Health Usage Monitoring Systems (HUMS) are being used more frequently in monitoring critical helicopter gearboxes, and also increasingly for gas-turbines – both those in helicopters and certain fixed-wing aircraft.

Vibration monitoring is a well-proven technology for preventing catastrophic failures of rotating components, with the piezoelectric accelerometer proving to be the best sensor for these applications.

Brüel & Kjær supplies a range of HUMS and engine-monitoring accelerometers, the design of which is focused on guaranteeing a highly robust and highly reliable sensor. Sensors must continuously operate in demanding environmental conditions, yet be sensitive enough to be able to detect incipient bearing and gear failures. Size and ease of mounting are equally important considerations for these applications.

Uses and Features

Uses
- Gearbox HUMS
- Engine monitoring
- Engine maintenance
- Active control response
- Pilot comfort
- Rotor balance
- Flight test

Features
- Flight certified
- Piezoelectric Shear designs
- Case isolated and internally shielded
- Wide frequency and temperature ranges
- CCLD (IEPE) and charge output types
- Low sensitivity to EMI

Accelerometer Design and Manufacturing

HUMS accelerometers typically have very specialised performance and reliability requirements. Strict environmental standards such as DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment” must be adhered to, together with aircraft specific requirements.

Brüel & Kjær understands market needs and the production and quality management processes necessary to ensure absolute reliability. Our extensive R&D, QA and production capabilities enable us to design and manufacture HUMS accelerometers to comply with specific tasks requirements.
We can provide:
- Comprehensive R&D design and test facilities
- Aerospace standardised quality management
- Optimised production processes
- Worldwide support and service
- Accredited calibration laboratories
- Extensive domain expertise

**Research and Development**
Product development starts with Finite Element Model (FEM) and other simulation tools. From these models we can begin to optimise the performance of the new design. This not only reduces design time and cost, it provides a greater understanding of the accelerometer operation. This enables our engineers to optimise designs for maximum reliability by identifying and consequently removing internal resonances.

Following verification of the mathematical model, prototypes are produced for initial review by our customers and for extensive in-house testing against relevant environment and operating specifications.

**Quality Management**
Brüel & Kjær operates AS/EN9100 and ISO 9001:2000 quality management systems to provide the organisational structure, policies, procedures, processes and resources needed to ensure quality and safety of products. This demonstrates our organisations ability to meet the strict requirements and needs of our customers.

**Production Processes**
Production processes optimised to produce quality products for these tough aerospace applications are paramount. Clean-room production, extended accelerometer burn in, component process optimisation to withstand high g effects, annealing processes to remove residual strains, electron-beam welding and multi-axis CNC machines to ensure tight manufacturing specifications, are all processes used in the production of Brüel & Kjær accelerometers.

**World-wide Support and Service**
Brüel & Kjær is a global company. With more than 90 sales offices in 55 countries supported by a team of application specialists at our Headquarters in Denmark, we have the largest sound and vibration sales network in the world. With eight accredited calibration centres worldwide, and 500 employees working within local sales, service and support, we provide you with immediate customer support no matter where you are.

**Calibration Laboratories**
Our calibration laboratories are accredited in many regions, fulfilling the requirements of ISO A2LA and other standards, in accordance with the quality standard for laboratories – ISO 17025. Brüel & Kjær offers a comprehensive range of calibration services to meet national and international requirements – traceable to national institutes (DPLA, NIST, NPL, PTB).

**Brüel & Kjær Heritage**
Brüel & Kjær is no newcomer to innovative accelerometer design. Back in 1943, the company founder, Dr. Per V. Brüel, developed the world's first commercial piezoelectric accelerometer, made from Rochelle salt crystals. Since those early days, Brüel & Kjær has been at the forefront of transducer technology. The DeltaShear, OrthoShear and ThetaShear piezoelectric designs, on which many of the world's present-day accelerometers are based, were all invented by Brüel & Kjær, and the IEEE1451 TEDS standard that adds plug and play capabilities to analog transducers was driven by Brüel & Kjær.

Transducers have been, and will remain, a core part of our business.

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**Industrial Accelerometers**

All Brüel & Kjær industrial accelerometers are hermetically sealed to protect against environmental contamination. They are based on Shear piezoelectric designs to provide the combination of enhanced performance characteristics with better size-to-weight ratio, and environmental stability. We guarantee long-term reliable sourcing of materials.

