Investigation into the risk and impact associated with non-diesel fuel engine vehicles, by type, whilst entering or working within hazardous storage locations

Presenter

EI / JSHP Consulting Ltd

Background

- The oil and gas sector is committed to supporting the DEFRA Clean Air strategy and the Department of Transport's Road to Zero policy.
- Currently many oil and gas facilities only allow routine non-permitted access by diesel fuelled vehicles.
- However, transport strategy includes the increased use of ultra-low emission vehicles.
- These vehicles may introduce additional hazards and it is important that designers, vehicle operators and facilities consider whether and how these vehicles can safely access site.

Process

- Energy Institute identified the need to develop new industry guidance regarding these hazards.

- Working group set up including:
  - Oil and gas companies.
  - Industry bodies.
  - Vehicle manufacturers.

- Pull together existing knowledge, rather than carrying out new modelling or research.

Scope

The following alternative powered vehicles were considered:

- LNG
- CNG
- Electric
- Petrol
- Hybrid
- LPG
- Hydrogen combustion
- Hydrogen fuel cells

Only addresses recently manufactured vehicles, not older designs, or after-market conversions.

Application

Within:

- Refineries.
- Terminals.
- Storage sites.
- Other oil and gas facility operations.

Target audience:

- Oil and gas facility personnel (site managers, engineers etc.).
- Haulage companies working within oil and gas facilities.
- Contractors working within oil and gas facilities.
- Vehicle manufacturers and suppliers.

Project Phases

Phase 1 – Review of hazards and risks associated with alternative fuelled vehicles.

Phase 2 – Identification of key risk management measures for LNG, CNG, LPG and Hydrogen Combustion powered vehicles.

Phase 3 – Identification of key risk management measures for Electric, Hybrid, Petrol and Hydrogen Fuel Cell powered vehicles.

Phase 1

- Only considers key hazards associated with the powertrain of the vehicle type including the power source and storage i.e. batteries etc.
- Does not include peripheral equipment such as reversing cameras.
- Does not consider impacts to the environment, neither negative impacts such as a loss of containment of the fuel, nor positive impacts such as reductions in CO_2 emissions.

Approach

- Actual risk levels differ for each site and are impacted by issues such as:
  - Number of vehicles on site.
  - Proximity of personnel.
  - Other products that are present on site.
  - Etc.

- Risks therefore considered in comparison to diesel powered vehicles.

- Assumptions included a temperate climate, and there being no maintenance, refuelling or charging of the vehicles on site.

Hazards Considered

- Powertrain sparks.
- Powertrain high surface temperatures.
- Powertrain fires.
- Ignited releases from the vehicle fuel system.
- Rupture of the fuel storage due to external heat.
- High pressure fuel releases.
- Low temperature fuel releases.
- Rapid expansion of fuel releases.
- Toxicity and asphyxiation.
- Fuel compatibility.
- Electric shocks from the powertrain.
- Quiet vehicle running.
- Powertrain runaway.

Guidance Layout

- Separate sections for each alternative fuelled vehicle type.
- Separate sub-section for each hazard showing:
  - An initiating event.
  - A description of what this event could lead to.
  - The severity of the consequences associated with the event (in comparison to diesel vehicles).
  - How likely the identified consequences will occur (in comparison to diesel vehicles).

Comparative Risk example
Low temperature releases of LNG:

Initiating event – low temperature releases of LNG

There is a low temperature release of LNG from the vehicle's fuel system, which may impact personnel or equipment.

Hazards - low temperature releases of LNG

LNG is stored in the vehicle's fuel tanks at cryogenic temperatures (typically -132^{o}C). If there is an unignited release of LNG from the vehicle (either via the relief valves, or from a damaged fuel system) then this could lead to personnel who come into contact with the release receiving cryogenic burns.

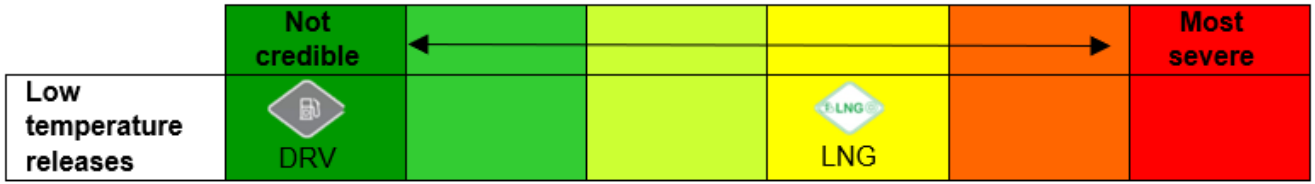
In addition, if cryogenic LNG releases were to impinge on equipment then this could result in brittle fractures occurring.

