

The SOBANE Strategy for the Management of Risk, as Applied to Whole-Body or Hand–Arm Vibration

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Objective: The objective was to develop a coherent set of methods to be used effectively in industry to prevent and manage the risks associated with exposure to vibration, by coordinating the progressive intervention of the workers, their management, the occupational health and safety (OHS) professionals and the experts. The methods were developed separately for the exposure to whole-body and hand–arm vibration. **Results:** The SOBANE strategy of risk prevention includes four levels of intervention: level 1, Screening; level 2, Observation; level 3, Analysis and; level 4, Expertise. The methods making it possible to apply this strategy were developed for 14 types of risk factors. The article presents the methods specific to the prevention of the risks associated with the exposure to vibration. **Conclusions:** The strategy is similar to those published for the risks associated with exposure to noise, heat and musculoskeletal disorders. It explicitly recognizes the qualifications of the workers and their management with regard to the work situation and shares the principle that measuring the exposure of the workers is not necessarily the first step in order to improve these situations. It attempts to optimize the recourse to the competences of the OHS professionals and the experts, in order to come more rapidly, effectively and economically to practical control measures.

Keywords: whole body vibration; hand–arm vibration; risk management; SOBANE; Déparis; participation

INTRODUCTION

The European Directive 2002/44/CE of 25 June 2002 provides exposure limits for the vibration transmitted to the hand–arm (HAV) and the whole body (WBV). All countries of the European Union must transcribe this directive in their national safety and health regulations by 2005.

For a working population of 28 million in 2005 in the UK, the Medical Research Council estimates that 9 million are exposed to WBV and 4.9 million to HAV, and that 2.7 million are above the action limits prescribed in the new legislation (HSE, 2005). The cost of the requested exposure assessments is estimated to be €25 million and the total cost for the implementation of the legislation between €3.2 and €5.5 billion.

In contrast, only 19 among the 62 industrial hygiene consulting firms listed in the BOHS directory

(BOHS, 2005) mention explicitly that they can provide services (mainly monitoring and assessment) concerning vibration exposure.

Although the first figures might be overestimated and the directory far from complete, the discrepancy between the supply and the demand is obvious, and the position that an industrial hygienist is required to conduct any exposure assessment in any condition is just unrealistic. This is all the more true at the European and the world level, and a better strategy is needed for the experts to deal with the major problems that really need their qualification, while relying on less specialized but more available occupational health and safety (OHS) professionals and on the workers and their management themselves to solve more effectively, economically and rapidly the common problems.

This pragmatic—and not philosophical—conclusion was also reached by the international movement called ‘control banding’ supported by ILO (2004), WHO, IOHA and HSE (2004) among others.

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This conclusion becomes more philosophical when it rests also on the following principles.

- No effective action can be taken without the participation of the workers who are the only ones to know exactly the exposure conditions.
- The workers and their direct management must be the actors and not only the objects of the prevention actions: OSH professionals should consider that they take part in the actions conducted by these people, instead of the opposite.
- The aim of industrial hygiene as well as ergonomics, safety, etc. is to act not to simply record and assess.
- The aim is to insure the best possible working conditions and not to 'comply' and simply get just below the limit values.
- Quantitative assessments do not lead necessarily to control measures and must be performed after and not before simple control measures are taken.
- The workers will not understand and cooperate with interventions limited to one aspect while other aspects that interfere as much, or more, with their living conditions are neglected.
- All occupational health problems are related and a comprehensive approach is needed in any case.

These principles, which will not be discussed here, form the basis of the SOBANE strategy.

The strategy was applied and validated in 14 fields: social facilities; safety (accidents, falls, etc); machines and hand tools; electricity; fire and explosion; lighting; work on VDUs; noise; thermal environment; chemical agents; biological agents; musculoskeletal disorders; WBV; HAV. Some were already recognized at the international level for the problems of noise (Malchaire 2000), heat stress (prEN ISO 15265 2004, Malchaire *et al.*, 1999) or musculoskeletal disorders (Malchaire and Piette, 2002).

The 'operational' validation consisted of verifying in 10 work situations that the documents could be understood and used by the workers and the management, and led to fruitful discussions. Based on the comments and finding, the methods were optimised.

DESCRIPTION OF THE SOBANE STRATEGY

A detailed description of the SOBANE strategy has been published (Malchaire, 2004) and the main points only are pointed out below.

The SOBANE Strategy includes four levels of intervention for which methods were developed:

Level 1: 'Screening'

Whatever the problem that justified the interest in the working condition (vibration in this case because of the new legislation), the whole context is reviewed

during a 2 h meeting between four or five representative workers and managers. This Screening level leads directly to simple, straightforward and economical solutions and significantly contributes to the education of the partners in adopting better work procedures. It might confirm that vibration is indeed a problem that needs to be investigated further, but that, at the same time, other problems such as safety of the equipment, work organization or mental load must be considered and solved.

