

Integrating Vibration Meters

types 2513 and 2516

USES:

- Measurement of machine condition for maintenance procedures
- Vibration Severity measurements of rotating and reciprocating machinery
- Production quality control
- Occupational health investigations of powered hand-tools
- Vibration and shock testing
- General vibration measurements for design, research and development work

FEATURES:

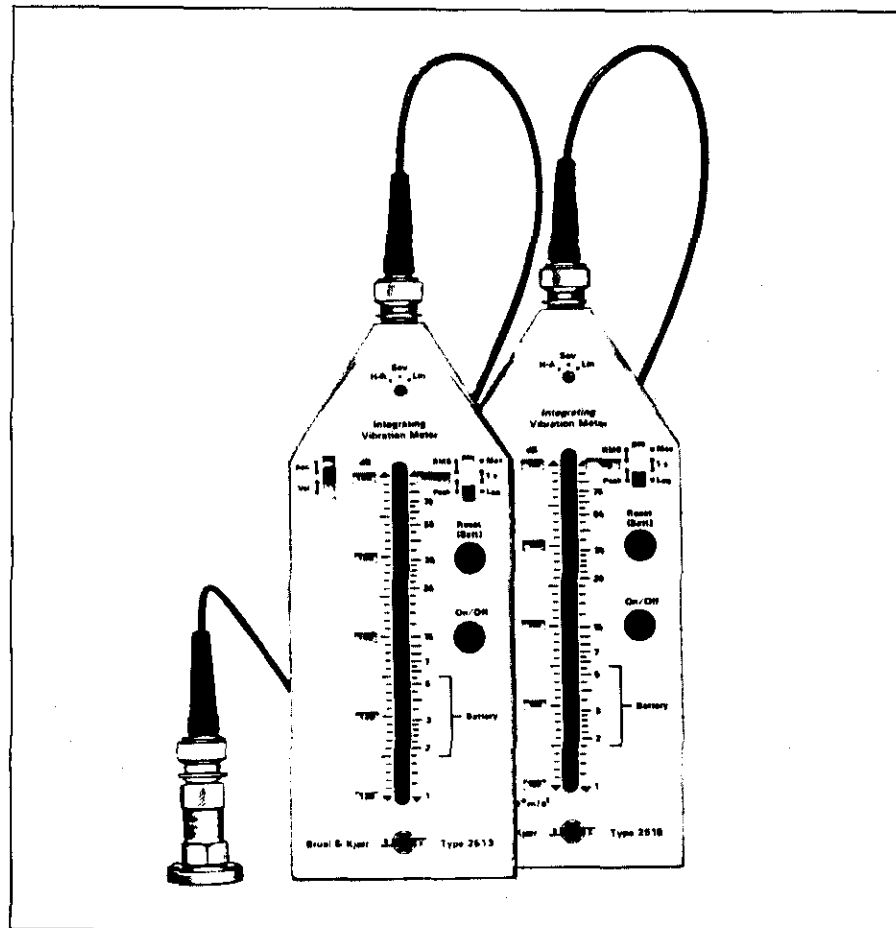
- Choice of measurement units — SI with 2513, g's and in/s with 2516
- Robust, slim-line construction

- Compact pre-calibrated Piezoelectric Accelerometer, with robust connection-cable, supplied
- True Peak, Max-Peak, RMS, or RMS-Max. indication of vibration acceleration or velocity
- Vibration acceleration ranges cover 1 to 1000 m/s² (2513), 0,1 to 100g (2516)
- Vibration velocity ranges cover 0,1 to 100 mm/s (2513), 0,01 to 10 in/s (2516)
- Electronic integration of measurement for L_{eq} display (equivalent-energy level) selectable
- Solid-state thermometer-type read-out covers 100:1 range
- Measures Hand-Arm vibration (to ISO/DP 5349 with Charge Attenuator available to order or alternative Accelerometer), Vibration Severity (to ISO 2954), or wide-band vibration 10Hz to 10kHz
- AC output for use with recorder, analyzer etc.
- Low-energy circuits for long battery life

The Types 2513 and 2516 Integrating Vibration Meters have been developed to meet the needs of the user who requires an economical yet accurate instrument for day-to-day vibration measurements. Compact and light enough to be carried in the Document Folder supplied, they incorporate several advanced features which enable them to be used easily by busy personnel for whom mechanical vibration measurement is only one of many activities. The 2513 is graduated in metric units, and the 2516 in g's and in/s.



