Methanol as a Marine Fuel

Mark Penfold | December 11, 2018

ABS

Outline

- Background
- Rules and Regulations
- Safety Concepts
- Fuel Gas Supply Systems
- Prime Movers

ABS Mission

- Is to serve the public interest as well as the needs of our members and clients by promoting the security of life and property, and preserving the natural environment

Compliance Options

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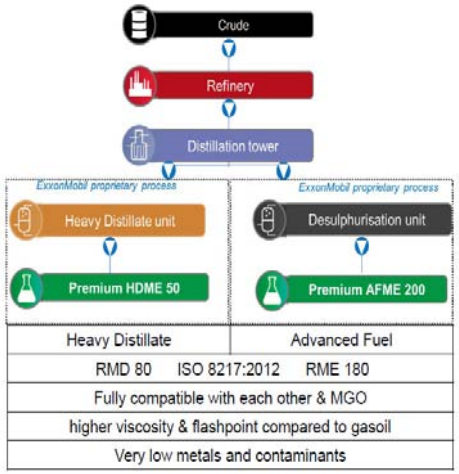

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DISTILLATE OR BLENDED FUELS

- MGO 0.1%S
- MDO 0.5%S

HIGH SULHUR FUELS

- With EGCS

ALTERNATIVE FUELS

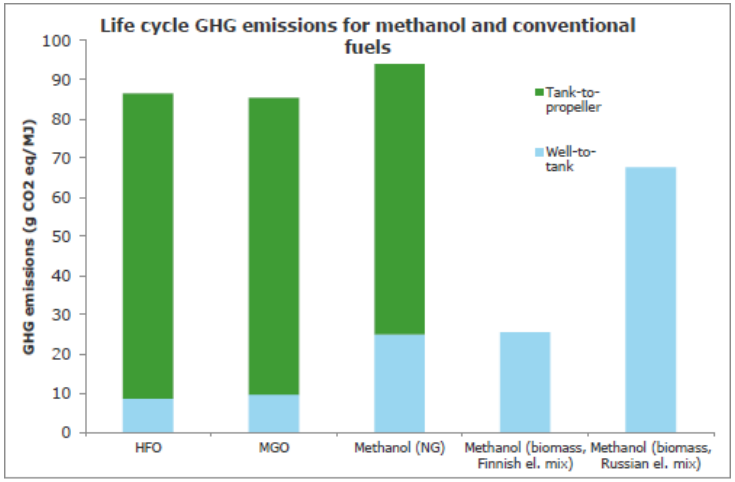
- LNG
- Methanol
- LPG
- Ethane

NEW FUELS

- New marine fuels
- ‘Hybrid’ - residual or distillate source
- Bio-fuels
- GTL
- Synththetic fuels

Methanol as a Marine Fuel

- Technically feasible
- Lifecycle NOx reductions (45% of conventional fuels)
- Lifecycle SOx reductions (8% of conventional fuels)
- Methanol is produced from natural gas but can be substituted by bio methanol in the future - source of methanol important for GHG reductions
- Commercially viable with high MGO prices
- Methanol as fuel on methanol carriers and pilot project
  - Waterfront Shipping (MOL, Westfal-Larsen, Marinvest)
  - Stena Germanica



Source: IMO MEPC 69/INF.10

Alternative Low Flashpoint Fuel Challenges

- Supply infrastructure
- Cost
- Lack of marine fuel quality standards and other regulations
- Low experience level

- Fuel properties !!
- Similar safety concepts to natural gas (double barriers, ventilation, gas detection, hazardous areas, etc.) but …. no single safety framework – fuel specific solutions – risk assessment

	MGO	HFO	Methane	Ethane	Propane	Butane	DME	Methanol	Ethanol	Hydrogen	Ammonia
Chemical Composition			CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_2H_6O	CH_3OH	C_2H_5OH	H_2	NH_3
Boiling Point, deg.C 1bar	180-360	180-360	-166	-89	-43	-1	-25	65	78	-253	-33
Density, kg/m^3 liquid	900	991	450	570	500	600	670	790	790	76.9	696
LHV, MJ/kg	42.7	40.2	48	47.8	46.3	45.7	28.7	19.9	26.8	120.2	22.5
Auto ignition temp, deg.C	250	250	650	515	470	365	350	450	420	535	630
Flash point, deg.C	>60	>60	-188	-135	-104	-60	-41	11	16	-	132
Flammable Range, % vol in air	0.6-7.5%	0.6-7.5%	5-15%	2.9-13%	1.9-9.5%	1.5-8.5%	3.3-18%	5.5-26%	3.5-15%	4-74%	15-28%
Energy density, MJ/lt	38.4	39.8	21.6	27.2	23.2	27.4	19.2	15.7	21.2	9.2	15.7
Volume comparison MGO	1	0.96	1.78	1.41	1.66	1.40	2.00	2.44	1.82	4.16	2.45
CO2 factor, kg CO2/kg fuel	3.206	3.114	2.750	2.927	3.000	3.030	1.911	1.375	1.913	0	0
Carbon content	0.8744	0.8493	0.7500	0.7989	0.8182	0.8264	0.5214	0.3750	0.5217	0	0
CO2, kg CO2/kWh	0.2701	0.2787	0.2061	0.2205	0.2331	0.2385	0.2397	0.2486	0.2568	0	0