Consequences

In the event of extended exposure, personnel could receive cryogenic burns requiring hospital treatment, lost time injuries or even permanent disabilities, while equipment could suffer from brittle fractures.

Releases of diesel from diesel powered vehicles would be at ambient temperature, and as such would not result in any cryogenic impacts.

Therefore, it is considered that the comparative severity of a low temperature release of LNG would be much more severe than for diesel-powered vehicles".



Comparative severity – low temperature releases of LNG

Likelihood

As it is assumed that there will not be LNG refuelling on site, LNG will therefore remain contained within the vehicle unless there is a release from a relief valve or damage/failure of the LNG tank or associated equipment. The likelihood of a release of natural gas from an LNG powered vehicle's relief valve depends on how likely the pressure within the system exceeds the set point. This is impacted by a number of factors, such as the engine design, how recently the vehicle has been used, how full the fuel tank is, and the ambient temperatures. As such it is credible that the relief valve can be activated within the terminal area resulting in a release of natural gas. However, it is likely that the valve will be only activated for a short duration until the pressure has been relieved which reduces the likelihood of personnel being impacted by a release.

The LNG tank or associated equipment could also be damaged/fail causing a release. However, the more likely time for this to occur is while the vehicle is off-site, partly due to the proportion of time spent off-site, but also because it is more likely to be subject to a road traffic collision and harsher driving conditions. This could result in a longer duration release, although the likelihood of a release from a damaged/failed fuel system occurring while the vehicle is on site is very low.

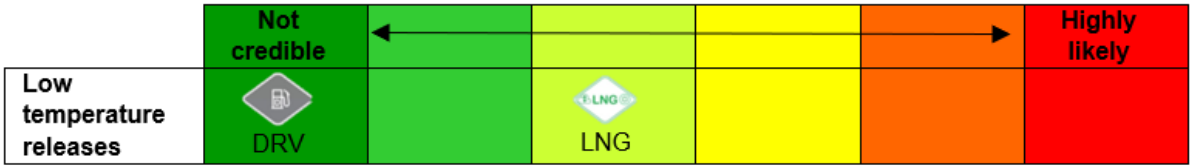
The overall likelihood of a release of fuel from an LNG powered vehicle is therefore made up of a combination of the likelihood of a release from a relief valve and the likelihood of a release from damage/failure of the fuel system.

Releases would initially be very cold (typically -132^{o}C), however small volumes would rapidly warm up. Cryogenic burns or embrittlement would only occur if personnel or equipment were in close proximity to the LNG release. The design of LNG vehicles is such that the most likely location of a release is from the primary relief valve which is typically located at roof level at the rear of the cab. As such personnel and equipment are unlikely to be impacted by a release, and if exposed are likely to only be exposed for a relatively short duration.

The actual likelihood of there being cryogenic injuries or damage from the LNG fuel systems at a particular site will depend on a number of factors, such as the number of LNG vehicles that enter the site, the amount of time they spend on the site and the amount of time personnel spend in close proximity to the fuel system.

