LPG as a motive fuel for vehicles in the transport of Dangerous Goods

97th Meeting of the WP.15
Transport of Dangerous Goods
Alexander Stöhr
## Contents

- Introduction
- General Information
  - Properties of LPG
  - Description of Systems
- Risk Assessment
  - Interaction between cargo and fuel
  - Effect of fuel spillage on the construction
  - Effect of cargo fire on fuel system installation
  - Different types of hazard posed by using LPG instead of diesel as fuel
  - Adequate safety distance during refuelling operation
Introduction

• Diesel Dual Fuel Technology
  – Part of diesel fuel is supplanted by gaseous fuel (LPG or others)
  – LPG industry would like to use their own fuel (at least in part)
• feasible for heavy duty vehicles
• Support from European Commission
• Heavy Duty Dual Fuel Task Force (subgroup of informal Gaseous Fuel Vehicle Group – GFV in WP.29)
## Properties of LPG

<table>
<thead>
<tr>
<th>Properties</th>
<th>Petrol</th>
<th>Diesel</th>
<th>LPG</th>
<th>CNG</th>
<th>LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower Explosive Limit (LEL)</strong></td>
<td>1.2%</td>
<td>0.6%</td>
<td>1.8%</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td><strong>Upper Explosive Limit (UEL)</strong></td>
<td>7.1%</td>
<td>7.5%</td>
<td>8.5%</td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td><strong>Auto ignition Temperature</strong></td>
<td>246 °C</td>
<td>210 °C</td>
<td>450 °C</td>
<td>540 °C</td>
<td></td>
</tr>
<tr>
<td><strong>Boiling temperature</strong></td>
<td>40°-200°C</td>
<td>180°-360°C</td>
<td>-42.6°C</td>
<td>-161°C</td>
<td></td>
</tr>
<tr>
<td><strong>Flash point</strong></td>
<td>-43 °C</td>
<td>55 °C</td>
<td>-104 °C</td>
<td>-188 °C</td>
<td></td>
</tr>
<tr>
<td><strong>Dispersion quality</strong></td>
<td>none</td>
<td>none</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
</tr>
</tbody>
</table>
Properties of LPG

- Flash vaporisation under normal atmospheric conditions
- Flows to the ground due to higher density than air
- Disperses under even moderate wind conditions
- Difficult to ignite in windy weather
- Fire brigades (HAZMAT crew) have established validated procedures for LPG leaks
- Has cryogenic mild effect, relatively simple protective gear sufficient
LPG Systems

Components type approved according to Regulation R.67-01

Installation according to rules and guidance in R.67-01 (Part II)

Safety

Certified installer workshops with trained qualified personnel

Operators with practice in handling dangerous goods
LPG System Components

- Tank (one or more tanks or tank bundles)
- Single fuel line (some cases return line)
- Vaporiser / regulator with shutoff solenoids (in some cases separate shutoff solenoids are used)
- Injectors (or other methods of metering / needlevalve)
- Electronic controls (ECU, sensors etc.)
Exemplary Schematic of one Manufacturer

GASotronic
ECOTRONIC
DIS III

CAN SAE J1939
Read/Write

TRUCK ECU
With CAN Bus
J1939 Protocol

Turbo
Charger

LPG Fuel Tank 1 - 4

Fuel Level

Safety Valve

Reducer Vaporizer

GAS Filter

Safety Valve

Temperature Pressure Sensor LPG

Stepper Motor Regulator Valve

Inlet Manifold

Inter Cooler
LPG Tank safety

- Fuel tank designs shall be:
  - compliant with the requirements of R67-01 Annex 10,
  - impact and drop tested (besides passing pressure tests),
  - tested under fire conditions with the fire temperature exceeding at least 590° C
- The tank shall not burst but safely relieve internal pressure by discharging in a controlled manner as described by the manufacturer.
- high resistance to engulfing fire conditions is thus proven
- Composite fuel tanks specimens are pressure cycled 20,000 times
Additional Safety Elements

• Orientation of PRV needs to be taken into account
  – high pressure discharge from the (emergency) PRV
  – discharged gas needs to be directed away from the load
    (as already prescribed for LNG in the ADR regulation)

• Fuel systems and engine injection system have safety barriers
  – shut off valve
  – excess flow valve

to prevent outflow of gas when system integrity is compromised

• Engine stoppage (deliberate or accidental) leads to automatic shutting off of the tank preventing the outflow of gas.
Example Tank Installations
Risks to be addressed

• Interaction between cargo and fuel
  – LPG noncorrosive and chemically stable
• Effect of fuel spillage on the construction
  – only moderate chill effect (evap temp ~-40°C)
• Effect of cargo fire on fuel system installation
  – bonfire test ensures safe behaviour under fire conditions
• Different types of hazard posed by using LPG instead of diesel
  – LPG tanks by far more resistant to damage
  – leakage from piping system prevented by shut-off valves
• Adequate safety distance during refuelling operation
  – refuelling infrastructure designed to fulfil general requirements for third party refuelling
  – CEN Standards EN14678-1 and EN 14678-3 written for dispenser respectively forecourt installation
• Measures to be taken in case of an engine fire
  – no difference in behaviour known in comparison to other fuel
  – no special methods or procedures prescribed
  – automatic fuel shut-off minimises fuel leakage