inter·noise 83

METHODOLOGIES OF THE VIBRATION MEASUREMENT OF PNEUMATIC TOOLS

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1. INTRODUCTION

"Would you please supply me with the vibration levels produced on the handles of your grinding machines?" This is a request frequently received by manufacturers of vibrating equipment. "Exposure to vibration levels above this value for a significant length of time will lead to a risk of developing vibration disorders of the hand". This is a typical statement in a standards document in the field of hand arm vibration. In order to respond meaningfully to a request for vibration measurement data or to assess a tool in terms of the risks incurred by its use then it is necessary to have available a methodology for vibration measurement. This methodology should be precise, lead to consistent measurements and should be widely adopted.

Pneurop, the European committee of manufacturers of compressors, vacuum pumps and pneumatic tools has been looking at the problem of measurement of vibration on the handles of tools for some years. The committee has proposed methodologies for several tools and has tested them using a "round robin" test. In this test a specific tool is sent to many laboratories where measurements are made according to the proposed methodology and the results subsequently compared. This paper presents some of the progress made by the Pneurop committee in determining adequate methodologies for three pneumatic tools.

2. GENERAL CONSIDERATIONS

It is generally accepted that the parameter required to be measured is the one-third or octave band spectrum in the frequency range 6 Hz to 1200 Hz. In each band the rms acceleration (ms^{-2}) is reported. A weighted value can be calculated or measured using the filter network described in ISO DIS 5349.

Where possible the methodology should describe a measurement procedure which simulates the real working situation.

There are a number of specific points which are common to a methodology for any tool.

2.1 Location of the transducer

Vibration levels vary at different positions on the handles. The levels in the high frequency bands are those most affected. It is recommended that the location of the transducer be specified precisely.

2.2 Direction

It is necessary to specify the directions for the measurement of the vibration. Usually a tool has one direction in which the vibration is greatest. For example this direction is parallel to the blow axis in a percussive tool or the direction perpendicular to the surface being ground for a grinding machine.

2.3 Rotation speed or repetition rate

In many cases the vibration signal is quite periodic with a period determined by the rotation speed or the repetition rate. The spectrum is then very dependent on changes of speed. The speed must be specified within a certain range and monitored. The speed should be chosen according to some criteria relating to the tool such as speed for maximum power. If possible the frequency should be near to the centre of the appropriate band so that small changes in speed do not move the fundamental out of the band.

2.4 Percussive vibration

It is well known that very high peak accelerations found with many percussive tools often cause the accelerometers to behave in a non linear manner. The methodology should ensure that such problems are avoided by use for example of mechanical filters. Information on this topic can be found in reference [1].

2.5 Measurement of r.m.s. value

The methodology should recommend the method used for determining the band r.m.s. values. These can best be evaluated using true integration for an appropriate length of time. The Pneurop committee conducted a 'round robin' test in which a taped signal was sent round the laboratories and an octave band spectrum obtained. Errors as large as 4dB were found in results obtained using 'eyeball' averaging with sound level meters. [1]

The length of the vibration signal taken in the measurement needs to be specified and also the number of repeated measurements required to give an acceptable statistical result should be stated.

3. DETAILS FOR SPECIFIC TOOLS

A major factor determining the vibration on a tool is the work process. When considering a methodology for a specific tool this work process must be carefully defined.

3.1 Portable grinding machines

Pneurop have issued a methodology for the measurement of vibration on portable hand grinders [2]. The procedure details, inter alia, the operation of the machine during the measurement. A specific shaped piece of steel is held in a vice and ground for two minutes. The grinding wheel used is partially specified but a problem was discovered with respect to the balance of the wheel. Numerous tests were carried out to determine the effect of the out of balance in the wheel on the measured vibration spectrum. It was discovered that the running free vibration level was a good measure of the dynamic out of balance of the mounted wheel. The out of balance can change during a grinding operation but it was found that after several grinds the wheel tends to stabilise. It is recommended that the wheels should be conditioned in this way before the measurements are taken. There was a good correlation between the vibration level in the band containing the rotational frequency when grinding and the residual out of balance of the wheel. This resulted in a good correlation between the measured weighted value and the out of balance. It may be necessary to be more specific about the grinding wheel used, in particular the balance characteristics.

In the round robin tests seven laboratories measured the vibration on the handles of an angle grinder using a cup wheel. The machine is illustrated in Fig. 1. The agreement was typically within 20% but in the 63Hz octave band the spread of results was quite a lot higher. [3]

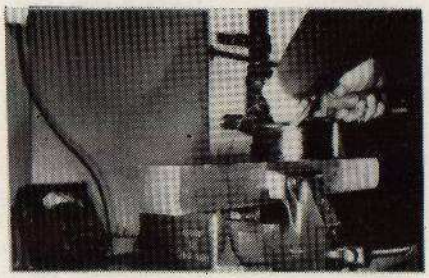

Fig.1. An angle grinder grinding steel.

3.2 Chipping hammers

Initially Pneurop found that the non linear behaviour of the accelerometers was the greatest problem in measuring vibration on these percussive tools. By use of the mechanical filter and investigating the performance of the mounted transducer with the 'back-to-back' test [1] the committee was confident that correct measurement could be made.

For the methodology the tool is used to cut a chip from a piece of steel. The size and quality of the steel is specified. A simple rig is described to enable an operator to cut an even and known thickness chip from the steel. The cutting speed is defined. A round robin test obtained agreement with a standard deviation less than 30% in the frequency bands from 31.5Hz to 1000Hz [1].

The methodology for chipping hammers has been agreed by the Pneurop committee and will be available shortly.

3.3 Road breakers

The primary problem in setting up a methodology for these tools is the operating process. Currently both hand held and rig mounted systems are being investigated. Also the work process i.e. breaking concrete or by the use of some energy absorbing rig e.g. steel shot or a hydraulic system is being assessed. There is a need to devise a work process which will give repeatable values and also be representative of the tool as used in the practical situation. At the present time it is thought that it may not be possible to satisfy both these criteria precisely. It has been found that a steel shot absorbing system gives repeatable results and is comparatively simple to set up. The road breaker mounted in this rig is illustrated in Fig.2.

Fig.2. A road breaker in the rig.

A round robin is underway which will test the proposed methodology and also compare measurements obtained using both a test rig and a man breaking concrete.

4. CONCLUSIONS

It is very difficult to obtain a methodology which allows for very accurate assessments of the vibration of any specific vibratory tool. But only by using the same methodology can sensible decisions be made about the level of vibration from a specific tool or can comparisons be made of the vibration from different tools.

Methodologies although imperfect should be adopted by both national and international bodies. The uncertainties in the measurements even when using these methodologies should be recognised and this knowledge be reflected in the setting up and the use of standards in the field of human exposure to hand arm vibration.

5. REFERENCES

[1] Vibrations in Pneumatic Hand-held Tools: investigations on hand-held percussive tools Pneurop.

[2] Test procedure for the measurement of vibration from hand-held portable power driven grinding machines.

[3] Vibrations in Pneumatic Hand-held Tools: investigations on hand-held grinding machines. Pneurop.

Copies of these documents can be obtained from: British Compressed Air Soc.(BCAS) 8 Leicester Street, LONDON WC2H 7BL, UK.