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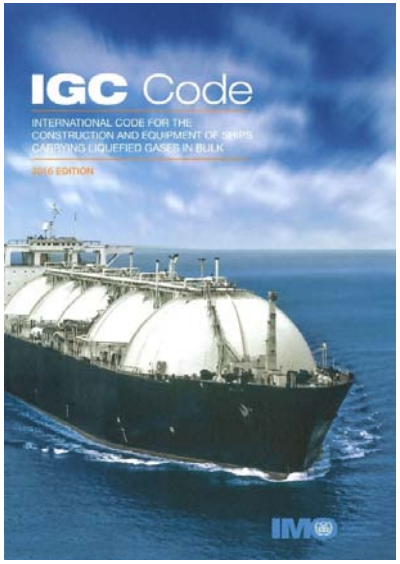
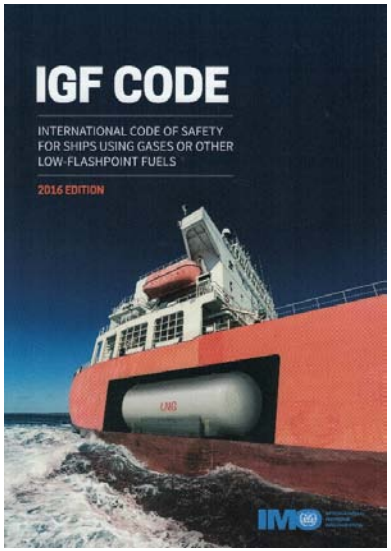
Current Rules and Regulations

- IGC Code
  - Gas carriers
  - Revised Code effective July 2016
  - Alternative fuels considered under 16.9
  - IGC Code incorporated under 5C-8 of SVR
- IGF Code
  - Adopted June 2015 – MSC.391(95)
  - EIF 1 January 2017
  - IGF Code does not apply to gas carriers using cargoes or other low flashpoint fuels as fuel
  - Detailed requirements for natural gas only
  - Methyl/ethyl requirements under development – IMO CCC 5 Sep 2018 completed draft Interim Guidelines for methyl/ethyl alcohol fuels – referred to MSC 100 and CCC 6
  - IGF Code incorporated under 5C-13 of SVR





ONE SHIP – ONE CODE

Current Rules and Regulations

ACTION REQUESTED OF THE SUB-COMMITTEE

32 The Sub-Committee is invited to approve the report in general and, in particular, to:

.1 approve the draft amendments to regulation 9.5.6 of the IGF Code, as contained in annex 1 to document CCC 4/12, for submission to MSC 100 as an urgent matter (paragraph 5);

.2 agree, in principle, to the draft interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel, and invite MSC 100, as an urgent matter, to endorse referring safety topics identified by the group to other technical sub-committees for consideration and advise to CCC 6 (paragraphs 18 to 20 and annexes 1 and 2);

The basic philosophy of these interim guidelines is to provide provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using methyl/ethyl alcohol as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

Source: IMO CCC 5/WP.3

Current Rules and Regulations

- MSC 99 invited ISO to develop a standard for methyl/ethyl alcohol as marine fuel
- Some concerns on lack of sufficient experience as a marine fuel
- ISO marine fuel standards fall under the TC 28 technical committee
- The TC 28 sub-committee SC4 is developing the marine fuel standard for LNG

8 CARRIAGE OF CARGOES AND CONTAINERS

Report of CCC 4

8.1 The Committee approved, in general, the report of the fourth session of the Sub-Committee on Carriage of Cargoes and Containers (CCC) (CCC 4/12 and MSC 99/8) and took action as indicated in paragraphs 8.2 to 8.13 below.

Standards for methyl/ethyl alcohol as a marine fuel and for methyl/ethyl alcohol fuel couplings

8.2 The Committee agreed to invite ISO to develop:

.1 a standard for methyl/ethyl alcohol as a marine fuel; and

.2 a standard for methyl/ethyl alcohol fuel couplings,

and requested the Secretariat to communicate with the ISO Secretariat accordingly.

8.3 In this regard, the observer from ISO expressed their willingness to develop these standards, but pointed out that there was a lack of sufficient use of such a fuel and industry was short of experience. In this context, the Committee noted the view of the delegation of the Cook Islands that the appropriate IMO legislation should be developed prior to the development of the ISO standards, which should take into account the safety concerns associated with the low flashpoint and volatile nature of methyl/ethyl alcohol as a marine fuel.

Source: IMO MSC 99/22

Standards catalogue

ISO/TC 28/SC 4

Classifications and specifications

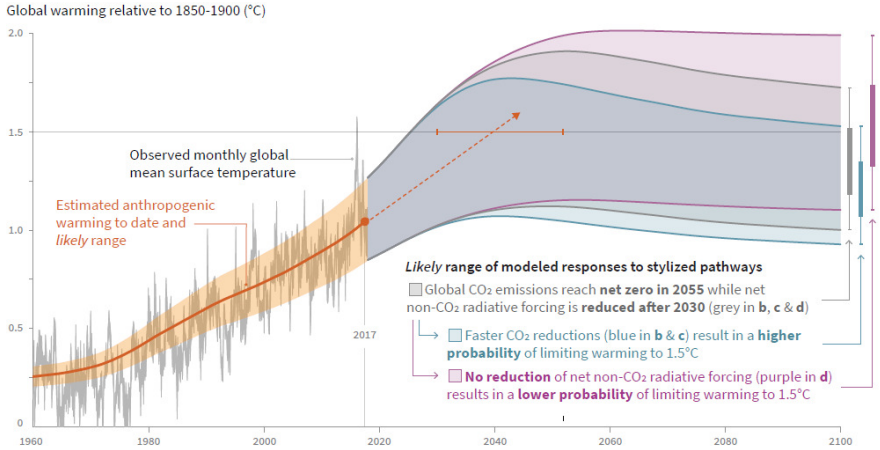
Filter: Published standards | Standards under development | Withdrawn standards | Projects deleted

