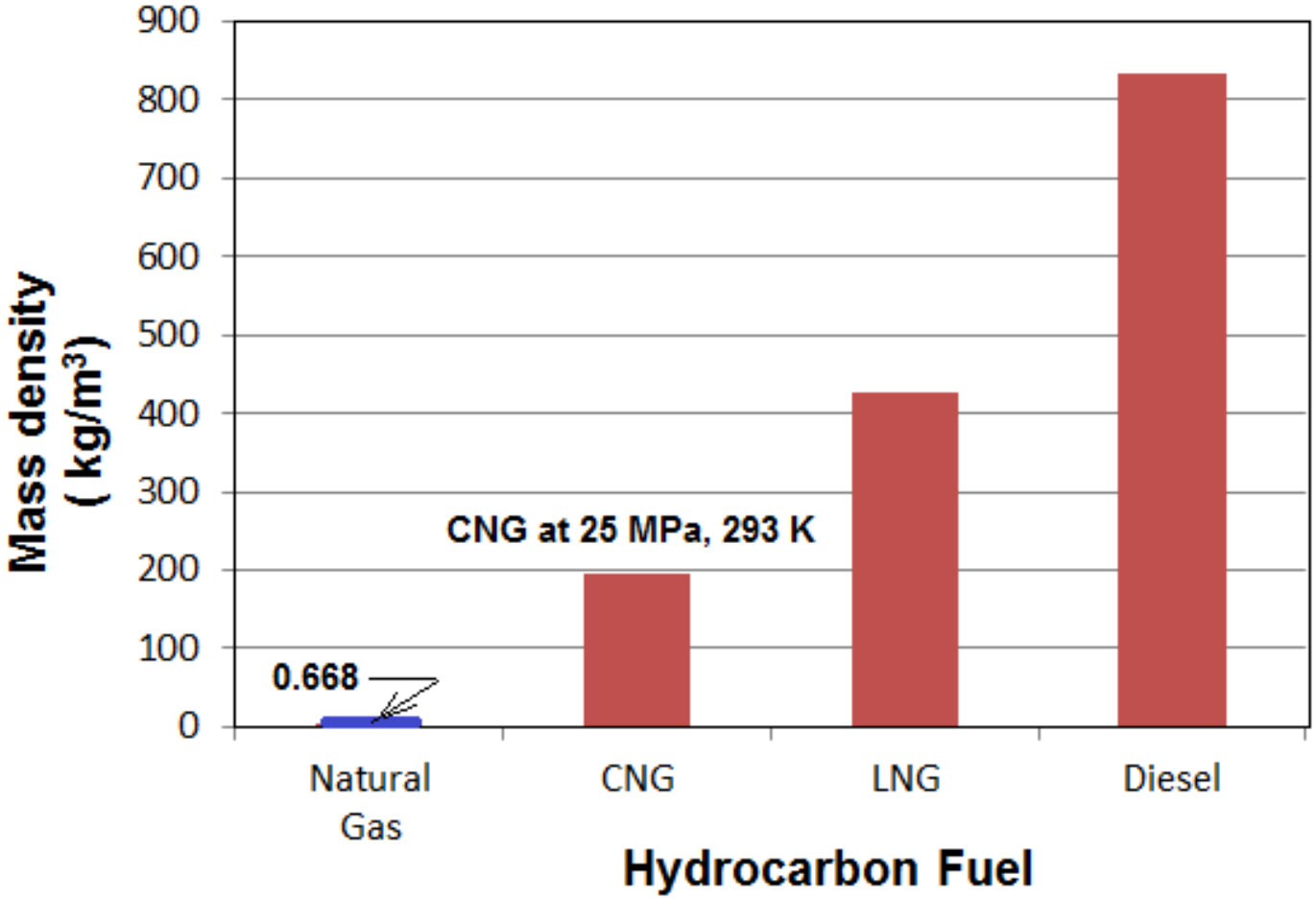
- **FRA accomplishes the mission *"through promulgation and enforcement of Regulations, and conducting research to support regulations."***

- **FRA's Office of Safety provides support to the Department in achieving this mission in regard to transportation of hazardous materials on rail.**

