Vibration Transducers

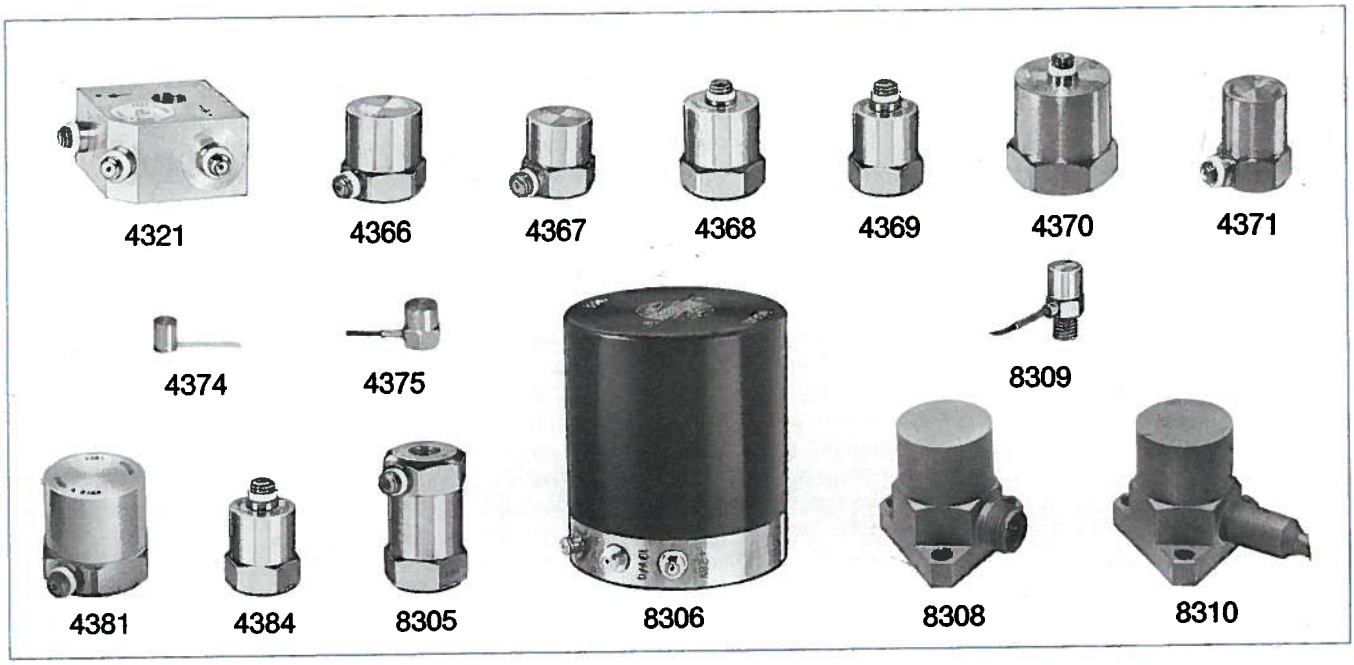
types 4321, 4366, 4367, 4368, 4369, 4370, 4371, 4374, 4375, 4381, 4384, 8305, 8306, 8308, 8309 and 8310

FEATURES:

- Acceleration ranges cover 20 μms^{-2} to 1000 kms^{-2}
- Frequency ranges cover from near DC to 60 kHz (+ 10% limit)
- Temperature range cover –200°C to + 400°C
- Low sensitivity to extraneous environmental influences
- Robust, sealed construction
- Individual calibration data supplied
- Artificially aged for good long term stability
- Uni-gain® types

USES:

- Shock and vibration measurement and analysis
- Transducer calibration
- Vibration monitoring
- Production control
- Vibration test control



The Brüel & Kjær accelerometer range incorporates transducers suitable for most application requirements both in the laboratory and under field conditions. In addition to a group of wide range, multi-purpose transducers a number of transducers are available for special purposes; i.e. high temperature, high shock, very low acceleration levels, fluctuating temperatures, calibration of other accelerometers and measurements on delicate structures. The application areas of the individual transducers naturally overlap, but by reference to the summary table on the back cover the user can isolate the transducers of interest. Full specifications can be found inside the back cover of this brochure.

General

An accelerometer is an electromechanical transducer which produces an electrical output proportional to the vibratory acceleration to which it is subjected.

The active element of B & K accelerometers consists of one or more piezoelectric discs or slices. These are top or side loaded by one or more seismic masses and are held in position by a stiff spring. When the accelerometer is subjected to vibration the combined seismic mass exerts a variable force on the piezoelectric element which due to the piezoelectric effect produces a corresponding electrical charge.

For frequencies from very near DC up to approximately one third of the resonance frequency of the accelerometer assembly, the acceleration of the seismic mass is equal to the acceleration of the whole transducer. Consequently the charge produced by the piezoelectric element is proportional to the acceleration to which the transducer is subjected. This charge can be measured electronically at the output terminals of the accelerometer and used for accurate determination of the vibration amplitude, frequency and waveform.

Design and Construction

For operation of accelerometers over wide dynamic and frequency ranges with low sensitivity to extraneous environmental influences, careful design is necessary. In the design of B & K piezoelectric accelerometers three basic constructions are used. These are illustrated in Fig.1 and each offers particular advantages.

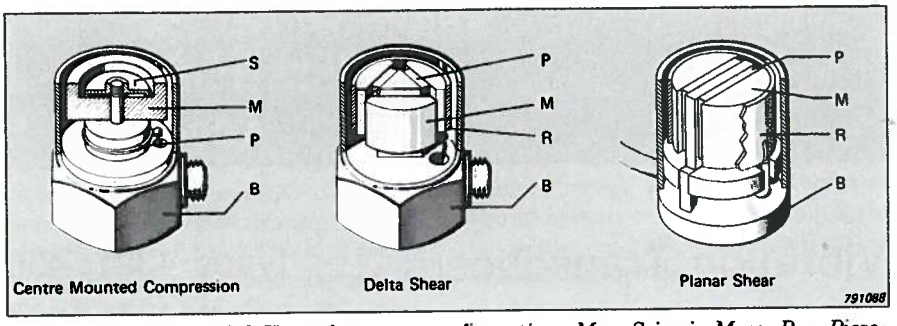


Fig. 1. Schematic of B & K accelerometer configurations M = Seismic Mass, P = Piezoelectric Element, B = Base, R = Clamping Ring and S = Spring

Centre Mounted Compression Design is a simple, sturdy construction that gives a moderately high sensitivity to mass ratio and can withstand high levels of continuous vibration and shock. The piezoelectric element-mass-spring system is mounted on a cylindrical centre post extending from the base of the accelerometer. However, despite the use of a relatively thick base, its sensitivity to base strain and temperature transients is somewhat higher than that of other B & K designs.

Compression design is employed with B & K Accelerometers Types 8305, 8306, 8308, 8309 and 8310.

Delta Shear Design® is a Brüel & Kjær innovation that combines the very best characteristics of traditional compression and shear design accelerometers. It gives a high sensitivity to mass ratio with moderately high resonance frequency and particularly low sensitivity to base strain and temperature transients. It employs three piezoelectric elements each with their own seismic mass which for reduced sensitivity to extraneous environmental forces are arranged in the shear mode around a triangular centre post. All mating surfaces are worked to a very fine degree of precision enabling the piezoelectric elements and seismic masses to be solidly clamped to the centre post using a high tensile strength, preloading ring. In this way the use of adhesives for bonding the piezoelectric elements and seismic masses are avoided, enabling an exceedingly good amplitude linearity and long term stability to be maintained.

Delta Shear design is used with B & K Accelerometers Types 4321, 4366, 4367, 4368, 4369, 4370, 4371, 4375, 4381 and 4384. The excellent overall characteristics of these accelerometers makes them eminently suitable for most vibration work.

Planar Shear Design is an extension of the well proven Delta Shear design. It employs two piezoelectric elements each with their own seismic mass which are rigidly clamped to a rectangular centre post using a high tensile preloading ring. This construction lends itself to miniaturization enabling small, lightweight accelerometers with a high sensitivity to mass ratio and resonance frequency to be constructed. At the same time sensitivity to extraneous environmental forces is very much reduced, compared with traditional shear design counterparts.

Planar Shear design is used with the B & K Miniature Accelerometer Type 4374.

Piezoelectric Element

The suitability of piezoelectric accelerometers for different vibration measurement applications also depends on the piezoelectric material used. With B & K accelerometers four different types are employed.

PZ 23 belongs to the lead zirconate titanate family of ferroelectric ceramics and may be used at temperatures up to 250°C. Owing to its good all round characteristics, it is used in most B & K accelerometers.

PZ 27 is similar to PZ 23 but with improved sensitivity and temperature response.

PZ 45 is a specially formulated ferroelectric ceramic with particularly flat temperature response and may be

used at high temperatures. Is used with the B & K 400°C and high shock accelerometers.

PZ 100 is a carefully selected and prepared quartz crystal. It exhibits excellent long term stability plus particularly flat temperature response and therefore is used with the B & K reference standard accelerometer.

