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SUMMETH

Sustainable Marine Methanol

Safety assessment of methanol for smaller vessels: road ferry case study

Final Seminar
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PROJECT PARTNERS

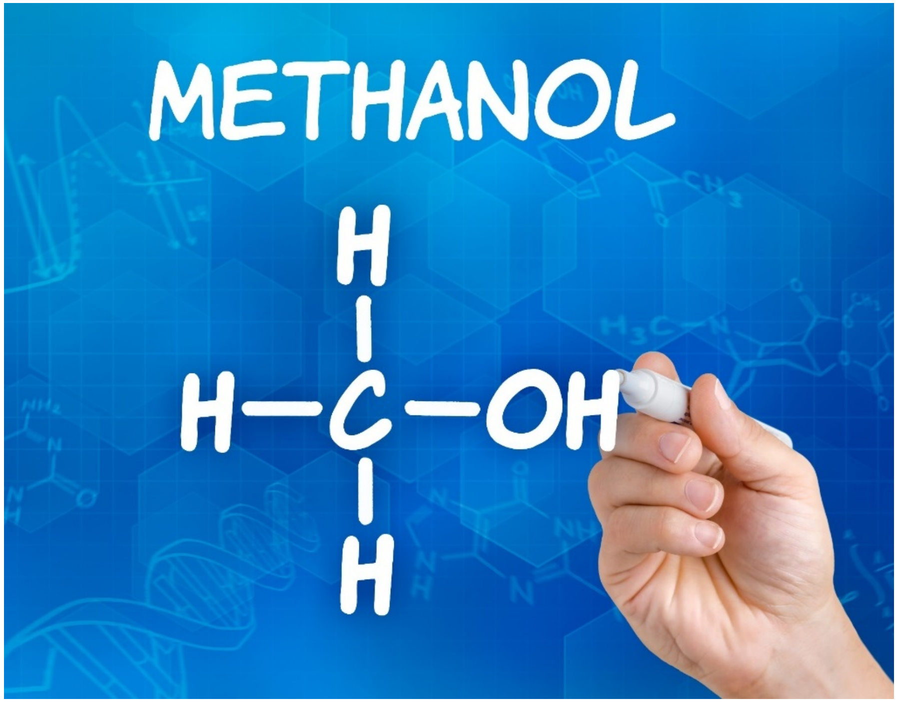
Outline

- Overview
  - Methanol properties
  - Regulations
  - Risk assessment process
- Hazard Identification: Case Study
  - Purpose
  - Method
  - Results
  - Safeguards / Conclusions

Properties to consider regarding safety

Methanol characteristics to consider from a safety perspective:

- flammable liquid with flashpoint of 12 °C
- burns with a clear flame that is difficult to see in daylight
- vapour pressure 0.12 bar at 20°C; boiling temperature 65°C
- vapour density 1.1 (compared to air at 1)
- flammability limits 6 – 36%
- corrosive – take care with material selection (stainless steel ok)
- toxic to humans by ingestion, inhalation, or contact



Properties compared to other fuels

Property	MGO	LNG	Ethanol	Methanol
Physical State	Liquid	Cryogenic liquid	Liquid	Liquid
Boiling Temperature at 1 bar [°C]	175-650	-161	78	65
Density at 15°C [kg/m³]	Max. 900	448 (-160°C,1bar)	792	796
Dynamic Viscosity at 40°C [cSt]	3.5	-	1.1	0.6
Lower Heating Value [MJ/kg]	43	50 (-62°C,1bar)	28	20
Lubricity [µm]	280-400	-	1057	1100
Vapour density air= 1	>5	0.55	1.6	1.1
Flash Point (TCC) [°C]	>60	-175	17	12
Auto ignition Temperature [°C]	250-500	540	363	464
Flammability Limits [% Mixture Volume]	0.3-10	5-15	3.3-19	6-36

Methanol – toxicity; added body burden from various exposure routes

- "the toxicity (mortality) of methanol is comparable to or better than gasoline"
  Ref.: Bromberg, L. and W.K. Cheng. 2010. Methanol as an alternative transportation fuel in the US: Options for sustainable and/or energy-secure transportation. Cambridge, MA: Sloan Automotive Laboratory, Massachusetts Institute of Technology

Table 6.6. Exposure of methanol for a 70-kg person (source: Statoil, Methanex).

