The Dry Package: a combined solution for emission reduction on “Z“ engines
More and more attention is being placed on the impact that emissions from diesel engines have on the environment: this thanks to the increased awareness and concern towards the effects of commercial and industrial operations on the environment, individuals and communities. Thanks to environmental regulations on emissions, at both global and local level, International Organisations and State Authorities are controlling levels of smoke, particulates, NOx, SOx and other pollutants.

The emission of pollutants into the air is controlled and limited both from a chemical (NOx, SOx present in the exhaust gas) and a physical point of view (visible smoke emitted).

Responding to the market signals, the Wärtsilä Dry Package confirms the commitment to provide our customers with environmentally sound solutions that help to achieve lower smoke and NOx emissions while, at the same time, improving operational performances.
BENEFITS ON THE "DRY PACKAGE"

Considerable reduction of smoke visibility at low load
The Dry Package effect is to balance the higher smoke emission level coming from a non-optimal combustion process when engines are running at low loads, typical situations present when a ship is in manoeuvring or in low load cruise mode.

Reduction of NOx emissions at any load
With the Dry Package the NOx emissions are reduced to a level considerably lower than the IMO requirements. Benefits of this reduction can be seen both on engines already E.I.A.P.P. certified and on those for which certification is not required by Marpol 73/78 - Annex VI.

More stable and lower lubricating oil consumption
When the Dry Package is installed, the formation of carbon deposits in the combustion chamber is reduced and this results in a cleaner lubricating oil and engine. Moreover, less carbon deposits on the piston top landing surface mean a decrease in lube oil consumption, a critical step towards achievement of major savings in lube oil operational costs.

Test performed on 6LZA40S showed up to 60% reduction in smoke emissions (Filter Smoke Number, FSN) at 25% load and lower visible smoke at 30% load

THE PRODUCT AT A GLANCE

The Dry Package is the latest solution developed by Wärtsilä Services for reducing emissions of diesel engines in marine installations.
By means of different technologies, the Dry Package offers multiple benefits in terms of:
• Visible smoke, which is reduced at low loads
• NOx, which is reduced at any load
• Operational performances, which result improved.

The Dry Package is a combination of different packages developed by Wärtsilä Services for Sulzer ZA40S engines, all together now combined into one single solution with optimized performances:
• Variable Inlet valve Closing (VIC),
• Combustion Chamber Modification (CCM),
• Anti Polishing Ring (APR).

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NOx REDUCTION & E.I.A.P.P.

With the installation of the Dry Package, lower level of NOx emissions is obtained compared to the standard engine.
Tests performed on a laboratory engine measured 9,7g/kWh of NOx, instead of the already certified 10,5-10,8g/kWh of the standard configuration.
Based on these results, the new engine configuration, with Dry Package installed, is E.I.A.P.P. certified by Lloyd Register with NOx emission of 9,7g/kWh.
Combustion chamber configuration is one of the primary factors which influence efficient combustion and consequent engine performances. Geometry of the spray nozzles and piston crowns directly determines the spray patterns and the related effectiveness of the combustion processes. Starting from the standard combustion chamber configuration available on the latest version of ZA40S engines produced, Wärtsilä Services has designed a modified version with a dedicated and optimized engine set-up. Before arriving at the final configuration, several combinations of piston crown, nozzles with different spray patterns and timing have been tested. The new set-up chosen, while maintaining the same compression ratio as the standard engine, achieves the best performance in terms of smoke and NOx emissions.

**VARIABLE INLET VALVE CLOSING (VIC)**

Higher smoke emission levels are mainly related to engine start-up, transient conditions, fast loading, low load operations, or manoeuvring mode. This is the typical consequence of the fact that conventional engines operations are optimized (in terms of air and fuel for combustion) at higher loads, those of normal operation, generally from 75 to 85% load.

The VIC system has been designed to overcome the effect of non-optimal combustion at low loads. The functioning principle, based on the delayed inlet valve closing, determines a better air filling in the combustion chamber and an increased compression pressure prior to injection which results in an optimized combustion.

**The working principle** of VIC is based on the modification of the Miller timing when engine is running at loads under a specified value, usually 50% MCR (other values can be set depending of operational needs). Over 50% MCR the system is back to standard engine functioning.