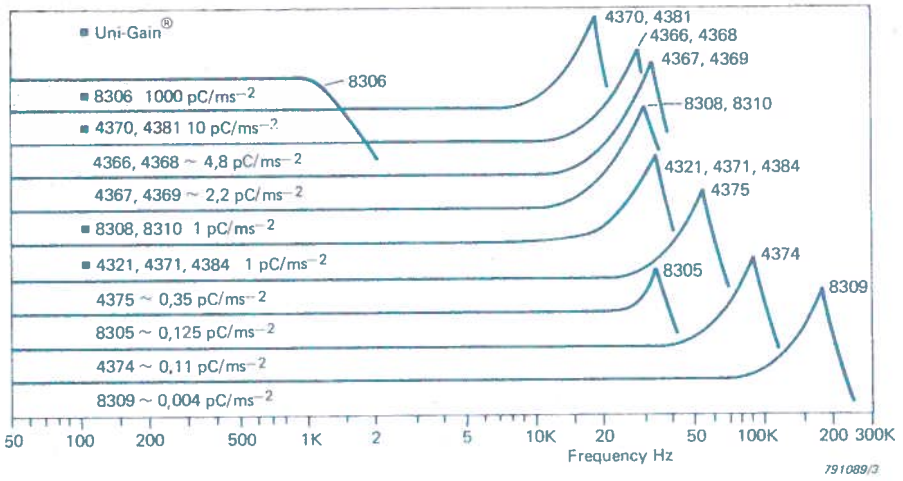


Fig. 2. Typical frequency response curves of B & K accelerometers

Characteristics

Charge and Voltage Sensitivity

A piezoelectric accelerometer may be treated as a charge or voltage source. Its sensitivity, which is the ratio of its electrical output and the acceleration causing the output, may therefore be expressed in terms of charge per unit of acceleration:

$$S_{qa} = pC/ms^{-2}$$

or in terms of voltage per unit of acceleration:

$$S_{va} = mV/ms^{-2}$$

The sensitivity depends not only on the type and size of piezoelectric element, but also on the weight of the seismic mass loading it. Consequently increased sensitivity is usually accompanied by increased physical size and weight. What balance of sensitivity and size is appropriate is largely determined by the application and the frequency range required for measurements.

Uni-Gain® Sensitivity

Certain B & K accelerometers have had their measured sensitivity especially adjusted during manufacture to be within 2% of a convenient unified value, for example 1, 10, 100 or 1000 pC/ms^{-2}. The use of these accelerometers with fixed gain preamplifiers makes sensitivity adjustment of the measuring system an easy matter. Setting-up time is reduced to a minimum and calculations during measurements are avoided.

Transverse Sensitivity

Accelerometers are also slightly sensitive to acceleration in a plane normal to their main sensitivity axis. This is due to minute irregularities in the structure and the alignment and in polarization of the piezoelectric element. At B & K particular attention is paid to selection of homogenous piezoelectric ceramics and in careful machining, polishing and lining-up of accelerometer parts, thereby ensuring that the majority of B & K accelerometers have a maximum transverse sensitivity of less than 3 or 4% of their main axis sensitivity at 30 Hz.

Because the transverse sensitivity varies for different directions in the base plane, most B & K accelerometers are individually measured and marked with a red spot to indicate the direction of minimum transverse sensitivity. See Main Specification Table for details.

Frequency Response

Typical frequency range characteristics for each accelerometer are shown in Fig.2. The upper frequency limit is usually taken to be one third of the mounted resonance frequency for less than 1 dB (12%) error, or one fifth of the resonance frequency for less than 0,5 dB (6%) error. This assumes that the accelerometer is properly fixed to the test specimen, as the use of poor mounting techniques can have a marked effect on the mounted resonance frequency of accelerometers. See section headed "Mounting".

The low frequency response of an accelerometer depends primarily on the type of preamplifier used in the vibration measurement set-up. With voltage types, the preamplifier input resistance effectively decreases the electrical time constant of the accelerometer. Consequently voltage preamplifiers having an exceedingly high input resistance have to be used to permit measurements at low frequencies. With charge preamplifiers there is no such problem as capacitive feedback on the preamplifier input effectively increases the accelerometer time constant, enabling a reduced lower frequency measurement limit to be easily obtained.

Phase Response

Owing to their low damping factors, B & K accelerometers may be used at all frequencies up to 0,3 times their mounted resonance frequency without noticeable phase distortion being introduced. This is especially important with regard to investigation of shock and transient vibrations where poor phase linearity can seriously distort the reproduced waveform.

Dynamic Range

The dynamic range of an accelerometer defines the range over which its electrical output is directly proportional to the acceleration applied to its base.

Upper Limit. This is determined by the mechanical strength and preloading of the piezoelectric element. In general, the smaller the accelerometer, the higher the vibration level at which it may be used.

The maximum shock and continuous vibration limits specified for B & K Accelerometers (see Fig.3) apply for vibration in the direction of the accelerometer main sensitivity axis and at frequencies up to one third of the accelerometer mounted resonance frequency. With vibrations containing high level components of a higher frequency, a mechanical filter should be used for mounting the accelerometer. This will reduce unwanted high frequency stimulation of the accelerometer at its resonance frequency, thus enabling it to be used within specified limits.

Lower Limit. As indicated in Fig.3 piezoelectric accelerometers may be used for measurement of very low vibration levels. Theoretically their output is linear down to zero, but a practical limit is imposed by the noise level of the measurement system and by the environment in which measurements are made. Therefore where measurements of the very lowest levels are of interest, it is important that a low noise preamplifier be selected (see Table 1), and that cables are kept short and well anchored to minimize noise imparted by mechanical motion. Also important, is selection of an accelerometer with low environmental sensitivity.

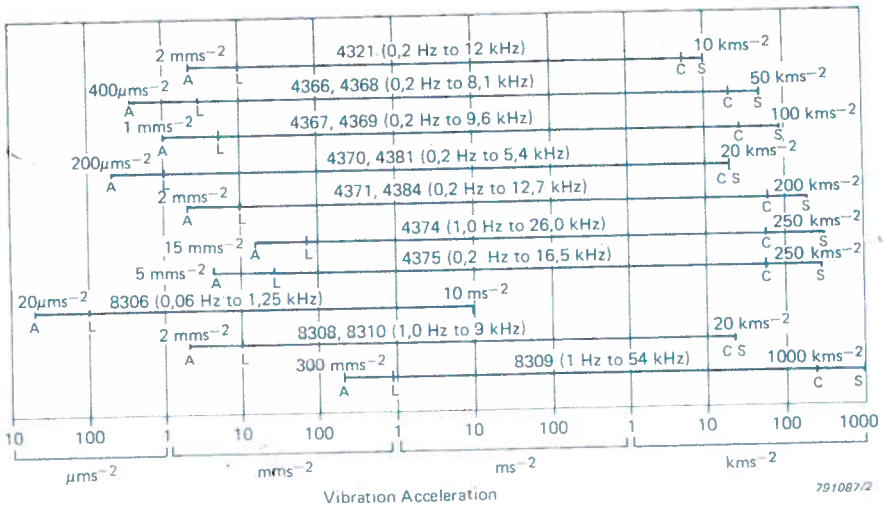


Fig. 3. Typical max. and min. vibration levels measurable with B & K Accelerometers plus conditioning Amplifier Type 2626. Max. limits (C = continuous vibration and S = shock) are peak values. Min. limits (A = ≤ 1/3 oct. and L = Lin 2 Hz to 20 kHz bandwidths) are RMS values

Environmental Sensitivity

When selecting an accelerometer, attention should be given to the likely environmental conditions under which it is to be used. The most important environmental factors which need be considered are:

Temperature. All B & K accelerometers are rated for a maximum operating temperature limit (see Main Specifications). At lower temperatures, the accelerometer piezoelectric element will exhibit temperature dependent variations in charge and voltage sensitivity, as well as capacitance. Details of the exact variation are given on the individual calibration chart supplied with each B & K accelerometer. As indicated in Fig.4, the sensitivity variation with accelerometers using PZ 23, PZ 27, PZ 45 and PZ 100 types of piezoelectric material is very small.

Piezoelectric accelerometers also exhibit sensitivity to temperature fluctuations (temperature transients). This effect is of no great importance until low frequency, low level accelerations are being measured. In such conditions the use of B & K "shear" types of piezoelectric accelerometer are advantageous as these have very low temperature transient sensitivities.

Acoustic Pressure. The acoustic sensitivity of B & K accelerometers is low and for most vibration measurement applications can be neglected. Normally the acoustically induced vibration in the structure being measured in much greater than the signal due to the acoustic sensitivity.

Nuclear Radiation. With the exception of Type 8306 all B & K accelerometers may be used under gamma radiation (10 k Rad/h, 7 MeV) up to accumulated doses of 2 M Rad. Tests indicate that Types 8308 and 8310 show less than 3% change in sensitivity, whilst other types show less than 10%. Normal types of accelerometer cable may be employed.

Accelerometer Types 8308 and 8310 may also be used under heavy neutron radiation. With accumulated doses of 100 M Rad and 10^{18} n.cm^{-2} (1 MRad/h., 1 to 5 MeV) and with thermal neutron flux of 10^{12} n cm^{-2} s^{-1} the change in sensitivity is less than 5%. The use of special mineral insulated "hardline" cable, such as AC 0202 which is provided with the 8310, is recommended with such radiation. See under "Individual B & K Accelerometer Types".

Base Strains may be introduced into the accelerometer from distortion of the structure being measured. To minimize base strain outputs, B & K accelerometers are constructed with thick rigid bases – "Shear" types giving the very best isolation from base strains.

Mounting

Mounting Methods

The frequency response given on the calibration chart supplied with B & K accelerometers is for the best possible mounting of the accelerometer – accelerometer screwed with steel stud onto a clean flat surface. When less rigid mounting methods are used the mounted resonance frequency will be lower.