Exposure/dose	*Added body burden of methanol (mg)*	*Reference*
Background level in a 70 kg body	35[a]	Kavet & Nauss, 1990
Hand in liquid methanol, 2 min	170	IPCS, 1994
Inhalation, 40 ppm methanol for 8 hours	170	IPCS, 1994
Inhalation, 150 ppm for 15 min	42[b]	Kavet & Nauss, 1990
Aspartame sweetened products 0.8 litre diet beverage	2 – 77 42	Stegnik et al., 1984 Kavet & Nauss, 1990
Ingestion of 0,2 ml of methanol	170	
Ingestion, 25–90 ml of methanol	~21 000–71 000 (lethal)	IPCS, 1997

Notes:

[a] Estimated from 0.73 ml/litre in blood

[b] Assuming 100% absorption in lung (60–85% more likely)

From: Ekbom, T., Lindblom, M., Berglin, N., and P. Ahlvik. 2003. Technical and Commercial Feasibility Study of Black Liquor Gasification with Methanol/DME Production as Motor Fuels for Automotive Uses – BLGMF. Nykomb Synergetic AB: Stockholm.

Exposure limits compared to diesel

EC Indicative Occupational Exposure Limit Values and national Occupational Exposure Limit Values from Sweden for methanol and two types of diesel/fuel oil

Exposure Limits	Methanol	Diesel
Indicative Occupational Exposure Limit Value from European Commission Directive		
8 hour time weighted average reference period	200 ppm 260 mg/m^3	
Swedish Occupational Exposure Limit Value [i]		
Level Limit Value (LVL) – value for exposure for one working day (8 hours)	200 ppm 250 mg/m^3	Diesel MK1: 350 mg/m^3 Heating oil: 250 mg/m^3
Short Term Value (STV) – time weighted average for a 15 minute reference period	250 ppm 350 mg/m^3	

[i] Swedish Work Environment Authority. 2005. Occupational Exposure Limit Values and Measures Against Air Contaminants. Provisions of the Swedish Work Environment Authority on Occupational Exposure Limit Values and Measures against Air Contaminants, together with General Recommendations on the implementation of the Provisions. AFS 2005:17. Available: http://www.av.se/dokument/inenglish/legislations/eng0517.pdf

Regulations and Guidelines

Use as a Ship Fuel

IMO: SOLAS Alternative Design, existing regulation, requires a risk assessment (Stena Germanica and Methanol Tanker New builds have been approved after risk assessments showing equivalent safety)

IGF Draft covering methanol and ethanol is under development

Carriage of Methanol as Cargo

IMO Bulk Carriage: MARPOL Annex II, IBC Code sets out design and construction standards for ships carrying dangerous cargo

IMO Packaged Dangerous Goods: IMDG Code sets out design and construction standards for ships carrying dangerous cargo;

European: ADN European Agreement for Inland Waterways has carriage regulations

Transport of Methanol to the Ship for Bunkering

Ship Transport: IMO: MARPOL Annex II and IBC Code specify requirements for carriage of cargo, ship-to-ship transfer as fuel not defined

Road transport: ADR Existing European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)

ISM has some applicability, but does not specifically consider fuelling with methanol

Regulations and Guidelines – National and Class

National Regulations for use as a ship fuel: Vessels operating on a national certificate (not in international waters, possible service restrictions on distance travelled, etc.)

