ASSESSMENT OF HAND-ARM VIBRATION EXPOSURE

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1 INTRODUCTION

Regular exposure to vibration from hand-held tools or vibrating work-pieces can cause several kinds of injury to the hands and arms. Together these injuries are known as 'hand-arm vibration syndrome' (HAVS), although other names are sometimes used by industry, including 'dead finger', 'dead hand' or 'vibration white finger'. Exposure to excessive levels of vibration may not cause obvious and immediate harm, but continued exposure can cause permanent damage.

The Control of Vibration at Work Regulations[1] come into force in the UK in July 2005. To comply with these Regulations, an employer must assess the risks to his employees from vibration and plan for and implement their control. For all employees who are exposed to possible risks from vibration, an assessment of daily vibration exposure must be carried out. The Vibration Regulations contain an exposure action level (EAV) of 2.5 m/s^2 A(8) and an exposure limit value (ELV) of 5m/s^2 A(8). The daily exposure figures are compared with the EAV and ELV to determine what further actions are required.

If the daily exposure of an operator is likely to exceed the exposure limit value, the employer must take immediate action to prevent exposures above this level. If the exposure is likely to exceed the exposure action value, the employer must implement a programme of actions to minimise the exposures and control the risk and also provide health surveillance for vibration-exposed employees.

This paper gives guidance on estimating the daily vibration exposure of employees who are exposed to hand–transmitted vibration, and discusses sources of information on vibration magnitudes.

2 RISK ASSESSMENTS AND DAILY EXPOSURE ASSESSMENTS

The first step in carrying out a vibration risk assessment is to identify if there is a vibration problem that needs to be managed. If there is a problem, the employer needs to identify which individual employees are at risk. For each employee at risk, it is necessary to carry out an exposure assessment, to establish the level of risk and compare it to the EAV and ELV. The employer must develop and implement an action plan to control the exposure and manage the risks from vibration.

To assess an employee’s daily vibration exposure you need information on two quantities:

- The level (magnitude) of the vibration to which each operator is exposed
- The duration of the exposure at that level

The vibration magnitude is represented by the frequency-weighted r.m.s. acceleration on the surface of the tool, handle or workpiece in contact with the hand. The exposure time can be measured in hours, minutes or seconds. These two quantities can then be combined to estimate the

A(8) daily vibration exposure which is compared with the exposure action value and exposure limit value to determine what further action is necessary.

The equation to calculate the daily exposure is:

$$A(8) = a_{\mathrm{hv}} \sqrt{\frac{T}{T_0}}$$

where a_{hv} is the vibration magnitude (in m/s^2), T is the daily duration of exposure to the vibration magnitude a_{hv} and T_0 is the reference duration of eight hours.

Alternatively, the vibration calculator on the HSE website can be used - www.hse.gov.uk/vibration .

3 SOURCES OF VIBRATION MAGNITUDE INFORMATION

When it comes to obtaining a value for the vibration magnitude from the tool or vibrating surface, there are a number of possible sources of vibration magnitudes that might be useful for making an initial estimate of daily exposure. These sources of vibration data may not be ideal for various reasons, however they can be used as a starting point to estimate the risk and implement adequate control measures.

3.1 Manufacturers/suppliers of tools

In accordance with the Supply of Machinery (Safety) Regulations 1992[2], as amended, suppliers of portable hand-held and hand-guided machines must provide information on risks from vibration and declare a vibration emission value. However, vibration emission values declared by machine manufacturers are measured using standard laboratory-based test codes and some of the values may underestimate the vibration likely to be produced in real use. There are a number of reasons for this, which are described in detail in Hewitt and Brereton 2000[3] and Hutt and Smeatham 2003[4].

