MARITIME

IMO / CESNI

International codes and standards for fuel cells in ship application

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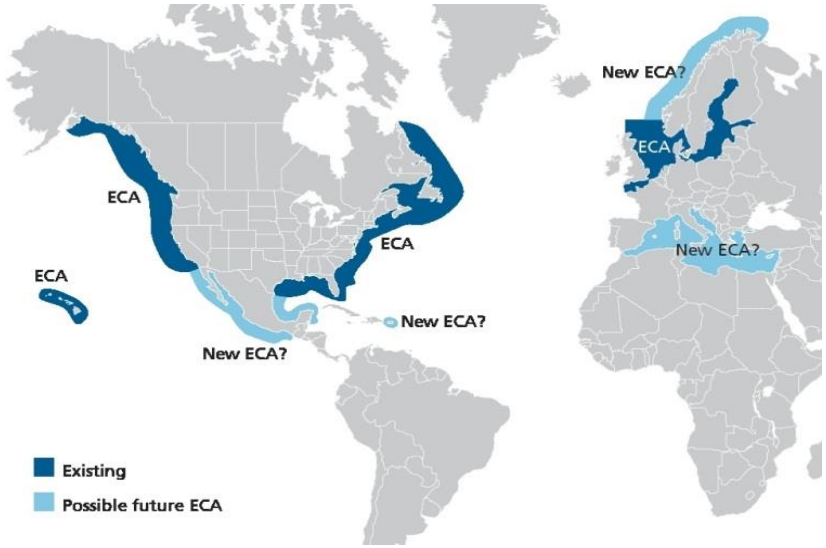
Introduction

Motivation

- Improvement of Ship Energy Efficiency
- Reduction of emissions to air
- Reaching insignificant noise and vibration level

Driver

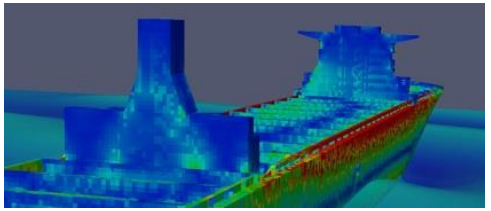
- Environmental regulations and initiatives to
  - Increase efficiency of ship operation
  - Reduce NO_X, SO_X, CO_2 and particle (PM) emissions

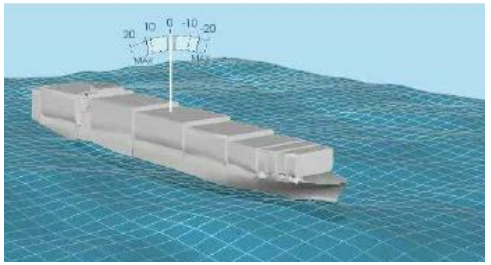


Introduction

Challenges for FC in shipping

- Maritime Environment
  - ship motions
  - vibrations
  - humidity till 60 %
  - salty air
  - temperatures:
    - Full load capacity and efficiency till 45 °C
    - Full response for electrical equipment till 55°C
- Design requirements
  - testing criteria (add-ons to land-based application)
  - reliability and availability
  - fuel storage, transport, processing onboard



