



**Acoustics'08
Paris**
June 29-July 4, 2008
www.acoustics08-paris.org

A new instrument for the measurement of occupational vibration

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Directive 2002/44/EC relative to the risks arising from vibration has been transcribed into national laws of most Member States. This directive deals with the determination of limits and action values for the daily exposure to vibration. Two physiological domains are addressed: the “hand-arm” and the “whole-body” domains, the acceptable statutory values of which are specified in the text. The experimental protocol, as well as indicators relevant for assessment, is defined in Standards ISO 5349-2 and ISO 2631-1. The equivalent frequency-weighted acceleration shall be measured on the 3 axes x, y and z, the bandwidth of which is defined for each domain.

01dB-Metravib introduces a new portable instrument that perfectly meets the requirements of this statutory application. A blind metrological instrument connected to a triaxial accelerometer is installed on site. The instrument is remotely controlled by the operator using a wireless remote control of the Pocket PC type. This remote control is used to manage measurement configurations (“whole-body”, hand-arm”), to start acquisitions (immediate, delayed mode) and to collect measured data for post-processing and archiving purposes.

We will present metrological and operational advancements of this new instrument and describe a real case study dealing with the assessment of daily exposure to vibration.

1 Introduction

Vibrations on working sites increasingly influence accidents and working conditions [1]. European Directive 2002/44/EC deals with minimum safety and health prescriptions relative to workers’ exposure to risks due to physical agents, as vibration. This directive proposes the ‘vibration exposure limit values’ and the ‘vibration exposure action values’. It also specifies employers’ obligations with regard to determining and assessing risks, sets out the measures to be taken to reduce or avoid exposure and details how to provide information and training for workers. It has recently been transcribed into all national laws of Member States. In this statutory context, 01dB-Metravib has designed and developed a new vibration meter named Vib008 and software dBMaestro for industrial health specialists. Integrating users’ operating requirements, this device allows for an innovating and optimised approach on the work place.

2 Hand-arm and whole-body vibrations

Hand-arm disturbance is caused by vibration transmitted into the hand and arms through the palm and fingers. Workers whose hands are regularly exposed to hand-arm vibration suffer from damage to the tissues of the hands. They cause damage to the level of blood vessels and nerves, resulting in a loss of sensitivity, of grip strength and which are known under the term of “syndrome of the fingers dead or Raynaud’s disease. Cold weather amplifies this phenomenon when people are working in outdoor conditions.

People affected by this pathology work in many sectors of activity: they usually use “hand tooling” as hammer-action tools, chain saw, rivet tools ...

The risks are greatly increased with use of higher vibration equipment and with prolonged and regular use of the equipment.

Whole body vibration is caused by vibration transmitted through the seat or the feet by workplace machines and vehicles.



Fig.1 Measurement of whole body vibration

Exposure to high levels of whole-body vibration can lead to risks to health and safety. The risks are maximum when the vibration magnitudes are high, the exposure durations long, frequent, and regular, and when the vibration includes severe shocks or jolts. Work that involves exposure to whole-body vibration often occurs in building work, transport and handling sectors, wood and sheet metal industries. It can also occur for drivers, in lorries and trucks, in boats and in aircrafts. Operators on vibrant platforms (sits, floors,...) can be affected by vibration effects too. But duration, frequency and level of exposure are often the main critical factors in the onset of the symptoms.

For Hands-arm and Whole-Body vibration the frequency range is respectively 5Hz to 1500Hz and 0.5Hz to 80Hz.

3 European Directive 2002/44/EC

Assessing individual exposure to vibrations covers two domains:

- Hand-arm vibrations (HA domain)
- Whole-body vibrations (WB domain)

WB vibrations can be assessed according to different sensitivity levels: “Health quality” level, “Comfort quality” level, “Perception quality” level.

Each domain and quality level have their own indices required for vibration assessment. For each domain (HA and WB) European Directive 2002/44/EC [2] has set two thresholds, an alarm threshold (action-triggering value) and a danger threshold (maximum exposure value).

The exposure values for daily vibration, above which it requires employers to control the HA vibration risks of their workforce and which workers must not be exposed, are respectively:

- a daily exposure action value of 2.5 m/s^2
- a daily exposure limit value of 5 m/s^2 .

However, there is some risk of HA vibration injury where exposures are below the exposure action value. Directive 2002/44/EC places responsibilities on employers to ensure that risks from hand-arm vibration are eliminated or reduced to a minimum.

The exposure values, above which it requires employers to control the WB vibration risks of their workforce and which workers must not be exposed are respectively:

- a daily exposure action value of 0.5 m/s^2

(or, at the choice of the EC Member State, a vibration dose value VDV of 9.1 $\text{m/s}^{1.75}$);

- a daily exposure limit value of 1.15 m/s^2

(or, at the choice of the EC Member State, a vibration dose value VDV of 21 $\text{m/s}^{1.75}$);

Directive 2002/44/EC places requirements on employers to ensure that risks from WB vibration are eliminated or reduced to a minimum.