Standard and/or project under the direct responsibility of ISO/TC 28/SC 4 Secretariat (6)	Stage	ICS
ISO/DIS 6521-1 [Under development] Lubricants, industrial oils and related products (Class L) -- Family D (compressors) -- Part 1: Specifications of categories DAA and DAB (lubricants for reciprocating and drip feed rotary air compressors)	40.20	75.100
ISO/DIS 6521-3 [Under development] Lubricants, industrial oils and related products (Class L) -- Family D (compressors) -- Part 3: Specifications of categories DRA, DRB, DRC, DRD, DRE, DRF and DRG (lubricants for refrigerating compressors)	40.20	75.100
ISO 8068:2006/FDAmd 1 [Under development] Filterability tests according to ISO 13357-1 and ISO 13357-2 -- Requirements related to the stage of the test method	50.00	75.100
ISO/CD 12922 [Under development] Lubricants, industrial oils and related products (class L) -- Family H (Hydraulic systems) -- Specifications for hydraulic fluids in categories HFAE, HFAS, HFB, HFC, HFDR and HFDU	30.99	75.120
ISO/AWI PAS 23263 [Under development] Petroleum products -- Fuels (class F) -- Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of maximum 0,50 % S in 2020	20.00	
ISO/AWI 23306 [Under development] Specification of liquefied natural gas as a fuel for marine applications	20.00	

Source: ISO

IMO GHG Strategy

- Vision
  - IMO remains committed to reducing GHG emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible
- Ambition
  - … to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008 …
  - …to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 …



© Source: IPCC special report on climate change Oct 2018

Class and Government

- The role of classification has been recognized in SOLAS and the International Convention on Load Lines
- Classification societies also act as Recognized Organizations (ROs) performing statutory inspections on behalf of flag States
- This statutory activity is distinct from but complementary to Class requirements

ABS Rules - IMO IGF Code

- IGF Code incorporated under 5C-13 of the SVR
- ABS GFS Guide incorporated in 5C-13 from July 2017
- Notations now available for other low flashpoint fuels, e.g. **LFFS(DFD – Methanol)**

PART
5C

CHAPTER **13 Vessels Using Gases or other Low-Flashpoint Fuels**

SECTION **1 General (ABS)**

Note: Text in *italics* comes from the International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels (IGF Code). See 5C-13-1/5. Operational, training, or national requirements are shown in *Arial Italic*.

1 Classification Notations (ABS) *(1 July 2017)*

1.1 Gas Fuelled Ship

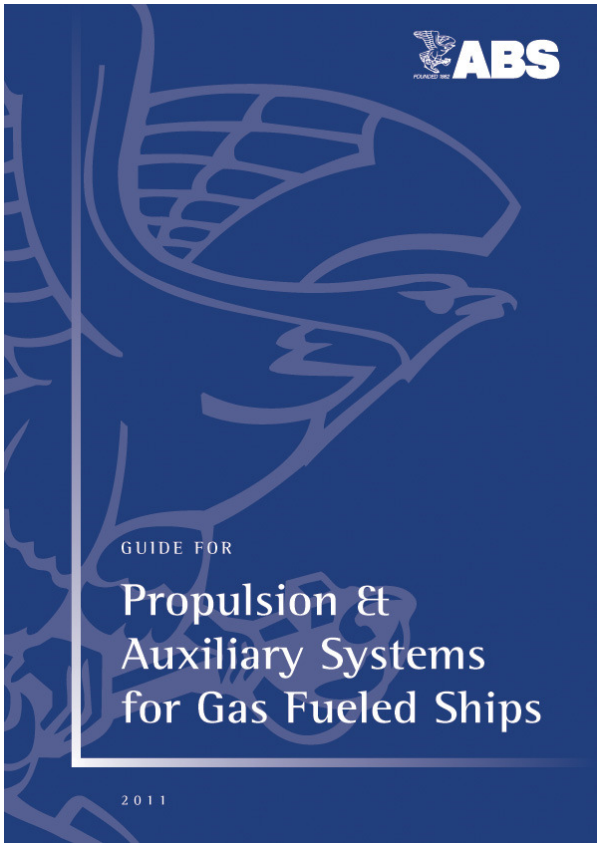
The **GFS** notation may be assigned where a vessel is arranged to burn natural gas as fuel for propulsion or auxiliary purposes and is designed, constructed and tested in accordance with the requirements of this Chapter of the Rules. The **GFS** notation will be assigned in association with one or more of the following additional notations (e.g., **GFS(DFD, GCU)**). Upon special consideration, the equipment notations referenced below may be assigned on an individual basis for specific ship types.

1.2 Alternative Low Flashpoint Fueled Ship *(2018)*

The **LFFS** notation may be assigned where a vessel is arranged to burn a low flashpoint fuel other than natural gas for propulsion or auxiliary purposes and is designed, constructed and tested in accordance with the requirements of this Chapter of the Rules. The equivalence of the design is to be demonstrated by application of the Alternative Design criteria detailed under 5C-13-2/3. The **LFFS** notation will be assigned in association with the specific low flashpoint fuel and one or more of the following additional notations (e.g., **LFFS(DFD - Methanol)**).

1.3 Reliquefaction System

Where a Reliquefaction System is designed, constructed and tested in accordance with 5C-13-6/9.1 and 5C-13-6/9.3, the **RELIQ** notation will be assigned.



IGF Code – Fuels other than Natural Gas

- IGF Code 'Part 1' covers natural gas only
- Other fuels can be used provided they meet the intent of the goals and functional requirements and provide equivalent level of safety
- Alternative design
- Equivalence to be demonstrated as specified in SOLAS regulation II-1/55
- II-1/55 refers to the IMO Guidelines for alternative design and arrangements, MSC.1/Circ.1212 – Risk Assessment
- This approach is already in the SVR under 5C-13-2/3

2.3 Alternative design

2.3.1 This Code contains functional requirements for all appliances and arrangements related to the usage of low-flashpoint fuels.

2.3.2 Fuels, appliances and arrangements of low-flashpoint fuel systems may either:

.1 deviate from those set out in this Code, or

.2 be designed for use of a fuel not specifically addressed in this Code.

Such fuels, appliances and arrangements can be used provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant chapters.

2.3.3 The equivalence of the alternative design shall be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration shall not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Code.