- TSFS 2014:1 Transportstyrelsen

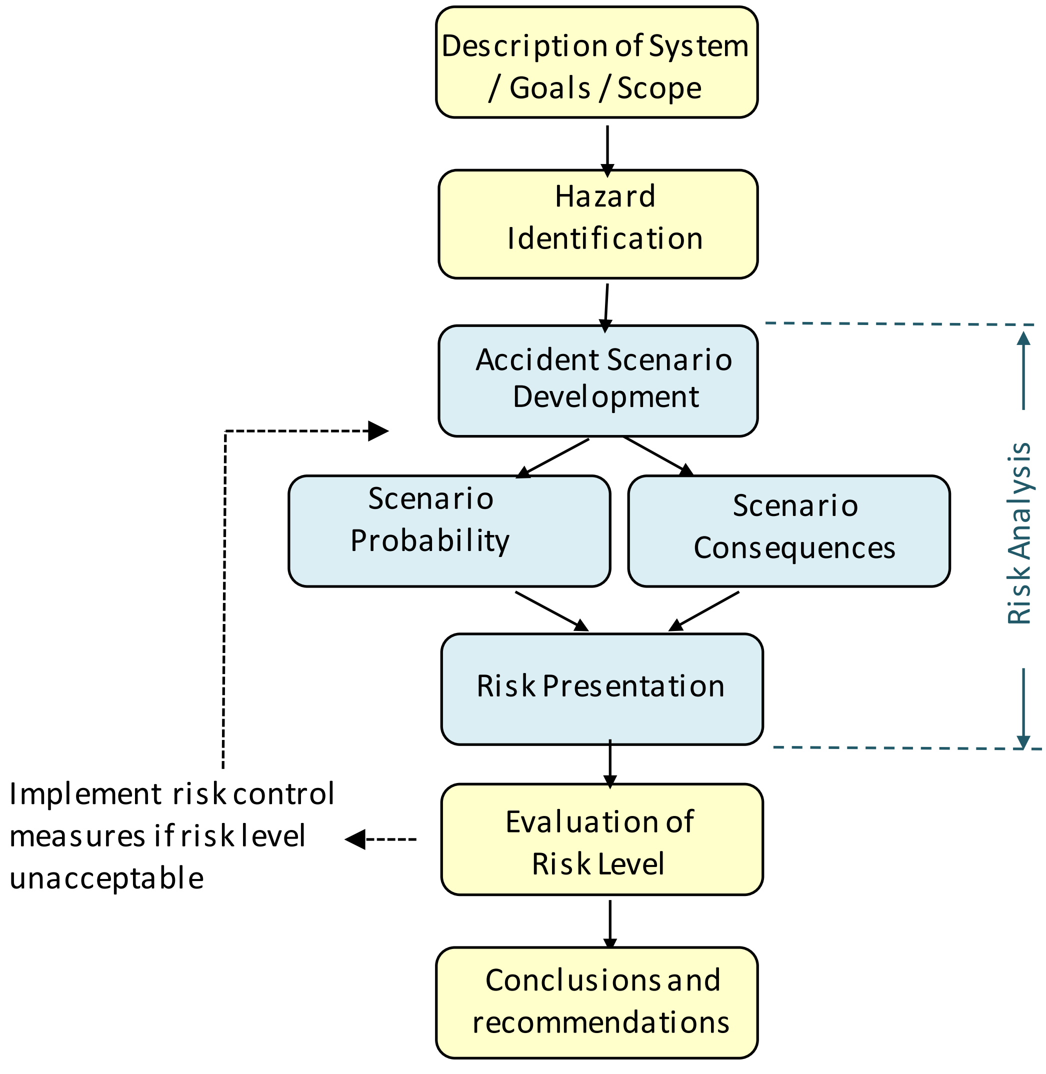
Transportstyrelsens föreskrifter och allmanna råd om maskininstallation, elektrisk installation, och periodvis obemannat maskinrum

Use of low flashpoint fuels constitutes an “Alternative Design”, which requires a risk assessment

Classification Society Rules

Lloyds Register: Provision Rules for Methanol Fuelled Ships (2015)
DNV / GL: Tentative Rules for Low Flashpoint Liquid Fuelled Ship Installations (2013)

Risk assessment process



Case study – *M / S Jupiter* conversion design

M/S Jupiter Vessel Particulars	
Main Dimensions	
Length Overall (LOA)	86 m
Breadth	14 m
Depth	3.45 m
Ramp Length	11 m
GT	737 tonnes
Design speed	11.6 knots
Cargo	
Passengers	397
Passenger cars	60
Loading capacity	340 tonnes

- 4 main engines, 2 fuel tanks
- Östana – Ljusterö route length is about 1100 metres, and the crossing time is 7 minutes
- Vessel operates year round

Hazard identification study objectives

The objectives of the hazard identification study were to:

- identify relevant and foreseeable hazards associated with the methanol conversion design for the *M/S Jupiter*, focussing on the areas of bunkering, fuel tank room (including pumps), and engine room
- describe cause and effects of hazards
- estimate the frequency and severity of hazards where possible
- identify any scenarios and hazards that may potentially need more in-depth risk analysis or risk mitigation measures.

