# PRODUCT DATA

## Human Vibration Analyzer — Type 4447

*Brüel & Kjær's Human Vibration Analyzer Type 4447 is a portable system designed for those who work with human vibration and require quick and reliable results that are in compliance with EU Directive 2002/44/EC. With an easy-to-understand control panel, comprising four pushbuttons and a colour LCD display, the instrument can be operated with minimum learning time. The 124 × 124-pixel colour display shows details of the instrument's configuration and the resulting vibration parameters during and after measurement.*


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*This hand-sized instrument is battery powered and has a lightweight yet rugged design, making it the ideal tool for measuring human vibration in the working environment. Type 4447 supports individual triaxial and single-axis measurements as well as simultaneous triaxial and single-axis measurements. Furthermore, all measurements can be carried out as logging measurements, where RMS, MTVV, Peak and VDV are logged at 1 second intervals. Type 4447 also includes PC software for data management and post-processing.*

## USES AND FEATURES

### USES

- Hand-arm vibration measurements
- Whole-body vibration measurements
- Assessment of vibration exposure
- SEAT (Seat Effective Amplitude Transmissibility) factor measurements

### FEATURES

- Compact, rugged, battery-powered instrument
- Four-button operation: Easy to use, ideal for field work, and can be operated using gloves
- Minimal cable connections: Only one transducer cable connection in the basic setup
- RMS, MTVV, VDV (Whole-body) and Peak with 1 s interval logging
- Several hours of logging capacity
- Triaxial, single-axis and 3+1 measurements
- EU Directive parameters measured and displayed
- In-field assessment of vibration exposure – all necessary data are displayed
- Simultaneous display of X, Y and Z axes' vibration, as well as total value
- USB connection allows battery charging and data transfer to a computer for post-processing and archiving
- Included PC software, 4447 Vibration Explorer BZ-5623, for data transfer, management and calculations on a PC

Brüel & Kjær

## Introduction

Hand-tools, machinery and heavy vehicles cause vibration. The damage caused depends on the intensity and frequency content, and the duration of exposure to the vibration. Human Vibration Analyzer Type 4447 was designed for those who work with human vibration and require quick and reliable results, including:

- Occupational health departments
- Occupational health authorities
- Consultants
- Contractors
- Manufacturers of building and construction machinery, freight vehicles and any other machinery that causes vibration
- Manufacturers of anti-vibration pads, seats and personal protection equipment
- Manufacturers of hand tools
- Service and repair personnel
- Educational institutions
- Medical institutions

### EU Directive 2002/44/EC

- Specifies daily 'exposure action values' (whole-body vibration: 0.5 $m/s^2$ (VDV = 9.1 $m/s^{1.75}$); hand-arm vibration: 2.5 $m/s^2$) and 'exposure limit values' (whole-body vibration: 1.15 $m/s^2$ (VDV = 21 $m/s^{1.75}$); hand-arm vibration: 5 $m/s^2$), over which workers should not be exposed
- Specifies employers' obligations with regard to risk determination and assessment
- Places requirements on employers to ensure that risk is eliminated or reduced to a minimum. Any employer who requires employees to carry out work involving risk arising from exposure to vibration must implement a series of protective measures before and during the work
- Sets out the measures to be taken to reduce or avoid exposure and details how to provide information and training for workers
- Requires EU Member States to put in place a suitable system for monitoring the health of workers exposed to risk arising from vibration

#### *Type 4447 Compliance*

The relevant measurement parameters to comply with the EU directive are implemented from the following international standards:

- ISO 5349–1:2001, Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 1: General requirements
- ISO 2631–1:1997, Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements

Type 4447 implements the health and safety measurement requirements of the international standard ISO 8041:2005 – Human response to vibration – Measuring instrumentation.

## User Interface

Type 4447 can be operated easily with only four pushbuttons, as shown in Fig. 1.

