Industrial Health 2012, **50**, 370–376

Review Article

Joël's Breaker: Forty Years of European Vibration Prevention

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Received September 1, 2011 and accepted August 6, 2012

Abstract: Although the risks associated with vibration exposure have been known for a long time, the importance of risk prevention has increased in Europe since the implementation of the Machine Directives in 1989 (1989/392/EC) and the Vibration Directive in 2002 (2002/44/CE). These Directives challenged manufacturers to design low-vibration tools, and employers to manage the site-specific risks of vibration exposure. Field experience has shown that many companies using vibrating tools have never carried out a risk-management program, and that they continue to ignore their responsibilities in the Vibration Directive. Because of this, European States are now developing alternative approaches to prevention, which typically shift the balance of risk management responsibility entirely onto employers. The ongoing challenge will be to increase workplace awareness of, and attention to, the risks of vibration exposure.

Key words: Vibration exposure, Hand-arm vibration, Risk prevention

Introduction − The Prehistory of Vibration Prevention

Figure 1 provides a humorous interpretation of the evolution of man and his work tools over the centuries. Technological advances in tools used at work appear to be re-shaping Joël, our evolutionary man, in the image of his early ancestors.

Joël has had pneumatic breakers to use as a tool, for breaking rock or road pavement, for many years. The technology of Joël's breakers did not change for the first 70 years of use. In the 1960's, in France, the only requirement for Joël to be authorized to use a pneumatic breaker professionally was that he be at least 18 years of age. At that time, this was the only legal measure of protection in France against the effects of vibration on the tool operator. At that time, it was also considered normal for a worker to work continuously with a vibrating tool, such as a breaker. And yet, the risk of developing pathology in the hand-arm system was acknowledged as an occupational disease. In the 1980's, an inquiry in France showed that half the compensated cases of occupational hand arm vibration syndrome (HAVS) were related to the use of pneumatic hammers, or breakers[1)].

In 1975, pioneering work by scientists at the Institut National de Recherche et de Sécurité (INRS) resulted in the development of the first anti-vibration pneumatic breaker (see Fig. 2). This work enabled a 50% reduction in vibration transmitted to the operator[2)].

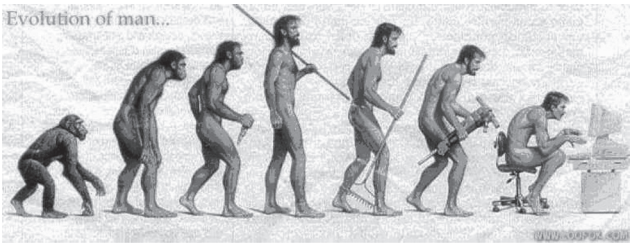

Fig. 1. Evolution of man

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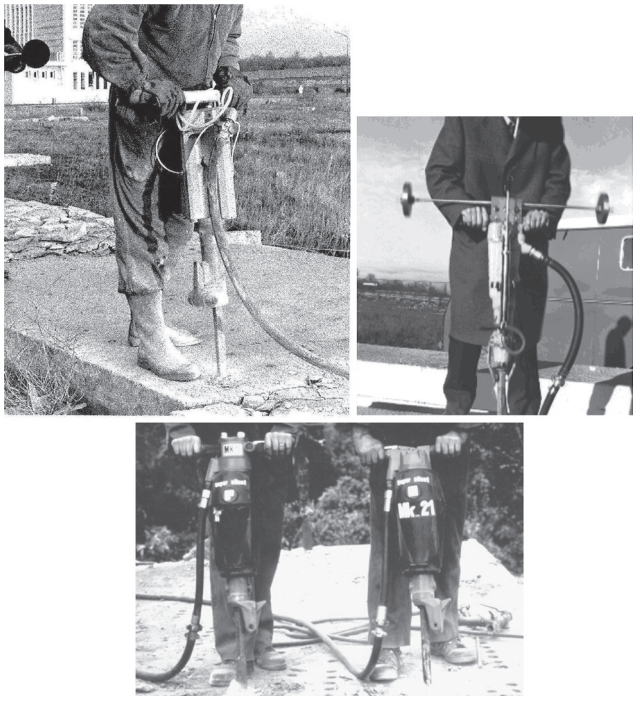

Fig. 2. The first low-vibration pneumatic breakers − prototypes and tools.

Fig. 3. A conventional rammer, and a prototype of low-vibration rammer[2)].

