1. INTRODUCTION

Tecforce was commissioned in late 1996 by one of the UK's major manufacturer and refurbisher of railway rolling stock to risk assess employee exposure to hand arm vibration (HAV) from a variety of hand held pneumatic tools used in the manufacture and refurbishment of railway rolling stock and associated activities.

An additional requirement of the client organisation was that Tecforce Ltd. identified and evaluated control measures as to their effectiveness and suitability and these measures should include alternative vibration reduced hand held tools, processes and anti-vibration gloves.

These 2 requirements (risk assessment and evaluation of controls) were fundamental to assisting the client organisation develop a HAV Management Programme.

The requirements for the workplace risk assessments was the result of an increasing level of civil claims within the rail transportation sector for the condition commonly referred to as Vibration White Finger (VWF).

To assist Tecforce Ltd in the workplace risk assessments the client organisation completed a simple tool checklist, including details of tools and activities to be assessed, complete with numbers of employees exposed and their exposure duration in hours for each of the tools/activities declared. Initial estimates as to the number of tools/activities likely to be assessed was anticipated to be in excess of 100 but the final number was in fact in excess of 200.

An additional requirement was that assessments had to be undertaken during routine production activities.

The client organisation comprised in excess of 35 autonomous/semi-autonomous businesses located at up to 10 sites throughout the UK at locations ranging from Lancashire in the North West of England to Kent in the SouthEast.

2. RISK ASSESSMENT CONSIDERATIONS

2.1 Choice of measurement techniques

Given the requirement to carry out risk assessments during routine workshop operating activities, it was decided at the onset, that the only practical means of measuring the levels of vibration on the surface of hand held tools and subsequently transmitted to the Hand Arm System, was by means of an indirect method of attaching the vibration transducer to the tool being evaluated.

Indirect attachment methods involve attaching the vibration transducers to a small lightweight metal block secured to the tool surface by either gripping it between the hand and vibrating surface, or, alternatively, attaching it by other means, such as a plastic electrical cable tie.

Direct attachment methods include attachment of the transducers directly to the vibrating surface of the tool by means of glue, beeswax or a threaded stud. The direct method of attachment was considered to be totally impractical for the type of study being undertaken.

The decision to adopt an indirect attachment method was made following discussions with the Rolls Royce Company Environmental Unit in based in Derby as to developments over the last decade, especially with respect to measurement techniques.

Rolls Royce has been actively engaged in the management of HAV for over 10 years and is currently one of the leaders in the field in terms of vibration assessments and clinical measurements of the condition.

From their initial HAV workplace assessments which began in the late 1980's the Rolls Royce Company Environmental Unit have successively adopted and developed over the past decade the indirect method of attaching the transducers.

For their initial HAV assessments which took 20 months to complete, from March 1987 to November 1989, a Bruel and Kjaer Human Response Vibration Meter Type 2512A was used in conjunction with either the hand adapter (Bruel and Kjaer type UA 0891) or a handle adapter (Bruel and Kjaer type UA 0894). The Hand Adapter is recommended for tools with low frequency vibrations, such as grinders with the handle adapter being the preferred option for high frequencies associated with percussive tools. The hand and handle adapters are both examples of indirect attachment techniques involving them being interposed between the operator's hand and tool surface and gripped.

Both of these devices gave comparable results with mounting the vibration transducers in a mounting block and attaching it to the tool with a plastic electrical cable tie.

Because the correlation was acceptable and because the adapters offered improved practicability for attachment and speed of measurements, they were adopted by Rolls Royce.

This protocol has been progressively amended to take account of developments in measurement instrumentation, assessment criteria, standards and authoritative guidance over the last decade.

The instrumentation currently used and endorsed by Rolls Royce is the Castle GA 2001 Vibration and Harm meter complete with triaxial pre-amp box and HARM BLOK fitted with miniature HARM accelerometers. The HARM BLOK is almost identical to the B & K Hand adapter.
Based upon Rolls Royce's experiences and satisfaction with. the results obtained, Tecforce made the decision to purchase similar instrumentation for their workplace assessments.

