Reduce costs with closed-loop combustion control

Marine & Stationary
Reliable efficiency improvements with combustion monitoring and control in large engines with sensor technology from Kistler
Absolute Attention for tomorrow’s world

Kistler develops solutions for challenges in measurement technology with a portfolio that comprises sensors, electronics, systems and services. We push the frontiers of physics in fields such as emission reduction, quality control, mobility and vehicle safety: our products deliver top performance to meet the standards of tomorrow’s world, providing the ideal basis for Industry 4.0. This is how we pave the way for innovation and growth – for our customers, and with our customers.

Kistler: the byword for advances in engine monitoring, vehicle safety and vehicle dynamics. Our products deliver data that plays a key part in developing efficient vehicles for tomorrow’s world.

Measurement technology from Kistler ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and many other applications where absolutely reliable measurements are required despite extreme conditions.

By supporting all the stages in networked, digitalized production, Kistler’s systems maximize process efficiency and cost-effectiveness in the smart factories of the next generation.
Now that about 25 years have passed since the start of globalization, one thing is clear: it’s essential for all players in industry and business to take an active role in continuing to develop existing technologies and expanding specialist know-how. This is the only way to reconcile the requirements of a globally interconnected economy with the need to keep the environment intact.

In the marine and stationary engine segment, we are proud to play our part by responding consistently to the market’s needs with new and efficient solutions. Dependable products that ensure high operational reliability, and our constant striving for technical excellence: based on these cornerstones, we are still setting standards in sustainable resource optimization. Our commitment goes well beyond the development of durable, energy efficient sensors and systems to optimize large engines. As a division of the Kistler Group, we offer professional advice and Kistler’s worldwide service as part of our daily endeavor to boost your company’s business success over the long term!

Jürg Stadler, 
Head of Strategic Business Field 
Engine Research & Development/Engine Marine & Stationary

Editorial

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Sensor and system expertise – from one single source

When you need to monitor and control large engines, look no further than Kistler: we offer high-quality cylinder pressure sensors backed by all the service and system expertise you require – so we can develop cost-effective solutions tailored to each customer’s specifications.

Trouble-free operation with lower fuel consumption
Efficient, safe and reliable operation of large marine and stationary engines depends on one critical factor: monitoring and control of cylinder pressure. Optimal adjustment and accurate monitoring of combustion during continuous operation will deliver major benefits: you will make substantial savings on fuel consumption while reducing the risk of breakdowns and premature wear. Sensor technology from Kistler delivers reliable solutions to achieve these goals.

Increased efficiency means long returns
At Kistler, we can draw on our lengthy experience of developing custom solutions for manufacturers of large engines all over the world. Our know-how is recognized by numerous shipbuilders, shipping companies and power plant operators. By drawing on our expertise in sensor technology and our all-round system know-how, we can assist with improving the efficiency of large marine and stationary engines. The basis: cooperation amongst all parties involved. The objective: to develop more cost-effective solutions.
Benefits

Excellent operational reliability
- Proven, high quality products ensure trouble-free, continuous operation

Technical excellence
- Repeatable, high resolution cylinder pressure data
- Accurate feedback for optimized combustion
- Customized sensors for any application
- Ideal for engines with multi-/flexible fuel options

Optimized resources
- Fuel consumption reduction
- Lower emissions
- Reduced service requirements
- High return on capital from long sensor life
Simple handling and first-class results: reliable online monitoring with Kistler pressure sensors.

**Continous monitoring**

Rugged piezoelectric cylinder pressure sensors from Kistler are designed to give many years of service providing continuous monitoring of cylinder pressure in internal combustion (IC) engines.

**Closed-Loop Combustion Control (CLCC) for increased efficiency**

The continuous monitoring of the cylinder pressure provides the key element to optimize combustion efficiency in any IC engine – feedback control of the actual combustion process. Enabling this, the engine operator gains not just optimized fuel consumption and emissions but also reduced engine wear and the tool to access critical data for preventative maintenance.

**Application areas**

Many industries today have to meet ever greater business expectations with stricter regulatory requirements on their engines. The response: more widespread use of cutting-edge engine technology to maximize engine efficiency – with CLCC a highly regarded route to improve efficiency in all industries operating IC engines. The major exceptions to this are in engines where dual fuel or variable fuel quality requires continuous monitoring not just to make efficiency improvements but to ensure engine health under the highly variable combustion regimes these engines can operate in. Leading engine manufacturers put their trust in the quality of Kistler’s sensors to deliver the combustion data necessary – where data reliability and consistency are high on their list of priorities. Kistler sensors are installed in both two and four stroke applications, operating on diesel, gas or diesel/gas dual fuels, in low and medium speed engines.

