



Design for a multi-centre experimental study of the power absorbed as a consequence of hand-transmitted vibration

**Appendix H3C to Final Report
May 2001**

EC Biomed II concerted action BMH4-CT98-3291

prepared by Ronnie Lundström, PhD, and Paolo Lenzuni, PhD
April, 2000

1. General

The aim of this document is to establish a common methodology of investigation among the various European Institutions which are involved in a multi-centre experimental study of the absorption of power associated to the exposure to hand-transmitted vibration.

Two institutions will participate in this experimental study:

1. The Department of Technical Hygiene of the National Institute for Working Life (**NIWL**), Umeå Sweden.
2. The Physical Agents Unit of the Italian National Institute for Occupational Prevention and Safety (**ISPESL**), Rome, Italy

These institutions will conduct a common set of experiments aimed at measuring the power absorbed by a few tested subjects as a consequence of exposures to hand-transmitted vibration with different magnitudes and frequencies. Although absorbed power is the outcome of the experiments discussed in this document, it can also be seen as a substitute for acceleration as an input in any of the exposure – response relationships which are being investigated in the context of the present European Union project. Indeed, absorbed power is possibly best visualised as an intermediary between the quantities which characterise the mechanical vibration and the individual physical properties of the operator on one side, and the various vascular, neurological and muscle-skeletal disorders on the other side. Because absorbed power needs to be correlated to the results of neurological and vascular experiments described in a previous report, conditions have been selected for the present study in such a way as to create a substantial overlap with the conditions used in the vascular and neurological experiments.

2. Proposal for an experimental study designed to measure absorbed power as a function of frequency and magnitude of the vibration transmitted to the hand

- **Subjects:** 10 healthy men will be selected with no occupational exposure to hand-transmitted vibration.
- **Measures of absorbed power:** Power will be computed from measurements of force, acceleration and phase between the two.
- **Experimental procedure:** The experiments will be performed in a laboratory with ambient temperature controlled between 22 and 25°C. Sinusoidal vibration will be produced with various combinations of frequency and rms magnitude. Two separate sets of experimental conditions have been created.

	Frequency [Hz]	Unweighted acceleration [ms ⁻²]	Weighted acceleration [ms ⁻²]
A11	8	5	5
A12	16	5	5
A13	31.5	5	2.5
A14	63	5	1.25
A15	125	5	0.63
A16	250	5	0.315
A17	500	5	0.16
A21	8	20	20
A22	16	20	20
A23	31.5	20	10
A24	63	20	5
A25	125	20	2.5
A26	250	20	1.25
A27	500	20	0.63

This first set of experimental conditions is intended to replicate some of the conditions tested in neurological experiments. Overlap involves conditions A13, A15, A17, A23, A25, A27

	Frequency [Hz]	Unweighted acceleration [ms ⁻²]	Weighted acceleration [ms ⁻²]
B11	8	2.75	2.75
B12	16	2.75	2.75
B13	31.5	5	2.75
B14	63	11	2.75
B15	125	22	2.75
B16	250	44	2.75
B17	500	88	2.75
B21	8	5.5	5.5
B22	16	5.5	5.5
B23	31.5	11	5.5
B24	63	22	5.5
B25	125	44	5.5
B26	250	88	5.5
B27	500	176	5.5
B31	8	11	11
B32	16	11	11
B33	31.5	22	11
B34	63	44	11
B35	125	88	11
B36	250	176	11
B37	500	352	11

This second set of experimental conditions is intended to replicate some of the conditions tested in vascular experiments. Overlap involves conditions B22 to B 27.

The subjects will be asked to grab, with a force of 20 N, a vertical handle mounted on a shaker. The posture of the subject will be standardised, sitting with the arm along the trunk, the forearm bent at 90° and resting on a soft support adjusted in height, the hand in prono-supination. The resulting axis

of vibration is the Y axis as defined in ISO 5349. The exposure to vibration will last 6 minutes.

- **Safety and ethical aspects:** The study will be conducted according to the safety recommendations included in ISO 13090-1. The experimental subjects will give informed written consent to the study, and the experimental procedures shall be approved by local Ethical Committees.

The results of the experiments at the various European centres will indicate the influence of the magnitude and frequency of vibration on absorbed power, and will be used to propose alternative methods of frequency weighting of vibration. Measurements of absorbed power in different time intervals will also provide indications on the evolution in time of this quantity.

The influence of other exposure variables relevant to the absorbed power during hand-transmitted vibration, such as direction of vibration, contact force (grip force, feed force), contact area, intermittence and/or impulsiveness of exposure, posture of the hand, forearm and arm will be also assessed by appropriate experimental procedures. These results will provide valuable information for the assessment of the exposure-response relationships in the epidemiological studies which will be conducted in the context of Work Package 2 of this European Union project program.

3. Resources for the experimental multi-centre study

The following is a short description of the available instrumentation for generating vibration and measuring absorbed power.

3.1 Department of Technical Hygiene of the National Institute of Working Life, Umeå Sweden

- Various vibration exciters shaking masses weighting up to 200 kg
- A handle, especially designed for laborative exposure to hand-transmitted vibration, which includes force cells and purpose-built strain gauges to control and/or monitor grip, push and pull forces applied by the subject
- Set of several piezo-electric or piezo-resistive accelerometers of varying shapes and sizes
- Various amplifiers, including several systems developed within the laboratory for acceleration and force transducers
- *HVLab* data acquisition and analysis software (ISVR, Southampton)
- *Brüel & Kjaer PULSE* system for data analysis
- *LabView* system for both vibration generation and data acquisition and analysis

3.2 Physical Agents Unit of the Italian National Institute for Occupational Prevention and Safety, Rome, Italy

- *RMS* Electrodynamic vibrator (characteristics)
- *Vibration Research* controller and signal generator in a closed loop with the electrodynamic vibrator
- A handle, especially designed for laboratory exposure to hand-transmitted vibration, which includes force cells and purpose-built strain gauges to control and/or monitor grip, push and pull forces applied by the subject
- Several piezo-electric (ICP ?) or piezo-resistive accelerometers of different sizes and sensitivities
- *OROS* data acquisition and analysis software
- *LabView* system for alternative data acquisition and analysis

4. References

1. European Committee for Standardization. Mechanical vibration. Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration. *EN 25349*, 1992.
2. International Organization for Standardization. Mechanical vibration - Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration. *ISO 5349*. Geneva, 1986.
3. International Organization for Standardization. Mechanical vibration – Measurement and assessment of human exposure to hand-transmitted vibration – Part 1: General guidelines. *ISO/CD 5349-1*, 1999.
4. International Organization for Standardization. Mechanical vibration and shock – Guidance on safety aspects of tests and experiments with people – Part 1: Exposure to mechanical vibration and repeated shock. *ISO 13090-1*, 1997.