

# Product Data

## Integrating Vibration Meters — Types 2513 and 2516

### USES:

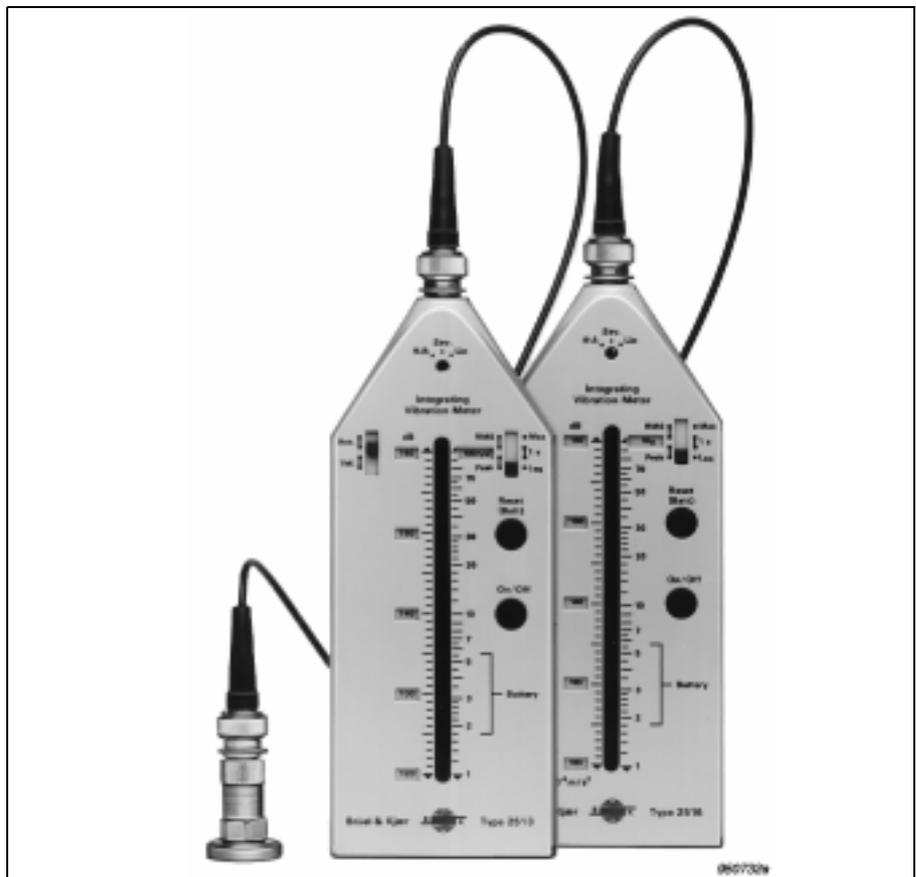
- Measurement of machine condition for maintenance purposes
- Vibration Severity measurements of rotating and reciprocating machinery
- Production quality control
- Occupational health investigations of powered hand-tools
- Vibration and shock testing
- General vibration measurements for design, research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

### FEATURES:

- Choice of measurement units — SI with 2513, g's and in/s with 2516
- Robust, slim-line construction
- AC output for use with recorder, analyzer etc.

- 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 1000m/s<sup>2</sup> (2513), 0.1 to 100g (2516)
- Vibration velocity ranges cover 0,1 to 100mm/s (2513), 0.01 to 10in/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
- 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.



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 applicable 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.



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

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 recording 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 1 minute  $L_{eq}$  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/WH2258 computes 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