Fig.1. Documentation of measurements taken on site with the Vibration Meter in its folder



roller-bearing defects, etc. The phase response has also been optimized for accurate shock measurement. This weighting can be used for such measurements in both acceleration and velocity modes. However, the instruments must be set to velocity for Vibration Severity or Hand-Arm measurements in accordance with the ISO standards quoted (even though as shown in Fig.5, Hand-Arm is a measurement of a weighted vibration acceleration). The High Pass Filter which replaces Hand-Arm in the modified instruments 2513/WH 2258 and 2516/WH 2260 should be used with the instruments set to acceleration.

Vibration Transducer

The Type 4384 Piezoelectric Accelerometer supplied with the 2513 and 2516 is of Delta-Shear[®] construction, and is trimmed during manufacture to achieve a Uni-Gain[®] sensitivity of 1pC per m/s². This ensures interchangeability between all 2513/2516's and 4384's, and eliminates the need for sensitivity adjustment of the Vibration Meter by the user. Calibration of the overall measuring system (4384 plus 2513/2516) is not normally necessary, but it can be checked using the Type 4294 Accelerometer Calibrator (not included).

The Mounting Magnet UA 0642 supplied with the Accelerometer is designed to exploit the full frequency range of the 2513/2516 system. A disc made of self-adhesive PTFE (2 supplied) may be placed under the Magnet if electrical isolation of the Accelerometer from the mounting surface is required. Ferromagnetic Cementing Discs YO 0070, like the one supplied with the Magnet, may be glued to regular measuring positions, using epoxy resin or cyanoacrylate adhesive, and left permanently in place. Alternatively the Accelerometer can be mounted directly by a Threaded Stud (supplied) in a tapped hole in the mounting object.

To connect the Accelerometer to the Vibration Meter, a sturdy Cable AO 0193, designed to withstand the rigours of regular shop-floor use, is provided. This Cable is suitable for use over a wide temperature range (-74° to +180°C), and generates negligible internal noise. It is terminated with robust TNC coaxial connectors. Connection to the Accelerometer is via an Adaptor, UA 0641, which incorporates a seal to provide good mechanical contact and moisture-resistance. The Accelerometer may alternatively be used with a standard Accelerome-

