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Review Article

The European Vibration Directive

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Abstract: The European Union adopted a Directive in 2002 on minimum requirements for the health and safety of workers exposed to vibration. This is known as the Physical Agents (Vibration) Directive. It builds on existing general employers' duties to manage risks to health and safety, and introduces exposure action and limit values for both hand-arm vibration and whole-body vibration, setting minimum standards for the control of vibration risks across Europe. New Regulations on Vibration at Work will be introduced in Great Britain on 6 July 2005 to implement the Directive. These Regulations should serve to strengthen the continuing work of the Health and Safety Executive (HSE) to reduce exposures to hand-arm vibration in British industry. Implementation of the Directive for whole-body vibration presents a different challenge and the HSE is currently preparing appropriate guidance to accompany the Regulations. This will form part of an holistic approach to back pain in professional drivers, setting vibration in context with other risk factors, particularly postural concerns and manual handling operations.

Key words: Occupational vibration, Hand-arm, Whole-body, European Directive legislation

Introduction

The Member States of the European Union have agreed to the harmonisation of certain "social provisions", including minimum standards for ensuring health and safety in workplaces. Article 137 (formerly 118A) of the Treaty of Rome empowers the European Council to adopt directives for this purpose. European Directive 89/391/EEC[1], (known as the 'Framework Directive'), requires employers to assess and control risks to the health and safety of people at work, and it includes provision for the adoption of "daughter directives" which contain requirements relating to particular hazards. In 2002 Directive 2002/44/EC[2] was adopted. This is known as the Physical Agents (Vibration) Directive. It applies the principles of the Framework Directive to risks arising from hand-arm vibration and whole-body vibration, setting minimum requirements for the prevention of vibration-related ill health. Member States are required to implement the Directive by 6 July 2005. This paper explores the requirements of the Vibration Directive and discusses plans for its implementation in Great Britain through the introduction of new regulations on vibration at work.

History and Development of the Directive

New European Directives on the health and safety of workers are proposed by the European Commission (the European Union's administrative body) and must be agreed jointly by the directly-elected European Parliament and the Council of the European Union (which represents the governments of the individual Member States).

The Commission was invited in 1990, by a resolution of the Parliament, to draft a directive to protect workers from noise, vibration and other physical agents. The first draft was published in 1993 and amended the following year[3]; this addressed noise, hand-arm and whole-body vibration, optical radiation and electromagnetic fields and waves. Employers were given duties to minimise exposure and risk

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from all these potential sources of risk to health. In a separate annex for each physical agent, a 'threshold level', 'action level' and 'exposure limit value' were proposed; these were intended to ensure a harmonised maximum level of vibration exposure and to clarify for employers the levels of exposure above which risk control measures are expected.

This proposal made little progress, largely because understanding of the health effects for the various physical agents was not sufficient for a common approach to be appropriate. In early 1999 the German Presidency offered an alternative approach; they proposed a directive covering only with hand-arm vibration (HAV) and whole-body vibration (WBV), leaving the other physical agents to be dealt with later. In this proposal, the numerical vibration exposure criteria were called "exposure action values" and "exposure limit values". These were expressed as daily (8 h equivalent) and 'short term' frequency-weighted root-mean-square acceleration values. The Council's Social Questions Working Group developed the German proposal and political agreement between the (then) fifteen Member States was reached in November 2001, during the French Presidency. The draft directive was then passed to the European Parliament, which proposed some amendments. After further negotiations between the Council and the Parliament, the final content was agreed and Directive 2002/44/EC was adopted and published on 6 July 2002. Member States of the European Union were given three years from that date to implement the 'Vibration Directive' in national legislation.

Requirements of the Directive

General points

The Vibration Directive is a so-called 'daughter' of the Framework Directive, and is compatible with it, so much of its content reiterates existing general duties of employers to assess and manage risks to health and safety. These duties of employers include:

- assessing risk and exposure;
- planning and implementing the necessary control measures;
- providing and maintaining suitable work equipment;
- providing workers with information and training on risks and their control; and
- monitoring and reviewing the effectiveness of the risk control programme.

Where risk to health is identified, workers have a right to health surveillance.

The Vibration Directive provides added value to the existing requirements of the Framework Directive by establishing agreed levels of exposure above which employers must take certain actions to control risks, and in setting the daily exposure limits.