FRA Office of Safety

- **Develops, with PHMSA, rail hazmat (HM) transportation regulations and their promulgation.**
- **Enforces HM transportation on rail regulations (49CFR §100-180) and rail operations, including locomotive & equipment performance (§200-299).**
- **Develops tank car design and specification standards in cooperation with the AAR.**
- **Inspects manufacturing/repair facilities related to tank cars and locomotives, and conducts train inspections on hazmat cargoes.**
- **Supports full scale testing of railroad equipment and tank cars to understand safety issues.**

Hydrocarbon fuel property
Mass density



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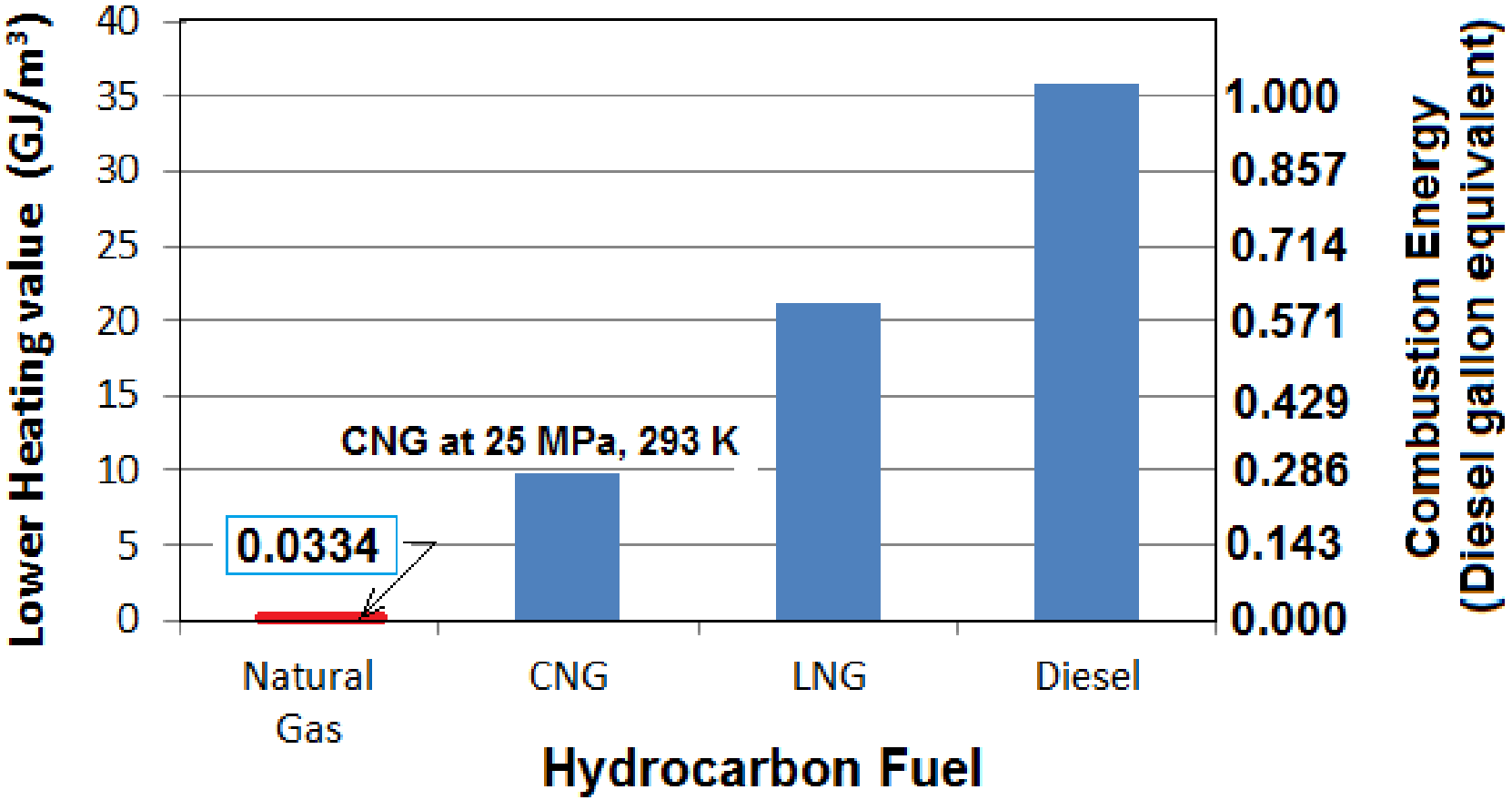
Hydrocarbon fuel property
Energy in a unit volume