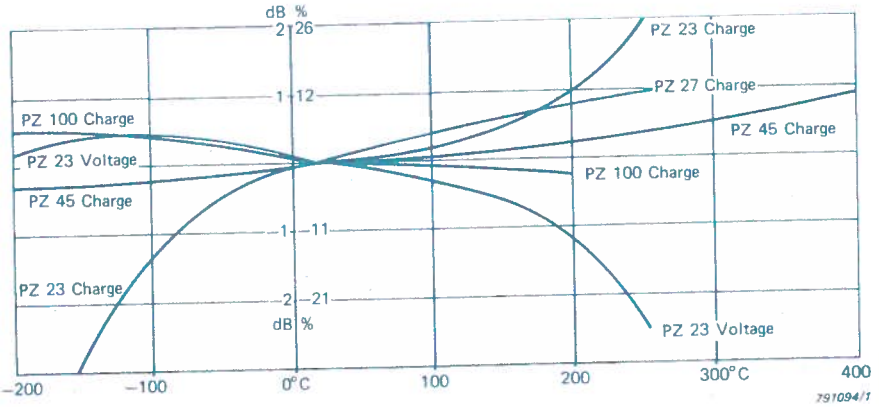


Fig. 4. Typical charge and voltage sensitivity characteristics of PZ 23, PZ 27, PZ 45 and PZ 100 piezoelectric materials as a function of temperature

In Fig.5 are shown some of the most commonly used types of accelerometer mounting. Those employing a steel or isolated stud may be used with all B & K accelerometers except Types 4374, 8308, 8309 and 8310. Due to its small size, the subminiature Accelerometer Type 4374 has a plane base and should be fixed by means of wax, double sided adhesive discs, dental cement or a quick setting cyanoacrylate cement. Types 8308 and 8310 are attached with screws through three fixing holes in their base flange, while Type 8309 has a threaded fixing stud as an integral part of its base.

Whatever type of mounting used, it is good practice to roughly ascertain what mounted resonance frequency is obtained before proceeding with actual measurements. This can be done from response curves published in the B & K "Piezoelectric Accelerometers and Vibration Preamplifiers" Handbook and is important in selecting an appropriate upper frequency limit on the preamplifier which will exclude vibration components amplified by resonance. If a preamplifier without selectable upper frequency limits is employed, then unwanted high frequency stimulation of an accelerometer at its resonance frequency can be considerably reduced using a Mechanical Filter UA 0559 for mounting.

Mechanical Filter UA 0559 also serves to electrically isolate the accelerometer housing from grounded test specimens. This is particularly useful as it prevents ground loops which can interfere with measurement of low vibration levels. Accelerometers may also be electrically isolated using a Permanent Magnet UA 0642 together with a self-adhesive PTFE Disc DS 0553 or, where it is required to retain the high frequency measurement capability of accelerometers, they may be mounted using an isolated stud and mica washer. With the Balanced Accelerometers Types 8308 and 8310 additional electrical isolation is unnecessary as these accelerometers are fully isolated internally.

Cooling

For measurements on specimens with surface temperatures up to 400°C, the Balanced Accelerometers Types 8308 and 8310 can be used. With accelerometers having lower maximum temperature limits (see Main Specifications Table), some form of cooling is necessary. For example, with a thin heat conductive plate and mica washer mounted beneath the base of a 250°C accelerometer (see Fig.6), measurements may be made on surfaces with temperatures up to 350°C. With extra cooling by directing a stream of cooling air at the plate, surface temperatures up to 450°C can be tolerated.

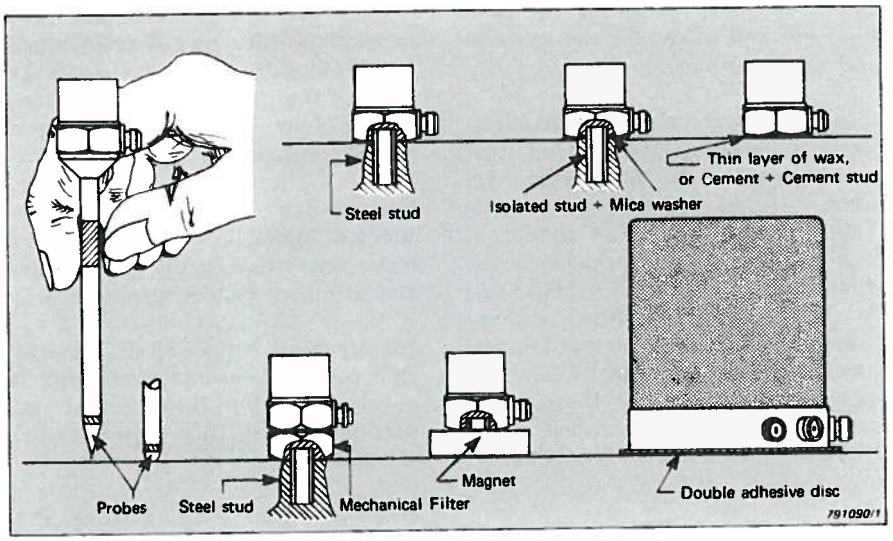


Fig. 5. Different methods of mounting accelerometers

Sealing

B & K accelerometers have a high resistance to many of the corrosive agents commonly encounted in industry and are sealed – Types 8305, 8308 and 8310 being all welded and the remainder epoxy sealed.

Sealing ensures reliable operation in humid environments and with extra precautions such as the use of moisture impervious Teflon cable with the accelerometer outlet sealed in the manner shown in Fig.7, permits operation in wet environments. A suitable sealant is the room temperature vulcanizing rubber Dow Corning Silastic 738 RTV (B & K no. AW 8858).

Laboratory tests indicate that accelerometers correctly sealed in the above manner, can for short periods withstand total immersion in liquids.

Connecting Cables

Two types of miniature, single core, coaxial cable are available. These are a standard 1,2 m long plain Teflon insulated cable AO 0038, plus a separate 3m long Teflon insulated cable reinforced with plated copper braid, AO 0122. The cables are supplied fitted with miniature coaxial plugs suitable for direct connection to most B&K accelerometers. Exceptions are the Miniature Accelerometers Types 4374, 4375 and 8309 which have an integral cable and miniature coaxial plug and the 400°C Balanced Accelerometers Types 8308 and 8310 (see under "Individual B&K Accelerometer Types"). All cables include a special noise reduction treatment and are individually tested with regard to mechanical and electrical performance. Their maximum temperature rating is

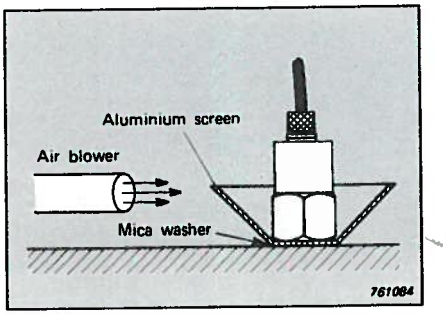


Fig. 6. Forced air cooling of accelerometer

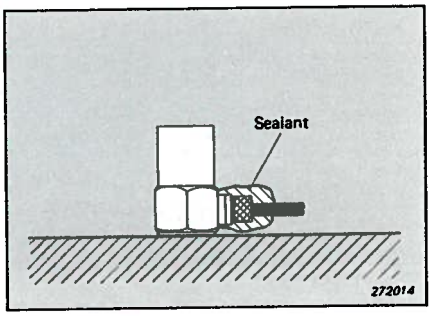


Fig. 7. Sealing of accelerometer cable output

260°C and with extra sealing as in Fig.7 are well suited for use in moist and wet environments.

Where longer cables are required, they may be obtained on special order in any length up to 180 m, with plugs already fitted. Alternatively, plain Teflon cable AC 0005 or reinforced Teflon cable AC 0200 which are the same as used with cables AO 0038 and AO 0122, may be ordered without plugs fitted to enable the user to make up cable lengths as required. The sets of connection plugs for these cables are illustrated and described under "Additional Accessories Available".

Preamplifiers

B & K produce a wide selection of vibration transducer preamplifiers for connection of piezoelectric accelerometers to measuring and analyzing instruments. These have the summarized specifications listed in Table 1 below and with one exception are all exclusively charge sensitive types. This means that very long accelerometer connection cables up to 0,5 km in length may be employed without altering the specified sensitivity of the accelerometer and preamplifier combination.

Since ease of calibration and measurement are usually just as important as overall gain and frequency range, most of the preamplifiers listed have one or more of the following signal conditioning aids:

Sensitivity Conditioning Networks. Allow direct dial-in of transducer sensitivity on the preamplifier, giving unified system sensitivities.

Integration Networks. Automatically convert measured acceleration to a velocity and/or displacement proportional signal, thus saving manual calculation.

High and Low Pass Filters. Permit selection of different lower and upper frequency limits on the preamplifier to exclude unwanted signals and accelerometer resonance from measurements.

In addition to the preamplifiers listed in Table 1, B&K produce a number of portable, battery operated measuring instruments that have their own built-in preamplifiers allowing direct connection of accelerometers. Vibration Meters Type 2511, 2512, 2513 and 2516 have built-in charge preamplifiers, whilst Precision Sound Level Meters Types 2230 and 2233 may be used as vibration meters, having ultra high input impedance voltage preamplifiers.

An important point to be considered when using a Sound Level Meter, or for that matter any other instrument with voltage preamplifier input, is that accelerometers must be used with the standard 1,2 m long connection cable with which they are supplied. This is because the voltage sensitivity of accelerometers is dependent on the capacitance of the connection cable. If a shorter or longer cable is used, then the voltage sensitivity will have to be calculated using the relation:

$$S_{va} = \frac{S_{qa}}{C_t}$$

where S_{qa} is the charge sensitivity of the accelerometer and C_t is the accelerometer source capacitance plus the capacitance of the particular connection cable employed.

Calibration

Factory Calibration

All B & K accelerometers are thoroughly checked and examined at all stages of manufacture and assembly. Furthermore, each accelerometer undergoes an extensive calibration procedure and artificial ageing process so as to ensure completely predictable performance and stable operation. Accurate numerical details of the individual calibration are reported on the calibration chart supplied with each transducer, a typical example of which is shown in Fig.8.

