Portable Sound Level and Noise Dose Meters

Impulse Precision Sound Level and Vibration Meter

FEATURES:
- Complies with all existing standards for impulse and precision sound level meters
- Equipped with individually calibrated, high sensitivity, precision condenser microphone
- Conical shaped front-end for minimum disturbance of sound field
- RMS detector with crest-factor capability up to 40
- Peak detector with 20 µs rise time and Hold facility
- Impulse detector with Max. RMS Hold facility
- "D", "A", "B", "C" and "Lin" frequency weighting
- 2 Hz or 10 Hz selectable low frequency cut-off
- Interchangeable meter and attenuator scales facilitate direct reading of sound and vibration figures
- Performs as Octave or Third-octave analyzer with system-matching filter sets
- AC and DC outputs for recorders etc.
- Overload indicators for both input and output amplifiers
- Performs as Vibration Meter or Analyzer combined with appropriate accessories
- Wide selection of accessories

USES:
- Noise and Vibration measurements for health protection
- Noise and Vibration measurements in industry for quality inspection and development
- Measurement of Shock and Maximum Acceleration
- Audiometer Calibration
- Acoustic Measurements
- Noise and Vibration Analysis with Filter Sets Type 1613 and Type 1616

The Impulse Precision Sound Level Meter Type 2209 provides the sound and vibration analyst with almost everything desirable in a single, portable measuring instrument. The A, B and C weighting networks, as well as the D weighting network intended for aircraft noise measurements, are built-in. The meter response may be switched to the standardized Slow, Fast and Impulse time constants, as well as to indicate the absolute peak value of the measured signal. The impulse facility of the instrument gives the feature of being able to measure the maximum of the short-time RMS value of impulsive sounds (1 to 1000 ms) with a time weighting response in accordance with IEC Recommendation 179-A. This puts strict requirements on the RMS detector which is able to handle signals with crest factors as high as 40 (10 at full scale deflection). The Peak mode allows objective measurements of signal peaks with duration as short as 20 µs, which is of importance both when determining...
the harmful effect of impulsive noise and when investigating vibration shocks, overload indicators in both in- and output amplifiers give warning of excessive signal levels. To allow frequency analysis of the measured signal, the instrument is equipped with in- and output sockets for connection of external filters. AC and DC outputs give the facility for connection of headphones, level recorders, tape recorders etc.

The instrument complies with the requirements of IEC 179 and 179A for precision and impulse sound level meters as well as DIN 45 633 parts 1 and 2 and ANSI S1.4-1971 requirements for Type 1 sound level meters.

It is powered from 3 built-in standard batteries giving it a continuous operating time of 8 hours. Rechargeable NiCd-cells giving 14 hours of continuous operation may also be used. A built-in reference voltage permits easy electrical calibration of the instrument.

Ten interchangeable double-sided attenuator scales and a reversible meter scale are provided with the 2209, thus allowing it to be used as a direct-reading precision sound level meter, vibration meter, and voltmeter. These 20 interchangeable scales allow the 2209 to be used with microphones and accelerometers with widely varying sensitivities, as follows: microphones from 0.4 to 160 mV per Pa, and accelerometers from 1 to 285 mV per m/s², both with indication in British or metric units. Furthermore, voltages up to 10V RMS may be measured. Direct measurement of vibration velocity or displacement, as well as acceleration, may also be made if an optional Integrator ZR 0020 is used.

Sound Measurements

As standard, the instrument is equipped with a B & K high-sensitivity 1/2" diameter free-field Condenser Microphone Type 4165, giving it a measuring range from 24 to 140 dB(A) and a wide frequency range both in free and diffuse sound fields, due to its excellent omnidirectionality. The microphone is delivered with its own individual calibration chart giving all relevant calibration data and complete frequency response curve.