The exposure action and limit values

The daily exposure action and limit values in the Directive (Article 3) are all specified as an 8-hour energy-equivalent frequency-weighted acceleration (known as the $A(8)$ value), although vibration dose value (VDV) alternatives are given for WBV. The 'short term' action and limit values, which appeared in earlier drafts, do not appear in the final Directive. (The 'short term' limit values would have effectively set limits on the allowable vibration emission of machines which transmit hand-arm or whole-body vibration.)

The agreed exposure values are:

- HAV daily exposure action value (EAV): 2.5 ms^{-2} $A(8)$
- HAV daily exposure limit value (ELV): 5 ms^{-2} $A(8)$
- WBV daily exposure action value (EAV): 0.5 ms^{-2} $A(8)$ (or VDV 9.1 $ms^{-1.75}$)
- WBV daily exposure limit value (ELV):1.15 ms^{-2} $A(8)$ (or VDV = 21 $ms^{-1.75}$)

The exposure metrics are specified in two Annexes (for HAV and WBV respectively) which refer to ISO 5349-1:2001[4] for HAV and ISO 2631-1:1997[5] for WBV. Thus, HAV exposures are derived from the tri-axial 'vibration total value' (i.e. the root-sum-of-squares of the three single-axis values) and WBV is considered separately for each of three directions of vibration at the seat (when sitting) or the feet (when standing).

These exposure action and limit values were agreed, taking into account current understanding of the risks to health from vibration exposure (as documented in annexes to ISO 5349-1 and ISO 2631-1) and also the practicability or cost of achieving exposures below these values. The exposure limit value for whole-body vibration was set at 0.63 ms^{-2} $A(8)$ in the original proposal. During discussions in the Social Questions Working Group this was shown to be unachievable in many work activities and was raised to 1.15 ms^{-2} $A(8)$ in the final agreed version of the Directive.

The choice of metric for WBV exposure ($A(8)$ or VDV) is for individual Member States to make when producing their implementing legislation. The VDV options appear to have been derived using the method given in ISO 2631-1:1997 for estimating a VDV from the root-mean-square acceleration magnitude and the exposure time, and by assuming a daily exposure duration of 8 h. Because many exposures are shorter than 8 h, and because the VDV is

more sensitive than the r.m.s. acceleration to shocks with high peak accelerations, the *VDV* options for the EAV and ELV will often be more protective than their $A(8)$ counterparts.

Determination and assessment of risks

Article 4 of the Vibration Directive refers to the duties of employers (under the Framework Directive) to carry out a risk assessment competently and to identify the measures required to control or manage the risk. It requires the daily exposure to vibration to be assessed and compared with the EAV and ELV, but the employer must also consider other risk factors, such as intermittent exposure, repeated shocks, workers who may be particularly sensitive to vibration, the workplace temperature and other factors in the workplace and the findings of health surveillance.

Employers are required to "assess and, if necessary, measure" the vibration exposure of workers. It is apparent that vibration measurement is not expected in all cases and determining probable vibration magnitudes using vibration information from equipment manufacturers is specifically mentioned. This provides a link with the European Machinery Directive[6]; this directive places duties on manufacturers and suppliers of machinery to provide information on residual risks (having first designed and constructed their products to be 'state-of-the-art' with regard to safety) and to declare vibration emission values for hand-held, hand-guided and mobile machines.

The employer's risk assessment must also identify the measures required for appropriate avoidance or reduction of vibration exposure and provision of worker information and training. An employer who has identified risks to his workers' health from vibration is therefore expected to have an action plan for controlling those risks.

Avoiding or reducing exposure

Article 5 of the Directive is concerned with avoiding or reducing vibration exposures. It places on the employer a duty requiring risks arising from vibration exposure to be eliminated or reduced to a minimum, "taking account of technical progress and the availability of measures to control the risk at source". Again, there is a reference to the Framework Directive for the general principles of risk prevention and this duty applies whether or not the EAV is exceeded.