B & K Type and Main Data	2626  1:10Δ 3 digit charge conditioning amplifier with direct and transformer coupled outputs for multi-purpose vibration work	2634  1:10Δ Small, robust, charge amplifier with differential input for multi channel work and severe environments	2635  1:10Δ 3 digit charge conditioning amplifier for multipurpose vibration work	2644  1:2Δ Miniature line-drive charge amplifier for general vibration work and use in severe environments	2650  1:10Δ 4 digit charge and voltage conditioning amplifier for multi-purpose vibration work and transducer calibration	2651 1:10Δ Low frequency charge amplifier for multi-channel, vibration severity and shock work
Measurement Modes	Acceleration	Acceleration	Acceleration Velocity Displacement	Acceleration	Acceleration	Acceleration Velocity
Acceleration Sensitivity *	0,1 mV to 1 V/pC (–20 to + 60 dB)	0,9 to 10 mV/pC (0 to + 20 dB)	0,01 mV to 10 V/pC (–40 to + 80 dB)	1 mV/pC (0 dB)	0,1 to 100 mV/pC (mV) (–20 to + 40 dB)	0,1–1–10 mV/pC (–20 to + 20 dB)
Frequency Range	0,3 Hz to 100 kHz selectable LLF and ULF	1 Hz to 200 kHz	0,1 Hz to 200 kHz selectable LLF and ULF	0,5 Hz to 100 kHz	0,3 Hz to 200 kHz selectable LLF and ULF	0,003 Hz to 200 kHz selectable LLF
Noise* (2 Hz to 20 kHz)	$5\ 10^{-3}$ pC	$15\ 10^{-3}$ pC	$5\ 10^{-3}$ pC	$10\ 10^{-3}$ pC	$10\ 10^{-3}$ pC or 10 μV	$15\ 10^{-3}$ pC
Power Requirements	AC Mains	Ext. Battery	Int. or Ext. Battery	Line-Drive Supply Type 2813	AC Mains	Ext. Battery

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*1nF source capacitance

Δscale

Table 1. B & K Accelerometer Preamplifiers

260°C and with extra sealing as in Fig.7 are well suited for use in moist and wet environments.

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Preamplifiers

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Sensitivity Conditioning Networks. Allow direct dial-in of transducer sensitivity on the preamplifier, giving unified system sensitivities.

Integration Networks. Automatically convert measured acceleration to a velocity and/or displacement proportional signal, thus saving manual calculation.

High and Low Pass Filters. Permit selection of different lower and upper frequency limits on the preamplifier to exclude unwanted signals and accelerometer resonance from measurements.

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Measurement Modes	Acceleration	Acceleration	Acceleration Velocity Displacement	Acceleration	Acceleration	Acceleration Velocity
Acceleration Sensitivity *	0,1 mV to 1 V/pC (−20 to + 60 dB)	0,9 to 10 mV/pC (0 to + 20 dB)	0,01 mV to 10 V/pC (−40 to + 80 dB)	1 mV/pC (0 dB)	0,1 to 100 mV/pC (mV) (−20 to + 40 dB)	0,1–1–10 mV/pC (−20 to + 20 dB)
Frequency Range	0,3 Hz to 100 kHz selectable LLF and ULF	1 Hz to 200 kHz	0,1 Hz to 200 kHz selectable LLF and ULF	0,5 Hz to 100 kHz	0,3 Hz to 200 kHz selectable LLF and ULF	0,003 Hz to 200 kHz selectable LLF
Noise* (2 Hz to 20 kHz)	5 10^{-3} pC	15 10^{-3} pC	5 10^{-3} pC	10 10^{-3} pC	10 10^{-3} pC or 10 μV	15 10^{-3} pC
Power Requirements	AC Mains	Ext. Battery	Int. or Ext. Battery	Line-Drive Supply Type 2813	AC Mains	Ext. Battery

*1nF source capacitance

Δscale

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Table 1. B & K Accelerometer Preamplifiers

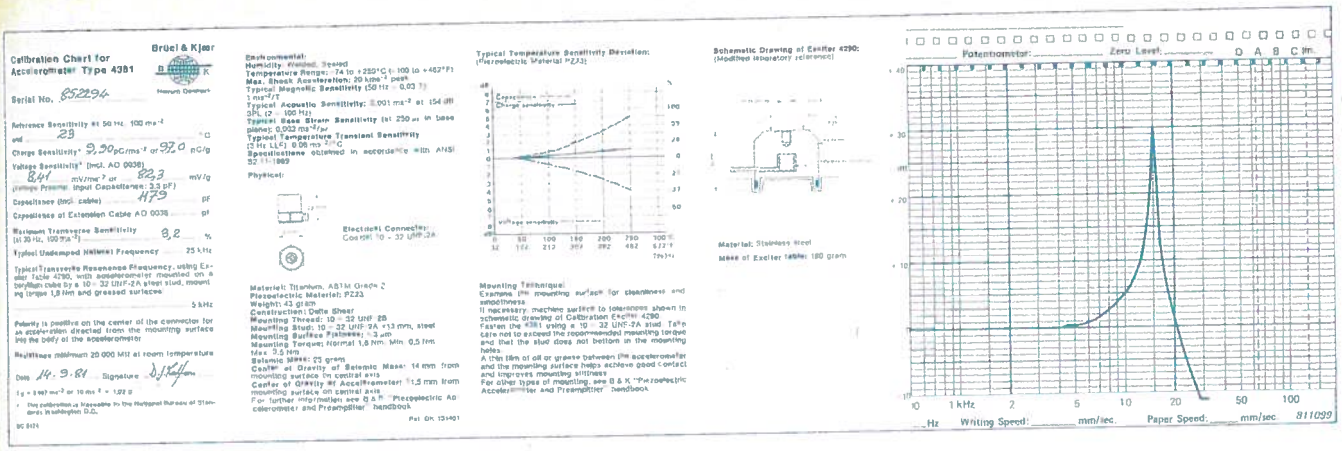


Fig. 8. Example of calibration chart supplied with B & K accelerometers

With the Reference Standard Accelerometer Type 8305 sensitivity calibration is by the absolute laser interferometry method, whilst with other B&K accelerometers it is by back to back comparison with a primary reference standard accelerometer which is regularly checked both by the American National Bureau of Standards (NBS) and by laser interferometry calibration. The overall accuracy of these two methods of sensitivity calibration is better than ±0,6% and 2% respectively with a 99% confidence level. For further information on these and other methods of calibration, the B&K "Accelerometer Calibration Brochure" should be consulted.

Subsequent Calibration

Regular calibration of accelerometers helps maintain confidence in the measurements taken and warns whether accelerometers have been damaged by abusive treatment. To help users perform their own frequency response and sensitivity calibration, the following apparatus is available.

Calibration Exciter Type 4290 is a small electro-magnetic vibration exciter which may be used in checking the frequency response of accelerometers in the frequency range from 50 Hz up to 50 kHz. It has a maximum force rating of 2 N and has its own control accelerometer built-in.

Accelerometer Calibrator Type 4291 is a compact, portable vibration exciter with self-contained battery supply and generator, producing a reference acceleration level of 10 ms^{-2} peak. It is particularly useful in rapid sensitivity calibration of accelerometers and in adjustment of vibration measuring systems to provide a direct read-out in ms^{-2} or g. In addition, provision is made for back to back comparison and reciprocity calibration of accelerometers.

Accelerometer Calibrator Type 4294 is a pocket-sized, self-contained vibration reference source which facilitates rapid calibration and checking of vibration measuring and monitoring systems at a reference level of 10 ms^{-2} RMS.

Calibration Set 3506 contains a Reference Standard Accelerometer Type 8305 and Accelerometer Conditioning Amplifier Type 2626 which are calibrated as an integral pair using the laser interferometry method. The overall calibration accuracy is better than ± 0,6% with a 99% confidence level. See under "Individual B & K Accelerometer Types".

Sensitivity Comparator Type 2970 aids rapid back to back comparison calibration of accelerometers in conjunction with two Accelerometer Conditioning Amplifiers Type 2626 and a Reference Standard Accelerometer Type 8305. With the sensitivity of the 8305 dialed in on one 2626 and the sensitivity of the other adjusted to achieve a balance indication on the 2970 when the 8305 and an unknown accelerometer are vibrated back to back using a vibration exciter, the exact sensitivity of the unknown accelerometer can be observed from the settings of the conditioning knobs of the 2626.

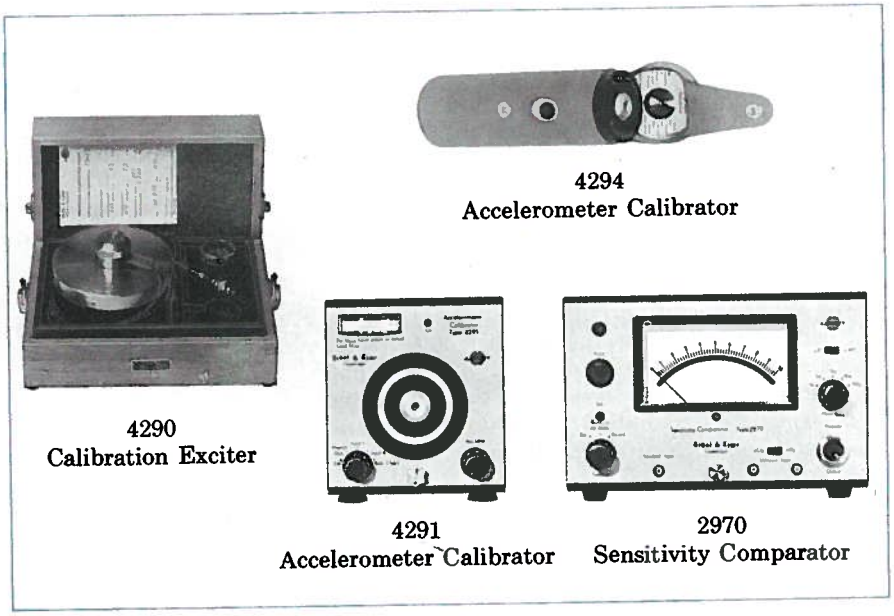


Fig. 9. Instruments for accelerometer calibration

Individual B & K Accelerometer Types

Dimensions and specifications of the complete range of B & K piezoelectric accelerometers can be found in the schemes given towards the end of this brochure. In addition to wide range, multi-purpose types of accelerometer there are also types that have been designed for more specialized applications. The special features of these accelerometers are discussed below.

