Workshop on Modernisation of Danube Vessels Fleet

Vienna 18/4/2018
Sebastiaan Creten
Making the World Greener

- 35 years of experience in automotive industry
- Located in Belgium close to Brussels
- Design, manufacture and supply diesel engine emission aftertreatment systems
- Flexible approach and customized solutions,
- OEM and retrofit, in a wide range of market sectors
1994 Multronic expands its business on production of retrofit systems for industrial engines

1996 Delivery and installation of catalysts and closed loop systems

1999 Main focus is brought to quickly expanding diesel engines market

2001 DE-Tronic ECU system development started for in-house applications

2005 An industrialization agreement for software development and hardware production was signed with Fuel System Solutions/BRC in Cherasco, Italy

2007 OES agreement signed with Scania Benelux for all DPF SYSTEMS EURO III=> EURO V for PM

2010 Licensing agreement with TU Graz for their SCR dosing technology

2012 OEM agreement signed with ZETOR Tractors for Stage IV and TIER 4F for turn key solution

2013 OEM agreement signed with YAMZ for Euro V turn key solution

2014 OEM agreement signed with LIAZ/MAZ/URALAZ/YAMZ for EURO V turn key solution
Milestones

2014 Agreement signed with European Commission and TNO/TUV to develop OBD MARINE standard for marine Stage V

2016 Supply to ZETOR Tractors of the Stage IV system begins

2016 Supply to LIAZ, MAZ, URALAZ, KRAZ begins

2017 KUS® exclusive distribution agreement for all of Europe and Turkey.

2017 Development agreement signed with Ashok Leyland for TIER 4F and Bharat Stage 6

2017 Development of specific urea level /temp sensor and suction system for marine applications; flow rates > 200 kg/h

2017 Development of specific multipurpose diesel level sensor and suction system for marine applications flow rates > 250 kg/h

*Multronic continuously enlarges the number of active partners and ongoing projects and looks for new business opportunities and engineering solutions.*
Marine market
The scoped marine legislations are **MARPOL VI [TIER III]** for coasters and sea going vessels, and **Stage V** for inland shipping in Europe and **EPA TIER 4** for the inland vessels in U.S.A.:

To fulfill **Stage V**, NO$_x$ must be reduced between 80 and 95 %.

This can be achieved by the Multronic SCR and SCR + DPF systems.
Marine Diesel engines

The marine market is characterized by an enormous variety of engines and power ranges. Each type, application must fulfill different emission requirements.

<table>
<thead>
<tr>
<th>Name</th>
<th>Low speed (l/cyl)</th>
<th>Medium Speed</th>
<th>High Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement (l/cyl)</td>
<td>200 - 2000</td>
<td>16-120</td>
<td>0.8 - 3</td>
</tr>
<tr>
<td>Power range (kW)</td>
<td>4000 – 100000</td>
<td>800 - 40000 kW</td>
<td>Up to 10000 kW</td>
</tr>
<tr>
<td>Combustion type</td>
<td>2-stroke &amp; 4 stroke</td>
<td>2-stroke &amp; 4 stroke</td>
<td>4 stroke</td>
</tr>
<tr>
<td>Rotation speed (rpm)</td>
<td>70-300</td>
<td>350 - 850</td>
<td>600 - 2200</td>
</tr>
</tbody>
</table>

Multronic scope
# Emission systems

<table>
<thead>
<tr>
<th>Inland vessels, coaster and luxury yachts</th>
<th>Large cargo vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium and high speed diesel engines</td>
<td>Low &amp; medium speed diesel engines</td>
</tr>
<tr>
<td>4 stroke</td>
<td>2 and 4 stroke</td>
</tr>
<tr>
<td>Good quality fuels</td>
<td>Heavy fuel oil, high sulphur levels, phosphor and ash.</td>
</tr>
<tr>
<td>Good engine load profile</td>
<td>Good engine load profile</td>
</tr>
<tr>
<td>High efficient aftertreatment technology similar to on-road EURO VI heavy duty emission systems</td>
<td>Requires specific EAT solution</td>
</tr>
</tbody>
</table>
Validation of DPF + SCR on ships
(Build in 2011 and 12000 engine hours performed on 1/7/2017)