Source: IMO IGF Code

IMO IGF Code – Risk Assessment

- For ships using natural gas as fuel (part A-1 of the IGF Code) and complying with the detailed prescriptive requirements contained within the Code, a risk assessment need only be conducted where explicitly required by the prescriptive parts of the Code
- Other low flashpoint fuels must apply risk assessment approach

Table A3. Risk Levels

Likelihood Categories	Consequence Severity				
	Low	Minor	Moderate	Major	Critical
	1	2	3	4	5
Almost Certain (E)	Medium	Medium	High	High	High
Likely (D)	Moderate	Medium	Medium	High	High
Possible (C)	Low	Moderate	Medium	High	High
Unlikely (B)	Low	Low	Moderate	Medium	High
Rare (A)	Low	Low	Moderate	Medium	Medium

IMO IGF Code – Methanol RA

4.2 Risk assessment

4.2.1 A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration shall be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.

4.2.2 For ships to which part A-1 applies, the risk assessment required by 4.2.1 need only be conducted where explicitly required by paragraphs 5.10.5, 5.12.3, 6.4.1.1, 6.4.15.4.7.2, 8.3.1.1, 13.4.1, 13.7 and 15.8.1.10 as well as by paragraphs 4.4 and 6.8 of the annex.

4.2.3 The risks shall be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock shall as a minimum be considered. The analysis shall ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Administration.

IMO IGF Code – Methanol RA

IACS International Association of Classification Societies

No.146

No. 146 (Aug 2016)

Risk assessment as required by the IGF Code

1.1 General

To help eliminate or mitigate risks a risk assessment is required by the IGF Code[1]. In this regard it requires that the risk assessment is undertaken using acceptable and recognised techniques, and the risks and their mitigation are documented to the satisfaction of the Administration.

It is recognised that there are many acceptable and recognised techniques and means to document a risk assessment. As such, it is not the intent of this document to limit a risk assessment to a particular technique or means of documentation. This document does, however, describe recommended practice and examples to help satisfy the IGF Code.

1.2 Risk assessment - Objective

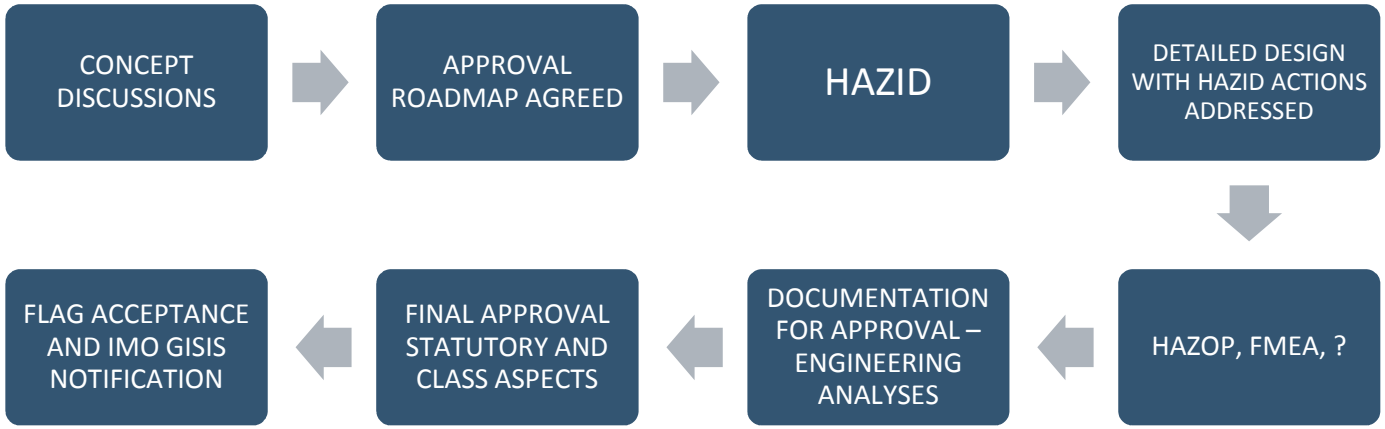
The objective or goal of the risk assessment, as noted in the IGF Code, is to help *"eliminate or mitigate any adverse effect to the persons on board, the environment or the ship"*[2]. That is, to eliminate or mitigate unwanted events related to the use of low-flashpoint fuels that could harm individuals, the environment or the ship.

Source: IACS Recommendation No.146

ABS

Roadmap for Approval

- Agree with flag and Class the approval roadmap to address safety and environmental aspects
  - Class compliance – Rules
  - Statutory safety – IGF Code
  - Statutory environmental – MARPOL Annex VI SOx, NOx, EEDI
- Low flashpoint fuels other than natural gas must apply risk assessment approach