At the time of writing this paper, most manufacturers' declared emission values are likely to be the highest (single) axis value, whereas the quantity required for a vibration exposure assessment is the total value, a_{hv} . The total value is the root-sum-of-squares of three axes of data a_{hwx}, a_{hwy} and a_{hwz} measured at the same point, given by:

$$a_{\mathrm{hv}} = \sqrt{a_{\mathrm{hw}x}^2 + a_{\mathrm{hw}y}^2 + a_{\mathrm{hw}z}^2}$$

Because of this relationship, a measurement of the total value, a_{hv}, can be between 1.0 and 1.7 times higher than a highest axis measurement, depending on the extent to which the vibration is dominated by a single axis. It is therefore important to know whether the data that has been provided is a highest axis or a total value.

Furthermore, in many existing vibration test codes the measurement may not be made at the hand position of greatest vibration and the specified tool operating task may not be representative of typical real work.

Ask the tool manufacturer or supplier if they can provide a total value, or better still a range of total values, which represents the likely vibration for the equipment or tool when used in work tasks and operating conditions similar to those in your own workplace. Some manufacturer's now provide this information.

3.2 Consultancies, Trade associations, Government information leaflets, scientific publications

If the manufacturer or supplier cannot provide suitable information, other possible sources of vibration data include trade associations, government bodies and specialist vibration consultants (some of whom now have extensive databases). Data can also be found in various technical or scientific publications and on the internet.

3.3 Databases available on the internet

Two freely accessible sources of vibration data available on the internet which may be of use are:

http://www.las-bb.de/karla/index_.htm
http://vibration.arbetslivsinstitutet.se

The vibration information used to estimate vibration exposures should have been measured on similar tools or machines and in broadly similar operating conditions. Ideally the information used will relate directly to the equipment (make and model) which is being, or will be used. However, if this is not available, it may be necessary to use data for similar equipment as a starting point, and replace this with more specific information when it becomes available.

If there is no available information on the likely in-use vibration, an estimate can be made using the tool manufacturer's declared emission value. Because the declared emission is likely to be less than the vibration in real use (see Section 4), it is recommended that as a starting point the declared value should be at least doubled.

3.4 Measuring vibration magnitudes

The Vibration Regulations do not automatically expect an employer to make vibration measurements, if exposures can be assessed adequately using available information. However, there may be situations in which an employer cannot adequately assess the vibration exposures, when it may be necessary to have vibration measurements made in the workplace.

For example:

- To decide which control actions might be most effective and practicable in reducing vibration exposure;
- To be more certain whether exposures are likely to exceed the action or limit values
- To check whether your controls are effective

Remember, that hand-arm vibration magnitudes can be highly variable, and what is measured on one occasion is only a sample. Whether measurements are made in-house or by a specialist consultant, it is important that that whoever makes the measurements has sufficient competence and experience.

Human exposure to hand-transmitted vibration should be evaluated using the method defined in British Standard BS EN ISO 5349-1:2001[5]. Detailed practical guidance on measurement of vibration at the workplace is given in BS EN ISO 5349-2:2002[6].

4 RELATIONSHIP BETWEEN MANUFACTURER'S DECLARED VIBRATION EMISSION AND IN-USE VIBRATION

HSL's program of research, commissioned and funded by the Health and Safety Executive (HSE), has been investigating the relationships between vibration information provided by tool manufacturers and in-use vibration and has covered the major tool types as identified in the BS EN ISO 8662 series of standards. Results from the tools investigated so far are contained in this paper and include; chipping hammers, rock drills, grinders, demolition hammers and road breakers, impact drills, impact wrenches, sanders, rammers, saws, die grinders and needlescalers. For further information about the research at HSL, see Hewitt & Brereton 2000[3] and Hutt & Smeatham 2003[4].

The information gathered from this research is used here to give guidance on the suitability of manufacturers' declared vibration in the estimation of exposure as well as highlighting the variation which is inherent in the process of vibration measurement.

Since the commencement of the first project in 1996, the standard for measurement and assessment of vibration exposure ISO 5349:1986 has been revised. The current version[5] specifies triaxial assessment of exposure whereas the old version used the axis of highest vibration. However, the standards for emission test procedures have yet to be modified in this respect and consequently manufacturers' data are still typically presented in terms of the highest axis of vibration.

