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HAND ARM VIBRATION, MEASUREMENT AND EVALUATION

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Introduction

If the hand is subjected to vibration as a result of holding a vibrating tool or workpiece then eventually the fingers are liable to develop a disorder of the blood supply which leads to attacks of blanching. This condition was named Vibration Induced White Finger (V.W.F.) by the Industrial Injuries Advisory Council (1975). V.W.F. is found in many sections of industry particularly amongst workers using pneumatic drills and chipping hammers, hand held and pedestal grinders and chain saws.

In February 1975, the British Standards Institution published a Draft for Development: Guide to the Evaluation of Exposure of the Hand Arm System to Vibration (DD43 1975). The purpose of this document was to recommend some provisional exposure limits for hand transmitted vibration which when used as guidance by users and designers of vibratory tools would help to reduce the incidence of V.W.F.

Since the publication of DD43, research has continued and the purpose of this paper is to identify the areas of difficulty likely to be encountered in the measurement of hand transmitted vibration, to indicate what precautions can be taken and to review current recommended exposure limit proposals; in particular those suggested in DD43 and those which are to be recommended by the International Organisation for Standardisation (I.S.O.). The appropriate sub-committee of I.S.O. has agreed the format of these recommendations and as they differ somewhat from those made in DD43, some comparative evaluation would clearly be helpful.

Vibration Measurement.

In general the vibration must be considered as a random process and hence must be characterised in terms of time averaged quantities. The most usual way of doing this is to determine root mean square values of the signal in either octave or

third octave bands over the frequency range 4Hz to 1000Hz. The parameter measured is acceleration because of the availability of good transducers. Velocity or displacement can be determined using integrating circuits. There are a number of practical points to which particular attention must be paid in order that meaningful vibration measurements are made.

1) Choice and mounting of the accelerometer.

The accelerometer should have a sensitivity of the order of 2.0 pC/ms^{-2} with a high resonant frequency and good temperature and base strain sensitivity characteristics. In many situations the vibration is produced by a series of impacts associated with shock pulses having very high peak acceleration levels which can cause the DC level on the output of the accelerometer to change. This results in difficulties in the subsequent analysis. These can be overcome by placing a resilient pad between the accelerometer and the vibrating surface. The pad behaves as a low pass mechanical filter and prevents the very high peaks associated with the high frequencies from disturbing the accelerometer.

2) Dynamic Range of the instrumentation.

The dynamic range of the instrumentation is usually limited by the characteristics of the tape recorder. Often the signal will have large contributions from frequencies above 2000Hz and these can be reduced by the use of a low pass electrical filter before the tape recorder. An integrator to obtain velocity would act as such a filter. It is important that the input stage of the preamplifier is not instantaneously overloaded by the very high peaks. If the time constant of the overload indicator is too long it will not indicate an overload from a pulse of very short duration.

3) Short duration signals

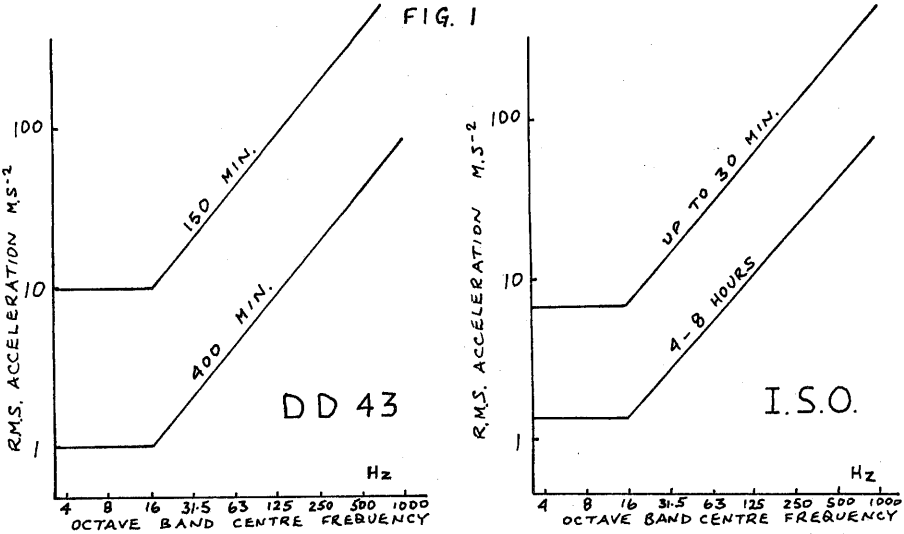
Many vibration processes consist of bursts of short duration, e.g. fettling, grinding of castings etc. In order to obtain reliable estimates of the R.M.S. values a loop may need to be formed so that a long averaging time can be used. It is better to form an electronic loop rather than a tape loop to obviate the difficulties due to the pulse produced by the tape splice. If true integration is available, then analysis of a single sample may be possible but then many samples will be required