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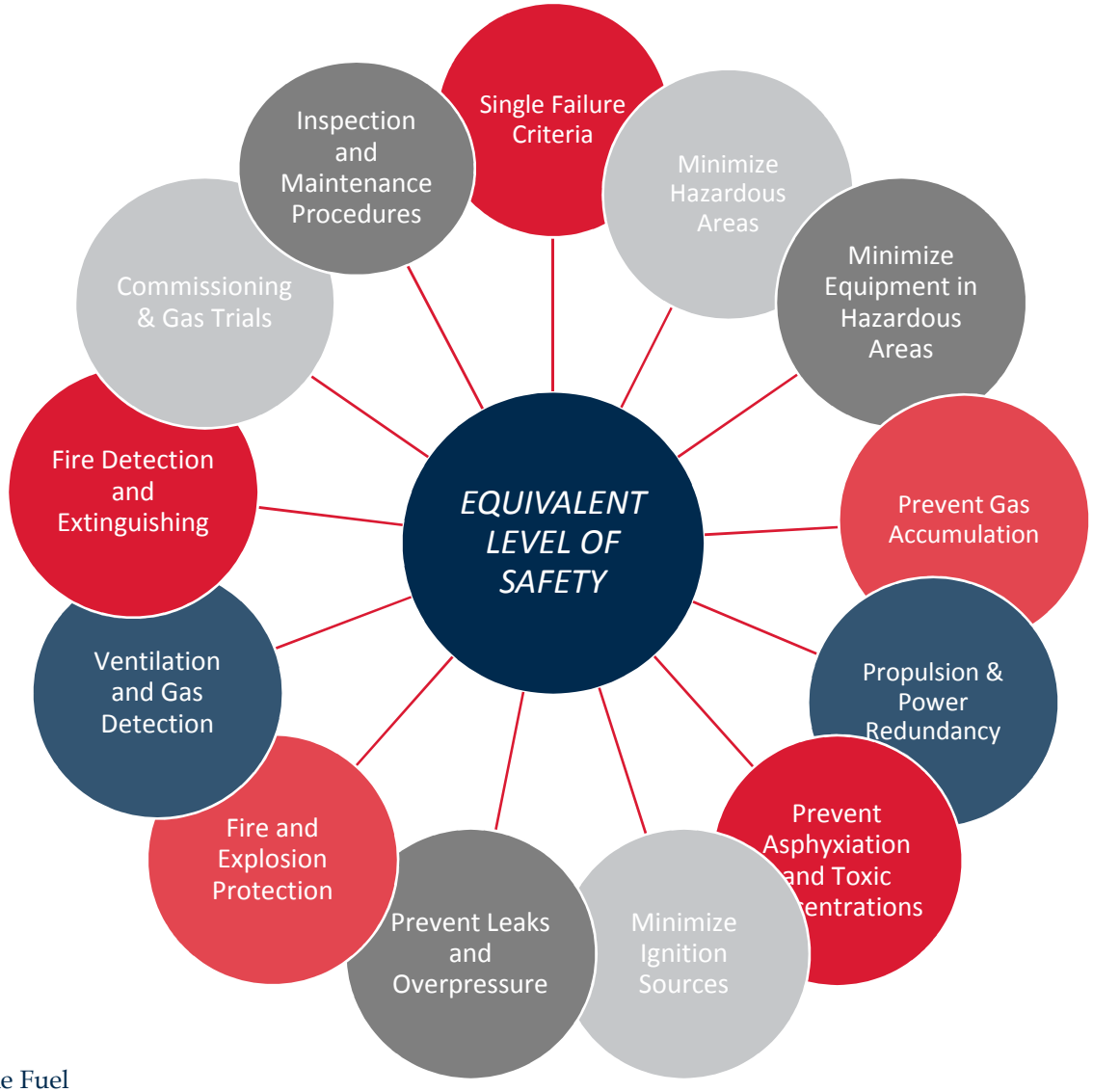
IGF Code – Functional Requirements



Safety Concepts and Challenges

- Prevention of leakage
  - Double barriers
  - Sealing systems
- Prevention of explosive atmosphere
  - Ventilation and gas detection
  - Block and bleed
  - Purge and inert
  - Hazardous area classification
- Explosion mitigation
  - Design for worst case
  - Pressure relief systems
- Toxicity
  - Double barriers
  - Cofferdams
  - Air Locks
- Prevention of explosive atmosphere
  - Inert blanket for fuel tanks
  - P/V valves
  - Vents
  - Fuel prep/pump room – category A
  - Master fuel valve - FVT
  - Drain and purge
- Fi-fi
  - Invisible flame
  - Alcohol resistant foam