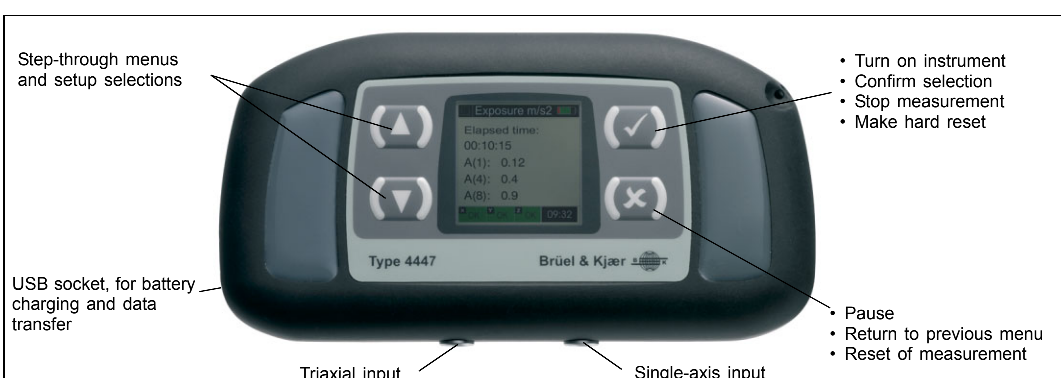
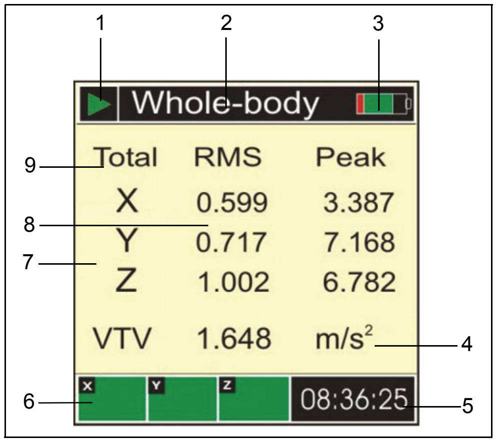



***Fig. 1*** *The four buttons on the front panel control the user interface of Type 4447*

Type 4447's graphical colour interface makes it easy to set up measurements and display results. Readings are in $m/s^2$ and $m/s^{1.75}$ by default but can be displayed in g, dB re. $\mu m/s^2$ or $g{\cdot}s^{0.25}$. During a measurement the results for the individual and combined axes are displayed (Fig. 2). You can step through additional screen displays at any time during a measurement.

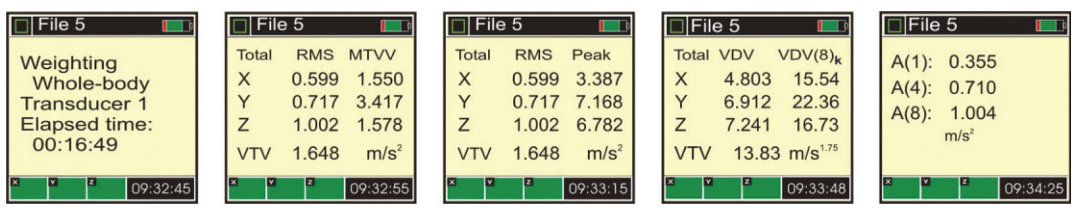
*__Fig. 2__*
*Example of a measurement display*




1. Measurement status (Measure, Pause, Stop)
2. Frequency weighting (measurement type)
3. Battery status
4. Units
5. Time or elapsed time (during measurement)
6. Status indication:
   - Green: CCLD mode
   - Red: Open- or short-circuit or overload
   - Yellow: Under range
   - Purple: Applying new settings
7. Axes
8. Display of results
9. Parameter symbols

Measurements and logged data can be stored in a non-volatile memory. Stored measurements, including calculated exposure values can be displayed (Fig. 3).

