

AVL EPOS™

Predictably Powerful – Condition Monitoring of Large Engines





AVL EPOS™

AVL – YOUR PREFERRED PARTNER FOR FIELD OPERATION OF LARGE ENGINES

AVL EPOS™ (Engine Performance Optimization System) is AVL's condition monitoring platform for large engines. It combines class leading R&D measurement technology with large engine engineering and combustion expertise of the world's largest, independent powertrain engineering and measurement company.

Based on AVL's long term experience in development, testing, and field support of large engines, AVL is able to offer products and services which are tailor-made for customer-specific needs.

AVL EPOS™ and AVL field support services are designed to support you in

- increasing engine efficiency and reducing fuel costs
- reducing maintenance and service costs (by providing information for condition based maintenance)
- preventing engine damages and standstills, by continuously monitoring the condition of your engines

CUSTOMIZED TO YOUR NEEDS

The following building blocks can be combined depending on customer needs:

- AVL EPOS™, the software platform for condition monitoring of large engines
- AVL measurement hardware for cylinder pressure measurement and data acquisition
- AVL engineering's services including on-site measurements, data analysis and field operation support

Additionally, AVL offers customized solutions and software modules e.g. for

- emission monitoring (AVL EPOS™ – NO_x Module)
- turbocharger monitoring (AVL EPOS™ – Turbocharger Module)
- fleet monitoring (AVL EPOS™ – Multiengine)
- portable engine diagnosis (AVL EPOS™ – Portable)



AVL Field
Support &
Expertise
Services

AVL EPOS™
Software

Third party
modules

AVL
Measurement
Hardware

AVL EPOST™ – THE PLATFORM

AVL EPOST™ provides condition monitoring based on automated engine diagnosis – for monitoring of large combustion engines and their auxiliaries.

UNIQUE – by using expert algorithms AVL EPOST™ provides valuable information regarding probable malfunctions or upcoming failures of the engine at a glance at component level of each cylinder.

Thus, in comparison to all other engine condition monitoring systems on the market, AVL EPOST™ does not leave the evaluation and analysis of data solely to the engine operator.



AVL EPOST™ – Main Window GUI

AVL MEASUREMENT HARDWARE – THE BACKBONE

Central source of information of the system is the cylinder pressure measurement. However, any other source of information can be used and integrated into the system to improve engine diagnostics (e.g. exhaust temperature information from the automation system)

AVL provides cylinder pressure sensors for continuous monitoring (GO series) as well as the Smart Indicating Unit (SIU) for efficient data acquisition. Sensor lifetimes of more than 50,000 h for HFO and 25,000 h for gas operation have been achieved until today.

AVL EPOST™ is designed as an open diagnosis platform – accepting the systematic integration of third party sensors, systems, or information by supporting most interface types used in the industry (e.g. modbus).

AVL SERVICES – YOUR ADDITIONAL BENEFIT

In addition to AVL EPOST™ System, AVL also offers extended technical expertise services on a regular basis for continuous system optimization and for trouble shooting in addition.

The following services are available:

- on-site engine inspection & surveys (i.e. excessive component wear, TC retrofit, vibration problems etc.) and measurements (e.g. combustion analysis, emission measurements) Engine Performance Analysis & Report Generation
- Engine Diagnostics & Troubleshooting & root cause analysis
- Fleet Management & Condition-based Maintenance



AVL Smart Indicating Unit and AVL Cylinder Pressure Sensor for Continuous Monitoring (type approved by GL)

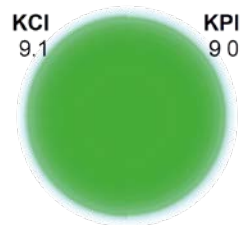


KEY FEATURES OF AVL EPOST™



AVL EPOST™ displays the engine status via a simple TRAFFIC LIGHT style indicator. Further screens show measurement data and diagnosis in different detail and depth. In case that one of the predefined fault patterns is identified, the system provides cylinder specific output on engine component level.

All measurement results as well as the diagnosis are stored into an internal database, supporting performance comparisons or trend analysis. The extent and depth of diagnosis is under continuous development.



Key condition index (KCI) – for tracking the engine condition via a single parameter – how “healthy” is the engine?

Key performance index (KPI) – for tracking the engine performance via a single parameter – how “efficient” is the engine?

Failure matrix – The implemented expert algorithms provide an evaluation of the measurement data regarding predefined engine failures. The results are illustrated in a “failure matrix”. The matrix covers failures related to fuel injection system, combustion process, liner/piston behavior, valves, cylinder balancing and also sensor self diagnosis functions.

