PRODUCT INFORMATION

Range of HUMS and Engine-monitoring Accelerometers
Type 4511-001, 4511-006, 4523, 8345 and 8347-C

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.

Photo courtesy of Airbus Helicopters 140113

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.

Brüel & Kjær

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.

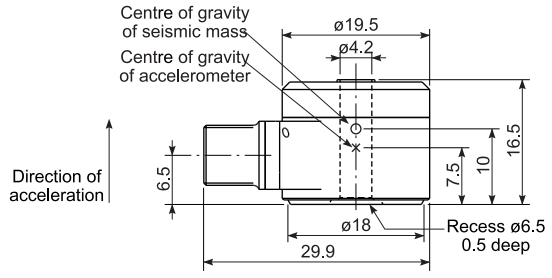
Industrial Accelerometers

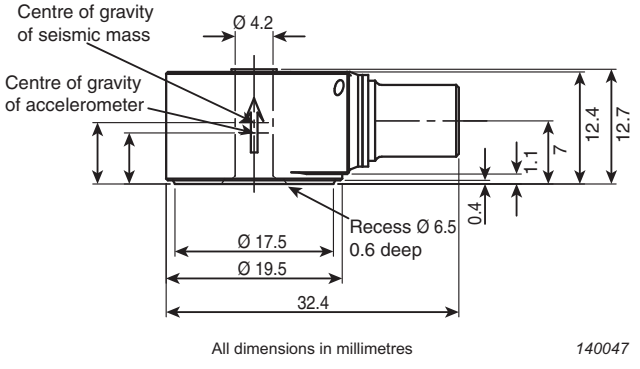
All Brüel & Kjær industrial accelerometers are hermetically sealed to protect against environmental contamination. They are based on Shear piezoelectric designs to provide the combination of enhanced performance characteristics with better size-to-weight ratio, and environmental stability. We guarantee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

HUMS Accelerometers

Table1 shows a selection of Brüel & Kjær's industrial HUMS and engine monitoring accelerometers.

Table1 *A selection of Brüel & Kjær's industrial HUMS and engine monitoring accelerometers*

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)
 *050016/2*	

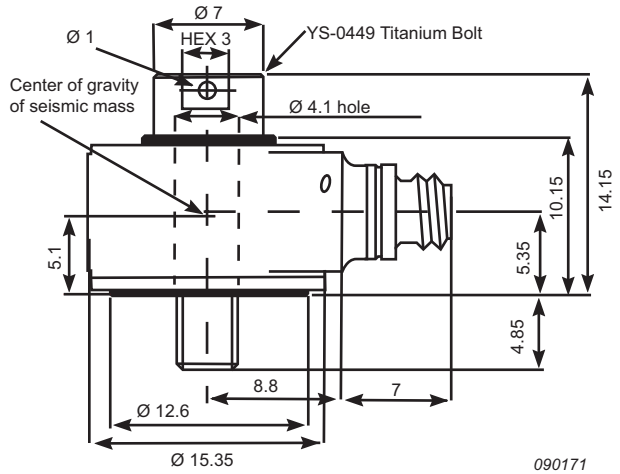
Type 4511-006	
Uses • Flight-test applications • Measurements in harsh environment • In Health Usage Monitoring Systems • Measurement on gearboxes	**Features** • Case insulated and internally shielded • High frequency (25 kHz) • High temperature (150°C) • EMI and radiation resistant • Ease of installation – centre bolt (360° orientation) design • Flight certified (for specific helicopters)
 *130215/1*	

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)