*__Fig. 3__*
*Examples of stored measurement and the calculated exposure values, A(1), A(4) and A(8) (1, 4 and 8 h exposure, respectively)*

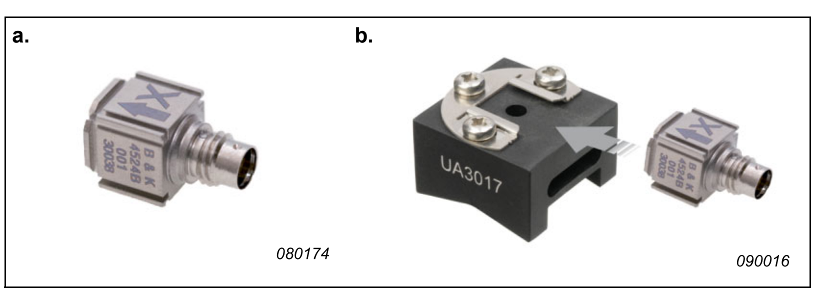



Stored results can also be sent over the USB interface to a PC for archiving and further processing. Software is included with the instrument for this purpose.

## Hand-arm Vibration Measurements with Type 4447

When measuring hand-arm vibration, please refer to ISO 5349–2:2001 Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 2: Practical guidance for measurement at the workplace; ISO 20643:2005, Mechanical vibration – Hand-held and hand-guided machinery – Principle for evaluation of vibration emission; as well as relevant manufacturing standards for the equipment that is to be evaluated.

*__Fig. 4__*
***a.** Triaxial accelerometer Type 4524-B-001*
***b.** Mounting Type 4524-B-001 in the clip on mounting adaptor UA-3017*




Hand-arm vibration is measured with the supplied triaxial accelerometer, Type 4524-B-001 (Fig. 4). The accelerometer is connected to the measurement surface by one of the three available mounting adaptors (each adaptor has a clip for the transducer; Fig. 4b) and connected to the instrument's triaxial input with Cable AO-0693.

To determine the vibration total value (VTV) in hand-arm measurements, the orientation of the transducer is not important, as all the axes have the same weighting. However, the vibration values on each orthogonal axis may be important for documentation and tool evaluation. It is, therefore, always good practice to correctly orient the transducer.

The adaptor used with the accelerometer in a measurement must be chosen carefully, as the transducer should be mounted on the vibrating tool as close as possible to the point where vibration is transferred to the hand, such as in the middle of the hand or between the index finger and thumb. If space allows, Cube Adaptor UA-3017 is recommended. If mounting on the tool is not possible, use Hand Adaptor UA-3015, or Handle Adaptor UA-3016.

**a.** UA-3015:

**b.** UA-3016:

**c.** UA-3017:


***Fig. 5***
*Examples of the accelerometer adaptors available for use in hand-arm vibration measurements*

During measurements the RMS values for each axis as well as the VTV (Vibration Total Value, the root sums of squares of the RMS values for all three axes) are constantly updated on Type 4447's display (Fig. 6). Further, when recalling measurements, Type 4447 displays daily exposure values based on the measured RMS VTV, assuming exposures of 1, 4 and 8 h, respectively. This gives a first indication of how long a particular tool may be safely used. To determine the actual daily vibration exposure for a particular operation, it is necessary to estimate the exposure time explicitly because often the time necessary to determine the vibration magnitudes can be much shorter than the complete task duration.

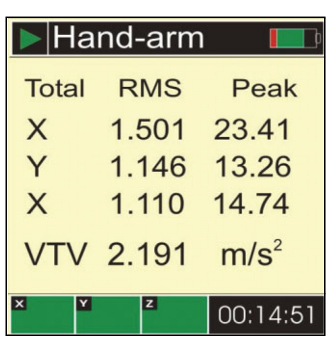



***Fig. 6***
*Example of the VTV values*

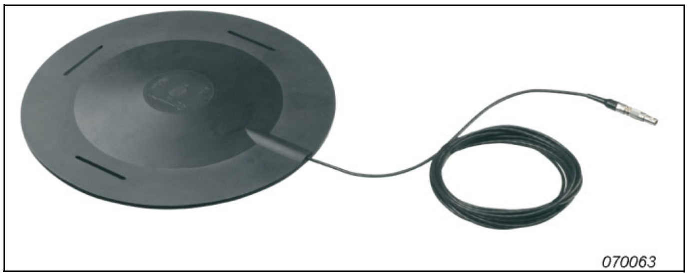
If a person is exposed to more than one source of vibration (perhaps due to the use of two or more different tools or processes during the day), then the 'partial vibration exposures' are calculated from the magnitude and duration of each one. The partial vibration values are combined to give the overall daily exposure value A(8), for that person. This can be done easily in the included PC software, 4447 Vibration Explorer BZ-5623.