In the 1980's, three European manufacturers adapted their products to incorporate this vibration reduction technology. In the beginning of the 1990's, the French institution responsible for worker protection launched, in conjunction with the three manufacturers, a costly national campaign to promote anti-vibration breakers[1–3)]. By 1995, all manufacturers of that time had anti-vibration breakers in their catalogues, and the cost differential between conventional and low-vibration pneumatic hammers had disappeared because of the economies of scale in production. The success in improving vibration protection with this tool took 20 years of massive efforts in France. Unfortunately, this success did not extend to similar results with other vibrating tools.

INRS was then persuaded that offering low-vibration tools on the market would be sufficient to solve the problem of vibration hazards. Therefore, INRS developed a policy of demonstrating the practicability of vibration emission reductions on other tools, such as grinders, rammers (e.g., see Fig. 3), and chipping hammers[4, 5)].

Although this approach was technically successful, it was not sufficient to persuade a significant number of employers to equip themselves with low-vibration tools. The reasons for these successive failures to promote vibration prevention included the absence of regulations, insufficient expertise, the cost and the difficulty of measurements, and the fact that the health risks of vibration exposures were under-estimated and not well known[6)].

A significant exception to these failures was the case of low-vibration chain saws for forestry workers. The high prevalence of Raynaud's phenomenon amongst foresters had led Japanese and Finnish authorities to implement efficient national campaigns of prevention[7, 8)]. The campaigns included the obligation to equip operators with anti-vibration chain saws, regulation of their operating times, protection against cold, health surveillance of the exposed population, and intervention in the form of treatment for workers suffering from the vibration syndrome[7)].

In the 1990's, chainsaws with vibration-isolated handles became a common tool in Europe. Since that time, the Japanese and Finnish approaches to risk management and prevention have demonstrated that it is possible to eliminate vibration-induced white finger (VWF) from worker populations.

Machine European Directive: a New State-of-the-Art − Design of Low-Vibration Tools

In 1989, the first version of the European Machine Directive (1989/392/EC) was published[9)]. This document was directed primarily towards manufacturers. Its text had two objectives − to harmonize requirements applicable to

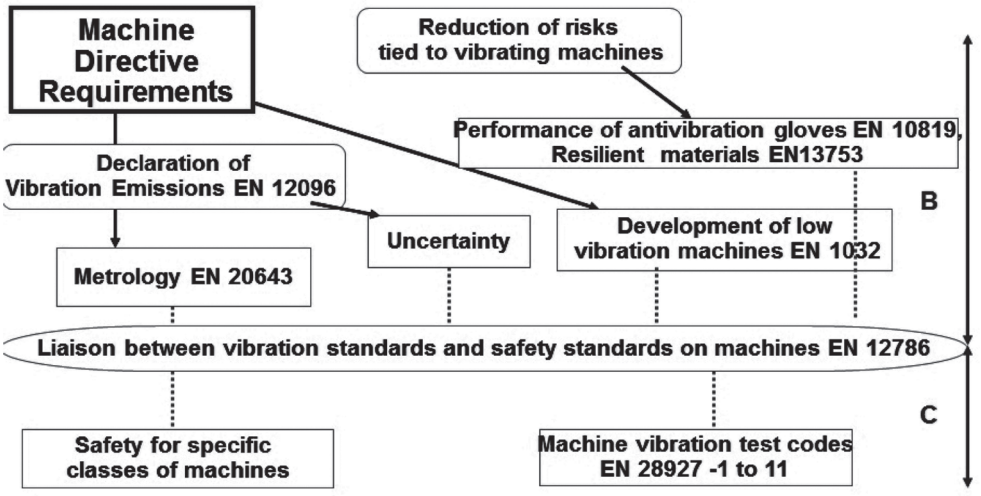

Fig. 4. Harmonized standards on vibration linked to the Machine Directive[11–19].

tools and machinery for worker health and safety, while ensuring free circulation of tools and machinery in the European common market. Manufacturers were required to design and construct their products so that risks to worker health were as low as possible.

The Machine Directive established no vibration emission limits. However manufacturers were required to declare vibration emission levels if they were above 2.5 m/s^2, as well as to specify the test code used to assess vibration emission levels. These two requirements were expected to make the comparison of tools easier for purchasers. Manufacturers were also required to list technical measures to reduce residual vibration exposures. In the most recent version of the Machine Directive (2006/42/EC), the vibration level to be declared has become the vibration total value to which the hand-arm system is subjected, and the uncertainty of measurement must also be given.

