DEVELOPMENT OF EXAMPLE HAND-ARM VIBRATION DATA FOR HSE GUIDANCE

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Abstract

Health and Safety Executive (HSE) guidance on the control of hand-arm vibration in the workplace is currently being updated. As part of this update, HSE wanted to provide some example data to help employers understand vibration magnitude values and provide a starting point for many workplace risk assessments.

For HSE it is important to be confident in the validity of any data provided to employers. Information from HSE should be sufficient to give a reasonable estimate of likely risk from hand-arm vibration, which will in many cases enable employers to take appropriate actions to begin to control that risk.

The example data for HSE guidance are to be based on the Health and Safety Laboratory (HSL) database of workplace vibration measurement. For this presentation of the data it was important to ensure that data were collated in to useful collections of machine types. This paper describes some the challenges encountered in producing reliable indicative data from the HSL database that are suitable for publication by HSE.

1. Introduction

Health and Safety Executive (HSE) guidance document L140 [1] supporting the Control of Vibration at Work Regulations 2005 [2] is in the process of being updated, along with supporting material, provided on the HSE web site [3]. As part of this update, HSE plans to provide examples of vibration magnitude data for a range of commonly used machines. The aim of the example data is to help employers understand the likely ranges of vibration magnitudes expected from these machine types and to provide information that will give initial help to those trying to assess the risks they have from hand-arm vibration.

The data for HSE guidance is extracted from the Health and Safety Laboratory's (HSL) database of work place hand-arm vibration measurements. This paper describes some of the challenges encountered in producing reliable indicative data from the HSL database that are suitable for publication by HSE.

2. Use of indicative values in vibration risk assessments

In many instances, the process of performing a hand-arm vibration risk assessment can be simple. The purpose of the risk assessment is to enable appropriate control measures to be identified. The precision required of that assessment will depend on where an employer is in the process of

determining and controlling risks. The vibration data required needs to be suitable and sufficient to enable the correct action to be taken.

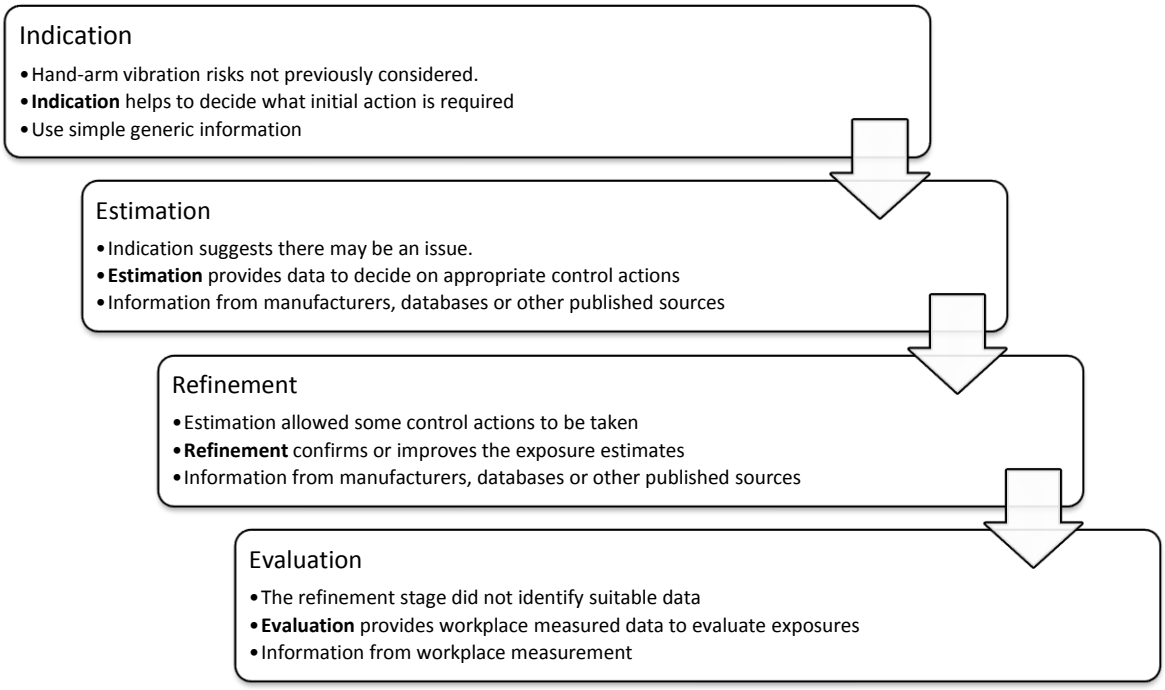

Figure 1 Stages of vibration risk assessment

The stages of assessment might be defined as those shown in **Figure 1**. At the *Indication* stage, a simple rule-of-thumb or use of indicative vibration data can help to quickly decide whether or not further action is necessary. If an employer needs to do work at the *Evaluation* stage, then the information they have been able to get from other sources has not been suitable or sufficient and only workplace measurement can provide the necessary data.

