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MEASUREMENT & ANALYTICS

# Cylmate systems

Combustion under control



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# Knowledge is a continuous process

With the Cylmate system you will reduce the costs for maintenance and fuel – resulting in a short payback time.

A modern engineer wants to feel secure and comfortable about the diesel engine performance. The Cylmate system will provide all the key knowledge for optimum engine operation.

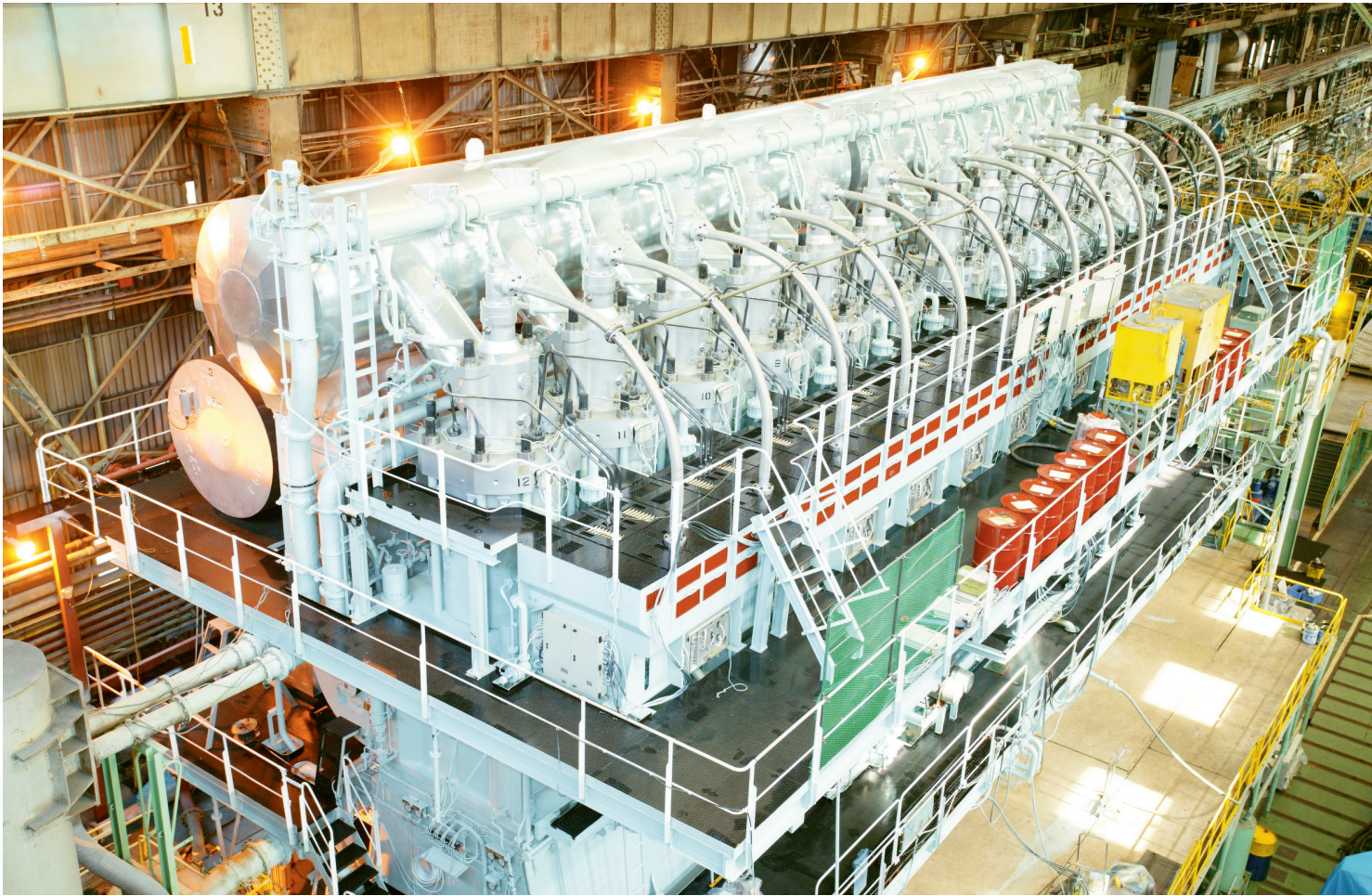
ABB's Cylmate system is a comprehensive system for continuous engine performance measurement and performance monitoring. A unique combination of measurements of cylinder pressure and crank shaft position in combination with advanced mathematical modeling of the engine provides very accurate, real-time data for monitoring and diagnostic analysis.

