

# Hydrogen as Fuel for Marine Applications – A view from Class

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for a safer world

# 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

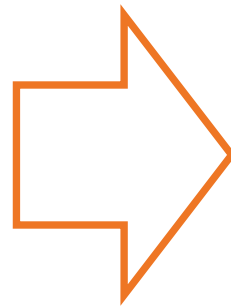


- Private entities with own rules & standards
- Historically the first to regulate shipbuilding (technically)
- Major ones associated into **IACS** for minimum technical standards & consistency
- Often acting in support or behalf of Flag Administration

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

## LNG regulations rough timeline

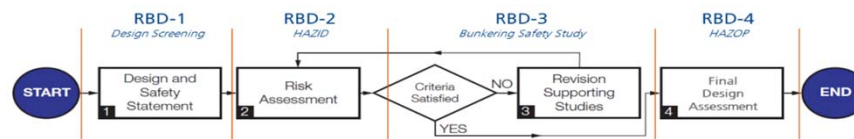
2007	LR provisional rules for Methane ships
2009	MSC.285(86) interim guidelines
2012	LR GF rules
2014	LR Risk-Based-Design procedure
2015	IGF code - MSC.391(95) adopted
2017	IGF code into force



## Hydrogen fuel regulations timeline

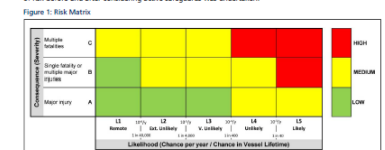
2016	MSC.420(97) interim guidelines for LH2 carriage
2019 ?	LR rules & test spec for fuel cells
2019 ?	IMO guidelines for H2 fuelled ships

- 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.



### 3.4 Risk Rating

Risks identified during the HAZID were rated in accordance with a risk matrix provided by LR Consulting as shown in the figure below. This matrix is based on LR Consulting's experience in using and developing matrices on behalf of operators in the oil and gas industries. An assessment of risk before and after considering active safeguards was undertaken.



It should be noted that the risk ranking is only based on the assessment of risk to personnel and that low severity consequences that could result in minor injury have been excluded from the assessment. This approach helps to ensure that the study team only concentrate on significant risks, which is considered to be an appropriate approach for a HAZID of this type.

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# A few safety Challenges

	Natural gas	Hydrogen
Boiling temperature [C°]	-163	-255
Ignition energy [mJ]	0.28	0.017
Flammability range (%vol)	5%– 15%	5%– 75%



Lower ignition energy -> tighter control on sources of ignition (ATEX)

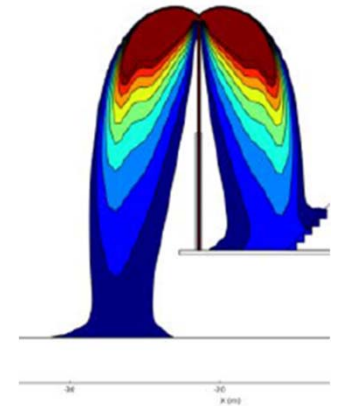
Higher flammable range -> increased ventilation, gas detection, is it enough?

Lower boiling point -> increased cryogenic risk, double wall containment

Leaks and H<sub>2</sub> 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,..



# From small boats to large ships – Scale factor



Additional challenges for technology and safety



Hydroville – First LR classed vessel to use H2 as fuel

Power & storage scale factor:  
~ E2 ÷ E3



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# From small boats to large ships – Storage, power & risk

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:

- **CH<sub>2</sub>** may not be viable for large ships; if chosen existing **LH<sub>2</sub>** 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 thorough understanding and assessment

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Questions?



Questions?

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# Thank you for the attention!

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