400°C Balanced Accelerometers Types 8308 and 8310

These accelerometers are intended for use in severe environments, that prevent the use of other accelerometer types. They are particularly well suited for high reliability, permanent monitoring of continuous vibrations on steam and gas turbines, aircraft engines, pressure vessels, nuclear reactors, as well as on electrical plant and industrial machinery in general. Except for differences in high temperature output connection, the accelerometers are similar.

Both the 8308 and 8310 have a Uni-Gain® charge sensitivity of 1 pC/ms^{-2} with useful frequency range which is linear to within + 10% up to 10 kHz. Being Uni-Gain® means that all 8308 and 8310 accelerometers have the same sensitivity to within ± 2%. This is of important benefit in permanent monitoring and multi-channel vibration measurement set-ups, as they may be directly interchanged or replaced by other 8308 or 8310 accelerometers without altering system sensitivity.

An additional feature of the 8308 and 8310 is that both poles of their piezoelectric element are electrically isolated from their housing and base giving them an electrically balanced output. This is advantageous when using the accelerometers with a proper differential amplifier such as the B&K Charge Amplifier Type 2634. Noise pick-up common to both poles of the accelerometer output and output cable, cancel in the preamplifier giving a very high degree of immunity from mains noise and noise due to electromagnetic radiation pick-up when working on electrical machinery. Furthermore, external precautions need not be taken to isolate the accelerometers from grounded measurement points, as both poles of their output are already electrically isolated internally.

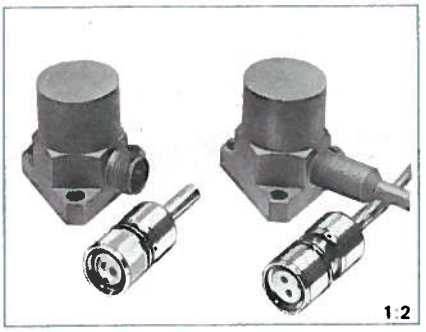


Fig. 10. 400°C Balanced Accelerometers Types 8308 and 8310

For vibration measurements on surfaces with temperatures up to 400°C, PZ 45 piezoelectric ceramic is used as the transducing element of the accelerometers. This gives them particularly good long term stability and flat temperature response, as well as enables them to withstand heavy nuclear radiation without significant change in characteristics. See under "Environmental Sensitivity".

To facilitate use in permanent vibration monitoring set-ups, the accelerometers have a robust, all welded, stainless steel housing with three hole base flange in line with the ARINC (Aeronautical Inc., USA) Characteristic 544, for bolting them solidly to the measuring point. In addition they are hermetically sealed, making long term operation in very wet and humid environments possible.

With the 8310 an integral, 3 metre long, "hard line" cable is included. This can tolerate surface temperatures up to 800°C and consists of a pair of twisted conductors in a flexible stainless steel shell filled with aluminium oxide insulation material. For connection to the B&K Charge Amplifier Type 2634, a 2 pole TNC plug is used to terminate the cable. The plug has a maximum temperature rating of 180°C.

On the 8308 the housing has an integral glass sealed output socket. This is supplied with a standard 2 pole TNC plug JP 0209 which can tolerate temperatures up to 180°C. For operation at higher temperatures special 2 pole plugs and cables are available from the B & K System Development Group. For further details, ask for the B & K System Development Data Sheet "Special Cable Systems for Vibration Monitors".

Where it is required to use the 8308 with preamplifiers having a conventional single ended input, the Adaptor JJ 0207 should be ordered. This can tolerate temperatures up to 180°C and grounds one of the poles of the accelerometer output permitting use of mininoise coaxial cables and plugs with the accelerometer.

Triaxial Accelerometer Type 4321

The 4321 consists of three separate accelerometers in a single housing which are accurately aligned so that vibration in three mutually perpendicular directions can be measured.

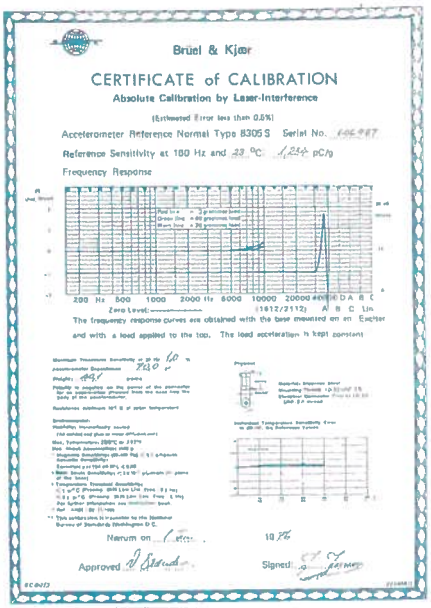
For reduced weight and a wide operating frequency range extending up to 12 kHz, the 4321 has a lightweight titanium housing. Low sensitivity to extraneous environmental influences, as well as tranverse vibrations in directions other than the three main sensitivity axes of the accelerometer, is obtained by using a delta shear construction for the three separate transducers contained in the accelerometer. Each transducing element is individually adjusted for a Uni-Gain® charge sensitivity of 1 pC/ms^{-2} (± 2%) which considerably simplifies system calibration and readout of measured levels especially when using charge preamplifiers with fixed sensitivity settings.

For mounting, the 4321 can be fixed to the measurement point either by means of an M4 steel screw passing through its body or by a 10–32 NF threaded stud screwed into its base.

Fig. 11. Triaxial Accelerometer Type 4321

Standard Reference Accelerometer Type 8305

This accelerometer is designed specially as a laboratory standard for the precise calibration of vibration transducers by the back to back comparison method. It has a 10–32 NF thread in its base for mounting onto a shaker table and a similar thread in its top for mounting it back to back with trans-



Brüel & Kjær

CERTIFICATE of CALIBRATION

Absolute Calibration by Laser-Interference

Accelerometer Reference Normal Type 8305 S Serial No.

Reference Sensitivity at 160 Hz and 23 °C: 1,254 pC/g

Frequency Response

200 Hz 500 1000 2000 Hz 6000 10000 20000

The frequency response curves are obtained with the base mounted on an Exciter and with a load applied to the top. The load acceleration is kept constant

Approved

Signed

Fig. 12. Typical Calibration Certificate as supplied with Type 8305

ducers to be calibrated. The use of a specially isolated and inverted centre mounted compression construction, has resulted in particularly low base strain and transverse vibration sensitivities, necessary to ensure a very high degree of accuracy in comparison measurements. Furthermore, a carefully prepared quartz material PZ 100 is used as the piezoelectric element, thus ensuring excellent long term stability and low sensitivity to temperature changes.

Each 8305 is issued with its own calibration certificate, giving detailed calibration data and frequency response curves for the individual transducer. Absolute calibration of its main axis charge sensitivity is performed at B&K by the laser interferometry method. The calibration equipment is regularly checked by calibrating a reference accelerometer which has been previously calibrated by the American National Bureau of Standards. The estimated error of the laser interferometry method of sensitivity calibration is less than ± 0,6% at a 99% confidence level.

Because of its relatively low internal capacitance, the 8305 should be used exclusively with charge types of preamplifier. One which can be particularly recommended is the Conditioning Amplifier Type 2626 which is available together with the 8305 in the Calibration Set Type 3506 shown in Fig.13. In this case the 8305 and 2626 are calibrated as an integral pair using

Fig. 13. Accelerometer Calibration Set Type 3506

the laser interferometry method. This is of benefit when using the 8305 and 2626 in set-ups for calibration of other vibration transducers, as it helps keep cumulative errors to an absolute minimum. For example, using the Calibration Set Type 3506 together with the Sensitivity Comparator Type 2970, vibration transducers may be calibrated with an estimated error as low as ± 0,7%.

For subsequent calibration checks on the 8305, with or without an accompanying preamplifier, a factory recalibration service is available.

Low g Accelerometer Type 8306

This accelerometer is a very high sensitivity Uni-Gain® type for measurement of very low level vibrations at frequencies extending from 0,3 Hz up to 1 kHz. With a third octave or narrow band filter included in the measuring arrangement, measurement of vibration levels down to 0,000 02 ms^{-2} is possible. Principal applications are in vibration investigations on large structures such as buildings, bridges and ships. It is also useful for seismic work.

Fig. 14. Low g Accelerometer Type 8306

The 8306 has its own built-in preamplifier. This provides separate charge and voltage outputs from the accelerometer with Uni-Gain® sensitivity of 1000 pC(mV)/ms^{-2}. Because of its very low output impedance, very long output cables may be used without introducing voltage sensitivity losses. Also noise induced by mechanical motion of cables is substantially reduced.

For a well defined upper limit frequency limit, a 1,25 kHz active low pass filter is incorporated in the built-in preamplifier. This has a steep high frequency roll off of 60 dB/decade which heavily attenuates high frequency components of the measured vibration, thus reducing possible influence of the accelerometer mounted resonance frequency on measurement results.

For powering the preamplifier of the 8306 an external + 28 V (2 mA) DC supply, such as is available from a small battery, is required. Alternatively, this may be obtained from the PREAMP INPUT socket of most B&K Measuring Amplifiers and Frequency Analysers when fitted with the Supply Adaptor ZR 0024, or it may be obtained directly from the +28 V OUTPUT socket of the B&K Vibration Meters Types 2511 and 2512. The use of these instruments is especially convenient as they also serve to give a direct meter indication of the measured vibration level from the charge or voltage output of the 8306.

The 8306 may be fastened to the surface of a vibration specimen using a 10–32 NF steel stud or by means of a double sided adhesive disc. The latter type of mounting is extremely simple to apply and provides good adhesion on most surfaces, including concrete and masonry. However, for optimum response without reduction of the accelerometer mounted resonance frequency, stud mounting is to be preferred.