The quality of the data ensures very significant benefits from improved reliability, reductions in operating costs and minimizing off-hire costs.

With the Cylmate system you will get the key knowledge for obtaining optimum and reliable engine performance:

- Reduced fuel consumption
- Performance monitoring 24/7 will detect and identify errors in the engine at a very early stage.
- A “black-box function” will keep track of the history behind the combustion alarms.
- Condition-based maintenance will prolong the life of components and minimize the operating costs.
- An engine in good balance will avoid thermal and mechanical overloads by assuring that the power distribution is equal between the cylinders.
- An optimized engine will make it easier to comply with environmental regulations.





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— 01 By installing the Cylmate system, already at the shop tests, invaluable data can be recorded at different load conditions and used as future reference comparison.

Knowledge will become even more important. Therefore the Cylmate system is designed to provide real-time information required by electronically controlled engines in order to optimize the engine operation by closed loop control of the combustion process.

The Cylmate system brings a new level of engine performance management.

The Cylmate system is a powerful tool developed by ABB for diesel engine performance monitoring. The system, which fits both marine and power plant applications, is designed to withstand marine environmental conditions and fulfills the requirements of classification societies.

The combustion pressure is measured in each cylinder, continuously and in parallel, under all load conditions.

The Cylmate analysis and monitoring functions mean that the risk of mechanical or thermal overload of individual cylinders or the engine itself can be avoided. Further, the cylinder conditions can be optimized and the engine can easily be balanced and tuned in order to improve the running performance. With the Cylmate system you will reduce the costs for maintenance and fuel – resulting in a short payback time.

# Cylmate system

## Key components

The pressure in each cylinder is measured continuously by ABB's accurate and proven transducer based on the Pressductor® technology.

- 01 Accurate scanning of the crank shaft angle position at the flywheel.
- 02 The pressure transducer design permits blow-through cleaning to prevent any build-up of combustion residues.

The position of each piston is determined by accurate measurement of the flywheel angle in combination with advanced crank shaft modeling. The pressure signal is then processed and shown against the corrected piston position throughout the combustion cycle; the vital engine performance parameters are derived from this data.

The Cylmate system consists of a pressure transducer on each cylinder and an angle transducer at the engine flywheel, which all are connected to the Cylmate transducer bus. The controller collects all measured data within each engine working cycle via the transducer bus.

A built-in mathematical engine model computes, in real-time, the crank shaft deflection in order to get the correct TDC angle and piston position of all cylinders. All combustion parameters such as Pmax, a-Pmax, Ptdc, MIP, Indicated Power and so on, are logged and monitored for each stroke and can be shown in trend diagrams.

Any deviation from normal performance will be presented as an alarm. Evaluated data, alarms and events are transmitted via Ethernet LAN to the Cylmate operator station as well as to superior systems, if connected.

### Pressure transducers, with 5 years warranty

The unique, patented, ABB Cylmate pressure transducer has proven its maintenance- and calibration-free performance and reliability during years of continuous operation.

The transducer is factory-calibrated and designed for continuous combustion pressure measurement – 24 hours per day, 365 days per year, without any need of recalibration.