Many employers will be able to get suitable and sufficient information at the *estimation* and *refinement* stages. At these stages the information is obtained from sources such as manufacturer's emission data, public databases or information from authorities such as HSE.

Indicative data published by HSE is likely to be used at the *indication* and *estimation* stages. It must be reliable and cover a wide range of machine types and industries. It should tend to over-estimate risk, so that using the data will not lead to under-protection of workers. The data must be based on reliable, representative workplace measurements made in accordance with the requirements of Physical Agents (Vibration) Directive 2002/44/EC [4] and the Control of Vibration at Work Regulations 2005 [2] and ISO 5349-1 [5].

3. HSL hand-arm vibration database

HSL's hand-arm vibration database has been used to collect data from hand-arm vibration measurements made by HSL since the 1990s. The database forms an integral part of all workplace hand-arm vibration analyses carried out by HSL and is systematically populated with all data on workplace hand-arm vibration that the team generates.

The database is designed to capture essential vibration measurement information along with details of the machines being used, including power source, weight, and inserted tools as well as information on parameters such as the work activity, materials used, location, worker occupation and industry group.

The vibration measurement information in the database has previously been used to provide information for European Commission's non-binding guidance on implementing the Physical Agents (Vibration) Directive 2002/EC/44 [6] [4]. It has also been applied to the evaluation of alternative frequency weightings for evaluation of hand-arm vibration eg: [7].

4. Challenges in producing summarised data

4.1. Producing appropriate statistical information

By default, the HSL database collates measurement records against one machine, for one set of operating conditions, at one location. The primary aim of the data collected is to enable an assessment of likely daily hand-arm vibration exposures. When collating this data for other purposes, it is important to understand the biases that may inadvertently be introduced by simple statistical analysis of the whole data set.

Most workplace measurements involve making multiple measurements of an individual machine. These multiple data sets need to be averaged to produce a single value for each machine (to avoid biasing the data towards machines for which many measurements have been made). The prime consideration has to be producing a data set that is representative of a machine type, incorporating the variations introduced by evaluations with different (experienced) operators and different work activities. Unfortunately, for HSL's database, this averaging is not always trivial, as in some cases, measurements on one unique machine actually cover more than one measurement site.

Many of HSL's projects over the period from 1997 to 2010 have been studies of machinery vibration emission. These projects have usually taken machines into a number of different work environments where they were used by several workers. When collating the data for these machines, each machine has to be considered as a single data set, even where that machine has been measured at a number of different sites. The data value used for each machines is then the average of the averaged values from all of the tests on that machine. To achieve this collation automatically within the database, the concept of a "unique machine" was used. A unique machine identification was determined automatically based on machine type, manufacturer, model and HSL identification.

To further complicate the process of isolating unique machines, some machines could be categorised in different sub-types, based on the inserted tool being used (e.g. a drill can be termed a *hammer drill* if fitted with a standard drill bit or a *core-drill* when fitted with a diamond core bit). The unique machine identification included information to separate out these different applications.

4.2. Identifying useful sub-groups

For any one machine group there is a distribution in measured vibration values. Much of the variation between results is due to differences between machines, operators, materials and inserted tools or

consumables. However, in some cases there are sub-groups within machine types that are characterised by quite different vibration magnitudes. In some cases these sub-groups are predictable, and differences between these subgroups were clear within the data sets. In other cases, the parameters causing the distinct groups within vibration distribution were less clear and prospective sub-groupings had to be tested.

As an illustration, Figure 2 shows the distribution of data from a collection of measurements on needle scalers. This distribution shows two groups, highlighted by different shading. Where such distributions were evident, the data were broken in to sub-categories to try and identify the significant dependant parameters, such as material, inserted tool size or type or fitted consumable. In the case of the needle scalers illustrated in Figure 2, the difference between the groups in the distribution is due to some tools having anti-vibration features and others being standard (non-A-V) tools.