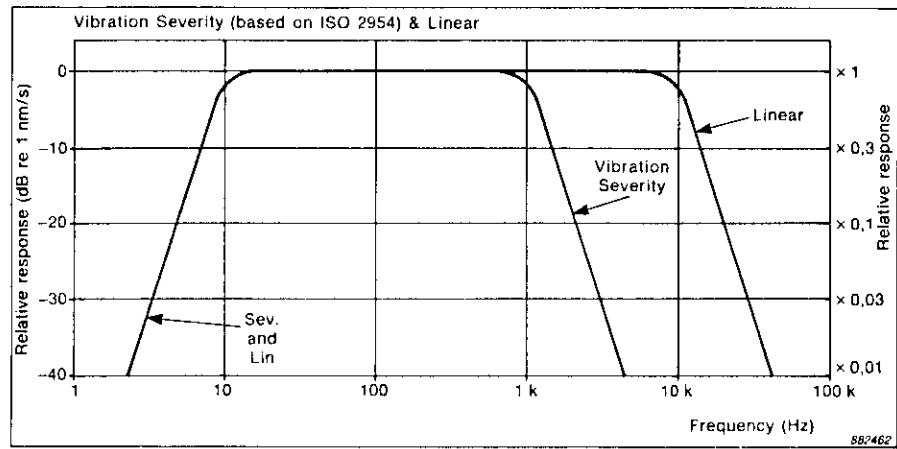


Fig. 4. The frequency response weightings of the 2513 (excluding Accelerometer) for Vibration Severity and Linear. To be understood as the weighted vibration level of a harmonic vibration 1 nm/s (rms) at the respective frequency, expressed in dB re 1 nm/s (For the 2516 the same curves apply but substitute 10⁻⁷ in/s for 1 nm/s)

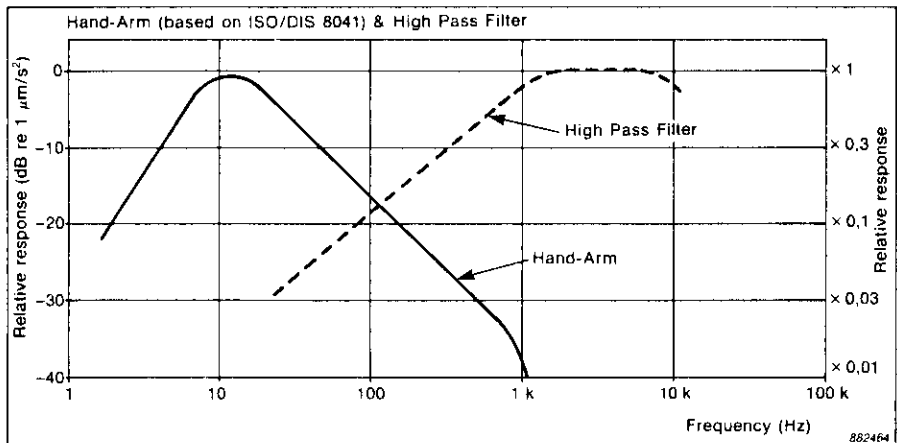


Fig. 5. The frequency response weightings of the 2513 and 2516 (excluding Accelerometer) for Hand-Arm vibration. To be understood as the weighted vibration level of a harmonic vibration 1 μm/s² (rms) at the respective frequency, expressed in dB re 1 μm/s². Also shown (dashed line) is the High Pass Filter, which replaces Hand-Arm in the 2513/WH 2258 and 2516/WH 2260

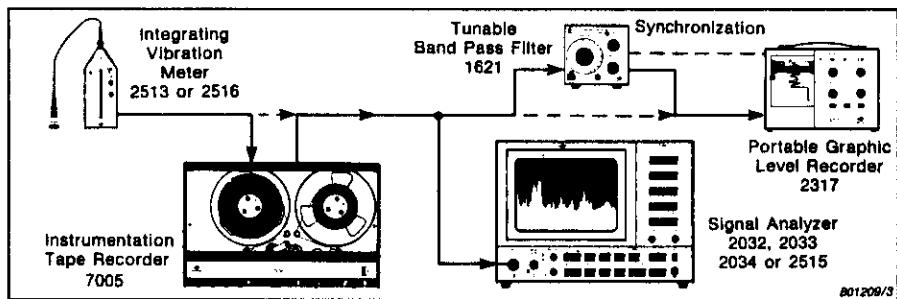


Fig. 6. Measurement and analysis systems which may be built round the 2513 or 2516

ter Cable (AO 0038, supplied) and Adaptor JP 0162 (available as an accessory) for measurements on light-weight structures.

A number of alternative Accelerometers are available from B & K for various applications. In particular, for Hand-Arm measurements to ISO/DP 5349 (1982-02-17), "Hand-Arm" Transducer Set Type 4392 is recommended for the 2513 (with some small correction for Accelerometer sensitivity tolerance). This set comprises a

miniature Accelerometer Type 4374 and two adaptors which overcome the problem of the transducer interfering with the operator's grip. Alternatively, for the 2516, the Miniature Accelerometer Type 4375 is available or, for both 2513 & 2516, the Accelerometer Type 4384 supplied can be used together with an optional Charge Attenuator.

