Hydrogen as Fuel for Marine Applications – A view from Class

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A glance on marine regulatory framework

**IMO: International Maritime Organization**
- Formed in 1948, part of the United Nation, currently counting 170 member states and three associates;
  - Several technical committees, including CCC – Carriage of Cargoes and Containers
  - Mandatory instruments: Resolution & Conventions (e.g. SOLAS, MARPOL)
  - Non mandatory: Circulars, guidelines

**Class societies**
- Private entities with own rules & standards
- Historically the first to regulate shipbuilding (technically)
- Major ones associated into IACS for minimum technical standards & consistency
- Often acting in support or behalf of Flag Administration

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**Evolution of marine regulations, where are we now with H2?**

<table>
<thead>
<tr>
<th>LNG regulations rough timeline</th>
<th>Hydrogen fuel regulations timeline</th>
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<tbody>
<tr>
<td>2007 LR provisional rules for Methane ships</td>
<td>2016 MSC.420(97) interim guidelines for LH2 carriage</td>
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<tr>
<td>2012 LR GF rules</td>
<td>2019 ? IMO guidelines for H2 fuelled ships</td>
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<tr>
<td>2014 LR Risk-Based-Design procedure</td>
<td></td>
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<tr>
<td>2015 IGF code - MSC.391(95) adopted</td>
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<tr>
<td>2017 IGF code into force</td>
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- For LNG abt. 10+ years from first provisional/interim rules to final codes.
- Rules should be based on experience and knowledge – get it right the first time!
- In the meantime? Risk based design assessment.
A few safety Challenges

<table>
<thead>
<tr>
<th></th>
<th>Natural gas</th>
<th>Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling temperature [°C]</td>
<td>-163</td>
<td>-255</td>
</tr>
<tr>
<td>Ignition energy [mJ]</td>
<td>0.28</td>
<td>0.017</td>
</tr>
<tr>
<td>Flammability range (%vol)</td>
<td>5%– 15%</td>
<td>5%– 75%</td>
</tr>
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</table>

Lower ignition energy -> tighter control on sources of ignition (ATEX)
Higher flammable range -> increased ventilation, gas detection, is it enough?
Lower boiling point -> increased cryogenic risk, double wall containment
Leaks and H2 fires in fuel cells -> what can be tolerated and what not? A different approach might be needed.
Buoyancy & dispersion of gas -> risk of explosive plumes
Hydrogen bunkering -> ESD, SIMOPS, leakages, exclusion zones,..

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From small boats to large ships – Scale factor

Additional challenges for technology and safety

Power & storage scale factor:
\[ \sim \frac{E2}{E3} \]

Hydroville – First LR classed vessel to use H2 as fuel
There already are a few vessels sailing with hydrogen, but scaling the technology up to large ships poses **significant challenges** for hydrogen storage and power technologies:

- CH2 may not be viable for large ships; if chosen existing LH2 technology to be developed & adapted.
- LOHC and Ammonia storage might be a feasible option, would need massive development from research to industrial/commercial stage.
- Fuel cells have been tested on board ships. They may lead to distributed generation vs. centralized generation (typical of diesel) and different PMS strategy. What about SRtP?
- Increase in societal risk would require through understanding and assessment

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Questions?
Thank you for the attention!

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