If the EAV is exceeded, an appropriate formalised preventative programme must be set up by the employer to reduce to a minimum the *exposure* to vibration and the *attendant risks*. Particular attention is drawn to:

- alternative working methods to reduce exposure;
- selection of work equipment suitable for the job and with the lowest vibration;
- use of auxiliary equipment to reduce vibration risks (e.g. vibration-isolating seats or handles);
- maintenance programmes for work equipment to prevent increases in vibration risks;
- workplace design and layout to reduce risks;
- information, instruction and training for employees (to use equipment correctly and reduce their vibration risks);
- limiting exposure duration and magnitude;
- appropriate work schedules and rest periods; and
- clothing to protect against cold and damp.

Workers must not be exposed above the ELV and the Directive includes a requirement for immediate corrective action by the employer if the ELV is exceeded.

Member States are given powers (Article 9) to allow a transitional period before enforcing the requirement to keep exposures below the ELV. The allowable transitional periods are a maximum of five years generally (i.e. to 5 July 2010) or nine years (i.e. to 5 July 2014) regarding equipment used in the agriculture and forestry sectors. These can only be applied where the work equipment producing the vibration was put into use before 6 July 2007 and where it is not currently possible to keep exposures below the ELV. The duties to minimise risk from vibration and to implement a programme of measures above the EAV are not affected by the transitional period, so exposures must still be reduced below the ELV where this is reasonably practicable. The transitional period does, however, allow employers some time to make the necessary changes to their processes and for improved work equipment to be developed and procured in the longer term.

Information, training and consultation with workers

There is a requirement for employers to inform workers of the outcome of the risk assessment and to provide them with information and training to enable them to understand the risks, the EAV and ELV, the measures taken to control risks and the actions employees need to take to minimise risk, report symptoms, etc. Workers or their representatives must also be consulted and allowed to participate decisions on matters covered by the directive.

Health surveillance

Article 8 expands on the Framework Directive's requirements for appropriate health surveillance where the risk assessment has indicated a risk to health and/or when

the EAV is exceeded. Health surveillance is intended to give an early indication of vibration-related ill health in individuals and also to provide information to the employer regarding the effectiveness of the control measures. Where ill health is found, the employer has specific duties to review the risk assessment and control measures, consider redeployment of affected workers and arrange continued health surveillance.

Derogations

Member States are permitted to grant derogations from the WBV exposure limit value in cases of air and sea transport where it is not possible to reduce the exposure below this level.

For WBV and HAV, derogation powers are also available to allow occasional exposures above the exposure limit value where the exposure is normally below the exposure action value. However, the exposure "averaged over 40 h" (perhaps meaning a weekly average, normalised to five working days) must be less than the exposure limit value and there must be evidence that risks from this pattern of exposure are lower than those at the exposure limit value. Increased health surveillance is also a condition for derogation.

Implementation and Impact in Great Britain

In Great Britain, new regulations on the control of risks from vibration at work will be introduced in 2005. A single set of regulations, covering both hand-arm and whole-body vibration will ensure that the requirements of the Directive are implemented in British law. The regulations will be made under the enabling powers of the Health and Safety at Work, etc. Act 1974 and will be enforced by inspectors of the Health and Safety Executive (HSE) and local authorities.

Before and since the adoption of the Directive in July 2002, the HSE has been undertaking an informal consultation process to obtain the views of employers, equipment manufacturers, trade unions, experts and consultants, etc. In November 2003 the Health and Safety Commission invited public comment on two Consultative Documents[7,8] that contained the draft regulations and draft guidance for employers on HAV and WBV respectively. Government approval of the finalised regulations was confirmed in early 2005 and it is expected that supporting guidance for employers and employees will be published in the summer of 2005.

Hand-arm vibration

1) Guidance

The risks to health from hand-arm vibration have been recognised in Great Britain for many years, and national guidance was first published by HSE in 1994[9] drawing on the general duties of employers, including those derived from the Framework Directive. British industry, therefore, already has access to information on good practice in assessing and controlling HAV risks and on national expectations for compliance with the existing legal duties. The 1994 guidance included a recommended exposure 'action level' above which employers were expected to take actions similar to those required by the Vibration Directive at exposures above the EAV.

HSE is preparing to publish its updated guidance on HAV. This will include material for employers, and their professional advisors, on legal duties, risk assessment and control and health surveillance. It will be supplemented by additional resources on HSE's website (www.hse.gov.uk/vibration), which is expected to include vibration risk control case studies and a vibration exposure calculator.