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Natural Gas as Locomotive Fuel

PROS

- NG is available in plenty in the US.
- NG is a cleaner burning fuel contributing less CO_2 and other pollutants per unit energy use.
- The current price difference between diesel and LNG is about $ 1.50 /diesel gallon equivalent [EIA, 2014].
- Annual diesel fuel consumption at a typical large class-1 railroad is about a billion gallons. Switching totally to NG can save about $1.5 billion/year, in fuel costs.

Advantages of LNG as locomotive fuel source

RANGE

- The range of a freight haul diesel locomotive is about 1600 miles (on 5000 gallons of diesel).
- The same locomotive would travel about 3800 miles with 20,000 gallon of LNG in a tender attached to a locomotive.

COST SAVING

- Annual diesel use in all class 1 RRs ≈ 3.5 billion gal
- With a current price differential of $ 1.5/dge, and 25% of diesel replacement by LNG, annual saving to the Class1 RRs ≈ $ 1.3 billion

Natural Gas as Locomotive Fuel

CONS

- The technology for long term NG use, in heavy freight locomotives, is still in its infancy.
- Infrastructure for NG/LNG storing, fueling and carrying in long haul (freight) rail service does not exist.
- Liquefaction of NG to LNG is an expensive and scale sensitive enterprise.
- Safety issues of LNG as locomotive fuel, potential releases in accidents, response actions and effectiveness, and public perception concerns are just beginning to be addressed.

Example of LNG tender (tank car type) hitched to locomotives

Tender car design with LNG bottom fill & bottom extraction

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Portable (ISO) tank LNG tender & locomotive

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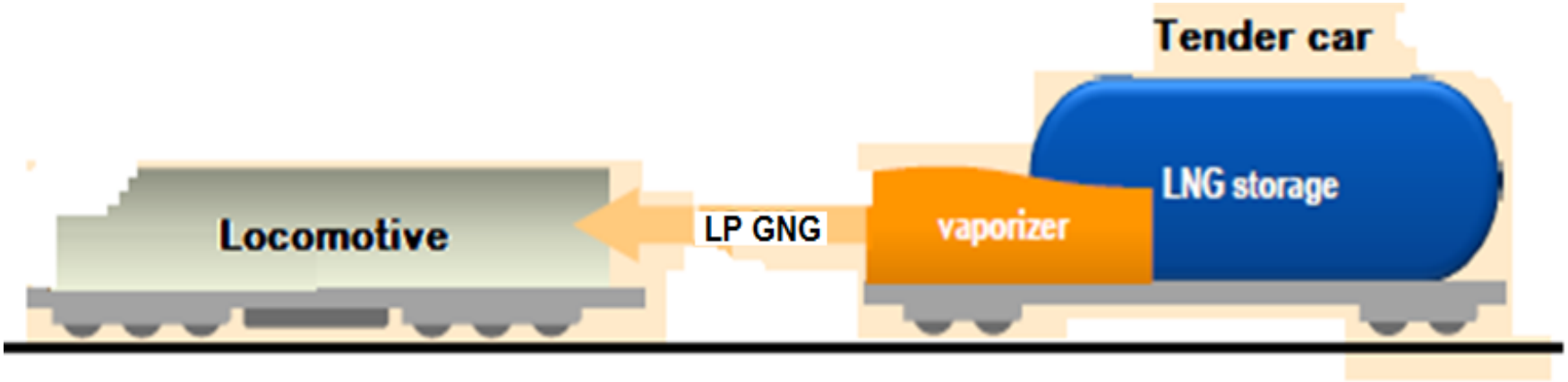
One type of NG fuel supply design
From tender to locomotive



LP GNG = Low Pressure Gaseous Natural Gas

Source: Presentation by Westport (Oct 2012)