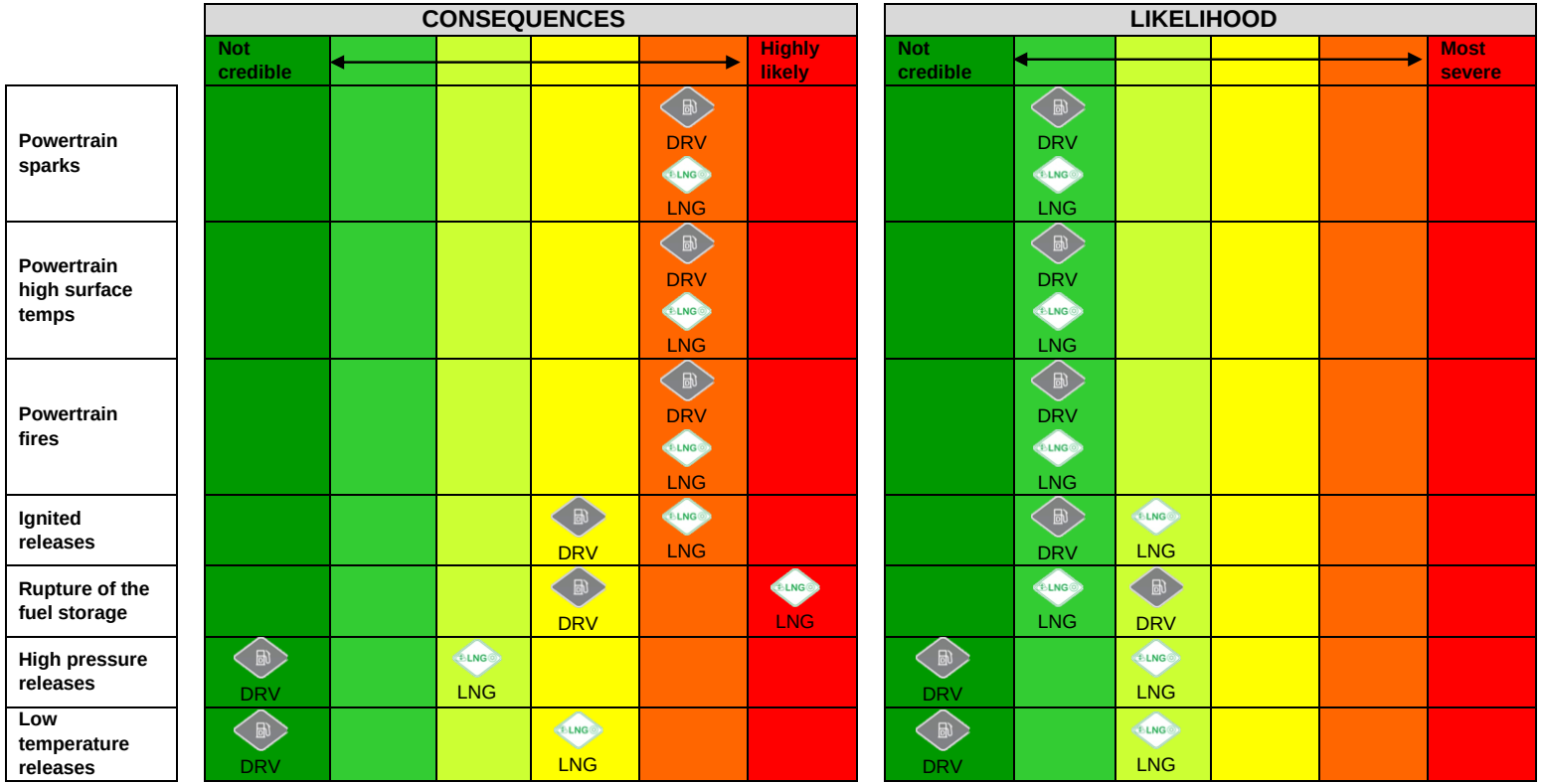
However, diesel powered vehicles do not present a risk of cryogenic injuries or damage.

Therefore, the comparative likelihood of cryogenic injuries or damage from low temperature releases of LNG is considered to be much more likely to occur than for diesel-powered vehicles.