**Benefits**

- Fuel is saved
- Emissions are minimized
- Wear is reduced
- Servicing intervals are optimized

**Certificates**
Closed-Loop Combustion Control – now online
Use our animation to experience convincing, first-class Kistler solutions – the sure way to achieve maximum engine efficiency:
www.kistler.com/continuous-monitoring
Offline engine diagnosis

Cylinder pressure is a crucial factor in monitoring low and medium speed combustion engines. The parameter provides meaningful information about the engine’s operation. This is why regular cylinder pressure measurement is a standard – and this data provides the essential basis for optimizing fuel consumption.

Pressure sensors and diagnostic equipment from Kistler
Kistler’s diagnostic equipment is the solution of choice for regular recording and evaluation of peak pressures on large engines. Quickly and easily mounted on the indicator valve, these rugged devices deliver accurate and reliable measurement data from sensors with long-term stability. That is why measurement technology from Kistler is also the preferred choice for equipment manufacturers who produce their own diagnostic instruments.

Kistler’s on-site service
Safe and reliable operation is the overriding priority for large engines – so our specialists are always standing by to assist you with advice and practical help at any time, anywhere in the world.

Benefits
• Damage is detected at an early stage
• Servicing intervals are optimized
• Emission limits are respected
• Cylinder balancing is simple
• Fuel consumption is optimized
Process offline engine diagnosis

Offline engine diagnosis – now online
Use our animation to experience convincing, first-class Kistler solutions – the safe way to achieve maximum engine efficiency:
www.kistler.com/continuous-monitoring
The right sensor for your application

Exact, reproducible pressure measurement values can only be obtained with reliable sensors that measure precisely. Piezoelectric sensors from Kistler are rugged and easy to maintain.

Accurate and reliable
The heart of a Kistler sensor is a specially developed piezoelectric measuring element. This forms the basis for accurate and stable measurement results throughout the whole sensor lifetime, even in demanding environments. Kistler sensors deliver high-precision measurements of pressure variations (range up to 350 bar) and/or temperature changes of up to 350°C.

Fits your unique environment
The Kistler patented “antistrain” design enables the measuring element to be insensitive to varying mounting conditions – this enhanced flexibility easily allows the integration of the sensors in individual environments.

The sensor’s lifetime
Flexible with regard to fuels, the sensor types can be used in gas as well as two- and four-stroke diesel engines.

The sensors are designed for a life of several thousand operating hours in a diesel or gas engine; however the individual sensor life time is strongly depending on the specific application and maintenance.
## Closed-Loop Combustion Control for 2-stroke engines

<table>
<thead>
<tr>
<th>Technical data</th>
<th>Type 7614CG2</th>
<th>Type 6613CG2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure range</td>
<td>bar</td>
<td>0 ... 250</td>
</tr>
<tr>
<td>Linearity</td>
<td>% FSO</td>
<td>≤±0.5</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>°C</td>
<td>–40 ... 350</td>
</tr>
<tr>
<td>Frequency range</td>
<td>Hz</td>
<td>0.01 ... 10,000</td>
</tr>
<tr>
<td>Signal output</td>
<td>4 ... 20 mA/3 wires galvanic isolated</td>
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</tbody>
</table>

**Properties**
- Front end sealing or shoulder sealing
- Excellent lifetime
- Suitable for knock detection
- Excellent lifetime
- Build-up of combustion deposits is reduced in combination with Kistler’s patented adapter, Type 7523B...
- Suitable for knock detection

**Certificates**
- GL, ABS, BV, LR, DNV, CCS – Marine type approval and ATEX, IECEx
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**Data sheet**
- 7614CG_003-044
- 6613CG_003-043

For direct installation in cylinder cover

Front end sealing or shoulder sealing possible

Vastly reduced build-up of combustion deposits in combination with patented adapter Type 7523B...

**Patented adapter Type 7523B...: Opening up new options for cylinder pressure monitoring**

Kistler has developed a special adapter for online sensors. It features a highly specific design of the inner surface that comes into contact with the combustion gases. The special patented geometry of the sensor adapter reduces carbon deposits at the measuring point – so measurement results are constantly stable.

Online sensor mounted in an optimized mounting adapter with a flat inner surface and reduced cross-sectional area.