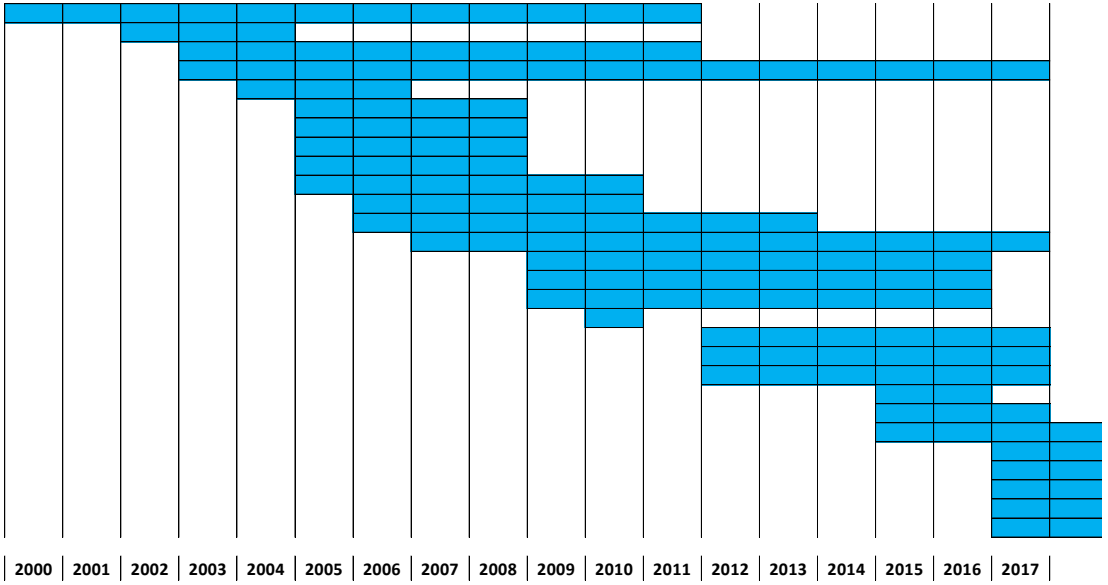


Introduction

Developments

- Start with first maritime FC applications in the early 2000
- Mostly basd on European and US development programmes
- Technology readiness was proven: **SOFC and PEMFC Technology are most promissing for maritime**
- Recent development projects focusing on a **common rule frame work for maritime Fuel Cells**

Maritime Fuel Cell Project Time table



Introduction

Ongoing developments

- **e4Ships** – German funded Lighthouse project for maritime Fuel Cell application
- **Aim** – Development of Fuel Cell auxiliary power generator capable for serial production and capable for type approval. Provide input for Rule development (e.g. IGF Code)
- Developments are in line with the objectives of the German *"mobility and fuel strategy"*:
  - Introduction of *alternative and regenerative fuels*
  - Development of *innovative power technologies*
  - Aiming a big share of Hydrogen and Fuel Cell application for all modes of transport in a long-term view

e4ships
Brennstoffzellen im maritimen Einsatz
nip

A project of

nip
Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Funded by

Bundesministerium für Verkehr und digitale Infrastruktur

Coordinated by

NOW
Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Seagoing vessels

International maritime legislation

- **IMO**: International Maritime Organization
- Established in 1948 as a UN agency
- Main purposes:
  - Prevent pollution from ships
  - Enhance safety of shipping and ships
- Main conventions:
  - **MARPOL** (marine pollution) from 1973 / 1978 → Environmental protection
  - **SOLAS** (Safety of Life at Sea) from 1974 → ships safety

➢ **Classification societies are approving in accordance to own rules and regulations on behalf of the flag state**

Role of classifiaction societies

Survey of ships during the whole lifetime based on own class rules and guidelines