The microphone may be mounted directly on the instrument, but should normally be mounted on the Extension Rod UA 0186, which is included, and which, together with the conical-shaped front-end of the instrument ensures the free-field characteristics required to fulfil the IEC, DIN and ANSI requirements for precision sound level meters. If it is desired to remove the microphone even further from the instrument, use can be made of the standard Brüel & Kjaer microphone Extension Cables available in lengths of 3, 10 and 30 metres. The cables are inserted between the removable input stage and the Sound Level Meter, and the influence of cable capacitance on calibration can therefore be neglected. The wide frequency range of the instrument, from 2Hz to 70 kHz, together with appropriate microphones from B & K's wide range, enables measurements both up in the ultrasonic range and down in the infrasonic range. If desired, the lower end of the frequency range can be limited to 10 Hz by a screw switch in the input stage, to avoid the influence of low frequency pressure variations which might disturb normal measurements in the audible range.

A windscreen, which should be fitted over the microphone when measuring outdoors in order to reduce wind noise, is included. Also included is an input adaptor, to be fitted instead of the microphone, allowing direct electrical input, for instance from accelerometers or hydrophones.

Use with other Microphones. For measurement of higher levels and frequencies than is possible with the 1/2" microphone Type 4165, or for a linear random incidence microphone response is required, other 1/2" microphones from the B & K range can be used directly, for instance Type 4133, 4134, 4163 or 4168. For measurement of lower levels, the 1" microphones Types 4145 and 4161 are recommended. Adaptors DB 0962 and DB 0375 are available for fitting these microphones directly onto the input stage or onto the extension rod.

In order to fulfil the standard requirements to omnidirectivity, the 1" microphones mentioned require the use of a Random Incidence Corrector UA 0055 instead of the normal microphone protection grid. For special applications the sound level meter can be used with other microphones than described here, and the Product Data Sheet for the B & K microphone range should be consulted. See also the survey of accessories available on page 4, Fig. 6.

Vibration Measurements

When the microphone is replaced by the Input Adaptor JJ 2614 (included) and one of the B & K accelerometers is connected, the instrument functions as a vibration meter. To give direct reading in vibration units, the meter scale is reversed and the attenuator scale which is calibrated to cover the sensitivity of the accelerometer chosen is fitted instead of the dB-calibrated scale for sound level measurement. If required, vibration velocity and displacement can be measured in addition to acceleration when an Integrator ZR 0020 is mounted between the accelerometer and sound

Fig.1. The sound level meter equipped with integrator and accelerometer for vibration measurements, and 1/3 octave filter for frequency analysis.
level meter. Also in this case, reading is direct and can be in either British or metric units.

Calibration
Acoustical calibration, which also tests the microphone, can easily be carried out by either of the two calibrators available: Pistophone Type 4220, which gives a SPL of 124 dB with ±0.2 dB accuracy at 250 Hz, and Sound Level Calibrator Type 4230, which gives a SPL of 94 dB with ±0.25 dB accuracy at 1 kHz. When using the sound level meter for vibration measurements, complete calibration can be performed by means of the portable Accelerometer Calibrator Type 4291, which calibrates the system at 1 g peak and 79.6 Hz.

Audiometer Calibration.
Hearing Aid Testing
When the microphone is replaced by an Artificial Ear Type 4152 or 4153 with microphone 4144 or 4134 respectively, a precise, compact and fully portable audiometer calibrator is produced. If the Artificial Mastoid Type 4930 is connected instead of the microphone, measurements on bone vibrators and bone conduction hearing aids can be made, and if the sound level meter is used with Hearing Aid Test Box Type 4217, a complete test facility for hearing aids is created.

Frequency Analysis
For frequency analysis of the measured sound or vibration level, the Octave Filter Set Type 1613 or the Third-Octave Filter Set Type 1616 may be attached directly onto the sound level meter, and is connected electrically with a connection bar. Type 1613 contains 11 octave filters (with adjustable attenuation) with centre frequencies from 31.5 Hz to 31.5 kHz. Type 1618 contains 34 third octave filters with centre frequencies from 20 Hz to 40 kHz. Narrower band frequency analysis, as is often required for vibration analysis, can be made using the battery powered Tunable Band Pass Filter Type 1621, or the Tracking Filter Type 1823.