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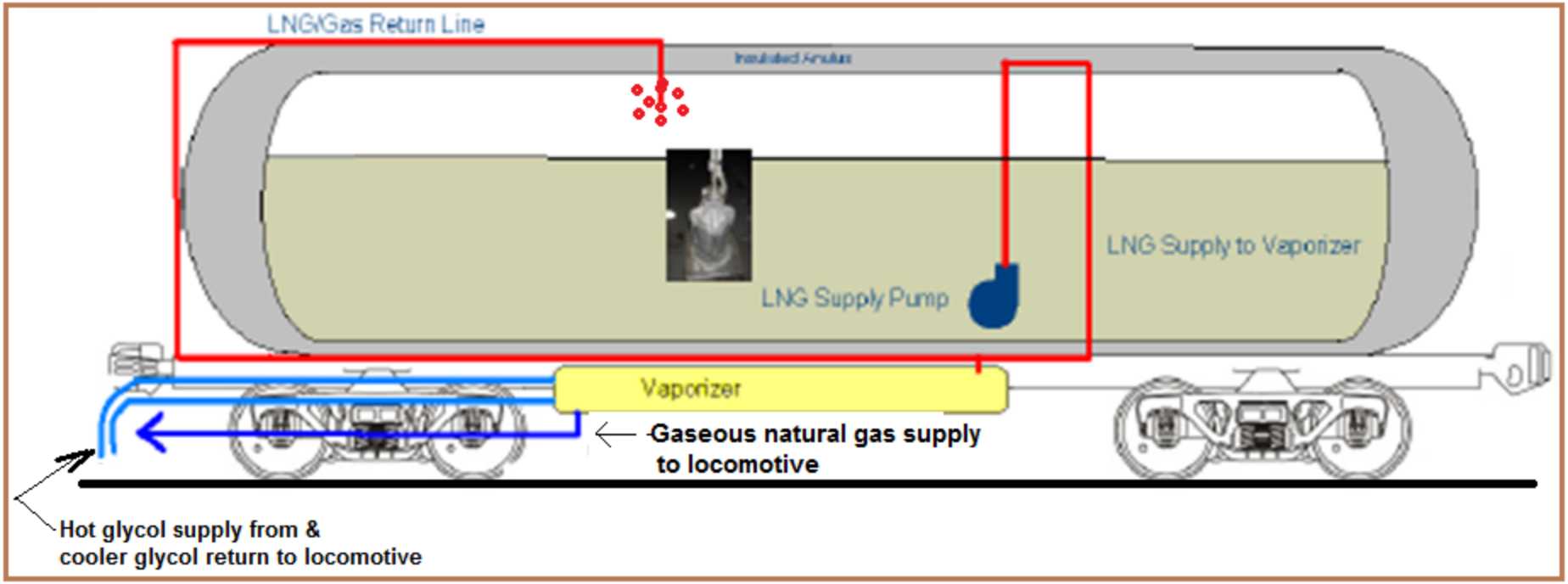
An example of LNG top fill & top extraction design tender



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Typical evaporator on a tender car

