Welcome to Methanol Technical Workshop 20th March 2018 in Copenhagen

This technical workshop is a cooperation between Methanol Institute and MDT designed to address options for ship owners in efforts to comply with IMO regulations on emission reduction strategies with methanol dual-fuel technology.
8.30 – 9.00  Registration and Coffee

9.00 – 9.15  Welcome  
Gregory Dolan  
Kjeld Aabo

9.15 – 9.35  Introduction to MDT and MDT 2-stroke engines and applications  
Kjeld Aabo

9.35 – 10.05  Service experience and latest engine design for Methanol application  
Lars Bay

10.05 – 10.25  Coffee
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker/Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.25 – 10.45</td>
<td>FGSS system for Methanol handling onboard</td>
<td>Roberto Camelli</td>
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<tr>
<td>10.45 – 11.05</td>
<td>Emission test and TIER III compliance</td>
<td>Rene S. Laursen</td>
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<td>11.05 – 11.25</td>
<td>Evaluation of Methanol</td>
<td>Daniel Sahnen, Dipl.-Ing.</td>
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<td></td>
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<td>Research and Development (RD)</td>
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<td>MEYER WERFT GmbH &amp; Co. KG</td>
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<td>11.25 – 12.10</td>
<td>Lunch – (and walk to DA/DRC)</td>
<td>Dan Porup</td>
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<tr>
<td>12.10 – 12.30</td>
<td>Methanol vessel operator safety training at Diesel Academy</td>
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<tr>
<td>12.30 – 13.30</td>
<td>Presentation of test engine 4T50ME-GI/ LGI at the Diesel Research Centre</td>
<td>Lars Bay</td>
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</tbody>
</table>
Volkswagen Group
12 brands

Volkswagen
Audi
SEAT
BENTLEY
BUGATTI
LAMBORGHINI
Porsche
Nutzfahrzeuge
SCANIA
MAN
DUCATI

VOLKSWAGEN FINANCIAL SERVICES
AKTIENGESELLSCHAFT
### MAN SE

#### Business areas

<table>
<thead>
<tr>
<th>Commercial Vehicles</th>
<th>Power Engineering</th>
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<tr>
<td>MAN Truck &amp; Bus</td>
<td>MAN Diesel &amp; Turbo</td>
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</tbody>
</table>

#### Divisions

<table>
<thead>
<tr>
<th>MAN Truck &amp; Bus</th>
<th>MAN Latin America</th>
<th>MAN Diesel &amp; Turbo</th>
<th>Renk (76 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue ‘16: € 9.2 bn</td>
<td>Revenue ‘16: € 0.7 bn</td>
<td>Revenue ‘16: € 3.1 bn</td>
<td>Revenue ‘16: € 0.5 bn</td>
</tr>
</tbody>
</table>

#### Investments

- **Sinotruk** (25.0 % +1 share), **Scania** (17.4 %*)

* Voting rights

### The MAN Group in 2016:

- €13.6 billion revenue, 53,824 employees
Design and production network
MAN Diesel & Turbo sites in Europe and Asia

- Augsburg
- Saint Nazaire
- Berlin
- Frederikshavn
- Copenhagen
- Holeby
- Hamburg
- Deggendorf
- Zürich
- Velká Bíteš
- Oberhausen

Turbo Plants:
- Aurangabad
- Bangalore
- Changzhou

Diesel Plants:
- Hamburg
- Deggendorf

Diesel & Turbo Plant:
- Holeby

- Diesel Plants
- Turbo Plants
- Diesel & Turbo Plant
Compressors, expanders, gas turbines and steam turbines for the oil & gas industry, the process industry and power generation

Full machinery train competence including compressor, drive and expander

Reactors for the chemical and petrochemical industry, special apparatus for science
Power Plants
Broad portfolio for engine-based diesel and gas power plants

- Two-stroke and four-stroke engines from 1,100 kW to 77,500 kW
- Diesel and gas power plants up to 300 MW
- Combined heat and power plants, motor combined cycle
- Excellent fuel flexibility: diesel, heavy fuel oil, biofuels, gas, dual fuel incl. Methanol.
- Operation and maintenance, complete services
- Expandable, modular concepts
Two-stroke and four-stroke engines for marine applications

