MAN Large Engine Portfolio

VW – MAN from 30 kW to 84280 kW

2 Stroke Engines
- MDT S35ME-B9: 3,200 kW
- MDT K98 ME-C: 84,280 kW

4 Stroke Medium Speed Engines
- MDT 5L16/24: 500 kW
- MDT 20V 45/60: 26,000 kW

4 Stroke High Speed Engine
- MTB 12VD28: 1,324 kW
- MDT 20V 28/33: 10,000 kW
Two Stroke New Engine Development
Continous Development of Engine Platform

The engine programme is defined by different engine technology platforms, which can be combined in different combinations.

Platforms

- **Mechanical**: G, S, L, K engines bore 30-98 cm, stroke
- **Control**: MC-C, ME-C, ME-B, ME-Gi, ME-LGi, MC-S
- **Performance**: Mark 7, 8, 9 process parameters (mep, $p_{\text{max}}$, $p_{\text{scav}}$)
- **Emissions**: IMO NO$_X$ Tier 0, 1, 2, 3 IMO SO$_X$, PM
- **Fuel**: HFO, MDO, natural gas, biofuel
Variation of Fuels

- LNG
- LPG
- CNG
- Biogas/biodiesel
- Hydrogen
- Methanol & DME
- HFO
- Distillate Fuels
- Battery
- Emulsions
### Four Stroke Product Portfolio

<table>
<thead>
<tr>
<th>Small Bore</th>
<th>16/24</th>
<th>21/31</th>
<th>27/38</th>
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<tbody>
<tr>
<td>175D</td>
<td>D7</td>
<td></td>
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<tr>
<td>32/40</td>
<td>32/40 G</td>
<td>32/40 G</td>
<td></td>
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<tr>
<td>32/44</td>
<td>32/44 K</td>
<td>32/44 CR</td>
<td>32/44 CR TS</td>
</tr>
<tr>
<td></td>
<td>35/44 DF</td>
<td>35/44 G</td>
<td>35/44 G TS</td>
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<tr>
<td>48/60</td>
<td>48/60 CR</td>
<td>48/60 CR TS</td>
<td>51/60 DF</td>
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<tr>
<td></td>
<td>51/60G</td>
<td>51/60G TS</td>
<td></td>
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<tr>
<td>45/60</td>
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</tbody>
</table>

- **12V/16V/20V**
- **6-9L**
- **6L/9L**
- **12V / 16V / 20V**
- **V12 / V18**
- **12V – 18V**
- **12V / 20V**
- **12V / 20V**
- **6-10L**
- **12V / 20V**
- **12V – 18V**
- **12V – 18V**
- **12V – 18V**
- **12V – 18V**
- **12V – 18V**

#### Key Points:

- **All engines for powerplant applications** with thermodynamic variants
  - 2 power versions
  - net electricity generation
  - combined cycle (CC)
  - combined heat power (CHP)
  + optimised for various climat zones

- **All Marine applications** with
  - Tier III ready with SCR Operation

- **All CR Marine applications** with power management options
### Four Stroke Engine Combustion Processes

**Diesel – Gas – Dual Fuel**

<table>
<thead>
<tr>
<th><strong>Diesel</strong></th>
<th><strong>Gas (SI)</strong></th>
<th><strong>Dual Fuel</strong></th>
</tr>
</thead>
</table>
| Compression ignition | Spark ignition / scavenged pre-chamber | **Diesel:** Compression ignition  
**Gas:** Compression ignition  
Premixed combustion |
| Diffusion controlled combustion | Premixed combustion | Diffusion controlled combustion |

**Diesel**:
- Compression ignition
- Diffusion controlled combustion

**Gas (SI)**:
- Spark ignition / scavenged pre-chamber
- Premixed combustion

**Dual Fuel**:
- **Diesel:** Compression ignition
- **Gas:** Compression ignition
- Premixed combustion
Instrumentation of a 4x/60 DF Engine

In total about 200+ sensors and magnetic valves are controlling the engine and can be used for condition monitoring

Engine Sensor Bill of Material (partial)

Cylinder specific Equipment

- **Gas System**
  - gas injection: 12 magnetic valves
  - ACC: 12 300 bar pressure sensors

- **CR Main Injection**
  - rail pressure after pump: 6 pressure sensors
  - fuel temperature after pump: 6 temperature sensors
  - injector valves: 12 magnetic valves
  - leakage flow: 12 magnetic valves
  - leakage pumps & injectors: 6 magnetic valves