Figures 1a and 1b show the results from the 93 tools tested in this study to date. In the figures, the tool categories are presented along the x-axis in the order in which they occur in the BS EN ISO 8662 series of standards[7]. Each vertical line represents an individual tool that was tested during the process of the research.
For each individual tool there are two types of data shown:

1. The manufacturers' declared ***a*** emission vibration (represented by ○) which is single axis data, and
2. The range of measured in-use vibration (total values).

The ***a*** emission level has been used, because this is the most commonly quoted figure, in manufacturers' data tables and can therefore be most readily compared. The emission should, according to BS EN 12096:1997[8], be declared with both an ***a*** value and a ***K*** value, where the ***a*** value represents the vibration emission for a machine and the ***K*** value represents the associated measurement uncertainty, however currently, most manufacturers only declare the ***a*** value.

The measured in-use vibration values are shown as a range of values with each small dot on the vertical line representing the vibration total value measured on one occasion for one experienced operator under one typical operating condition. The Figures show that for each tool there is always a range of vibration, which in extreme cases can be as much as 20 or 25m/s², although a more typical range is 5-10 m/s².

Analysis of the data which have been used to create Figures 1a and 1b show that when the manufacturers' declared ***a*** emission value is compared with the mean field value for each tool, the manufacturers' declared ***a*** emission only exceeds the mean in-use total value in 13% of cases. This is not surprising because the ***a*** emission figure is single axis and the field data are total values (root-sum-of-squares of three axes).

The following table shows the effect on the relationship between manufacturers ***a*** emission data and mean in-use vibration total value of using various multiplication or addition factors.

Table 1. Effect of multiplication or addition factors

	a emission x1.5	***a*** emission x2	***a*** emission x2.5	***a*** emission x3
Percentage of mean in-use total values exceeded	48%	61%	72%	80%

Table 1 shows that, for the data collected by HSL, if the manufacturers' ***a*** emission data is multiplied by a factor of 2 as a way of estimating the mean in-use vibration total value, the estimate of the vibration total value will be equal to or exceed the actual mean in-use vibration total value in 61% of cases.

It is therefore possible to make use of manufacturers' supplied emission test data for the purposes of risk assessment, in the absence of any better information, by applying a suitable multiplication factor to the data.

5 REFERENCES

1. Control of Vibration at Work Regulations 2005. Statutory Instrument 1093/2005.
2. Supply of Machinery (Safety) Regulations 1992. Statutory Instrument 1992/3073.
3. Hewitt S and Brereton P (2000). "Measurement of hand-tool vibration emission and workplace risk." Proceedings of IOA Spring Conference. 17-18 April 2000.
4. Hutt R and Smeatham D (2003). The relationship between vibration emission and workplace risk assessment, Proceedings of the Institute of Acoustics, Vol. 25 (Part 2), pp18-26.
5. BS EN ISO 5349-1:2001. Measurement and evaluation of human exposure to hand-transmitted vibration – Part 1: General Guidelines.
6. BS EN ISO 5349-2:2002. Measurement and evaluation of human exposure to hand-transmitted vibration – Part 2: Practical guidance for measurement at the workplace
7. BS EN 28662/BS EN ISO 8662 series of standards. Hand-held portable power tools - Measurement of vibrations at the handle. *Test codes for specific families of power tools, especially pneumatic tools. Subject to a programme of revision to reflect requirements of BS EN ISO 20643:2005.*
8. BS EN 12096:1997. Mechanical vibration – Declaration and verification of vibration emission values.

Figure 1a. Comparison of manufacturer's declared emission data (highest axis) with HSL measured field data (total values) for chipping hammers, rock drills, angle grinders, demolition hammers and road breakers.