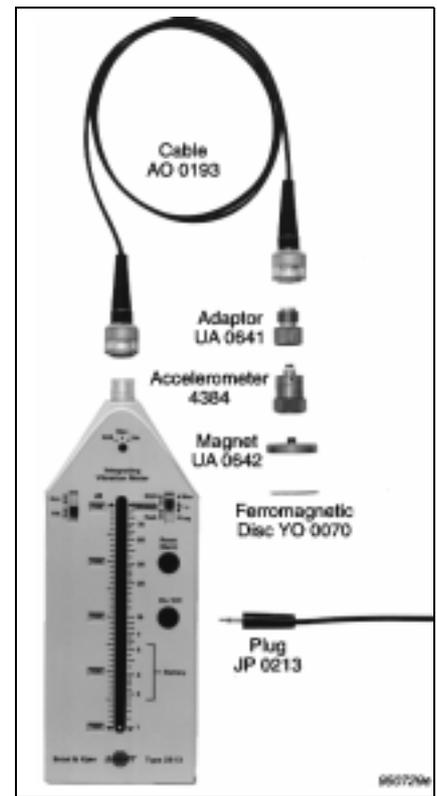


Fig.2 Interconnection arrangements for the 2513 and 2516

2513/WH2258), 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 vi-

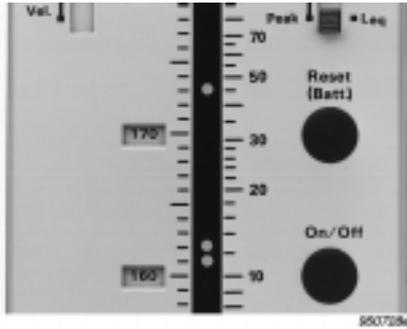


Fig. 3 The display of the 2513, showing  $L_{eq}$  and Max. Peak indications simultaneously. The ratio of Peak to  $L_{eq}$  gives the Crest Factor of the vibration signal, which is used for detecting faults in rolling-element bearings

bration 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, 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). A high-pass filter which replaces Hand-Arm in the modified instrument 2513/WH2258 should be used with the instrument 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  $m/s^2$ . 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).

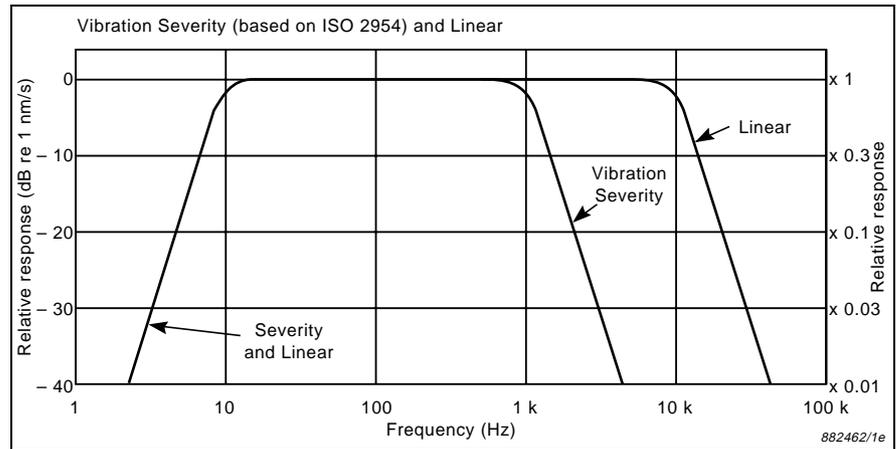


Fig. 4 The frequency response weightings of the 2513 (excluding Accelerometer) for Vibration Severity and Linear. To be understood as the weighted vibration level of a harmonic vibration 1 nm/s (rms) at the respective frequency, expressed in dB re 1 nm/s (For the 2516 the same curves apply but substitute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

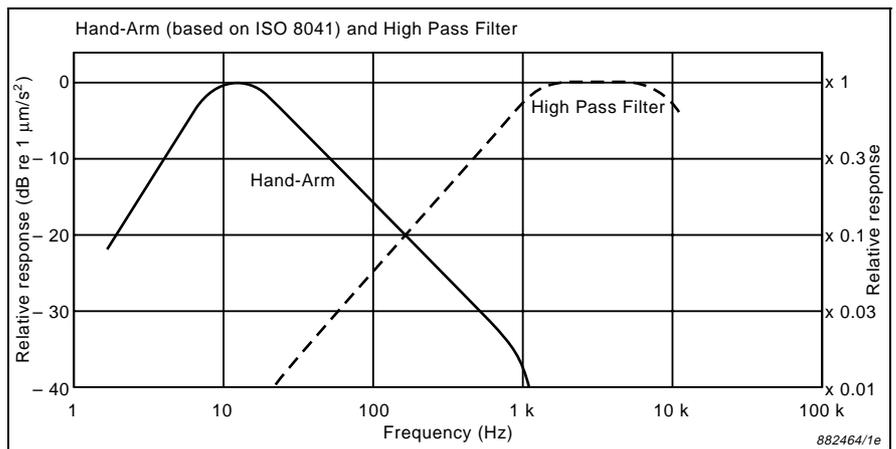


Fig. 5 The frequency response weightings of the 2513 and 2516 (excluding Accelerometer) for Hand-Arm vibration. To be understood as the weighted vibration level of a harmonic vibration  $1\mu m/s^2$  (rms) at the respective frequency, expressed in dB re  $1\mu m/s^2$ . Also shown (dashed line) is the high-pass filter, which replaces Hand-Arm in the 2513/WH2258

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 ( $-74^\circ$  to  $+180^\circ C$ ), 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 Accelerometer 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.