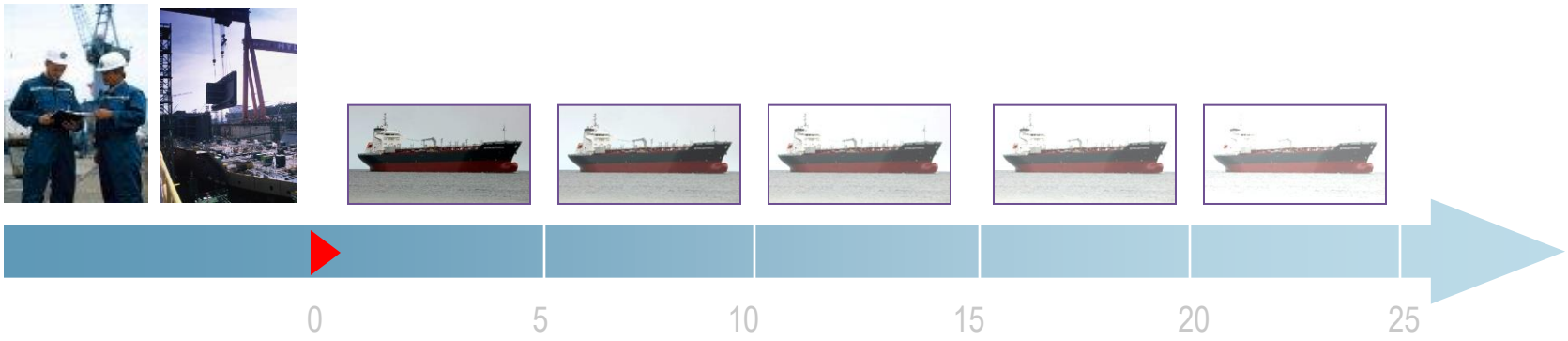
Newbuildings

- Drawing approval
- Construction supervision
- Approval

Fleet in service

- Periodical survey

Class societies does have their own rules & guidelines



Overview Rules and Regulations

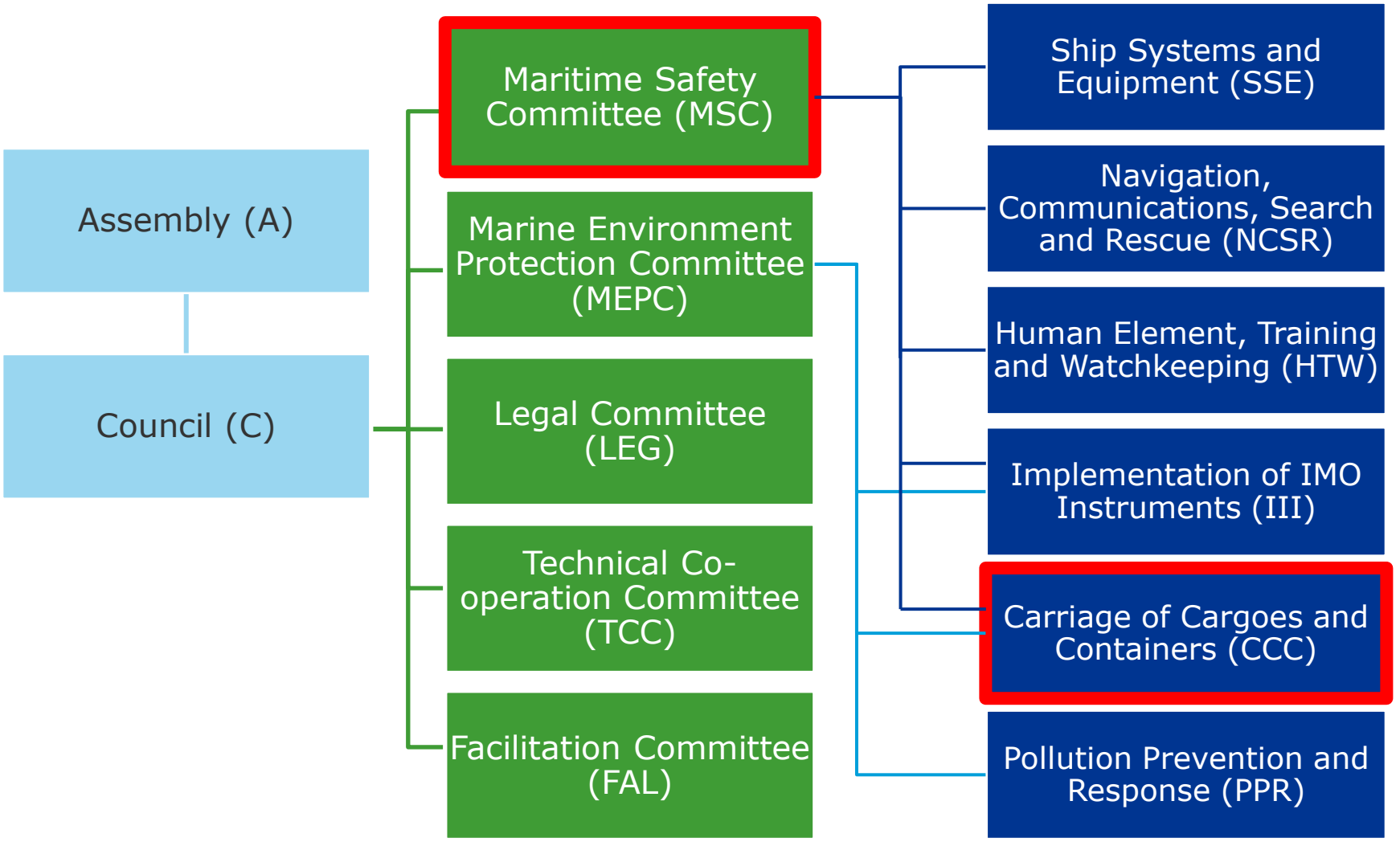
International Maritime Regulations

Class Rules

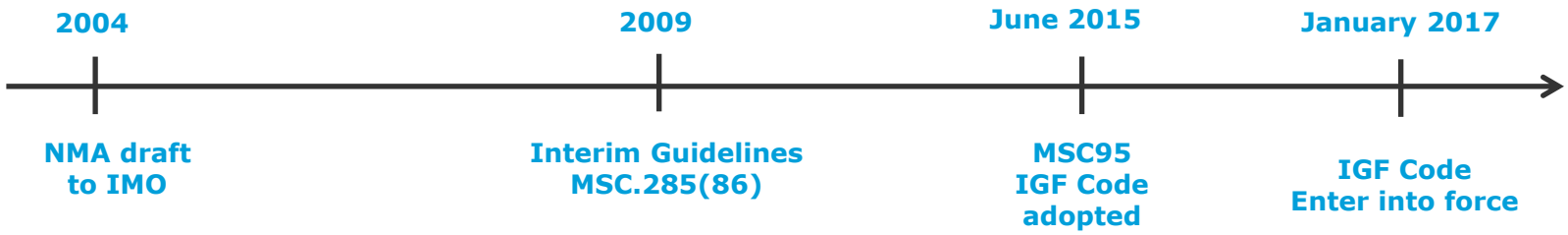
International Standards

National Regulations

Committees and Sub-committees of IMO



Current Status – Statutory requirements



- Main driver: New rules for gas as ship fuel (initiated by the Norwegian Maritime Authority (NMA) in 2004)
- Interim guidelines for natural gas-fuelled ships, Voluntary guidelines MSC.285(86) from 2009.
- **IGF Code -** Code of Safety for Ships using Gases or other Low flashpoint Fuels, adopted by IMO June 2015, replaced the interim guidelines by January 2017
- The IGF Code will provide mandatory provisions for low-flashpoint fuels and fuel cells
- Currently natural gas regulated. General provisions for low flashpoint fuels defined. The use of other low flashpoint fuels including **hydrogen can be approved based on alternative design**.

Current Status - Alternative Design

Currently, for Fuel Cells and Hydrogen

- IGF codes provides the possibility for alternative design process
- The *equivalence* of the alternative design shall be demonstrated by a ***risk-based approach*** as specified in SOLAS regulation II-1/55 and approved by the Administration
- The "Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III (MSC.1 / Circ. 1212)" providing guidance to perform the ***Alternative Design Process***

Preliminary Analysis

- Identification of rule deviations
- Hazard Identification
- Scenarios, methods and assumptions for quantification