Fig. 2. The Pistophone Type 4220 and Sound Level Calibrator Type 4230

Fig. 3. The portable Level Recorder Type 2306

Field Recording
When measuring in the field, the tedious work of plotting levels by hand can be completely eliminated by use of the small, portable, battery-operated Level Recorder Type 2306. It is connected via a cable to the output of the sound level meter and can record either sound levels as a function of time, or if the sound level meter is equipped with a filter, sound levels as a function of frequency. For time recordings, use can be made of very slow recording paper speeds, so that diagrams showing sound level variations over longer periods of time can be recorded on a reasonable length of paper. Such charts are of great help in almost any type of noise investigation and simplify the location of noise events with respect to time, as well as the possible source. Frequency spectrograms can be recorded directly on frequency-calibrated paper, and can be made semi-automatically in a few minutes, using the filters Type 1616, 1621 and 1623. The recorded spectrogram and time histories provide immediate documentation of the measurement made and can be inserted directly in the measurement report. If further investigation of the measured signal is required back in the laboratory, the battery-operated, portable Tape Recorder Types 7003 and 7004 should be used.

Complete Sets
The 2209 can be ordered with accessories according to requirement. However, to simplify ordering, four sets containing the most commonly used accessories have been assembled. There are two sets for sound and vibration measurements in the field, the difference being the filter included (Type 1613 or 1616), and two sets for audiometer calibration, the difference being the filter included.

The sets combine complete portability with laboratory accuracy and are delivered in the sturdy fibreglass carrying case KE 0055 which has separate compartments for each item. The contents of the sets are listed below:

Sound and Vibration Sets
Types 3507 and 3511
Impulse Precision Sound Level Meter with standard accessories 2209
Octave Filter Set 1613
Third Octave Filter Set 1616
Pistophone 4220
Accelerometer Set 4366
Microphone 1/2” 4166
Nose Cone 1/2” 0386
Integrator ZR 0020
Adaptor for Tripod UA 0354
Extension Cable AO 0027
Carrying Case KE 0055

Audiometer Calibrators
Types 3508 and 3512
Impulse Precision Sound Level Meter with standard accessories 2209
Octave Filter Set 1613
Third Octave Filter Set 1616
Pistophone 4220
Artificial Ear 4162
Microphone 1” 4144
1” Adaptor DB 0375
Carrying Case KE 0055
Accessories

A wide selection of accessory equipment is available to expand the application possibilities of the sound level meter. A survey showing the connections of the most useful items is given in Fig. 6. For more information on the individual instruments and transducers indicated, please ask for separate data sheets.

Description

The impulse Precision Sound Level Meter Type 2208 contains a condenser microphone, a removable preamplifier input stage, a low noise amplifier and a detector circuit with a moving coil meter. A built-in reference signal provides a ready check of the amplifier and meter circuit. A power supply delivers stabilized voltages to the amplifier circuits and polarization voltage for the microphone.

Microphone

The B&K microphone Type 4165 employed in the sound level meter.

Fig. 6. Survey of accessories available for sound and vibration measurements and audiometer calibration.
is a precision condenser microphone. It is designed to have a linear frequency response for free-field sound measurements and 0° angle of incidence (perpendicular to microphone diaphragm). The microphone has excellent directional characteristics over a wide frequency range. These characteristics, of the microphone alone and of the complete instrument, are shown in Figs. 16 and 17 on page 7. Figs. 7 and 8 show the frequency response curves of the complete instrument for 0° incidence sine waves and in a diffuse field. All curves are well within the requirements of the relevant standards. A calibration chart with frequency response curve and sensitivity data (individually determined for each microphone) is supplied with the sound level meter. The microphone is extremely reliable and unaffected by humidity and temperature variations over a wide range. The diaphragm is quartz-coated to offer protection in humid and corrosive atmospheres and back venting allows it to be used with the Dehumidifier UA 0308 for further protection in humid environments. The sensitivity of the microphone is typically 50mV/Pa (5 mV/µbar) with a polarization voltage of 200 volts.