Output range from 450 kW to 82.4 MW

Marine GenSets from 450 kW to 11.2 MW

Fuels: heavy fuel oil, diesel, gas, dual fuel

Propellers and complete marine propulsion systems incl. fuel gas systems (MAN Cryo)

Axial and radial turbochargers for two-stroke and four-stroke engines, injection systems, systems electronics
MAN Diesel & Turbo – Out of one hand:

- MAN PrimeServ
- Turbocharger
- MAN 2-stroke dual fuel main engine
- LNG tanks
- Fuel gas supply system
- Auxiliary dual fuel GenSets
- Propulsion system
- Emission after treatment

MAN Diesel & Turbo
System Supplier for the Maritime Industry
Marine applications
Powered by two-stroke and four-stroke engines

- Container Ship
- LNG Tanker
- Navy
- General Cargo
- Cruise
- Offshore
- Bulker
- Tanker
- Fishing
Design and Manufacturing
Copenhagen, Denmark

- Design of Two-Stroke Engines
- Production of Spare Parts
- PrimeServ Academy
- R&D Center
- Diesel House

Employees (31.12.2016): 1,250
Most comprehensive engine programme
Diesel engines from 450 kW to 82,440 kW

Four-stroke engines
450 - 21,600 kW

Two-stroke engines 3,200 - 82,440 kW

Comparison (number VW Golf TDI)

4 29 195 747
## Licensees Network

More than 100 years of license business

<table>
<thead>
<tr>
<th>Country</th>
<th>Licensees</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China P.R.</strong></td>
<td></td>
</tr>
<tr>
<td>CSIC, Shanghai Qiyaq Engine (SQE)</td>
<td>◼ 1980</td>
</tr>
<tr>
<td>CSIC, Shaanxi Diesel Engine Heavy Ind., (SXD)</td>
<td>◼ 1978</td>
</tr>
<tr>
<td>CSIC, Henan Diesel Engine Heavy Industry (HND)</td>
<td>◼ 2007</td>
</tr>
<tr>
<td>CSIC, Dalian Marine Diesel (DMD)</td>
<td>◼ 1980</td>
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<tr>
<td>CSIC, Yichang Marine Diesel (YMD)</td>
<td>◼ 1989</td>
</tr>
<tr>
<td>CSIC, Qingdao Haixi Marine Diesel (QMD)</td>
<td>◼ 2014</td>
</tr>
<tr>
<td>CSIC, China Shipbuilding Industry Corporation Diesel Engine Co., Ltd.(CSE)</td>
<td>◼ 2017</td>
</tr>
<tr>
<td>CSSC, CSSC Marine Power (CMP)</td>
<td>◼ 1980</td>
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<tr>
<td>CSSC, Hudong Heavy Machinery (HHM)</td>
<td>◼ 1978</td>
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<tr>
<td>CSSC – CSSC-MES Diesel (CMD)</td>
<td>◼ 2007</td>
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<tr>
<td>Yuchai Marine Power Co., Ltd. (YCMP)</td>
<td>◼ 2016</td>
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<tr>
<td>JingJiang Dingkun Machinery Co., Ltd. (DKM)</td>
<td>◼ 2018</td>
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<tr>
<td>Weichai Heavy Machinery (WMM)</td>
<td>◼ 2008</td>
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<tr>
<td>Hefei RongAn Power Machinery (RPM)</td>
<td>◼ 2008</td>
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<td>CNPC Jichai Power Company Limited (CNPC)</td>
<td>◼ 2009</td>
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<td><strong>Croatia</strong></td>
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<tr>
<td>Brodorsplit</td>
<td>◼ 1967</td>
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<td>Uljanik</td>
<td>◼ 1954</td>
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<tr>
<td><strong>Japan</strong></td>
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<tr>
<td>Kawasaki Heavy Industries (KHI)</td>
<td>◼ 1911</td>
</tr>
<tr>
<td>Mitsui Engineering (MES)</td>
<td>◼ 1926</td>
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<tr>
<td>Mitsubishi Heavy Industries (MHI)</td>
<td>◼ 1929</td>
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<tr>
<td>Hitachi Zosen Corp.</td>
<td>◼ 1951</td>
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<tr>
<td>J.F.E. Engineering (JFE)</td>
<td>◼ 1964</td>
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<tr>
<td>Diesel United (DU)</td>
<td>◼ 1963</td>
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<tr>
<td>Niigata Power Systems</td>
<td>◼ 1973</td>
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<tr>
<td><strong>Korea</strong></td>
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<tr>
<td>Hyundai Heavy Industries (HHI)</td>
<td>◼ 1976</td>
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<tr>
<td>STX Engine (STX)</td>
<td>◼ 1977</td>
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<tr>
<td>STX Heavy Industries (STX HI)</td>
<td>◼ 1977</td>
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<tr>
<td>Doosan Engine</td>
<td>◼ 1983</td>
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<tr>
<td><strong>Poland</strong></td>
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<tr>
<td>H. Cegielski Poznan (HCP)</td>
<td>◼ 1959</td>
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<tr>
<td>Fabryka Silnikow Agregatowych (FSA)</td>
<td>◼ 1995</td>
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<tr>
<td><strong>Spain</strong></td>
<td></td>
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<tr>
<td>Navantia</td>
<td>◼ 1965</td>
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<tr>
<td><strong>U.S.A.</strong></td>
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<tr>
<td>Fairbanks Morse Engine (FME)</td>
<td>◼ 1995</td>
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</tbody>
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### Licensee Types
- ◼ Low-Speed
- ◼ Medium-Speed/MAN
- ◼ Medium-Speed/Pielstick
- ◼ Turbocharger
Worldwide location
Global network of service hubs
Global megatrends
Drivers of our business