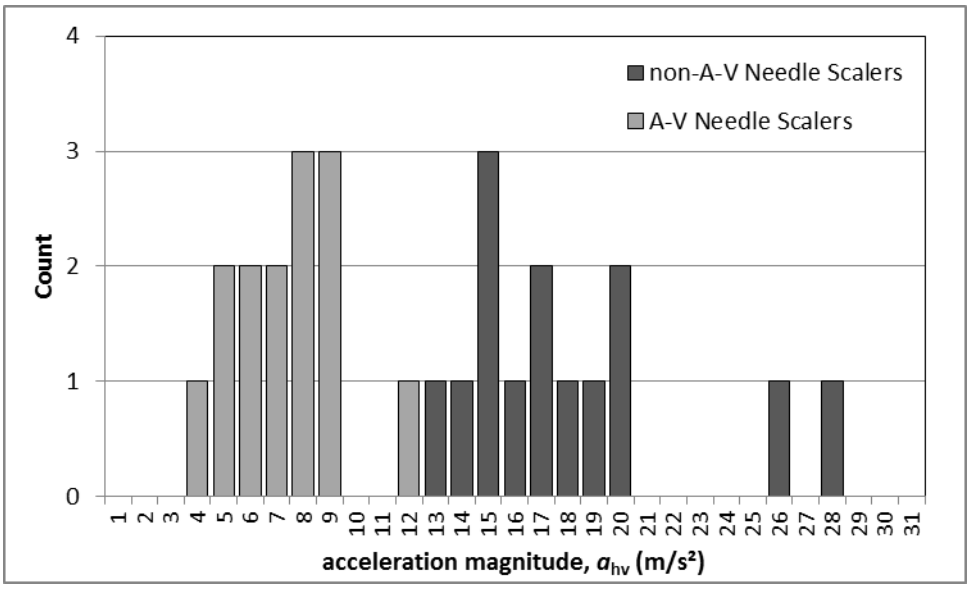

Figure 2 Illustration of vibration magnitude distributions for sub-categories of needle scalers

4.3. Presentation of data in HSE guidance

When presenting vibration values in HSE guidance it is important to make sure that the information is presented in a way that is appropriate for the target audience. In general, the audience for HSE guidance will have familiarity with general health and safety issues, but will not be technically familiar with the topic. The audience is likely to be looking for a way to comply with all health and safety duties without having to understand all of the technical detail of the topic; hand-arm vibration will be just one of many issues they have to address.

The action and limit values in the Control of Vibration at Work Regulations 2005 [2] tend to focus people's attention on the daily exposure values. However, the Regulations are aimed at reducing risks, with the exposure action value used as just one indicator of the likelihood of an employee being at risk. By presenting numerical data in the guidance, there are dangers of the data being used indiscriminately. Therefore, some consideration must be given to how any numerical data is presented.

Figure 3 shows the 10th, 25th, 50th and 90th percentile values for all of the machine groups extracted from the HSL database. Data similar to this has previously been presented by the European Commission in non-binding guidance to implementing directive 2002/EC/44 [6] (the hand-arm vibration data presented in this EC guide is also largely based on data from the HSL database). The presentational format in the EC guide is useful because it indicates not only the magnitudes of the vibration, but also the range of vibration values that might be expected with machine types. However, for a non-technical audience, looking for information to complete a simple risk assessment, this presentation provides too much information, which can be open to misinterpretation or misuse.

Collated information on machine vibration is often valuable in the initial stages of carrying out risk assessments. For this reason it is HSE's preference that such collated data are representative of the worst case vibration values, so that the result of the assessment is that workers are more likely to be over-protected than under-protected. For this reason the 75th percentile is the preferred value for presentation. However, it is also important to give some indication that the value given is only a representation of a range of possible values. The range of values will suggest to readers that, within a machine type, there may be lower vibration machines available or that they may actually have lower vibration magnitudes for their work, but they have to do some additional work to refine their initial assessment.

5. HSE guidance

Table 1 shows the information proposed to HSE for inclusion in a revision of guidance on the Control of Vibration at Work Regulations 2005, L140 [1], currently scheduled for publication in 2015. The Table is planned for inclusion as an Annex relating to sourcing vibration magnitude data for vibration risk assessments.

HSE wants employers to carry out vibration risk assessments that are fit-for-purpose, so that they can move on and focus their efforts on implementing vibration controls. In many cases, sample vibration data and information on exposure times can be quickly combined to give assessments that show clearly what issues the employer needs to address. A more precise risk assessment may be required once controls are in place, particularly when it is not clear whether the controls have reduced the risk to an acceptable level.