**HUMS Accelerometers**
Table 1 shows a selection of Brüel & Kjær’s industrial HUMS and engine monitoring accelerometers.
Table 1  A selection of Brüel & Kjær’s industrial HUMS and engine monitoring accelerometers

<table>
<thead>
<tr>
<th>Type 4511-001</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uses</strong></td>
<td><strong>Features</strong></td>
</tr>
<tr>
<td>• Flight-test applications</td>
<td>• Case insulated and internally shielded</td>
</tr>
<tr>
<td>• Measurements in harsh environment</td>
<td>• High frequency (15 kHz)</td>
</tr>
<tr>
<td>• In Health Usage Monitoring Systems</td>
<td>• High temperature (150°C)</td>
</tr>
<tr>
<td>• Measurement on gearboxes</td>
<td>• EMI and radiation resistant</td>
</tr>
<tr>
<td></td>
<td>• Ease of installation – centre bolt (360° orientation) design</td>
</tr>
<tr>
<td></td>
<td>• Flight certified (for specific helicopters)</td>
</tr>
</tbody>
</table>

**Type 4511-006**

<table>
<thead>
<tr>
<th>Uses</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Flight-test applications</td>
<td>• Case insulated and internally shielded</td>
</tr>
<tr>
<td>• Measurements in harsh environment</td>
<td>• High frequency (25 kHz)</td>
</tr>
<tr>
<td>• In Health Usage Monitoring Systems</td>
<td>• High temperature (150°C)</td>
</tr>
<tr>
<td>• Measurement on gearboxes</td>
<td>• EMI and radiation resistant</td>
</tr>
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<td>• Ease of installation – centre bolt (360° orientation) design</td>
</tr>
<tr>
<td></td>
<td>• Flight certified (for specific helicopters)</td>
</tr>
</tbody>
</table>

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### Type 4511-001

- **Uses**: Flight-test applications, Measurements in harsh environment, In Health Usage Monitoring Systems, Measurement on gearboxes
- **Features**: Case insulated and internally shielded, High frequency (15 kHz), High temperature (150°C), EMI and radiation resistant, Ease of installation – centre bolt (360° orientation) design, Flight certified (for specific helicopters)

![Image](image1.png)

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### Type 4511-006

- **Uses**: Flight-test applications, Measurements in harsh environment, In Health Usage Monitoring Systems, Measurement on gearboxes
- **Features**: Case insulated and internally shielded, High frequency (25 kHz), High temperature (150°C), EMI and radiation resistant, Ease of installation – centre bolt (360° orientation) design, Flight certified (for specific helicopters)

![Image](image2.png)
Type 4523

**Uses**
- Flight-test applications
- Measurements in harsh environment
- In Health Usage Monitoring Systems
- Measurement on gearboxes

**Features**
- Isolated mounting surfaces
- High frequency (13 kHz)
- High temperature (150°C)
- EMI resistant
- Ease of installation – centre bolt (360° orientation) design
- Flight certified (for specific helicopters)

![Type 4523 Image]

All dimensions in millimetres

Type 8345

**Uses**
- Measurements in harsh environment
- Triaxial measurements
- Permanently installed machine condition monitoring
- In Health Usage Monitoring Systems

**Features**
- Ruggedized connector
- Isosceles triangle footprint to avoid misalignment

![Type 8345 Image]

All dimensions in millimetres
## Type 8347-C

### Uses
- Measurements in harsh environment
- Measurements on engines and industrial gas turbines
- Measurements on turbo pumps
- Measurements in nuclear power plants
- High-temperature and cryogenic applications
- In Health Usage Monitoring Systems

### Features
- Wide temperature range –196°C to +482°C
- High resistance to radiation
- Usable frequency range up to 12.8 kHz
- Low sensitivity to EMI
- Transverse resonance frequency 17 kHz
- Industry standard ARINC footprint

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![Image of Type 8347-C](image)

**ALL dimensions in millimeters**

120026/2
Individual Accelerometer Calibration Charts

Every accelerometer produced at Brüel & Kjaer undergoes the strictest production and quality control processes to ensure reliability, and also to maintain the smallest of spread amongst devices of the same type. The accelerometers are then individually calibrated to provide accurate data on several parameters, and this means that each accelerometer comes complete with an individual calibration chart containing extensive calibration information. Calibration charts include data on sensitivity, measurement range, frequency response, electrical parameters, dimensions, weight and a comprehensive collection of environmental specs.

The amplitude and phase frequency response are measured with a full 1600-point resolution – providing a complete response characterisation, showing the true response of the individual units over the frequency range.

An example of a Calibration Chart for the Type 4511-001 is shown in Fig. 1.

**Fig. 1** Calibration chart for Type 4511-001
Specifications, Compliance with Standards and Ordering Information

For specifications, compliance with standards and ordering information, please see the relevant accelerometer Product Data:

- Piezoelectric (CCLD) Accelerometer Type 4511-001 (BP 2064)
- CCLD Accelerometer Type 4511-006 (BP 2477)
- Piezoelectric (CCLD) Accelerometer Type 4523 (BP 2261)
- Triaxial CCLD Accelerometer Type 8345 (BP 2459)
- High-temperature Industrial Charge Accelerometer Type 8347-C (BP 2431)