



## **PROTOCOL FOR HAND-ARM TRANSMITTED VIBRATION (HAV) MEASUREMENTS**

### **1. Measuring equipment**

Vibration are measured by using an equipment able to provide the effective value (r.m.s. value) of the acceleration of the surface that comes in contact with the user's hand-arm system. Equipment shall be compliant to the Standard ISO 8041.

The equipment shall be made, besides the accelerometers, by:

- a) a spectrum analyser (at least three channels) without the recording chain. This method presents the advantage of an immediate reading of the acquired spectra, but does not allow the subsequent processing of the signals acquired by analysis modes that are different from those used in the acquisition phase;

or:

- b) a measurement signal recorder (at least three channels). The signal is then analysed by a spectrum analyser. The recorder shall necessarily be equipped with an overload gauge, in order to prevent distortions in the recorded signal.

**For the purposes of quality control of measurements to be inserted in the VDB, the spectral analysis of measurements, in thirds of octave, is required.**

#### Measurement procedures

Measurements shall be compliant to the Standards ISO 5349-1 and ISO 5349-2.

If the accelerometer is attached directly on the vibrating handle, metal or plastic clips shall be used. If the accelerometer is mounted directly on an adapter, its transfer function shall be known; *such transfer function* can be provided by the manufacturer or directly measured by the Laboratory.

Mechanical Filters : in the case of measurements on percussive or roto-percussive tools, in order to exclude the "dc shift" *phenomenon*, which entails the total unreliability of the measurement results, a mechanical filter with a well-known transfer function shall be put between the accelerometer and the handle.

### **2. Duration of measurement**

The total measurement time, i.e. the number of acquired samples multiplied by the duration of acquisition of each sample, shall last at least one minute.

If the operation to be measured has a duration of vibration which is less than 1 min, the recording of such operation can be repeated a number of times until the total duration of the records of the operation is not less than 1 min.

Any movement of the vibrating tool occurred during a measurement, such as, for example the normal change of position of a workpiece being worked, the replacement of accessories, the displacement of the tool for machining requirements, etc., can generate noise signals during the data acquisition phase. Such interferences can be excluded by performing the measurements in simulated conditions, which therefore generally appear preferable for the assessment of hand-arm system transmitted vibration.

### **3. Assessment of uncertainty**

The uncertainty factors that follow shall be assessed; the person responsible for the measurement shall determine, in each specific case, the main sources of uncertainty, and, in accordance to that, increase the number of acceleration measurements in order to quantify, by calculating the standard deviation, the extent of the error associated with the main indetermination factors.



The measuring equipment and the related calibrator shall undergo calibration at an accredited calibration laboratory (national or EA center) at least every two years.

#### **Uncertainty factors**

- a) Biases due to the acquisition system (weight, location and mounting of accelerometers, electrical interferences, calibration). These measurement errors can be minimized by selecting an appropriate measurement technique. In this case the measurement error associated with this component is < 4 %.
- b) Errors due to random fluctuations of the concerned physical parameters (temperature, humidity, stability of the machine power supply, homogeneity of the material being worked, etc.). These errors can be minimized by increasing statistics of the samples. The estimate of the random measurement error is obtained by the standard deviation (or from the *standard deviation*) of at least three measurements performed under **identical** experimental conditions. The operating characteristics shall be reported in detail in the description of the measurements.
- c) Changes in the ways of use of the working tool by different operators: this factor shall be taken into account, since the exposure reported in the test report is assessed for homogeneous working tasks and not for the individual worker. The measurements shall be repeated in the same operating conditions, with at least two operators displaying different anthropometric characteristics and/or professional experience. If the coefficient of variation of the performed measurements is greater than 20% the number of measurements shall be increased by including a third operator.
- d) Changes in the maintenance conditions of the tool (e.g.: unbalancing of the disk in the case of grinders, wear of tools, etc. ). The measurements shall be carried out on equipment in good maintenance conditions.

#### **4. Results of measurements**

The results will be expressed in terms of mean value, standard deviation and coefficient of variation of the repeated measurements, calculated as follows:

$$C_v = \frac{S_{n-1}}{\bar{x}} \quad \text{Coefficient of Variation}$$

$$S_{n-1} = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^n (x_i - \bar{x})^2} \quad \text{Standard Deviation}$$

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad \text{Mean Value}$$

#### **5. Quality Control**

The laboratory intends to participate in intercalibration programs (Round Robin Test), by performing specific tests defined by the scientific referents.