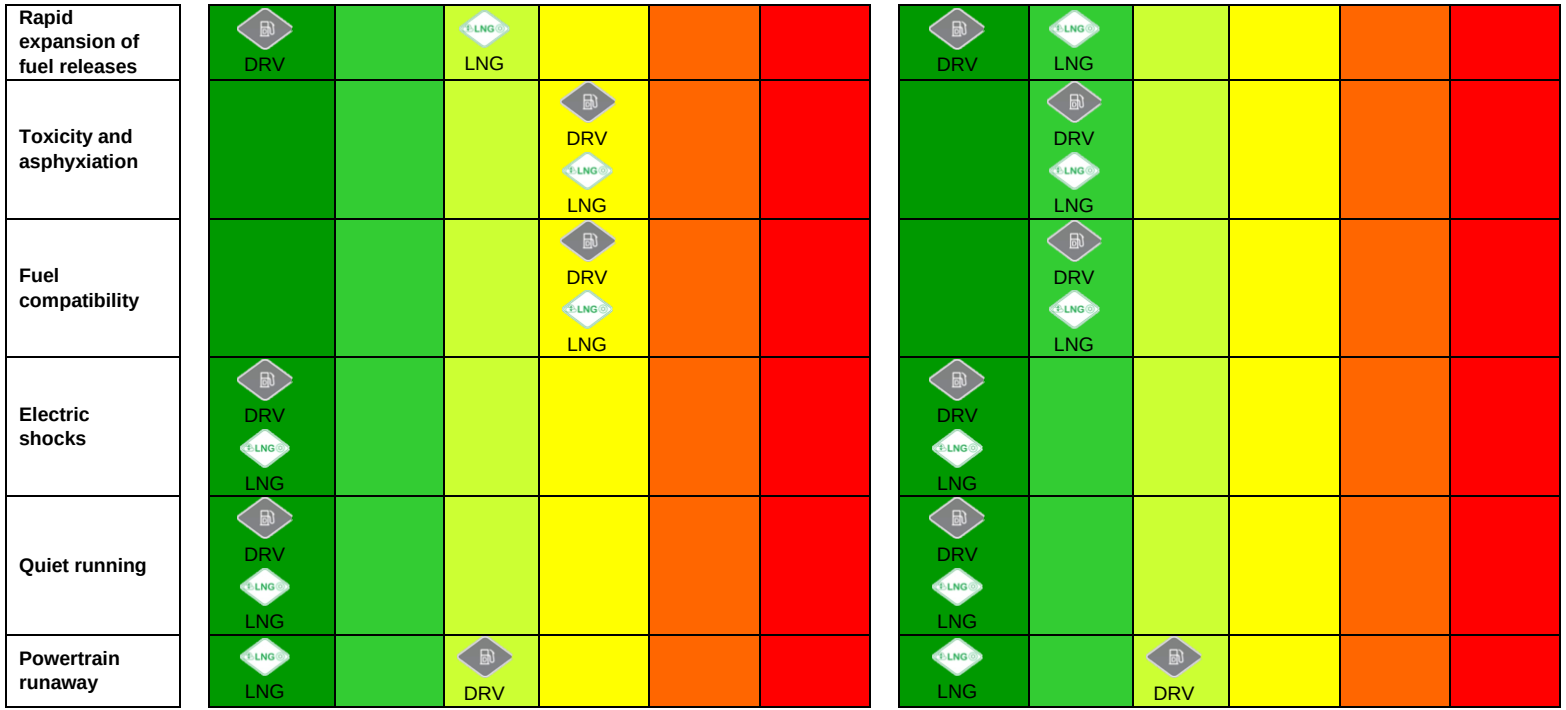


Comparative likelihood – low temperature releases of LNG

LNG Risk Summary



LNG Risk Summary



Site Risk

- Some comparative risks have been identified as being higher for alternative fuelled vehicles than diesel, and some lower.
- The actual impact between sites will differ. For example, depending on what other products are stored on site.
- Key is to use the risk information provided in the guidance to support a site specific risk assessment that considers the specific circumstances on site.
- This assessment should identify effective risk reduction measures to ensure that the risks associated with the use of alternative fuelled vehicles are ALARP.

Status of Phase 1

- Guidance has been written and reviewed by the Working Group.
- Publication is expected 2021.