100012/2



All dimensions in millimetres

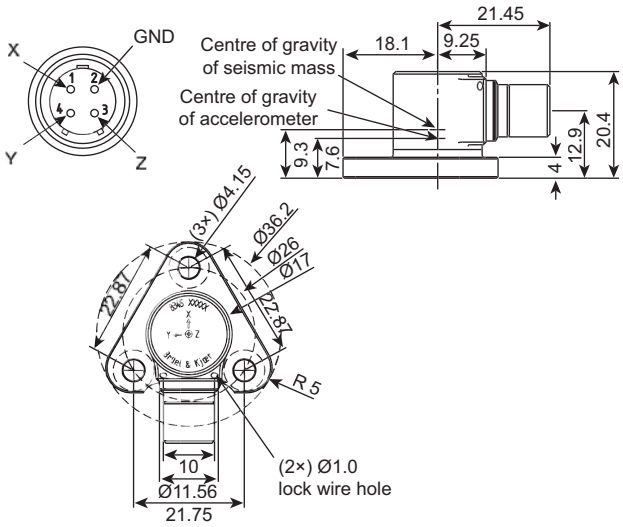
090171

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

130007



All dimensions in millimetres

120715

Type 8347-C

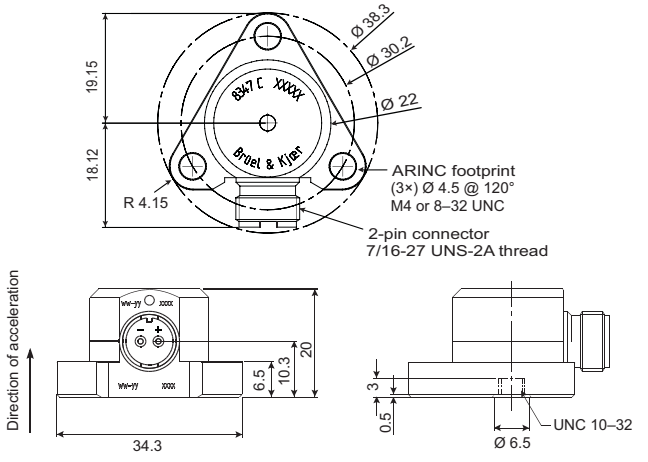
Uses

- 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

120026/2



ALL dimensions in millimeters

120250/2

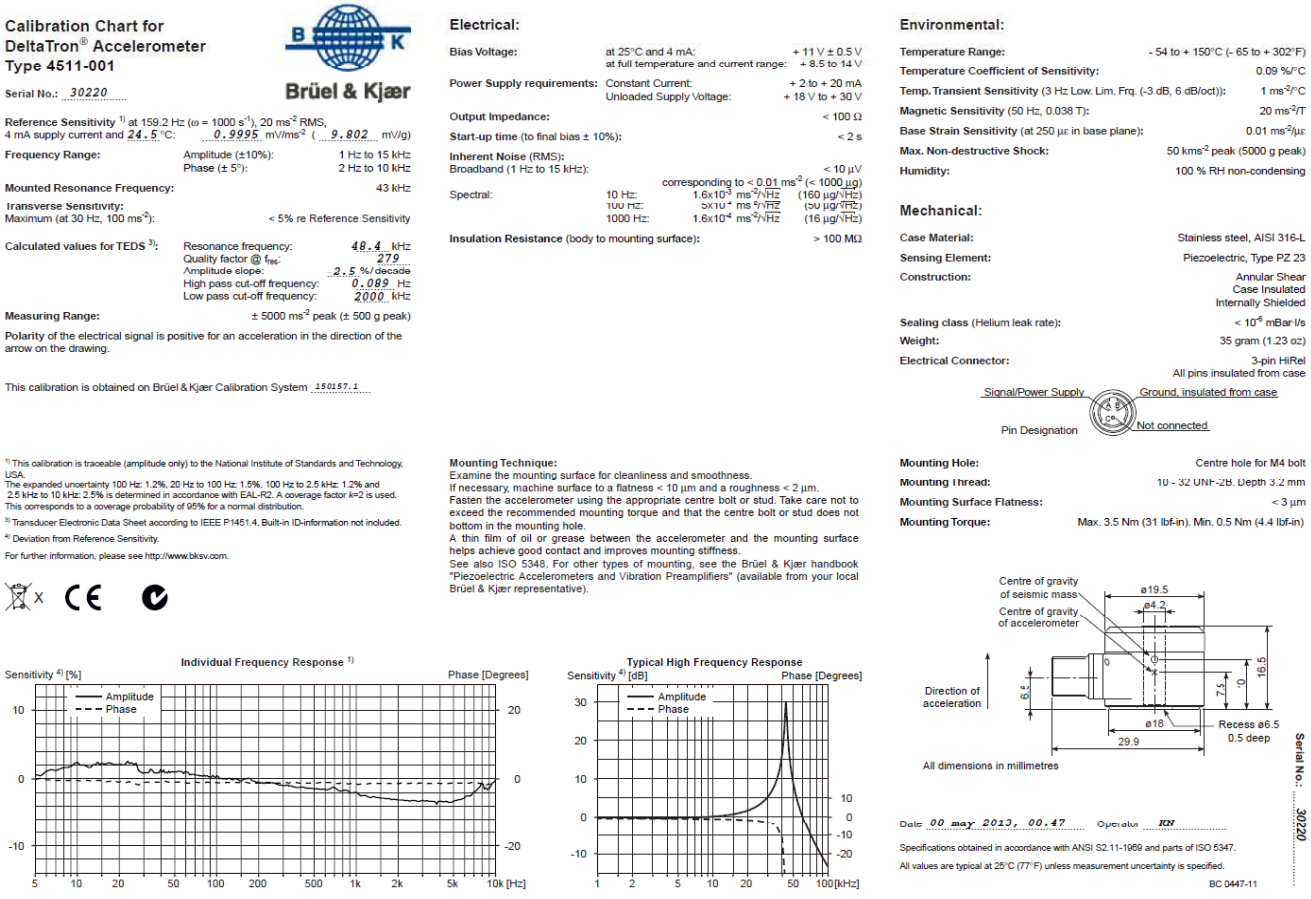
Individual Accelerometer Calibration Charts