**TECHNICAL FORM FOR HAND-ARM SYSTEM TRANSMITTED VIBRATION MEASUREMENT COLLECTION**

Test report form for vibration measured at the handles of hand-held portable machines

**Personal details (\*)**

|                          |   |
|--------------------------|---|
| Test performed by: _____ | Report responsible person: _____                                  |
| Date: _____              | I declare to be authorized to publish the following proposed data |
| Place: _____             | <input type="checkbox"/>  |
| WORKING SECTOR: _____    |   |

**Examined machine**

|                  |                         |
|------------------|-------------------------|
| Type: _____ (*)  | Manufacturer: _____ (*) |
| Model: _____ (*) | Serial number: _____    |

**Inserted tool**

|                 |                       |
|-----------------|-----------------------|
| Type: _____ (*) | Characteristics _____ |
|-----------------|-----------------------|

**Operating conditions**

|   |                        |
|---|------------------------|
| Percussion/rotation frequency, Hz, _____  | Attach JPEG PHOTOS (*) |
| Pressure, bar: _____  |                        |
| Duration of each test, s: _____ (*)<br>N.B. The total duration of each measurement (N of tests X duration of each test) shall last at least 1 minute. |                        |
| Type of the material being worked (e.g. wood, rock) (*)   |                        |
| Work operating conditions (e.g. rock drilling, wood sanding etc.) (*)   |                        |
| PHOTOS OF THE MACHINERY UNDER OPERATING CONDITIONS (*)  |                        |

**Measuring equipment**

|   |
|---|
| Accelerometer - manufacturer, type, weight: _____   |
| Mechanical filter - adapter - manufacturer, type, weight: _____                                   |
| Preamplifier (optional) - manufacturer, type: _____   |
| Tape recorder (optional) - manufacturer, type: _____  |
| Data related to the calibration of the instruments issued by the EA center (or equivalent): _____ |

**Mounting of transducer and of mechanical filter (\*)**

|                               |
|-------------------------------|
| ATTACH PHOTOS OF THE MOUNTING |
|-------------------------------|

**Signal processing** Report the signal integration type

|   |                          |
|---|--------------------------|
| Rms time constants _____  | Sampling frequency _____ |
| Additional specifications (Report any other details related to measurements, if applicable) _____ |                          |

|              |
|--------------|
| Notes: _____ |
|--------------|



**Results:** Results shall be expressed as reported in the following tables:

**Effective values - A operator:** a(x,y,z) values in meter per square second (m/s<sup>2</sup> r.m.s.)

| Test |                 |                 |                 |                                     |                  |                  |                  | Measurement conditions<br>Handle (*) |  |
|------|-----------------|-----------------|-----------------|-------------------------------------|------------------|------------------|------------------|--------------------------------------|--|
|      | linear          |                 |                 |                                     | weighted         |                  |                  |                                      |  |
|      | a <sub>hx</sub> | a <sub>hy</sub> | a <sub>hz</sub> | a <sub>hvs<sub>sum</sub></sub> (**) | a <sub>hwx</sub> | a <sub>hwy</sub> | a <sub>hwz</sub> | a <sub>hw<sub>sum</sub></sub> (***)  |  |
| 1.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 2.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 3.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |

**Effective values - B operator:** a(x,y,z) values in meter per square second (m/s<sup>2</sup> r.m.s.)

| Test |                 |                 |                 |                                     |                  |                  |                  | Measurement conditions<br>Handle (*) |  |
|------|-----------------|-----------------|-----------------|-------------------------------------|------------------|------------------|------------------|--------------------------------------|--|
|      | linear          |                 |                 |                                     | weighted         |                  |                  |                                      |  |
|      | a <sub>hx</sub> | a <sub>hy</sub> | a <sub>hz</sub> | a <sub>hvs<sub>sum</sub></sub> (**) | a <sub>hwx</sub> | a <sub>hwy</sub> | a <sub>hwz</sub> | a <sub>hw<sub>sum</sub></sub> (***)  |  |
| 1.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 2.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 3.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |

*On the measurements related to the A+B operators:*

|                           |  |  |
|---------------------------|--|--|
| Arithmetic mean:          |  |  |
| Standard deviation:       |  |  |
| Coefficient of Variation: |  |  |

**Effective values - C operator** [to report if the coeff of total variation is > 20 % ]: a(x,y,z) values in m/s<sup>2</sup> r.m.s.

| Test |                 |                 |                 |                                     |                  |                  |                  | Measurement conditions<br>Handle (*) |  |
|------|-----------------|-----------------|-----------------|-------------------------------------|------------------|------------------|------------------|--------------------------------------|--|
|      | linear          |                 |                 |                                     | weighted         |                  |                  |                                      |  |
|      | a <sub>hx</sub> | a <sub>hy</sub> | a <sub>hz</sub> | a <sub>hvs<sub>sum</sub></sub> (**) | a <sub>hwx</sub> | a <sub>hwy</sub> | a <sub>hwz</sub> | a <sub>hw<sub>sum</sub></sub> (***)  |  |
| 1.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 2.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |
| 3.   |                 |                 |                 |                                     |                  |                  |                  |                                      |  |

(\*) = mandatory fields

$$(**) = a_{hvs\text{sum}} = \sqrt{a_{hx}^2 + a_{hy}^2 + a_{hz}^2}$$

$$(***) = a_{hw\text{sum}} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

Signature: \_\_\_\_\_