2.2 Vibration measurement period

Because the number of tools / activities requiring to be assessed was in excess of 200, spread over 35 businesses at 10 or more sites, it meant that there were time constraints for the assessments undertaken to the extent that measurement duration was restricted to 5 minutes under representative operating conditions.

2.3 Arbitrary categorisation of tools / activites

Based upon the H S E action level of 2.8 ms^2 (A8), Tecforce arbitrarily classified the tools / activities assessed in terms of high, medium and low risk activities to help prioritise HAV Management action relative to control. The (A8) values assigned were as follows: -

< 2.0 ms^2 Low

2.0 – 2.8 ms^2 Medium

2.8 – 5.6 ms^2 High

2.4 Monitoring costs

No corporate funding was made available by the client organisation for the workplace assessments and, because Tecforce were providing their services on a consultancy basis for which they were charging at a daily rate, it meant that the businesses were expected to fund the cost of their own assessments. Some businesses were reluctant to meet the assessment costs and would only spend the bare minimum on them. This placed additional pressure on Tecforce assessors to complete assessments and report on their findings within the budgeted timescales.

2.5 VWF Project co-ordinator

Difficulties with the initial assessments undertaken, centred on the problems of co-ordinating the tools to be assessed and the availability of workpieces for them to be used on within the allotted time scales allowed for in the budget price to each business.

This problem was overcome to some degree, by the client organisations appointing a series of VWF Project Co-ordinators with responsibilities for co-ordinating assessment arrangements between Tecforce and the individual businesses. The Co-ordinators were part of the client organisation's steering group, which included Tecforce representation

2.6 Presentation of assessment findings

Initial reports of the assessment findings included details of the potential incidence rate (if any) for the exposed population for the onset of vascular symptoms based upon the vibration level and duration of exposure at that level.

2.7 Control monitoring versus exposure monitoring

The time constraints associated with assessments meant that time did not permit the exposures of individual employees within a group to be measured and the results obtained were therefore only valid for the purposes of control monitoring.

2.8 Time constraints

The assessment programme, including an evaluation of alternative tools, processes and gloves, was completed over a 22-month period with the initial assessments involving 35 businesses and 212 assessments being completed in 18 months. This represented a completion rate for the initial assessments of 2 businesses per month with an average of 6 assessments per business being undertaken. The average time taken to complete 6 assessments and report on the findings was between 1.5 and 2 days.

3. Risk Assessment Development

3.1 Problems Encountered

3.11 Employee Awareness

When operators involved in the risk assessments were not briefed beforehand, those whose sympathies lay with colleagues who have VWF, or who had not yet been re-deployed themselves, as health surveillance had not been completed at all sites, were apt to attempt to ensure that the levels of hand-transmitted vibration measured were high.

Operators felt that the assessments were being imposed by management, who wished to minimise the ability of those with VWF to claim compensation, which was exacerbated by the intrusive nature of measuring hand-transmitted vibration. Consequently, awkward questions were posed, or attempts were made to ensure that the activity was measured during the worst-case scenario, in terms of HAV transmitted, rather than the normal procedure. Measurements were repeated, or confirmation sought with superiors, as necessary. The need for employee awareness training, or briefing as a minimum, was apparent.

3.12 Declared Exposure Time

By far the most important factor which was affected by the lack of briefing beforehand was the declared exposure time. Even when it was explained to the operator that the 'tool contact time', as opposed to the activity duration, was required, he would still generally over-estimate the time, as the question was perceived to be performance-related.

The A(8) value for each activity assessed was calculated from the vector sum and the duration of exposure. However, the assessments were employed to categorise activities, and the general over-estimation of exposure time would primarily affect the calculation of daily vibration exposure. For the desired outcome, the method of time estimation was still considered satisfactory, as the over-estimation was normal, although times were confirmed with supervisors and/or risk managers where this was considered critical, ie where a partial A(8) was close to a category limit. The process of accurately estimating exposure times, in order to determine daily vibration exposures, is ongoing, co-ordinated by VWF Project Managers.

