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# VIBRATION EXPOSURE AND SUBMARINE CONSTRUCTION

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## 1. INTRODUCTION

High levels of vibration can be transmitted to the hands, arms and shoulders of operators using vibrating tools and machines. The degree of vibration transmitted to these body parts is dependent on many factors. Besides the type of tool or machine used, vibration exposure is also related to the way in which the tool or machine is used, how it is gripped, the amount of push force used, its orientation, etc. These and other relevant factors can also vary considerably between operators.

Vibration of the hand-arm-shoulder system can be a source of discomfort to the operator, leading to reduced proficiency in the use of the tool or machine. Habitual exposure to such vibrations can also cause occupational diseases in those parts of the body exposed to vibrations, such as Vibration White Finger (VWF).

Vibrating hand tools are used extensively in shipbuilding industries, and as such the vibration exposure of construction workers has to be monitored and reduced where necessary. In the UK, the Health and Safety Executive [1] have recommended that programmes of preventative measures and health surveillance should be carried out where daily 8 hour hand exposure regularly exceeds a frequency weighted acceleration dose (AEQ) of 2.8 $ms^{-2}$. An exposure at this level may cause VWF in about 10% of the exposed personnel after 8 years [2].

This paper discusses aspects of the occupational vibration control programme used in the UK submarine construction industry and the steps made to limit vibration exposure to this level.

## 2. USE OF HAND TOOLS IN THE SUBMARINE INDUSTRY

There are many types of metal working tools and machines used in the construction of submarines. This paper will concentrate on three of the most commonly used pneumatic hand tools, namely: grinders, rotary files and needle scalers.

Grinders are used to cut metal plates, and grind down welds and protrusions. They are usually held by two handles at right angles to each other in the plane of the grinding disk (Fig. 1). The disks are dependent on the make and size of the machine, and in this study varied from 75 mm to 225 mm in diameter and rotated at speeds between 6000 rpm and 17000 rpm.

Rotary files are cylinder shaped (Fig. 1) and are gripped along their length by both hands. They are used as polishing tools, or to grind in areas where it is inaccessible for grinders. Rotary files are used with a selection of attachments, mainly rotary burrs, but also with buffs and mini grinding disks. The rotational speeds of rotary files again vary with the make of file, and those in this study, attached with rotary burrs, ranged from 18000 rpm to 32000 rpm.

Needle scalers are used to descale rust or paint from metal plates or grillages. They are normally 'pistol' shaped with a handle and trigger, with a series of metal rods ('needles') protruding from the barrel (Fig. 1).

From observations of tool operators progressing actual tasks, it was found that the above tools types were typically used for up to 4 hours in an 8 hour working day. A vibration exposure of 4.0 $ms^{-2}$ over 4 hours is equivalent to an AEQ of 2.8 $ms^{-2}$ [2]. This 4 hour target level will be referred to in this paper.

## 3. VIBRATION MEASUREMENT PROCEDURE

The first stage of the vibration control programme was to measure the vibration levels of hand tools whilst they were being used. Each tool operator who took part in this study wore a ring mount, over his middle finger and protective glove on each hand, on which 3 miniature accelerometers were attached to enable vibration measurements to be made in the x, y and z directions relative to the hand [2]. The accelerometers were connected to a sound level meter vibration analysis system.

At the beginning of each test, the operator was requested to hold the tool in the normal manner and use it on a metal test block in the way that would mimic normal operating conditions. In order to minimise the effects of DC shifts associated with sudden large impacts (eg. when putting the tool to the job), vibration measurements were commenced after the tool was put to the job and completed before the tool was removed from the job and stopped.

Simultaneous vibration measurements for each hand in the x, y and z directions were taken over 2 to 3 minute time periods for each tool run. This period was chosen to ensure that sufficient time was allowed for the vibration meters to record the required weighted frequency range of vibrations, but sufficiently short to prevent the operator from tiring. The meters were also configured to take 'snap shot' sample measurements every 30 seconds during the tool run as a means to identify whether any DC shifts were evident. Measurement were repeated several times for each tool with various operators and the vibration levels then averaged. A summary of the average levels for the tools used in this study are shown in Fig. 2.

## 4. RESULTS

During this study, it was found that there was a considerable variance in vibration levels between tools of the same type (Fig. 2) and also when different operators used the same tool.

Of the tools investigated, needle scalers were found to produce the greatest magnitude of vibration. The highest average vibration level in any one direction was always found to be in excess of 4.0 $ms^{-2}$ and along the y axis (across the knuckles) for the left hand. The highest average vibration level was found to be 22.0 $ms^{-2}$ (Fig. 2). Subjective comments made by the tool operators indicated that needle scalers were by far the most uncomfortable tools to use with regard to vibration transmitted to the hands.