This evaluation must be planned and carried out by competent persons at appropriate intervals and with the assistance if any of the occupational health service.

The results of evaluations or measurements must be made available to health services for a period of 10 years.

4 Innovating products: vibration meter Vib008 and processing software dBMaestro

When the exposure values are exceeded, the employer establishes and implements a programme of technical and organizational measures aimed at minimizing exposure to mechanical vibrations and the resulting risks.

The need to make objective measurements becomes an imperative necessity.

The Vib008 has been studied to be compliant with the standards ISO 8041, ISO 5349 [3] and ISO 2631 [4], to fulfil the requirements of the European Directive 2002/44/EC and to allow the “health and safety” end users to handle the problem of workplace vibration.

4.1 Vib008, compact technology

Vib008 consists of a portable, ergonomic and miniaturised housing (dimensions: 105mm*60mm*25mm, total weight: 145g), hosting acquisition unit, signal processing, data storage and data transfer.

Vibration meter Vib008 is totally blind including start/stop button and 3 LED on the front panel (Battery, On/Off and Bluetooth communication). Diodes turn on depending on the instrument status and inform the user on the progress of its operations. They can be inactive upon request of the operator, thus limiting any possible disturbance of the operator.

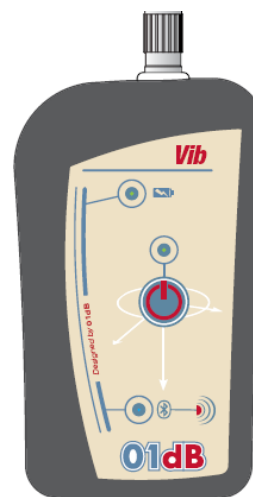


Fig.2 Vib008, new vibration meter

Vib008 can be used on site in stand-alone mode (instrument only) or in remote control mode.

In stand-alone mode, the instrument is started manually. The latest configuration is active, vibration measurements are launched after clicking on On/Off key. When the test is completed, stored data are immediately - or later on - transferred to a PC and processed with software dBMaestro.

In remote control mode, the operator can remotely manage measurements from up to 5 instruments simultaneously. This is the most technologically advanced type of use as far as monitoring of workers' vibration exposure is concerned. It gives Vib008 unrivalled power and user-friendliness, which are required for an optimised occupational vibration study.

Based on a multiple-point metrological approach, a set of Vib008 is deployed in the work place. The management of the instrument set is achieved from a single Pocket PC: the user operates and controls active Vib008 instruments.

All the deployed vibration meters can then be configured remotely. Several default configurations are pre-programmed for set-up simplification purposes. The user programs the immediate, delayed or periodic start of measurements. During the tests, the operator can control indicators that are displayed in real time on each Vib008 using his/her remote control. The Pocket PC colour screen is the remote, single and user-friendly interface of several Vib008 vibration meters. All acquired information (time/frequency data, written/oral comments synchronised with vibration measurements, etc.) is transferred to the Pocket PC or to a PC using Bluetooth communication. Simple transfer (selected file) or global transfer (all files) is defined by the operator.

4.2 Vib008, unrivalled performances

Considering the HA domain, Vib008 measures the 3 axes accelerations, x y z to upper limbs. The triaxial accelerometer is connected to the system under test with a mechanical piece mounted on a bangle. The device calculates and displays the following values: peak and weighted accelerations band pass filtered 6,3-1250Hz and weighted effective and multiaxial acceleration.



Fig.3 Vib008 hand arm accessories

Considering the WB domain, Vib008 is connected to a triaxial seat pad accelerometer to measure the vibrations applied to the whole body according to 3 axes, x y z.

The seat pad is composed by a miniature accelerometer associated with a presence detector able to detect the driver. This tool allows the automatic start-up of the measurement or the elimination of the artefacts due to operator movements.

Vib008 stores the peak and effective accelerations x y z (weighted or not weighted) and the multiaxial acceleration calculated according to 2 methods (root of the acceleration sum or acceleration's maximum). It allows calculation of the following additional results: the vibration dose value (VDV), the maximum transient vibration value (MTVV) with the following time constants: 1 second, 0.5 second or 125 milliseconds. Vib008 can also be connected to a monoaxial accelerometer put on a magnetic mounting base, in order to measure the seat efficiency determined by the

ratio between the z acceleration measured on the seat and the z acceleration measured on the floor. This parameter, named SEAT, is useful to adjust the damping of the seat.

The sensors are directly connected to the Vib008 worn by the worker, remotely piloted by the remote control. The operator monitors vibration measurements, triggered in immediate or delayed start.