The information in Table 1 provides some guide vibration magnitude values, for those wanting to assess likely risk, but also indicates that there are a range of values that might be expected for each machine type. The introductory text to the Table will explain that the 'recommended initial value' vibration magnitudes may be used in combination with exposure durations (trigger times) to make an initial estimate of daily vibration exposures. It will further state that in many cases these estimates will be sufficient to determine duties under the regulations and to review control measures and revise them as necessary.

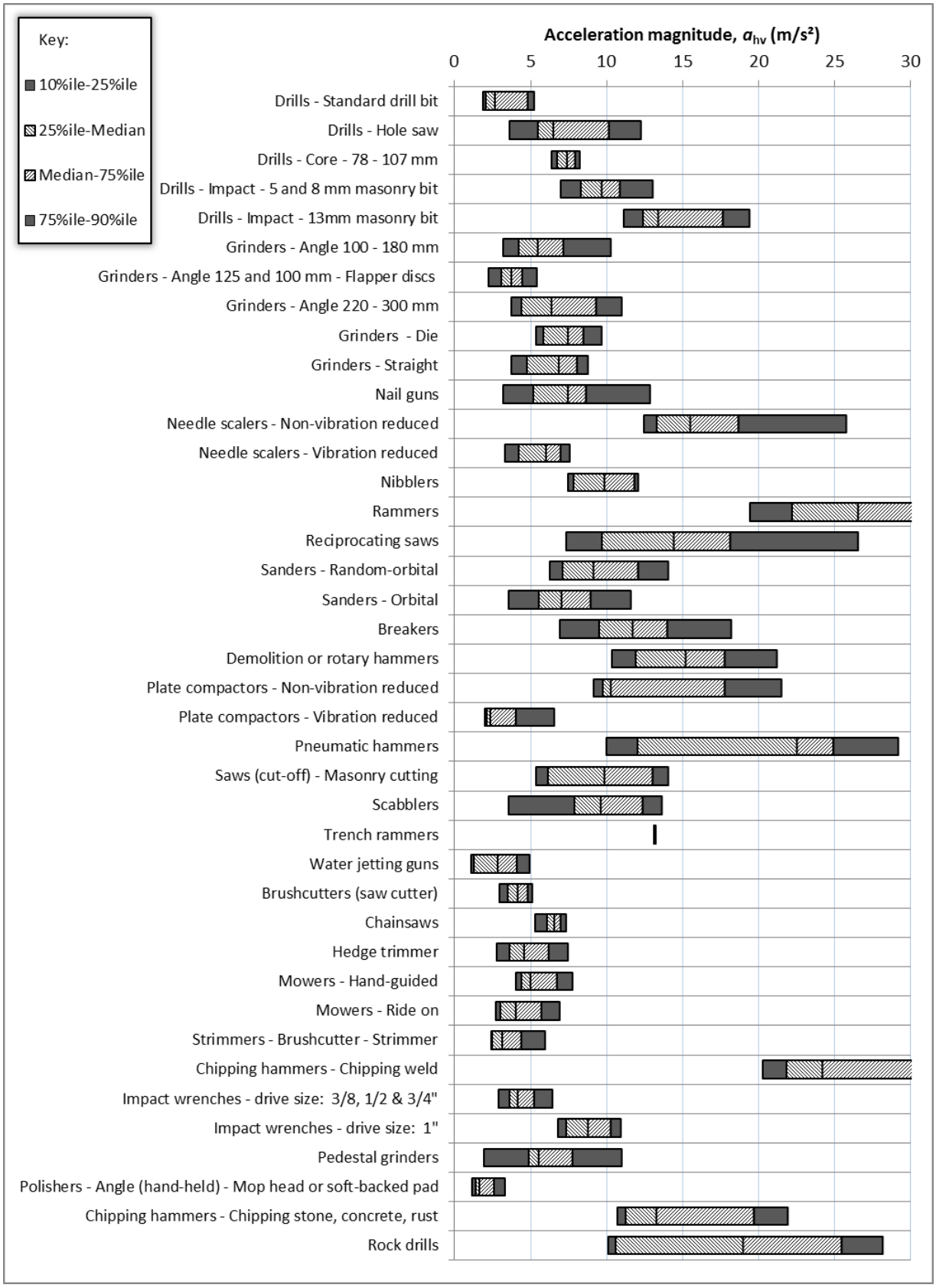

Figure 3 Summary vibration magnitudes for all machine categories
(a_{hv} is the frequency weighted vibration total value, based on the hand position giving the highest vibration value for that machine)