3.13 Reporting Constraints

The need for improvement, or more accurately flexibility, in reporting, was identified following a request, by one of the depot risk managers, to remove any comments relating to the potential for blanching from the assessment report. Related factors, including the lack of alleviation of rated severity of exposures to hand-transmitted vibration from rest periods, in current standards, were also questioned.

This prompted a review of the current literature relating to assessment[1] and control[2] of exposure, with more comprehensive information added to the reports, as necessary, taking into account customer needs. For example, where it was possible to introduce process changes cost-effectively, specific recommendations were made, where practicable, based upon Health and Safety Executive guidance.[2,3] The scope of the reports was expanded to take account of noise and ergonomic factors, in general, and particularly other work-related upper limb disorders (WRULDs). Although the consensus of opinion was that the reports were too technical, it was agreed that a minimum of technical information should be retained in the reports, for explanation of calculations and methods used.

3.2 Evaluation of Gloves

When the risk assessments had been completed at the major sites, Tecforce began to evaluate gloves from major market distributors. The methodology used was, initially, to invite the major glove manufacturers to provide samples of their 'anti-vibration gloves', in order to assess them during a selection of activities which had been identified during risk assessments as high or medium risk. The HARM BLOK™ was inserted through a hole made in the glove, on both hands where practicable, thereby ensuring that the adaptor could detect the vibration transmitted through the glove. In all cases, all attempts were made to ensure that the connections to the transducers were not disturbed during measurements, in order to reduce tribo-electric effects.

All attempts were made to ensure that the same operators, tools and contact times were employed during glove evaluations. Where practicable, the same consumables were also used, but may not have been in the same condition, eg grinding discs may have worn during tests. Where practicable, measurements were also undertaken on the same component and during the same activity, although the latter in particular was fraught with difficulties, eg there was not enough rusting and contamination of components for removal using a chipping hammer during one evaluation.

Practical difficulties, related to full-fingered glove use (common to personal protective equipment evaluations), were identified, eg sanding pads were difficult to remove when wearing full-fingered 'anti-vibration gloves'.

In the majority of cases, it was found that, as expected, the gloves only provided minimal reductions in hand-transmitted vibration, as a result of only being effective at the potentially less damaging higher frequencies, which were moderated by the frequency weighting of the instrument. Based upon meetings and telephone discussions with the major international suppliers of 'anti-vibration gloves', it was apparent that the development of an effective material which will reduce the transmission of vibration is still in its infancy.

3.3 Evaluation of Tools

The evaluation of tools was far more complicated. Initially, representatives of major tool suppliers were invited to meet with Tecforce risk assessors, in order to determine the vibration-reduced, or low vibration, tools they could realistically provide. The importance of assessing activities in terms of all (human science) ergonomic aspects was emphasised, including force adopted and working positions[4,5]. Matching tools and consumables, tool procurement, tool maintenance, the air volume supplied to the tool and training issues, eg tool tightening techniques, were all discussed. It was agreed that these factors, which had only previously been considered for inclusion in the 'Recommendations' section of reports, should form part of the assessment procedure in future, where practicable. In particular, the type and condition of consumable used, can have a significant effect upon values measured, and should be representative of normal activity.

The initial difficulty which arose during evaluations related to the business selected. It had been agreed that, for ease of controlling tools loaned and the other major variables identified above, ie operator, consumable, component, activity and contact time, it would be prudent to undertake the evaluations within one area, so far as is practicable. However, the person selected to control the project locally, ie the person maintaining the tools within the business area, favoured one particular tool manufacturer, leading to difficulties in completing evaluations and a lack of reliable feedback. Therefore, evaluations of different tool types were completed in different areas, resulting in an ability to control only one of the above variables effectively, ie the tool. As with the glove evaluations, particular difficulties were experienced in controlling the activity satisfactorily.

In addition to improved tools of the same type, both in terms of lower levels of hand-transmitted vibration and process effectiveness, alternative tools were identified, eg Roto-Peens as replacements for orbital sanders. Long-term prospects for designing-out hand-arm vibration, including employing alternative processes, were considered following evaluations.