Increase of world trade and international passenger traffic

- Worldwide seaborne trade will double until 2030
- Growing demand of energy efficient ships and propulsion solutions
Global megatrends
Drivers of our business

- Worldwide seaborne trade will double until 2030
- Growing demand of energy efficient ships and propulsion solutions

- Global energy demand will almost double until 2030
- Growing importance of decentralized energy generation
Global megatrends
Drivers of our business

### Increase of world trade and international passenger traffic
- Worldwide seaborne trade will double until 2030
- Growing demand of energy efficient ships and propulsion solutions

### Increase of energy demand
- Global energy demand will almost double until 2030
- Growing importance of decentralized energy generation

### Increasing demand of industrial products
- Worldwide consumption will nearly double until 2025 with another 1.8 billion people entering the global consuming class
Global megatrends
Drivers of our business

- Increase of world trade and international passenger traffic
  - Worldwide seaborne trade will double until 2030
  - Growing demand of energy efficient ships and propulsion solutions

- Increase of energy demand
  - Global energy demand will almost double until 2030
  - Growing importance of decentralized energy generation

- Increasing demand of industrial products
  - Worldwide consumption will nearly double until 2025 with another 1.8 billion people entering the global consuming class

- Climate change
  - Introduction of emission standards
  - Growing significance of gas as fuel
Influencing Factors on Fuel Choice

Fuel choice

CAPEX and OPEX

Legislation

Logistics

Fuel price

Sustainability of fuels

Flexibility (dual fuel)

Distillates

Heavy fuel

ULSFO

LNG

Ethane

LPG

Methanol

Biofuel

Man Diesel & Turbo

Dorthe Jacobsen/Ioannis Gekas
### Fuel Types

<table>
<thead>
<tr>
<th>Fuel Type</th>
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<tbody>
<tr>
<td>Residual</td>
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<tr>
<td>Distillates</td>
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<tr>
<td>ULSFO</td>
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<tr>
<td>Methane</td>
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<tr>
<td>Methanol</td>
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<tr>
<td>LPG</td>
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<tr>
<td>Ethane</td>
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<tr>
<td>Biofuel (2nd+3rd gen.)</td>
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**MAN Diesel & Turbo supports all**
ME-GI engine

GI components
Comparing Transport Efficiency
Fuel consumption per tonne-kilometers

Fuel needed per 1km transport of 1 ton of goods

- Ship: 1.5 g
- Train: 7 g
- Truck: 18 g
- Plane: 224 g

- 50% of world trade powered by MAN engines
MAN Diesel & Turbo
“Engineering the Future – since 1758.”
Disclaimer

All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.