To supplement the Machine Directive, the European Committee for Standardization developed harmonized standards, including approximately 20 which refer to vibration measurements (summarized by Fig. 4)[10–19]. Many of these standards apply to manufacturers. These successive regulations have encouraged manufacturers to develop state-of-the-art low-vibration tools. First, manufacturers are required to reduce the vibration at source by design and construction measures. Then, if necessary, vibration may be further reduced by integrating protective measures, such as vibration isolation or suspension systems. Finally, manufacturers must inform users about residual vibration emissions of their products, so that protective measures can be taken.

The effects of these initiatives were expected to encourage users to buy low-vibration tools, by taking into account the manufacturers' declarations of vibration emission levels, determined in accordance with harmonized European standards. Because these declarations of measured vibration emission levels were published in technical and commercial leaflets, users were able to compare tools before purchase.

The impact of these initiatives on the availability of low-vibration tools can be seen clearly when comparing before and after publication of the Machine Directive. After the Directive, numerous low-vibration tools appeared in the market (chipping hammers, brush cutters, needle hammers, grinders, sanders, perforators, hammers, circular saws, and wackers). The obligation to declare emission values apparently stimulated competition among manufacturers. Before the Directive, commercial acceptance of tools required good performance, reliability and low cost. However, after the Directive, another quality became valued − best suitability of the tool for human ergonomics.

Now, however, 20 years after the first Machine Directive, many tools still emit high levels of vibration. Moreover, it appears that most factory purchasers buy new tools without taking into account the vibration levels declared by manufacturers. At the end of the last century, INRS started to realize that a prevention strategy based mainly on tool manufacturers was inadequate to protect workers. It was becoming clear that it was also essential to make users aware of vibration risks, so that they could demand more as customers and users[20].

What about the pneumatic breakers? At the beginning of this century, at the request of the French Ministry of Employment, INRS systematically checked all the vibration

emission values declared by 12 different breaker manufacturers, representing 52 different models. Subsequently, an Advisory document was published by the Ministry in 2004, fixing an emission level of 8 m/s^2 to differentiate the low-vibration tools (the state-of-the-art for these machines) from conventional ones (above 8–10 m/s^2).

Vibration European Directive: Assessment and Actions

In 2002, the European Union introduced the Vibration Directive (2002/44/CE) to provide European workers with a minimal level of health and safety protection against risks of vibration exposures[21]. This Directive marks a turning point in the protective strategies used to date. It defines the employer as responsible for the health and safety of employees, establishes exposure limits, and specifies employer obligations and requirements for the surveillance of worker health.

The employer is responsible for assessing all health risks of work processes, and for implementing means for worker protection. This Directive specifically requires assessment of vibration exposure risks in workplaces, and the comparison of results with specified thresholds called the "action value" (2.5 m/s^2 for hand arm vibration) and the "exposure limit" (5 m/s^2).

Where the risk of worker exposure to vibration is assessed to be greater than the action value, preventative measures are required to reduce exposures to the lowest possible level. Employers have to take into account technical developments and the possibilities of controlling risks at source. Employers must also provide increased medical surveillance for workers exposed to vibration above the action values. When a health problem in connection with vibration exposure is observed, the worker must be informed by the medical officer.

Employees must not be exposed to vibration levels which exceed the exposure limit value. If the employers' assessments of worker exposures exceed the exposure limit value, the employer must implement all available means to reduce worker exposures below this limit.

Vibration exposure assessments must be made at regular periods by trained persons, in parallel with a health assessment. Assessments must be repeated when equipment, work organization or processes are changed (see Fig. 4). These assessments shall take into account information provided by tool manufacturers, work procedures, forces required to be exerted on tools, interaction with a cold environment, and the sensitive worker. The risk assessment reports must be kept on file for 10 years, with copies accessible on site and available to medical services and site inspectors.

Labour inspectors check to ensure employers follow the recommended requirements. This is done generally by reviewing the organization's risk assessment books which must contain vibration assessments at the workplace. If there is no risk assessment report, inspectors may order risk assessments to be carried out by a Notified Body. An organization may be fined if it does not apply this regulation. In France, inspectors send more than 200 written reports annually of inadequate responses to the Vibration Directive[22].

In June 2005, the 27 European member states took measures to adopt the Vibration Directive into their national laws. The Directive lays down minimum requirements, thus giving Members States the option of maintaining or adopting more stringent requirements for worker protection, for example, by establishing lower action or exposure limit values. In practice, most countries adopted the same rules for hand-arm vibration. Some adopted an additional short term exposure limit and additional restrictions for young workers.