Barge
This is considered as a normal application
Engine: Scania V8 16 liter 450 kW

Police Patrol ship
Considered as a worst case scenario
Engine: 2 x MTU V2000-01 600 kW
1 x Caterpillar 3516
1590 kW
SCR and DPF

1 x Caterpillar 3512
1250 kW
SCR and DPF
Patrol ship: DPF & SCR

The housing

DPF & SCR

AUS dosing

HC dosing

DOC
Tanker vessel: DPF & SCR

- Spark arrestor also used for urea mixing and distribution
- DPF elements (with SCR coatings)
- SCR and ASC catalysts

- Diesel dosers
- DOC element
- Urea injection area

Flow
Tanker vessel: installation work
Stage V: DPF and SCR

Developed within PROMINENT
To achieve **Stage V** both NO\textsubscript{X} and PM must be reduced between 60 and 90%. This can be achieved with the Multronic modular Stage V marine packages.
Modular Stage V systems

Validation of the Multronic modular Stage V package

- Start of feasibility 01/01/2010
- First ships fitted with proof of concept 01/05/2012
- DPF modules: fitting and removal for maintenance validated
- Electronics, pumps, urea injectors, sensors fully tested
- Main validation for Stage V within PROMINENT
Modular Stage V systems

Design targets

- Easy installation
- Scalable solution for large engine range
- Stainless steel housing
- Airless AdBlue injection
- Compact setup
- Fast electrical and hydraulic fitting

MULTRONIC
Emission Systems
Smaller, Smarter, Sustainable
Cost improvement on catalyst substrates & DPF substrates

**Substrates**
- Available in high number of diameters & lengths and materials and specifications
- Options to reduce cost here is to limit variety

**DOC**
- 6 models
- 1 coating type / washcoat and PGM loading covering full range of ships

**SCR and SCR/ASC**
- 1 substrate model and type package for 50 kW

**DPF substrate**
- Component with the highest constraint
- Largest cost driver over life time (maintenance & service item)
- Drives design complexity (access to substrates for service)
- High volume required to improve cost
- 1 DPF element and package type for 50 kW
Modular Stage V systems

Standard shapes / volumes and module # in function of exhaust flow rate

Standard shape

Square box design

Elements are modular

Housing size varies

Dosing is modular

DOC size varies

3 x 5
Modular Stage V systems

Stage V box design integrated mixing pipe / DOC delivered seperately with cones

<table>
<thead>
<tr>
<th>LAYOUT</th>
<th>DPF &amp; SCR LAYOUT</th>
<th>Flange DIN 2573-PN6</th>
<th>DOC SECTION</th>
<th>DPF &amp; SCR BOX SIZE</th>
<th>Sales price ex works</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Dia p</td>
<td>Dia DOC</td>
<td>DOC L</td>
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<td>mantel mm</td>
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<td>TWIN ROW SYSTEMS</td>
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<tr>
<td>3</td>
<td>2</td>
<td>6</td>
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<td>8</td>
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<td>2</td>
<td>12</td>
<td>200</td>
<td>494</td>
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<tr>
<td>9</td>
<td>2</td>
<td>18</td>
<td>300</td>
<td>574</td>
<td>130</td>
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</table>
Modular Stage V systems

Standard shapes / volumes and module # in function of exhaust flow rate

DOC size varies

Housing size varies

Elements are modular

Dosing is modular

Fixation & gaskets

2 x 3
Modular Stage V systems

CFD study of the different layouts

Targets:
- Standard injection configuration
- Guaranteed performance
- Back pressure estimation
Modular Stage V systems