## Whole-body Vibration and SEAT Factor Measurements with Type 4447

When measuring whole-body vibration, please refer to ISO 2631–1:1997, Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements; EN 14253:2003, Mechanical vibration – Measurement and calculation of occupational exposure to whole-body vibration with reference to health – Practical guidance; and relevant manufacturing standards for the equipment that is to be evaluated.

Vibration is measured along three orthogonal directions defined relative to the surface at which the vibration comes into contact with the human body. When measuring whole-body vibration, Triaxial DeltaTron Seat Pad Accelerometer Type 4515-B-002 is used (Fig. 7).

***Fig. 7***
*Triaxial DeltaTron Seat Pad Accelerometer Type 4515-B-002*




RMS vibration magnitude is expressed in terms of frequency weighted acceleration at the seat of a seated person, or at the feet of a standing person. RMS vibration magnitude represents average acceleration over a measurement period and is expressed in $m/s^2$. ISO 2631–1 requires multiplying by the *k*-factors for whole-body measurements on all axes. The *k*-factor for both the X- and Y axes is 1.4, but for the Z-axis, *k* always equals 1.0. It is the highest value of the three orthogonal axes ($1.4a_{wx}$, $1.4a_{wy}$ or $a_{wz}$ in Type 4447 – 1.4 × Total RMS X, 1.4 × Total RMS Y, or Total RMS Z) that is used for risk assessment.

Vibration dose value (VDV) provides an alternative indicator of vibration exposure. The units of measurement of VDV are metres per second to the power 1.75 ($m/s^{1.75}$), and unlike the RMS vibration magnitude, the measured VDV is a cumulative value, that is, it expresses total exposure over the measured time with emphasis on transient events such as shocks. It is, therefore, important for any measurement of VDV, to know the period over which the value was measured. It is the highest of the three orthogonal axes' values ($1.4VDV_{wx}$, $1.4VDV_{wy}$ or $VDV_{wz}$), which is used for risk assessment. Type 4447's display shows both the current VDV and the $VDV(8)_k$ calculated based on an 8 h duration and multiplied with the respective *k*-factor (1.4, 1.4 and 1). The VDV measured can be used for calculating the overall risk assessment in association with other exposure situations in Vibration Explorer Software (for post-processing on a PC).

SEAT factors can be measured directly with Human Vibration Analyzer Type 4447. Simply mount the uniaxial accelerometer (Type 4507-001) on the vehicle floor and place the seat pad (Type 4515-B-002) on the seat. On the Analyzer, choose the 3+1 transducer mode and whole-body weighting, activate the SEAT feature and start the measurement. During measurement the Analyzer will give the instantaneous read-out of the SEAT factor, based on RMS values and VDVs. For more detailed analysis, the saved data contain the measured acceleration values for the seat pad's three axes and the uniaxial accelerometer separately.

## Logging

By setting Type 4447 to logging mode, you can log RMS, Peak, MTVV and VDV (whole-body) of the acceleration with a 1 s interval. Selecting 'triaxial accelerometer' creates a separate logging profile for each of the three axes. Type 4447's memory can store several hours of logging data (capacity varying on the amount of data to be stored for each second). This gives you the ability to record a longer working period and then use the Vibration Explorer PC software to split these data into tasks for further post-processing.

