

Technology Pitch: Subcooled Liquid Hydrogen (sLH2)

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- 1) Advantages of the sLH2 Fueling Station
- 2) Advantages of the sLH2 Vehicle Tank System
- 3) Detailed Fueling Process Description
- 4) Summary



### sLH2 Fueling Stations for heavy duty land vehicles

#### Main characteristics of sLH2 Fueling Stations:

- Filling of subcooled LH2 at approx. 26 K into a vehicle tank to pressures up to 1.6 MPa
- Advancement of known technology LH2 filling (at pressures up to 0.6 MPa)
- sLH2 Filling offers many advantages over LH2 filling
- Allows high flow fueling (> 400 kg H2/h) with very low TCO
- Linde and Daimler collaborate on making sLH2 the leading heavy duty H2 technology
- sLH2 Fueling Process and Interface shall be standardized in open CEP working groups



Press Releases in December 2020



## sLH2 Fueling Stations offer key advantages



Layout of sLH2 Fueling Station

- 400-500 kg/h flow rate per sLH2 pump
- 4.000 kg LH2-storage Tank
- Total energy demand 0.05 kWh/kg dispensed (compared to 1.5 kWh/kg for 70 MPa GH2 fueling with Linde Cryopump CP90/100)
- Back-gas free single flow fueling
- No data transmission necessary
- Stop of fueling at target pressure of 1.6 MPa
- Fueling of multiple vehicle tank in parallel
- Fueling capability 4.000 kg / 10 h
  (continuous, back to back, upgradable)
- Low station footprint (50 m<sup>2</sup> w/o dispenser)
- Low TCO

#### Main Process Parameters of sLH2 Fueling Stations



Flow Diagram of sLH2 Fueling Station

- Average fueling time 10 15 minutes
- Safety valve at sLH2 pump: 1.8 MPa
- Safety valve at hose and nozzle: 2.6 MPa
- Dedicated H2 purging of hose and nozzle
- Backline for cool down of system
- Pressure corridor of sLH2 fueling is typically between 0.4 MPa to 1.6 MPa
- Automatic cool down of warm vehicle tanks
- Low design pressures allow to use standard components with low wall thickness, good insulation and small dimensions



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### sLH2 Tank System is engineered for efficient Usage



#### **Key Specification**

MAWP (Maximum Allowable Working Pressure) between 2.0 MPa(a) to 2.5 MPa(a)

Vacuum insulated lines between receptacle and tank for simultaneous filling of multiple vehicle tanks

Low design pressures allow the use of stainless steel containers without additional reinforcement

No data communication to fueling station needed for safe fueling process, e. g. stop of filling at 1.6 MPa(a)



#### sLH2 Tanks enable high Driving Range for Long Haul Trucks



		sLH2
Operating Pressure		0.4 0.8 MPa (adjustable via software)
Total Tank Volume (2500 x 710 mm incl. BoP)		ca. 760 l
Max. Filling Level		100%
Net Usable H <sub>2</sub> in 2 Tanks		up to 88 kg
Multiple Tanks		Fueling via one connection
Hold Time <sup>(1)</sup>	@100 %	10 h
	@ 80 %	130 h
	@ 50 %	200 h
	@ 20 %	130 h

<sup>(1)</sup> Assuming 5W heat transfer and depending on operating pressure





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#### sLH2 Operating Conditions - Boundaries





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#### sLH2 Operating Conditions - Fueling





#### sLH2 Operating Conditions - Defueling





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**High Storage Capacity** Up to 88 kg H<sub>2</sub> usable in Tractor

**Cost efficient** 

No Carbon Fiber for Tanks required **Energy efficient** 

Fueling with significantly lower Power than CHG

# Thank you very much for your attention!