Miniature Accelerometers Types 4374 and 4375

These accelerometers are well suited for measurements on lightweight structures where relatively high level, high frequency vibrations are commonly encountered, and where the use of heavier transducers would alter the

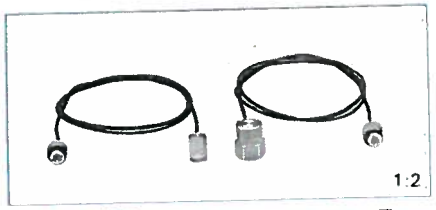


Fig. 15. Miniature Accelerometers Type 4374 and 4375

Fig. 16. Shock Accelerometer Type 8309

mode of vibration, invalidating measurements. Typical application areas are measurements on thin vibrating panels including aircraft and automobile bodies, model testing, work in confined spaces and measurement of moderately high level shock.

Type 4374 is a planar shear construction, weighs approximately 0,65 grams and is suitable for measurement at frequencies up to 26 kHz, whilst Type 4375 is of delta shear construction, weighs approximately 2,5 grams and can be used for measurement of frequencies up to 18 kHz. Both accelerometers have an integral 40 cm long connection cable with miniature coaxial plug attached – Type 4374 having a plane base for wax or cement mounting and Type 4375 having an M3 screw thread for stud mounting. For vibration severity measurements on hand-tools etc., a miniature triaxial version 5852 of the 4374 can be ordered from the B & K Systems Engineering Group.

Accelerometer Type 8309 is especially intended for measurement of very high level continuous vibration and mechanical shock up to 300 kms^{-2} and 1000 kms^{-2} peak, respectively. Important applications are in the measurement of shocks due to explosions, tests on pneumatic tools such as rock drills and shock measurements and analysis on valves of internal combustion engines.

The 8309 is of particularly robust construction, necessary for withstanding the severe conditions imposed by very high level continuous vibration and shock. Its PZ 45 piezoelectric element is especially prepared and treated to withstand very high dynamic stress with negligible problems of "zero shift" which is a charge retention phenomenon peculiar to measurement of very high level shock with piezoelectric devices. For small size and low weight, an essential requirement where any extra mass can alter the dynamic characteristics of small test objects, the use of an output socket is avoided. Instead the 8309 has an integral 300 mm long output cable, which gives the added advantage of a reliable output connection at very high shock levels.

All charge and voltage preamplifiers are suitable for use with the 8309. However, when measuring very high shock levels it is important that the maximum charge or voltage rating of the preamplifier input is not exceeded. With voltage preamplifiers this can be avoided by adding extra cable between the transducer and the preamplifer.

Since mechanical shocks generally contain a very large number of frequency components, the 8309 has been designed with a very high mounted resonance frequency of 180 kHz. This enables half sine wave type shock pulses as short as 30 μs to be accurately measured with amplitude errors due to excitation of the accelerometer at its mounted resonance frequency of less than 10%. If a Conditioning Amplifier Type 2626 is used with the Accelerometer then shock pulses as short as 6 μs may be measured, as the "Linear" mode high frequency response of this amplifier will damp the resonance. With other types of amplifier the resonance may be damped using a low pass filter which has a cut-off frequency of between 80 and 100 kHz with high frequency attenuation slope of approximately 40 dB/decade.

For rigid mounting, which is of particular importance when measuring high shock levels, the base of the 8309 has an integral threaded fixing stud which is adequately dimensioned to transmit the full motion of the test object to the piezoelectric element without distortion.

What to Order

Accelerometers available from B & K are supplied in the form of a **Set** or **Package. Accelerometer Sets** (suffix S after type number) consist of a single accelerometer complete with cable and a range of accessories in a mahogany case such as shown in Fig.17. **Accelerometer Packages** (suffix P after type number) consist of five accelerometers, individually packaged with cable and studs as shown in Fig.18.

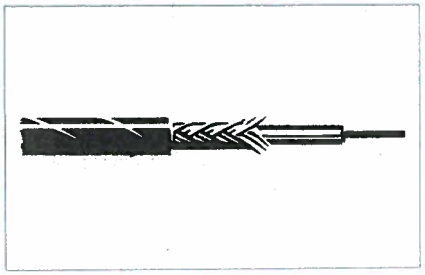
Fig. 17. A typical accelerometer set

Accelerometers Types 4321, 8305 and 8306 are supplied only as an Accelerometer Set. Types 8308 and 8310 are supplied singly packed only.

A complete list of accessories as supplied with each accelerometer set or package, is shown under "Standard Accessories". Additional accessories are available on separate order.

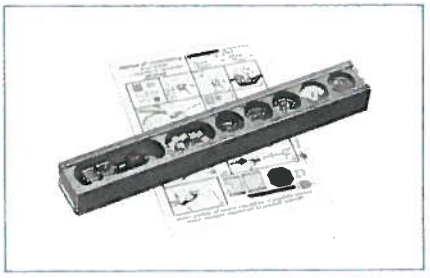
Fig. 18. Accelerometer package

Additional Accessories Available

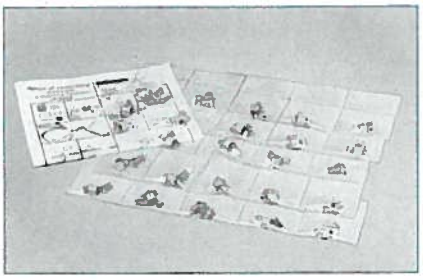


AC 0005. Teflon insulated, low noise cable for use up to 260°C. Available in any length up to 180m.
AC 0200. Reinforced version of AC 0005.

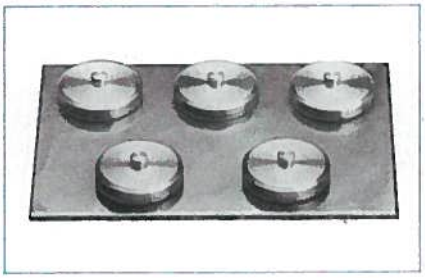
UA 0125. Set of 10 isolated studs YP 0150, 10 steel studs YQ 2960, 10 nuts YM 0414, 10 mica washers YQ 0534 plus 10–32 NF tap and 3/32″ hexagonal key.



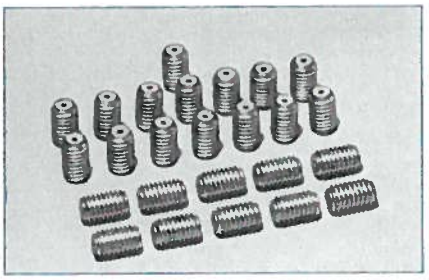
UA 0129. Set of 20 miniature plugs JP 0012 for accelerometer cable AC 0005. Assembly tool included.



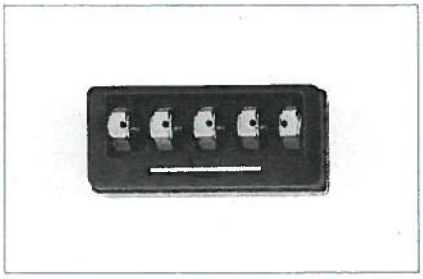
UA 0130. Set of 25 plugs JP 0012 for cable AC 0005. **UA 0730.** Set of 25 plugs JP 0056 for cable AC 0200. For mounting the plugs, the assembly tool supplied with UA 0129 is required. See above.



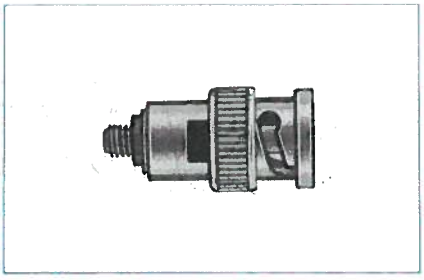
UA 0643. Set of 5 mounting magnets UA 0642. Includes PTFE self adhesive discs for electrical isolation.



UA 0186. Set of 25 extension connectors JJ 0032 for miniature cables with plugs JP 0012 and JP 0056.



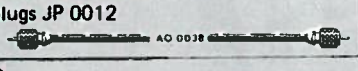
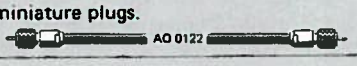
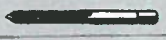
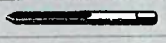
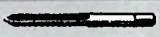
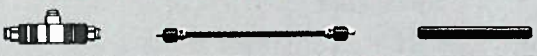
UA 0553. Set of 5 electrically isolated Mechanical Filters UA 0559, plus tommy bar for mounting.



JP 0145. BNC socket adaptor for connection of miniature cables with JP 0012 or JP 0056.

AW 8858. Acid-free, room temperature vulcanizing rubber for sealing cable connectors. Withstands temperatures from –70 to + 260°C.