Quantitative Analysis

- Quantification of selected scenarios
- Comparison to conventional design

Report of Assessment

- Documentation
- Presentation to flag

Current Status – Class Rules

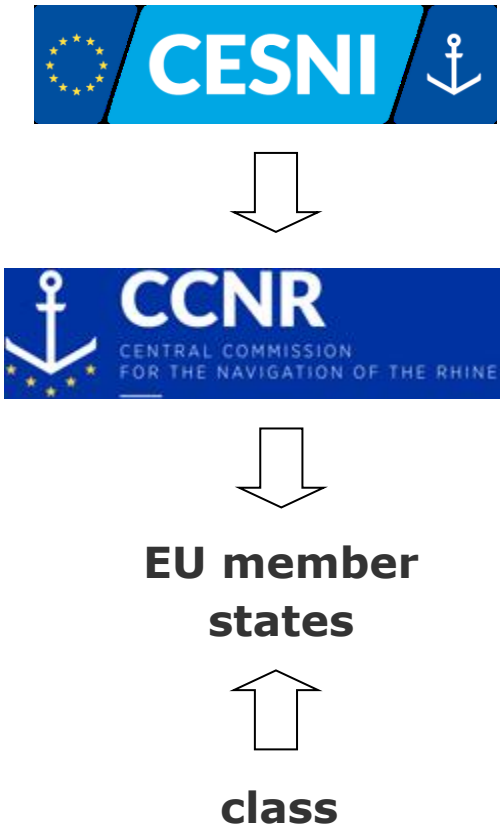
Most of the maritime fuel cell process chain covered by Class rules and recommended practices

- **Fuel Cell installation acc. class rules**
  - Pt.6 Ch.2 Sec.3 FUEL CELL INSTALLATION – FC
- **Fuel Cells acc. existing standards**
  - IEC 62282 Fuel cell technologies series
  - + Fuel cell system environmental test
    - + Vibration
    - + heat
    - + Cold
    - + Corrosion
    - + Flame retardant
    - + EMC

Inland vessels

Maritime legislation

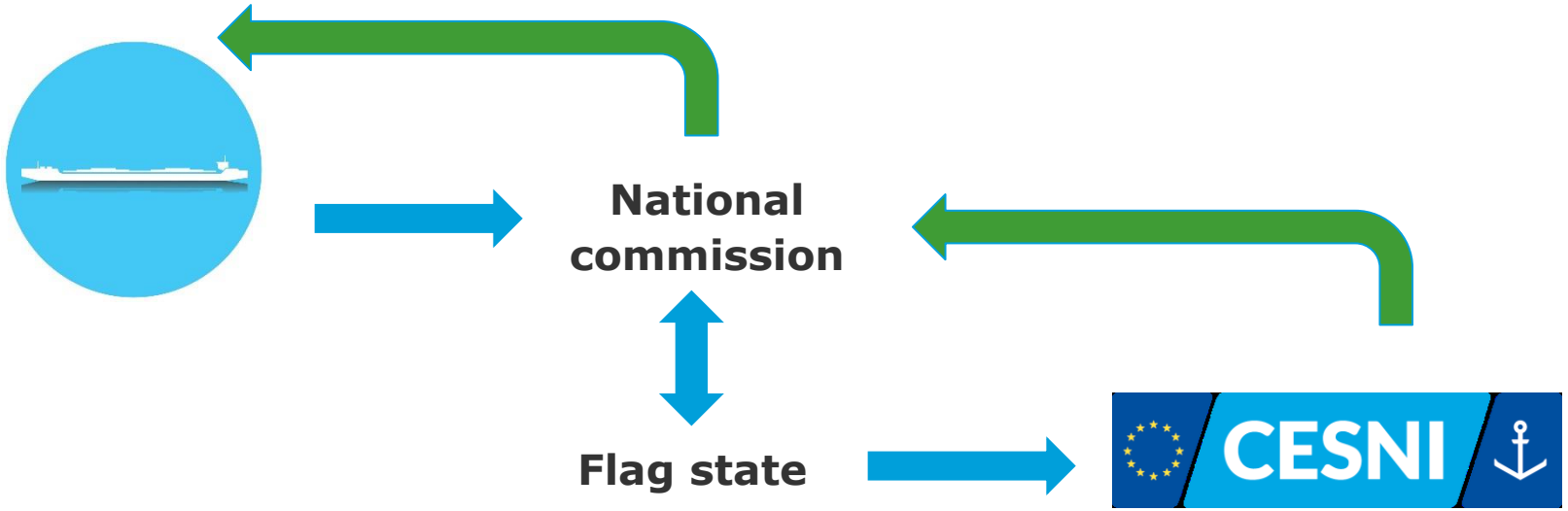
- **CESNI:** European committee for drawings up standards in the field of inland navigation
- Established in June 2015 as european committee of the CCNR
- Main purpose: Development of uniform standards for the european inland navigation
- Main standards:
  - **ES-TRIN**: European standard on technical requirements for inland vessels
  - Legally binding for EU member states sind September 2016 acc. EU Directive 2016 / 1629
- Special inland vessles are to be approved and periodically surveyed by a class society e.g. inland vessels carrying dangerous goods, passenger vessels, ferries, high speed crafts.
- Relevant class rules are recognized by the CCNR