Heat Exchanger/Evaporator
LNG to Gas

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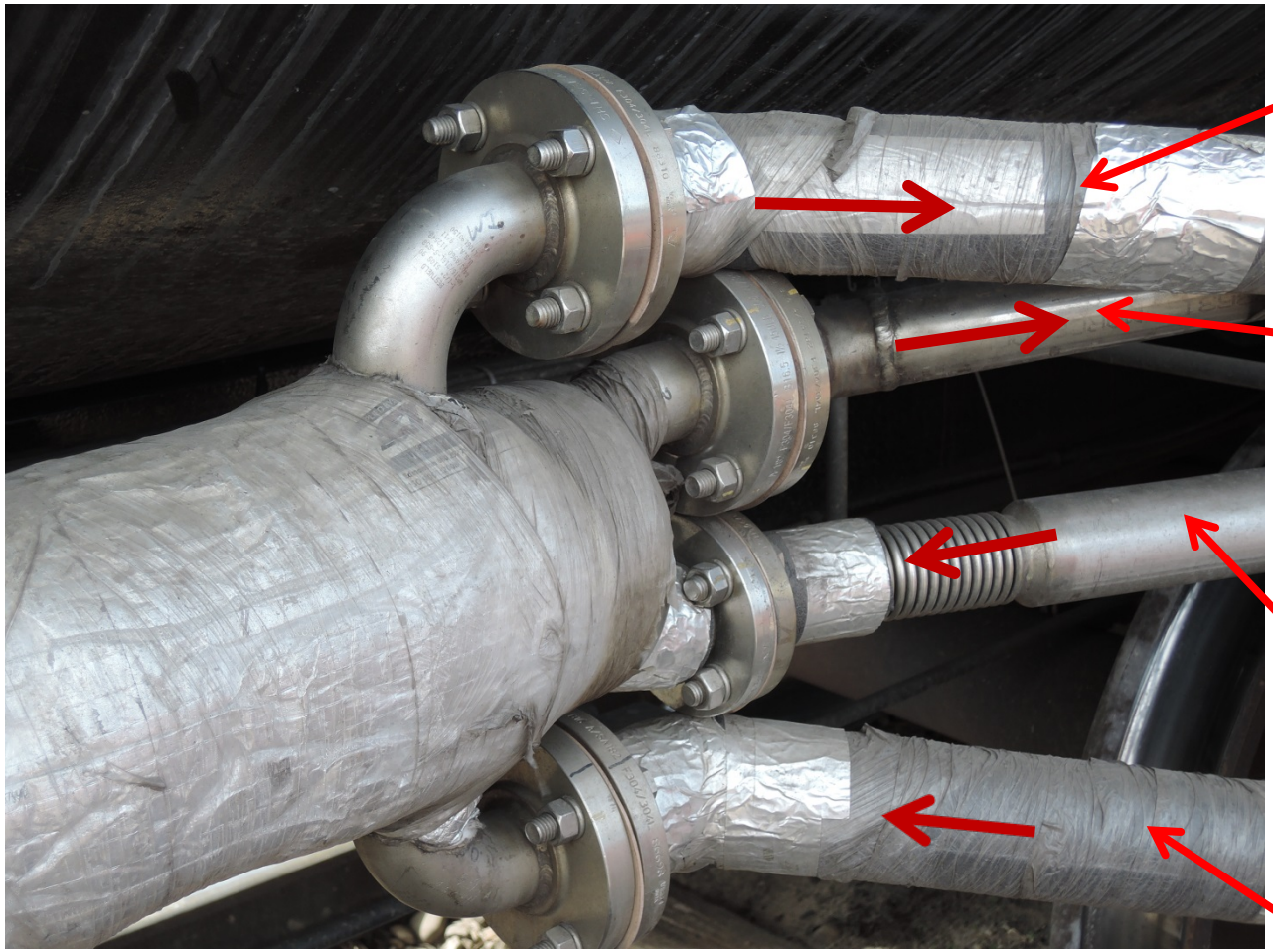
Typical evaporator on a tender car