DATA ANALYSIS

In addition to the unique diagnosis functionality, AVL EPOST™ provides state of the art combustion and engine performance analysis functionality.

Illustrations of cylinder pressure curves, combustion data including all relevant combustion parameters (e.g. p_{max} , α_{Pmax} , MIP) and statistical values are available.

Tuning recommendations are given by cylinder balancing diagrams for optimum engine operation.

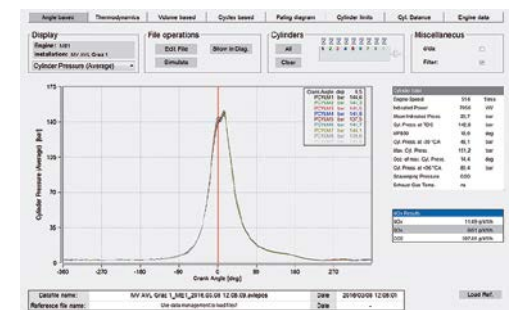
Further, diagrams for the investigation of history and trend data are available.



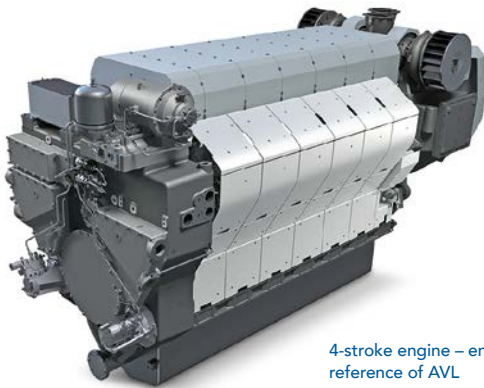
Data Analysis –
Balancing Diagram

Fault type	C 1	C 2	C 3
Cylinder Status			
Piston rings leaking			
Intake throttling			
Exhaust valve leaking			
Small injection quantity			
Large injection quantity			
Early injection			
Late injection			
Injection system			
Pre-ignition			
Clogging of indicator channel			
Compression loss			
Sensor failure			

AVL EPOST™ – Failure Matrix (example)



Data Analysis – Cylinder Pressure Curves



4-stroke engine – engineering reference of AVL

APPLICATION RANGE

AVL EPOS™ is applicable to all types of large-bore engines:

- 2- and 4-stroke
- HFO, diesel, gas, dual-fuel and biofuels
- slow, medium and high speed
- all types of installations (marine, rail, off-road, stationary, etc.)
- no reference data (e.g. shop test) needed for failure detection

HARDWARE SOLUTIONS

AVL EPOS™ – Permanent (online) installation

This installation type uses permanently installed cylinder pressures sensors on all cylinders. It ensures continuous monitoring of the engine condition, providing maximum functionality and operational safety (e.g. for the continuous monitoring of main engines)

AVL EPOS™ – On demand (offline) installation

This installation type uses a movable pressure sensor to allow for on-demand engine diagnosis. This installation type is typically used as an cost effective extension to a permanent installation e.g. for condition monitoring of auxiliary engines.

AVL EPOS™ – Portable

AVL EPOS™ – Portable is AVL's mobile diagnosis solution for large engines, providing the full expert diagnosis functionality. Designed as a carry-on measurement system, it provides maximum value at minimum costs.



2-stroke engine



2-stroke engine – testing with AVL equipment

SOFTWARE SOLUTIONS

AVL EPOS™ – NO_x Module

This is the world's first model based expert system for emission monitoring. On the main emission monitor online values for NO_x, SO_x and CO₂ emissions are displayed. In addition, the engine emissions can be evaluated according to the relevant maritime emission test cycle (e.g. E3). The system complies with IMO regulations for the on-board NO_x verification procedure (confirmation of compliance by DNV GL).

AVL EPOS™ – Turbocharger Module

The turbocharger module provides information on performance and condition of turbochargers and its auxiliaries (charge air cooler, air filter). It is based on a thermodynamical assessment of the turbocharger operation, providing detailed insight on the "health" status and efficiency of turbine and compressor.

AVL EPOS™ – Multiengine

For operators with more than one installation, AVL EPOS™ – Multiengine provides an overview on multiple installations at a glance – allowing the comparison and management of multiple installations on plant and/or fleet level.