Current Status – Special permit

Currently, for Fuel Cells and Hydrogen

- ***ES-TRIN*** provides general provision for low-flashpoint fuels
- ***EU Directive 2016/1629/EU*** provides the possibility for a special permit by the CESNI
- The *equivalence* of safety shall be demonstrated by a risk assessment



Fuel bunkering

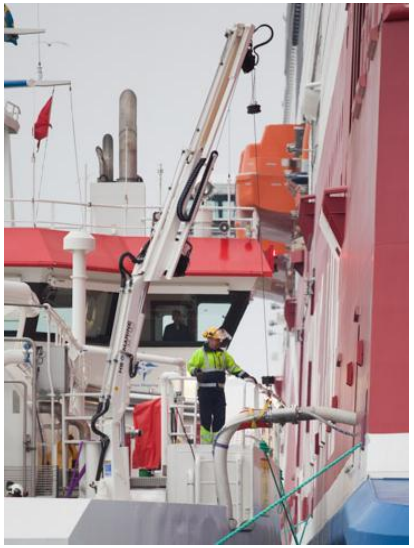
Current Status – Fuel Bunkering

From road trucks

Shore storage tank

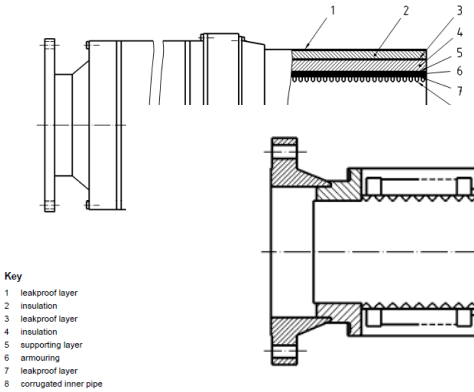
Portable Gas fuel tank

Ship to ship transfer



Current Status – Fuel Bunkering

- **Flexible hoses**
  - Proven solution for STS ops
  - Good safety record
  - Require hose handling cranes
  - Become bulky at higher transfer rates



Key
1 leakproof layer
2 insulation
3 leakproof layer
4 insulation
5 supporting layer
6 armouring
7 leakproof layer
8 corrugated inner pipe

Safety concept?

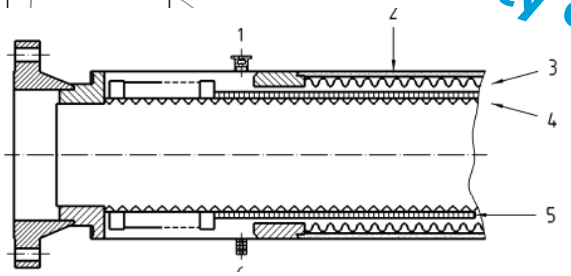


Figure 1 —

Key
1 pumping port
2 armouring
3 corrugated outer pipe
4 corrugated inner pipe
5 super insulation vacuum
6 vacuum supervision leak

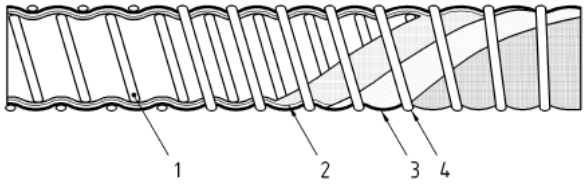
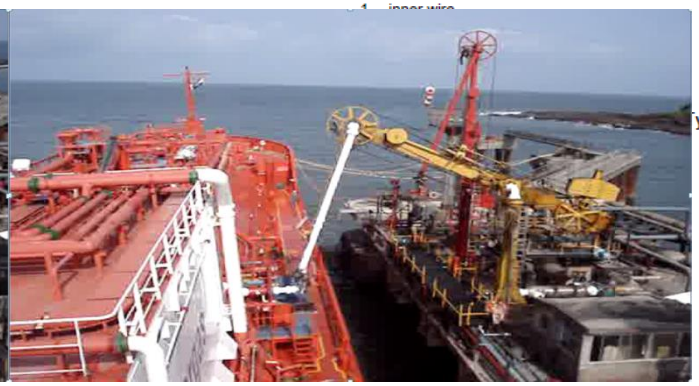


