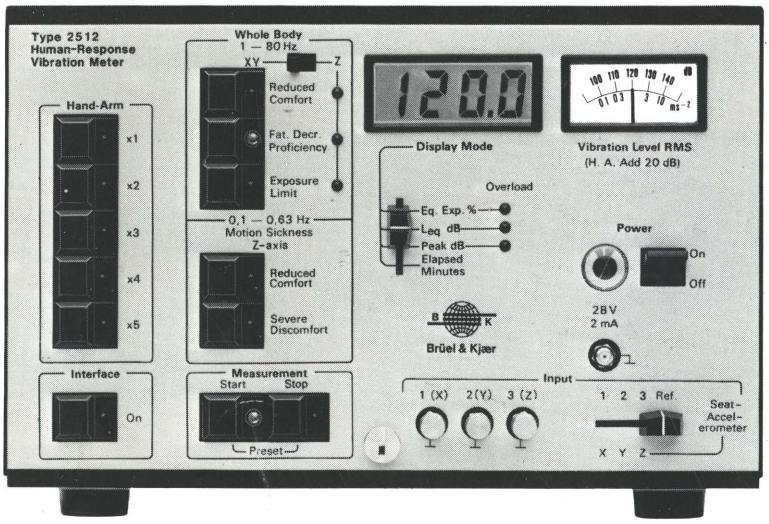


2512

Instruction Manual

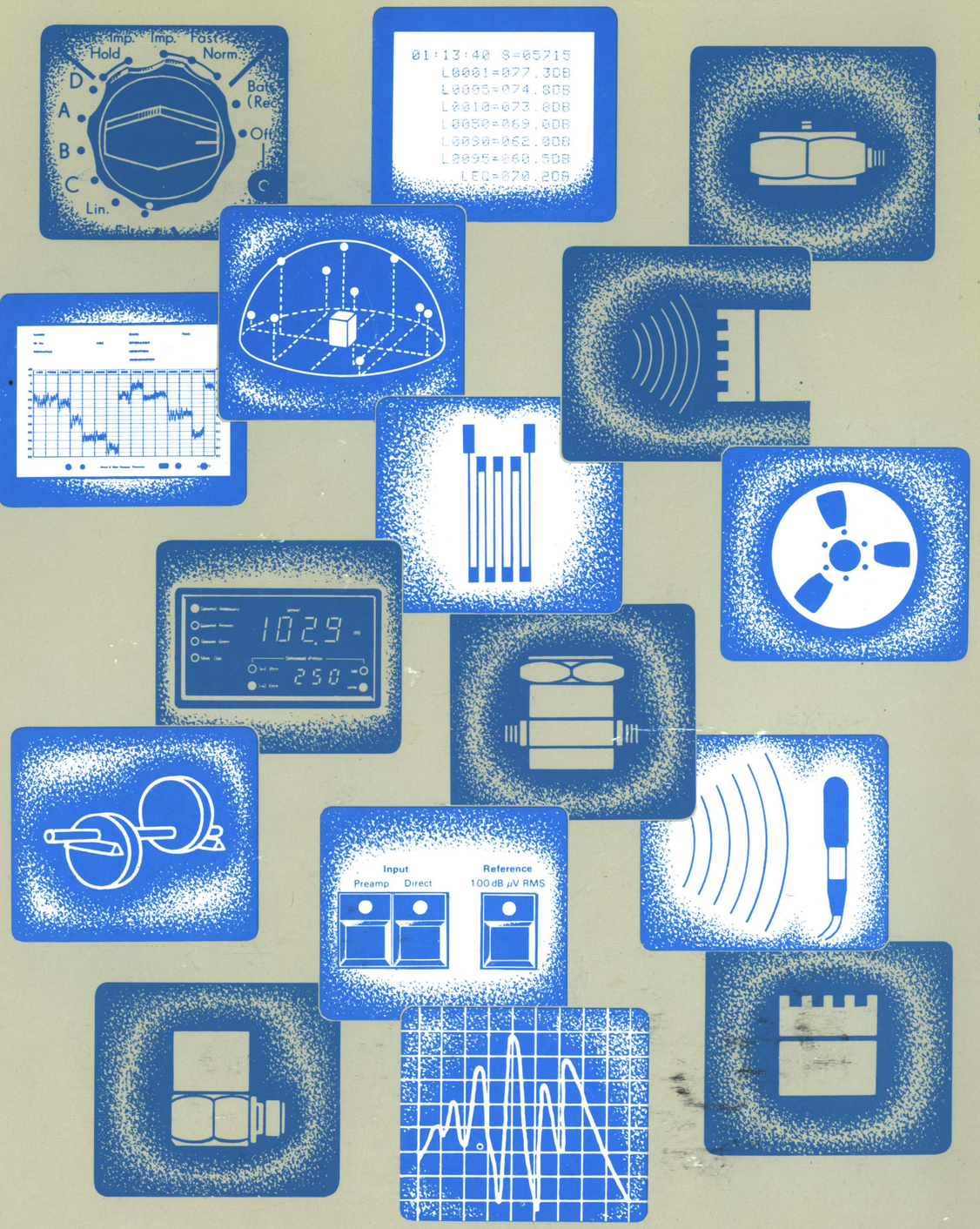
Human-Response Vibration Meter Type 2512



The 2512 is a single, easy to operate instrument designed for the evaluation of the effects of vibration on the human body in agreement with current standards for Hand-Arm and Whole-Body (including Motion Sickness) measurement. The complex relationship between level, frequency, and time, is automatically taken into account in the computation of equivalent continuous vibration level and exposure dose. Either of these parameters, the maximum peak vibration level, or the elapsed time, can be displayed at any time. Powered from internal batteries for both field and laboratory use, it is designed for use with Uni-Gain® Accelerometers, including the Tri-axial Seat-Accelerometer Type 4322 for measurements with seated persons.

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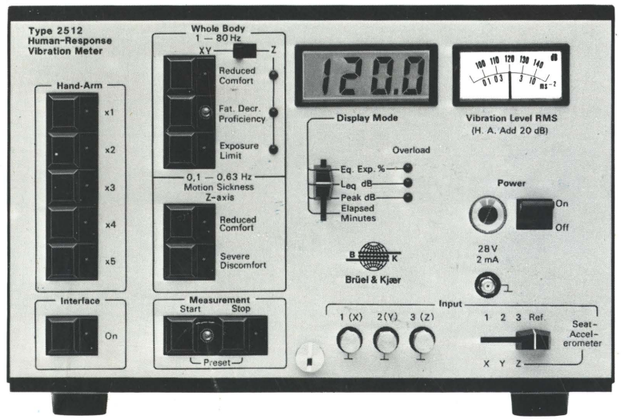
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2512

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033-0659

Brüel & Kjær

HUMAN-RESPONSE VIBRATION METER
TYPE 2512

Applicable to instruments from serial number 927661

April 1981

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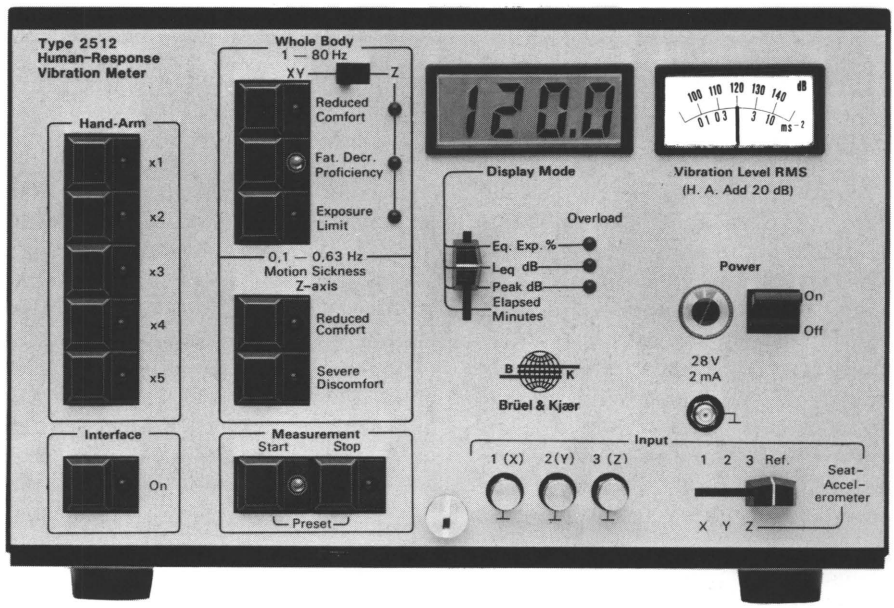
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types 2512 and 4322

Human-Response Vibration Meter and Triaxial Seat-Accelerometer

USES:

- Measurement of vibratory motion based on standardised human response criteria
- Measurements in the design, development and inspection of passenger vehicles, tractors, earth-moving equipment etc., and powered hand-tools for increased comfort and reduced fatigue
- Monitoring human exposure to vibratory environments
- Frequency analysis of vibration together with external filters



FEATURES (2512):

- Whole-Body, Hand-Arm and Motion Sickness measurements, weighted in accordance with standards and recommendations, with a single portable instrument
- Digital readout of percentage of permitted exposure dose, equivalent RMS exposure level (L_{eq}), peak acceleration level (giving crest factor) and elapsed time
- X-Y-Z inputs and appropriate weighting
- Analogue meter aids signal monitoring and m/s^2 to dB conversion
- Built-in battery or external DC power supply
- Provision for connecting external filters
- Analogue (AC and DC) output for tape and graphical recorder or level analyzer
- Digital data output via IEC 625 compatible interface bus for automatic readout of full data to alphanumeric printer, calculator etc.

FEATURES (4322):

- Detects vibration in three mutually perpendicular directions
- Built into a flexible rubber pad for comfortable seating
- Integral robust cable



The emergence of standards and recommendations specifying boundaries for human exposure to mechanical vibration has prompted the development of the **Human-Response Vibration Meter Type 2512**, a single easily operated instrument designed specially for making measurements in accordance with these standards.

The 2512 includes comprehensive measurement facilities enabling the evaluation of "human" vibration as covered by current standardisation, Hand-Arm and Whole-Body including Motion Sickness. The complex computation of level, frequency and time factors is automatically carried out by the 2512 which displays either the exposure dose, the equivalent continous vibration level, or the max. peak vibration level.

Its small size and built-in battery power supply make the 2512 ideal for both field and laboratory use. Several vibration pick-ups are available including Triaxial Seat-Accelerometer Type 4322 which is specially designed for whole-body measurements.

Standards and Recommendations

Human-Response Vibration Meter Type 2512 is designed to make frequency- and time-weighted vibration measurements in accordance with (1) International Standard ISO 2631-1978, "Guide to the evaluation of human exposure to whole-body vibration". (2) Draft Amendment to ISO 2631 DAM 1 submitted 14-2-80 (3) Revised draft addendum to ISO 2631 DAD 2 (16-9-80). "Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0,1 to 0,63 Hz. (4) Draft International Standard ISO/DIS 5349, Submitted 18-1-1979, "Principles for the measurement and the evaluation of human exposure to vibration transmitted to the hand".

Numerous national standards can be expected to appear which will be based on these international documents. Current status of both national and international standards should be requested from the relevant national standards institute.

Triaxial Seat-Accelerometer Type 4322 is dimensioned in accordance with the requirements of SAE Recommended Practice J 1013 (1973).

Human-Response Vibration Meter Type 2512

Introduction

Human-Response Vibration Meter Type 2512 is a dedicated, battery operated instrument for measuring vibratory motion with respect to its ability to cause discomfort or damage to the human body. The instrument is conditioned to measure vibration in accordance with criteria laid down in several national and international standards and recommendations. Three categories are covered: (1) "Whole-Body" vibration relative to the "Reduced Comfort", "Fatigue Decreased Proficiency" and "Exposure Limit" boundaries (2) "Hand-Arm" Vibration covering vibration from tools and appliances held in the hand, and including correction factors for interrupted use, and (3) "Whole-Body Vibration" at very low frequencies which causes "Motion Sickness" (dealt with in an addendum to the "Whole-Body standard"*).

The standards and recommendations define frequency dependent vibration amplitude limits for various periods of exposure and for various degrees of discomfort or danger. As the limits are both frequency and time dependent, both factors need to be included in any calculation to obtain the degree of discomfort or danger. Human-Response Vibration Meter Type 2512 is equipped with the appropriate frequency weighting filters and time weighting functions to enable a single figure measure of the severity of the motion to be obtained.

Measured values are computed and displayed in three different modes; (1) the equivalent exposure, expressed as a percentage of the vibration dose allowed for the measured time; (2) the equivalent RMS vibration level (L_{eq}) over a chosen measurement period; and (3) the maximum peak vibration level which has occurred during the chosen measurement period. Automatic hard-copy print-out of the measured levels can be obtained from an Alphanumeric Printer Type 2312 or any printer equipped with an IEC compatible interface bus.

Basic Operating Procedure

One of the three possible input signals is chosen by means of the "Input" selector switch. As security against losing previously accumulated data both "Measurement" "Start" and "Stop" pushbuttons must be depressed simultaneously before the vibration category i.e. "Whole-Body" "Hand-Arm", or "Motion Sickness", together with the relevant discomfort or danger criterion, may be selected. The measurement period is commenced by depressing "Start". At any time during measurement the "Display Mode" switch may be moved at will to display the accumulated exposure dose ("Eq. Exp."), the equivalent continuous level ("L_{eq}"), the maximum peak level, or the elapsed time from the start of the measurement period. Depressing "Stop" interrupts measurement but the measurement may be restarted by depressing "Start" without losing data already accumulated. Pressing "Start" and "Stop" simultaneously clears all accumulated data.

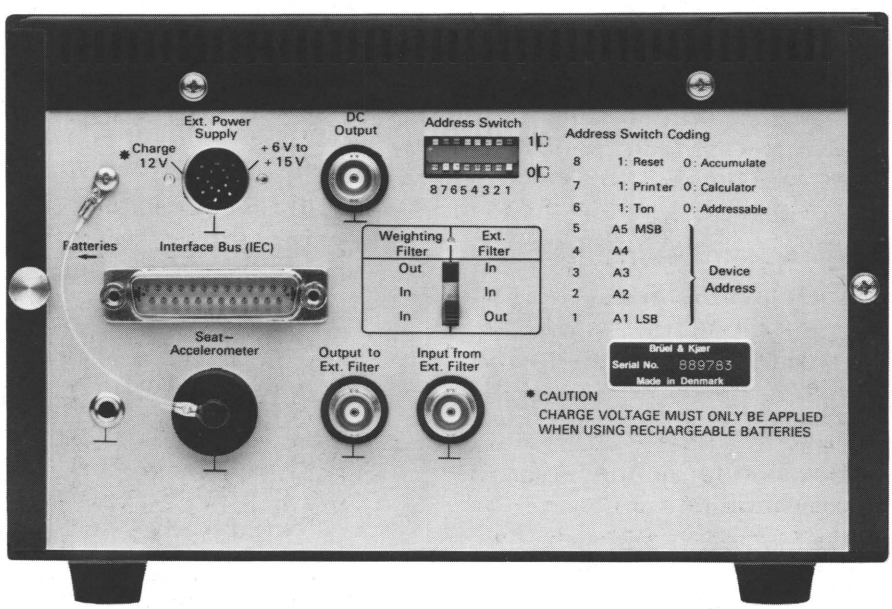


Fig.1. Rear panel view of the Human-Response Vibration Meter Type 2512

* Additionally included in 2512 is a "reduced comfort" mode in the motion sickness category of whole-body vibration, this is valuable for research-oriented measurements.

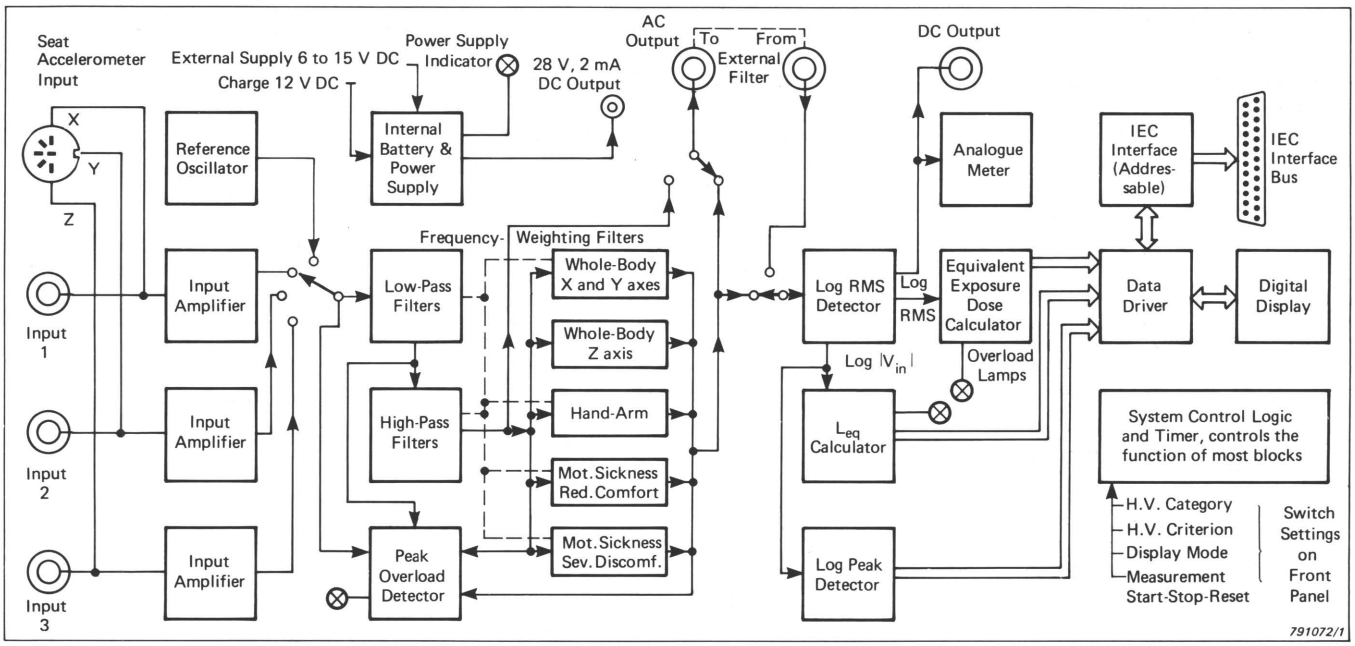


Fig.2. Simplified schematic block diagram of the Human-Response Vibration Meter Type 2512

Description

The various facilities included in the 2512 are described in the following sub-sections. Fig.2 is a simplified schematic block diagram showing the 2512's "black box" layout.

Signal Input and Transducers

Any one of the three input sockets on the front panel can be selected by means of the adjacent slide switch to provide a signal for measurement. The 6-pin DIN input socket on the rear panel, which accepts the connecting cable for the Triaxial Seat-Accelerometer Type 4322, is wired in parallel with the three sockets on the front panel. The X, Y and Z positions on the selector switch correspond with the three individual measuring directions of the seat transducer.

The sensitivity of the 2512 is calibrated to suit transducers having a sensitivity of 1 pC/ms^{-2}. Several B & K Uni-Gain® transducers are suitable. Traixial Seat-Accelerometer Type 4322 is mainly used for whole-body and motion sickness measurements with seated persons, but can also be strapped to the chest. Triaxial Accelerometer Type 4321 and single-axis Accelerometer Types 4371 and 4384 can be mounted on the handle of tools for general hand-arm measurements. Miniature Accelerometers Types 4374 and 4375 are especially suitable where a hand-arm measurement handle is employed. With pneumatic tools, which yield very high acceleration peaks, the High g Accelerometer Type 8309 should be used; alternatively other accelerometers can be used together with the mechanical filter UA 0559.

For very low level and low frequency vibrations, such as in motion sickness and building vibration measurements, the single-axis Accelerometer Type 4370 or the very high sensitivity Accelerometer Type 8306 are recommended.

An appropriate correction factor must be applied to peak and L_{eq} readings when using accelerometers having a sensitivity other than 1 pC/ms^{-2}. Exposure dose readings are ignored in this case but the exposure dose can be evaluated using Fig.7.

The minimum measurable levels with the 2512 are as follows. With Accelerometer Types 4321, 4322, 4371 and 4384, 0,1 ms^{-2}; With Type 4370, 0,01 ms^{-2}; and with Type 8306, 0,001 ms^{-2}. Accelerometer Type 8306 has a built-in preamplifier requiring a 28 V, 2 mA power supply, this is provided from a socket on the front panel of the 2512.

