

INVESTIGATION OF THE RELATIONSHIP BETWEEN VIBRATION EMISSION AND IN-USE VIBRATION FOR ELECTRICAL TOOLS

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1. INTRODUCTION

The Health and Safety Executive has a programme of research with the Health and Safety Laboratory (HSL) investigating the relationship between manufacturers' declared vibration emission, HSL measured emission and vibration measured during real, or simulated real use for different categories of tool. Current research investigates the emission test codes for electric hand-held tools defined in the BS EN 60745 series of standards.

The work described here investigates the repeatability and reproducibility of the BS EN 60745 series of test codes for tools that are considered to represent the greatest health risk from hand-arm vibration exposure: hammers, angle grinders, saws and drills. Individual reports for two of the test codes are published (HSE Research Reports RR717 and RR754) and two are in press.

2. EQUIPMENT AND METHODS

Triaxial hand-arm vibration measurements were made at the prescribed hand locations on each tool using three single axis piezoelectric accelerometers bolted to a mounting block. The blocks were fixed to the tool handle(s) using either a plastic cable tie and tensioning gun system or cyano-acrylate glue. Data from the accelerometers was collected and processed using a real-time frequency analysis system giving frequency-weighted vibration total values for each measurement location. Five consecutive measurements were made for each of three operators on each tool. The overall arithmetic mean, a , was obtained from the mean vibration total values for the three tool operators. A value for the individual tool deviation, K , was also calculated according to the provisions of BS EN 12096:1997 Annex B.2, where a single tool is used to declare the vibration emission. Following the emission tests, in-use measurements were made using the same accelerometer mounting locations. Operating conditions were chosen to represent typical use of the tool under test.

For comparison purposes, the data were summarised in terms of the tool manufacturers' declared vibration emission, the HSL measured vibration emission and the HSL measured field vibration. BS EN ISO 20643:2008 (ISO 20643:2005) requires that test codes produce values indicative of the upper quartile of real-world use, therefore field data is presented here as upper quartile values. For each test code investigated, tools used were anonymised and assigned an alphabetic identification.

3. RESULTS

3.1. Hammers (BS EN 60745-2-6:2003+A2:2009)

Figure 1 illustrates summary vibration data values for each hammer with a rotary drilling mode when drilling into concrete. Data for hammers in a chiseling or breaking application were also obtained but are not illustrated here.

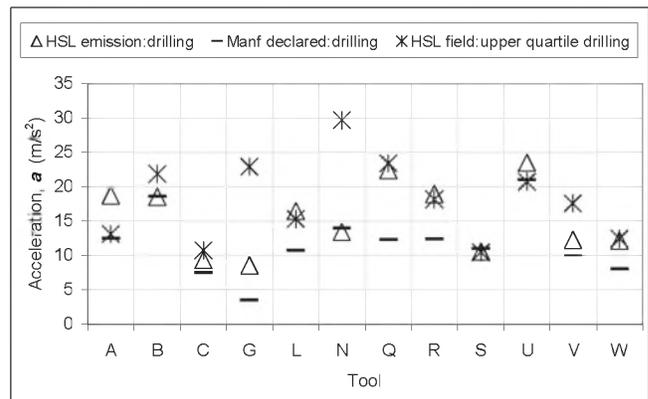


Figure 1. Vibration from hammers (drilling application).

3.2. Angle grinders (BS EN 60745-2-3:2007)

Figure 2 illustrates summary vibration data for angle grinders. Manufacturers' declarations have been assumed to be single axis. All HSL data displayed are triaxial. Field data include both grinding and cutting operations. All emission data were produced using an out of balance aluminium disc.