## PC Software: Vibration Explorer Software– BZ-5623

4447 Vibration Explorer Software BZ-5623, included with Type 4447, enables the transfer of results to a PC and data manipulation. For instance, you can use the software to combine the vibration levels from different operations and measurement points, calculate the combined exposure by assigning exposure time for each operation, and give exposure limits for the combined operations (Fig. 8). Both hand-arm and whole-body vibration scenarios can be modelled, and measurements can be assigned to different working points or operators.

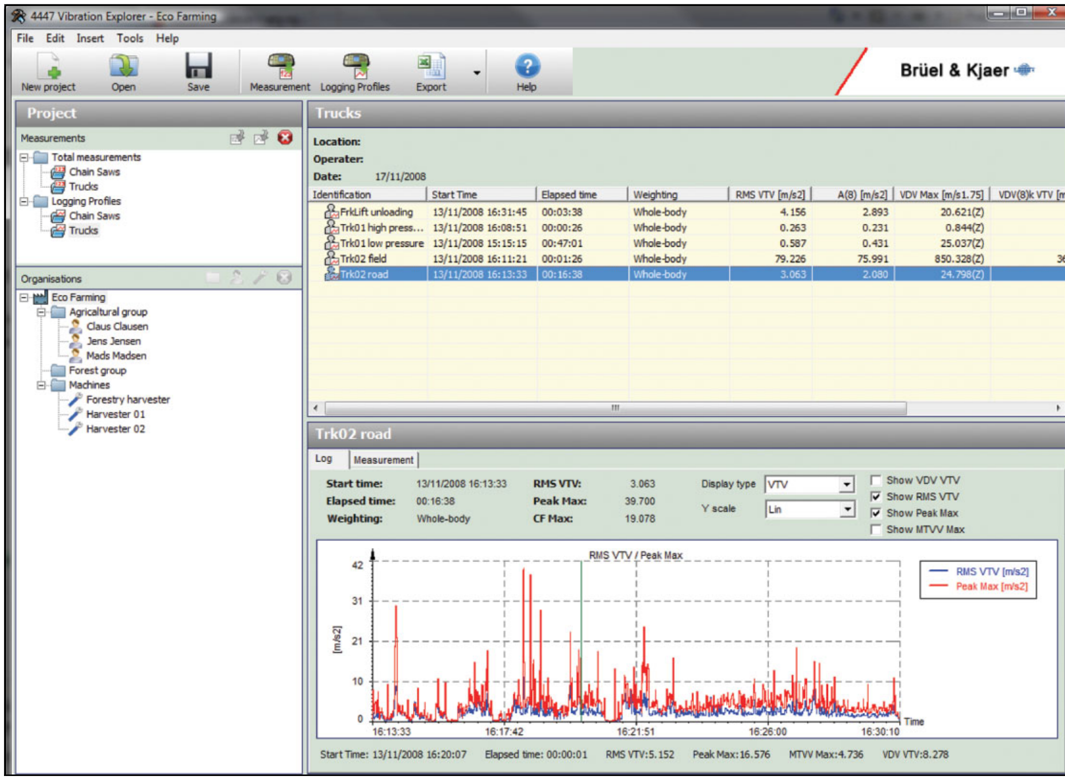



***Fig. 8***
*BZ-5623 PC software showing calculated exposure limits for combined operations*

## Compliance with Standards

| | |
|---|---|
| | CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.<br>C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand. |
| **Safety** | EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.<br>ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use. |
| **EMC Emission** | EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments.<br>EN/IEC 61000–6–4: Generic emission standard for industrial environments.<br>CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits.<br>FCC Rules, Part 15: Complies with the limits for a Class B digital device. |
| **EMC Immunity** | EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments.<br>EN/IEC 61000–6–2: Generic standards – Immunity for industrial environments.<br>EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements.<br>**Note 1:** The above is only guaranteed using accessories listed in this Product Data sheet. |
| **Temperature** | IEC 60068-2-1 & IEC 60068-2-2: Environmental Testing. Cold and Dry Heat.<br>Operating Temperature: –10 to +50°C (14 to 122°F)<br>Storage Temperature: –25 to +70°C (–13 to 158°F) |
| **Humidity** | IEC 60068–2–78: Damp Heat: 93% RH (non-condensing at 40°C (104°F)) |
| **Mechanical** | Non-operating:<br>IEC 60068-2-6: Vibration: 0.3 mm, 20 $ms^{-2}$, 10 – 500 Hz<br>IEC 60068-2-27: Shock: 1000 × 40g<br>IEC 60068-2-29: Bump: 6 × 1000 bumps at 40g |
| **Enclosure** | IEC 60529: Protection provided by enclosures: IP 42 |