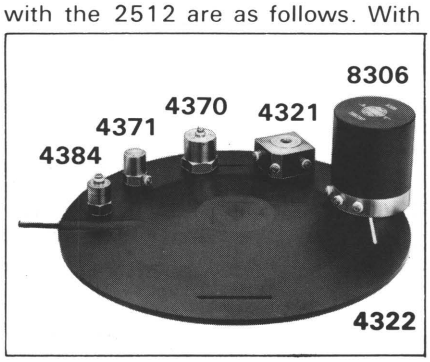


Fig.3. Some accelerometers suitable for use with the 2512

Vibration signals recorded on Portable Tape Recorder Type 7003 may be input to the 2512 via a special adaptor.

Frequency-Weighting Filters

The frequency weighting filters incorporated into the 2512 are in agreement with the relevant standards and recommendations for the three categories of human vibration which it measures. Fig.4 shows the filter characteristics graphically. The reference levels, 0 dB, for the curves in Fig.4 are a function of several factors as specified by the relevant standards and recommendations. These factors are tabulated in Fig.5.

Sockets are provided on the rear panel (Fig.1) for connecting an external filter which can be used together with, or instead of, the built-in weighting filters. The B & K Third-Octave and Octave Filter Set Type 1618 (mains powered) and Tunable Filter Type 1621 can thus be coupled directly to the 2512. Measurements with external filters are of

particular interest where wide-band weighted measurements made with the 2512 show that the prescribed limits have been exceeded, but where it is possible that third-octave analysis will reveal levels below these limits. Filter Set Type 1618 has its lowest frequency third-octave filter centred at 2 Hz and covers the whole of the hand-arm vibration measuring range. Battery operated Tunable Filter Type 1621, which has a 23% (~ 1/3 octave) bandwidth, covers down to 0,2 Hz and therefore covers the whole-body (excluding motion-sickness) and hand-arm measuring ranges.

Where it is required to perform measurements with the user's own special weighting filters these can also be connected as external filters instead of the 2512's built-in standard filters.

The unweighted or weighted AC vibration signal can be accessed at the output socket for external filters for output to a statistical analyzer, tape recorder or for one-third octave frequency analysis, to the Digital Frequency Analyzer Type 2131.

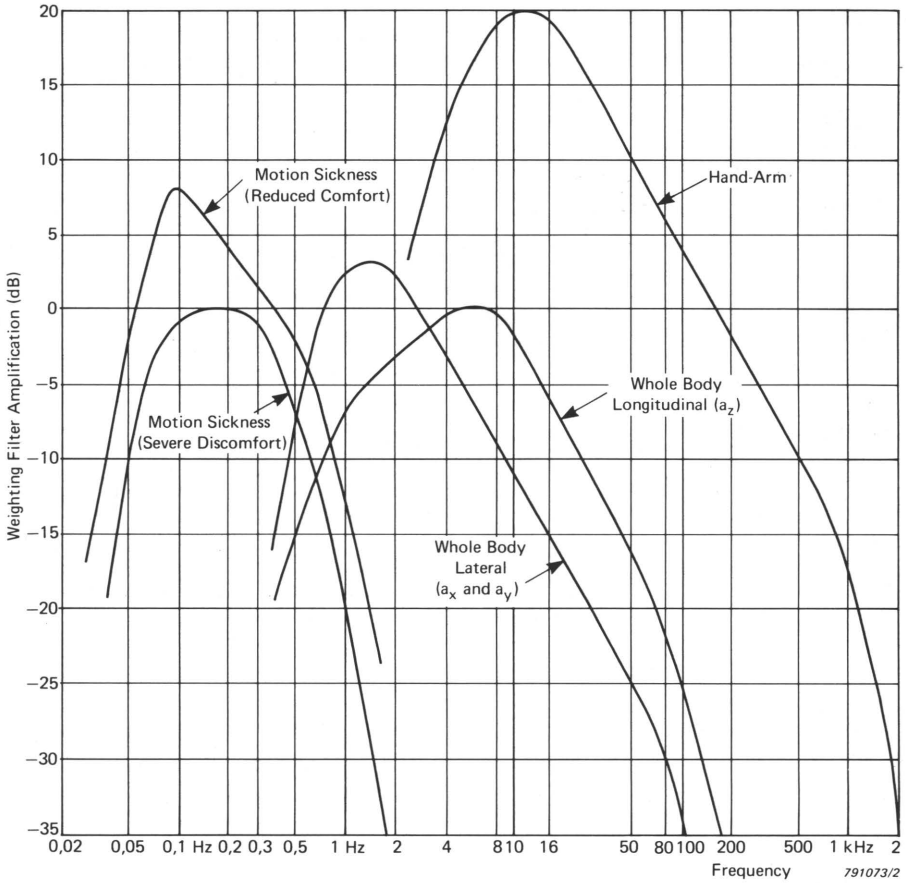


Fig.4. Response of frequency-weighting filters included in Type 2512.

Measurement Modes

Following the input circuitry and frequency weighting stages of the instrument are the signal detector and calculation stages which compute the signal level-time relationship. The instrument simultaneously measures the signal in the following three modes.

Equivalent Exposure Measurement. In this mode the instrument computes the accumulated vibration dose expressed as a percentage of the vibration dose allowed for the measured time. The computation is made in accordance with the calculation method prescribed by the whole-body vibration standard ISO 2631. The calculation procedure for hand-arm and motion sickness equivalent exposures is carried out in a similar way. The filtered vibration signal is first rectified by a logarithmic root-mean-square (RMS) detector which is interrogated every two seconds (t_i = 2). Each two-sec-

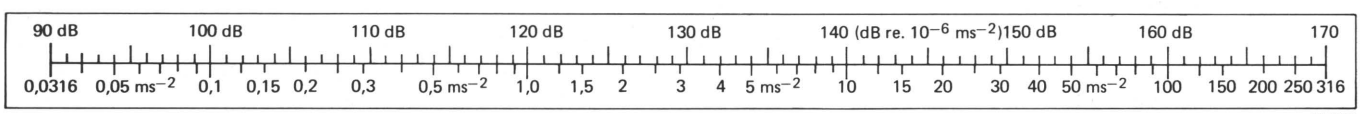
Hand-Arm Vibration Exposure (ms^{-2}rms) (Reference Frequency 160 Hz)						
Exposure time during daily shift (8h)	Uninterrupted or not regularly interrupted	Regularly Interrupted				
		Duration of regular time interval WITHOUT vibration (minutes per working hour)				
		Up to 10	> 10 to 20	> 20 to 30	> 30 to 40	> 40
Up to 30 min.	40	40	–	–	–	–
> 30 min. to 1h	32	32	–	–	–	–
> 1h to 2h	24	24	24	32	40	40
> 2h to 4h	16	16	16	24	32	40
> 4h to 8h	8 (x1)	8 (x1)	8 (x1)	16 (x2)	24 (x3)	32 (x4)

Whole Body Vibration 1 to 80 Hz	Exposure Time	Exposure Limit (ms^{-2}) rms	Fatigue Decreased Proficiency Boundary (ms^{-2}) rms	Reduced Comfort Boundary (ms^{-2}) rms
Longitudinal axis (a_z) (Reference Frequency 4 to 8 Hz) Transverse axes (a_x and a_y) (Reference Frequency 2,8 Hz)	24h	0,28	0,14	0,044
	16h	0,42	0,21	0,067
	8h	0,63	0,31	0,098
	4h	1,1	0,53	0,17
	2,5h	1,4	0,71	0,23
	1h	2,4	1,2	0,37
	25min	3,6	1,8	0,57
	16min	4,2	2,1	0,67
	1min	5,6	2,8	0,90

Whole Body Vibration 0,1 to 0,63 Hz (Mot.Sickness)	Exposure Time	Reduced Comfort Boundary (ms^{-2}) rms Ref. fr. 0,36 Hz	Severe Disc.Boundary (ms^{-2}) rms (Ref. fr. 0,1 to 0,3 Hz)
Vertical Motion in longitudinal (a_z) axis	8h	–	0,25
	2h	–	0,5
	30 min	–	1,0
	1 to 4 min	0,86	–

791097/2

Fig.5. Absolute RMS acceleration amplitudes corresponding to the 0 dB reference level on the frequency weighting curves in Fig.4. (In accordance with the relevant standards and recommendations and valid for one-third octave bandwidth measurements)



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Fig.6. Scale for conversion of acceleration level (dB re. 10^{-6} ms^{-2}) to absolute acceleration units ms^{-2}. (Note: 1 g = 9,81 ms^{-2})

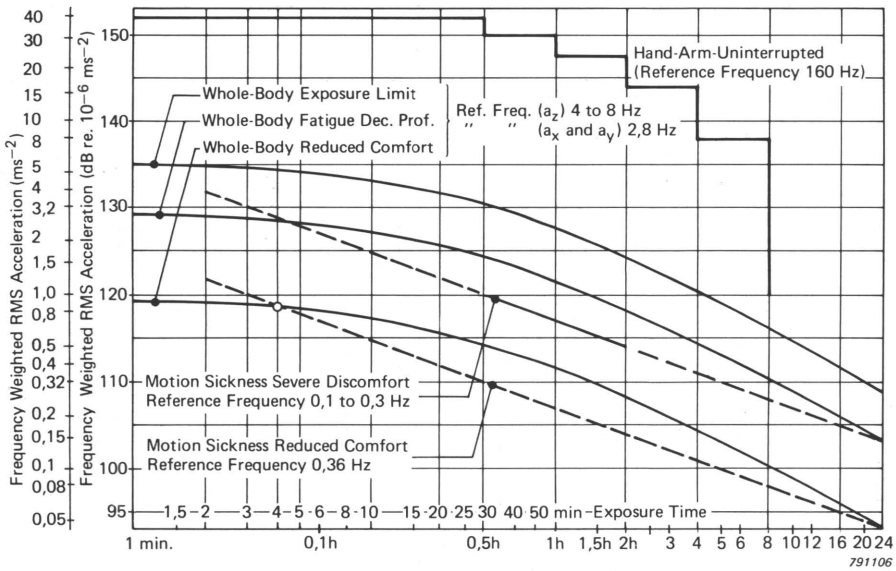


Fig.7. Frequency-weighted amplitude versus time weighting functions built into the 2512. The form of the permissible limit lines shown are as prescribed in the relevant standards and recommendations and are normalised to the reference frequencies indicated

ond RMS level is compared to the vibration level versus permissible exposure time relationship specified by the document defining the human vibration criteria chosen. These relationships, which are shown graphically in Fig.7 are preprogrammed into a digital memory (ROM) built into the 2512. The memory then provides the permissible exposure time (τ_i) for the two-second RMS level. The sum of the individual two-second ratios $\Sigma \frac{ti}{\tau i} \times 100\%$ is defined as the "equivalent exposure" and by definition must be $< 100\%$ to be within the permissible exposure limit. Continuous summation of these two-second doses to obtain the equivalent exposure is performed by the dose calculator which updates the digital readout accordingly every two seconds. The display is calibrated to indicate 100% when the permissible exposure limit is reached.

L_{eq} Measurement. L_{eq} (equivalent continuous vibration level) is a logarithmic function of the frequency-weighted energy mean vibration level averaged over the whole measuring period. It can be considered as the vibration level which would have the same (frequency weighted) vibration energy as the actual fluctuating vibration signal measured over the same period of time. In the 2512 the varying level of the actual vibration signal is continuously sampled, squared, and "parked" in a digital memory. The L_{eq} calculation circuitry continuously calculates the average of the values accumulated in the memory from the beginning of the measurement period. A corrected averaged level updates the digital display every eight seconds. The equivalent level obtained can be expressed as follows:

$$L_{eq} = 20 \log \sqrt{\frac{1}{T} \int_0^T \left(\frac{a(t)}{10^{-6}} \right)^2 dt}$$

where L_{eq} is in dB re. 10^{-6} ms^{-2} and a(t) is frequency weighted acceleration in ms^{-2}

The digital memory used to store L_{eq} data can accommodate data from at least a 1000 s (~ 17 minutes) and up to a 53 minutes measurement period depending on the signal level. A full memory is indicated by a lamp.

Whole-body vibration measured over a short period in the L_{eq} mode can be entered into the level-time curves shown in Fig.7, to find directly the maximum permissible exposure period, assuming the measurement period to be representative.

The L_{eq} measurement mode is useful for quick-look measurements since the measuring period can be terminated at will, logically when the L_{eq} reading has stabilised at an approximately steady value. Periodic readout and resetting of the L_{eq} calculator can be performed automatically in conjunction with readout to the Alphanumeric Printer Type 2312, or other device connected via the IEC compatible interface bus.

Triaxial measurements are made by sequentially measuring L_{eq} in the X, Y and Z directions, then taking the square root of the sum of the squares of the three L_{eq} s (in ms^{-2}). This will yield the max. weighted L_{eq}, which can be evaluated with Fig.7.

Peak Measurement. A peak detector continuously monitors the fluctuating vibration signal and stores the maximum level which has occurred during the measuring period. The maximum peak level is registered on the digital readout in dB re. 10^{-6} ms^{-2}.

It is generally recommended (for example in ISO 2631) that when reporting human vibration environments, the crest factor, that is the peak value to rms value ratio of the signal, should also be determined. This is simply calculated, first converting the peak and RMS levels measured, to absolute values using Fig.6.

Measurement Period. The period during which the measurement and calculation circuits are active is governed by the "Start" and "Stop" buttons. The elapsed measurement time in minutes (resolution 0,1 min., 6 s) may be displayed.

Analogue Meter. A small moving coil meter mounted on the front panel indicates the RMS level of the filtered and rectified vibration signal. It has a scale calibrated to read in dB re. 10^{-6} ms^{-2} and in ms^{-2}. It aids visual monitoring of the signal level and can be used for unit conversion between the two scales. When switched to measure hand-arm vibration, 20 dB (× 10) should be added to the indicated level.

Overload Indicators

Three light emitting diode (LED) lamps mounted adjacent to the "Display Mode" switch indicate various overload conditions so that false measurements can be avoided. The Eq. Exp. LED lamp lights when the equivalent exposure "dose" exceeds 9999%. It also indicates when the

RMS acceleration level is so high during a two second dose calculation period that the maximum permissible dose (in Fig.7), would be exceeded if the level was maintained over a 1 min. period. In this case the overload lamp lights for about 2 s for each excess. Levels exceeding the limit are interpreted as max. levels but dose counting continues as normal.

The L_{eq} overload LED lights when the L_{eq} calculator memory is filled to capacity. Under worst-case conditions this will occur after a 1000 s (~ 17 minutes) measurement period. Where L_{eq} is less than 135 dB the maximum measurement period of 53 minutes is obtained, after which the overload lamp lights.

The AC signal level is monitored at several points in the high-pass, low-pass and weighting filter circuitry by a peak overload detector. Overloads are indicated by the "Peak" LED lighting for the duration of the overload condition.

Reference Oscillator

A built-in oscillator generates a 16 Hz reference signal which enables the instrument's operation to be checked-out. The reference level is precalibrated according to the vibration category chosen. Switching the input selector to "Ref." starts the oscillator. The analogue meter indicates 120 dB (1 ms^{-2}) and the digital display indicates 120 dB in the L_{eq} mode and 123 dB in the "Peak" mode (140 and 143 dB respectively for hand-arm). In the "Equivalent Exposure" mode the digitally displayed value will increase with time as determined by the time weighting characteristic defined in the human vibration standards and recommendations (Fig.7). For example, with the 2512 switched to measure whole-body vibration in the X and Y direction according to the "exposure limit" criterion, the digital readout will register 10% after 26,9 minutes (± 15% i.e. ± ~ 4 mins). In the hand-arm × 1 position the dose readout will indicate 5% after 12 minutes. As 16 Hz lies outside the range of motion sickness measurements the reference oscillator cannot be used for this category.

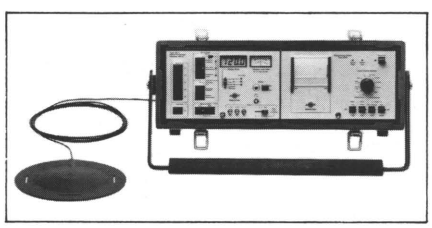


Fig.8. A self-contained battery-operated human vibration measurement and recording set consisting of Human-Response Vibration Meter Type 2512, Alphanumeric Printer Type 2312, Triaxial Seat-Accelerometer Type 4322 and Carrying Case KA 2000

Analogue and Interface Bus Outputs

A BNC socket on the rear panel of the 2512 carries the DC output. This is the Log RMS level of the frequency-weighted vibration signal taken directly from the RMS detector. This output is useful for coupling to a DC recorder such as the Level Recorder Type 2306 for recording level variations with respect to time.

Comprehensive measurement data is provided at the interface bus (IEC 625) output. This output is used to feed information to a digital recorder such as the Alphanumeric Printer Type 2312. As the 2512 is equipped with an addressable IEC interface it may also be coupled to a computer or calculator controlled data gathering system.

A switch on the front panel enables the interface to be switched on or off as required. With the interface on, the 2512 can be addressed by an external controller and is able to transmit full data at 2 s or greater intervals.

A fully portable self-contained measurement and recording system is achieved together with the Alphanumeric Printer Type 2312, which is also battery operated. Fig.8 shows the two instruments mounted in a carrying case KA 2000, which can also contain two battery chargers ZG 0113. The 2512's measurement period can be controlled by the printer, which can be preset to terminate a measuring period, record full data, then reset and start the measurement period every 20 s, 1 min, 5 mins., 15 mins., 50 mins. or 1 hour as desired. Data transfer takes 5 s. Alternatively, accumulated data can be read out to the Alphanumeric Printer at the intervals mentioned without terminating the measurement period and resetting the vibration meter. Each print-out from the 2312 contains the relative or actual time of readout, the measuring period in minutes, the maximum peak and L_{eq} levels during the measuring period and the equivalent exposure dose together with a code indicating the human vibration category and discomfort/danger criterion chosen. A typical readout is shown in Fig.9.

```
00:13:16
  ELAPSED TIME
MINUTES...0009.2
PEAK....DB 138.5
LEQ.....DB 125.5
    EQ EXPOS
WB-Z-FDP.. % 047
                 810023
```

Fig.9. A typical printout from the Alphanumeric Printer Type 2312 used to record data from the Human Vibration Meter Type 2512

The Output to External Filter, on the rear panel of the 2512, is an AC signal output which may be switched to take the AC signal either before or after the frequency weighting filters. This enables signal amplitude distribution analysis to be performed together with the Level Analyzer Type 4426, which continuously samples the vibration signal and sorts it into 0,25 dB level classes.

Power Supply

The internal power supply consists of six alkaline cells which give a continuous operating capacity of 18 hours. Rechargeable cells, QB 0008, can be supplied as an optional extra, their capacity covers 12 hours operation. An optional battery charger, ZG 0113 can fully charge these cells in 14 hours. The charger also functions as a mains adaptor as it provides sufficient power to run the instrument (via the rechargeable cells) and charge the cells simultaneously.

An external DC power supply of + 6 to + 15 V, such as Power Supply Type 2808 or an automobile battery can also be used to power the 2512.

A 28 V power outlet rated at 2 mA is provided on the front panel specifically for powering the integ-

rally mounted preamplifier of the high sensitivity Accelerometer Type 8306.

A miniature meter on the front panel indicates whether the internal battery or external power supply voltage is sufficient to power the 2512 satisfactorily.

Triaxial Seat-Accelerometer Type 4322

Accelerometer Type 4322 is specially designed for detecting vibratory motion in connection with the measurement of whole-body vibration and is intended to be positioned under the buttocks of a seated person. It contains a triaxial pickup able to detect vibration in three mutually perpendicular directions, that is, vertically (Z-axis) buttocks to head, transverse (Y-axis) right to left side, and (X-axis) back to chest.

The transducer consists of a semi-rigid nitrile rubber disc 205 mm (~ 8,1") diameter with a contoured bulge in its centre housing a triaxial accelerometer which is in turn mounted on a stiff 75 mm dia. metal disc. To make the transducer comfortable to sit on, the rubber disc is only 3 mm thick at its periphery, increasing to 12 mm thick at its centre and is flexible so that it it is able to deform to follow the seat contours.

Transducer dimensions are in accordance with the requirements of SAE Recommended Practice J 1013 (1973).



Fig.10. Accelerometer Type 4322 seen from the underside

Two 1,2 m long straps (DH 0411) are provided which can be threaded through the 40 mm wide slots in the transducer to hold it in position on the seat during rough rides, or for example, to strap the transducer to the human chest.

The accelerometer pickup contained in the 4322 has three separate Delta Shear® elements assembled in a common housing. They are of the Uni-Gain® Type which means that their sensitivity has been adjusted during manufacture to be 1 pC/ms^{-2} (~ 10 pC/g) within a 2% tolerance. This feature avoids the necessity of separate gain adjustment in each channel of the measuring instrument.