The new guidance emphasises that a high level of precision is not generally required (or indeed possible) in exposure assessment; it provides employers with advice on obtaining suitable and sufficient information to help them decide whether the EAV and/or ELV is likely to be exceeded, and what action they need to take to reduce or eliminate risk. It encourages employers to consider the risk assessment qualitatively (i.e. identifying what needs to be done to achieve acceptable control of risk) alongside the quantitative task of exposure evaluation, for which advice is given on obtaining and interpreting vibration information available from machine manufacturers and other sources.

There is no demonstrably effective personal protective equipment against HAV, so some workers with high exposures will continue to be at risk, after all reasonably practicable actions have been taken to reduce the exposure. Health surveillance therefore plays an important role in preventing progression to advanced and disabling stages of HAVS. Much experience with health surveillance for HAVS has been gained since the present British guidance was published in 1994. The HSE recognises that, with the reduced action value, more people will be need to be included in HAVS health surveillance schemes provided by employers. The updated guidance therefore recommends a tiered, risk-based health surveillance protocol[10]. This should provide a simple and cost-effective means of surveying workforces and identifying any new cases of vibration-related ill health, with referral of affected individuals to occupational health professionals for further investigation, monitoring and advice on future exposure.

2) Impact on British industry

Research conducted by Palmer *et al.*[11] for the HSE suggested that at least 1.2 million workers in Great Britain were exceeding the 1994 HSE action level. As shown in Fig. 1, the new EAV is set at a lower value than the 1994 action level, and about 40% more workers than before will need to be included in programmes of risk control measures and health surveillance. However, those employers who are already following HSE's guidance, working to minimise exposures and complying with existing legal duties, will not need to do much more to comply with the new regulations.

The major impact of the directive is likely to be the requirement to bring all daily exposures below the ELV. Figure 1 also shows that, of the 1.7 million exposed above the EAV, almost a million may also be exceeding the ELV. Bringing all exposures below the ELV will be difficult for some employers and will require changes to work processes in several sectors of British industry; employers in many other European countries are likely to face a similar challenge. The transitional period to 2010 will be used in Great Britain to allow time for employers to bring exposures below the ELV and for improved work equipment to be developed and procured. (Although the ELV need not be enforced during the transitional period, it should be remembered that the employers' duty to minimise and control risks and exposures is not subject to the transition period and all employers will be expected to comply with this requirement so far as is reasonably practicable.)

The HSE intends to concentrate its resources on the industry sectors with the most people exposed at the highest levels (i.e. where the ELV is frequently exceeded), and where it can make the greatest impact in terms of reduction of risks from vibration and prevention of HAVS. The study by Palmer *et al.* included a breakdown, by industry sector, of the minimum numbers of workers in Great Britain exposed above the 1994 action level. The numbers of workers exceeding the new ELV will be smaller, but are likely to be similarly distributed between industries. The construction sector was found to employ the most vibration-exposed workers with about 40% of the workforce exposed at or above the action level (this includes all construction-related trades such as masons, bricklayers, carpenters, fitters, electricians and plumbers). In common with many industrialised nations, Great Britain's manufacturing industry is reducing in size, but manufacturing overall remains the second largest group of people at risk from vibration. Agriculture/forestry and motor vehicle repair are the third and forth groups.

This information provides a broad overview of the distribution of HAV exposures in Great Britain, but a more detailed picture is required for an understanding of where the high exposures actually occur. Further exploitation of this data source, together with information on numbers employed, tools used in the industries, typical vibration emissions and HSE's existing knowledge, will be undertaken to identify priority sectors for focussed intervention during the first years of the Vibration Regulations.

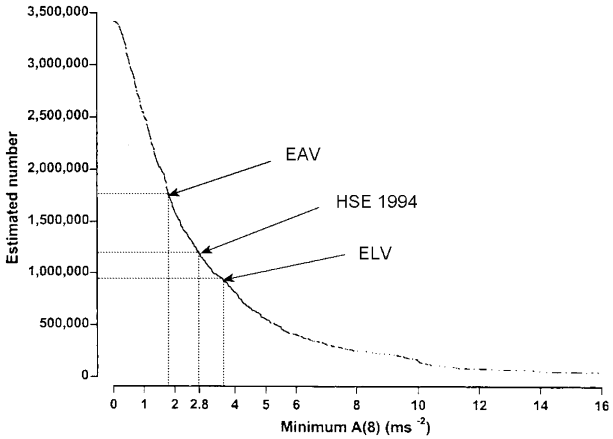

Fig. 1. Estimated numbers of male workers in Great Britain exposed to hand-arm vibration at levels above the 1994 HSE action level and the EAV and ELV which will apply from 2005.
The $A(8)$ exposures are expressed here as 'dominant axis' values in accordance the 1986 edition of ISO 5349. Adapted from Palmer *et al.* (1999)[11].