## Specifications – Human Vibration Analyzer Type 4447

Type 4447 complies with the following national and international standards:

- ISO 8041:2005: Human response to Vibration – Measuring Instrumentation
- ISO 5349–1:2001: Mechanical Vibration – Measurement and Evaluation of Human Exposure to Hand-transmitted Vibration – Part 1: General Requirements
- ISO 5349–2:2001: Mechanical Vibration – Measurement and Evaluation of Human Exposure to Hand-transmitted Vibration – Part 2: Practical Guidance for Measurement at the Workplace
- ISO 2631–1:1997: Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-body Vibration – Part 1: General Requirements
- EU Directive 2002/44/EC

**SUPPLIED ACCELEROMETERS**

| | 4524-B-001 | 4515-B-002 |
|---|---|---|
| | Hand-arm vibration | Whole-body vibration |
| Nominal Sensitivity | 1 mV/(m/s$^2$) | 10 mV/(m/s$^2$) |
| Filter | $W_h$ | $W_d$, $W_k$ |
| Frequency Range | 2 Hz to 7 kHz | 0.25 to 900 Hz |
| Linear Operating Range[a] | 1 to 3200 m/s$^2$ | 0.1 to 320 m/s$^2$ |
| Instrument Noise | <0.1 m/s$^2$ | <0.01 m/s$^2$ |

a. Linear operating range is the instrument's measuring range. It is specified according to ISO 8041:2005. Outside this range, either 'Overload' or 'Under-range' is indicated.

**SHOCK LIMITS**

Max. Shock level for recommended transducers (± peak): 50 km/s$^2$

**INPUT CHANNELS**

Type 4447 has 3 and 1 analogue input channels and a USB digital I/O. The inputs are designed for triaxial and/or single-axis accelerometers and are equipped with selectable CCLD power supplies. Input-channel sensitivity is designed for typical transducers used in human vibration measurements

**CABLES**

The maximum accepted accelerometer cable length is 3 m (9.84 ft)

**DETECTOR**

Simultaneous measurement of weighted RMS, VDV, MTVV and Peak vibration value for each channel

**FREQUENCY WEIGHTING**

Filters for frequency weightings conform to ISO 8041:2005, including filters $W_h$, $W_d$, $W_k$, and $W_m$

**DISPLAY**

Colour graphical display with a resolution of 124 × 124 pixels
Basic information regarding the instrument status is shown through icons, including:

- Battery indicator
- Measurement status: Measure, Pause, Stop
- Channel status
- Overload (O)
- Under-range (U)
- Elapsed time: hh:mm:ss

**SETUP MODES**

Weighting filters (measurement type)
Display units

**MEASURING PARAMETERS**

Measured parameters are selected according to the selected setup mode. The following parameters are measured, calculated and displayed during or after measurement:

| Parameter | Symbol | Units |
|---|---|---|
| Time Averaged Weighted Acceleration Value over measurement duration using linear averaging | Total RMS X, Y, Z | m/s$^2$, g or dB[a] |
| Vibration Total Value of Total RMS: The three orthogonal values × their respective *k*-factors | Total RMS VTV | m/s$^2$, g or dB[a] |
| Running RMS Acceleration Value: Frequency-weighted instantaneous vibration exponentially averaged with a time constant of 1 s | Curr RMS X, Y, Z | m/s$^2$, g or dB[a] |
| Maximum Transient Vibration Value: Maximum of Curr RMS during the measurement duration | MTVV X, Y, Z | m/s$^2$, g or dB[a] |
| Peak Vibration Value: Maximum modulus of the instantaneous (positive and negative) peak values of the frequency-weighted acceleration. Measured over measurement duration | Peak X, Y, Z | m/s$^2$, g or dB[a] |
| Vibration Dose Value (VDV): The fourth root of the time integral of the fourth power of the instantaneous frequency-weighted vibration acceleration. Measured over measurement duration | VDV X, Y, Z | m/s$^{1.75}$, g·s$^{0.25}$ or dB[a] |
| Vibration Total Value of Total VDV: RMS of the three orthogonal values × their respective *k*-factors | Total VDV VTV | m/s$^{1.75}$, g·s$^{0.25}$ or dB[a] |
| 8-hour Vibration Dose Value: The VDV measured over the measurement duration is extrapolated/interpolated to the value that the same signal would have given if the measurement duration was 8 hours and multiplied by the respective *k*-factor | $VDV(8)_k$ | m/s$^{1.75}$, g·s$^{0.25}$ or dB[a] |
| Measurement duration | Elapsed time | hh:mm:ss |
| 8-hour Daily Vibration Exposure A(8): In hand-arm results, A(8) = total RMS VTV. In whole-body results, A(8) = maximum of the three axes total RMS × their respective *k*-factors | A(8) | m/s$^2$, g or dB[a] |
| 4-hour Daily Vibration Exposure: A(8) recalculated to 4 hour exposure | A(4) | m/s$^2$, g or dB[a] |
| 1-hour Daily Vibration Exposure: A(8) recalculated to 1 hour exposure | A(1) | m/s$^2$, g or dB[a] |

a. dB reference 1 μm/s$^2$ (for VDV: 1 μm/s$^{1.75}$)

**BATTERY**

Rechargeable Li-ion battery 3.7 V, 2600 mA. Up to 4 h continuous use at room temperature after more than 6 h charging with the supplied charger, ZG-0459

**Note 1:** If the instrument is operated at low temperatures, the operational time is reduced

**Note 2:** External Charger (ZG-0459) is not recommended for use during measurements as it may introduce noise

**CLOCK**

Real-time clock and time-stamped measurements

**CALIBRATION**

**Calibration Check Vibration Value:** 10 m/s$^2$ (3.16 m/s$^2$ for high-sensitivity accelerometers – positions 5 and 10)
**Calibration Check Frequency:** 159.2 Hz
**Electrical Calibration Check Voltage:** 100 mV for Type 4515-B-002 and 10 mV for Type 4520

**PHYSICAL DIMENSIONS**

**Size:** 70 × 135 × 28 mm (2.7 × 5.3 × 1.1 in)

**Weight:** 260 g (9.2 oz.), battery included

**MEMORY**
64 kB, equivalent to 750 (3 axes) measurements or 4.7 hours logging can be stored in non-volatile memory

**USB INTERFACE**
Conforms to USB 2.0
**Connector:** Mini B

## Ordering Information


**Human Vibration Analyzer Type 4447-A, including:**

| | |
|---|---|
| Type 4515-B-002 | Triaxial DeltaTron Seat Pad Accelerometer, with built-in Type 4524-B, 10 mV/(ms$^{-2}$), TEDS, with 3 m (9.84 ft) integral cable to 4-pin LEMO and Strap for Seat Pad Accelerometer, DH-0411 |
| Type 4524-B-001 | Miniature Triaxial DeltaTron Accelerometer, 1 mV/(ms$^{-2}$), TEDS |
| AO-0693-D-025 | LEMO to 4-pin 1/4–28 MicroTech connector cable, 2.5 m (8.20 ft) |

and the following accessories:

- AO-1476: USB standard A to USB mini-B interface cable, 1.8 m (5.90 ft)
- UA-3015: Hand Adaptor
- UA-3016: Handle Adaptor
- UA-3017: Cube Adaptor for direct fixation
- BZ-5623: 4447 Vibration Explorer, software for data transfer, organising measurement site and calculation
- ZG-0459: Charger, 100–240 V, 50–60 Hz
- QA-0232: Screwdriver
- YJ-0216: Bees wax for mounting
- DB-0756: Cementing Stud, 10–32 UNF
- DH-0750: Wrist Strap for Type 4447
- DG-0517: Velcro Strap
- KE-0455: Travelling Bag

**Human Vibration Analyzer Type 4447-B, including:**
All Type 4447-A components and accessories **plus**:

- Type 4294: Calibration Exciter
- DV-0459: Small Calibration Clip

**Human Vibration Analyzer – Hand-arm Type 4447-C, including:**
All Type 4447-A components and accessories **except**:

- Type 4515-B-002: Triaxial DeltaTron Seat Pad Accelerometer and Strap for Seat Pad Accelerometer, DH-0411

**Human Vibration Analyzer – Whole-body Type 4447-D, including:**
All Type 4447-A components and accessories **except**:

- Type 4520-002: Miniature Triaxial DeltaTron Accelerometer
- AO-0693-D-025LEMO to 4-pin 1/4–28 MicroTech connector cable, 2.5 m (8.20 ft)
- UA-3015: Hand Adaptor
- UA-3016: Handle Adaptor
- UA-3017: Cube Adaptor for direct fixation
- DG-0517: Velcro Strap

**OPTIONAL ACCESSORIES**

| | |
|---|---|
| Type 4294 | Calibration Exciter (included in Type 4447-B) |
| DV-0459 | Small Calibration Clip (included in Type 4447-B) |
| Type 4515-B-002 | Triaxial DeltaTron Seat Pad Accelerometer, with built-in Type 4524-B, 10 mV/(ms$^{-2}$), TEDS, with 3 m (9.84 ft) integral cable to 4-pin LEMO |
| Type 4524-B-001 | Miniature Triaxial DeltaTron Accelerometer, 1 mV/(ms$^{-2}$), TEDS |
| Type 4520-004 | Miniature Triaxial Accelerometer, 0.1 mV/(ms$^{-2}$) |
| Type 4507-001 | Miniature Uniaxial DeltaTron Accelerometer, 1 mV/(ms$^{-2}$) |
| AO-0694-D-012 | LEMO male to 3 × 10–32 UNF cable, 1.2 m (3.94 ft) |
| AO-0695-D-025 | LEMO male to 10–32 UNF cable, 2.5 m (8.29 ft), for single-axis measurements, 4th channel |
| DV-0459 | Small Calibration Clip (included with Type 4447-B) |
| DV-0463 | Spring Clip for Adaptors UA-3015, UA-3016 and UA-3017 |
| DV-0497 | Belt Clip for Analyzer |
| UA-2085 | 10 × Screws for Seat Pad Accelerometer |
| DH-0411 | Strap for Seat Pad Accelerometer (included with Types 4447-A, 4447-B and 4447-D) |

**SERVICE PRODUCTS**

| | |
|---|---|
| 4447-A-CVF | Accredited Calibration of 4520-002, 4524-B, Verification of Analyzer and Battery Change |
| 4447-A-CVI | Accredited Initial Calibration of 4520-002, 4524-B and Initial Verification of Analyzer |
| 4447-B-CVF | Accredited Calibration of 4520-002, 4524-B, 4294, Verification of Analyzer and Battery Change |
| 4447-B-CVI | Accredited Initial Calibration of 4520-002, 4524-B, 4294 and Initial Verification of Analyzer |
| 4447-C-CVF | Accredited Calibration of 4520-002, Verification of Analyzer and Battery Change |
| 4447-C-CVI | Accredited Initial Calibration of 4520-002 and Initial Verification of Analyzer |
| 4447-D-CVF | Accredited Calibration of 4524-B, Verification of Analyzer and Battery Change |
| 4447-D-CVI | Accredited Initial Calibration of 4524-B and Initial Verification of Analyzer |
| 4447-RE3 | 4447 Battery Change |
| 4447-TCF | Conformance Test with Certificate |



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