Signal output from the accelerometer is via three miniature coaxial sockets feeding three screened teflon cables which are grouped into a common 3 m long output cable. The output cable is secured in the pickup by a bush crimped to the cable, this prevents excess tension being applied to the three connectors.

A 6-pin DIN screw-locking plug matching the input of the Human-Response Vibration Meter Type 2512 terminates the 3 m long output cable.

The bottom plate of the transducer is fastened with six screws and sealed with a rubber gasket. In the event of cable damage it is therefore possible to gain access for replacement.

Specifications 4322

Charge Sensitivity:
1 pC/ms^{-2} ± 2%
(~ 10 pC/g)

Frequency Range:
Built-in triaxial accelerometer element: 0,1 Hz to 2 kHz (+ 5%)
Complete seat accelerometer on simulated seat: 0,1 Hz to 100 Hz (+ 5%)

Capacitance:
1200 pF including 3 m integral cable

Maximum Transverse Sensitivity:
(of each element) < 4%

Piezoelectric Material:
PZ 27

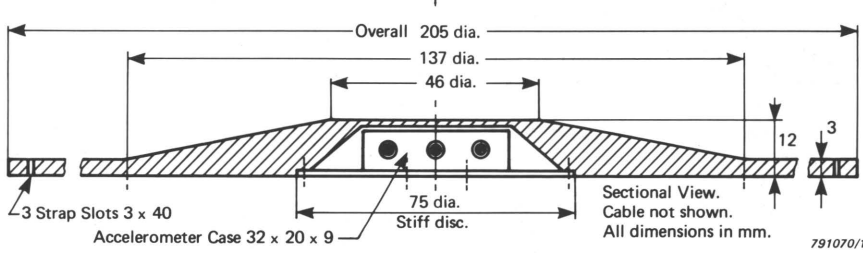
Configuration:
Delta Shear®

Minimum Leakage Resistance:
(at 20°C)
> 20 GΩ

Typical Temperature Transient Sensitivity:
(Measured with Human-Response Vibration Meter Type 2512. Worst case with motion sickness selected)
3 ms^{-2}/°C

Materials:
Accelerometer Case: Nickel-plated brass
Base Disc: Nickel-plated brass
Moulded Cushion: Oil resistant nitrile rubber, hardness ~ 80 IRHD

Dimensions:



Environmental Temperature:
—10 to + 70°C
(—60 to + 150°C for short periods)
Accelerometer alone 200°C

Cable:
Three in one, low-noise, individually shielded, Teflon insulated
Length: 3 m (10 ft)
Connectors: Accelerometer end, three miniature coaxial plugs
Remote end, 6 pin DIN screw-locking plug JP 0602

Specifications 2512

Vibration Categories Measured:

Whole-Body vibration: in accordance with ISO 2631-1978, and draft amendment 1. Also Motion sickness in accordance with Draft Addendum to ISO 2631 DAD 2 (16-9-80)

Hand-Arm vibration: in accordance with Draft International Standard ISO/DIS 5349, submitted 18-1-1979

Inputs: (to three charge amplifiers)

3 miniature coaxial sockets on front panel in parallel with a 6-pin DIN socket on rear panel

Input Sensitivity:

Calibrated for accelerometer sensitivity 1 pC/ms^{-2}

Input Impedance:

> 18 GΩ DC shunt resistance

Frequency Response:

Dependent on category selected. See Fig.4

Frequency weighting curves have response and accuracy as required by the various standards mentioned

Log. RMS Detector:

Frequency range: 0,1 to 1000 Hz

Dynamic range: 60 dB including crest factor 3

Time constants: 2 s for whole-body and hand-arm (125 ms in "Preset") 10 s for motion sickness

Equivalent Exposure Dose Calculator:

Calculates equivalent exposure based on Log. RMS level every two seconds

Range: 0 to 9999% in 1% steps

Accuracy (expressed as a percentage of the dose readout): **Hand-arm** ± 5% except at step level changes (see Fig.7) **Whole body 0,1—0,63 Hz** (motion sickness) ± 15%. **Whole Body 1 — 80 Hz**

$$\pm\left(\frac{4\text{ min.} \times \text{Exp. dose readout \%}}{\text{Elapsed time (min)}}\right)\%$$

where equivalent 100% dose time is 10 min. to 27 min. or ± 15% where equivalent 100% dose time exceeds 27 min.

L_{eq} Calculator:

Calculates equivalent continuous vibration level according to the equal energy principle

Updates display every eight seconds

Capacity: at least 1000 s (16,6 min.) measuring time, maximum 53 minutes

Range: 104 to 139,5 dB (~ 0,16 to 9,4 ms^{-2}) for whole-body and motion sickness

124 to 159,5 dB (~ 1,6 to 94 ms^{-2}) for hand-arm

Accuracy: better than ± 0,5 dB

Crest Factor Capability: better than 3 (worst case at max. level)

Log. Peak Detector:

Stores Max. peak level during measurement period

Range: 100 to 146 dB (~ 0,1 to 20 ms^{-2}) for whole-body and motion sickness

120 to 166 dB (~ 1 to 200 ms^{-2}) for hand-arm

Accuracy: ± 1 dB

Digital Display:

7 segment LED, 4 digits

Quantities Selectable:

Equivalent exposure, 1 to 9999% resolution, 1%

L_{eq} 100 to 159,5 dB, resolution typically 0,5 dB

Peak level, 100 to 166 dB, resolution typically 0,5 dB

Elapsed minutes, 0 to 999 minutes, resolution 0,1 minutes

Analogue Meter:

Indicates Log RMS level in dB re 10^{-6} ms^{-2} and in ms^{-2}

20 dB must be added to meter reading for hand-arm measurements

Overload Indicators:

Equivalent Exposure: LED lamp indicates dose exceeding 9999% or exceeding of 2 s dose maximum (lights for ~ 2 s)

L_{eq}: LED lamp indicates memory full or 53 minutes exceeded

Peak: LED lamp indicates overload in AC circuitry

Reference Oscillator:

16 Hz reference signal gives L_{eq} = 120 dB (1 ms^{-2}) ± 0,5 dB in whole-body and 140 dB (10 ms^{-2}) ± 0,5 dB in hand-arm

Not applicable to motion sickness measurements

AC Output:

BNC socket ("Output to Ext. Filter")

Signal available either weighted or unweighted

Level:

200 mV/ms^{-2} (at ref. freq. in Fig.5.) in whole-body and motion sickness

20 mV/ms^{-2} (at ref. freq. in Fig.5.) in hand-arm

Output Impedance: 50 Ω

Min. Load Impedance: 5 kΩ

DC Offset: 300 mV max.

DC Output:

BNC socket

Signal from Log RMS detector

Level: 100 mV/dB. 0 V = 100 dB in Whole-Body (120 dB in Hand-Arm)

Min. Load Impedance: 5 kΩ

Interface Bus:

25 pin connector. Bus in accordance with IEC 625-1*

Functions Used: T3 (Addressable basic talker with "talk only" mode); provided with SH1 and AH1

Data: Readout of Max. peak and L_{eq} during measurement period

Equivalent Exposure

H.V. Category and Criterion selected on front panel

Elapsed time

Data Transmission Code: ASCII

External Filter Sockets:

Two BNC sockets

Output to Ext. Filter: As for AC Output

Input from Ext. Filter: Max. signal level 6 V peak

Input impedance: 147 kΩ in parallel with 100 pF

Environmental Conditions:

The instrument performs within specifications under the following conditions:

Temperature: —10°C to + 55°C

Humidity: 0 to 90% relative humidity non-condensing

Magnetic: Field strengths up to 100 A/m

Internal Power Supply:

Six IEC R20 type D cells

Operating capacity: 18 hours continuous with alkaline cells (12 hours with optional NiCd rechargeable cells)

External Power Supply:

Rear panel connection through 7-pin DIN socket

Requires + 6 V to + 15 V DC, 1,5 W

Power Supply Output:

28 V, 2 mA miniature socket, for Accelerometer Type 8306

Dimensions: (excl. feet, knobs etc.)

Height: 133 mm (5,2 in)

Width: 210 mm (8,3 in)

Depth: 200 mm (7,9 in)

(B & K module cabinet KK 0025 6/12 of 19" rack module)

Weight:

3,1 kg (6,8 lb) including battery

Accessories Included:

6 Alkaline Cells	QB 0004
1 7 pin DIN plug	JP 0703
3 BNC plugs	JP 0035
2 Spare fuses	VF 0050

Accessories Available:

Battery Charger	ZG 0113
6 Ni-Cd Cells	QB 0008
Triaxial Seat-Accelerometer Type 4322	
Triaxial Accelerometer Type 4321	
Accelerometer Types 4371, 4384, 4370 and 8306	
Mahogany outer cabinet KA 0063 (supplied as standard if 2512 B version ordered)	
Carrying Case KA 2000	
Input adaptor for tape recorded signals	
IEC 625-1 interface cable (2 m)	AO 0194
IEC (male, slide lock) to IEC 625-1 Interface cable (2 m)	AO 0184
Adaptor to convert IEEE instrument to IEC 625-1	AO 0195
Scale for interpretation of distribution diagrams (from4426)	**SC 2363**

* Compatible with IEEE Standard 488-1975 and ANSI MC 1.1-1975

2. CONTROLS

2.1. FRONT PANEL

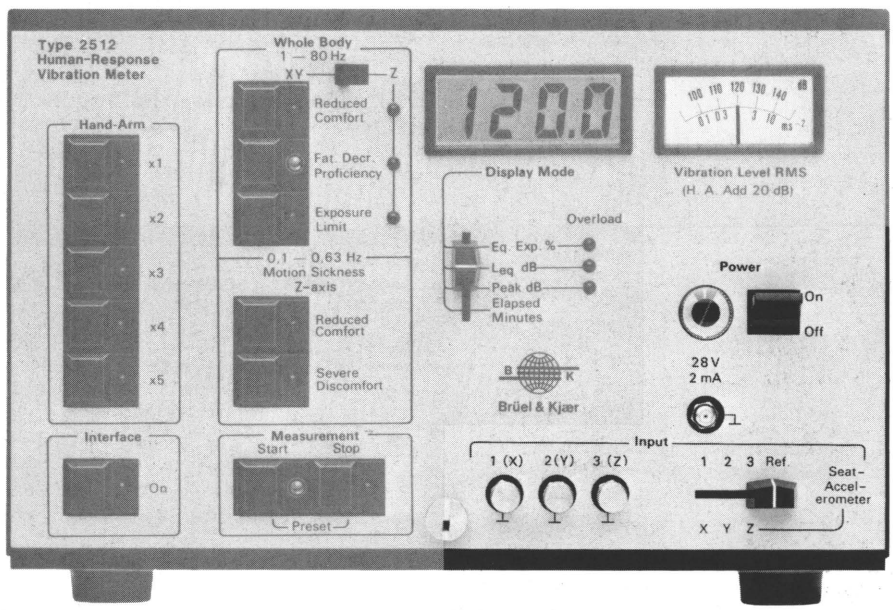


Fig. 2.1. Power and signal input controls

2.1.1. Power and Input Controls

POWER:

"Off" – In this position the instrument is switched off and the contents of the memory are erased. However, if rechargeable Nickel Cadmium cells are being used, they can still be recharged when the switch is in this position.

"On" – Power is on in this position and the battery voltage indicator should move from the red to the blue region, indicating that the voltage from the batteries, or from the external power supply where used, is sufficient for proper, reliable operation. In addition a number of the indicating light emitting diodes will come on, corresponding to the switch positions selected during the previous measurement, and the two displays will begin to indicate. Warm-up time depends on the mode of operation, 5 s for HAND-ARM, 10 s for WHOLE BODY 1 — 80 Hz, and 40 s for 0,1 – 0,63 Hz MOTION SICKNESS. The 2512 can be powered either from internal batteries or from external supplies. See section 3.2.

28 V 2 mA:

28 V (2 mA) micro-socket for supplying power to, for example, high sensitivity accelerometer Type 8306.

INPUT SOCKETS:

A group of three microsockets for connecting either three separate accelerometers or the Triaxial Accelerometer Type 4321. The sockets are connected in parallel with the 6-pin SEAT-ACCELEROMETER input on the rear panel, their connections indicated by the bracketed letters (X,Y,Z) over the respective sockets (1,2,3,).

INPUT CHANNEL SELECTOR:

A four-position slider switch to select the input signal to be measured and analyzed, or a reference signal. Input from sockets "1", "2", or "3" can be selected, corresponding to the "X", "Y", and "Z" axes of the SEAT ACCELEROMETER input socket on the rear panel of the instrument. See Fig.2.6. The "Ref." position connects internally generated reference signals to all outputs including the two displays. The signal is equivalent to 120 dB in the WHOLE BODY mode and 140 dB in the HAND-ARM mode of operation, at 16 Hz. It is therefore only available in HAND-ARM and WHOLE BODY 1 – 80 Hz modes of operation, whose frequency ranges include 16 Hz. It is not available in the WHOLE BODY 0,1 – 0,63 Hz MOTION SICKNESS Mode of operation, because 16 Hz is not included in its frequency range. See section 3.3.1 for further details.

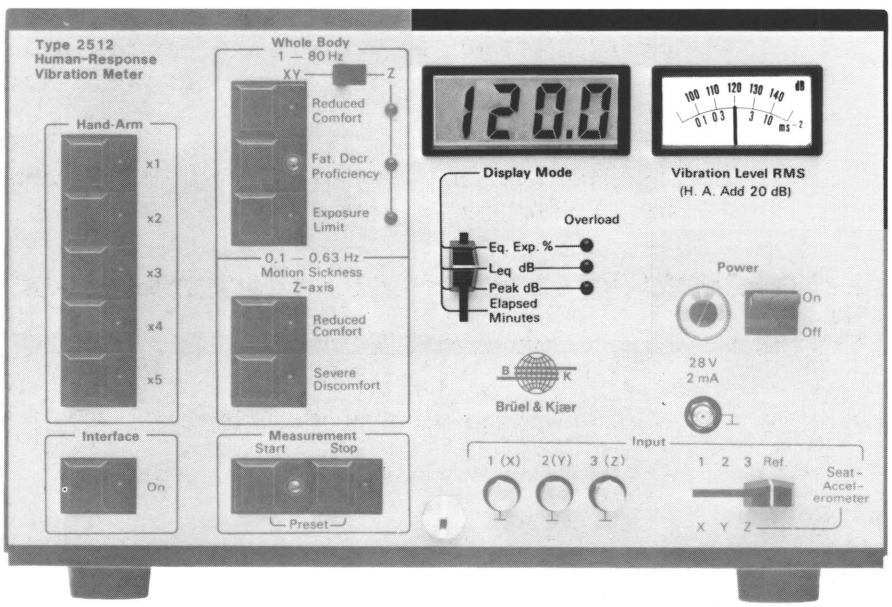


Fig. 2.2. Display and display control

2.1.2. Displays and Display Control

DIGITAL DISPLAY:

A four digit display for reading out the various parameters measured or calculated by the instrument. "L_{eq}" and "Peak" values can be read out to a resolution of 0,5 dB; "Eq. Exp." to 1%; and the elapsed time to 0,1 minutes.

ANALOGUE DISPLAY:

A small moving coil meter intended primarily for monitoring the signal level. The scale is calibrated in dB re. 10^{-6} ms^{-2}, and in ms^{-2} to read RMS value of the measured signal.

DISPLAY MODE:

A four position slider switch used to select the measurement parameter to be displayed on the digital display. Three measurement parameters, each with an LED overload indicator, and the elapsed time in minutes, can be selected. These are:

"Eq. Exp.%" – The Equivalent Exposure as a percentage of the vibration dose allowed for the measurement period. The overload indicator lights permanently if the equivalent exposure exceeds 9999% and lights for a period of approximately two seconds each time the RMS acceleration during a two second dose calculation period exceeds the permissible level for the shortest exposure time considered by the standard applicable to the selected measurement mode, or 2 minutes in the MOTION SICKNESS mode. Dose calculation continues normally, however, with the maximum permissible value used in the dose calculation.

"L_{eq} dB" – The equivalent continuous vibration level; a logarithmic function of the frequency-weighted energy mean vibration level averaged over the entire measurement period. The overload LED lights when the L_{eq} calculator memory is full. This occurs between 17 and 53 minutes after the start of measurement, depending on the level of the signal. The value is presented in dB re. 10^{-6} ms^{-2}.

"Peak dB" – Displays the maximum peak level which occurs during the measurement period. The value is presented in dB re. 10^{-6} ms^{-2}. The overload LED indicator comes on if the peak frequency weighted level exceeds the maximum allowable value at any time during its passage through the instrument and remains lit for the duration of the overload and at least 130 ms. Overload detection is thus carried out at a large number of positions in the circuit.

"Elapsed Minutes" – Displays the elapsed time of the current measurement with 0,1 minute (6 s) resolution.

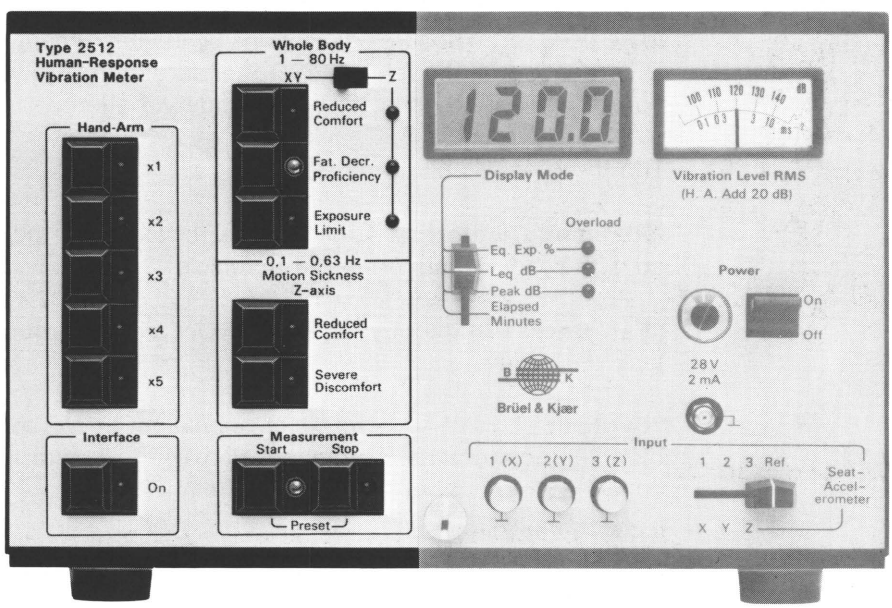


Fig. 2.3. Measurement selection and control

2.1.3. Measurement Selection and Control

The measurement selection and control switches are divided into two main fields concerned with the selection of criteria for either whole body or hand-arm vibration, and the measurement start/stop and interface switches as follows:

HAND-ARM:

A set of five push-keys for selecting Hand-Arm frequency weighting filters and time weighting functions for Hand-Arm measurements. Pressing any of these five pushkeys selects the Hand-Arm filters, whereas each individual pushkey (labelled "x1", "x2", "x3", "x4", "x5") corresponds to a certain proportion of interruption of exposure time during the working day. Each pushkey has a built-in LED to indicate that it has been selected.

Whole Body Panel

Two groups of pushkeys; the upper group concerned with the ISO standardized frequency range from 1 to 80 Hz, the lower one concerned with the frequency range from 0,1 to 0,63 Hz, which is most relevent to the prediction of motion sickness.

1 – 80 Hz range

AXIS SELECTOR:

Two-position slider switch to select one of the two different frequency weightings which apply to the vertical and horizontal directions when measuring in the whole body mode, 1 to 80 Hz.

The right (Z) position connects the frequency weighting filters aplicable to vertical motion, and thè left (X,Y) position connects the frequency weighting filters applicable to horizontal motion.

When "Z" is selected, one of the three LEDs to the right of the selected LIMIT SELECT OR pushkeys lights. If "X Y" is selected, the LED in the corresponding pushkey itself lights.

LIMIT SELECTOR PUSHKEYS:

A group of three pushkeys for selecting the whole body exposure criterion to be used for exposure calculations by the instrument. These criteria are in accordance with the relevant ISO Standard, ISO 2631, Guide for the evaluation of human exposure to whole-body vibration.

The three selectable criteria are:

"Reduced Comfort" – Applicable to, for example, the difficulties associated with reading and writing in a vehicle.

"Fat. Decr. Proficiency" – Fatigue Decreased Proficiency, applicable to task performance.