## Specifications 2513 and 2516

### MEASUREMENT AMPLITUDE RANGES:

**2513 Selectable Ranges:** 1 to 100 and 10 to 1000 m/s<sup>2</sup> 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<sup>-6</sup> m/s<sup>2</sup> when used with a suitable Charge Attenuator or alternative Accelerometer

**Maximum Internal Noise:** 2513: 0.2 m/s<sup>2</sup> acceleration, 0.1 mm/s velocity; 2516: 0.02 g acceleration, 0.007 in/s velocity

### 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

### 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) ±7% (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:** (with half-sine impulse) +2 -3 dB for 0.1 to 5 ms impulse, ±1 dB for 0.5 to 2 ms impulse, typical.

**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

**$L_{eq}$ /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); display is held until total 2 min. after the last "Reset" (2.5 min. for 2513/WH 2258)

**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/s<sup>2</sup> and mm/s on 2513, g's and in/s on 2516) with logarithmic

graduations, plus dB re 1 μm/s<sup>2</sup> and 1 nm/s (2513) as 0 dB (10<sup>-7</sup> 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

### 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 im-

pedance 10 Ω in series with 33 μF. Open-circuit voltage 1 V corresponds to full scale indication. Min. load 10 kΩ

### 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 room lighting. In bright sunlight continuous measurement life falls to 10 hours

### 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)

### COMPLIANCE WITH STANDARDS:

	CE-mark indicates compliance with EMC Directive
Safety	IEC 348: Safety Requirements for electronic measuring apparatus
EMC Emission	EN 50081-1 (1992): Generic emission standard. Residential, commercial and light industry EN 50081-2 (1993): Generic emission standard. Industrial environment CISPR 22 (1993): Radio disturbance characteristics of information technology equipment. Class B Limits FCC Rules, Part 15: Complies with the limits for a Class B digital device
EMC Immunity	EN 50082-1 (1992): Generic immunity standard. Residential, commercial and light industry EN 50082-2 (1995): Generic immunity standard. Industrial environment <b>Note 1:</b> The above is guaranteed using accessories listed in this Product Data sheet only <b>Note 2:</b> The above is guaranteed only when the AC output is not in use
Temperature	IEC 68-2-1 & IEC 68-2-2: Environmental Testing. Cold and Dry Heat Operating Temperature: -10 to +55°C Storage Temperature: -25 to +70°C IEC 68-2-14: Change of Temperature: -10 to +55°C (2 cycles, 1°C/min.)
Humidity	IEC 68-2-3: 90% RH (non-condensing at 40°C)
Mechanical	Non-operating: IEC 68-2-6: Vibration: 0.3 mm, 20 m/s <sup>2</sup> , 10-500 Hz IEC 68-2-27: Shock: 1000 m/s <sup>2</sup> IEC 68-2-29: Bump: 1000 bumps at 250 m/s <sup>2</sup>
Enclosure	IEC 529 (1989): Protection provided by enclosures. IP 20

# Ordering Information

<p><b>Types 2513/6:</b> Integrating Vibration Meters Include the following accessories:</p> <p>Type 4384 Piezoelectric Accelerometer KE0198 Document Folder AO0193 1.2m (4ft) TNC-to-TNC Accelerometer Cable UA0641 Adaptor, TNC plug to Accelerometer UA0642 Mounting Magnet (includes 1 Ferromagnetic Disk YO0070 and 2 PTFE Isolating Disks DS0553) JP0213 2.5mm (0,1in) Sub-Miniature Jack Plug</p>	<p>QB0013 3 Alkaline Cells QP4992 Measurement Record Pad</p> <hr/> <p><b>Optional Accessories</b></p> <p>Types 2513/6: <b>AO0173</b> 2.5mm-Jack-to-BNC Cable (1.5m) <b>JP0162</b> Adaptor, 10–32 UNF miniature coaxial connector to TNC (for connection of other</p>	<p>Accelerometer Cables to 2513 or 2516) <b>WB0726</b> 20dB Charge Attenuator <b>WB0778</b> 12dB Charge Attenuator <b>WB0772</b> 1 kHz High-pass Filter <b>UA0553</b> Set of 5 Mechanical Filters UA0559 <b>Type 4392</b> "Hand-Arm" Transducer Set (for 2513) <b>Type 4375</b> Miniature Accelerometer (for 2516) <b>DB1112</b> Tripod Bush Adaptor <b>Type 4294</b> Accelerometer Calibrator</p>
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Brüel&Kjær reserves the right to change specifications and accessories without notice