Multronic EAT system sizing chart
Triple rows DPF + SCR

<table>
<thead>
<tr>
<th># elements</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
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<td>300 °C</td>
<td>2250</td>
<td>2700</td>
<td>3150</td>
<td>3600</td>
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<td>4500</td>
<td>4950</td>
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<tr>
<td>350 °C</td>
<td>3000</td>
<td>3500</td>
<td>4000</td>
<td>4500</td>
<td>5000</td>
<td>5500</td>
<td>6000</td>
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<td>400 °C</td>
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<tr>
<td>600 °C</td>
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<td>9450</td>
<td>10800</td>
<td>12150</td>
<td>13500</td>
<td>14850</td>
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<tr>
<td>MAF (kg/h)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Allowable back pressure (mbar)

Smaller, Smarter, Sustainable
Modular Stage V systems

Advantages

• Standardized modular package for marine
• Over 90% of all components are modular
• Flexible standard solutions for in and outlet position of the systems
• Compliance with marine lifetime expectations
• Long maintenance intervals
• Scope from 300 to 1600 kW
• Mass flow from 1500 up to 18000 kg/h
• Software incorporates all necessary OBD and diagnostic functions
• EPM (environmental performance monitor) integrated
• Low cost system calibration / SW package
• Ready for diesel electrical power trains & gensets
PROMINENT Stage V field validation
PROMINENT field validation

Motorization:
CAT 3508
750 kW
CCR 2

Control system
AUS tank
DOC package
Conversion of existing tank

DPF & SCR system
Engine
Engine
PROMINENT field validation

Visual inspection of DPF performance

SCR at installation

SCR after 10 months of use
PROMINENT field validation

Day 1
Day 2

Warm up ~1 h
PROMINENT field validation
Costs and advantages
Purchase cost

Budget example

• Engine:
  • Caterpillar 3512
  • CCNR 2
  • 746 kW

• Setup:
  • DOC: 30 liter
  • SCR / DPF: 15 modules

• System cost:
  • 100 000 euro / system
    • 25 000 euro baseline
    • 100 euro / kW

• Installation:
  • 1 week at shipyard (for 2 systems incl. tank)
  • 20 000 euro / system (incl. tank)
System cost

Budget example

- Engine:
  - Caterpillar 3512
  - CCNR 2
  - 746 kW
- Purchase cost:
  - System: 100 000 euro
  - Installation: 20 000 euro
  - 1 week out of service
- Operational cost
  - 10 000 l AdBlue on 1 year (~2500 euro)
  - Maintenance: 6000 – 10000 euro
Advantages and drawbacks

Advantages

- Retrofit solution which guaranty to comply to Stage V
  - Emission reductions >90%
  - Mature technique
- Durability and performance of the DPF+SCR system demonstrated on large scale on HD road applications (EURO VI, China VI, BSIV, US 2010 Stage IV and Stage V)
- Limited volume and modifications to ship required
  - Volume of the existing muffler is normally sufficient
  - Possibility to adapt the geometry to the actual situation
  - AdBlue tank volume is limited
- Free choice of engine
- No requirement for new distribution network
  - AdBlue is available on bunker ships
- Commercial value of a green ship
- Several ports give reductions to green ships
Advantages and drawbacks

**Advantages**
- Guaranty to comply to Stage V
- Limited vessel adaptation required
- Mature technology: durability and performance demonstrated on large scale on HD road applications
- Free choice of engine
- Available distribution network

**Drawbacks**
- Operational costs
- Small numbers still result in high installation and system cost compared to HD road applications
- CO2 emissions are not affected
  - Fuel consumption can be tuned in parallel
Please come and visit our stand on the

MARITIME INDUSTRY EXHIBITION,

EVENEMENTENHAL, GORINCHEM,
THE NETHERLANDS
29-31 MAY, 2018
HALL 2 STAND L122

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