"Exposure Limit" – A level which should not be exceeded; the exceedance of which could cause permanent damage to health if the exposure were continued throughout the working lifetime.

0,1 – 0,63 Hz MOTION SICKNESS Z–AXIS range

LIMIT SELECTOR PUSHKEYS:

Two pushkeys with integral LED indicators, for selecting the required exposure criterion. Only a Z–axis weighting is available in this mode of operation. The two selectable criteria are:

"Severe Discomfort" as described in "Draft Addendum ISO 2631/DAD2"

"Reduced Comfort" as described in earlier drafts of this standard.

MEASUREMENT:

Two pushkeys with integral LED indicators for starting, stopping and resetting the measurement.

"Start" starts a measurement, or continues a measurement which was temporarily halted using the "Stop" pushkey.

"Stop" stops the measurement in progress. It may be continued by pressing "Start", or the internal registers can be cleared and a completely new measurement can be initiated by pressing the "Start" and "Stop" pushkeys simultaneously, the "Preset" position.

"Preset" is the only position which allows the measurement mode to be altered, the HAND-ARM, LIMIT SELECTOR and AXIS SELECTOR switches are otherwise locked in the previously selected positions. The LEDs in both pushkeys will light when pressed simultaneously to indicate that a reset has occured, that the instrument has been initialized, that a new measurement mode can be selected, and that a new measurement can be begun by pressing "Start". In the "Preset" mode, the time constant is very short (0,125 s in the HAND-ARM and WHOLE BODY 1 – 80 Hz modes, and 0,6 s in the WHOLE BODY 0,1 – 0,63 Hz MOTION SICKNESS mode) to give a short settling time when changing measurement mode. It may also be used when recording on a level recorder to obtain an output with relatively short time constant.

INTERFACE SWITCH:

A single pushkey with integral LED indicator, which lights when the switch is in the "On" position and the interface is connected. The instrument can then transmit the full data list at intervals of 2 s or greater.

2.2. REAR PANEL

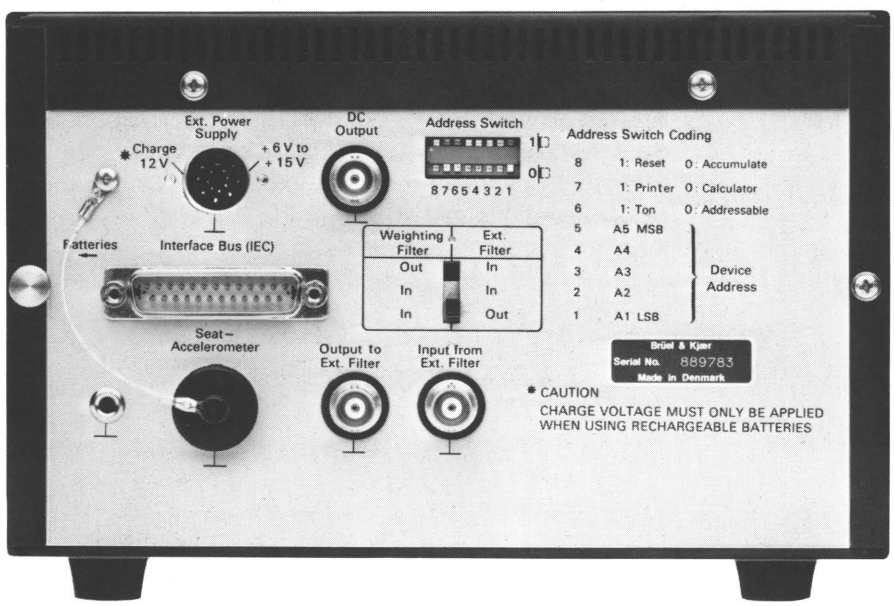


Fig. 2.4. Rear Panel

BATTERY COVER RELEASE SCREW:

A knurled screw which allows the side panel to be removed to give access to the battery compartment for installation of new batteries. See section 3.1.

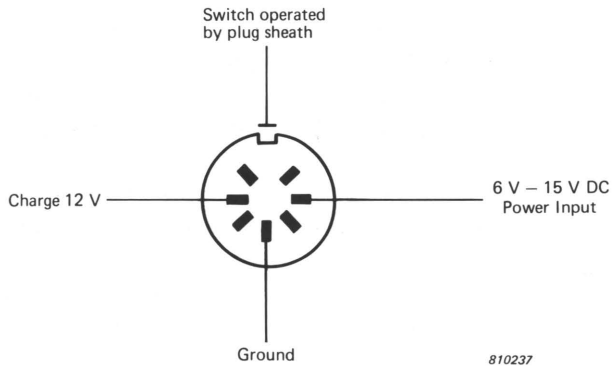


Fig. 2.5. Pin connections of the EXT. POWER SUPPLY socket looking into the socket or from the soldering side of the plug

EXT. POWER SUPPLY:

A 7-pin DIN socket accepting plug JP 0703 for connecting external power to the instrument for either direct operation or charging rechargeable internal cells. The pin diagram is shown in Fig.2.5. The socket may be connected directly to the OUTPUT socket of the Power Supply ZG 0199 using the cable AQ 0035 to provide both the operating and charging voltage (when nickel-cadmium rechargeable cells are used), or to a battery charger ZG 0113 which supplies sufficient power to run the instrument via the internal rechargeable cells, where fitted, and keep them charged. For further details on powering the instrument, see Section 3.2.

WARNING: Never attempt to recharge normal dry cells. Only nickel-cadmium cells can be recharged.

FILTER SELECTOR:

A three-position slider switch to select various combinations of internal weighting filters and external filters. With the FILTER SELECTOR in the "Weighting Filter - Out, Ext. Filter - In" position and the "Output to Ext. Filter" and "Input from Ext. Filter" BNC sockets connected by cable AO 0087 i.e. short circuited, unweighted measurements can be carried out.

SEAT-ACCELEROMETER

A 6-pin DIN socket for connecting the corresponding plug (JP 0600) of the Seat Accelerometer Type 4322. The connections are in parallel with the three microplugs for the three axes on the front panel of the instrument. The pin connections are shown in Fig.2.6.

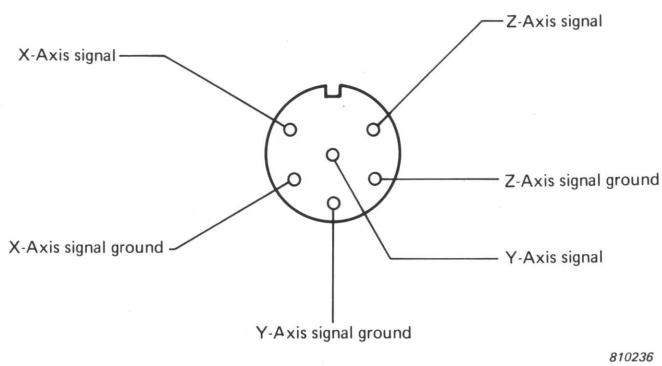


Fig. 2.6. Pin connections of the SEAT-ACCELEROMETER socket looking into the socket or from the soldering side of the plug

INTERFACE BUS (IEC):

25-pin socket for direct connection of the Type 2512 to an instrument with an interface bus such as the Alphanumeric Printer Type 2312 using the B & K cable AO 0194 (AO 0184 for early models of the 2312, before serial number 920925). Complete details are given in Section 4.1.

ADDRESS SWITCH:

A set of eight subswitches each with two positions; the top of the switch pressed in (1), and the bottom of the switch pressed in (0).

SUBSWITCH 8:

Controls whether or not the current measurement is to be continued or a new measurement is to be started when data transmission takes place.

"1: Reset" – As soon as data transmission begins, the registers of the 2512 are cleared and a new measurement is begun.

"0: Accumulate" – The current measurement is continued when a data transmission command is received.

SUBSWITCH 7:

Controls the format of the transmitted data.

"1: Printer" – Primarily for use with the Alphanumeric Printer Type 2312. The data is accompanied by explanatory text. See Section 4.1. for further details.

"0: Calculator"– Output is in accordance with IEC 625-2 without explanatory text. Primarily intended for transmission to a calculator for further processing or to a digital cassette recorder. For further details see Section 4.1.

SUBSWITCH 6:

Controls the mode of operation of the interface.

"1: Ton" – Talk only – Enables the 2512 to output data to a listener without the use of an external controller. Primarily for use with the Alphanumeric Printer Type 2312 or Digital Cassette Recorder Type 7400.

"0: Addressable" – Allows the 2512 to be addressed by an external controller, e.g. a desk-top calculator, using a unique name which is determined by the settings of the next 5 switches, numbers 5 to 1.

SUBSWITCHES 5 – 1:

These switches are the last five bits of a 7-bit ASCII coded word, the first two bits of which are assumed to be "1" and "0" respectively. They select the address code for the 2512 in an addressable system and are preset at the factory to binary 01100, which corresponds to the alphanumeric character "L". Switch "5" sets the most significant bit (MSB) A5, and switch "1" selects the least significant bit (LSB) A1. Depressing the upper part of the switch corresponds to 1, and pressing the lower part of the switch corresponds to a 0, as indicated alongside the switch. They allocate a binary number to the 2512 corresponding to its address in the system. They have no effect unless the INTERFACE switch on the front panel is "On".

DC OUTPUT:

A BNC socket providing a DC signal from the logarithmic RMS detector. Output level is 100 mV/dB with 0 V equivalent to 100 dB in the WHOLE BODY mode and 120 dB in HAND-ARM mode. Minimum load impedance is 5 kΩ.

OUTPUT TO EXT. FILTER:

A BNC socket providing an AC signal for connection to an external filter set or other external device. The Sensitivity is 200 mV/ms^{-2} (weighted or unweighted) with a DC offset of 300 mV maximum for the WHOLE BODY mode, and 20 mV/ms^{-2} (weighted) or 2,0 mV/ms^{-2} (unweighted) in the HAND-ARM mode, at the appropriate reference frequencies. Output impedance is 50 Ω and minimum load impedance is 5 kΩ.

INPUT FROM EXT. FILTER:

A BNC socket to return the externally filtered signal to the 2512. Maximum signal level is 5 V peak. Input impedance is 147 kΩ in parallel with 100 pF. Sensitivity is 200 mV/ms^{-2} in the WHOLE BODY mode, and 20 mV/ms^{-2} in the HAND-ARM mode.

GROUNDING SOCKET:

For grounding the instrument. Accepts plug JB 0002.

3. OPERATION

3.1. MOUNTING

The 2512 is delivered in a metal cabinet with a metal stand for raising the front of the instrument for easier reading. It may also be mounted in Carrying Case KA 2000, which is highly suitable for field use, along with Alphanumeric Printer Type 2312. To mount the instrument in the Carrying Case KA 2000, first ensure that the instrument is switched off and then remove the bottom panel. This is done by loosening the screw on the bottom of the front panel by half a turn. The bottom panel can now be slid off to the rear. Remove the plastic feet from the panel. These are each fixed by one screw and nut. The panel can now be screwed into place in the KA 2000 and the 2512 slid onto it and fixed in place by tightening up the locking screw on the front panel.

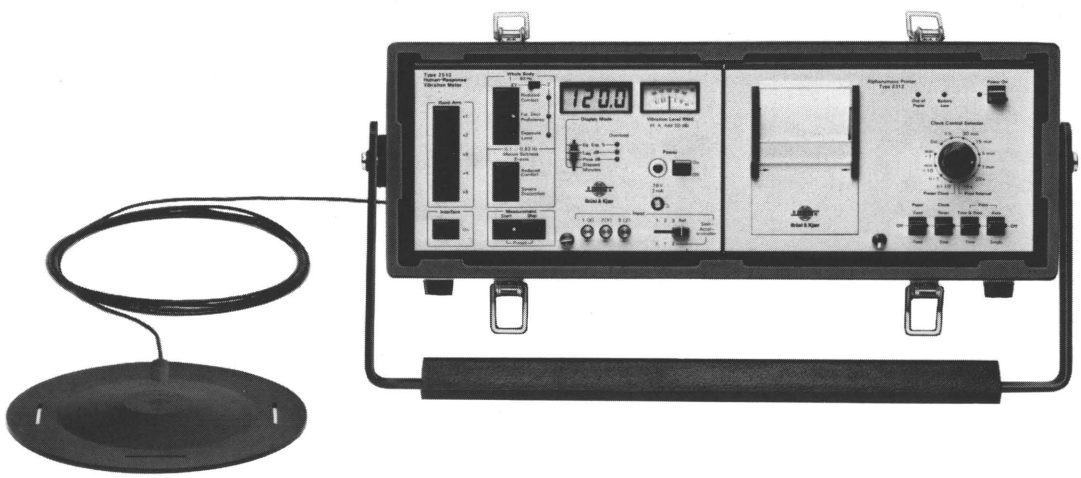


Fig. 3.1. Human-Response Vibration Meter Type 2512 and Alphanumeric Printer Type 2312 mounted in carrying case KA 2000 and Seat-Accelerometer Type 4322, ready to carry out measurements

3.2. POWER SUPPLY

The 2512 may be powered by internal cells or by an external mains power supply such as the Power Supply ZG 0199. The internal cells may be of the normal alkaline type (QB 0004), as supplied with the instrument, or rechargeable nickel-cadmium cells (QB 0008) which are available as accessories. Alkaline cells have an operating life of 18 hours and fully charged nickel-cadmium cells a life of 12 hours. In addition, the instrument may also be operated via re-chargeable batteries using the battery charger ZG 0113, though **not** via conventional or alkaline batteries. Under no circumstances should an attempt be made to apply a charging current to non-rechargeable batteries. Operation with these different types of supply is discussed in the following sections:

3.2.1. Battery Check

To check the state of the internal batteries, switch the instrument on and ensure that the pointer of the indicating meter is within the blue section of the scale. If not, the internal batteries should be replaced, or if they are rechargeable types, recharged.

Note: To obtain an accurate battery check, all external DC supplies must be disconnected.

3.2.2. Replacement and Installation of Internal Batteries

In order to install or replace internal batteries of either rechargeable or alkaline type, proceed as follows:

1. Loosen the knurled screw holding the left side panel (looking at the rear of the instrument), and slide the panel from the instrument to gain access to the battery compartment, as shown in Fig.3.2. The screw will remain captive in the panel.

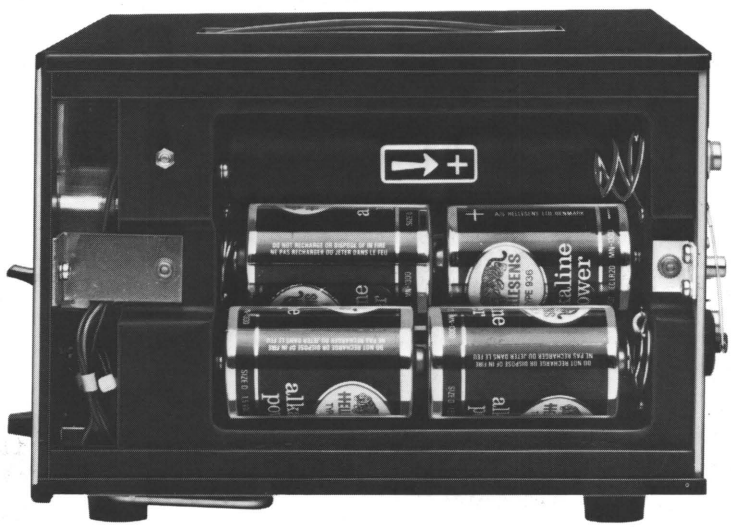


Fig. 3.2. Location of the six cells in the battery compartment of the Type 2512

2. Remove the spent batteries and insert new or freshly charged batteries, ensuring that they are correctly orientated as indicated by the arrows on the inside of the battery compartment, i.e.that the positive pole on the battery, (the stud on the battery case), points in the direction of the arrows.

Replace the side panel of the battery compartment and put a label on it stating the type of batteries installed. If alkaline or conventional batteries have been fitted, this should also include the warning:

"Explosion risk - Not to be recharged"

3.2.3. Power Supply ZG 0199 for AC Line Operation and Recharging Rechargeable Internal Batteries

AC Line Operation

The 2512 may be operated from 100 V to 240 V (50 to 60 Hz) AC line supplies using the Power Supply ZG 0199, which is available as an accessory. It is connected directly to the EXT. POWER SUPPLY socket on the rear panel of the instrument using cable AQ 0035, as shown in Fig.3.3. There is an internal switch on the EXT. POWER SUPPLY socket which is activated when the DIN plug of the cable AQ 0035 is inserted. This connects a diode into the internal circuit in order to protect the internal batteries and causes a small voltage drop (approximately 0,8 V) in the internal supply, which can be noticed as a slight drop in the reading on the battery condition meter. When using the internal batteries to power the instrument, the DIN plug should always be removed from the socket if it not simultaneously being used to recharge the batteries, in order to conserve battery power. If rechargeable nickel-cadmium cells are installed, the ZG 0199 may also be used to recharge these in situ, as it is capable of supplying full charging current (330 mA) as well as sufficient current to power the instrument directly. If alkaline or conventional batteries are installed, the OUTPUT SELECTOR switch on the ZG 0199 **must be in the "Charge - Off" position.** Better still, remove such batteries before connecting the external supply in order to be quite sure that they cannot inadvertently be charged.

Note: Never attempt to recharge non-rechargeable cells.



Fig. 3.3. Powering the Type 2512 or recharging its rechargeable internal batteries from the Power Supply ZG 0199

The ZG 0199 may also be used to power another instrument, e.g. Alphanumeric Printer Type 2312 at the same time. In this case it must be inserted into the battery compartment of the Type 2312, which it then powers directly, the 2512 receiving its power from the OUTPUT socket of the ZG 0199 via the connecting cable AQ 0035.

If the ZG 0199 is used in this manner to power two instruments at the same time, care should be taken to ensure that ground loops are not formed. With the OUTPUT SELECTOR in the "Drive Voltage - Off, Charge - On" position, and with the use of rechargeable Ni-Cd cells, this problem can be avoided. See the ZG 0199 Instruction Manual for further details.

Recharging nickel-cadmium rechargeable cells

The rechargeable nickel-cadmium cells available as optional accessories can be recharged while still in the battery compartment of the 2512 using the Power Supply ZG 0199 via the EXT. POWER SUPPLY socket on the rear panel of the 2512. They may also be charged externally in the Battery Box ZG 0146 using the Charging Adaptor AQ 0157 and the ZG 0199.

In situ

Connect the OUTPUT socket of the ZG 0199 to the EXT. POWER SUPPLY socket of the 2512 using the cable AQ 0035 as shown in Fig.3.3. and set the OUTPUT SELECTOR switch on the ZG 0199 to one of the "Charge - On" positions. Recharging time for fully discharged cells is 19 hours, and they cannot be overcharged if they are left on charge indefinitely. The ZG 0199 supplies sufficient current to power the 2512 and charge the batteries at the full rate while the instrument is in use.

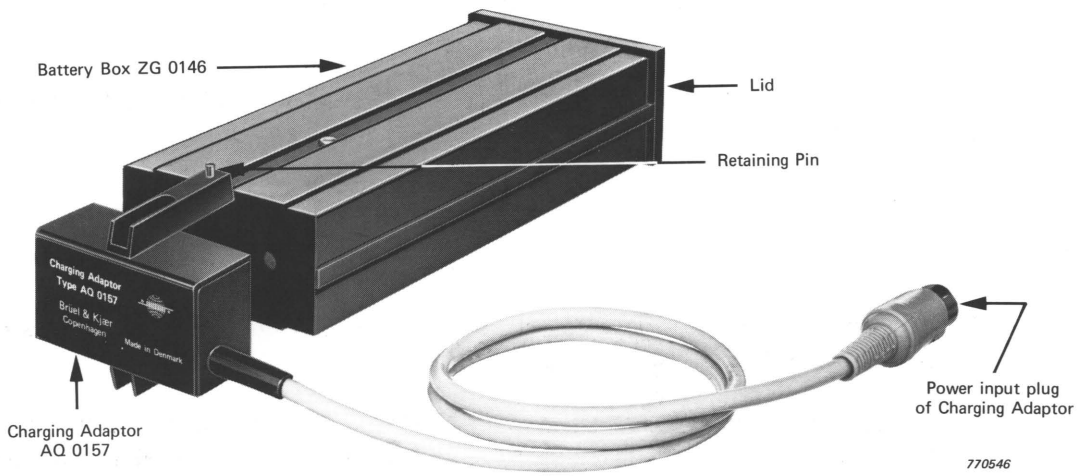


Fig. 3.4. The AQ 0157 about to be fitted to the battery box

Using the Battery Box ZG 0146

It is often convenient to have a spare set of rechargeable cells on charge outside the instrument. These cannot be charged using the method above. Instead, a Charging Adaptor AQ 0157, as shown in Fig.3.4., must be used. The Charging Adaptor is placed on the battery box at the opposite end from its lid. Its two locating arms are slid down the grooves at the top and bottom of the Battery Box ZG 0146, and the Charging Adaptor is held in position by a spring-loaded retaining pin in each of the arms. A further locating pin, which fits into the end of the Battery Box ensures that the Charging Adaptor is fitted the correct way up to ensure the correct polarity. The power supply contacts are also spring loaded, and this holds the retaining pins in position. A seven-pin DIN plug from the Charging Adaptor connects directly to the Power Supply ZG 0199, which should be set to "Charge".