- **CR Pilot Injection**
  - (analog CR main injection)

- **Cylinder Head**
  - exhaust temperature: 24 temperature sensors

Crank Case Surveillance

- splash oil temperature: 12 temperature sensors
- main bearing: 16 temperature sensors
- oil mist detector: 4 Opacity sensors
Adaptive Combustion Control

Cylinder Pressure with ACC
Figure 7b: Effect of the ACC Control on knocking intensity
Overall Solution

Parameters to be measured and calculated based on cylinder pressure and crank angle

- knocking detection
- Calculate pmi (mean effective pressure)
- detection of misfiring
- max firing pressure
- combustion curve (SoC, CoC, DoC)
- air fuel ratio
- combustion temperature
- determination of NOx

SoC  start of combustion
CoC  centre of combustion
DoC  duration of combustion
VPX  cylinder pressure variance over time
PGV  pilot gas valve
PFO  pilot fuel oil

Flexible Applications
in line with the engine market requirements
SaCoS 5000 Full, LTS, XS

HW-Building Kit
Development of a modular H/WI building kit
→ capability of fast development of additional control units for further engine applications

Sw-Building Kit
Realisation of a SW building kit for firmware and systems
→ efficient use of system resources
simple application development
strong improvement of quality

Fct.-Building Kit
Development of a function building kit
→ efficient use of system resources
simple application development
strong improvement of quality
reduction of testing

Methods & Tools
Data management and Tools have been developed. → single source of truth, and improvements in traceability, development efficiency, maintenance and commissioning
Modular Hardware Building Kit

Modular Hardware
- CPU
- DI (digital input)
- AI (analog input)
- TI Temperatur
- FI Frequenz
- CO Current out
- IO injector out
- DO digital out
- AO analog out
- PO Power out
- PS Power supl.
- CAN
- RS485
- Ethernet
- USB

Functional H/W Package
- Temp. Modul
- Power output
- Input Module
- Control Module
- Knock Control
- Injection Control
- Extension Board
- Gateway Com.
- Display

Housings
- 4 Connector
- 5 Connector
- 6 Connector
- 7 Connector
- ICM
- ICM R
- GCM
- DMS

Control Devices

The modular hardware building kit allows to develop quickly further applications such the control units are scalable.
The software function building kit allows short development times to handle all engine variants to fulfil customer requirements.
Data Management Flow

Full round-trip data flow with PREEvision as Data Backbone

1. Engineers create harmonized data.
2. Data Backbone connects data.
3. Business Data Analyst loads correct software and data.
4. Secure transmission of software and data.
5. Technical Data Analyst creates harmonized data.
6. Analyze data for business development.

Configuration:
- Data Backbone
- Engineers
- Technical Data Analyst
- Business Data Analyst

Create harmonized data:
- Analyze data for product improvement
- Analyze data for business development
- Secure transmission of software and data

Web Connection:
- Engine
Condition Based Maintenance
Condition Monitoring + Diagnostics

CBM provides an added value to each step of data processing.

Customer

Uncompressed live data algorithms → Stationary Point detection

Site Data → Data Logger → VPN Client & Firewall → Internet

MDT

More data bases → combine OS data with PrimeServ Lab data etc.

OSWeb

VPN Gateway & Firewall → Data-warehouse

Viewer (& Analyser)

OSWeb

PrimeServ

More data bases → combine OS data with PrimeServ Lab data etc.

Algorithms → Maintenance Indicator, TC cleaning etc.

CBM

Value Creation & Data Stream

Site Data

Data Logger

VPN Client & Firewall

Internet
On Line Ship Surveillance

200 Sensors in the engine Room
7000 channels monitored
2 GB data storage every day
20 GB data transmission every day
2800 Sensors wired to the vessel's main control system
Ship motion data acquired with 20Hz

Source https://worldmaritimenews.com/
Roll Out of a new Satellite Network

- 40 Satellites launched in 2017
- 35 Satellites planned for launch in 2018
Carrier Type Falcon provided by Space X
Bandwidth for Marine download 1.4 Mbit/s
 upload approx. 528 Mbit/s
Possibility of satellited to satellite communication to allow contact to any ground station around the globe
Polar orbit – (connection at angles larger 9° above horizon)
Remote controlled unmanned shipping