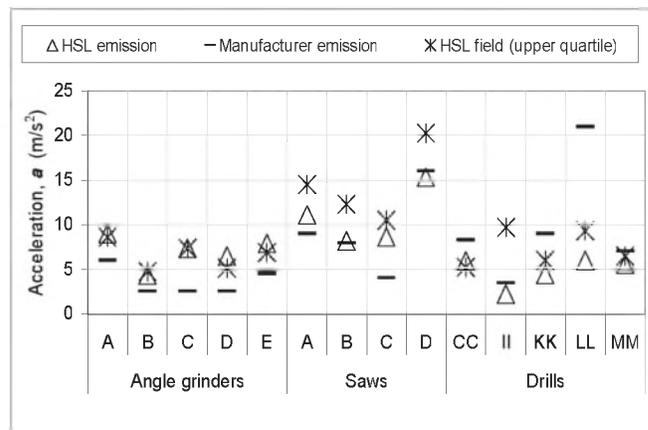


Figure 2. Vibration from angle grinders, reciprocating saws and drills.

3.3. Reciprocating saws (BS EN 60745-2-11:2003)

Figure 2 also illustrates summary vibration data for reciprocating saws. This tool type was tested cutting metal and wood. HSL emission data is at the highest handle for the highest value activity. HSL upper quartile data is for all field activities.

3.4. Drills (BS EN 60745-2-1:2003)

Figure 2 also includes vibration data for drills drilling into metal. Data for impact drilling into concrete, wet diamond core and dry diamond core drilling were also obtained but are not illustrated here.

4. DISCUSSION AND CONCLUSIONS

Manufacturers' declared vibration emissions from test codes such as the BS EN 60745 series and its predecessors were not primarily designed for the assessment of human vibration exposure. However, anecdotal evidence suggests that with the lack of any other information, manufacturers' declared emissions are routinely used in this fashion, and this is actively encouraged by UK and European workplace exposure legislation. BS EN ISO 20643:2008 (ISO 20643:2005) introduced the requirement that results from emission test codes should produce "vibration emission values and uncertainties corresponding to the upper quartile of vibration magnitudes resulting from intended uses of the machinery". As Table 1 shows, this requirement has not yet been met.

Table 1. Summary of BS EN 60745 test code investigations.

	Hammers	Angle Grinders	Saws	Drills
Repeatable (HSL $C_v < 0.15$)	Yes	Yes	Yes	Yes
Reproducible (HSL $a \leq \text{manf. } a+K$)	33-40%*	60-100% [†]	50-75%*	9-100%*
Manf. emission representative of HSL field upper quartile	27%	0-80% [†]	0%	0-80%*
HSL emission representative of HSL field upper quartile	65-83%*	100%	25%	20-100%*

*Dependent on operating mode. Manf. = manufacturers'

[†]Dependent on whether single axis or triaxial emission declaration

It is not always clear from tool instruction manuals which versions of standards the manufacturers have used for vibration emission declaration. This means it is difficult to be certain whether data is single axis or triaxial, as was the case here for angle grinders. A recent revision to the European Machinery Directive (2006/42/EC) requires

manufacturers to use the latest versions of the standards, in which triaxial measurements are required. Hence in future, all vibration declarations should be triaxial; tool manuals should identify which standard has been used.

Both the manufacturers' declared vibration emissions and the HSL measured emission values under-estimated exposures when compared to HSL field upper quartile values, but HSL data compare more favourably. Several factors were found likely to influence manufacturers' declared and HSL measured emissions, including:

- operating mode of the tool, e.g. drill II was capable of drilling metal, dry diamond core drilling, and impact drilling concrete, producing emissions of 2.2-15.9m/s²;
- orientation of the tool during use, e.g. hammers produced about 30% more measured vibration when drilling vertically compared to drilling horizontally;
- accelerometer location on the tool, e.g. angle grinder measured vibration ranged from 15.1m/s² to 6.0m/s² at the outer and inner edges for the same tool handle.

The BS EN 60745 standard series still allows for a fair comparison between tool emission values. However, declared emissions are not always reproducible and may fail to warn users of the potential workplace vibration hazard.

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