Note: Do not attempt to charge dry cells.

When charging is completed, the Charging Adaptor is released by pressing it towards the Battery Box thus disengaging the spring-loaded retaining pins. The Charging Adaptor may then simply be slid off the Battery Box.

3.2.4. Recharging Batteries in situ using the Battery Charger ZG 0113

For recharging nickel cadmium cells QB 0008, a Battery Charger ZG 0133 can be supplied. This is shown in Fig.3.5 and is a double insulated mains operated supply which can provide up to 400 mA at 12 V DC. To protect the Charger against current overload, a self resetting thermal trip which operates at 80 °C is built-in.

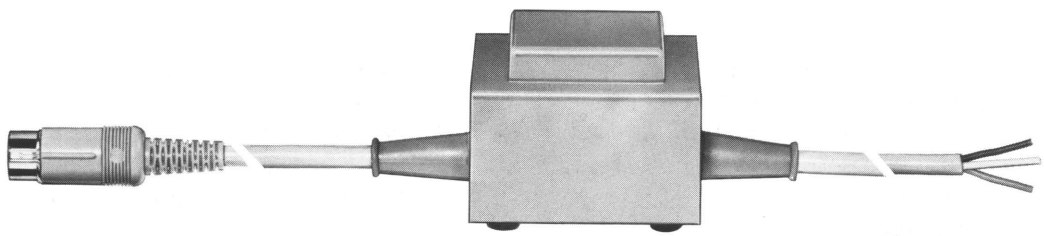


Fig. 3.5. Battery Charger ZG 0113

For operation from different supply voltages, the mains cable of the Charger has the following colour coding:

Blue	Neutral
Black	100 to 130 V (50 to 400 Hz)AC
Brown	200 to 240 V (50 to 400 Hz)AC

Before connecting the Charger to the mains, the particular Brown or Black mains lead not used should be clipped short and covered with insulating tape.

To commence charging, connect the EXT. POWER SUPPLY socket on the rear panel with the 7 pin DIN plug of the Charger. The cells will start to recharge immediately the mains supply is connected. For totally discharged cells the recharge time is approximately 19 hours, however the cells may be left on charge for an indefinite period without danger of overcharging. At the end of the charge period, disconnect the Charger from the 2512 and carry out the Battery Check procedure described in section 3.2.1. If the cells fail to give a suitable battery check indication then they should be replaced.

Note: The Battery Charger ZG 0113 cannot be used for recharging nickel cadmium cells whilst the 2512 is being used for measurements. However, provided the cells are not completely discharged, then it may be used to power the 2512 whilst preventing further discharge from the cells.

3.2.5. Using an External DC Supply

For connection of an external battery or other external DC source, the EXT. POWER SUPPLY socket of the 2512 has the pin identities shown in Fig.3.2. Do not connect a +12 V charge source, if alkaline or standard dry cells are fitted. With nickel cadmium cells QB 0008, the recharge time is approximately 19 hours. There is no danger of overcharging by leaving the cells on charge for a longer period.

For simultaneous operation and recharging using a single external DC source, the EXT. POWER SUPPLY socket may be connected with a 12 V car battery, as shown in Fig.3.7. If a car's own 12 V battery is used for this purpose, then the ignition system may be left running whilst recharging is carried out, but not when operating the 2512. Also care should be taken to ensure that the cabinet of 2512 and of other instruments with which it is used are not touching

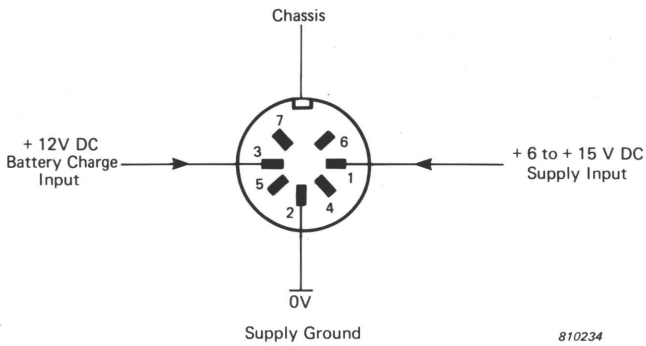


Fig. 3.6. External view of the EXT. POWER SUPPLY socket of the 2512

the metal bodywork of the car. This is particularly important with cars having a positive earth system, as when the battery is connected, the chassis of the instruments will be at a potential 12 V lower than that of the car chassis and could short circuit the battery if allowed to touch the car bodywork. In this case the fuse will blow to protect the instrument.

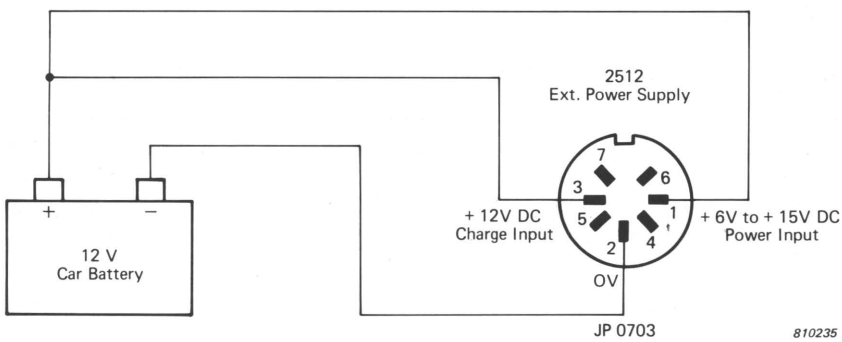


Fig. 3.7. Connection of a 12 V car battery for simultaneous operation and recharging with the 2512

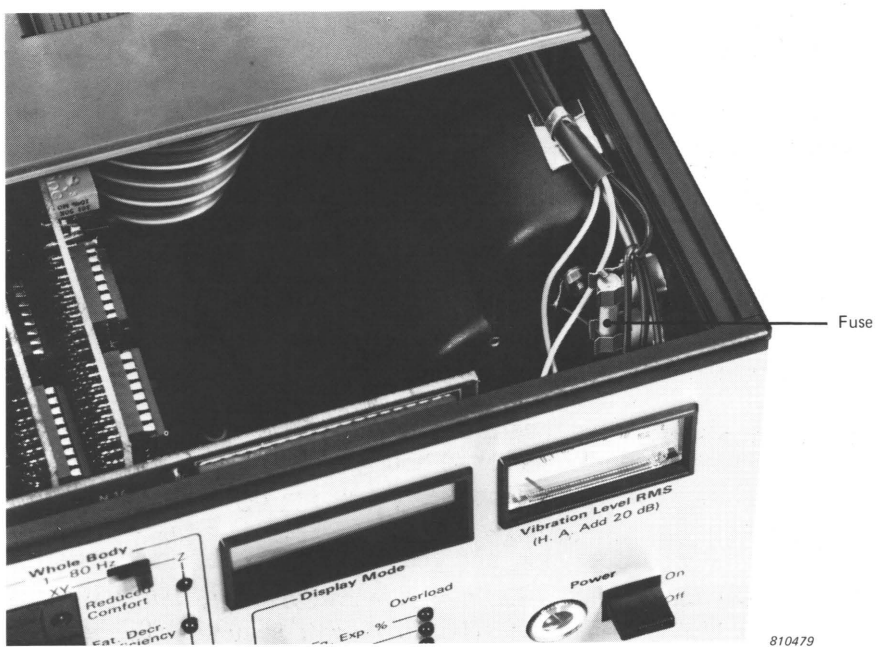


Fig. 3.8. Position of the fuse. Access is via the top panel

To replace the fuse it is necessary to gain access by sliding back the top panel (see Fig.3.8.), after removing the two screws which hold it to the rear panel. The fuse can then be seen at the front of the instrument, can be removed from its clip, and a new one inserted. The fuse rating is 800 mA.

3.3. CALIBRATION

The Type 2512 is intended primarily to be used with one of the Brüel & Kjær range of Uni-Gain Accelerometers which have a unified sensitivity of 1 pC/ms^{-2} ($\pm$ 2%). The special Seat-Accelerometer Type 4322 for whole-body measurements on seated persons is a triaxial accelerometer, all of whose individual sensitivities are unity within the stated tolerances. With any of these accelerometers, the Type 2512 forms a compatible precalibrated measurement system which is easy to set up and operate both in the field and in the laboratory. The need for laborious calibration procedures is thus virtually eliminated, and the setting up procedure is effectively reduced to an instrument check, using the internal reference signal. There is no sensitivity adjustment on the instrument, nor should one be required during normal use. If a calibration check such as either of those in the following sections shows that the instrument is not operating correctly, e.g. the counting rates are not within the limits stated, then the instrument should be serviced.

The most straightforward method of checking is to use the instrument's internal reference signal. For or a more thorough calibration, including a check of the accelerometer and its connections to the Type 2512, the Accelerometer Calibrator Type 4291 can be used, and, being powered from internal batteries, is equally suitable for field or laboratory use. This instrument supplies an accurate vibration level of 10 ms^{-2} (1 g on early models) at 79,6 Hz (500 radians-.sec^{-1}) directly to the accelerometer. Both methods are described in the following sections.

The two checking procedures are described in the following sections.

3.3.1. Calibration using the Internal Reference Signal

The internal reference signal is obtained by placing the INPUT CHANNEL SELECTOR in the "Ref." position. A 16 Hz reference signal is then applied to the whole of the measurement and analysis chain after the normal input stage. The actual level of the reference signal is controlled by the type of measurement selected, so that the attenuation of the frequency weighting curve at 16 Hz for that measurement is compensated for by a corresponding increase in the reference signal input level. The resulting level after passing through the weighting filter, Log RMS detector, and L_{eq} calculator is therefore always constant for a given measurement mode. This level is 1 ms^{-2} or 120 dB (re 10^{-6} ms^{-2}) for whole-body vibration measurements and 10 ms^{-2} or 140 dB (re 10^{-6} ms^{-2}) for hand-arm vibration measurements.

It should be noted that the internal reference signal, at 16 Hz, lies outside the frequency range of the Motion Sickness measurement region and can not therefore be used for checking or calibrating this mode of operation of the instrument.

The procedure is as follows:

1. Select "Ref" on the INPUT CHANNEL SELECTOR. The needle of the analogue meter should now come to the middle of the scale indicating 1 ms^{-2} (or 120 $\pm$ 0,5 dB).

2. "Preset" the instrument by pressing both of the MEASUREMENT pushkeys simultaneously. The LEDs in both keys will come on to indicate that the registers have been cleared and that the instrument has been initialized and ready to begin a new measurement. Only in this state can the measurement mode be selected.

3. Select the required measurement mode by pressing one of the HAND–ARM or WHOLE BODY pushkeys. If a WHOLE BODY mode is required, then it will first be necessary to put the AXIS SELECTOR switch in the required position, i.e. "XY" or "Z".

4. Press START to begin the measurement. The LED in the STOP pushkey will now go out but that in the START pushkey will remain on, indicating that the measurement is in progress. If WHOLE BODY "Reduced Comfort" is selected, the "Eq. Exp. %" overload LED will also come on because the reference level is greater than would cause a maximum permissible dose in less than one minute. In other measurement modes this LED will remain off.

5. The DISPLAY MODE switch can now be set to "L_{eq} dB" to display the L_{eq} value of the reference signal, which will appear after a delay of 16 s. This value is 120 dB for the Whole Body mode and 140 dB for the Hand-Arm mode. The corresponding values in the "Peak dB" position are 123 and 143 dB, as the reference signal is a sine wave. If the displayed values vary from these by more than 1,0 dB the instrument should be serviced.

In the "Eq. Exp. %" position, the display will show the accumulated exposure in % of the allowed dose. Because this dose is different for all the different exposure criteria, i.e. Whole Body Reduced Comfort, Fatigue Decreased Proficiency and Exposure Limit, and Hand-Arm, it accumulates at a different rate for the constant input level of the reference signal. The rates of accumulation of exposure dose produced by the internal reference signal are given in Table 1 for each of the measurement modes which can be checked in this way. It can be seen that only the Whole Body Reduced Comfort and Fatigue Decreased Proficiency Limits can be checked in a practical length of time in this way.

Measurement Mode	Accumulation Rate s / %	
WB Reduced Comfort XY	72	± 10,8
WB Reduced Comfort Z	10	± 2,4
WB Fat.Decr. Prof. XY	400	± 60
WB Fat.Decr. Prof. Z	100	± 15
WB Exposure Limit XY	>15 mins	–
WB Exposure Limit Z	250	± 37,5
Hand-Arm x1	144	± 7,2
Hand-Arm x2	288	± 14,4
Hand-Arm x3	288	± 14,4
Hand-Arm x4	288	± 14,4
Hand-Arm x5	288	± 14,4

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Table 1. Equivalent Exposure Accumulation rates for the internal reference signal for the various measurement modes available on the 2512

3.3.2. Calibration using the Accelerometer Calibrator Type 4291

The use of an external calibration source allows the transducer and the cable connections to be brought into the calibration procedure, and thus checks these points as well. However, since the Type 2512 is designed and calibrated at the factory to be used with the B & K range of Uni-Gain Accelerometers with unified sensitivities, there is no sensitivity adjustment on the instrument, nor should one be required during normal use. If calibration checks using both the Type 4291 and the internal reference signal show the instrument to be operating incorrectly, then it should be serviced. If only the Type 4291 shows a fault, then the problem lies with the accelerometer or its cable connections.

Although it is not recommended, the Seat-Transducer Type 4322 can be dismantled so that the transducer element can be removed and mounted on the vibration table of the Accelerometer Calibrator if required.

The Accelerometer Calibrator Type 4291, shown in Fig.3.9., provides a test vibration of 10 ms^{-2} peak (1 g for early models) at a frequency of 79,5 Hz. This lies within the frequency range of the Hand-Arm and Whole Body measurement ranges, but outside the Motion Sickness range, and cannot therefore be used to check this function.



Fig. 3.9. The Type 4291 Accelerometer Calibrator

The procedure is as follows:

1. Determine the mass of the accelerometer from the calibration chart supplied with it.

2. Mount the acclerometer finger tight to the vibration table of the Calibrator via a 10-32 UNF stud. The 3 mm to 10-32 UNF adaptor (DB 1425) should be used with accelerometers with a 3 mm stud. Accelerometers without either a stud or a tapped hole for a stud should be fitted to the cementing stud (DB 0756) with wax or cement.

3. If using the internal battery supply of the 4291, switch the FUNCTION SELECTOR to "Batt. Check". If the meter deflection is below the "BATT." region on the scale, the batteries should be replaced.

4. Switch the FUNCTION SELECTOR to "Internal Gen." The Calibrator will now vibrate the accelerometer at 79,6 Hz (500 radians.sec^{-1}).

5. Adjust the ACC. LEVEL control of the 4291 until the meter pointer coincides with the load mass on the "grams 0 ... 100" scale. The load mass is the total mass attached to the vibration table, usually the accelerometer to be calibrated and the stud (usually negligible). The accelerometer is now subjected to an acceleration of 10,0 ms^{-2} peak $\pm 2\%$.

6. "Preset" the Type 2512 by pressing both of the MEASUREMENT pushkeys simultaneously. The LEDs in both keys will come on to indicate that the registers have been cleared and that the instrument has been initialized and ready to begin a new measurement. Only in this state can the measurement mode be selected.

7. Select the required measurement mode by pressing one of the HAND- ARM or WHOLE BODY pushkeys. If a WHOLE BODY mode is selected, then it will first be necessary to put the AXIS SELECTOR switch in the required position, i.e. "XY" or "Z".

8. Press START to begin the measurement. The LED in the STOP pushkey will now extinguish and that in the START pushkey will remain on, indicating that the measurement is in progress.

Measurement Mode	Accumulation Rate s / %
WB Reduced Comfort	0,6 –
WB Fat. Decr. Prof.	50,0 ± 7,5
WB Exposure Limit	160,0 ± 24
Hand-Arm x1	144,0 ± 7,2
Hand-Arm x2	288,0 ± 14,4
Hand-Arm x3	288,0 ± 14,4
Hand-Arm x4	288,0 ± 14,4
Hand-Arm x5	288,0 ± 14,4

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Table 2. Equivalent Exposure accumulation rates for an input vibration level of 10 ms^{-2} as provided by the Accelerometer Calibrator Type 4291 for the various measurement modes available on the 2512

9. The DISPLAY MODE switch can now be set to "L_{eq} dB" to display the L_{eq} value of the calibration signal, which will appear after a delay of 16 s. These values are 108 dB for the Whole Body " XY" mode, 117 dB for the Whole Body" Z" mode, and 143 dB for the Hand-Arm mode. If the displayed values vary from these by more than 1,0 dB the instrument should be serviced. In the "Eq. Exp. %" position, the display will show the accumulated exposure in % of the allowed dose. Because this dose is different for all the different exposure criteria, i.e. Whole body Reduced Comfort, Fatigue Decreased Proficiency and Exposure Limit, and Hand-Arm, it accumulates at a different rate for the constant input level of the calibration signal. The rates of accumulation of exposure dose produced by the calibration signal of 10 ms^{-2} peak produced by the Calibrator are given in Table 2 for each of the measurement modes which can be checked in this way. It can be seen that, from the point of view of the time taken, it is only practical to check the Whole Body Reduced Comfort mode in this way.

3.4. STAND ALONE OPERATION OF THE INSTRUMENT

The preliminary instructions concerning powering the instrument and calibration check in sections 3.1. to 3.3. should be carried out first and the accelerometer (or accelerometers) connected to the instrument either via the microsockets on the front panel or, if the Seat-Transducer Type 4322 is to be used, via the 6-pin DIN socket on the rear panel. Whichever input is used, the other inputs should be covered with their respective caps to minimise the pick-up of noise which may interfere with measurements. The cap for the DIN socket on the rear panel of the instrument is permanently attatched to the rear panel via a plastic wire to retain it when unscrewed. The three caps for the microsockets, however, are loose and should be kept carefully when these outputs are in use. When the sockets are not in use, the caps should always be in place on them.

The procedure for using the Type 2512 in the stand alone mode is as follows:

1. Switch the instrument on and check the batteries as in section 3.2.1. If the battery condition meter reading is not within the blue region, the batteries should be replaced.

2. Set the FILTER SELECTOR switch on the instrument's rear panel as required. When the Type 2512 is used alone this will normally be in the bottom position labelled Weighting Filter "In" and Ext. Filter "Out", in which position the internal weighting filters are in use.

3. Set the INPUT CHANNEL SELECTOR to the position required, corresponding to the input socket from which the signal to be analyzed is to be taken. The use of the "Ref" position is described in detail in Section 3.3.

4. Preset the instrument by pressing both the MEASUREMENT pushkeys "Start" and "Stop" simultaneously. The LEDs in both pushkeys come on to indicate that the instrument has been successfully preset. This is the only state in which the measurement mode of the instrument, i.e. the filter characteristic or limit criterion, can be altered. Presetting empties all the registers and initiates the instrument ready for a new measurement.

5. Select the required filter characteristic and limit criterion via the MEASUREMENT MODE pushkeys. If the WHOLE BODY 1 — 80 Hz mode is selected, then it will also be necessary to select the required axis via the AXIS SELECTOR. An LED in the relevant pushkey will come on to indicate the selected mode of operation. The needle of the analogue meter should now be allowed to settle down before progressing to the next step. This is necessary because the time constants are relatively long at the frequencies of interest, especially in the MOTION SICKNESS mode.

6. If the analysis is to be output on the IEC bus to an Alphanumeric Printer Type 2312, or to another instrument using the digital interface, the INTERFACE pushkey should be pressed to activate the digital output. The LED in the pushkey will light to indicate that the digital output is active.

7. Press the MEASUREMENT "Start" pushkey in order to start the measurement. The LED in the "Stop" pushkey will now go out but that in the "Start" pushkey will remain on to indicate that the instrument is in the process of making a measurement. The measurement may be halted temporarily at any time by pressing MEASUREMENT "Stop", and may then be resumed by pressing MEASUREMENT "Start" again. A new measurement may be begun by presetting and then pressing MEASUREMENT "Start".