Level 2: 'Observation'

For each aspect identified at the Screening level, a more detailed discussion is conducted, again between the workers and their technical management, in order to come to more specific control measures or resolutions. The Observation method, therefore, extends the general discussion started at the Screening level to go further towards the root of the specific problem. No reference is made to measurements and the best possible solutions are looked for the situation in general.

At the end of the meeting, the group takes stock of the proposed control measures, assesses qualitatively the residual risk and decides whether or not to pursue the investigations at the subsequent Analysis level of the strategy.

Level 3: 'Analysis'

At this level, the assistance of an OHS professional becomes indispensable and more specific and expensive analysis techniques are used to identify more technical control measures. Again the group, with the OHS professional, is invited to look for more elaborate measures, to assess the effectiveness of these measures and to estimate the residual risk.

If this is not possible or if the risk still remains unacceptable, clearly an expert in vibration control is needed and the study must be continued at the fourth level.

Level 4: 'Expertise'

With the assistance of the expert, measurements might be performed to identify specific problems, to find the optimal solutions or to quantify the residual risk.

THE SOBANE STRATEGY APPLIED TO VIBRATION CONTROL

As indicated, the method for the Screening level is always the same whatever the specific problem considered, while the Observation and Analysis methods are specific to the vibration problem. The methods were developed separately for WBV and HAV as the physiological effects, their location, the vibration origins, the control measures, the aggravating biomechanical factors and the exposure

conditions are quite different. This article will describe both sets of methods.

At the Observation and Analysis levels, the documents briefly redefine the actors, the objectives and the procedure. Then, they guide the users in the study of the work situation, providing them only with the items useful at this intervention level to search for solutions, to estimate the risk and to draw up an assessment of the situation.

Additional information, adapted to the different levels of the strategy, is provided in the form of assistance sheets linked to the various items of the method.

Level 1: 'Screening'

The Screening guide (first level of the SOBANE strategy) includes 18 headings concerning: the operating areas; the technical organization between workplaces; the work sites; the risks of accident; the controls and signals; the tools and work material; the repetitive work; the handling operations; the mental load; lighting; noise; the thermal environment; the chemical and biological agents; vibration; the work relationships between workers; the local and general social environment; the work content; the psychosocial environment. Table 1 provides items to be considered for vibration.

This table shows that the discussion will be about the state and the conditions of use of the machines or tools and that this will not usually be sufficient to control the risk. Therefore a level 2, Observation will most of the time be required.

It would be, however, inappropriate and against the SOBANE principles to use the heading on vibration separately, or simply to bypass this level and go directly to the Observation level for vibration on the grounds that the information collected is too limited or unreliable.

Level 2: 'Observation'

The Observation methods were developed so that they can be used directly by the same people as at the Screening stage, alone, without an OHS professional or an expert having to intervene necessarily. Thus, the methods take advantage of the knowledge that this group of people have of the everyday work situation. Their opinion might not correctly reflect the risk really incurred but could overestimate as well as underestimate this risk, depending upon the education in health and safety of the persons involved. However, and contrary to measurements, it has the advantage of reflecting how the group of people 'live' the exposure to vibration, not at a given time on a given day (when measurement would be made) but in all the various work circumstances. At this Observation stage, therefore, this appears as the least erroneous and indeed the best base for discussion.

Table 1. Heading vibration in the Screening guide of the first level of the SOBANE strategy

Vibration	
To be discussed:	What to do in practical terms to improve the situation?
The vehicles, forklift trucks, stackers, etc.	<ul style="list-style-type: none"> • Are appropriate to the work to be performed. • The ground, the tires, the suspensions, the seats are in good state.
The machines or vibrating tools.	<ul style="list-style-type: none"> • Are appropriate to the work to be performed, not too heavy. • Are in good state and regularly maintained.
The tools, bits, discs, etc. are appropriate and in good state.	
The machines, tools etc are correctly used: work postures, forces, work with one or 2 hands, etc.	
What needs to be investigated more in detail:	

Observation for WBV. The Observation procedure requires collection over the course of time of all information regarding:

- the transport vehicles: description, age, weight, nominal load, real load, suspensions, and seat;
- the state of the machines, seats, tires, suspensions, the frequency and the nature of the maintenance programme;
- all the activities performed with each machine;
- the driving conditions for each activity: driving path (road, rails etc), state of the path, shocks caused by holes or unevenness of the path and driving speed;
- the postures adopted by the workers: access to the driver's cab, forward or backward driving;
- the additional activities, such as manual handling of load that could increase the risks of musculo-skeletal constraints.
- The training of the operators to drive the vehicle and to adjust seating in order to minimize vibration.

