Hydrogen and fuel cells: the key to decarbonising the shipping industry

23 June 2021 • 09:00-09:45 BST

Panellist documents

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Page 9: Ivan Østvik, Norled
Page 18: Mads Friis Jensen, Blue World Technologies
Design & safety of hydrogen ships

Equivalence for pressure relief valves on hydrogen storage tanks

M. Godjevac PhD MSc
Why hydrogen powered ships?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>No harmful exhaust emissions</td>
<td>Space requirements</td>
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<tr>
<td>Less vibrations</td>
<td>Low ignition energy</td>
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<tr>
<td>Hydrogen is non-toxic</td>
<td>Low and wide explosion level limits</td>
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<td>Hydrogen is highly buoyant and dissipates quickly</td>
<td>Limited maritime experience and regulations</td>
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Where to begin with design?

How to design and verify an inland vessel on hydrogen when there are no specific rules.

- Risk based design.
- Starting point are rules for LNG vessels (Estrin, Chapter 30 and Annex 8, and many other applicable rules).

Source: LR Risk Based Design
To sail on inland waters.

- Swappable hydrogen container tanks.
- Redundant battery and fuel cell system.
- Hydrogen installation mostly in open air.
- Additional fire fighter monitors on the deck.
- Hydrogen vent line at the aft and Hydrogen containment approach.
Hydrogen containment

- Estrin: Each tank to have two pressure relief valves.
- Highest hazard from fire on the deck.
- How to prevent unwanted release?
- No pressure relief valves and three safety layers:
  - Passive 90 minutes buffer time.
  - Active water spray 12,5 l/min.
  - Ultimate: controlled release through vent line.
Discussion and future work
Is it applicable for others? Other considerations?

Safe and controlled release of hydrogen is ensured.

Our design includes secondary and often tertiary safety barrier:

- additional ventilation for enclosed spaces.
- enhanced firefighting capabilities.
- state of art sensors and leakage detection systems for system monitoring.

Future work

- Other types hydrogen tubes require other approach, but same questions remain.
Let’s define shipping’s new normal together!

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MF Hydra – world’s first LH₂ driven ship and the path towards zero-emission shipping

May 2021
A major transport player in Norway

#2 Ferry company
57 ro-ro ferries
29 routes

#1 Express boat company
28 fast ferries
18 routes
World’s first LH2-driven ship “MF Hydra”

- Length: 82.40 m
- Beam: 16.75 m
- Draught: 2.8 m
- Car capacity: 80
- Truck capacity: 10
- Passenger capacity: 299
The LH₂ arrangement

- Cold vent mast
- LH₂ storage
- Processing area: from liquid to gas
- Fuel cell modules
PEM fuel cells (Ballard)

- 2 pcs. of 200 kW each onboard MF Hydra
- App 2 m high and 1 m² footprint
- No emissions, runs on hydrogen (high purity)
- Last for app. 5 years before major overhaul
- Efficiency 50-60% - depending on load factor

- First maritime application, but will have teething problems (control, alarms, etc.)
- Rules being updated to accommodate technology

- App. 95% of components are recyclable, materials used are not “limited” earth resources

- MW solutions being developed, optimising design and support systems (ventilation, cooling water)
Risk-based design process

- Alternative design IMO MSC1 Circ. 1455
- Explosion analysis, consequence simulations, frequency studies
- Alternative design used for LNG-driven ships
  - IGF code
- Starting point for developing hydrogen-driven ships
- Risk-based design experience
- HAZID/HAZOP, risk analysis process, ALARP, QRA
- IGF Code partly used/challenged, as well as ship rules, standards
- Route study, design concept, technical solutions, equipment
- Risk-based design process

- • Alternative design used for LNG-driven ships
  - IGF code
  - Starting point for developing hydrogen-driven ships
  - Risk-based design experience
Hydrogen-driven ship projects

- Race for Water (2018)
- Elektra (2019)
- Maranda (2019)
- HYSEAS III (2020)
- Susio Frontier (2020)
- Heidelberg/Felleskjoetpet (2022)
- Havila (2023)
- Topeka (2023)
- Hydrogen Viking (2023)
- Water-Go-Round (2023)
- Finnøy (2023)
- Vestfjorden ferry (2023)
- Bill Gates Yacht (2025)
- Ulstein OSV (2025)
- Østensjø OWSP (2026)
- DFDS (2026)
- Viking Cruises (2026)
- Samskip (2026)
- Veidekke (2026)
- Kawasaki LH2 carrier (2026)

[Image of various ships]
Why hydrogen-driven ship projects

Ship technology (storage and fuel cells) will develop, improve and see cost reductions. The new technology will be effectively integrated in new ship designs.

Hydrogen production supply will have a high-rate growth towards 2030 and costs will be greatly reduced.

Hydrogen fuels can be provided as GH\(_2\), LH\(_2\), NH\(_3\) and LOHC.

Target costs quoted from suppliers range 1,5-2,5 Euro for GH2 in 2030. NH3 and LH2 will initially see a cost premium.

CO2 taxation will, in addition, add costs to fossil fuels by 2030.

Hydrogen infrastructure will come in place in ports and supply chains develop.
Methanol Fuel Cell

Hydrogen and fuel cells: the key to decarbonising the shipping industry

Date: Wednesday 23 June - Time: 09:00-09:45 BST

By Mads Friis Jensen, CCO and Co-founder of Blue World Technologies
Methanol fuel cells - a green alternative

Markets
- APU
- Automotive
- Heavy duty

General USPs
- CO₂ reduction
- Cost savings
- Zero harmful emissions
Superior High Temperature PEM technology

- No external heat needed as waste heat drives fuel evaporation process = higher conversion efficiency
- No gas clean-up needed = simple and cost effective system
- Water regeneration = increased energy storage
Marine Methanol fuel cell module

- Integrated HT PEM stack and reformer
- Distributed controls for maximum redundancy and operations flexibility
- Simple fuel cell control and thermal management

200kW modular fuel cell solution

Main engine

Marine battery

Fuel storage + supply
Transforming sea transport

Benefits of HT-PEMFC and methanol for marine applications

- Compact 200kW design
- Modular design for simple scaleup (up to 5MW)
- Simple integration for new- and retrofit of existing vessels
- High electrical efficiency; methanol to power (40-55%)
- Clean solution with zero harmful emissions
- Low maintenance requirements with no moving mechanic parts
- Simple and safe bunkering of fuel with existing infrastructure
- Superior on-board energy density with liquid methanol
- Combustion engine CAPEX parity in the future

200kW modular marine fuel cell solution
For further information please contact

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