Use with Other Instruments

Fig.6 shows a number of other B & K instruments which may be used to extend the applications of the 2513 or 2516.

The 2513 and 2516 are intended for four main kinds of application —

General vibration measurements. Vibration measurements are valuable in many branches of industry. Examples of applications are: shock measurement in rolling mills, leak detection in pipes, and pulsation measurements in pneumatic and hydraulic systems. Fields of use include power generation, mining, motor vehicles, ships, and railways.

Condition monitoring. It is well known that most kinds of machinery failures are preceded by a rise in vibration level. Regular measurement of machine vibration level can be used to decide whether the machine requires maintenance. This can form the basis of a systematic and economical technique for scheduling maintenance. It is appli-

cable to a very wide range of industrial plant, including machine-tools, steel, board and paper mills, chemical plants, cement ovens, compressors, diesel engines, and power stations.

Vibration Severity measurements. Vibration Severity is a quantity particularly useful in the evaluation of the running quality of rotating and reciprocating machinery. The 2513 and 2516 meet the requirements for an instrument suitable for measuring Vibration Severity as laid down in ISO 2954 (1975). Vibration Severity criteria are covered by ISO 2372, 2373 and 3945, and corresponding national standards. For quality-assurance personnel and technical staff engaged in buying or selling machinery, the 2513 and 2516 provide ideal means of checking that the vibration generated by a machine in operation

meets its contractual requirements. Because of their simplicity of operation, only the briefest of introductions is needed before the user starts making accurate measurements with the 2513 or 2516.

Hand-Arm Vibration. Of particular concern to manufacturers and users of portable power tools, and environmental health authorities, are the effects of sustained exposure to vibration transmitted into the hands and arms of their operators. The 2513 and the 2516 incorporate an electronic weighting filter, in accordance with ISO/DIS 8041 Draft 1987, to permit measurements to be made of the overall level of exposure, in accordance with ISO/DP 5349 (Draft 1982-02-17) when used with a Charge Attenuator available to order or a suitable alternative Accelerometer.

The Types 2513 and 2516 are compact battery-powered instruments easily held and operated in one hand. The 2513 measures in SI units, and the 2516 in g's and in/s. A document folder designed to contain both the Vibration Meter and an A4 note-pad for record-

ing measurements taken on site is also included (Fig.1). Each Vibration Meter is supplied with a light-weight Piezoelectric Accelerometer, connected by a 1,2m coaxial cable (see Fig.2).

Display

The 2513 and 2516 feature a solid-state thermometer-type display which makes them especially easy to use without sacrificing accuracy. It consists of 41 red light-emitting diodes (LEDs) covering a relative amplitude range of 1 to 100. The amplitudes are logarithmically spaced, giving a constant accuracy over the whole range. The LEDs, however, are equally spaced, so each successive LED corresponds to an amplitude 11% greater than the one below. If the amplitude measured falls between two LEDs, they both light giving a resolution of 6%.

The display range itself can be switched between two settings differing in level by a factor of 10, giving an overall measurement range of 1000:1. The main graduation levels are framed in "windows", and change automatically with function setting. A decibel (dB) scale is provided in addition to the engineering-units scale.

The L_{eq} ("Equivalent Level") facility on the 2513 and 2516 takes the vagueness out of vibration measurement when the level is fluctuating. In this mode of operation, the L_{eq} is computed by mathematical integration from all the mean square levels occurring since the measurement started (hence the name "Integrating Vibration Meter"). The standard instruments compute a one-minute L_{eq} , but the 2513/WH 2258 & 2516/WH 2260 compute a 10s L_{eq} . A steady figure for the vibration measurement is obtained, that is repeatable.