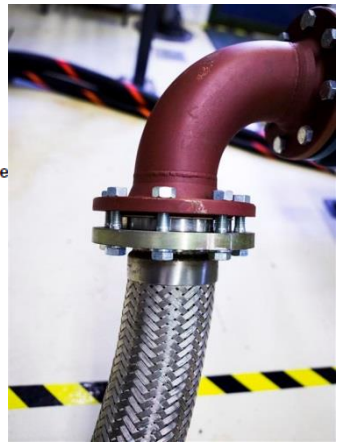
Figure 2 — Typical l

Key

- **Rigid arms**
  - Well developed standards
  - Allow reduced manning
  - Sensitive to sea/weather conditions



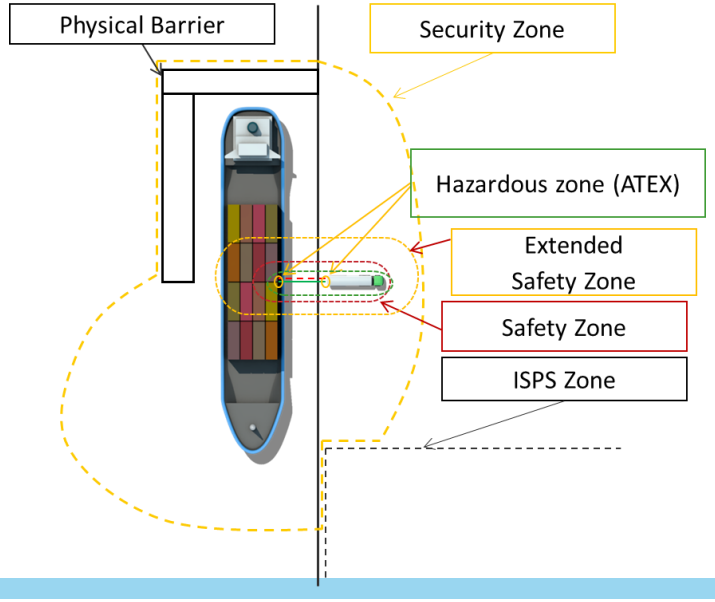
ypical hose

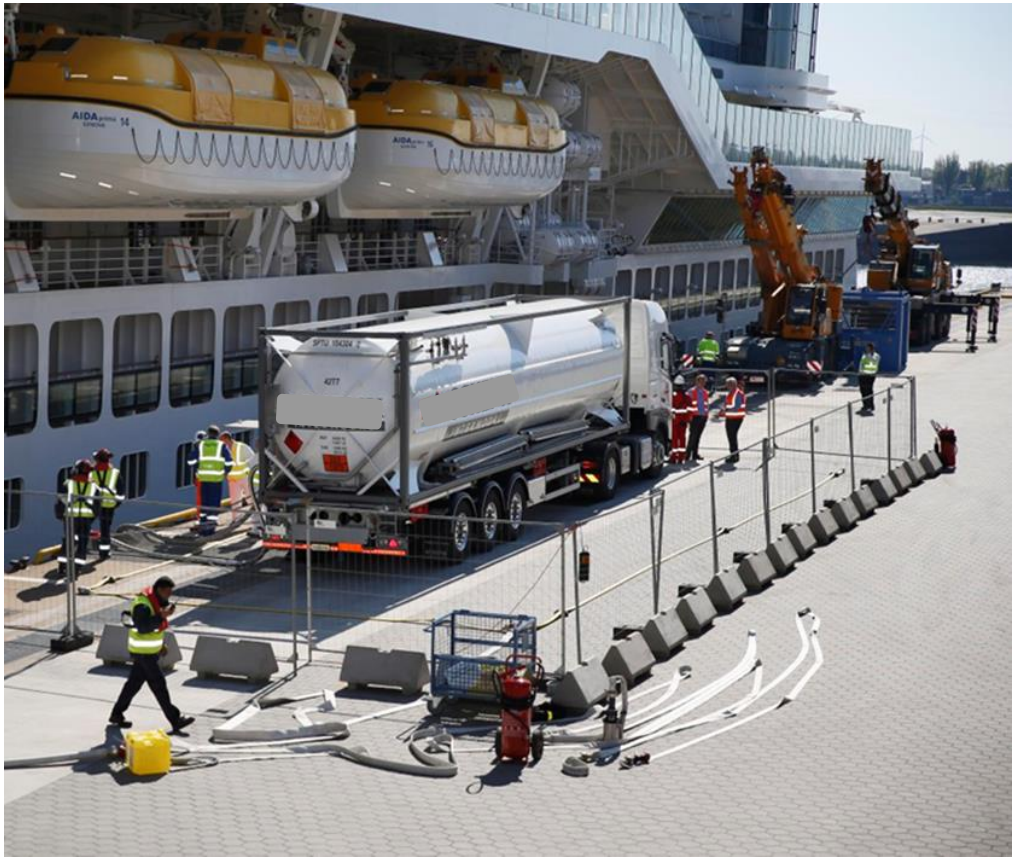


Current Status – Fuel Bunkering

Requirements in ISO 20519 (for Natural Gas only)

- Perform Risk Assessment
- Establish Safety Zone
- Establish Security Zone
- Use suitable standards for equipment and processes





- Consider SIMOPS (Simultaneous Operations)

Summary & outlook

Summary & outlook

- Natural gas as fuel for seagoing and inland vessels already in place (IGF Code, ES-TRIN)
- Regulations for other low flashpoint fuels and fuel cells are on the agenda of the IGF Code (driven by e4ships)
- Similar developments are to be out on the development agenda of CESNI
- Major Class Societies published rules for maritime fuel cell applications serving as guidance
- IGF Code and ES-TRIN providing regulations for special permits (risk-based approaches)
- Harmonization with land based standards is done by considering relevant ISO and IEC standards
- Main GAP: Bunkering of low flashpoint fuels other than Natural Gas are not regulated
- ISO 20519 for Natural Gas could give guidance

More on FC in shipping

- e4ships lighthouse project for the development of maritime fuel cell applications
- http://www.e4ships.de/