8. Set the DISPLAY MODE as required to display the elapsed time in minutes, the peak value in dB, the equivalent continuous vibrataion level in dB or the equivalent exposure of the measurement in % of the allowed exposure for the selected limit criterion. All these parameters are held simultaneously within the instrument; the DISPLAY MODE selector merely allows the user to display the one required.

Special Considerations Relating to Hand–Arm Measurements

The HAND–ARM panel of the 2512 contains five pushkeys, each of which represents a different proportion of rest period to vibration exposure during a working hour. Any of these pushkeys can be selected to measure the equivalent vibration and peak level, although use of the "x1" pushkey is recommended if either equivalent exposure is not required or the length and frequency of rest periods is not known. The table below can be entered at the measurement value obtained to find the allowable duration of the working day, for either uninterrupted work or for work regularly interrupted with rest periods of the stated duration.

Hand-Arm Vibration Exposure (ms^{-2}rms, dB re 10^{-6} ms^{-2}) (Reference Frequency 160 Hz)						
Exposure time during daily shift (8h)	Uninterrupted or not regularly interrupted	Regularly Interrupted				
		Duration of regular time interval WITHOUT vibration (minutes per working hour)				
		Up to 10	> 10 to 20	> 20 to 30	> 30 to 40	> 40
Up to 30 min.	40, 152	40, 152	–	–	–	–
> 30 min. to 1h	32, 150	32, 150	–	–	–	–
> 1h to 2h	24, 147,5	24, 147,5	24, 147,5	32, 150	40, 152	40, 152
> 2h to 4h	16, 144	16, 144	16, 144	24, 147,5	32, 150	40, 152
> 4h to 8h	8, 138 (x1)	8, 138 (x1)	8, 138 (x1)	16, 144 (x2)	24, 147,5 (x3)	32, 150 (x4)

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In the Draft International Standard ISO/DIS 5349, 1979, "Principles for the measurement and the evaluation of human exposure to vibration transmitted to the hand", on which the HAND–ARM section of the 2512 is based, equivalent exposure is not specifically defined, as it is for WHOLE BODY measurements. However, using the amplitude–time weighting function for uninterrupted Hand–Arm vibration of Fig.7, chapter 1, the 2512 calculates an equivalent exposure which depends on the proportion of rest periods to vibration exposure per working hour, as defined by the pushkey selected on the HAND–ARM panel. When this proportion is known before making the measurement, and the appropriate pushkey selected, the increase in allowable exposure time resulting from the inclusion of rest periods is automatically taken into account by the instrument when calculating the equivalent exposure. The appropriate pushkey (x1, x2, x3, x4, but not x5, which was included in previous drafts but is now not used) can be found from the table above.

Special Considerations Relating to Motion Sickness Measurements

The Equivalent Exposure in this mode of measurement is calculated using a linear relationship between the square of the frequency–weighted vibration level (proportional to the energy content of the signal) and time according to the equivalent energy principle, i.e. a factor of $\sqrt{2}$ times the level (an increase of 3 dB) corresponds to a halving of the duration of vibration exposure allowed. For further details, see the relevant curves in Fig.7, chapter 1. This fact allows the long term Equivalent Vibration Level (in engineering units or in dB re 10^{-6} ms^{-2}) to be simply calculated from the equivalent exposure and the elapsed time readings using the following equations:

For engineering units:

$$\text{Equivalent Vibration Level (RMS)} = \sqrt{\frac{\text{Equivalent Exposure (\%)} \times 0{,}3}{\text{Elapsed Time (min)}}} \quad ms^{-2}$$

For dB re 10^{-6} ms^{-2}:

$$\text{Equivalent Vibration Level } (L_{eq}) = 20 \log_{10} \frac{RMS}{10^{-6}} \quad dB$$

4. USE WITH OTHER INSTRUMENTS

4.1. USE WITH THE ALPHANUMERIC PRINTER TYPE 2312

The Alphanumeric Printer is powered by internal batteries and can be fitted into carrying case KA 2000 with the Type 2512 to form a convenient portable system for field measurements of vibration as it affects human beings. A photograph of this system is reproduced in Fig.3.1., Section 3.1.

To obtain a printout of the output from the 2512 on the Alphanumeric Printer Type 2312, carry out the following procedure:

1. Connect the two instruments together via the digital interface sockets on the rear of the instruments using the interface cable AO 0194 (AO 0184 if the Alphanumeric Printer is an earlier type).

2. Set the INTERFACE MODE SWITCH on the rear panel of the printer to the "IEC - Listen Always" position.

3. Set the leftmost of the two PRINT switches on the front panel of the printer in the "Time & Data" position (up), or in the data only position (mid), as required, and the rightmost switch in the "Auto" (up) position.

4. Turn the CLOCK CONTROL SELECTOR on the front panel of the printer to either:

"Ext."	In which case the print interval will be controlled by the 2512 and a new set of values will be printed out every six seconds if subswitch number 7 of the ADDRESS SWITCH on the rear panel of the 2512 is set to "Printer", or every 2 seconds if the switch is set to "Calculator".

or:

One of the "Print Intervals" "1 h", "30 min", "15 min", "5 min", "1 min", "20 s", or "10 s"	In which case the print interval will be controlled by the internal clock of the printer at the preset value.

5. Set the first three subswitches (numbered 8, 7, and 6) of the ADDRESS SWITCH on the rear panel of the Type 2512 as follows:

Subswitch 8	should be set to "0: Accumulate" to continue the measurement after each data readout and thus accumulate data, or to "1: Reset" if the 2512 is to be reset at each readout and a new measurement period is to be begun.

Subswitch 7 — should be set to "1: Printer" to output the data in a format containing explanatory text suitable for the printer, or to "0: Calculator" if the data alone is to be sent to another instrument with an IEC bus where the text is not required. In this case the explanatory text is omitted.

Subswitch 6 — should be set to "1" so that the instrument operates in "talk only" mode. For connection into a system with an external controller, in which case each of the devices would normally have its own unique address, see section 5.3.

6. Set up the Type 2512 to carry out the type of measurement required, as described in section 3.4.

7. Ensure that the INTERFACE pushkey on the Type 2512 is on, as indicated by a lit LED.

8. Begin the measurement by pressing START on the Type 2512. The data will be output automatically at intervals as defined in step 4 above in the form shown in the example of Fig.4.1.

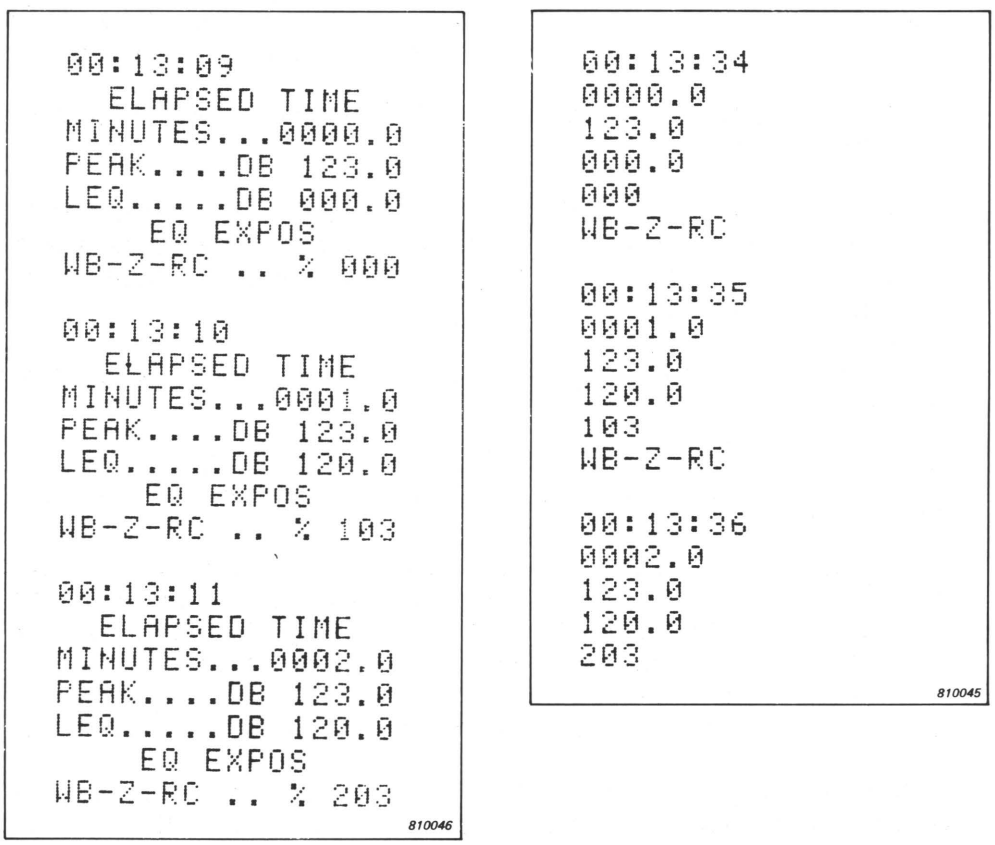


Fig. 4.1. Examples of output from the 2512 to the Alphnumeric Printer Type 2312, using the Internal Reference source of the 2512
Left) With explanatory text as usually output to the 2312, with ADDRESS SWITCH 7 in the "Printer" mode
Right) Data values alone as usually output to a desk-top calculator or a Digital Cassette Recorder Type 7400, with ADDRESS SWITCH 7 in the "Calculator" mode

Note:

The above step 8 in the procedure does not synchronize the time of start of the measurement as initiated from the 2512 with the time of the first printout as defined by the printer's internal clock, although the time interval between subsequent printouts will be as set on the printer's CLOCK CONTROL SELECTOR. The first printout will occur when the printer's internal clock first reaches a value which is a whole number of these preset intervals. For example, if the CLOCK CONTROL SELECTOR is set to "1 min" on the 2312, the first printout will occur when the clock reaches a whole minute, regardless of how long has elapsed since the measurement was started from the 2512, and printouts will occur at minute intervals thereafter. If, however, the CLOCK CONTROL SELECTOR is set to "10 s", the first printout will occur when the clock reaches a time which is a round number of 10 s, i.e. 00, 10, 20, 30, 40, 50 s, and printouts will occur at 10 s intervals thereafter.

It is possible to synchronize the measurement start time and the printout time by continually checking the printer's internal time by pressing the left of the two PRINT switches down to the "Time" position, and starting the measurement by pressing "Start" on the 2512 immediately the minute value changes. The PRINT switch on the 2312 should be returned to the "Time & Data" position simultaneously. The printer will now print out the data for the start time and subsequent printouts will occur at the interval selected on the CLOCK CONTROL SELECTOR of the 2312.

If the actual time of day is not of importance, the internal clock of the printer can be reset to 00:00:00 and the measurement started from the 2512 at the same time as follows:

1. Turn the CLOCK CONTROL SELECTOR on the front panel of the printer to any of the four "Preset Clock" positions.

2. Start the measurement from the 2512 by pressing the MEASUREMENT "Start" pushkey and reset the time on the printer by raising the CLOCK paddle switch to the "Reset" position and turning the printer's CLOCK CONTROL SELECTOR to the required "Print Interval" immediately afterwards.

The data list will now be printed at the start time and at the selected "Print Interval" subsequently.

4.2. USE WITH THE PORTABLE LEVEL RECORDER TYPE 2306

The Portable Level Recorder Type 2306 shown in Fig.4.2. (or the two channel Type 2309) may be used to obtain an accurate hard copy of vibration levels recorded by the 2512 in the field. A vibration level can be recorded from the 2512 onto the Portable Level Recorder Type 2306 from either the DC OUTPUT (which takes the DC signal just after it has passed through the Log RMS detector of the Type 2512) or the OUTPUT TO EXT. FILTER (which takes the AC signal just before it passes through the Log RMS detector) on the rear panel of the Type 2512.

With DC recording, the 2512 is used to rectify and average the signal before it is fed to the recorder. The time constant is therefore accurately determined by the Type 2512. In the "Preset" mode, the time constant is very much shorter (0,125 s in the HAND - ARM and WHOLE BODY 1 - 80 Hz modes, and 0,6 s in the WHOLE BODY 0,1 - 0,63 Hz MOTION SICKNESS mode) to give a very short settling time when changing measurement mode. DC recordings may be made with this mode active, in which case the time constant of the signal recorded is as stated above, although of course measurements cannot be carried out on the 2512 at the same time. It is recommended that level recordings are made using the "DC Lin." RECORDING MODE of the level recorder and the DC OUTPUT signal of the 2512 in preference to the AC signal, whenever possible.



Fig. 4.2. The Portable Level Recorder Type 2306

With AC recording, on the other hand, the AC output signal of the 2512 is rectified and averaged by the rectifier and writing system of the recorder. This extracts the RMS level of the measured vibration signal level, and plots it with a logarithmic amplitude (linear dB). However, the lowest lower limiting frequency available on the level recorder lies within the frequency range of WHOLE BODY measurement and therefore can affect measurements. In addition, the time constant is no longer determined by the Type 2512 but by the level recorder writing system, and will not in general fulfil the relevant recommendations. It is therefore recommended that level recordings are made from the DC OUTPUT of the 2512 whenever possible, using the "DC Lin." RECORDING MODE of the level recorder.

A reference signal for setting up and calibrating the level recorder can be obtained from the Type 2512, i.e. its internal reference signal, or directly from the Accelerometer Calibrator Type 4291. In practice, however it will generally be found more convenient to use the internal reference signal of the 2512. This is because internal compensation is made for the effect of the frequency weighting filters on the 16 Hz reference signal so that the reference signal delivered to both the meters and to the DC OUTPUT socket always corresponds to 1 ms^{-2} (120 dB) in the WHOLE BODY mode and to 10 ms^{-2} (140 dB) in the HAND-ARM mode, i.e. 20 dB above the lower measurement limit.

The signal from an accelerometer vibrated by the Accelerometer Calibrator will be weighted differently by each of the weighting filters in the 2512 giving a different calibration value for each mode. Furthermore, the frequency at which the Accelerometer Calibrator operates lies at one end of the WHOLE BODY frequency range.

It is therefore recommended that the internal reference signal of the 2512 is used for level recorder calibration purposes whereever possible.

The setting up and calibration procedure for recording from the 2512 is similar for both the Type 2306 and the Type 2309, so in the following procedures specific reference is made only to the Type 2306.

4.2.1. DC Linear Recording

DC Linear recording is easy to calibrate and perform, and, because of the low frequencies encountered in human vibration measurements and the reasons given in the above section, is recommended for use with the 2512 whenever possible. The dynamic range of the 2512 is 46 dB, which fits conveniently with the 50 dB potentiometer available for the 2306. The procedure is as follows:

1. Fit the Level Recorder with the 50 dB potentiometer and a roll of suitable recording paper (QP 0102 is recommended for general purposes), and switch the level recorder on by pressing in the POWER push-button.

2. Set the RECORDING MODE switch on the level recorder to the "DC Lin" position and turn the SENSITIVITY switch to "0".

3. Make sure that there is no connection to the SIGNAL INPUT socket of the level recorder, switch the PEN DRIVE on by pressing the push-button in, and adjust the DC LIN. POSITION control to line the pen up with one of the thick lines, e.g. the thick line at the bottom of the recording paper. Then set the POLARITY switch on the side of the level recorder to "+".

4. Connect the DC OUTPUT socket on the 2512 to the SIGNAL INPUT socket on the level recorder using the BNC to BNC cable AO 0087.

5. Using the internal reference source of the 2512, i.e. with the CHANNEL SELECTOR of the 2512 in the "Ref" position and any of the HAND-ARM or WHOLE BODY 1 - 80 Hz pushkeys activated, adjust the SENSITIVITY control on the Level Recorder so that the pen lies 20 d B above the line chosen in step 3, i.e. on the third thick line from the bottom of the paper as shown in the example of Fig. 4.3.

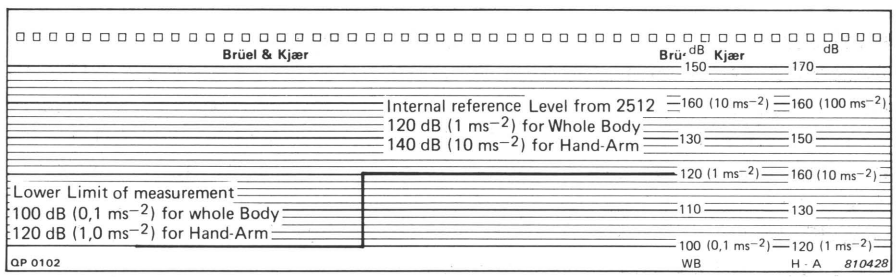


Fig. 4.3. Calibrating the Level Recorder

As the internal reference voltage of the 2512 corresponds to a vibration level of 1 ms^{-2} (120 dB re 10^{-6} ms^{-2}) in the WHOLE BODY mode or 10 ms^{-2} (140 dB re 10^{-6} ms^{-2}) in the HAND-ARM mode, these lines should be labelled accordingly. The bottom line corresponds to 0,1 ms^{-2} and the top line corresponds to 30 ms^{-2} (100 to 150 dB) in the WHOLE BODY mode and to 1 ms^{-2} to 300 ms^{-2} (120 to 170 dB) in the HAND-ARM mode.

The pen deflection will now correspond to the RMS value of the vibration level measured continuously by the Type 2512, with the averaging time corresponding to the mode selected. It is this value which is displayed on the analogue meter. The digital meter displays only the equivalent continuous or peak levels.

6. Select a suitable PAPER SPEED setting and set the WRITING SPEED/LF LIMIT control to "250 mm/s / 25 Hz".

7. Set up the 2512 to perform the required measurement as described in section 3.4.

8. Switch on the level recorder by pressing in the PAPER DRIVE push-button to start recording, and press again to release it and thus stop the recording.

For further details on the use and operation of the level recorders, their Instruction Manuals should be consulted.

Note: It is also possible to record the time history of the signal from the OUTPUT TO EXT. FILTER socket in the MOTION SICKNESS mode using the above technique, because the Level Recorder Type 2306 will faithfully record frequencies up to 1,6 Hz in the "DC Lin" position, covering the entire frequency range of MOTION SICKNESS measurements.

4.3. USE WITH THE STATISTICAL NOISE LEVEL ANALYZER TYPE 4426

The Noise Level Analyzer Type 4426 is a statistical analyzer suitable for use with the Type 2512, which can easily connected and calibrated. A special transparent scale (SC 2363), which can be laid over the level recorder output from the 4426 enables the statistical distribution to be found and the L_N values (the vibration level exceeded for N % of the measurement time) to be read directly from the cumulative distribution curve. The procedure for using the 2512 with the Noise Level Analyzer Type 4426 and the Portable Level Recorder Type 2306, see Fig.4.4., is described below:

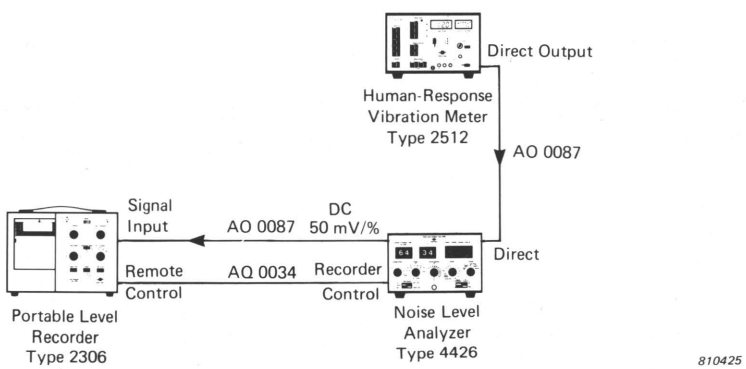


Fig. 4.4. Statistical analysis of vibration using the Noise Level Analyzer Type 4426 and Portable Level Recorder Type 2306 with the 2512

1. Connect the DC OUTPUT socket on the rear panel of the Type 2512 to the DIRECT input socket on the rear panel of the Type 4426 using a BNC to BNC cable AO 0087, and ensure that the INPUT SELECTOR control on the 4426 is switched to the "DC 0 - 6,4 V" position.

2. On the 2512:

   a. Set the FILTER SELECTOR on the rear panel to the "Weighting Filter In, Ext. Filter Out" position.

   b. Set the INPUT SELECTOR on the instrument's front panel to the "Ref." position.

   c. Ensure that any of the WHOLE BODY 1 - 80 Hz or HAND - ARM modes are selected, giving a 120 dB nominal output, (140 dB for HAND - ARM), which is indicated on the analogue display.