When the L_{eq} function is selected, the display simultaneously indicates the maximum peak value. There is no ambiguity because maximum peak values can never be less than L_{eq} values (Fig.3). The display flashes until measurement is complete and is then held until 2 minutes after the last "Reset" (or 2,5 minutes with the 2513/WH 2258 & 2516/WH 2260), then the instrument switches off to save batteries.

The display can also be set to read running peak levels only, with 1s decay-time constant, and RMS values, with a 1s time constant. Either instantaneous or maximum RMS indication may be selected.

All the display functions are available with a choice of indication of vibration acceleration or velocity. The preferred parameter depends on the application. Three different weightings may be selected — Linear, Severity and Hand-Arm. The Linear weighting (Fig.4) uses the extended frequency response of the 2513/2516 measuring system, which is of advantage where vibrations to be measured are caused by cavitation, turbulence,

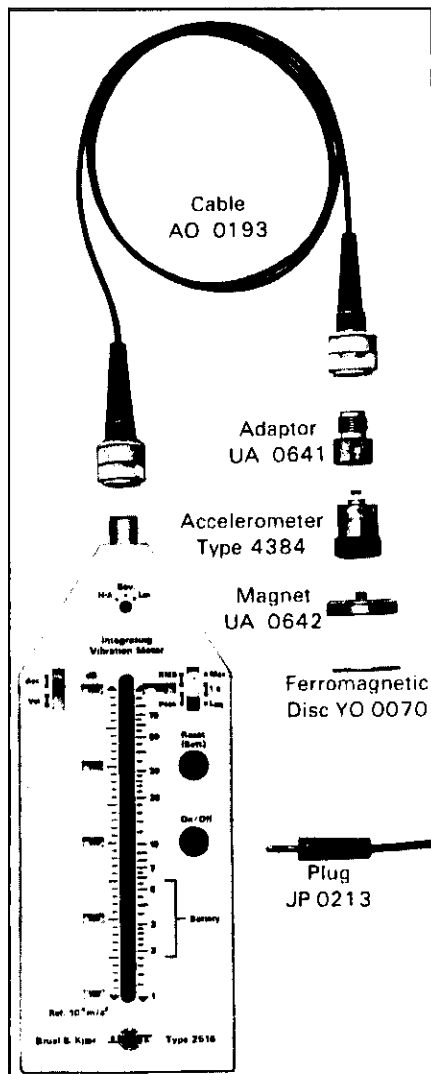


Fig.2. The interconnection arrangements for the 2513 and 2516 (illustrated)

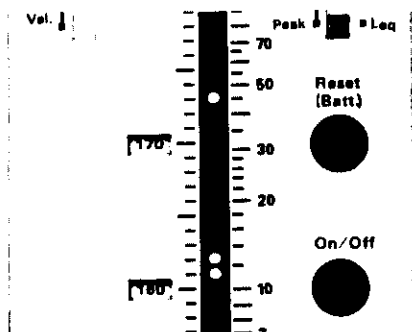


Fig.3. The display of the 2513, showing L_{eq} and Max. Peak indications simultaneously. The ratio of Peak to L_{eq} gives the Crest Factor of the vibration signal, which is used for detecting faults in rolling-element bearings