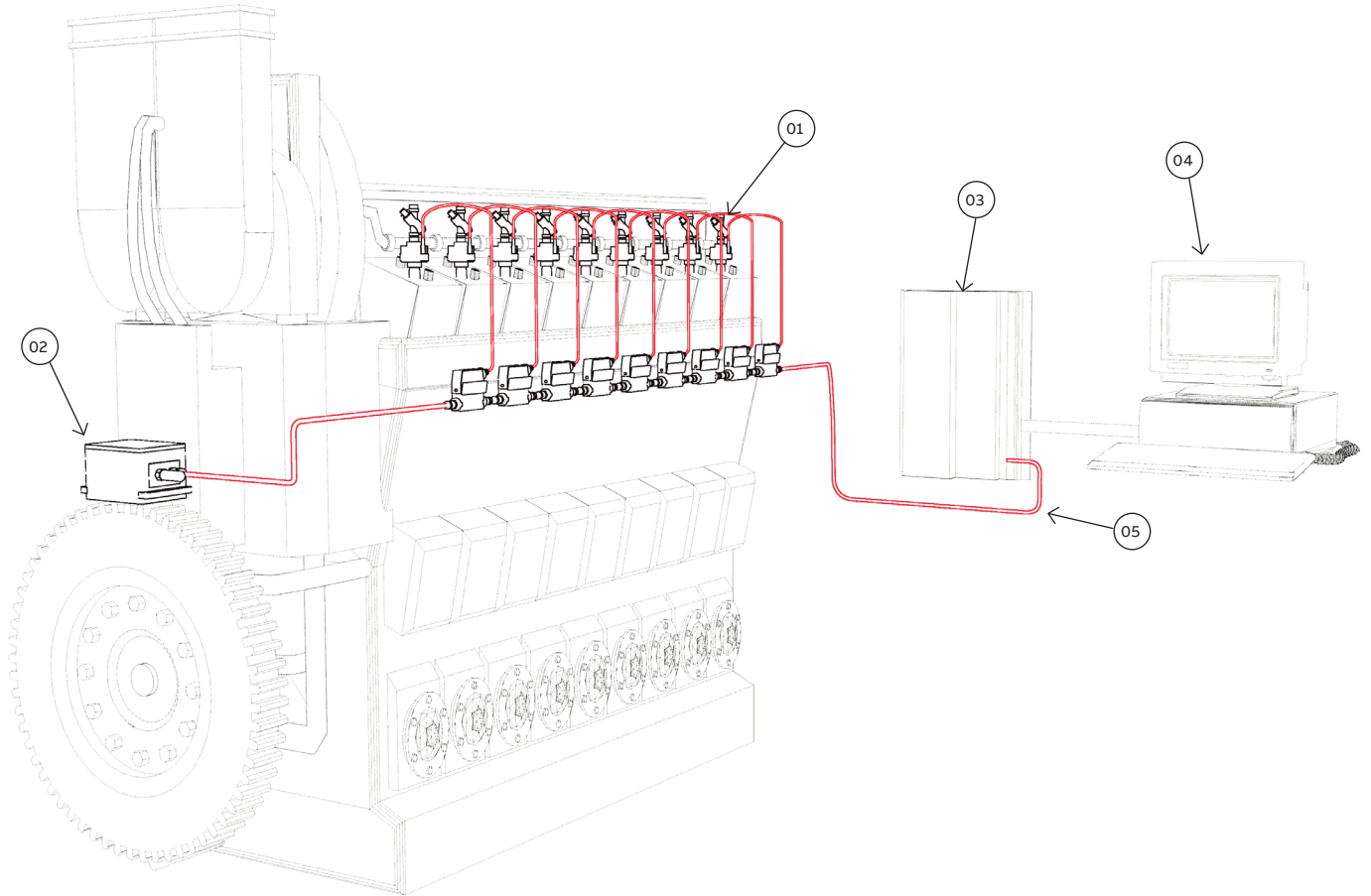
The measuring accuracy is 0.5 % over the full measuring range and the accuracy is not influenced by any clogging or heat flash from the combustion gases, which is a common problem of membrane-based pressure transducers.



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- 01 Cylmate pressure transducers.
- 02 Cylmate angle transducer.
- 03 Cylmate controller.
- 04 Operator station.
- 05. Cylmate transducer bus.

### Angle transducer

The angle transducer is mounted close to the flywheel and is based on the Pulsed Eddy Current technology, patented by ABB. It will find the middle of each tooth with an accuracy better than  $0.05^\circ$ .

Since the number of flywheel teeth may not be that big and the fact that the flywheel rotates with an irregular velocity, the system interpolates the angle value between two teeth using the speed information from the four closest tooth passage according to a 2nd order polynomial. The angle measuring concept gives an outstanding accuracy and repeatability of angle measurement independent of temperature, distance, rotating speed and speed variations.

### Controller

The powerful Cylmate controller has the capacity of data handling for all relevant engine and cylinder parameters in real-time. The engine parameters are continuously monitored against load-dependent performance limits.

The controller has an I/O interface, which enables the connection of external engine parameters in order to get a total picture of the engine and the combustion performance. There is also a 100 Mbit TCP/IP port for Ethernet connection to the Cylmate operator station.