Whole-body vibration

1) The choice of exposure metric

The Vibration Directive allows the Member State to choose between the $A(8)$ and VDV options for the exposure limit and action values. In Great Britain, the implications of this choice have been considered with care, after a public consultation exercise. Action to control demonstrable risk is required regardless of the exposure level relative to the action value, and risk appears likely from activities resulting in frequent and regular exposure to high amplitude peak accelerations such as those encountered in some off-road mobile machinery and small fast boats. The EAV, whether set in terms of $A(8)$ or VDV, is close to the lower limit of any suggestion of risk, and is therefore unlikely to prove a useful indicator of risk. The choice of metric for the ELV is arguably even less critical, given that all reasonable risk control measures (in proportion with the assessed level of risk) will be required above the action value.

In the British regulations the ELV and EAV will be set at 1.15 and 0.5 m/s^2 $A(8)$ respectively; these have been chosen, rather than the alternative vibration dose value (VDV)

versions, after careful consideration of the implications discussed above. The $A(8)$ metric is already known to many employers familiar with hand-arm vibration, and it is expected that most European countries will also adopt it for whole-body vibration when implementing the Vibration Directive. However, the alternative metric (VDV) is likely to be more appropriate for assessing daily exposures for risk and when assessing and evaluating actions to control risk, particularly where shocks are present. VDV will continue to be recommended for such use in the United Kingdom when appropriate.

2) Other risk factors

The relationship between exposure to hand-arm vibration and ill health is sufficiently well established to give confidence that compliance with the Vibration Directive will result in a healthier working population. The situation for whole-body vibration, however, is not so straightforward. While studies have shown an association between exposure to whole-body vibration and shock with low back pain, there are often other contributory risk factors for back pain[12,13]. There is also a high prevalence of back pain in the general population and musculoskeletal problems affecting the back are the most reported work-related illnesses in manual workers in the UK; there was an estimated prevalence of more than 600,000 in 1995[14] many of whom had no significant history of vibration exposure. In HSE's investigations of reported back pain in professional drivers, ergonomic factors such as manual handling or restricted or awkward postures were found to be at least as likely a cause of the back pain as exposure to vibration. Back pain can, of course, be caused by activities in or out of work, unrelated to use of vehicles. However, there is no doubt that exposure to whole-body vibration can aggravate existing back problems (however, and wherever caused) and can result in back pain while driving or riding in vehicles. The HSE currently takes the view that whole-body vibration is one of several stressors that may contribute to occupational back pain but that it can rarely be identified as the sole cause. Therefore, instead of considering vibration on its own, employers are advised to manage risks from whole-body vibration (as required by the Vibration Directive) and from other significant risk factors for back pain (as required by the Framework Directive) through a common process of risk assessment and control actions.

3) Guidance

HSE's existing guidance on WBV for employers[15] acknowledges that there is often potential for some reduction in levels of WBV and shock from interventions on operating techniques (choice of terrain, driving speed, etc.). It recommends sensible precautions, such as ensuring that the vehicle or machine is suited to the task, that it is not driven at excessive speed, that it is properly maintained, that appropriate seating is fitted and used correctly (particularly in the case of suspension seats) and that operators have training in the risks and in correct adjustment and operation of the machine. All of these measures will usually be considered to be reasonably practicable, but where exposures are high it is not always reasonable to limit daily exposure times sufficiently to achieve the desired reduction in daily exposures. Other opportunities for exposure control lie in the selection of machinery suitable for the work, but this may only be reasonable in the long-term. (The transitional periods allowed by the Vibration Directive for introduction of enforcement of the ELV reflect an understanding of this.) The guidance includes consideration of working posture and manual handling in its advice on risk assessment. It identifies people who may be at risk (particularly drivers of off-road mobile machines in the agriculture, forestry, quarries and construction sectors)