Amplifier

The removable input stage of the amplifier has an extremely high input impedance, to match the high impedance of transducers such as condenser microphones and piezoelectric accelerometers. A switch, built into the preamplifier, allows the low frequency cut-off to be switched between 2 and 10 Hz. See also Fig. 10. Following the input stage are the input amplifier and output amplifier, between which the built-in weighting networks A, B, C or D or external filters can be inserted.

Fig. 7. Free-field frequency response of complete instrument to sine waves with 0° incidence

Fig. 8. Diffuse field (random incidence) frequency response of complete instrument

Fig. 9. Block diagram of Type 2209
The input amplifier and the two first sections of the output amplifier are preceded by attenuators which are controlled by the two concentric measuring range selectors on the front panel. The second section of the output amplifier supplies 0.5 V RMS at full scale deflection to the AC output socket. This voltage can be increased to 5 V RMS when the meter switch is set to “Batt. (Rec.)” position, which, however, puts some limitations to the allowable load at the output. The third section of the output amplifier drives the meter detectors. As short-duration high-amplitude peaks in the measured signal can readily overload the amplifiers without resulting in meter overdeflection, overload indicators are provided for both input and output amplifiers. These indicators will respond to either positive or negative peaks of a duration as short as 50 μs and will continue to flash for about 1 s after overload.

**Detector**

The detector is of the RMS type and is equipped with three time constants, “Fast”, “Slow” and “Impulse” in accordance with the standard requirements for Precision and Impulse sound level meters. Fig. 12 shows the response of the circuits to tone bursts of varying duration. The decay time of the impulse circuit is 3 s, as required by the standards.

An “Impulse Hold” mode, where the RMS value measured with the Impulse time constant is stored in the Hold circuit, is introduced for easy measurement of the max. RMS value of, for instance, impulsive sounds or impacts.

To enable the instrument to measure the Peak value of signals, the time constant of the RMS circuit is reduced to approx. 10 μs in the “Peak Hold” position. The output of the detector is then stored in the hold circuit in order to obtain a signal of sufficient duration to allow the meter pointer to deflect. Other time constants can be obtained by a small internal modification. A DC output of 0.8 V for full scale deflection is available from the detector circuit. The meter is a ribbon suspended moving coil type. The meter scale is graduated from −10 to +10 dB on its “Sound Level Meter” side and from 0 to 10 and 0 to 30 on its “Vibration Meter” side. Addi-

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**Fig. 10.** The adjustable low frequency responses of the instrument with 1” and 1/2” microphones.

**Fig. 11.** Frequency response curves of the A, B, C and D weighting networks.

**Fig. 12.** Response of meter rectifier and meter to tone bursts of varying duration.

**Fig. 13.** Maximum permissible input voltage with different lengths of extension cable at input, as a function of frequency.
Specifications 2209

(Specifications refer to 2209 with Extension Rod UA 0138 and Microphone 4165, unless otherwise stated)

Measuring Ranges:

<table>
<thead>
<tr>
<th>Microphone Type No.</th>
<th>Max. Level (dB)</th>
<th>Weighting Network</th>
<th>Minimum Level (dB)</th>
<th>External Filter Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>31.5 - 63 Hz</td>
<td>125 - 250 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.6 - 10 (31.5 kHz)</td>
<td>20 - 400 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.6 - 15 (40 kHz)</td>
<td>Lin</td>
</tr>
<tr>
<td>1</td>
<td>4144 – 4146</td>
<td>140</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>1/2</td>
<td>4165 – 4166</td>
<td>140</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>1/2</td>
<td>4133 – 4134</td>
<td>150</td>
<td>46</td>
<td>44</td>
</tr>
</tbody>
</table>

* Included in 2209

Frequency Response (Microphone)*
(Zero degree incidence, free-field)

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 dB</td>
<td>1 Hz to 12.5 kHz</td>
</tr>
<tr>
<td>2 dB</td>
<td>3 Hz to 20 kHz</td>
</tr>
</tbody>
</table>

* Individually calibrated

Frequency Response (Amplifier)

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 dB</td>
<td>6 Hz (20 Hz) to 30 kHz</td>
</tr>
<tr>
<td>1 dB</td>
<td>2 Hz (10 Hz) to 70 kHz</td>
</tr>
</tbody>
</table>

(figures in parentheses obtainable by switch in input stage)
Frequency Weighting:
A, B and C to IEC 179
D to IEC proposal
(See Fig. 11.)