### Mathematical model

The Cylmate controller also includes a mathematical engine model. The model calculates the crank shaft deflection in order to obtain the correct crank angle and TDC at each cylinder, independent of load variations. This guarantees an accuracy of the crank angle of  $0.1^\circ\text{CA}$ .

The MIP value is strongly related to the accuracy of the crank angle. An error in the crank angle of  $1^\circ\text{CA}$  gives about 8 % error in the calculated MIP value.

# Cylmate operator station

The Cylmate system offers one system concept for all applications.

It is installed as stand-alone with the possibility to communicate with superior systems and can handle single as well as multi-engine arrangements.

Increase the engine safety by keeping track of the engine performance 24/7. The unique feature is that every single stroke is measured and used in the data evaluation. This feature makes it possible to identify errors in the engine at a very early stage, and to follow up and analyze the running conditions of the engine.

Protect your main engine by continuous monitoring in order to detect any deviation from recommended running condition according to the performance curves issued by the engine builder.

Use the performance curves, to set up load-dependent alarm limits for desired performance parameters. Any deviation from normal performance will be monitored, according to the alarm limits.

An alarm will be generated when a monitored parameter value exceeds its alarm limit. The alarm is presented on the alarm page as well as on a digital output, which can be connected to the main alarm system.

The Cylmate operator station is based on an industrial version of a standard PC, and includes the Cylmate software, which is running under Windows.

The Cylmate system has comprehensive on-screen presentation of all collected data, both current and historical. Alarm, event and trend pages as well as graphic and tabular forms of the engine parameters are available e.g. Pcomp, Pmax,  $\alpha$ -Pmax, MIP, Indicated Power, engine speed, SFOC, etc.

## **Specific Fuel Oil Consumption (SFOC)**

The fuel economy monitoring function will calculate the actual fuel consumption, independent of load and operating conditions. The engine tuning impact on SFOC will easily be verified. The SFOC calculator will calculate the accumulated indicated energy (kWh) with high accuracy – better than 2 %.

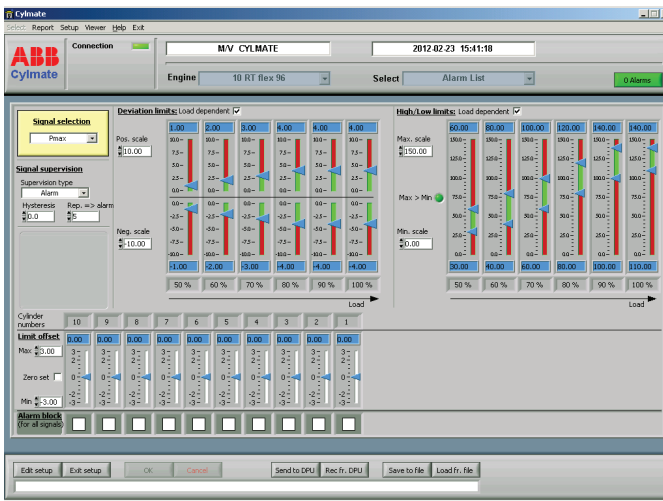
## **Logging**

The Cylmate logger continuously records engine and combustion data stroke-by-stroke, and the log files are stored on the hard disk. These long-term trend chart clearly indicates the trends of the logged parameters, which help you to predict emerging faults.

The short-term trend chart, which is a real-time trend logging, always shows the latest 6000 strokes. This chart will instantaneously show the effect of any tuning adjustments.