Table 1 Information proposed for revision of HSE guidance

Industry	Tool type	Tool characteristic, Inserted tool, size, process	Range (m/s^2)	Initial value (m/s^2)
General				
	Drills	Standard drill bit	2 - 5	**5**
	Drills	Hole saw	4 - 12	**10**
	Drills - Core	78 - 107 mm	6 - 8	**8**
	Drills - Impact	5 and 8 mm masonry bit	7 - 13	**11**
	Grinders - Angle	100 - 180 mm	3 - 10	**7**
	Grinders - Angle	125 and 100 mm Flapper discs	2 - 5	**4**
	Grinders - Angle	220 - 300 mm	4 - 11	**9**
	Grinders - Die		5 - 10	**8**
	Grinders - Straight		4 - 9	**8**
	Nail guns		3 - 13	**9**
	Needle scalers	Non-vibration reduced	12 - 26	**19**
	Needle scalers	Vibration reduced	3 - 8	**7**
	Nibblers		7 - 12	**12**
	Reciprocating saws		7 - 27	**18**
	Sanders - Random-orbital		6 - 14	**12**
	Sanders Orbital		4 - 12	**9**
Construction				
	Breakers		7 - 18	**14**
	Demolition or rotary hammers		10 - 21	**18**
	Plate compactors	Non-vibration reduced	9 - 22	**18**
	Plate compactors	Vibration reduced	2 - 7	**4**
	Pneumatic hammers		10 - 29	**25**
	Saws - Cut-off	Masonry cutting	5 - 14	**13**
	Scabblers		4 - 14	**12**
	Trench Rammers		13 - 13	**13**
	Water jetting guns		1 - 5	**4**
Forestry / Horticulture				
	Brushcutters	Saw head	3 - 5	**5**
	Brushcutter & Strimmers	Strimmer head	2 - 6	**4**
	Chainsaws		5 - 7	**7**
	Hedge trimmers		3 - 7	**6**
	Mowers - Hand-guided		4 - 8	**7**
	Mowers - ride on		3 - 7	**6**
Engineering				
	Chipping hammers	Chipping weld	20 - 32	**31**
	Impact wrenches	Drive size: 3/8, 1/2 & 3/4"	3 - 6	**5**
	Impact wrenches	Drive size: 1"	7 - 11	**10**
	Pedestal grinders		2 - 11	**8**
	Polishers - angle (hand-held)	Mop head or soft-backed pad	1 - 3	**3**
Stone working / mining / quarrying				
	Chipping hammers	Chipping stone, concrete, rust	11 - 22	**20**
	Rock drills		10 - 28	**26**
	Stone hammers		7 - 22	**18**
Woodworking				
	Jigsaws		9 - 17	**11**
	Routers		2 - 3	**3**
	Staplers		2 - 6	**4**

6. Conclusions

The information in Table 1 is intended to support employers when first carrying out vibration risk assessments. It also provides a reference list of real workplace vibration magnitudes, which employers purchasing hand-held machines can use to compare with manufacturer's declaration data.

The HSL database continues to be updated with new vibration measurement data, and the information in Table 1 may be updated prior to publication. The requirement to provide 10^{th} and 90^{th} percentile estimates in Table 1 placed a practical restriction on the machines that could be included to those where 10 or more sets of data were available (this restriction was relaxed in some cases, for categories of commonly used machine that would otherwise have been excluded from the table). Part of HSL's ongoing work is to look for opportunities to collect information on commonly used machines and processes that are currently not well represented within the database.

It is known that guides providing indicative vibration values are seen as valuable resources by industry. The information currently available in European guidance [6] is known to be popular and widely used by both specialists and employers across Europe. Incorporating similar indicative vibration values into HSE guidance will make the information available to a wider UK audience and help to facilitate the process of assessing vibration risk for employers.

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7. References

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[4] European Parliament, Council, "DIRECTIVE 2002/44/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) ...," *OJ L 177, 6.7.2002.*

[5] International Organization for Standardization, *ISO 5349-1:2001 Mechanical Vibration and Shock – Evaluation of human exposure to hand-transmitted vibration – Part 1 General requirements,* ISO, 2001.

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