- EMSA: Study on the use of fuel cells in shipping
- http://emsa.europa.eu/emsa-documents/latest/item/2921-emsa-study-on-the-use-of-fuel-cells-in-shipping.html

"water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable"

Jule Verne, the mysterious island, 1874

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SAFER, SMARTER, GREENER

Current Status – Class Rules

Most of the maritime fuel cell process chain covered by Class rules and recommended practices

- **Gas-fuelled ships**
  - Pt.6 Ch.2 Sec.5 GAS FUELLED SHIP INSTALLATIONS – GAS FUELLED
  - The requirements cover all aspects of the gas fuel installation, from the ship's gas fuel bunkering connection all the way up to and including all gas consumers
- **Low flashpoint fuels**
  - Pt.6 Ch.2 Sec.6 LOW FLASHPOINT LIQUID FUELLED ENGINES – LFL FUELLED
- **Fuel Cells**
  - Pt.6 Ch.2 Sec.3 FUEL CELL INSTALLATION – FC
- **Batteries**
  - Pt.6 Ch.2 Sec.1 BATTERY POWER
- **Bunker vessels**
  - Pt.6 Ch.5 Sec.14 GAS BUNKER VESSELS – GAS BUNKER
  - Focus on **equipment and arrangements for safe transfer** and operation

Current Status - Main principles relevant DNV GL Rules

Segregation

Protect gas fuel installation from external events

Double barriers

Protect the ship against leakages

Leakage detection

Give warning and enable automatic safety actions

Emergency shutdown

Reduce consequences of a leakage