US Patent No.: 8,079,252 B2
### Closed-Loop Combustion Control for 4-stroke engines

**Technical data**

<table>
<thead>
<tr>
<th>Type 6635A1</th>
<th>Type 6613CG1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M10 cylinder pressure sensor for 4-stroke engines</strong></td>
<td><strong>Online cylinder pressure sensor with PiezoStar crystal technology enabling long sensor service life. Patented diaphragm design providing maximal strength and minimal thermal shock. New signal transmission system with welded connections and no moving parts ensuring reliable, wear-free signal transmission in harsh environments with high levels of vibration and mechanical shock. The sensor is linked by a robust FPM cable of 1 m length to a charge amplifier. The rugged design and high temperature resistance allow for flush mounting in the cylinder head. The sensor is suitable for knock detection during engine characteristics measurement and for high pressure ranges (350 bar) in 4-stroke medium speed engines.</strong></td>
</tr>
</tbody>
</table>

| Pressure range | bar | 0 ... 350 | 0 ... 250 |
| Operating temperature range | °C | –40 ... 350 | –40 ... 350 |
| Frequency range | Hz | 0.016 ... 10,000 | 0.1 ... 10,000 |
| Signal output | 4 ... 20 mA/3 wires galvanic isolated |
| Sensitivity | 37.0 μA/bar |
| Certificates | ATEX, IECEx, EU-RO Mutual Recognition | GL, ABS, BV, LR, DNV, CCS – Marine type approval and ATEX, IECEx |
| Data sheet | 6635A1_003-331 | 6613CG_003-043 |

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| Data sheet | 7614CG_003-044 | 6613CG_003-043 |
### Instruments for machinery maintenance

#### Technical data Type 2516B...

**Engine peak meter Type 2516B...**

Type 2516B... supports monitoring of engines with speeds of up to 4,000 min⁻¹. The data evaluation software included in the accessories supplied with the Peak Meter provides graphic visualization and recording of following parameters:

- Maximum peak pressure (pmax)
- Minimum peak pressure (pmin)
- Average peak pressure (pav)
- Standard deviation of the peak pressure (Sdev)
- Maximum gradient of the pressure curve (dp/ca)
- Speed (r/min)
- Current peak-pressure; measuring function unlimited in time (ppeak)

#### Data sheet

| 2516B_000-941, 2516B_000-940 |
---|---|

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#### Technical data Type 6513A Type 6513AK

**Thompson adapter**

The Thompson adapter is a standard tool that fits almost all indicator valve on most engines. It is intended for short-term pressure measurements only.

2-stroke engines: it’s recommended to use the sensor with adapter Type 6513A.

4-stroke engines: it's recommended to use the sensor with adapter Type 6513AK, as the higher operating temperature of 4-stroke engines necessitates additional cooling to reduce the temperature of the sensor and maximize the life time.

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#### Technical data Type 6019A... Type 6619AP Type 6013CA

**Pressure range bar**

| 0 ... 300 | 0 ... 250 | 0 ... 250 |
---|---|---|

**Linearity %FSO**

| <0.3 | <0.3 | <1 |

**Operating temperature range °C**

| –40 ... 350 (max. 400°C for <10 min) | –40 ... 350 (max. 400°C for <10 min) | –40 ... 350 |

**Sensitivity pC/bar**

| 30 | 20 mV/bar (Piezotron®) | 20 pC/bar |

**Properties**

- Highest precision available with PiezoSmart extended
- Extended temperature range 400°C

Available adapters:

- Thompson adapter 6513A
- Thompson adapter 6513AK

**Data sheet**

| on request | on request | 6013C_000-402 |
---|---|---|
Kistler – your partner for innovation

Kistler provides customer support with customized service options available throughout our global service network. Depending on the individual customer situation, Kistler will determine the optimum location to complete the service to best meet customer timing requirements.

Recalibration and repair
Kistler piezoelectric sensors are market leaders based on their long term stability. However abnormal combustion or extended use can lead to a degradation of the sensors sensitivity. Regular recalibration is recommended – to ensure accurate and reliable measurement results at all times.

PMI calibration-box
The PMI auto-tuning system installed at MAN ME-engines measure the cylinder pressure with online sensors. For commissioning and regular calibration the Kistler PMI Calibration-Box (consisting of a handheld device and a highly accurate reference sensor) is used. To ensure correct functionality Kistler recommends a recalibration of the device and sensors every 5 years. Efficient engine operation is assured. The proposed time for recalibration is during overhaul.

Onsite measurements
Outside of basic data retrieval, or automated calibration procedures, analyzing and interpreting the data from cylinder pressure measurements does require a certain level of expertise. Kistler supports your individual measurement questions or a more detailed technical analysis of any engine with experienced professionals and additional rental equipment, for example our portable Combustion Analysis System – the Kistler KiBox.

Retrofit and adaptation
Existing large diesel/gaseous/multi fuel engines can benefit from the advantages of cylinder pressure monitoring by retrofitting with combustion control technology. Our experts are available to discuss the best technical solution for any specific engine application.

Consulting and engineering
Experienced Kistler experts can offer guidance and advice at any time. This can range from a customized solution for a specific technical issue to an in-house training session on pressure measurements or combustion control. Kistler has the technical knowledge to assist our customer in finding solutions promptly.
At our customers’ service across the globe

Thanks to Kistler’s global sales and service network, we are always close to our customers. Some 2,200 employees at more than 60 locations are dedicated to the development of new measurement solutions, and they offer customized on-site support for individual applications.