3.4 Measurement Instrumentation

During the tool evaluations, the accuracy of the HARM meter, when used with the HARM BLOK™, was questioned by a representative from a company who had been requested to tender for competency training of Tecforce staff. Specifically, it was suggested that results are inaccurate, by a factor of two to three, unless measurements of hand-transmitted vibration are undertaken using hard mounting of transducers. The reasons for selecting the HARM meter have been outlined above, including trials with an adaptor and hard mounting. Evaluations of other adaptors have also successfully concluded that the devices are suitable for collecting vibration exposure data in the field, provided that the behaviour of accelerometers used can be assured under high shock vibration conditions[6].

The main remaining concern relating to the HARM meter expressed by other professionals, regardless of the ability to check the acceleration values at certain frequencies, is with respect to the reproducibility of results, ie that the meter allows no comprehensive analysis of spectra, which is recommended by leading exponents of hand-transmitted vibration measurement[1]. It has been emphasised that the meter was employed to aid the establishment of vibration exposure data.

Although Tecforce were uncertain of the ability of the meter, when used with the HARM BLOK™, to accurately measure highly percussive tools, eg riveting hammers, and fastening devices, the results obtained were as expected. Tecforce have always employed new technological improvements to the meter, eg elastomeric devices for minimising DC shifts. Cable ties, for securing the HARM BLOK™ to a tool handle, are used where this is considered necessary.

4 Improvements In Measurement Instrumentation and Techniques

Although the risk assessment of hand-transmitted vibration is only one element of a risk management procedure within the rail company for whom measurements were undertaken, it is the most important. Risk control systems should be introduced, where required, based upon the assessment findings. Measurement is the basis for accurate risk assessment and there is a fundamental requirement that it be undertaken by competent persons, using equipment which meets the instrumentation standards[7,8] and employing techniques based upon standardised methods[9,10]. Organisations with evidence of inaccuracy in any measurement instrumentation or techniques are encouraged to publish their findings, with supporting data, in an effort to improve standardised methodology[9,10].

Tecforce intend to investigate the availability, at present and in future due to current development, of measuring equipment which is both practical to use in all working situations likely to produce exposure to hand-transmitted vibration requiring measurement, and which allows the analysis of spectra. This will place more emphasis upon the importance of frequency in cause-effect, in addition to acceleration magnitude and tool contact time. Measurement instrument designers/manufacturers need to concentrate upon these issues, in addition to further minimisation of other potential inaccuracies, eg DC shifts and overloads. In the interim, Tecforce will continue to monitor use of the HARM meter.

It is recognised that persons undertaking HAV risk assessments will normally be suitably qualified in occupational hygiene, in general, or noise, in particular. It is recommended that any person undertaking HAV risk assessment should attend a course which is accredited for this purpose, or should seek peer review of their activities from a professional body, eg the Institute of Acoustics.

5 Further Developments

In addition to new processes, existing activities will require risk re-assessment when there are significant changes. What constitutes a significant change may include the replacement of old, inefficient, previously poorly maintained, and probably noisy, tools with ones which can complete the work with lower hand-transmitted vibration, and probably improved effectiveness resulting in more production. From a practical perspective, it may not be possible to measure all new tools in use and therefore a random sampling system, which complements audits of the hand-arm vibration management programme, may be instigated.

Effective assessment leads to a requirement for A(8) values to be determined for individuals. Tecforce decided to introduce a simple points rating system, which employees would use, and which would also help them to appreciate their exposures and related issues, over an extended period. At the time of producing this paper, the system is undergoing trials within two rail depots. The ultimate objective is for daily vibration exposures to be accurately determined, especially as a European Directive on hand-arm vibration may be issued in the near future.

The Steering Group assisting in the HAV management process within the client company is chaired by the Company Risk Manager, who is responsible for the production and review of a Risk Management Procedure for the Control of Hand-Arm Vibration, which has only just been issued. Working within this framework has been very beneficial for Tecforce, in terms of co-ordination and completion of activities. The company is currently sending all interested parties on a one day course aimed at raising awareness of HAV, whilst at the same time improving the culture of the organisation, including change management issues. In view of the long time period involved with the implementation of procedures and training, it may be prudent to ensure that information provided prior to risk assessments is included in normal local briefings, safety meetings, or tool-box talks.

References

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