Beside recording this information, the purpose is for the group to discuss whether the machines are the most appropriate for the tasks, whether work could be better distributed over time, whether they are adequately maintained, whether the activities and the driving conditions could be improved and whether better postures could be adopted

The method ends with

- a synthesis of the control measures with specifying 'who could do what and when',
- a list of points to investigate further at the Analysis level,
- an estimation of the vibration risk for each activity by comparison with the following four common exposure situations:
 - car on asphalt: comfort
 - truck on ordinary road: light discomfort
 - truck on badly paved road: average risk
 - shocks: high risk.

A similar procedure is proposed specifically for the vibrating platforms, drawing the discussion to isolate the platform mechanically or use anti-vibration supports.

Observation for HA vibration. Similarly, the Observation method for HAV seeks to collect and discuss information regarding:

- the vibrating machines or tools: description, date of bringing into operation, rotating or percussion speed, weight, type of energy, handles, tools, etc.
- their state and date of the last maintenance
- the materials machined (steel, wood, etc.)
- the various activities: description, employees concerned, machines and tools used, exposure duration
- the work postures and efforts
- the work circumstances (work organization, environment, noise, dust, etc.)
- the training of the operators to use the machines to minimize vibration.

The objective again is not to simply compile the information but to discuss why the situation is such (why this machine or this tool, why this posture, why these efforts, etc.) and how it can be improved (by using a more adequate machine or a different tool, by adjusting the height of the work surface, etc.).

The synthesis is similar, with the vibration level estimated by comparison with the following four situations, usually known by the workers:

- screw driving in wood: comfort
- drilling machine in wood: light discomfort
- grinding machine: average risk
- drilling machine with percussion: high risk.

Level 3: Analysis

The objectives of the Analysis level are to identify additionally more technical control measures and to evaluate more accurately the residual risk using published values for the vibration from particular machines, without resorting to measurement at this stage.

An OHS professional is indispensable here. A more complex terminology can consequently be used

[definition of the damage, risk for a homogeneous exposure group (HEG), stationarity interval (Machaire and Piette, 1997) etc] and the concepts of equivalent acceleration and personal exposure acceleration can be defined (with their units, m s^{-2}) and used for the estimation of the risk.

The OHS professional begins by reviewing with the group of people the information collected and the solutions proposed at the Screening and Observation levels. Then, the objectives of the Analysis itself are defined more precisely.

Analysis for WBV. All possible ways to reduce the exposure are reviewed: modifications of the work techniques, machine substitution, identification of the vibration sources (rotating parts, driving path, suspensions, etc.), reduction of the vibration at the source (through contacts with the manufacturer, improvement of the driving path, etc.), improvement of the postures (seat, etc.), reorganization of the work, modifications of the tasks and training of the workers on how to adjust their seating and how to operate in order to minimize vibration.

The Analysis continues with the quantitative evaluation of the exposure from the equivalent acceleration values (in m s^{-2}) and the durations of use of the different machines.

The employees having the same type of work with the same exposure to WB vibration are grouped in HEGs.

For each machine (or vibrating platform), the equivalent acceleration is estimated using the international Internet database available on: <http://umetech.niwl.se/vibration/WBVhome.lasso> (NIWL, 2004) or other sources. A table in the annex of the Analysis method of Malchaire (2005a) gives the average and maximum values according to the vertical axis for the most common 25 types of transport vehicles. The value (average or maximum) to consider depends on the good or bad conditions of use: condition of the machine itself, defective suspensions or not, irregular driving path or not, and existence or not of shocks.

If reliable data are not available through the Internet or literature for the given equipment, measurements might be needed. The investigation is then pursued at level 4, Expertise, described below.

The average exposure duration over a stationarity interval (a shift, a week or other period) for each machine and/or activity is determined and its contribution to the total exposure is calculated using a simple formula or a table included in the method. This partial personal exposure acceleration ($A_{EP,i}$) makes it possible to classify the machines and/or activities according to their impact on the total exposure and consequently to define priorities of actions.

The geometrical sum of these partial accelerations gives the personal exposure acceleration (A_{EP}) for the

HEG and the severity of the risk is estimated with reference values derived from the European directive 2002/44/CE and ISO standard 2631 (1997):

- comfort $< 0.32 \text{ m s}^{-2}$
- discomfort $< 0.50 \text{ m s}^{-2}$
- health problems (action value) $> 0.50 \text{ m s}^{-2}$
- unacceptable situation (limit value) $> 1.15 \text{ m s}^{-2}$

At the end of the Analysis, the OHS professional and the people of the company make the synthesis of the proposed control measures (who is going to do what and when). They determine whether the vibration problem is satisfactorily controlled or managed, or whether the intervention of an vibration expert is needed at a level 4, Expertise, of the SOBANE strategy.