3. On the 4426:

   a. Turn the DISPLAY control on the front panel to "Sound Level".

   b. Turn the FUNCTION SELECTOR through "Reset" to the "Standby" position.

   c. Select the sample period to be less than the time constant of the measurement mode being used. This setting will determine the minimum measurement duration because the minimum number of samples which can be set is 1000.

   d. Using a small screwdriver, adjust the DIRECT SENS. screw beside the DIRECT input socket on the rear panel so that the display shows a value which is 20 dB above the bottom of the range selected on the RANGE control. For example, if the RANGE control is in the "66 - 130 dB" position, the 4426 display will read 86,0 dB, i.e. 34 dB below the actual reference level, if the RANGE is "46 - 110 dB", it will display 66,0 dB, i.e. 54 dB below the actual reference level, etc.. These corrections will have to be added to the values displayed on the 4426 if the analysis is recorded manually from the display, or to the printed values if the analysis is output to the Alphnumeric Printer Type 2312

This procedure sets the bottom of the range on the 2512 (i.e. 100 dB nominal in WHOLE BODY mode or 120 dB nominal in HAND - ARM mode) to correspond with the bottom of the range selected on the 4426. This in turn allows the whole of the dynamic range of the 2512 to be conveniently covered by the 4426 and the results to be easily interpreted from a level recorder plot.

4. Set up the Type 2512 to carry out the desired measurement as described in section 3.4.

For full details of operation of the Noise Level Analyzer Type 4426 and recording of statistical distributions and cumulative histograms using the Portable Level Recorder Type 2306, reference should be made to the instruction manuals for these instruments.

Using the scale SC 2363

The Scale SC 2363 is similar in use to that delivered with the Type 4426 for finding the L_N values when measuring noise, SC 2362. It is transparent and designed to be placed over the cumulative histogram or statistical distribution as a simple means of calibration as shown in Figures 4.5 to 4.8.

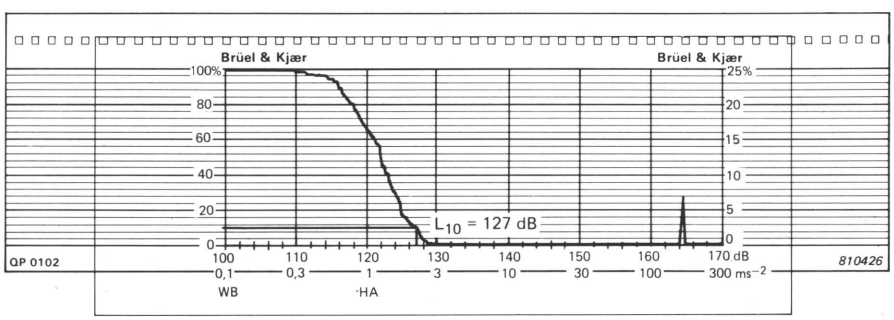


Fig. 4.5. Lining up the Scale SC 2363 *over a cumulative plot of Whole Body vibration measurements*

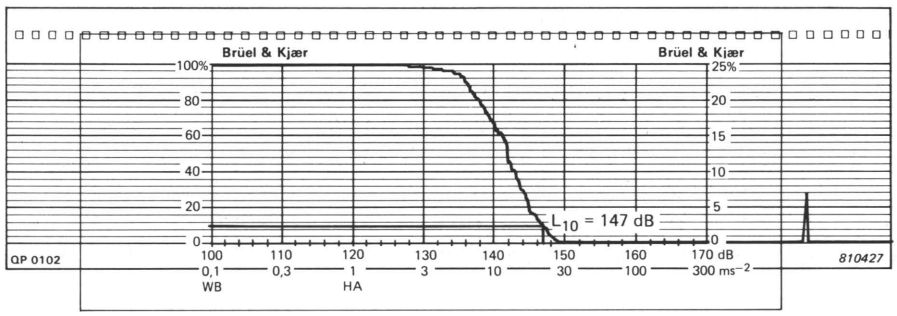


Fig. 4.6. Lining up the Scale SC 2363 over a cumulative plot of Hand-Arm vibration measurements

The Scale should be laid over the curve so that the calibration line, recorded when calibrating the level recorder paper, corresponds to the vertical line labelled WB (for measurements in the WHOLE BODY mode, Figs 4.5 and 4.6), or HA (for measurements in the HAND - ARM mode, Figs 4.7 and 4.8). If the calibration procedure has been carried out as described above, then this line will correspond to the bottom of the measurement range of the 2512, and each tick on the horizontal axis of the scale at 4 mm intervals corresponds to 2 dB.

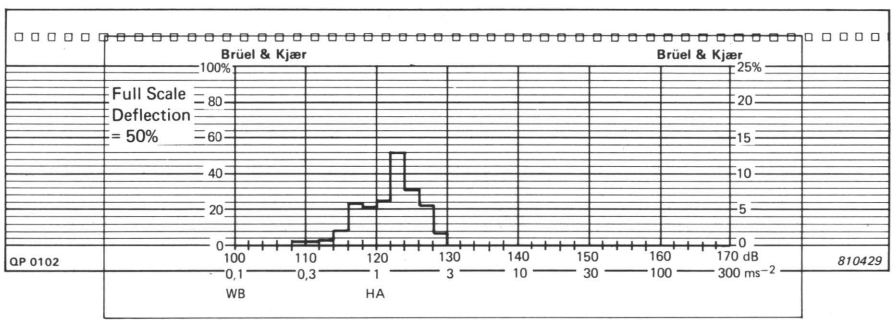


Fig. 4.7. Lining up the Scale SC 2363 over a statistical distribution plot of Whole Body vibration measurements

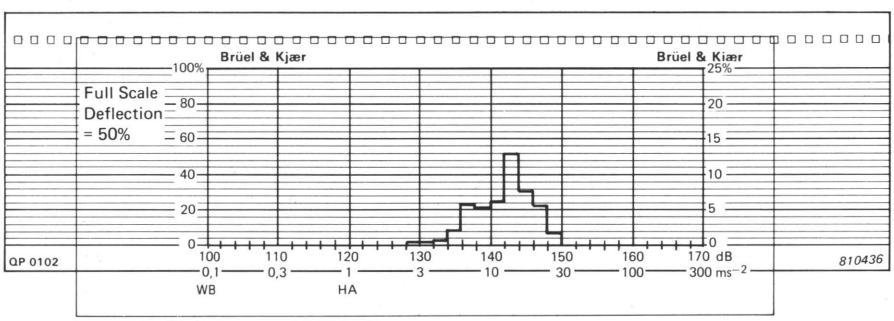


Fig. 4.8. Lining up the Scale SC 2363 over a statistical distribution plot of Hand-Arm vibration measurements

For cumulative distributions, the vertical axis of the paper is calibrated from 0 to 100 % using the left hand scale, and the L_N value can be found by entering the vertical axis at the required L_N, e.g. L_{10} in the examples in Figs.4.5 and 4.6., and reading off the dB value on the horizontal axis.

For statistical distributions, the full scale level is defined during the calibration of the level recorder prior to readout. The method of calibration is described in detail in the 4426 Instruction Manual. In the case of the examples in Figs.4.7 and 4.8, full scale represents 50 %.

4.4. USE WITH THE TAPE RECORDER TYPE 7005/6

The Tape Recorder Type 7005 is a multichannel instrumentation tape recorder, powered from internal batteries making it completely portable. The three FM channels, and low sensitivity to external vibration, make it highly suitable for recording simultaneous 3 axis human vibration measurements in the field, prior to analysis on the Type 2512. A typical system for recording a three-axis signal from the Seat Transducer Type 4322 or Triaxial Accelerometer 4321 is shown in Fig.4.9. and a typical analysis system using the 2512 is shown in Fig.4.10.

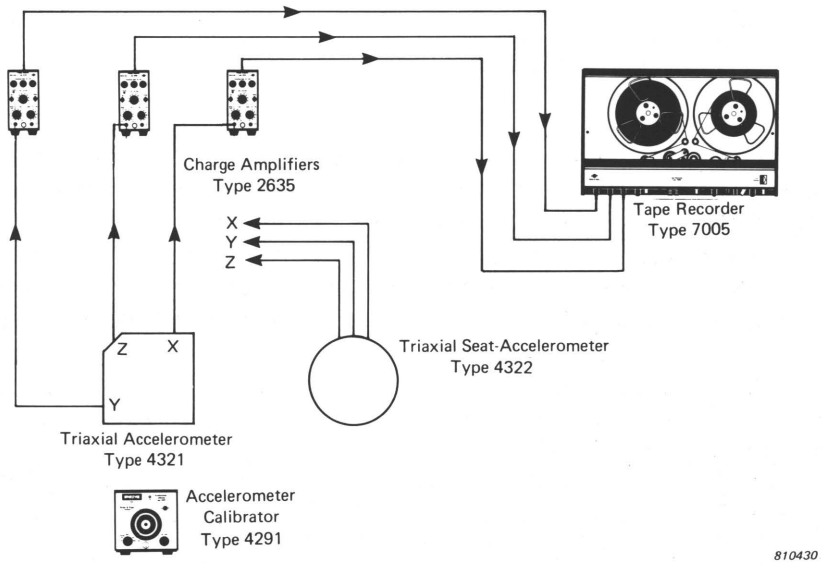


Fig. 4.9. Recording 3-axis vibration using the Tape Recorder Type 7005 for subsequent analysis on the 2512

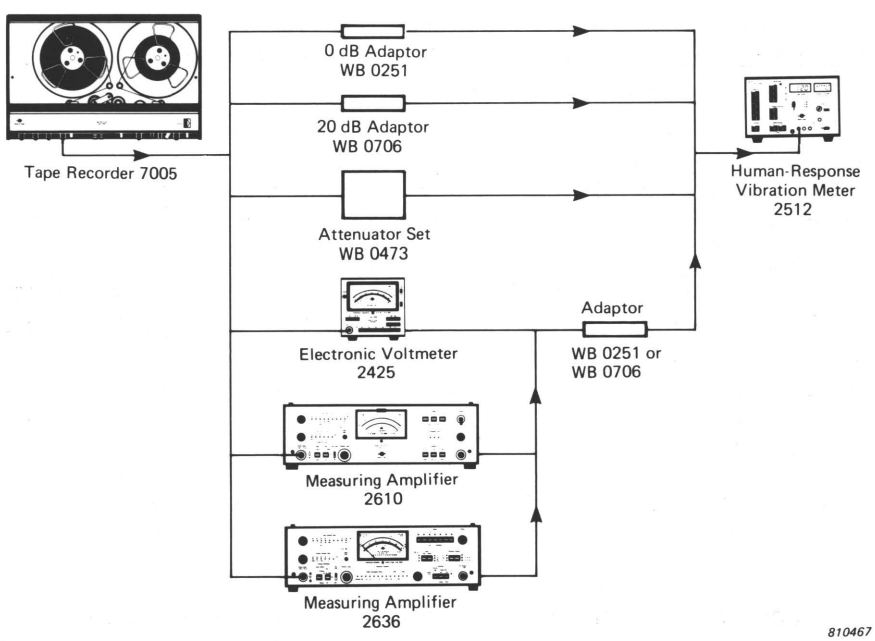


Fig. 4.10. Replay of vibration signals from a Tape Recorder Type 7005 for analysis by the 2512

The input of the 2512 is a charge input designed to accept a unigain accelerometer with a sensitivity of unity. A voltage output such as that from the Tape Recorder Type 7005/6 must

therefore be converted to a charge input to the 2512. This is most conveniently accomplished using one of the adaptors available for this purpose, e.g. WB 0251, for direct conversion, or WB 0706 with 20 dB attenuation, or the Attenuator Set WB 0473, which provides attenuations from 40 dB to -10 dB in 10 dB steps. These adapters may also be used together with the Measuring Amplifier Type 2610 or Electronic Voltmeter Type 2425 to allow tape-recorded signals to be matched in level to the fixed range of the 2512. The various possibilities are shown in Fig.10.

4.4.1. Recording Data for Later Analysis by the 2512

The system of Fig.4.9. is recommended. The Triaxial Accelerometer Type 4321 is suitable for measurements on both hand tools and vibrating objects which support the standing or sitting person. The Seat Transducer Type 4322 is specially designed for measuring the vibration applied directly via the buttocks to a sitting person, and is strongly recommended for this purpose. The instruments in the measurement arrangement should be connected as shown in Fig.4.9. The recommended recording procedure is as follows:

1. For each axis of the accelerometer, set up its Charge Amplifier Type 2635 as described in its Instruction Manual. In particular, ensure that the correct transducer sensitivity (given for each axis individually on the 4321 calibration chart) is dialled in for each axis of the accelerometer (or Seat–Accelerometer Type 4322, if used), and that the instrument is set up to output in ms^{-2} with a lower limiting frequency of 0,2 Hz. This covers the entire HAND - ARM region and the WHOLE BODY region down to within 0,1 Hz of the its lower limiting frequency. It is recommended that the Upper frequency limit is set at 0.1 kHz for WHOLE BODY measurements and 1 kHz for HAND - ARM measurements.

2. On the Tape Recorder Type 7005, set the following major controls:

ERASE	"Off"
TAPE SPEED	"38.1 mm/s"
FLUTTER COMPENSATION	"Off"

3. For each channel to be used on the Tape Recorder Type 7005, set the following controls on the respective channel module:

MODE SWITCH	"DC"
INPUT ATTENUATOR	"30 dB"

The "DC" position allows recording of signals right down to DC and in combination with a tape speed of 38.1 mm/s gives a frequency range of DC to 1.25 kHz, which conveniently spans the range of human vibration measurements, i.e. from 1 Hz to 80 Hz for Whole Body measurements and from 8 Hz to 1 kHz for Hand - Arm measurements.

The INPUT ATTENUATOR position "30 dB" gives full scale deflection on the monitor meter of the tape recorder for a 1 V signal on the input. For further information on the use of the tape recorder, please refer to its Instruction Manual.

4. With the signal to be recorded connected, adjust the mV / UNIT OUT switch on the 2635 or the INPUT ATTENUATOR on the tape recorder to give full scale deflection on the meter of the tape recorder without lighting the overload warning lights either on the 2635 or on the tape recorder. Care must be taken at this stage to ensure that the peak values of signals with a high crest factor lie within the range of measurement without causing overload. The degree of amplification (or attenuation if high signal levels are involved) must be noted for use later during the analysis process to match the output signal from the tape recorder to the input levels assumed by the 2512, i.e. a charge input of 1 pC corresponding to an acceleration of 1 ms^{-2}.

The measurement arrangement is now ready to record vibration signals.

Example of attenuation determination

Using the Triaxial Accelerometer Type 4321 to record a vibration with a maximum level of approximately 10 ms^{-2}, a setting on the 2635 of 1 mV/Unit Out (i.e. 1 mV/ms^{-2}, which would normally be expected by the 2512 if the measurement was being made direct) gives an output to the tape recorder of 10 mV, which is a factor of 100 (40 dB) below the level for full scale in the tape (i.e. 1 V). The full scale level can be achieved by increasing the output from the 2635 and/or reducing the input attenuation on the tape recorder INPUT ATTENUATOR. In this case, setting 10 mV/Unit Out on the 2635 and using the "10 dB" position on the tape recorder INPUT ATTENUATOR increases the signal by the required 40 dB so that the 10 ms^{-2} signal corresponds to nominal recording level of 1 V on the tape. Full scale deflection then corresponds to 10 ms^{-2}. This 40 dB must be reintroduced as an attenuation before the signal is played back through the 2512 during the subsequent analysis.

This technique may also be used with accelerometers having other sensitivities than unity, because the output of the 2635 is effectively converted to a "Unigain" sensitivity i.e. 0,1, 1, 10, 100, or 1000 mV / Unit Out, by dialling in the sensitivity of the transducer being used on the TRANSDUCER SENSITIVITY conditioning controls on the 2635.

4.4.2. Analyzing Recorded Data with the 2512

The input of the 2512 is a charge input designed to accept an accelerometer with a sensitivity of 1 pC/ms^{-2}. Only with an input signal of this sensitivity will the 2512 give the correct results. The level of the signal from the tape recorder must therefore be adjusted by the appropriate ammount to correspond to this sensitivity, and matched to the charge input of the 2512, as discussed in the example of the previous section. This may be done by means of the adaptors, attenuator set or a measuring amplifier as mentioned earlier. The general analysis arrangement is as shown in Fig.4.10, and a photograph of the 0 dB adaptor WB 0251 is reproduced in Fig.4.11.



Fig. 4.11. Photograph of the 0 dB Adaptor WB 0251

The general procedure is as follows:

1. Connect the instruments as in Fig.4.10. If the required attenuation of the tape recorded signal is 0 or 20 dB, one of the adaptors alone can provide the necessary attenuation, and this should be fitted. If the required attenuation lies between 40 dB and -10 dB (10 dB amplification) then Attenuator Set WB 0473 can be used. In other cases, a combination of one of these and a measuring amplifier will be necessary.

2. If the Measuring Amplifier Type 2610 is included in the analysis set-up, its controls should be preset as follows:

INPUT GAIN		"Cal."
INPUT SECTION GAIN		"1 V" ("0 dB")
OUTPUT SECTION GAIN		"1 Voltage Multiplier" ("0 dB")
INPUT		"Direct"
REF.		"Off"
AVERAGING TIME		"Fast"
FILTERS	Ext.	"Off"
	22,4 Hz	"Off"
	A	"Off"
DETECTOR		"Normal"
		"Normal"
		"RMS"

With these settings, full scale deflection on the measuring amplifier corresponds to nominal recording level on the tape recorder, i.e. 1 V RMS.

3. Introduce the attenuation required over and above that provided by the adaptor, via the INPUT SECTION GAIN selector on the front panel of the 2610, so that the sensitivity of the signal input to the 2512 corresponds to that originally input to the tape recorder.

4. The signal level is now correctly adjusted to be analyzed by the 2512 using the procedure of Section 3.4.

Example of attenuation determination

A signal with a maximum level of approximately 100 ms^{-2} was recorded applying a 20 dB amplification to bring the signal level up to the nominal record level of 1 V on the tape recorder. This gave a sensitivity of 0,1 ms^{-2} / mV, corresponding to 100 ms^{-2} at the nominal record level of 1 V. On replay, the sensitivity has to be reduced from 0,1 ms^{-2} / mV to 1 ms^{-2} / mV to match the input sensitivity of the 2512, an attenuation of 20 dB. This can be obtained by using the Adaptor WB 0706 directly, or, using the Attenuator Set WB 0473, selecting the 0,1 pC / mV (20 dB attenuation) position.

4.5. USE WITH THE TUNABLE BAND PASS FILTER TYPE 1621

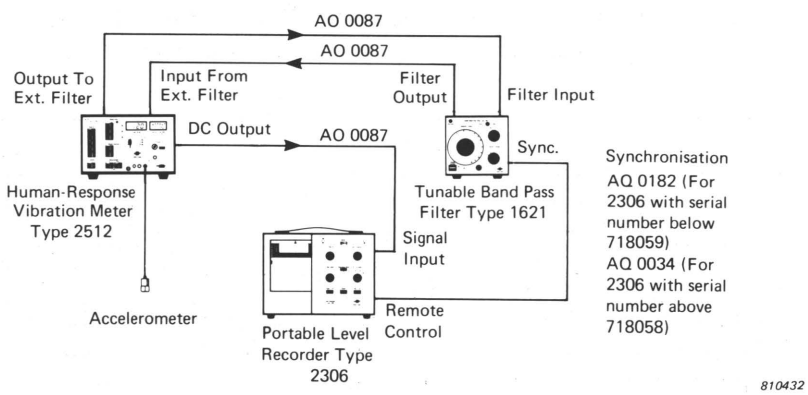


Fig. 4.12. Connecting the 2512 to the Tunable Band Pass Filter Type 1621

The Type 1621, which is powered from internal batteries, is ideally suited for use with portable instruments such as the 2512. Its frequency range (from 0.2 Hz to 20 kHz) covers the normal Whole Body range (from 1 Hz to 80 Hz) and the Hand - Arm range (from 8 Hz to 1 kHz), with bandwidths of 23 % (approximately one third octave) and 3 % available. Inclusion of a Portable Level Recorder Type 2306 in the measurement set-up allows the frequency analysis to be

carried out and recorded automatically. The measurement procedure using this arrangement of instruments is as follows:

1. Connect the instruments as shown in Figure 4.12. using the cables stated.

2. On the rear panel of the 1621, set the controls as follows:

POWER SELECTOR	"Internal Battery"
MAX. VOLTAGE	"1 V RMS"

3. On the front panel of the 1621, set the controls as follows:

SWEEP CONTROL	"Auto"
FILTER	"Linear"

4. On the 2306, ensure that frequency calibrated paper Type QP 0120, QP 0124, QP 0143, or QP 0224 is fitted, and that no signal cable is connected. Set the other controls as follows:

RECORDING MODE	"DC Lin"
WRITING SPEED/LF LIMIT	"250 mm/s / 25 Hz"
SENSITIVITY	"0"
PAPER DRIVE	"On"
PEN DRIVE	"On"
POWER	"On"

   Adjust the DC LIN POSITION control to place the pen on the bottom line of the paper, as in Fig. 4.13. and reconnect the signal cable, ensuring that the switch at the side is in the "+" position.

