Norway-Japan Maritime Green Innovation Seminar
4th June, 2015

KAWASAKI
Environment-friendly
New engine technology

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Diesel Engine Dep’t. Machinery Div.

Kawasaki
Powering your potential
Kawasaki Marine Machinery

- Controllable pitch propeller
- KAWASAKI-MAN B&W 2 stroke diesel engine
- KAWASAKI Marine gas engine
- Side thruster
- Azimuth thruster (Rexpeller®)
- Marine steam turbine & Reduction gear
- Marine Boiler
Today’s Agenda

Environment-friendly new engine technology
  Green Gas Engine for Marine
  K-ECOS (Kawasaki Ecology and Economy System)
  K-GET(Kawasaki Green Eco Turbine)

Summary
GREEN GAS ENGINE for Marine Model L30KG Series
Green Gas Engine for Marine

**L30KG**

**Pure Gas Engine covers 2.6 ~ 4.0 MW**

* Based on ISO3046. Without attached pumps
**Base Engine KG-18V for stationary**

- **Total Sales Number of Unit:** 75 Units
- **Total Capacity:** 568 MW
  
  **As of March 2015**

- **Electrical Output:** 7800/7500 kW (50/60Hz) (*)
- **Generating Efficiency:** 49.5% (*, **)  
- **NOx Emission:** <200 ppm (O2=0%)  
  Appr. 0.8 g/kWh

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* Based on ISO 3046-1  
  Without attached pumps  
** With KAWASAKI specified Lub. oil  
  Tolerance for warranty +5%
Efficiency & Cleanness

<table>
<thead>
<tr>
<th>Specific Fuel Gas Consumption</th>
<th>7200 kJ/kWh(<em>,</em>**)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx Emission</td>
<td>&lt; 1.0 g/kWh</td>
</tr>
<tr>
<td><strong>Well below IMO Tier 3 limit</strong></td>
<td></td>
</tr>
<tr>
<td>SOx Emission</td>
<td>≡ 0</td>
</tr>
<tr>
<td><strong>LNG has almost no Sulphur.</strong></td>
<td></td>
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</tbody>
</table>

* Based on ISO3046. Without attached pumps.
** Tolerance for warranty +5%. With KAWASAKI specified Lub. Oil.

IMO maximum allowable NOx Emissions

![Graph showing NOx emissions over engine speed](chart)

- Tier I
- Tier II
- Tier III
- GGE
**Application**

*KAWASAKI* can engineer your propulsion system and electric generation using its own products.
What is K-ECOS

K-ECOS is a system:
- to comply with IMO NOx Tier3 regulation,
- equipped with
  - Water Emulsified Fuel supply system,
  - Packaged EGR system,
  - Sequential Turbocharger system.
What is K-ECOS

K-ECOS is a system:
to comply with IMO NOx Tier3 regulation,
equipped with

**Water Emulsified Fuel** supply system,
Packaged EGR system,
Sequential Turbocharger system.

Water Particle

Surfactant

**Water in Oil (W/O) Emulsion**
What is K-ECOS

K-ECOS is a system:
to comply with IMO NOx Tier3 regulation,
equipped with
Water Emulsified Fuel supply system,
**Packaged EGR system,**
Sequential Turbocharger system.
**What is K-ECOS**

**K-ECOS** is a system: to comply with IMO NOx Tier3 regulation, equipped with

- Water Emulsified Fuel supply system,
- Packaged EGR system,
- **Sequential Turbocharging system.**

![Diagram of K-ECOS system components]

- **Exhaust gas receiver**
- **Packaged EGR system**
- **Small Turbocharger**
- **Large Turbocharger**
- **Air cooler**
- **Aux. blower**
- **Scavenging gas receiver**
Feature of K-ECOS

In ECA

Thanks to all the equipment, compliance with IMO NOx Tier 3 and same SFOC as conventional engine are achieved.

Outside of ECA

Thanks to WEF and Sequential TC, SFOC is reduced by 4% as conventional engine.

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In ECA:

- Compliance with IMO NOx Tier 3
- Same SFOC as conventional engine

Outside of ECA:

- Reduced SFOC by 4% compared to conventional engine

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Graphs showing:

- SFOC [g/kWh] vs. Load [%]
- Comparison of EGR, HL, and K-ECOS
- T/C Cut+WEF+EGR

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Graphs showing:

- SFOC [g/kWh] vs. Load [%]
- Comparison of HL, LL-EGB, and K-ECOS
- T/C Cut+WEF and WEF
Service test with K-ECOS

<table>
<thead>
<tr>
<th>Ship owner</th>
<th>K-Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipyard</td>
<td>Japan Marine United</td>
</tr>
<tr>
<td>Ship type</td>
<td>Pure car carrier (7500 cars)</td>
</tr>
<tr>
<td>Ship delivery</td>
<td>February 2016</td>
</tr>
<tr>
<td>Main engine</td>
<td>KAWASAKI-MAN B&amp;W 7S60ME-C8.2</td>
</tr>
<tr>
<td>Engine delivery</td>
<td>June 2015</td>
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</table>

All K-ECOS functions were confirmed on Shop test in May 2015
**K-GET** is a waste heat recovery system: converting waste heat into power by Power turbine and utilizing it as propulsion power.
Structure of K-GET

View from fore side

K-GET Power Transmission

Power turbine

Reduction gear

Clutch

Reduction gear

Elastic coupling
Shop trial with K-GET

Planned power turbine output (= improvement of main engine SFOC) has already been checked. (SFOC of -2～-3%)

6S50ME-B8.2 7,730kW x 108min-1
ISO Condition, LCV=42,700 kJ/kg

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Service test with K-GET

<table>
<thead>
<tr>
<th>Ship owner</th>
<th>Taiwanese ship owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipyard</td>
<td>Kawasaki Heavy Industries</td>
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<tr>
<td>Ship type</td>
<td>Bulk carrier</td>
</tr>
<tr>
<td>Main Engine</td>
<td>6S50ME-B8.2</td>
</tr>
<tr>
<td>Engine delivery</td>
<td>May 2014</td>
</tr>
<tr>
<td>Ship delivery (Test start)</td>
<td>January 2015</td>
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</table>
Summary

• Kawasaki Green Gas Engine realizes lowest fuel consumption and cleanness for marine application.

• With K-ECOS, Compliance with IMO NOx tier3 and fuel consumption as present at the same time.

• With K-GET, waste heat can be utilized for various kinds of vessel.

• Kawasaki will continue developing new technologies to answer calls for more environment-friendly marine vessels.
Kawasaki, working as one for the good of the planet
“Global Kawasaki”

Any questions, please contact

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