Every accelerometer produced at Brüel & Kjær 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*



Calibration Chart for DeltaTron® Accelerometer Type 4511-001

Brüel & Kjær

Serial No.: 30220

Reference Sensitivity [1] at 159.2 Hz (ω = 1000 s^{-1}), 20 ms^{-2} RMS, 4 mA supply current and 24.5 °C: 0.9995 mV/ms^{-2} (9.802 mV/g)

Frequency Range: Amplitude (±10%): 1 Hz to 15 kHz; Phase (± 5°): 2 Hz to 10 kHz

Mounted Resonance Frequency: 43 kHz

Transverse Sensitivity: Maximum (at 30 Hz, 100 ms^{-2}): < 5% re Reference Sensitivity

Calculated values for TEDS [3]: Resonance frequency: 48.4 kHz; Quality factor @ f_{res}: 279; Amplitude slope: 2.5 %/decade; High pass cut-off frequency: 0.089 Hz; Low pass cut-off frequency: 2000 kHz

Measuring Range: ± 5000 ms^{-2} peak (± 500 g peak)

Polarity of the electrical signal is positive for an acceleration in the direction of the arrow on the drawing.

This calibration is obtained on Brüel & Kjær Calibration System 150157.1

Electrical:

Bias Voltage:	at 25°C and 4 mA:	+ 11 V ± 0.5 V
	at full temperature and current range:	+ 8.5 to 14 V
Power Supply requirements:	Constant Current:	+ 2 to + 20 mA
	Unloaded Supply Voltage:	+ 18 V to + 30 V
Output Impedance:		< 100 Ω
Start-up time (to final bias ± 10%):		< 2 s
Inherent Noise (RMS): Broadband (1 Hz to 15 kHz):		< 10 μV
		corresponding to < 0.01 ms^{-2} (< 1000 μg)
Spectral:	10 Hz:	1.6x10^{-3} ms^{-2}/√Hz (160 μg/√Hz)
	100 Hz:	5x10^{-4} ms^{-2}/√Hz (50 μg/√Hz)
	1000 Hz:	1.6x10^{-4} ms^{-2}/√Hz (16 μg/√Hz)
Insulation Resistance (body to mounting surface):		> 100 MΩ