5. On the 2512, set the FILTER SELECTOR on the rear panel to the "Weighting Filter in, Ext. Filter in" position, the INPUT SELECTOR to "Ref.", select any measurement mode except the "0,1 — 0,63 Hz MOTION SICKNESS" mode, and press the START push-key. This gives a reference signal equivalent to 120 dB (1 ms^{-2}) in the WHOLE BODY mode or 140 dB (10 ms^{-2}) in the HAND-ARM mode.

6. Using only the SENSITIVITY control on the 2306, adjust the pen position to lie on the third line from the bottom of the paper, as shown in Fig.4.13. This line should be labelled 120 dB or 140 dB as appropriate. The system is now calibrated.

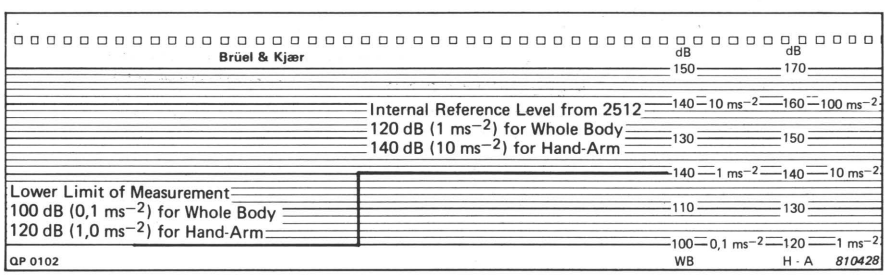


Fig. 4.13. Calibrating the Level Recorder

7. Adjust the paper position on the 2306 until the pen lies at a value beginning with 2 on the frequency axis, and set the FILTER and FREQUENCY RANGE controls on the 1621 as required.

8. Set the FILTER SELECTOR SWITCH on the rear panel of the 2512 to the required position, i.e. with or without the internal filters, and set the front panel controls to obtain the required measurement mode, as described in section 3.4.

9. Press the SWEEP CONTROL switch on the 1621 from "Auto" to "Start" in order to begin the analysis. The analysis will then proceed automatically through the decade chosen and come to a halt at the end. If the next decade is also required, this should now be selected on the FREQUENCY RANGE selector of the 1621 and the SWEEP CONTROL switch pressed again.

A typical 23 % bandwidth frequency response, weighted by the Hand-Arm filter of the 2512, of the vibration of an electric drill is shown in Fig.4.14.

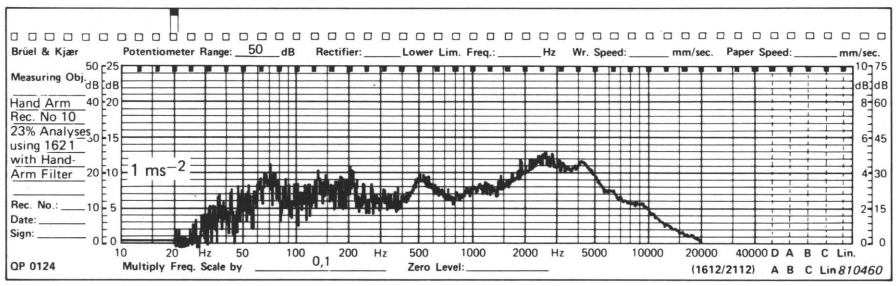


Fig. 4.14. Typical frequency analysis recorded using the system of Fig.4.12.

5. READING DATA FROM THE 2512 OVER THE IEC INTERFACE

The digital interface of the 2512 is designed according to the standard IEC 625-1 "Interface for Programmable Measuring Apparatus Byte-Serial Bit parallel". Since the only significant difference between this and the IEEE Standard 488-1978/ANSI MC1.1-1975 is the type of connector used, compatiblity with these standards is only a question of which connecting cable is used. Connection of the 2512 to an IEC 625-1 interface bus system is made from the INTERFACE BUS connector on the rear panel of the instrument using B & K cable AO 0194. Connection to an IEEE/ANSI interface bus system is made from the same connector using cable AO 0194 and the adaptor AO 0195. Connection to an earlier B & K instrument fitted with a female, slide-lock connector is made using cable AO 0184. For further details of instrument interconnections, refer to the Brüel and Kjær publication "INTERFACING BRÜEL & KJÆR INSTRUMENTS".

It is important to note that although the 2512 interface is designed according to the IEC standard, absolute compatibility with IEC or IEEE/ANSI interfaces designed by other manufacturers cannot be unconditionally guaranteed, since differences can occur within the limits of the specifications. Any problems encountered, however, will be of a software rather than a hardware nature. Where compatiblity is in doubt, contact our local representative for details.

5.1. IEC FUNTIONS IMPLEMENTED

The interface of the 2512 is primarily designed to output data to a recording device or calculator, and implements the following functions. The clauses referred to are the relevant sections of the IEC publication specifying the functions. The equivalent sections in the IEEE/ANSI standard are given in parentheses.

Clause 6, Source Handshake Interface (SH) Function, (Section 2.3.),
SH1 - Complete Compatability
Clause 7, Acceptor Handshake Interface (AH) Function, (Section 2.4.),
AH1 - Complete Compatibility
Clause 8, Talker Interface (T) Function, (Section 2.5.)
T3 - Basic Talker - Talk Only

For further details of the above functions, refer to the relevant section of the IEC publication or the IEEE/ANSI Standard.

5.2. INTERFACE BUS PIN CONNECTIONS

The pin connections of the INTERFACE BUS SOCKET on the rear panel of the 2512 are given in Table 3.

Contact	Signal Line	Contact	Signal Line
1	DIO 1	14	DIO 5
2	DIO 2	15	DIO 6
3	DIO 3	16	DIO 7
4	DIO 4	17	DIO 8
5	REN	18	Gnd (REN)
6	EOI	19	Gnd (EOI)
7	DAV	20	Gnd (DAV)
8	NRFD	21	Gnd (NRFD)
9	NDAC	22	Gnd (NDAC)
10	IFC	23	Gnd (IFC)
11	SRQ	24	Gnd (SRQ)
12	ATN	25	Gnd (ATN)
13	Shield		

Recommended Cable: 24 core, 12 of which are twisted pairs, and one shield

Max. Cable Length Between Instruments: 4 m

Max. Total Cable Length: 20 m

800177/1

Table 3. Interface Connector Contact Assignments

5.3. CONNECTING EXTERNAL DEVICES TO THE 2512 VIA THE IEC INTERFACE BUS

It is possible to connect a variety of other instruments to one or a number of 2512s via the interface bus. As the 2512 is only a talker, the instruments most usually connected to the 2512 will be recorders such as the Alpanumeric Printer Type 2312 or the Digital Cassette Recorder Type 7400. This will be referred to in this chapter as the manual mode. If an external controller, e.g. a desk-top calculator or mini-computer is used, the instruments will normally be addressed individually by the controller. This will be referred to as the addressable mode. The procedures for using the interface bus are described in the following sections.

5.3.1. Manual Mode

Connecting a Number of Instruments to a Single 2512 via the IEC Interface Bus

Fig.5.1. shows an arrangement for printing out measurements on an Alphnumeric Printer Type 2312 for immediate investigation and for recording onto a cassette using the Digital Cassette Recorder Type 7400 for further analysis at a later date. The procedure is as follows:

1. Connect the instruments as shown in Fig.5.1. using the interface cable AO 0194 if the instrument is a newer model, or AO 0184 if the instrument is an earlier model (prior to serial number 920925).

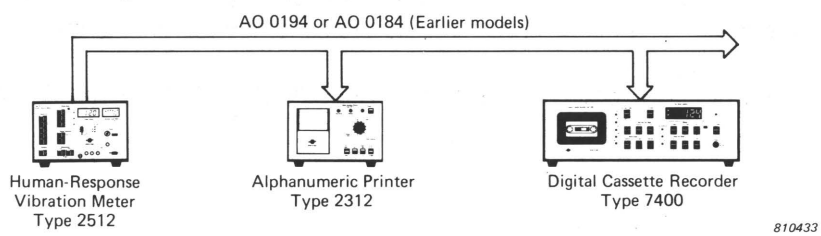


Fig. 5.1. Using the Alphanumeric Printer Type 2312 and the Digital Cassette Recorder Type 7400 to record data from a 2512

2. On the Alphanumeric Printer Type 2312:

   a. Set the INTERFACE MODE SWITCH on the rear panel to the "IEC - Listen Always" position.

   b. Set the CLOCK CONTROL SELECTOR on the front panel to the time interval required between readings. This controls not only the output to the 2312, but also to the other instruments on the bus. If the switch is set in the "Ext." position, data will be printed out and sent to the other instruments connected to the bus at the end of each averaging period i.e. every 2 seconds.

   c. Set the right hand PRINT switch to "Auto".

3. On the Digital Cassette Recorder Type 7400:

   a. Set the INTERFACE MODE switch on the rear panel to "IEC".

   b. Set the 7400 up for recording as described in its Instruction Manual.

   c. Press the two RECORD pushkeys "Data" and "Enable" simultaneously so that the LED in the "Data" pushkey comes on indicating that the 7400 is ready to receive data.

4. On the 2512:

   a. Set the ADDRESS SWITCH on the rear panel as in the table below:

Subswitch Number	Position	Function
7	0	Calculator
6	1	Ton

810042

   b. Set the front panel controls for the measurement required as in Chapter 3.

   c. Press the two MEASURMENT pushkeys simultaneously, so that their LEDs are lit, and press the INTERFACE pushkey to activate the interface.

5. Press START to begin the measurement.

   Data will now be transmitted from the 2512 to the external devices at an interval determined by the setting of the CLOCK CONTROL SELECTOR on the 2312. If 'Ext" has been selected, data will be output at an interval determined by the time constant of the 2512, i.e. once every two seconds.

   Switching off one of the instruments on the bus has no effect on the rest of the instruments on the bus, which continue to receive data without interruption.

7. To stop the measurement press MEASUREMENT STOP on the 2512.

Using a Number of 2512s in a Measurement Arrangement

More then one 2512 may be used in a measurement system as shown in Fig.5.2. In this case the state of the INTERFACE pushkeys on the 2512s determines whose data is transmitted to the recording devices. Only one 2512 at a time can transfer data, the one whose INTERFACE is active. The INTERFACE "On / Off" switch is thus used to select the required 2512. The procedure is exactly the same as in section 5.3.2.

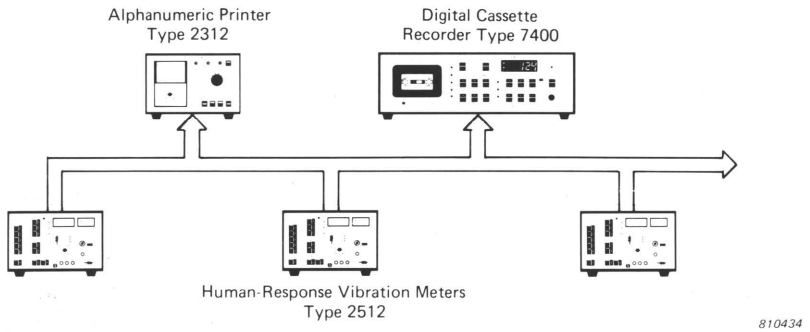


Fig. 5.2. Connecting a number of 2512s to external devices using the IEC Interface Bus

It should be noted, however, that no two 2512s can have an active INTERFACE at the same time. One should always be switched off before the next is activated. If this is not done, neither has priority over the other and there is a danger of the two instruments trying to send data to each other, leading to an unstable situation in which the recording device records invalid data.

5.3.3. Addressable Mode: Using an External Controller to Address the 2512 Individually

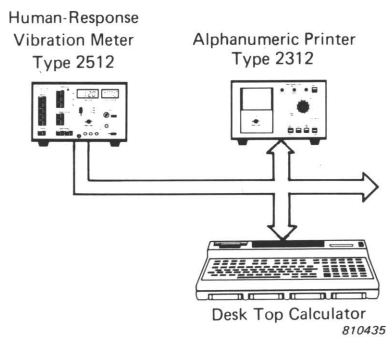


Fig. 5.3. Using the 2512 as an addressable device in a system with a desk-top calculator acting as an external controller

When a 2512 or a number of 2512s is used in an instrumentation arrangement with an external controller such as a desk-top calculator or mini-computer, see Fig.5.3., each instrument connected to the interface bus is addressed by a unique address which is set on the ADDRESS SWITCH on the rear panel of the instrument, see Fig.5.4. The address is set in ASCII 7-bit code, where bit 7 and bit 6 are always assumed to be "1" and "0" respectively. All codes except 11111 are permitted. 11111 corresponds to unlisten, and should never be set.

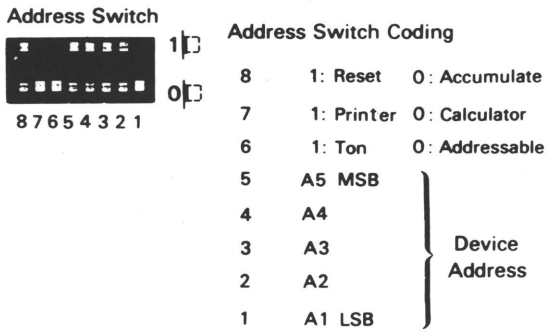


Fig. 5.4. The ADDRESS SWITCH on the rear panel of the 2512

When using the Type 2512 in the addressable mode, subswitches 7 and 6 of the ADDRESS SWITCH should be set as follows:

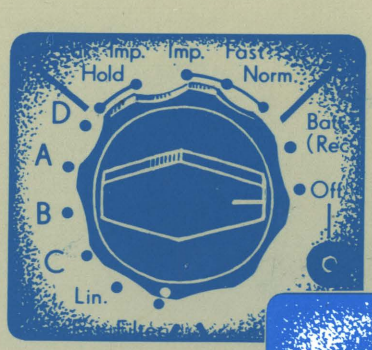
Subswitch 7	**"0: Calculator".** The data is then output in the shortened form without the explanatory text, only with a text code, as shown in Fig.4.1, section 4.I.
Subswitch 6	**"0: Addressable"**

The remaining positions from 5 to 1 can be set to the required address, which should be different from the addresses of all other instruments on the interface bus. 31 (2^5–1) different addresses can be formed via these five switches, although the limit of the interface bus is only 14 instruments. The address is set to 01100 at the factory.

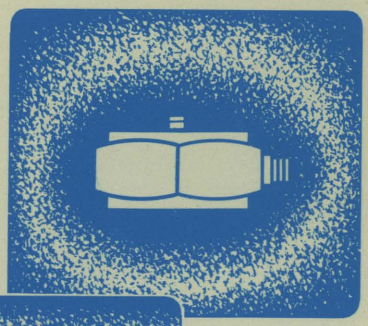
In addition, the INTERFACE pushkey on the front panel of the 2512 must be active, i.e. its LED must be on.

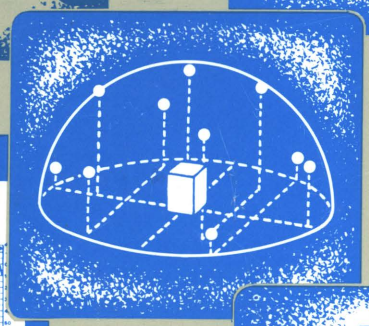
6. SERVICE AND REPAIR

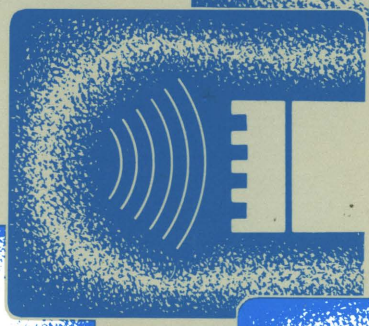
The 2512 is designed and constructed to provide the user with many years of reliable operation. However, should a fault occur which impairs its correct function, then all power should be disconnected to prevent the risk of further damage. For repair, consult the separate Service Instruction provided or consult your local B & K service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.

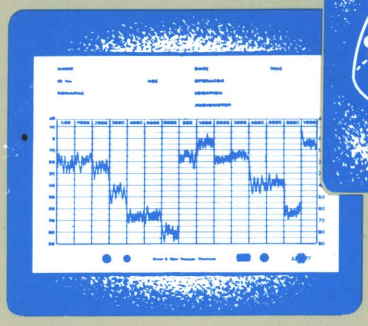


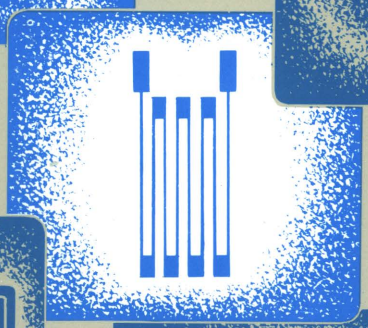


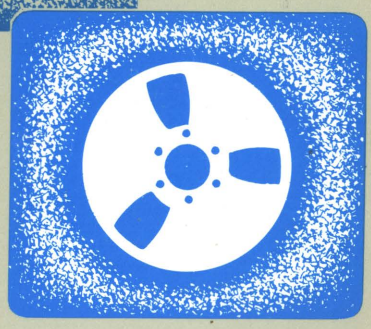




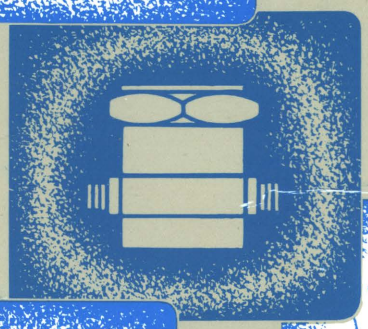


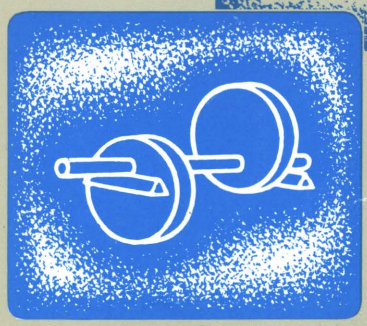


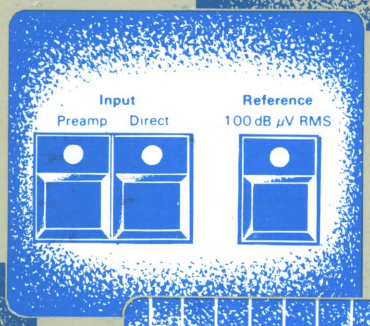


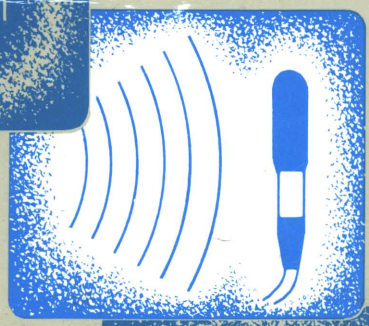


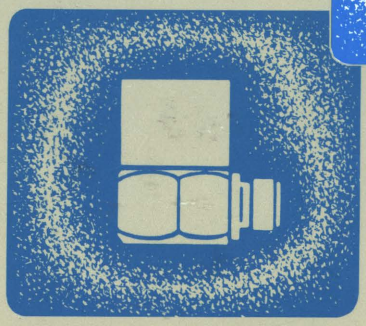


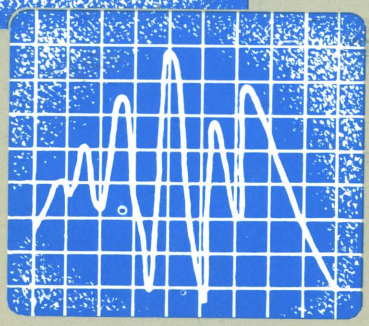


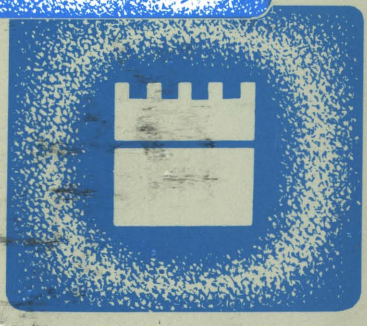












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