Input Impedance:
> 1 GΩ/"< 0.6 pF

Maximum Input Voltage:
10 V RMS (sinusoidal) (See also Fig. 13.)

Overload Indicators:
Indicate overloads over 50 μs in duration

Total Amplification:
114 dB

Attenuators:
20 to 140 dB FSD in 10 dB steps
Accuracy: 5 Hz to 60 kHz ± 0.2 dB
2 Hz to 80 kHz ± 0.5 dB

Output Impedance: (load does not affect meter deflection)
AC: 600 Ω (200 Ω in pos. “Batt. (Rec.)”)
max. load 10 kHz/200 pF, noise at least 50 pF below FSD voltage
DC: 25 kΩ

Output Voltage:
AC: 0.5 V RMS for FSD (5 V in “Batt. (Rec.)” noise, max. 100 V peak-to-peak)
DC: 0.8 V for FSD (dynamic range 25 dB)

External Filter Sockets:
Output Impedance: < 5 Ω in series with 470 μF (max. load 500 Ω)
Input Impedance: 145 kΩ

Inherent Noise:
Linear:
2 Hz to 70 Hz:
Max. 30 μV referred to input
10 Hz to 70 kHz:
Max. 30 μV referred to input
Curve A:
Max. 2.8 μV referred to input
* 300 μF across input, ** 60 pF across input

Detector:
Crest Factor Capability:
10 at FSD increasing to 40 at 12 dB below FSD
Meter Accuracy: (For crest factors up to 10)
≥ 0.5 dB from FSD to 12 dB below FSD
≥ 1 dB from 12 dB to 20 dB below FSD
(These limits are increased by 0.5 dB for crest factors between 10 and 20 and by
1 dB for crest factors between 20 and 40)

Effect of Vibration:
See curves Fig. 14 and Fig. 15

Effect of Sound Field:
At least 60 dB below sensitivity of microphone 4165

Effect of Ambient Pressure:
Approx. 0.0016 mbar per mbar at 1013 mbar (1 mbar = 100 Pa)

Effect of Electrostatic Field:
Negligible with microphone grid fitted

Effect of Electromagnetic Field:
80 A/m (1 G-Saturated) (50 Hz) gives:
< 28 dB(0)
< 18 dB(0)
< 24 dB(0)
< 26 dB(0)
< 26 dB(Lin)

Effect of Temperature:
−10 to 50°C (14 to 122°F) ± 0.5 dB

Batteries:
3 × 1.5 V, IEC Type R 20 (B & K order No. 80006)

Battery Life: (Continuous operation)
8 hours with standard batteries
(CEC Super Dry 282)
(Batteries Hi-Top UM 1NE)
20 hours with Alkaline batteries
(Mallory MN 1300)
14 hours with rechargeable NiCd-cells
(B & K order No. 80008, 3rd gen.)
(Soft Volta block VR 45)
(Varta LS 4)
Recharging from Power Supply Type 2805, Battery Box ZG 0073 and Charging Adapter AQ 0043 + 3 Dummy Cells
ZG 0017

Dimensions:
90 x 120 x 550 mm (4 x 5 x 21.7 in)
(320 mm, 13.7 in, without extension rod)

Weight:
3 kg (6.6 lb)

Accessories included:
1/2" Condenser Microphone 4165
Input Siegel ZC 0007
Flexible Extension Rod UA D 196
Input Adaptor JU 2014
Windscreen UA 0237
4 Screened Plugs JP 0006
Attenuator Scales SA 0012 to SA 0021
Screwdriver JA 0007

Accessories Available:
See survey Fig. 6