Environmental:

Temperature Range:	- 54 to + 150°C (- 65 to + 302°F)
Temperature Coefficient of Sensitivity:	0.09 %/°C
Temp. Transient Sensitivity (3 Hz Low. Lim. Frq. (-3 dB, 6 dB/oct)):	1 ms^{-2}/°C
Magnetic Sensitivity (50 Hz, 0.038 T):	20 ms^{-2}/T
Base Strain Sensitivity (at 250 με in base plane):	0.01 ms^{-2}/με
Max. Non-destructive Shock:	50 kms^{-2} peak (5000 g peak)
Humidity:	100 % RH non-condensing

Mechanical:

Case Material:	Stainless steel, AISI 316-L
Sensing Element:	Piezoelectric, Type PZ 23
Construction:	Annular Shear Case Insulated Internally Shielded
Sealing class (Helium leak rate):	< 10^{-6} mBar l/s
Weight:	35 gram (1.23 oz)
Electrical Connector:	3-pin HiRel All pins insulated from case

Signal/Power Supply; Ground, insulated from case; Not connected; Pin Designation

[1] This calibration is traceable (amplitude only) to the National Institute of Standards and Technology, USA.
The expanded uncertainty 100 Hz: 1.2%, 20 Hz to 100 Hz: 1.5%, 100 Hz to 2.5 kHz: 1.2% and 2.5 kHz to 10 kHz 2.5% is determined in accordance with EAL-R2. A coverage factor k=2 is used. This corresponds to a coverage probability of 95% for a normal distribution.

[3] Transducer Electronic Data Sheet according to IEEE P1451.4. Built-in ID-information not included.

[4] Deviation from Reference Sensitivity.

For further information, please see http://www.bksv.com.

Mounting Technique:
Examine the mounting surface for cleanliness and smoothness.
If necessary, machine surface to a flatness < 10 μm and a roughness < 2 μm.
Fasten the accelerometer using the appropriate centre bolt or stud. Take care not to exceed the recommended mounting torque and that the centre bolt or stud does not bottom in the mounting hole.
A thin film of oil or grease between the accelerometer and the mounting surface helps achieve good contact and improves mounting stiffness.
See also ISO 5348. For other types of mounting, see the Brüel & Kjær handbook "Piezoelectric Accelerometers and Vibration Preamplifiers" (available from your local Brüel & Kjær representative).

Mounting Hole:	Centre hole for M4 bolt
Mounting Thread:	10 - 32 UNF-2B. Depth 3.2 mm
Mounting Surface Flatness:	< 3 μm
Mounting Torque:	Max. 3.5 Nm (31 lbf-in). Min. 0.5 Nm (4.4 lbf-in)

Centre of gravity of seismic mass; Centre of gravity of accelerometer; ø19.5; ø4.2; Direction of acceleration; 6.5; 7.5; 0; 16.5; ø18; Recess ø6.5 0.5 deep; 29.9; All dimensions in millimetres

Individual Frequency Response [1]
Sensitivity [4] [%] / Phase [Degrees]
Amplitude; Phase
10; 0; -10; 20; 0; -20
5 10 20 50 100 200 500 1k 2k 5k 10k [Hz]

Typical High Frequency Response
Sensitivity [4] [dB] / Phase [Degrees]
Amplitude; Phase
30; 20; 10; 0; -10; 10; 0; -10; -20
1 2 5 10 20 50 100 [kHz]

Date 00 may 2013, 00.47 Operator KH

Specifications obtained in accordance with ANSI S2.11-1969 and parts of ISO 5347.
All values are typical at 25°C (77°F) unless measurement uncertainty is specified.

BC 0447-11

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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)

BN 1414 – 11 2014-05

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Local representatives and service organisations worldwide

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