Implementation of Vibration Directive

More than 10% of European employees are exposed to hand arm vibration[23]. Therefore, the application of this Directive concerns several million employers, many of whom are small businesses. Although the Vibration Directive has been obligatory in all European countries since 2005, it continues to provoke numerous questions from employers, industrial hygienists and exposed workers. Common questions include the manner of assessing vibration exposures, situations at risk, effects of vibration, ways of reducing vibration exposure risk, and methods of developing a prevention program.

In the author's experience, very few employers actually evaluate vibration risks (see Fig. 5), and even fewer take steps to reduce vibration exposures[23]. In small enterprises, the lack of knowledge, training, and measuring equipment can be seen as the main explanations for the poor response. Instructions for operating equipment typically have few warnings related to risks due to vibration. Reasonable technical solutions may not be undertaken due to lack of awareness and knowledge. There are also other factors contributing to the low compliance rate. For example, many companies still tend to tackle only those risks that may lead to severe accidents, while neglecting

	Belgium	Finland	France	Germany	Poland	Spain
Employers	Survey: 55% of employers assess risks of vibration	5% with sub-contractor	Very few	Uses emission values	Yes	No
Labs.	Universities	2 health & safety orgs.	9 health & safety orgs.	Approx 30 health & safety orgs.	4 health & safety orgs. Labour Inspectorate 100 groups of Occup. Health Physicians 150 labs. 50 consult's	139 health & safety orgs.
Accredited Organization	Lab. certified by Ministry of Labour Vibration specialists certified by gov't. Fund of occup. diseases	None	Approx. 6	Tech. Service Association Institutes for Accident Insurance & Prevention Consulting Engineers		Health & safety orgs.

Fig. 5. Who is doing vibration evaluation at work[23)]?

occupational health issues. Some criticize low-vibration tools and machines for their handling difficulties or higher costs. Some criticize low-vibration tools and machines because they are seen to be comfortable luxuries, rather than important improvements.

In order to assist employers in compliance with their requirements to conduct risk assessments, some countries have provided training in how to carry out vibration measurements, while other countries have developed various strategies to assist the largest number of firms to conduct their own risk management[23, 24)]. Various strategies include:

- "Increased Awareness": Brochures, booklets, and basic articles have been written to increase awareness among the different prevention stakeholders (users, occupational physicians, factory inspectors, machine distributor) of the health risks of vibration;
- "Increased Screening": Risk factors are monitored by workers and management, and obvious solutions get implemented. Interactive web sites, good practices guides[25–28)], and data banks are being improved to help vibration level assessments without the requirement for making measurements[29, 30)];
- "Increased Observation and Analysis": The remaining problems are studied in more detail, to observe contributing factors and find solutions. Simple and low cost dosimeters have become available, and enable stakeholders to carry out simple vibration exposure measurements to check the effect of changes made when trying to reduce vibration exposures;
- "Increased Expertise": In France a network of expert laboratories was trained to assist firms for the most complex cases. These trained personnel carry out appropriate vibration measurements, in order to assist firms develop specific solutions.

Conclusion: Prevention is a Step-by-Step Process

Forty years after the design of the first anti-vibration breaker, human vibration experts finally have all the necessary facilities to be able to ensure worker protection: laws and regulations, such as the Machine and Vibration Directives, numerous standards, instrumentation for measuring vibration and vibration exposures, both simple and complex, low-vibration tools and machines, more experience with effective solutions, and more scientific knowledge. So what is the next step? The ongoing challenge will be to increase workplace awareness of, and attention to, the risks of vibration exposures to millions of affected individuals. Another challenge will be to simplify the regulations.

What about the pneumatic breakers? Today, Joël's anti-vibration breaker has become the normal tool in general use. However his job remains hard and reports of osteoarthritis linked to the use of this tool continue to accumulate. Measurements on the handle gripping zones show that breaker operators still have to exert forces of 100N to 200N to manipulate their tools for common tasks[10]. In practice, even though strict rules provide oversight for the vibration risk, there is nothing that limits the effort and forces required to be exerted on tools to complete the tasks. Unfortunately, experience has indicated that without regulatory requirements and market competition, the progress towards improved protection of workers with even more ergonomically-friendly tools will be slow. Researchers are working in this field now, to find and develop the solutions of tomorrow[31].

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