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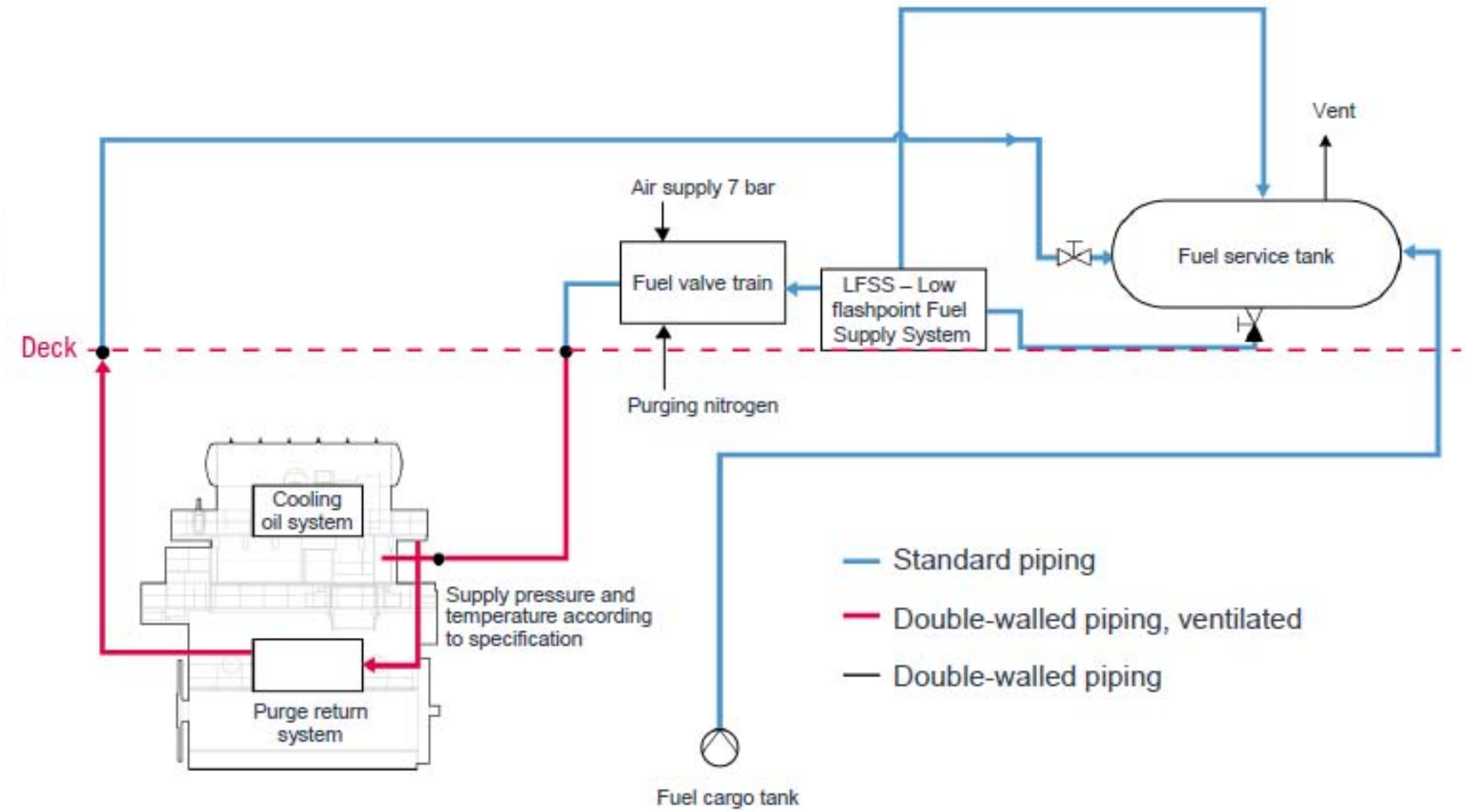
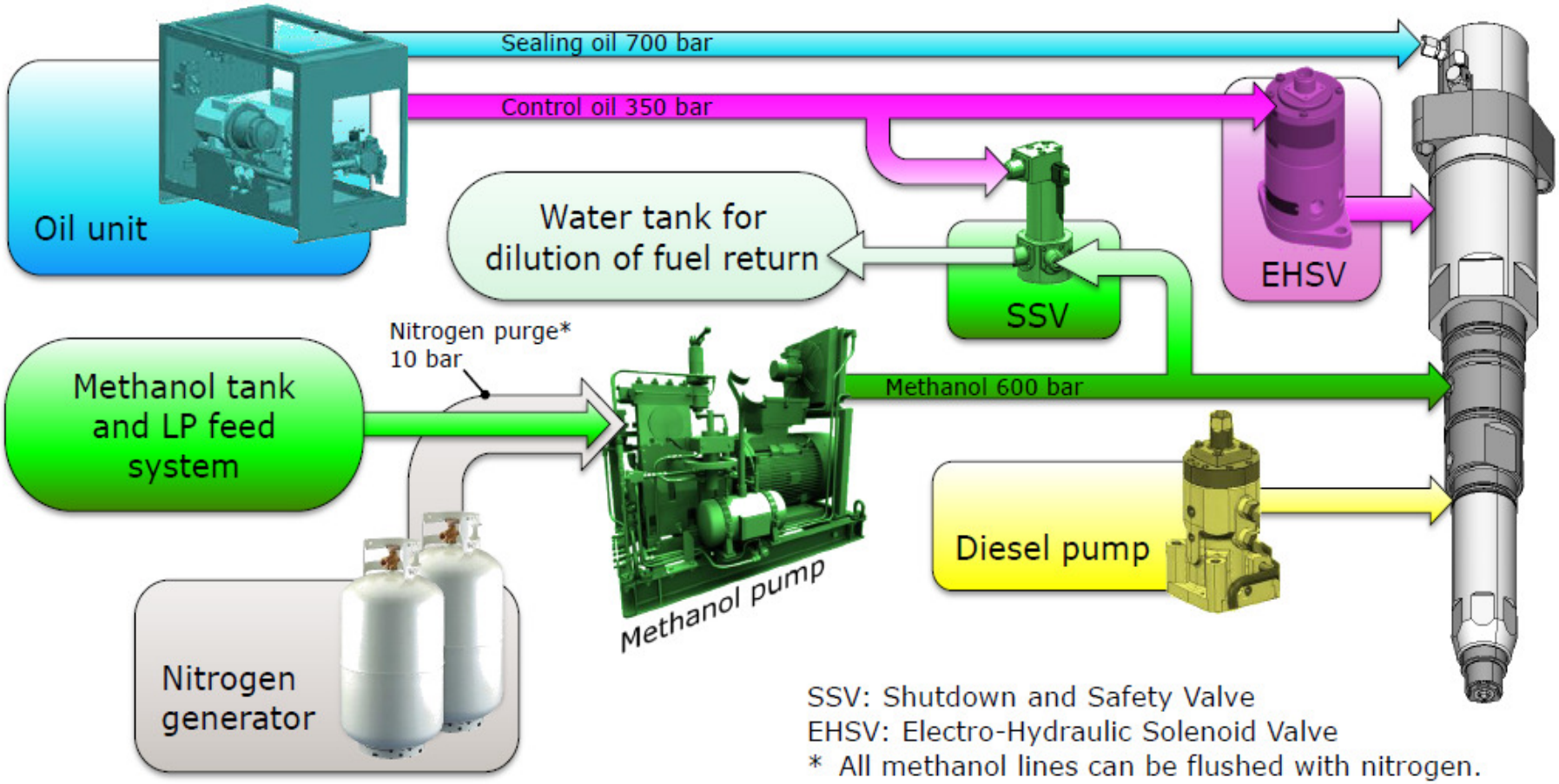
Fuel Gas Supply Systems



Fuel Gas Supply Systems



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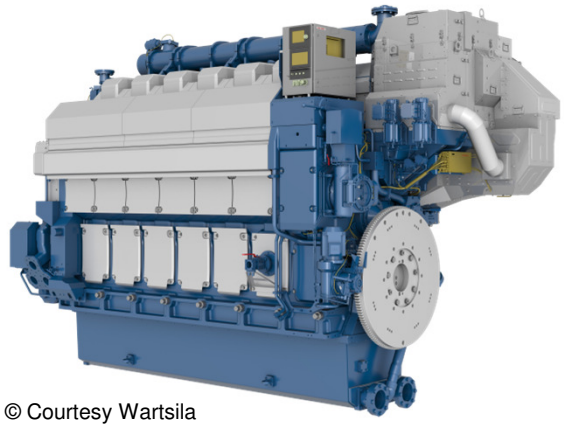
DF and Gas Prime Movers