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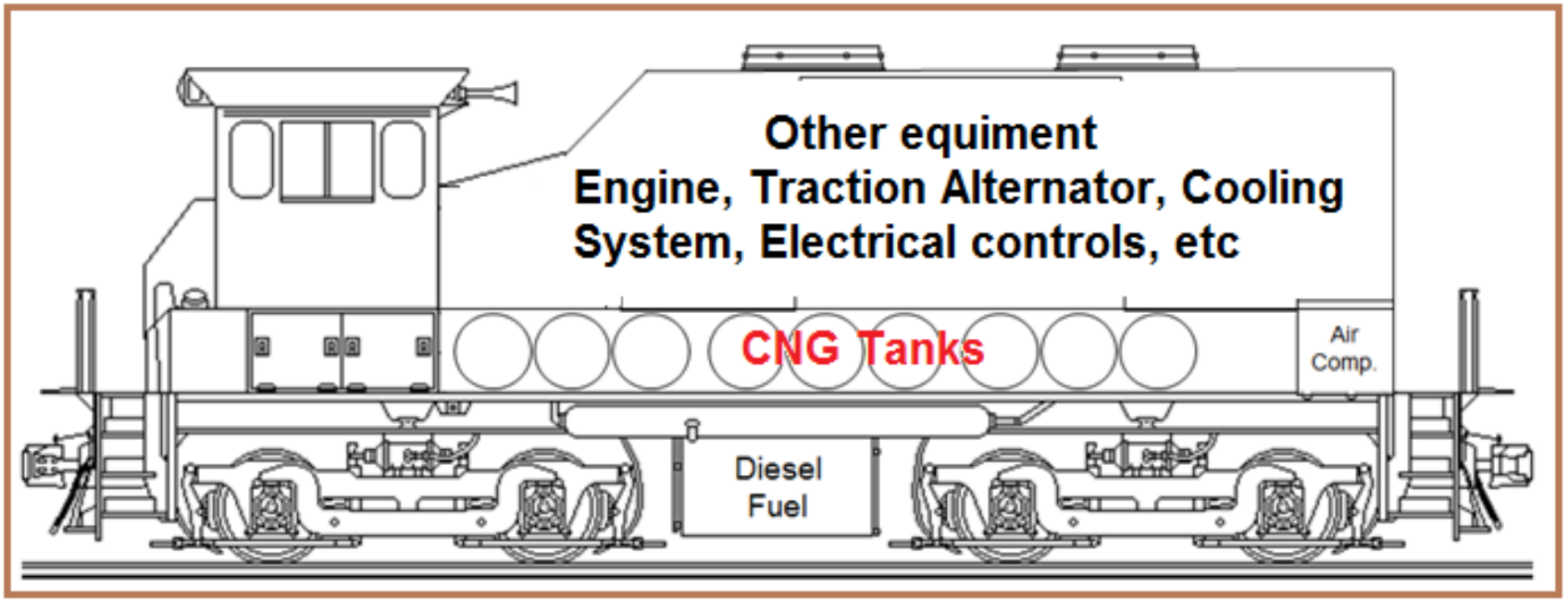
Glycol & GNG hoses across the coupler

CNG tanks (typical design) on a short haul locomotive



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Principal safety issues with LNG/CNG use as locomotive fuel

1) Crash-worthiness of the tender/tanks in several impact scenarios [Train-to-train head-on collision, side swipe collision, side impact vehicle crash, derailment, broken rail penetration, etc.]
2) Vacuum loss due to external tank puncture, pressure rise due to heat leak and vapor release through the PRVs.
3) PRD releases from CNG tanks on the locomotive and potential for fire.

LNG status in rail transportation

- **Currently LNG is prohibited from rail transport as a cargo in tank cars.**
- **LNG tenders are not subject to HM regulations; However, the safety rationale in the design and operation of hazmat carrying tank cars apply to LNG tenders.**
- **Tenders are subject to FRA Regulations in §200-299.**
- **40 U.S.C. §§ 20701-3 (*formerly the Locomotive inspection Act*) requires railroads to demonstrate equipment is in proper condition & safe to operate without unnecessary damage or personal injury.**
- **Use of LNG in a tender on US rail system requires FRA concurrence.**

Partial list of regulations applicable to rail transportation of LNG

The letters or the safety rationale in the following (49CFR) regulations are applicable to CNG/LNG use as locomotive fuel.

- **§ 174.85 Position in train of placarded cars, et al.**
- **§ 179.102 (3) Top fitting protection**
- **§ 179.400 Cryogenic liquid tank car tanks (general specifications)**
- **§ 179.401 Cryogenic tank inner tank specifications**
- **Part 229 Locomotive Safety Standards**
- **§229–Subpart C: Safety requirements**
- **§229–Subpart D: Crash worthiness design**
- **§229–Subpart E: Locomotive electronics**

FRA's Current Actions on CNG/LNG use as locomotive fuel

FRA

- **is supportive of the use of CNG/LNG as locomotive fuel.**
- **requires the conduct of a comprehensive safety analysis & its submission for approval before initiating (even pilot) projects on CNG/LNG use as fuel for locomotives.**
- **has been meeting with interested parties to discuss their implementation plans and to explain FRA's requirements for safe operation.**
- **Is conducting research on a number of related safety issues.**
- **Is participating in industry's efforts to develop LNG tender standards.**

Conclusions

- **FRA encourages the use of CNG/LNG in the rail industry.**
- **There are no current standards or specific regulations for use of CNG/LNG as locomotive fuel.**
- **FRA, requires that safety consideration be paramount in carrying CNG/LNG fuel in tenders and their use in rail operations.**
- **FRA is encouraging further research on (i) structural designs of tenders, (ii) dual use locomotives, (iii) operational issues, and (iv) standards development.**