With the introduction of regulations implementing the Vibration Directive, which include a numerical exposure action value for WBV set at a somewhat low level, there is potential for disproportionate allocation of resources to reduce vibration, while the principal risk factor for back pain remains unidentified. The HSE is therefore preparing new guidance, to coincide with the introduction of the new Vibration at Work Regulations. This is likely to include:

- simple guidance on good practice for duty holders, distinguishing between lower risk activities (including most road vehicle operations) and those work activities where WBV risk may be significant; and
- back pain guidance for the higher risk activities — such as use of off-road machines and industrial trucks — which will encourage an holistic approach to risk assessment and control and will include WBV as one of several risk factors.

The vibration assessment itself will need to establish whether the exposure action and limit values are likely to be exceeded and what actions are required to control the risk. For vehicles most likely to present a risk of injury from whole-body vibration and shock (usually off-road machinery or machinery with minimal suspension) the manufacturers of the machinery should be able to provide information on vibration risk and its control.

The Directive contains a requirement for *appropriate*

health surveillance. With WBV, however, there are considerable difficulties in identifying specific disorders, which are clearly attributable to the exposure. Low back pain and other lumbar disorders are the main health effects of concern, but at present no validated diagnostic techniques exist for the detection of changes which can reliably indicate the early onset of low back pain, because this is a symptom and not necessarily a specific disease/condition. HSE's guidance will advise that there is, at present, no appropriate health surveillance for WBV-related health risks, but that a less formal programme of health monitoring is good practice, and can inform the risk assessment.

4) Impact on British industry

About 9 million people in Great Britain are thought to be exposed to whole-body vibration at work[13]. However, most of these are users of road vehicles and are unlikely to be at high risk from vibration. More than 1.3 million workers are believed exposed above the EAV, but many of these will not be demonstrably at significant risk from WBV, and it is important that their employers are only expected to take sensible, simple, precautions that are in proportion with the vibration risks. More than 20,000 of these workers are thought to be exposed above the exposure limit value. These exposures are generally found in the operation of off-road machinery. The severity and extent of such exposures is the subject of current HSE-sponsored research, which should identify the industry sectors and work activities where guidance on good practice would help employers to comply. Some of the more severe exposures are in the agricultural sector. The option to extend the transitional period for enforcement of the limit value to the year 2014, for agriculture and forestry, will therefore be adopted in Great Britain, but for whole-body vibration only.

Conclusions

The European Vibration Directive places duties on employers regarding the management of risks from hand-transmitted and whole-body mechanical vibration. It clarifies the existing general duties, already defined in the Framework Directive, and applies them to vibration, defining exposure action values above which certain prescribed control measures must be in place and setting limits for daily exposure.

Hand-arm vibration is well known in Great Britain; the actions expected of industry have been widely publicised by the HSE since 1994 and are consistent with the requirements of the new Vibration Directive. The introduction of regulations on HAV should not bring any surprises to British industry, but will provide a useful reminder and clarification of what is expected of employers. The reduced exposure action value will, in some cases, require increased efforts to eliminate or reduce exposures and a wider deployment of health surveillance. Much has already been done to foster successful management of HAV and it is expected that progress made since 1994 will continue. The introduction of the ELV provides an challenging target for industry to protect the workers most at risk by eliminating or reducing the most severe exposures by 2010 (when transitional arrangements come to an end).

Risks from whole-body vibration have, hitherto, received less attention in Great Britain, and the Vibration Directive introduces numerical exposure action and limit values for the first time. The challenge here is to provide employers with a sound basis for the identification and control of high-risk activities (generally involving use of off-road machinery) while ensuring that disproportionate action is not taken with regard to low risk activities involving several million operators of road vehicles, even though exposure above the action value can occur. Furthermore, significant exposure to WBV rarely occurs without other ergonomic stressors (such as posture problems) and any occupational back pain may not necessarily be attributable to vibration. It is therefore important to consider the new duties regarding vibration risks alongside the general duties, taking a holistic approach to the assessment and control of risk, concentrating on the vibration only where it is a significant contributor to the risk to health.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily represent the opinion or policy of the Health and Safety Executive or any other government body.

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