- Dual fuel engine technology introduced to the marine market since 2005
  - Primarily through medium speed engine applications to LNG carriers
  - Also with spark ignited gas engines installed on ferries and patrol craft in Northern Europe
- Type and application of DF and gas engines is expanding
- Use of slow speed DFs for main propulsion on LNGC and other ship types is emerging



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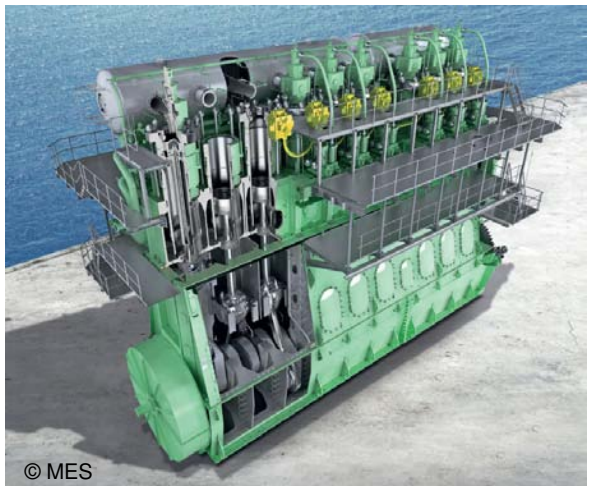

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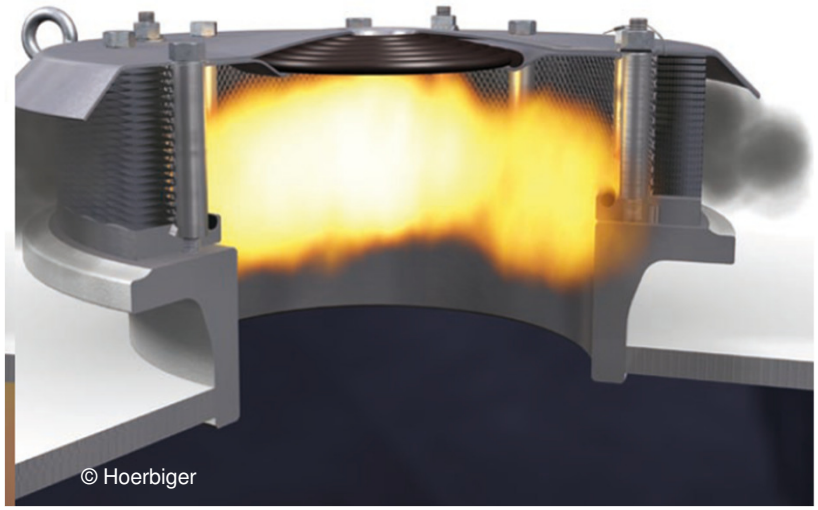
DF and Gas Engine Safety Concepts

- Prevention of gas leakage
  - Double barriers
  - Sealing systems
- Prevention of explosive atmosphere
  - Ventilation and gas detection
  - Master gas valve and block and bleed valves > master fuel valve and shut off valve
  - Purge and inert
  - Hazardous area classification
- Explosion mitigation
  - Design for worst case
  - Pressure relief systems
- Suitable redundancy
  - Fuel supply systems
  - Switch to oil mode (DF engines)
- Stable combustion



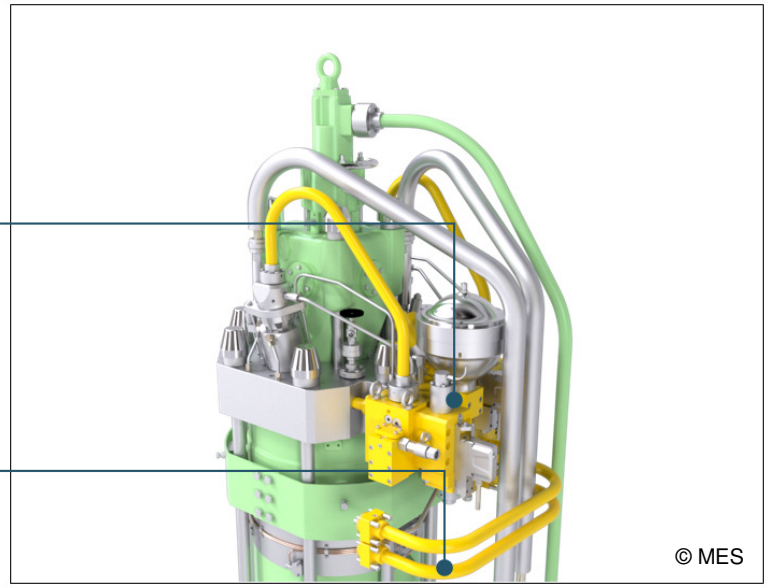
Methanol, LPG and Ammonia as Fuels

- MAN 2-stroke high pressure Diesel combustion concept for burning Methanol, LPG, DME or ammonia – the ME-LGI engine
- Diesel type injection system, as HFO injectors
- Fuel supply pressure 8-40 bar
- NOx Tier II compliance - combined with SCR for ECAs

Cylinder cover with LPG injection valve and gas block – same system to be used for NH3