Standard Accessories

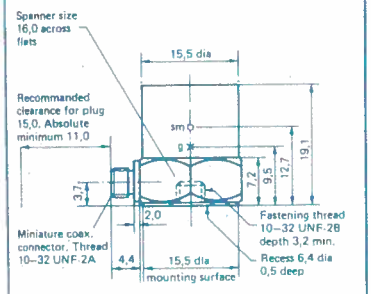
B & K Part No.	Standard Accessories	4366, 4367, 4368 4369, 4370, 4371 4381, 4384 S	4366, 4367, 4368 4369, 4370, 4371 4381, 4384 P	4321 S	4374 4375 S	4374 4375 P	8305 S	8306 S	8308 8310 S	8309 S	8309 P
AO 0038	260° Teflon mininoise cable AC 0005 fitted with miniature plugs JP 0012 Length 1,2 m (4 ft) 	1	5	3	1	5	1			1	5
AO 0122	260°C Reinforced cable fitted with reinforced miniature plugs. Length 3 m (10 ft) 							2			
YS 9419	8–32 NF steel screw Length 0,5 in. 								3		
JJ 0032	Extension connector for above B & K cables 				4	5				4	5
JP 0145	Microplug to BNC adaptor 	1		3	1			1		1	
JP 0209	2 pin plug for balanced accelerometers Max. temperature 180° C 								1 (Not 8310)		
YQ 2962	10–32 NF threaded steel stud. 0,312 in long 						2				
YQ 2960	10–32 NF threaded steel stud. 0,5 in long 	5	5	5			2	5			
YM 0414	10–32 Nut 	1		1			1				
YP 0150	10–32 NF insulated stud. 0,5 in long 	1		1			1				
YO 0534	Insulating mica washer 	1		1			1				
YQ 2007	M3 threaded steel stud. 0,25 in long 				6	5					
YM 0334	M3 nut 				1						
YQ 0093	M4 steel screw. 0,625 in long 			1							
QA 0029	Tap for 10–32 NF thread 	1		1			1				
QA 0041	Tap for M3 thread 				1						
QA 0068	Tap for M5 thread 									1	
DB 0756	Cement stud 10–32 NF 	1		1							
DB 0757	Cement stud M3 				2						
QA 0013	Hexagonal key for 10–32 NF studs 	1		1			1				
QA 0042	Hexagonal key for M3 studs 				1						
QA 0038	Hexagonal key for M4 studs 			1							
YJ 0216	Beeswax for mounting 	1		1	1			1		1	
YP 0080 DB 0544	Probe with sharp tip. 10–32 NF Round tip 	1									
UA 0642 DL 3014	Mounting magnet + 2 Iso. Discs DS 0553 Cable clip for magnet 	1									
UA 0322 AO 0047 DA 0064	Insert voltage adaptor with cable and tommy bar 						1 1 1				
DB 1440	Adaptor. 4–40 UNC to 10–32 NF thread 						1				
DB 1441	Adaptor. 6–32 UNC to 10–32 NF thread 						1				
DB 1442	Adaptor 8–32 UNC to 10–32 NF thread 						1				
DB 1443	Adaptor 1/4–28 UNF to 10–32 NF thread 						1				
DU 0079	1 x adhesive mounting disc. Dia 40 mm (1,6 in) 							5			
YO 0073	25 x adhesive mounting disc. Dia 5,5 mm (0,2 in) 				1						
QS 0007	Tube of cyanoacrylate adhesive 				1						
	Individual calibration chart	1	5	1	1	5	1	1	1	1	5

760876/4

Accelerometer Dimensions

Shown 85% natural size (except 8306)
All dimensions in mm

Type 4366



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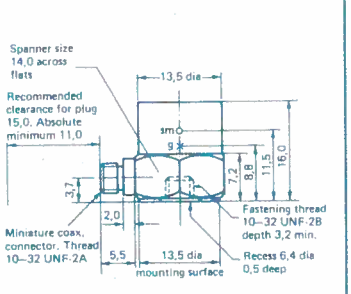
Type 4367



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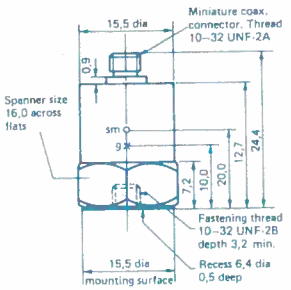
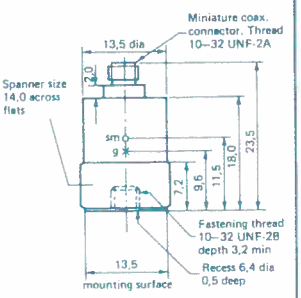
Type 4368



750114/1

Type 4369 and 4384



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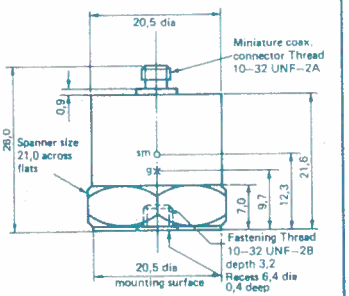
Type 4370



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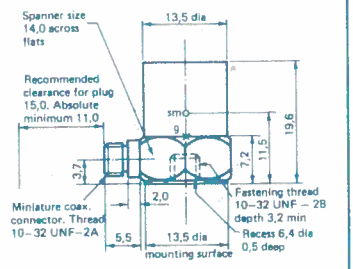
Type 4371



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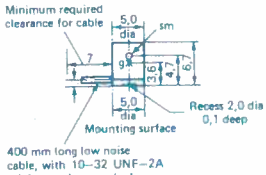
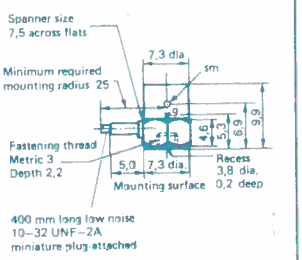
Type 4374



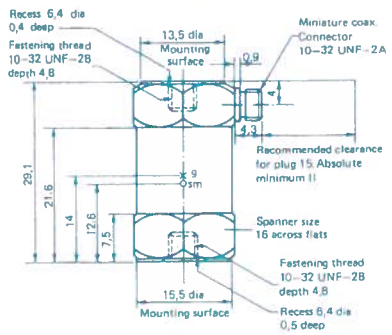
791003/2

Type 4375



791004/2

Type 8305



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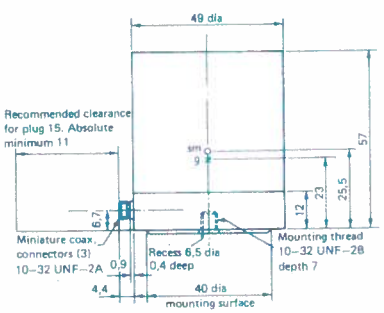
Type 8306



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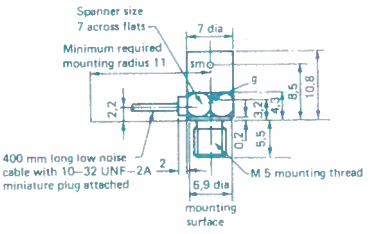
Type 8309



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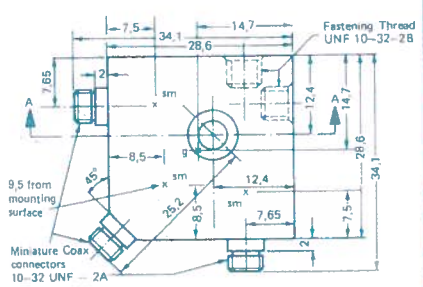
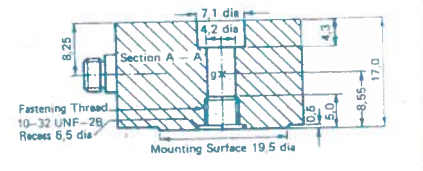
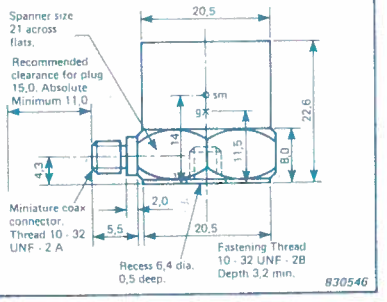
Type 4321