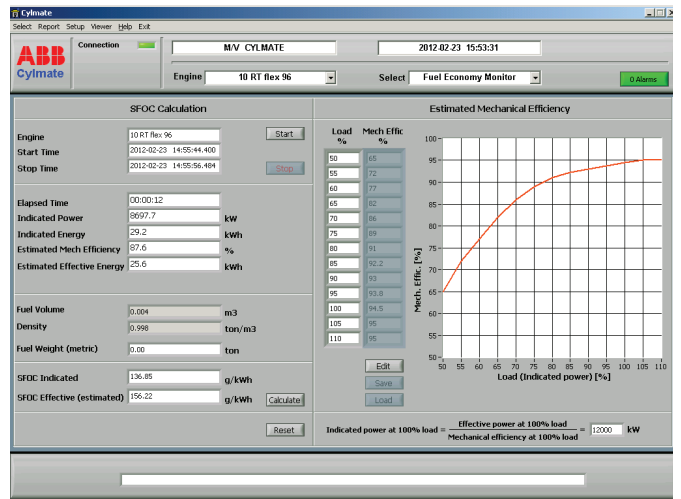
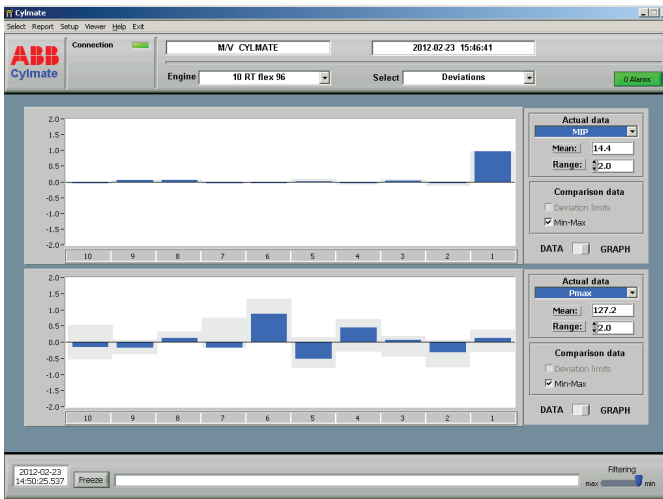
The Cylmate logger is a tool for:

- Trend analysis
- Fault prediction
- Fault tracing
- Voyage recording
- Performance optimization
- Performance history



The screenshot shows the 'Alarm List' window. It contains a table with the following columns: Date, Y-M-D, Time, H:R:SS.ms, Name, Description, and Repeat. The table lists 10 'CspMaxOver' alarms for cylinders 10 through 1, all occurring on 2012-02-23 at 14:48:03.995. The 'Repeat' column for all entries is 'No'.

Date	Y-M-D	Time	H:R:SS.ms	Name	Description	Repeat
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C10PMaxOver	Cyl 10 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C9PMaxOver	Cyl 9 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C8PMaxOver	Cyl 8 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C7PMaxOver	Cyl 7 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C6PMaxOver	Cyl 6 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C5PMaxOver	Cyl 5 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C4PMaxOver	Cyl 4 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C3PMaxOver	Cyl 3 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C2PMaxOver	Cyl 2 Max pressure Over	No
2012-02-23	14:48:03.995	14:48:03.995	14:48:03.995	C1PMaxOver	Cyl 1 Max pressure Over	No



# Cylmate engine

## Performance report functions

As important as continuous monitoring of all cylinders is the performance logging and reporting.

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strokes measured  
during 81 days.

Engine performance reports can be seen as an engine logbook that clearly presents an average summary of all important combustion parameters over a selectable number of strokes.

A clear and consistent performance report of all relevant combustion parameters will form the base for reliable verification of the engine condition. The report will also compose a powerful tool for advanced engine analysis and diagnosis, and will directly inform the engineers if the engine performance is optimal or not.

The content of the report can easily be selected from a set-up page, and it can be customized by marking relevant boxes. You can also select if the report should be previewed, saved and/or printed. Saved report files can later be copied to a USB memory stick.

Cylmate off-line reference and analysis function  
The Cylmate system has a large memory buffer where live combustion performance is recorded. The buffer always contains all combustion data and pressure curves from the latest 70 strokes.

This information is used for creating snapshots of the engine performance under different load and environmental conditions. For example snapshots can be taken during shop test, sea trial and at different climate and load conditions as well as after engine overhaul. The snapshot function can also be used to record abnormal behavior for later off-line comparison and analysis. Each snapshot recording is stored as a file or transmitted to the home office.

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02 The Cylmate viewer is the first commercial tool on the market that has all information of the combustion process stroke-by-stroke, before the alarm, at the alarm, and after the alarm.

That means it is possible to see the development of a fault and to get understanding of the mechanism that led to the fault.

03 The engine performance report, which can be stored on the hard disk, printed or copied to a USB memory stick, gives comprehensive information about the engine performance and condition.