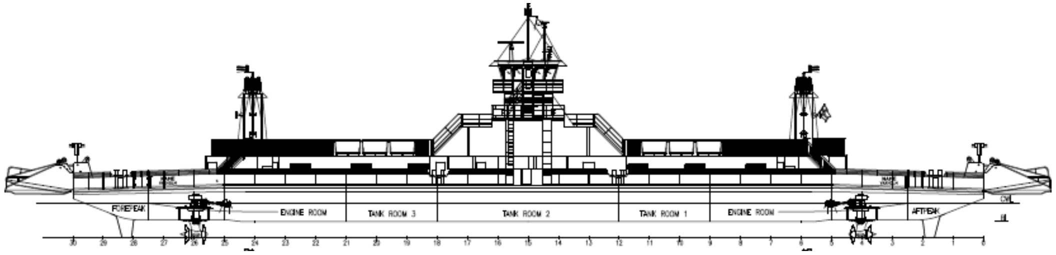
Methodology

The hazard identification study carried out for the methanol conversion design for the *M/S Jupiter* included the following:

- Two hazard identification meetings with participants from the project team, Swedish transport administration road ferry operations:
    - 24 March 2017: structured review of main functional areas to identify potential hazards.
    - 21 September 2017: smaller group meeting to continue the work done at the first meeting. This session also included an "open brainstorming" discussion regarding the design and possible incident scenarios
- Review of accident and incident data for road ferries from the Swedish Transport Agency's casualty database to estimate frequencies of base causes where possible.

HAZID Procedure

- Identify hazards associated with the main functional areas of the design for the Jupiter road ferry:
  - Bunkering
  - Fuel storage
  - Pump area
  - Engine room



- The following lead words were used to ”brainstorm” possible hazards:
  - Leakage, rupture, corrosion, fire, loss of structural integrity, mechanical failure, control system failure, human error, manufacturing defects, material selection
- Scenarios and hazards that may potentially need more in-depth risk analysis were identified
- Opinions/consensus on probability (frequency) and severity of the identified hazards and scenarios collected

Hazard identification session results

- Spreadsheet used to record identified hazards, safeguards, and ratings for each node

	ITEM	CAUSE/DESCRIPTION	HAZARD	POTENTIAL EFFECTS / CONSEQUENCES	SAFEGUARDS	COMMENTS	Risk Component Rating	
							Frequency	Severity
Node 1 Bunkering -	1.1.7	Leakage of valves or pipe in bunker line within vessel	Leakage of methanol into the vessel's tank room (ex classed area)	Fire/explosion	The tank room has gas / vapour detection, is ex-classed. If methanol is detected, the alarm would be triggered and bunkering would be stopped (written procedure to stop bunkering if the alarm sounds). Active ventilation of the tank room. Inspection and testing of piping, appropriate materials used.		extremely remote	minor given that detection systems and safeguards should prevent ignition if there is a spill
	1.2 Rupture							
Node 1 Bunkering -	1.2.1	Bunker pipe damaged by vehicle on car deck	Release of methanol		No vehicles on deck during bunkering	When repairing a damaged bunker pipe, must empty tanks (same procedure as currently happens for diesel). Consider extra protection for bunkering pipe on deck	remote	minor - limited amount of fuel in pipe
Node 1 Bunkering -	1.2.2	Hose rupture	as above for 1.1.2	as above for 1.1.2	as above for 1.1.2	as above for 1.1.2	reasonably probable for rupture, remote to have both rupture and ignition source, as bunkering should take place with no ignition sources	minor if no ignition
	1.2.3	Overpressure of bunker line			Not possible as it is a gravity fed line.		Extremely remote	
Node 1 Bunkering -	1.2.4	Bunker pipe damaged by vehicle on car deck (not during bunkering because vehicles will not be on deck during the bunkering procedure)	Leak of N_2 gas (limited amount - only what is existing in the pipe)	Small amounts of N_2 will leak to open air	Pipe inerted after bunkering, valve on pipe at tank is closed when no bunkering is in progress. Therefore only nitrogen will leak to the open air. Protection of the bunker pipe from vehicle traffic.	Recommend that the bunker pipe is protected from vehicle traffic.	Reasonably probable, at least to sustain damage to the protection	Minor
	1.2.5	Bunker pipe in tank room damaged	Release of methanol	limited release of methanol	Pipe is located in safe area, high up in the room, bunkering pipe enters the top of the tank.		Extremely remote	Minor
	1.2.6	Side impact collision on	Release of methanol vapour	N2 will leak out of the	Bunker line is inerted after			