While waiting for the implementation of the solutions, the problems of individual protection and health surveillance are discussed with the occupational physician.

Analysis for HA vibration. Similarly, a detailed study of the conditions of use of the vibrating tools is carried out seeking more elaborate possibilities: to avoid some tools; to modify the process by using less-vibrating tools; to use suspension system; better discs, drilling bits, chisels, etc; to improve the maintenance; to adapt the workplace so as to improve the work postures and efforts; to modify the work organization (reduction of the exposure duration, work rotations etc); and to retrain the workers to correctly use the vibration machine for their safety and minimize the vibration exposure.

The evaluation of the exposure values and the risk is carried out using the international database available on Internet: <http://umetech.niwl.se/eng/havsearch.lasso> (NIWL, 2004) or other sources. Again, a table in the Analysis annex of Malchaire (2005b) provides the global acceleration from the three vibration axes for the most frequent 20 types of tools. The table provides the average and maximum values according to the conditions of use: bad condition of the machine, disc or bits badly centred or unbalanced, very hard material to machine, particular shocks, etc.

Again, measurements are needed and the study must be pursued at the level 4, Expertise, when reliable data are not available through the Internet or literature for the given equipment.

The partial personal exposure accelerations ($A_{EP,i}$) resulting in the three axes are used to determine the most significant machines and/or operations and, after summarizing the partial exposures, the risk is estimated by comparing the personal exposure acceleration (A_{EP}) of the HEG to the following reference values:

- no discomfort $< 1.0 \text{ m s}^{-2}$

- discomfort $< 2.5 \text{ m s}^{-2}$
- health problems (action value) $> 2.5 \text{ m s}^{-2}$
- unacceptable situation (limit value) $> 5.0 \text{ m s}^{-2}$

The OHS professional and the people from the study group in the company carry out the final synthesis and the decision is taken to go further or not.

Level 4: 'Expertise'

No real procedure is proposed for this level of the strategy. The methods, however, underline what the study group of the company and the OHS professionals must ask and expect from the expert. This expert normally should have the necessary equipment and the competence to, if necessary, measure the vibration levels and estimate the residual risk in accordance with the ISO standards 2631 or 5349. However, the expert should be told where to perform these measurements, at what time, in what conditions, on which workers, etc. in order to get representative, reliable and useful data.

Following the results of the preceding levels of the SOBANE strategy, its intervention can be more specific for, for example, testing the real effectiveness of a suspension (seat, cabin, etc.) or of an anti-vibration device (suspended handles, sleeves, etc.). For those specific problems, he can be expected to know what to investigate, and how to identify and develop more sophisticated control measures. But again, he should be told what conditions to investigate and in what context the problems arise.

It is necessary to insist on the cooperation of the expert with the people of the company and the OHS professional: the problem should not be 'abandoned' to the expert but the study should be pursued with the active participation of the actors of the preceding levels.

DISCUSSION AND CONCLUSION

A common reaction towards strategies such as the one presented here is to contest the validity of any intervention or assessment not conducted by a trained professional.

Besides its trace of professional protectionism and of disdain for the working population, this position is clearly unrealistic if the objective is to improve the living conditions in the field.

The goal of the SOBANE strategy is not to reduce the role of industrial hygienists or other OSH professionals. It is to optimize the recourse to these few specialists and benefit from their knowledge and qualifications gradually and judiciously, as the need arises, to identify appropriate control measures. This strategy also specifically recognizes the capacities of the workers and their technical staff to identify and implement suitable control measures. It seeks to coordinate the efforts of these people, directly concerned by the working conditions, with the efforts

of the OHS professionals and the experts external to the company in order to lead to prevention measures more rapidly, effectively and economically.

The SOBANE strategy is addressed directly to the companies, resorting to OHS professionals and experts only when it becomes indispensable. At the present time, this is clearly utopian in many companies. The OHS professionals have, therefore, the choice of continuing to assist the company and the workers bit by bit, or to themselves use the strategy at the first levels so as to inform the company of the characteristics and possibilities of the SOBANE strategy, to show its simplicity and its effectiveness and prompt the company to appropriate the strategy.

Thereafter, it is hoped and expected that the methods of the first two levels will be used directly by the workers and the hierarchical line, while the role of the OHS professional will be more to manage the process and the results.

The OHS professionals remain, therefore, essential at these levels to launch, monitor, put right and revive the OHS policy and the application of the SOBANE strategy in the company. At the Analysis level, they will regain their more classical role in assessing exposure and designing control measures, their work lying, however, now in the framework of the overall prevention policy of the company.

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