The daily exposure A(8) is computed in regard of the WB and the HA domains. In addition, the dose value is also determined. These indicators are then compared to the EU action and limit values.

Furthermore, for a better understanding of the vibration phenomenon, Vib008 offers the capability to assess 1/1-octave or 1/3-octave measurements. The operator can also store in the memory the raw signal for a further expert analysis.

During the measurement, the operator can mark the file with some coding buttons to determine some working phases.



Fig.4 Saddlebag of Vib008

Furthermore, a Bluetooth wireless communication between Vib008 and the Pocket PC remote control offers the operators many benefits, which are greatly appreciated *in situ*:

- ease of use and flexibility: Vib008 instruments located within the Bluetooth range of action are automatically detected, operating control is user-friendly and intuitive (default setup)
- fast and unobtrusive operating: the implementation of Vib008 is immediate and without any wiring constraint, the monitoring of vibration levels and workers' exposure levels is performed in real time and remotely (the operator can, if he/she wishes so, move, talk, etc. without disrupting the measurement process)
- efficient and transparent with respect to the production cycle: the on-site deployment deals with a network of Vib008 performing simultaneous measurements, the worker forgets that he/she is wearing a dosimeter and performs his/her tasks with no constraint.

4.3 Operating software dBMaestro designed for occupational health specialists

At the end of each measurement sessions, the operator can transfer the files into the dBMaestro software to post-process the results.

dBMaestro is a data processing software compliant with the requirement of current standards and regulations, in particular ISO 5349-2 and ISO 2631-1.

dBMaestro can plot the time history of each parameter, compute some extra values and edit automatic reports.

Considering the Vib008 and dBMaestro association, the health and safety responsible can fulfil the requirements of the 2002/44/CE directive. He can also take the appropriate decisions and/or actions to protect the workers to excessive vibrations.

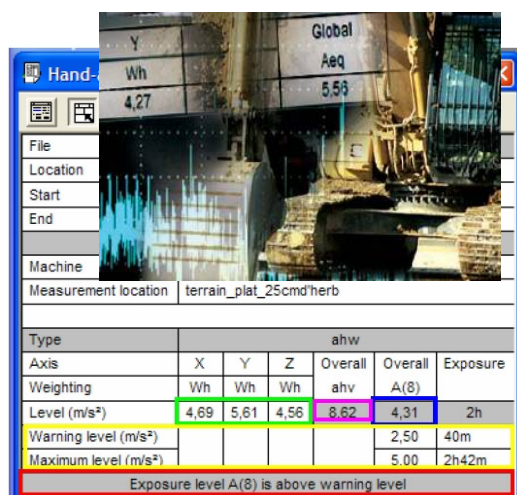
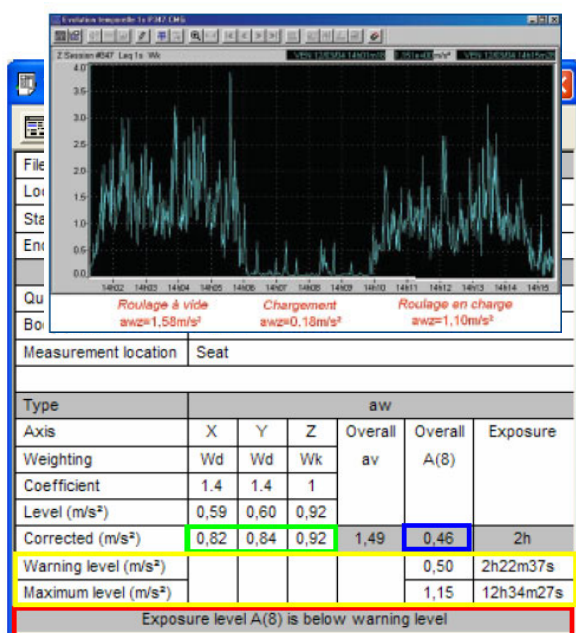


Fig.5 Automatic report dBMaestro

5 Conclusion

European Directive 2002/44/EC deals with minimum safety and health prescriptions relative to workers' exposure to risks due to physical agents (vibration). It has recently been transcribed into all national laws of Member States. Exposure limit values triggering actions have been imposed. Employers are now under the obligation to determine vibration risks and adopt appropriate solutions to reduce them. Vibration exposure meter Vib008 is the most relevant device to meet these requirements, as it combines technological performance and ease of use. With its full openness with respect to the production cycle, industrial health specialists can now operate by increasing on-site simultaneous measurements, optimised for the application of directive 2002/44/EC and the large requests of improvement of vibration working conditions [5]. Vib008 can be used in association with the noise dosimeter Wed007 to evaluate precisely the noise and vibration working conditions in a factory [6].

References

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