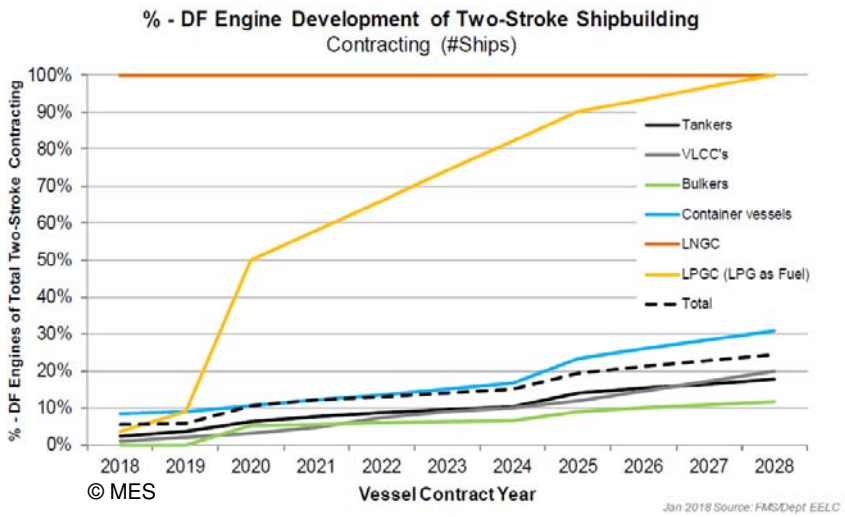
Valve control block:
- ELWI-valve (fuel pressurization)
- ELGI-valve (injection timing)
- Hydraulic accumulator
- Hydraulic and sealing oil connections

Double wall gas piping:
- LPG inlet
- LPG return



Methanol, LPG and Ammonia as Fuels

- MAN predicts 100% LPG as fuel take up on LPG carriers by 2028
- Diesel combustion process gives similar heat release and firing pressures to fuel oil



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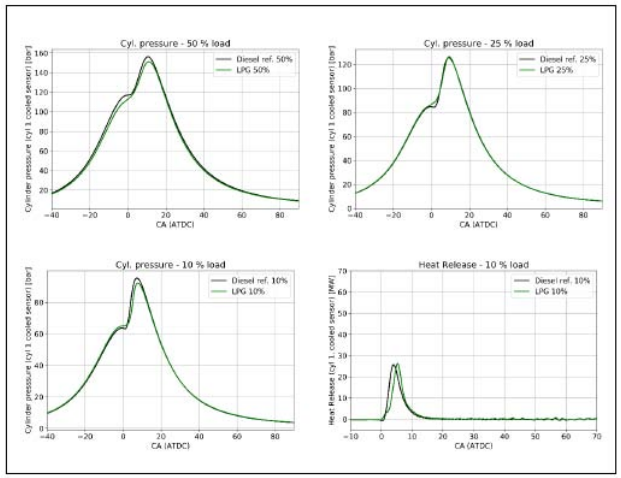

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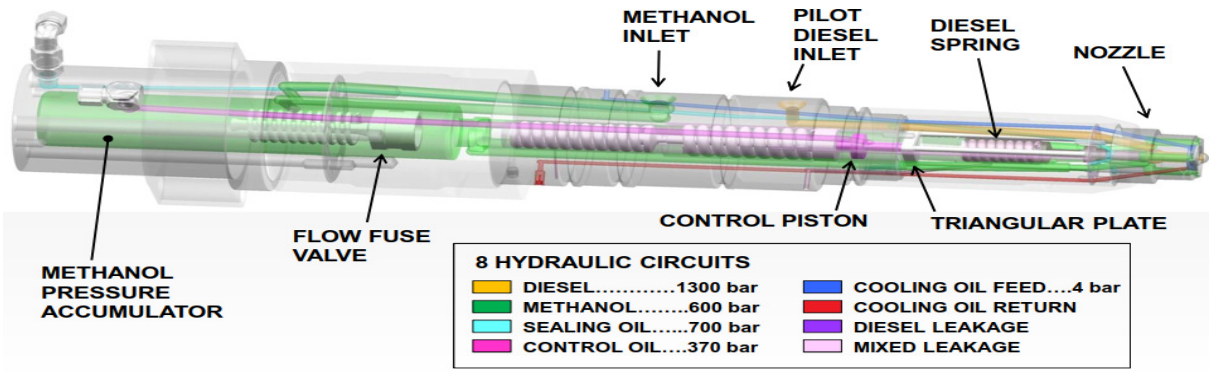
	NO_x	SO_x	PM	CO_2
LNG	20-30%	90-99%	90%	24%
LPG	10-15%	90-100%	90%	13-18%
Methanol	30-50%	90-97%	90%	5%
Ethane	30-50%	90-97%	90%	15%

– Compared with Tier II engines on HFO
– Based on estimates
Tier III can be met with EGR or SCR
Note: For methanol, Tier III can be met by blending with water

© MES

Methanol as a Marine Fuel

- Wartsila 4-stroke high pressure Diesel combustion concept for burning methanol
- Fuel supply pressure of 600 bar required (Diesel type injection system, as HFO injectors)
- NOx Tier II compliance - combined with SCR for ECAs
- Capability to operate fully on MGO/HFO



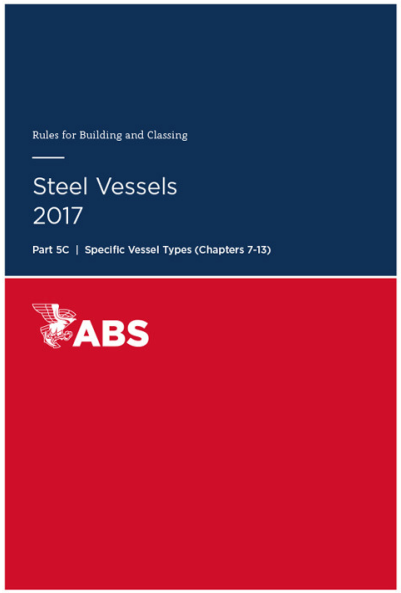
Conclusions

- Main Class and regulatory framework in place
- Established safety principles adapted for specific fuel characteristics
- Risk assessment is part of the approval process
- Experience with dual fuel technologies growing
  - LNG on LNG carriers
  - Methanol on methanol carriers
  - LPG on LPG carriers
  - Ethane on ethane carriers
- All alternative low flashpoint fuels can provide solution for SOx compliance
- Zero and low carbon fuels, from sustainable sources, may be the roadmap to IMO and global ambitions on limiting global warming

ABS

ABS Support

- Rules, Guides and Advisories
- Techno Economic Evaluation



Thank you

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