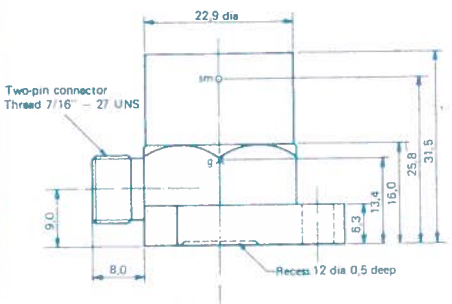
751129/2

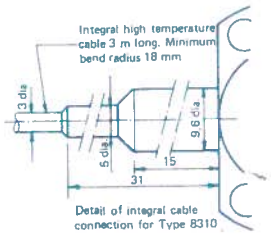
Type 4381

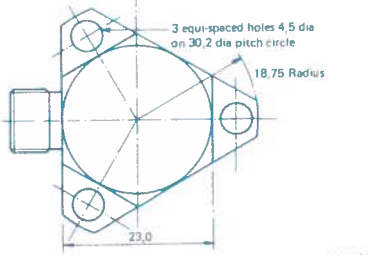


830546

Type 8308 and 8310







750122/2

800040/2

Centre of gravity: "o" seismic mass – "x" whole assembly

Specifications

■ Uni-Gain® sensitivity to ±2%

Accelerometer B & K Type		 4321■	 4366	 4367	 4368	 4369	 4370 4381	 4371■ 4384■
*Weight (grams)		55	28	13	30	14	54 / 43	11
*Voltage Sensitivity	mV/ms^{-2}	~ 0,8	~ 4,0	~ 1,8	~ 4,0	~ 1,8	~ 8	~ 0,8
	mV/g	~ 8	~ 40	~ 18	~ 40	~ 18	~ 100	~ 10
*Charge Sensitivity	pC/ms^{-2}	1 ± 2%	~ 4,8	~ 2,2	~ 4,8	~ 2,2	10 ± 2%	1 ± 2%
	pC/g	~ 10	~ 48	~ 22	~ 48	~ 22	~ 100	~ 10
*Mounted Resonance	kHz	40++	27	32	27	32	18	42
*Frequency Range†	5%	0,2–8700++	0,2–5900	0,2–9000	0,2–5000	0,2–7000	0,2–3900	0,2–9200
	10%	0,2–12000++	0,2–8100	0,2–9600	0,2–8100	0,2–9600	0,2– 5400	0,2–12700
Capacitance Incl. Cable	pF**	1200	1200	1200	1200	1200	1200	1200
Max. Transverse Sensitivity	%***	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Piezoelectric Material		PZ23	PZ23	PZ23	PZ23	PZ23	PZ23	PZ23
Construction		Delta Shear	Delta Shear	Delta Shear	Delta Shear	Delta Shear	Delta Shear	Delta Shear
Typical Base Strain Sensitivity**** (in base plane at 250 με)	$ms^{-2}/\mu strain$	0,02	0,006	0,008	0,006	0,008	0,003	0,02
	g/μstrain	0,002	0,0006	0,0008	0,0006	0,0008	0,0003	0,002
Typical Temp Transient Sensitivity****(3 HzLLF)	$ms^{-2}/°C$	0,8	0,1	0,4	0,1	0,4	0,08	0,8
	g/°C	0,08	0,01	0,04	0,01	0,04	0,008	0,08
Typical Magnetic Sensitivity (50 Hz–0,03 T)	ms^{-2}/T	7	3	6	3	6	1,0	7
	g/k Gauss	0,07	0,03	0,06	0,03	0,06	0,01	0,07
Typical Acoustic Sens. Equiv. Acc. at 154 dB SPL (2–100 Hz)	ms^{-2}	0,01	0,002	0,005	0,002	0,005	0,001	0,01
	g	0,001	0,0002	0,0005	0,0002	0,0005	0,0001	0,001
Min. Leakage Resistance at 20°C	GΩ	20	20	20	20	20	20	20
Ambient Temperature Range	°C	–74 to 250	–74 to 250	–74 to 180	–74 to 250	–74 to 180	–74 to 250	–74 to 250
Max. Shock	kms^{-2}	10	50	100	50	100	20	200
	g	1000	5000	10000	5000	10000	2000	20000
Max. Cont Sinusoidal Acceleration (Peak)	kms^{-2}	5	20	30	20	30	20	60
	g	500	2000	3000	2000	3000	2000	6000
Max. Acceleration (Peak) with Mounting Magnet	kms^{-2}	0,6	1	1,5	1	1,5	0,6	2
	g	60	100	150	100	150	60	200
Base Material		Titanium ASTM Gr. 2	Stainless Steel AISI 316	Titanium ASTM Gr. 2	Stainless Steel AISI 316	Titanium ASTM Gr. 2	Stainless Steel AISI 316 / ASTM Gr. 2	Titanium ASTM Gr. 2

- Individual values given on the calibration chart.
- ** With cable supplied as standard accessory, or integral cable
- *** Axis of minimum transverse sensitivity indicated by red dot on the accelerometer except 4321, 4374, 4375, 8306, 8308, 8309, 8310
- **** Re. ANSI S2. 11-1969 (American National Standard).
- † The low frequency cut-off is determined by the preamplifier and environmental conditions.
- †† Transverse resonance frequency at 11 kHz (typical) may limit the useful frequency range further.

760032/5A

Specifications

■ Uni-Gain® sensitivity to ±2%

Accelerometer B & K Type		4374	4375	8305	8306■	8308■	8309	8310■
*Weight (grams)		0,65 excl. cable	2,6 excl. cable	40	500	100	3 excl. cable	100 excl. cable
*Voltage Sensitivity	mV/ms^{-2}	~ 0,18	~ 0,45	–	1000 ± 2%	~ 0,9	~ 0,04	~ 1
	mV/g	~ 1,8	~ 4,5	–	~ 10000	~ 9	~ 0,14	~ 10
*Charge Sensitivity	pC/ms^{-2}	~ 0,11	~ 0,35	~ 0,125	1000 ± 2%	1 ± 2%	~ 0,004	1 ± 2%
	pC/g	~ 1,7	~ 3,5	~ 1,25	~ 10000	~ 10	~ 0,04	~ 10
*Mounted Resonance	kHz	85	55	38 with 20 gm load □	4,5	30	180	30
*Frequency Range†	5%	1–18500	0,2–12000	0,2–3700 1%	0,2–1000 10%	1–6500	1–39000	1–6500
	10%	1–26000	0,2–16500	0,2–5300 2%	0,06–1250 3 dB	1–9000	1–54000	1–9000
Capacitance Incl. Cable	pF**	600	750	180	1000▲	1100●	100	1900●●
Max. Transverse Sensitivity	%***	< 5	< 4	< 2	< 5	< 3	< 5	< 3
Piezoelectric Material		PZ27	PZ27	PZ100	PZ23	PZ45	PZ45	PZ45
Construction		Planar Shear	Delta Shear	Inverted Centre Mounted Compression	Centre Mounted Compression	Centre Mounted Compression	Centre Mounted Compression	Centre Mounted Compression
Typical Base Strain Sensitivity**** (in base plane at 250 με)	$ms^{-2}/\mu strain$	0,005	0,005	Top 0,01 Base 0,003	0,0005	0,08	2	0,08
	g/μstrain	0,0005	0,0005	Top 0,001 Base 0,0003	0,00005	0,008	0,2	0,008
Typical Temp Transient Sensitivity**** (3 Hz LF)	$ms^{-2}/°C$	4	2	0,5	0,0002	20	400	20
	g/°C	0,4	0,2	0,05	0,00002	2	40	2
Typical Magnetic	ms^{-2}/T	30	30	1	2	25	20	25
Sensitivity (50 Hz–0,03 T)	g/k Gauss	0,3	0,3	0,01	0,02	0,25	0,2	0,25
Typical Acoustic Sens. Equiv. Acc. at 154 dB SPL (2–100 Hz)	ms^{-2}	0,1	0,04	0,008	0,0003	0,003	4	0,003
	g	0,01	0,004	0,0008	0,00003	0,0003	0,4	0,0003
Min. Leakage Resistance at 20°C	GΩ	20	20	1000GΩ at 20°C 10GΩ at 200°C	–	100MΩ at 20°C 2MΩ at 400°C	20	100MΩ at 20°C 2MΩ at 400°C
Ambient Temperature Range	°C	–74 to 250	–74 to 250	–74 to 200	–40 to 85	–196 to 400	–74 to 120	–196 to 400
Max. Shock (± Peak) Along main axis	kms^{-2}	250	250	10	1▲▲	20	1000	20
	g	25000	25000	1000	100▲▲	2000	100000	2000
Max. Cont Sinusoidal Acceleration (Peak)	kms^{-2}	50	50	10	0,3▲▲	20	300	20
	g	5000	5000	1000	30▲▲	2000	30000	2000
Max. Acceleration (Peak) with Mounting Magnet	kms^{-2}	–	–	0,8	0,09	–	–	–
	g	–	–	80	9	–	–	–
Base Material		Beryllium †	Titanium ASTM Gr 2	Stainless Steel AISI 316	Stainless Steel AISI 303	Stainless Steel AISI 316	Stainless Steel AISI 316	Stainless Steel AISI 316

▲ Capacitance of charge output of built-in Preamplifier of 8306. Voltage output impedance < 500 Ω. Voltage output load 50 kΩ minimum.

▲▲ Handling limits. Measurement limit 9,81 ms^{-2} peak (1g peak)

● 2 pin balanced differential output with 40 pF to ground

●● 2 pin balanced differential output.

† Toxic Hazard in finely divided form.

□ Possibility of resonance between reference & test accelerometer.

4374 Pat. DK 138768 and GB 1522783 and US (Pending).

760032/5B

Summary of Accelerometer Types

*Uni-Gain®

Type	Weight (gms)	Sensitivity		Frequency Range +10% Limit (kHz)	Notable Characteristics	Application Areas
		Voltage mV/ms^{-2} (mV/g)	Charge pC/ms^{-2} (pC/g)			
4366	28	~4 (~40%	~4,8 (~48)	8,1	Side Connectors — Delta Shear® Types having good all-round characteristics with particularly low sensitivity to temperature transients and base strains	General shock and vibration measurements. Vibration testing and control
4367	13	~1,8 (~18)	~2,2 (~22)	9,6		
4368	30	~4 (~40)	~4,8 (~48)	8,1	Top Connectors	
4369	14	~1,8 (~18)	~2,2 (~22)	9,6		
4371	11	~0,8 (~10)	1 ± 2%* (~10)	12,7	Side Connector — Delta Shear® Types with features as above. Also have Uni-Gain® sensitivity calibration giving simple system calibration and interchangeability	
4384	11	~0,8 (~10)	1 ± 2%* (~10)	12,7	Top Connector	
4370	54	~8 (~100)	10 ± 2%* (~100)	5,4	Top Connector	General vibration measurements. Higher sensitivity for low level measurements
4381	43	~8 ~(100)	10 ± 2%* (~100)	5,4	Side Connector	
4374	0,65	~0,18 (~1,8)	~0,11 (~11)	26	Miniature Shear Type with extremely low weight and high resonance frequency. Integral cable	High level and high frequency vibration measurements. Shock measurements Vibration measurements on delicate structures and in confined spaces
4375	2,6	~0,45 (~4,5)	~0,35 (~3,5)	16,5	Miniature Delta Shear® Type with low weight and high resonance frequency. Integral cable	
8309	3	~0,04 (~0,14)	~0,004 (~0,04)	54	Small size. 5mm integral fixing stud. Integral cable	Shock measurements up to 1 million ms^{-2}. High frequency vibration measurements
4321	55	~0,8 (~8)	1 ± 2%* (~10)	12	Three Delta Shear® accelerometers of the same Uni-Gain® sensitivity combined into single unit	Vibration measurements in three mutually perpendicular directions
8305	40	-	~0,125 (~1,25)	5,3 (2% limit)	Quartz element. High stability over long time and wide temperature range. Laser calibration to ± 0,6% accuracy	Reference Standard Accelerometer for back-to-back calibration of accelerometers
8306	500	1000 ±2% (10000)	1000 ±2% (10000)	1	Very high Uni-Gain® Voltage and Charge sensitivity. Built-in preamplifier and low pass filter. Separate "Charge" and "Voltage" output. Power required 2mA. 28V	Ultra low level (down to 20 μms^{-2}) and low frequency measurements on large structures, i.e., buildings, ships
8308	100	~0,9 (~9)	1 ± 2%* (~10)	10	Robust construction. Balanced Uni-Gain® output. Tolerates temperatures up to 400°C	Permanent vibration monitoring. High temperature vibration measurements. Aeronautical, industrial and nuclear use
8310	100	~0,9 (~9)	1 ± 2%* (~10)	10	As Type 8308 but with integral high temperature (800°C) cable	