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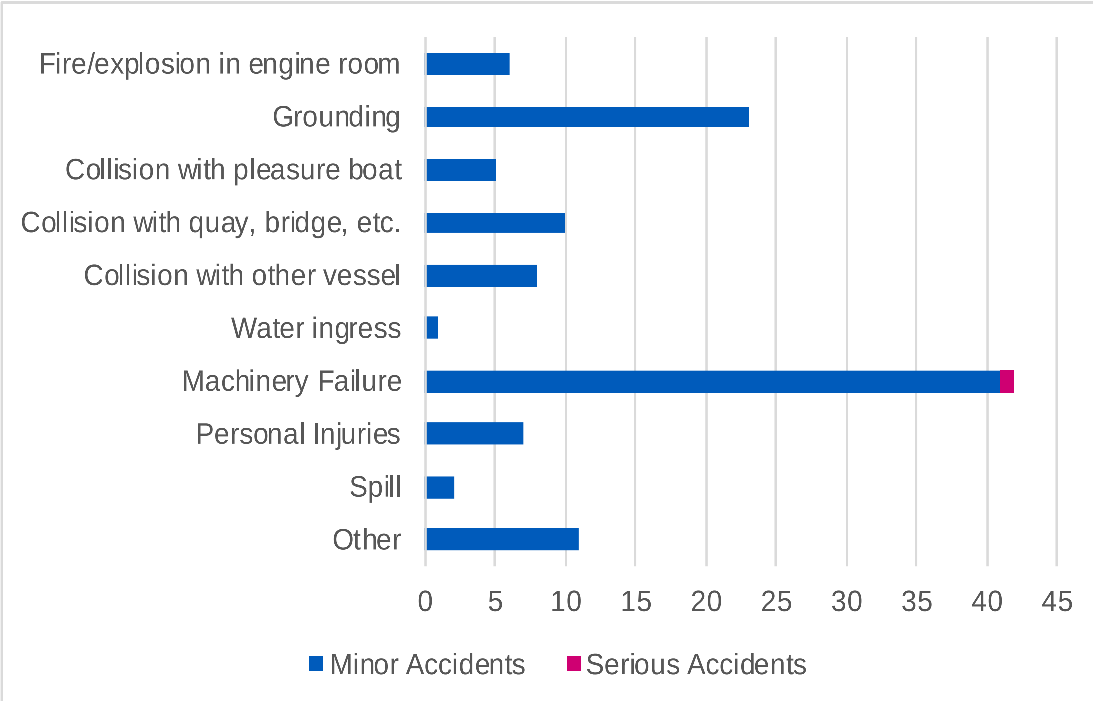
Ranking of Frequency and Severity

Frequency Index			
FI	FREQUENCY	DEFINITION	F (per ship year)
7	Frequent	Likely to occur once per month on one ship	10
5	Reasonably probable	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1
3	Remote	Likely to occur once per year in a fleet of 1000 ships, i.e. likely to occur in the total life of several similar ships	10^{-3}
1	Extremely remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships.	10^{-5}

Severity Index				
SI	SEVERITY	EFFECTS ON HUMAN SAFETY	EFFECTS ON SHIP	S (Equivalent fatalities)
1	Minor	Single or minor injuries	Local equipment damage	0.01
2	Significant	Multiple or severe injuries	Non-severe ship damage	0.1
3	Severe	Single fatality or multiple severe injuries	Severe damage	1
4	Catastrophic	Multiple fatalities	Total loss	10

Source: MSC 83/Inf 2, 2007, Consolidated Text of the Guidelines for Formal Safety Assessment (FSA) for Use in the IMO rule-making process

Road ferry accident from SjöOlycksSystemet
20 year period 1997 – 2016



Accidents involving free sailing Swedish road ferries during the 20-year period 1997-01-01 to 2016-12-31, categorized according to initiating event, as recorded in the Swedish Sea Accident database (SOS). 45 free sailing vessels in the fleet.

Risk Matrix

FIGURE 5
RISK MATRIX

FREQUENCY	Minor	Significant	Severe	Catastrophic
Frequent				High Risk
Reasonably probable	5	1		
Remote	14	”As Low as Reasonably Practicable” 5	6	(ALARP)
Extremely remote	Low Risk 12	3		

CONSEQUENCE

Number of scenarios per category as identified and ranked for the hazard identification study.

Safeguards

Procedures / training:

- Bunkering check list and procedures
- Basic safety training specific to methanol for those accessing pump room / engine room
- Procedures specified for draining possible methanol spills (for example if there is an accumulation under the methanol tank)
- Ensure that a tank entry procedure is in place for any maintenance, and procedures should be specified for when the ship goes for repairs and maintenance

Safeguards

- Method for detection of methanol in the annular space of the double-walled pipes
- Potential pump area leakage (EX-class area): consider ways to localize any leaks from connections for the four pumps in this area
- Review engine safeguards when engine selection has been finalized, considering issues such as vent hood, gas detection

Thank you!