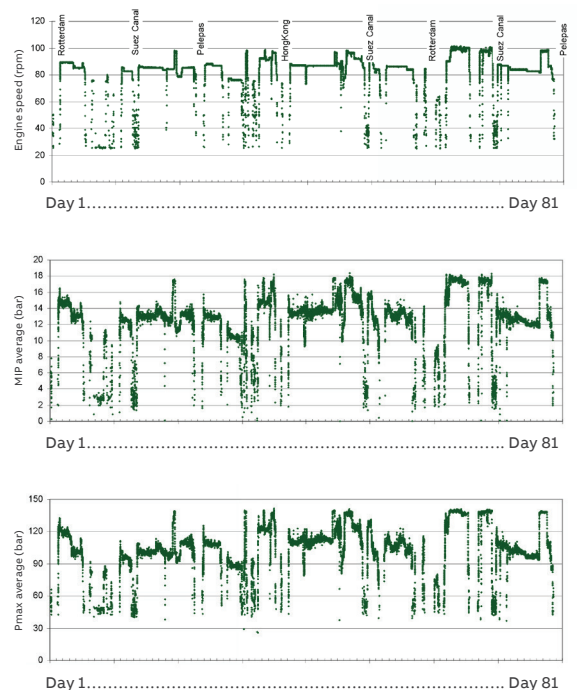
**Performance reference and performance alarm**

A performance reference snapshot is taken manually whenever needed. A performance alarm snapshot will be created automatically in conjunction with a combustion alarm. The performance alarm snapshot is an indispensable tool for engine fault analysis. As soon as the Cylmate system has detected an engine combustion fault, a snapshot of the latest strokes is automatically stored.

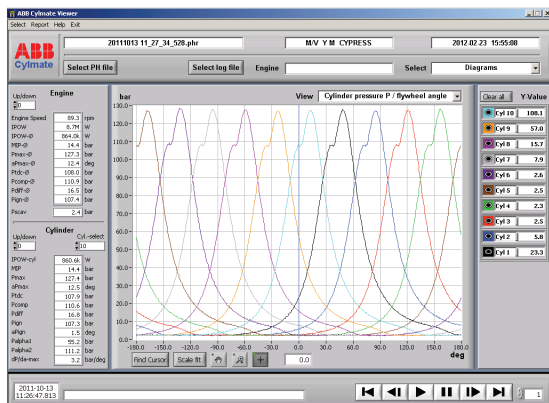
The stored snapshot includes all combustion data for 62 strokes before the alarm, data for the stroke at which the fault was detected and data for 7 strokes after the alarm stroke.

The off-line analysis and comparison of these snapshots is done by means of a freestanding tool, the Cylmate viewer. The viewer is a part of the operator station, but it can also be installed in any Windows-based PC as a tool for engineers, superintendents and the ship owners' technical departments.

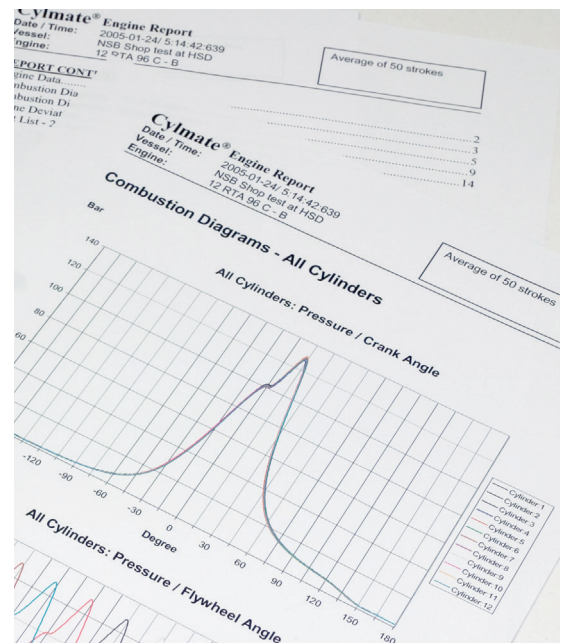
The Cylmate viewer works like a video player that can replay the recorded strokes, stroke-by-stroke, forward or backward. It will for each stroke show the pressure curves and related combustion data.



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# Recognized, verified and proven

Over the years the Cylmate system has been recognized with the CIMAC President's award, technically verified by many installations and the accuracy has been proven during engine shop tests.