to determine an ensemble average. The accuracy of the measurements decreases with short signals and with lower octave band centre frequencies.

Guidelines for safe exposure limits.

Both DD43 and the I.S.O. proposals present recommendations of safe exposure limits. These proposals are still largely based on subjective evaluation of vibration and do not purport to be damage risk curves. Figure 1 shows the recommended curves of DD43 and the I.S.O. document.

FIG. 1

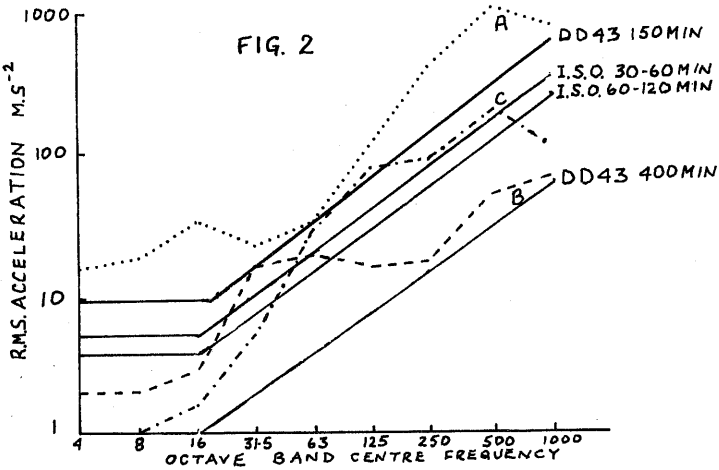


The shape of the curves is identical in both documents and the 4-8 hours exposure curve of I.S.O. is only a little higher than the 400 min. curve of DD43. The I.S.O. curves for shorter duration are close to those expected from the use of an equal energy principle but DD43 allows a 100 fold increase in the power for a 3 fold decrease in the exposure time. The I.S.O. curves are therefore stricter in terms of the allowed vibration levels and are easier to use in order to evaluate a complex exposure pattern.

Assessment of Recommended Exposure Limits.

A number of processes have been investigated and the vibration

spectrum compared with the recommendations of DD43 and the I.S.O. document to test the effectiveness of the recommendations. Only one such process will be discussed here. Figure 2 show the spectra from some pneumatic tools together with the proposals of DD43 and I.S.O.



Spectra A and B were recorded from a pneumatic hammer used for bending sheet metals and spectrum C was measured on an air drill used for enlarging holes in sheet metal. In both cases the exposure time was estimated at 1 hr. per day. Spectrum A relates to levels on the chisel itself and is clearly unacceptable whichever recommendation one applies. Spectrum B was measured on the barrel of the hammer. DD43 suggests that this level of vibration is close to being acceptable. However, the I.S.O. proposals indicate a contrary conclusion. Different conclusions are also drawn when Spectrum C is compared with the recommended exposure limits. As V.W.F. had occurred with the users of both tools, there is some suggestion that the I.S.O. min. limit from DD43 is not strict enough and that the I.S.O. proposals may be suggesting more realistic limits.

Conclusion

There is some suggestion that the 150 min. per day curve in DD43 is not strict enough. Consequently there is the possibility that a hazardous vibration would not be identified through the application of DD43. The I.S.O. proposals appear to be more consistent in the prediction of a hazard at present. Clearly more research is required in order that the correlation between vibration exposure and the epidemiology will lead to realiable damage risk criteria upon which a definitive standard can be based.