Specifications 2513 and 2516

<p>MEASUREMENT AMPLITUDE RANGES: 2513 Selectable Ranges: 1 to 100 and 10 to 1000 m/s² acceleration; 0,1 to 10 and 1 to 100 mm/s velocity 2516 Selectable Ranges: 0,1 to 10 and 1 to 100 g acceleration; 0,01 to 1 and 0,1 to 10 in/s velocity Hand-Arm Range (standard 2513 and 2516 only): 100 to 160 dB re 10⁻⁶ m/s² when used with a suitable Charge Attenuator or alternative Accelerometer Maximum Internal Noise: 2513: 0,2 m/s² acceleration, 0,1 mm/s velocity; 2516: 0,02 g acceleration, 0,007 in/s velocity</p> <p>MEASUREMENT FREQUENCY RANGES: Lin: 10 Hz to 10 kHz ± 3 dB (tolerance at higher frequencies in this range is dependent on good mounting of Accelerometer) Sev: 10 Hz to 1 kHz, to ISO 2954 (1975) H-A: 8 Hz to 1 kHz, to ISO D/P 5349 (Draft 1982-02-17) HP: 1 kHz to 10 kHz ± 3 dB only in 2513/WH 2258 & 2516/WH 2260, where the High Pass filter replaces Hand-Arm</p> <p>INDICATION: Level Indicated: Instantaneous or Maximum True Root-Mean-Square (RMS), with 1 s time constant True Peak, with 1 s decay-time constant L_{eq} simultaneously with Maximum Peak Overall Accuracy: (at 80 Hz) ± 6% (including Accelerometer sensitivity tolerance). Temperature sensitivity ± 0,05 dB/°C. Vibration sensitivity -20 dB (relative to the vibration level at the Accelerometer). Magnetic sensitivity negligible for field strengths up to 100 A/m Shock Measurement Accuracy: (with half-sine impulse) +2 -3 dB for 0,1 to 5 ms impulse, ± 1 dB for 0,5 to 2 ms impulse. RMS Crest-Factor: 3 for full scale indication, worst case, 100 at 3% of full scale RMS Max. Droop: Held indication will fall by not more than 6% of indication per minute Peak Rise-Time: 6% per μs. For a rectangular step, 60 μs</p>	<p>L_{eq}/Max.-Peak function: Display gives two simultaneous indications. Lower is L_{eq}, upper is Max.-Peak. Display flashes until measurement terminated (after 60 s ± 2% with the standard Instruments, 10 s with the 2513/WH 2258 & 2516/WH 2260); display is held until total 2 min. after the last "Reset" (2,5 min. for 2513/WH 2258 & 2516/WH 2260) Display: 41-element LED "thermometer" style Brightness Adjustment: Automatic compensation for ambient lighting by photo-sensitive transistor Resolution: 6% (0,5 dB). Intermediate levels are signified by illumination of 2 adjacent LEDs Scales: Engineering units (m/s² and mm/s on 2513, g's and in/s on 2516) with logarithmic graduations, plus dB re 1 μm/s² and 1 nm/s (2513) as 0 dB (10⁻⁷ in/s on 2516). For Hand-Arm measurements to ISO/DP 5349 (Draft 1982-02-17) a 20 dB Charge Attenuator WB 0726 (for 2513) and a 12 dB Charge Attenuator WB 0778 (for 2516) are available. Alternatively, a "Hand-Arm" Transducer Set Type 4392 (with 2513) or a Miniature Accelerometer Type 4375 (with 2516) may be used Overload Warning: Display flashes and level indication is suppressed until overload is removed</p> <p>OTHER CONTROLS: Reset: Operating any switch resets the instrument. Pushing "Reset" indicates battery condition on the display On/Off: Push for on, push for off AC Out: Sub-miniature socket accepting 2,5 mm jack-plug JP 0213 or cable AO 0173 for connection of a recorder or analyzer. Full insertion of plug disables automatic switch-off. Output impedance 10 Ω in series with 33 μF. Open-circuit voltage 1 V ± 6% corresponds to full scale indication. Min. load 10 kΩ</p> <p>BATTERIES: Type: 3 × 1,5 V cells to IEC specification LR6 ("Penlight" or "AA" size), e.g., alkaline cells QB 0013 Life: 24 hours continuous measurement in</p>	<p>room lighting. In bright sunlight continuous measurement life falls to 10 hours</p> <p>PHYSICAL CHARACTERISTICS: Weight: 350 g (12,4 oz) excl. 4384 Height: 187 mm (7,4 in) with 4384 cable disconnected Width: 72 mm (2,8 in) Depth: 22 mm (0,9 in) Temperature Range: -10° to +50°C (14° to 122°F) Humidity: 0 to 90% RH (non-condensing)</p> <p>ACCESSORIES SUPPLIED: Instruction Manual Piezoelectric Accelerometer..... Type 4384 Document Folder..... KE 0198 1,2 m (4 ft) TNC-to-TNC Accelerometer Cable..... AO 0193 Adaptor, TNC plug to Accelerometer..... UA 0641 Mounting Magnet..... UA 0642 (includes 1 Ferromagnetic Disc..... YO 0070 and 2 PTFE Isolating Discs..... DS 0553) 2,5 mm (0,1 in) Sub-Miniature Jack Plug..... JP 0213 3 Alkaline Cells..... QB 0013 Measurement Record Pad..... QP 4992</p> <p>ACCESSORIES AVAILABLE: Service Instructions 2,5 mm-Jack-to-BNC Cable (1,5 m)..... AO 0173 Adaptor, 10-32 UNF miniature coaxial connector to TNC (for connection of other Accelerometer Cables to 2513 or 2516)..... JP 0162 20 dB Charge Attenuator..... WB 0726 12 dB Charge Attenuator..... WB 0778 1 kHz High-Pass Filter..... WB 0772 Mechanical Filter..... UA 0559 (Available as a set of 5..... UA 0553) "Hand-Arm" Transducer Set..... Type 4392 (for 2513) Miniature Accelerometer..... Type 4375 (for 2516) Tripod Bush Adaptor..... DB 1112 Accelerometer Calibrator..... Type 4294</p>
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Specifications 4384