<table>
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<tr>
<th>&lt; 50% load: VIC Timing</th>
<th>&gt; 50% load: Standard Miller Timing</th>
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<tbody>
<tr>
<td>Inlet Valve opens at crank angle 35° before TDC</td>
<td>Inlet Valve opens at crank angle 35° before TDC</td>
</tr>
<tr>
<td>Inlet Valve closes at crank angle 15° after BDC</td>
<td>Inlet Valve closes at crank angle 16°±1 before BDC</td>
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Installed on the inlet valve assembly, the VIC system is fully hydraulic. It is controlled by charge air pressure via an electric control valve and it is powered by 7 bar air through an independent supply line.

**COMBUSTION CHAMBER MODIFICATION (CCM)**

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ANTIPOLISHING RING (APR)

The Anti Polishing Ring is a long term experienced product in the Wärtsilä group, available today for the majority of engine types. The APR is a centrifugal cast-iron separate ring installed in the upper part of the cylinder liner. The main beneficial effects of its installation are more stable lube oil consumption, reduced wear and consequent prolonged lifetime of cylinder liners, reduced quantity of hydrocarbon and carbon deposits in the combustion chamber; all the above results directly in a cleaner engine and indirectly in lower emissions.

How it works
The inner smaller diameter of the APR allows proper calibration of carbon deposits on the piston top land determining a reduction in the contact between the carbon deposits and the liner inner wall. This leads to a reduction of liner wear and stable lubricating oil consumption.

Typical example of increasing lube-oil consumption in time, in case of non use of APR.
The points on the blue line indicate the calculated hourly lube-oil consumption, based on periodical topping-up. On the contrary, when an APR is installed, a more stable Lube-oil consumption is achieved; the estimated lube-oil saving is represented by the orange lined area.
Data are given for reference only, as an example of the trend.

The new shape of piston crown top has been developed through thermal and mechanical analysis, supported by FEM simulations. The theoretical results were successively confirmed by laboratories tests performances.
E.I.A.P.P. CERTIFICATION

The Dry Package is applicable and can be installed both on "IMO engines" (already E.I.A.P.P. certified) and "not IMO engines" (engines for which certification is not required, as per Marpol 73/78 - Annex VI).

For "non IMO engines":
Referring to the NOx Technical Code, Regulation 13 of Annex VI of MARPOL 73/78, the Dry Package is not considered a "Major Conversion": after installation of the Dry Package on an existing engine, the EIAPP certification is not required. Certification can be in any case provided if requested by the engine owner (for example when specific local regulations require an official declaration of NOx level).

For "IMO engines":
After the installation of the Dry Package on an engine already E.I.A.P.P. certified, the related certification will be updated.

MARPOL

The most important Convention regulating air pollution by ships is the IMO International Convention for the Prevention of Pollution from Ships (MARPOL 73/78 - Annex VI) which entered into force on 19.05.2005. It addresses air pollution caused by NOx and SOx emissions, as well as pollution from chemicals, goods in packaged form, sewage and garbage.

Regulation 13 of Annex VI and related Technical Code is dedicated to NOx and sets the emission target for diesel engines as a function of engine rpm. All engines having a power output of more than 130kW, installed on ships, the keel of which was laid on or after 1st January 2000, need to comply with the regulation.
FIELD OF APPLICATION

The Dry Package can be applied to all ZA40S engines.
For engines having configuration 720 kW/cyl with internal lubrication, the full package can be provided as a standard solution.
For engines having other configurations extended upgrades can be provided.

INSTALLATION

Owing to the nature of the parts involved and changed settings, the installation of the Dry Package is recommended to be done during a major overhaul.
In case of short engine stops or major overhauls scheduled in the long term, specific preparation and installation plans can be done following customer’s need (sub-packages).

LOOKING TO THE PRESENT AND THE FUTURE

While the need for engine operation with non-visible smoke has grown in recent years, and is expected to become even stricter in the future, the environmental taxes tied to NOx emission levels are drawing the owners’ and operators’ attention to the IMO regulations and other local regulations requiring limited NOx emissions.

Wärtsilä is continuously looking for and developing new technologies for its customers to meet these requirements, to ensure environmentally sound operations in terms of low emissions, low environmental impact and sustainability.

The combined benefits of the Dry Package solution allow for significantly reduced smoke/NOx emissions, lower fuel consumption, more stable lubrication oil consumption and reduced liner wear.

Take advantage of Wärtsilä Dry Package solution and make your diesel engine environmentally friendly achieving savings in engine operations and in emission taxes!