Phase 2

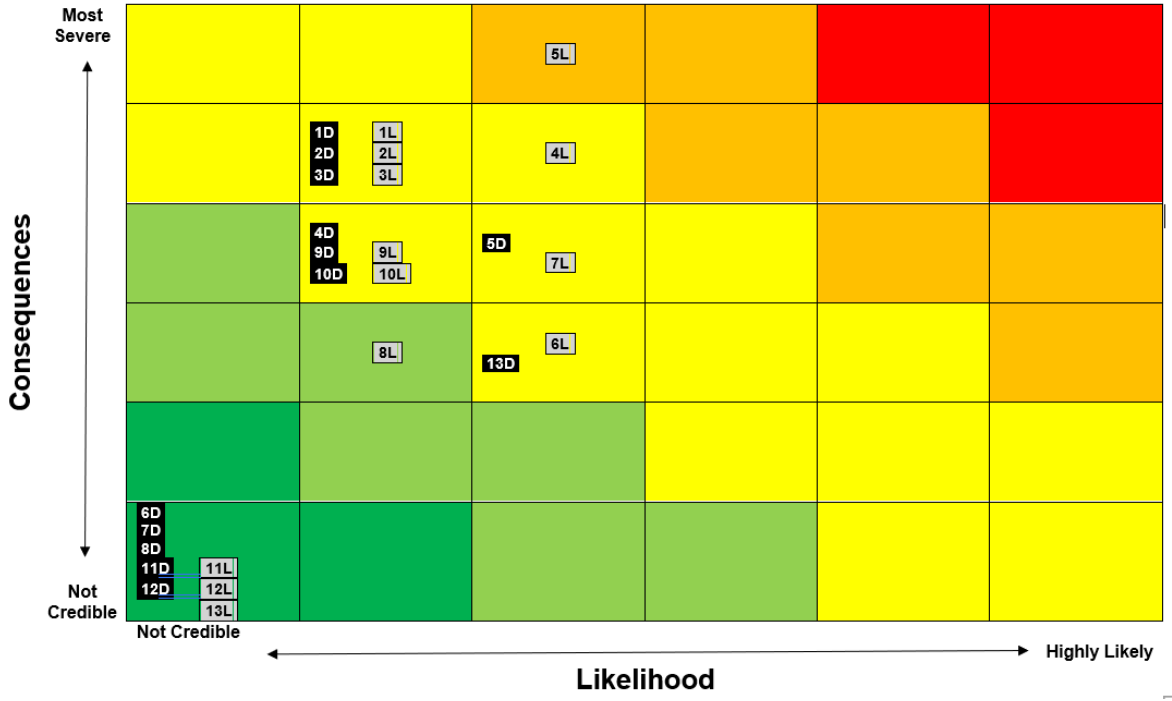
- Currently under development with a goal of publishing 2022.

- Scope - gases:
  - LNG
  - CNG
  - LPG
  - Hydrogen Combustion

- Risk matrix for each fuel type.

- Key Risk Reduction Measures.

Example Risk Matrix for LNG



Hazard	LNG	Diesel
Powertrain sparks	1L	1D
Powertrain high surface temps	2L	2D
Powertrain fires	3L	3D
Ignited releases	4L	4D
Rupture of the fuel storage	5L	5D
High pressure releases	6L	6D
Low temperature releases	7L	7D
Rapid expansion of fuel releases	8L	8D
Toxicity and asphyxiation	9L	9D
Fuel compatibility	10L	10D
Electric shocks	11L	11D
Quiet running	12L	12D
Powertrain runaway	13L	13D

Matrix showing comparable risk levels for LNG versus Diesel hazards

Risk Reduction Measures

- Key risk reduction measures will be identified to support sites in reducing their risk.

- These will be hierarchical:
  - Elimination
  - Prevention
  - Control
  - Mitigation

Eliminate

- Technical measures that eliminate a hazardous stage in the process or substitute it with a less hazardous alternative.

- For example:
  - Preventing delivery vehicles from entering hazardous areas.
  - Restricting hazardous activities on site such as refuelling, or vehicle maintenance and repairs.
  - Using vehicle types which are less risky for the specific site.
  - Etc.

Prevent

- Technical measures that prevent a hazard from occurring.

- For example:
  - Reviewing and updating hazardous areas and associated ATEX requirements.
  - Identifying and managing potential above and below ground enclosed spaces that could be impacted by fuel releases, such as canopies and drains.
  - Identifying and managing potential water filled areas that could be impacted by fuel releases e.g. lagoons.
  - Etc.

Control

- Measures to ensure that the facility and vehicles using the facility operate within the design envelope.

- For example:
  - Identifying and understanding the specific vehicle design entering site. Including key control measures such as relief valves.
  - Ensuring vehicles and their control measures are being maintained in line with manufacturer requirements.
  - Managing vehicle access such as via the safe loading pass scheme.

Cont …

Control

- Carrying out vehicle spot checks, such as checking the “red seal” on LNG vehicles.
- Managing the location and layout of parked vehicles, such as away from drains and canopies.
- Ensuring the use of suitable PPE.
- Ensuring the competence of personnel.
- Etc.

Mitigation

- Measures which reduce the consequences of the hazard.

- For example:
  - Gas and fire detection.
  - Evacuation arrangements.
  - Fire fighting plans which addressing issues such as frozen vents, and the application of water onto cryogenic liquids.
  - First aid provisions.
  - Etc.

Phase 3

- To be developed with a goal of publishing in 2023.

- Scope - Other:
  - Electric
  - Hybrid
  - Petrol
  - Hydrogen Fuel Cells

- Same approach as for Phase 2.

Thank you.

Questions?

www.energyinst.org

Follow us: @EnergyInstitute

Join us: Energy Institute