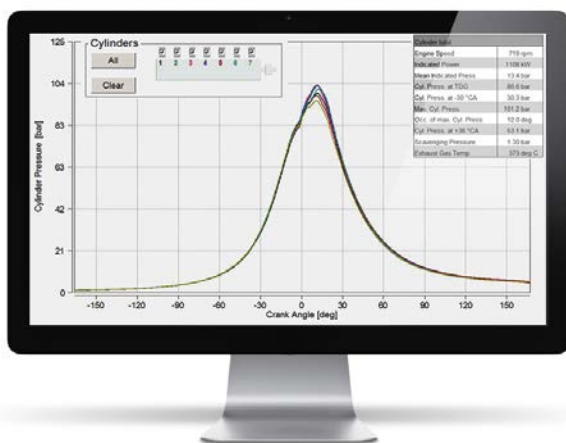
AVL EPOS™ – MIP

AVL EPOS™ – MIP is your entry to condition monitoring. Without expert diagnosis algorithms and failure indication all basic data analysis functionality are available. The software can be easily upgraded to the comprehensive functionality of AVL EPOS™.

Customized solutions

Depending on your demands, AVL is able to offer tailor-made functionalities. The implementation of customized functions or reporting formats can further extend the scope of AVL EPOS™.

Data Analysis – Injection Failure



A failure of the injection pump was thereafter confirmed by the chief engineer. In this case, the use of continuous engine monitoring enabled a detection of this failure within hours after occurrence – facilitating optimum engine performance and the consequent avoidance of subsequent engine damages.

REFERENCES

The first two installation of AVL EPOS™ were commissioned in 2008. Since then, two new software generations have been developed and numerous installations have been conducted – including power plants, locomotives and numerous vessel types (e.g. car carrier, container vessel, VLCC, ferry).

Based on these installations and corresponding run times of more than 50,000 h, AVL EPOS™ and the corresponding measurement hardware is under continuous development – providing a product with maximum value for customers and users. Systems with AVL EPOS™ have been installed all over the world – providing plenty of „stories“ on diagnosed engine malfunctions (of which some otherwise most likely never were detected):

- leaking injection pumps
- burned piston crowns
- frozen VITs
- damaged fuel injectors
- leaking exhaust valves
- unbalanced engine tuning
- and many more.

The picture of the failure matrix shows an exemplary engine diagnosis of an on board installation. A major fault is indicated for the fuel pump of cylinder 7 via a red flag (small injection quantity).

The corresponding cylinder pressure curves show a rather small deviation with regard to the maximum cylinder pressure of this cylinder – however, an analysis of the data relieves a discrepancy of the injected fuel mass by almost 10 % – verifying a severe malfunction.

Fault type	C 1	C 2	C 3	C 4	C 5	C 6	C 7
Cylinder Status							
Piston rings leaking							
Intake throttling							
Exhaust valve leaking							
Small injection quantity							
Large injection quantity							
Early injection							
Late injection							
Injection system							
Pre-ignition							
Clogging of indicator channel							
Sensor failure							
No combustion							
Early exh. valve opening							
Late exh. valve opening							

Failure Matrix – Injection Failure





RETURN ON INVESTMENT

SECURE ENGINE OPERATION

AVL EPOST™ continuously monitors the engine and warns of imminent damages. Engine malfunctions and resultant engine damages are very expensive for large-bore engines – each year millions of dollars are spent on engine repairs throughout the industry. On average, a main engine failure causes overall costs of more than 500,000 \$ (source: The Swedish Club). Therefore, preventing one major engine failure already easily returns the investment.

REDUCTION OF MAINTENANCE AND SERVICE COSTS

Continuous monitoring of upcoming faults in conjunction with a regular engine operation optimization increases the reliability and lifetime of the engine. If continuously used, AVL EPOST™ helps to avoid unplanned repair works, increased wear mechanisms and engine malfunction or even engine damage – supporting the implementation of condition based maintenance strategies with a potential cost advantage of up to 30 % compared to conventional preventative maintenance strategies.

PERFORMANCE AND EFFICIENCY OPTIMIZATION

AVL EPOST™ is your tool to optimize the engine operation by immediate recognition of engine malfunctions and unequal operation of single cylinders. Based on the experiences of existing AVL EPOST™ installations the optimization of the engine operation provides a significant fuel saving potential – reported fuel savings are in the range of 4–6 g/kwh for regularly maintained engines at high engine loads.

PAY BACK PERIOD

Depending on the application, installation type, and engine specification the pay back period varies. For most customers the system provides a return on investment within the duration of one year – contact us to discuss your ROI (epos@avl.com).

\$ **R** **O** **I** **Return**
On
Investment

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