For rotary files, the dominant axis of vibration was again found, with few exceptions, to be with the left hand. Certain rotary files produced average vibration levels up to 4.8 $ms^{-2}$ (Fig. 2) but most were within the 4.0 $ms^{-2}$ target.

Most grinders produced average vibration levels within the 4.0 $ms^{-2}$ target, but no pattern of dominant vibration axis was found. The highest average level produced by any one grinder was found to be 5.0 $ms^{-2}$ (Fig. 2).

Tests were also carried out on some of the grinders when fitted with proprietary vibration damped handles. It was found that such handles reduced the highest level in any direction by the order of 1 $ms^{-2}$ on average.

## 5. REDUCTION OF EXPOSURE

For the few types of grinders and rotary files that fell outside the 4.0 $ms^{-2}$ target, it was recommended that these be withdrawn from use, and be replaced by other tools investigated in this study which produced lower vibration levels, or be fitted with proprietary vibration damped handles.

For needle scalers, since each tool produced vibration levels in excess of 4.0 $ms^{-2}$, the short term recommendation would be to restrict their daily usage until they could be replaced with tools that produce less exposure.

For new tools, it was also recommended that vibration exposure be a criteria in the their purchasing policy.

In parallel with the above measures improved medical screening for symptoms of VWF have been instigated for all users of vibrating hand tools.

## 6. CONCLUSIONS

This paper has shown how the vibration exposure of personnel from hand tools has been identified as part of an occupational vibration control program, with the aim of reducing vibration exposures to within appropriate limits. Further studies have been proposed to investigate the effect of different grinding disks, tool speed and orientation, and further palliative measures for existing tools.

## 7. REFERENCES

[1] 'Hand Arm Vibration' (HSG88) Health and Safety Executive 1994
[2] BS 6842:1987 'Guide to Measurements and Evaluation of Human Exposure to Vibration Transmitted to the Hand'

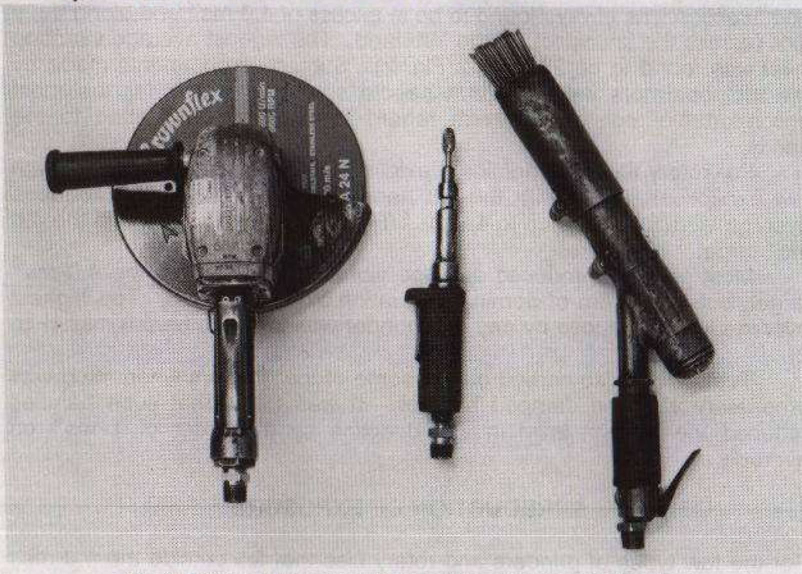

Fig. 1 Typical Grinder, Rotary File and Needle Scaler

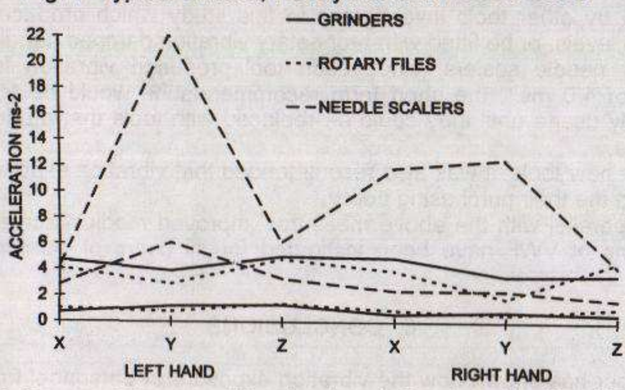


Fig. 2 Range of Average Vibration Levels Produced by Hand Tools