- 01 Barbados Light & Power
- 02 M/V Ever Conquest
- 03 M/V Ital Contessa

## NSB's large container vessels successfully running with Cylmate Engine Monitoring systems

We ask Mr. Bögemann, Chief Engineer onboard M/V Ever Conquest about the installation: "Before Cylmate we had movable monitoring systems and it took us just about an hour to measure all cylinders. Since Cylmate is a continuous, on-line system it is a very helpful tool in our daily work. We can see the condition inside the cylinders and before something serious happen get an early warning, a very good pro-active function in Cylmate. In general, it is very easy to navigate in the Cylmate system and I think there is a good level of information available."

## M/S Hanjin Ottawa

Mr. Michael Haufmann, Chief Engineer at M/S Hanjin Ottawa, has extensive experience using portable systems for combustion pressure measurement. He has seen the potential and benefits with a continuous monitoring system: "My personal summing-up of the experience with the Cylmate system is very positive. The system is extremely helpful in the daily engine operation, condition supervision and maintenance planning."

## Barbados Light & Power

We ask Mr. Ramon Jules, Senior Generation Engineer and Mr. Philip Browne, Generation Engineer, about the Cylmate installations: "The continuous measurement feature is of tremendous help to maintenance personnel when engine balancing is required. Previously, setting up equipment to perform the cylinder pressure measurements in preparation for engine balancing took approximately two hours. Now those measurements are obtained immediately with the use of the Cylmate. As a result, we can keep the engines running efficiently at all times"

## Shop test

Using pressure sensors at shop tests is very valuable:

- In present shop tests, cylinder pressure balancing and adjustment work can be finished in few minutes, at each engine load, by one person using cylinder pressure on-line monitoring system with pressure sensors. In the past, at least two persons and 20 to 30 minutes per engine load were needed for manual pressure measurement and mechanical adjustment.
- Reliability is one of the most important requirements on a marine engine for main propulsion of large vessels at present. Cylinder pressure on-line monitoring system with pressure sensors has become an important part for higher level of engine condition monitoring in order to detect/avoid abnormal tendency and condition. In the past, it was hard to apply such system due to manual measurement.



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# Cylmate combustion pressure transducer PFPL203

Pressure under control with 5 years warranty.

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01 Cylmate combustion pressure transducer PFPL203.

## Recognized, verified and proven

Combustion pressure measurement is very challenging in the aggressive application of 2-stroke engines. The unique and reliable Cylmate pressure transducer has proven its maintenance- and calibration-free performance during years of continuous operation.

## Over 500,000,000 strokes

Transducers installed for over a decade, and still in operation. User experience from several thousands of installed pressure transducers.

## Accuracy over time

The measuring accuracy is not influenced by any clogging or heat flash from the combustion gases, which potentially could be a problem with other pressure transducers.

Cylmate pressure transducers do not have any aging phenomena and is not affected by pressure cycling, temperature cycling, combustion gases or combustion residues. Therefore the Cylmate pressure transducers do not need any recalibration. The transducer critical parts are made of Inconel.

## Key component for automated tuning of electronically controlled engines

Today automated performance optimization is state-of-the-art feature on electronically controlled engines.

By means of online cylinder pressure signal integration into engine control system the timing of fuel injection and exhaust valves is automatically adapted to different operation conditions. Therefore the engine can be continuously optimized for lowest fuel consumption and load balanced for less bearing wear.



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Engine builders and their customers have over the years experienced that Cylmate pressure transducers are the ultimate solution for this application providing best reliability and lowest cost of ownership:

- Highest accuracy and long-term repeatability
- Maintenance-free and recalibration-free
- MTBF – more than 10 years
- Low life cycle cost

## Technical data

Calibrated measuring range	0 to 250 bar
Combined errors (sensitivity drift, linearity deviation and hysteresis)	<±0.5 %
Max. overload	600 bar
Max. ambient temperature at transducer	260 °C
Max. ambient temperature at electronic unit	70 °C
Cable length	4 m
Degree of protection	IP65
Warranty	5 years
Life time	>10 years



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**ABB AB**

**Industrial Automation**

Measurement & Analytics

Elektronikgatan 35

S-721 36 Västerås, Sweden

Phone: +46 21 32 50 00

**[www.abb.com/cylmate](http://www.abb.com/cylmate)**

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