<p>MEASUREMENT CHARACTERISTICS: Sensitivity: 1 pC per m/s² ± 2% (10 pC/g) Capacitance: 1,2 nF approx. (incl. 1,2 m cable). Actual value given on calibration chart Mounted resonance: 35 kHz (threaded-stud) Transverse sensitivity: Max. 4% of main-axis sensitivity. Orientation of minimum sensitivity marked on case Piezoelectric material: PZ23 Base-strain sensitivity: Typically 0,02 m/s² (0,002 g) per μStrain (measured in base plane at 250 μStrain to ANSI S2.11-1969) Temperature transient sensitivity: Typically 0,8 m/s² per °C (0,044 g per °F) (to ANSI S2.11-1969) Magnetic sensitivity: Typically 7 m/s² per T (0,07 g per k Gauss), measured at 50 Hz and 0,03 T</p>	<p>Acoustic sensitivity: Typically 10 mm/s² (0,001 g) at 154 dB SPL (2 to 100 Hz) Temperature range: -74°C (-101°F) to +250°C (+482°F) Shock: ± 200 km/s² (± 20 000 g) max. peak parallel to main axis Vibration limit (within linear frequency range): 60 km/s² (6000 g) continuous peak sine wave along main axis; 1 km/s² (100 g) with magnet UA 0642</p> <p>PHYSICAL CHARACTERISTICS: Weight: 11 g (0,4 oz), excl. mounting accessories Height: 19,6 mm (0,8 in), excl. mounting and miniature 10-32 UNF screw-locking coaxial connector</p>	<p>Diameter: 13,5 mm (0,53 in) body and mounting-surface Base: Titanium, 14 mm (0,6 in) hexagon, with central 10-32 UNF tapped hole for mounting</p> <p>ACCESSORIES SUPPLIED: 1,2 m (4 ft) Accelerometer Cable with miniature 10-32 UNF screw-locking coaxial connectors..... AO 0038 10-32 UNF Threaded Steel Stud..... YQ 2960</p> <p>ACCESSORIES AVAILABLE: 3 m Accelerometer Cable with miniature 10-32 UNF screw-locking connectors..... AO 0122 Tube of Cyanoacrylate Adhesive..... QS 0007</p>
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