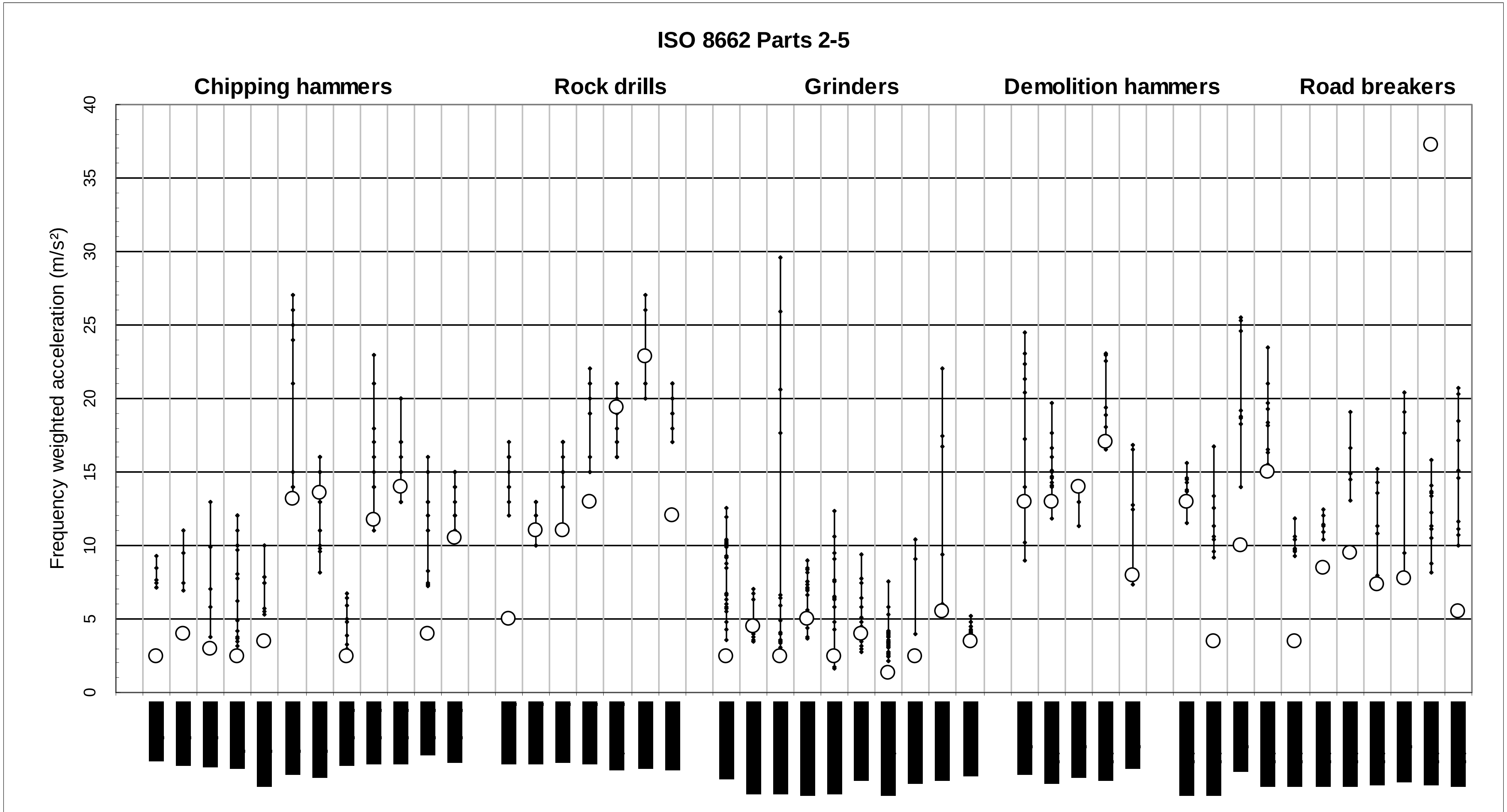

Figure 1b.Comparison of manufacturer's declared emission data (highest axis) with HSL measured field data (total values) for impact drills, impact wrenches, sanders, rammers, saws, die grinders and needle scalers.