LEGISLATION AND STANDARDIZATION RELATED TO WHOLE BODY VIBRATION

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Summary: *Whole-body vibration is caused by machines or vehicles that transmit vibration through the operator's feet, buttocks and back into his or her body. Employees who are regularly exposed to whole-body vibration may suffer from lower back pain as well as disorders of the sensory functions or fine motor co-ordination. To prevent negative influence on the health of workers related to vibration it is necessary, among other things, to provide permissible exposure values, as well as preventive measures to reduce or completely remove the threat of action due to vibration. Therefore, it is necessary to have laws, regulations and standards that will govern the measurement and evaluation of human exposure to whole-body vibration and set minimum health and safety requirements regarding the exposure of workers to the risks due to vibration. Currently over a hundred rules, norms and standards related to whole body vibration are in use in the world. Probably the most important and, certainly, the most commonly used are European Directive 2002/44/EC and ISO 2631-1:1997. This paper will give an overview and comment on the most important standards and regulations (international and national) related to whole-body vibration.*
Keywords: *whole body vibration, Directive 2002/44/EC, ISO 2631-1:1997.*

1. INTRODUCTION

Whole body vibration (wbv) are mechanical vibrations which are transmitted, from their source, to the body of a man through the lower part of the back, in case of the sitting position, or through the feet, in case of standing working position. Operaters in heavy construction industry, operaters of mining and agricultural transshipping machinery, locomotive drivers, helicopter pilots and military vehicles drivers, operaters of presses and vibrating platforms as well as the operaters of powerfull tools are all subjected to whole body vibration.

As a consequence of whole body vibration negative effects to health occur. Continuous short-term exposure to vibrations can cause pain in abdomen and chest, shortage of breath, nausea, loss of balance etc., while constant long-term exposure can lead to disorders in psychomotoric, physiological and psychological systems of an operater.

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Although the negative effects of vibrations to opearaters (wbv, especially), they are still underestimated. One of the reasons is the impossibility of determining the correlation between the vibration impact and health deterioration, because of the combination of vibration and other occupational hazards and harms.

Legal framework concerning the work in vibration related conditions is extremely important in understanding this issue. First standards in this field were set in the seventies of the last century, whereas the most important regulations were established only at the end of the last and at the beginning of this century. The laws and standards concerning this matter are subject to constant changes in accordance with the technological and technical improvements in measuring of vibration levels. Most of local laws and standards are taken from international regulations.

This paper will give an overview of most important occupational health and safety (OHS) laws and standards concerning whole body vibration. The most important documents in this field, and they are Directive 2002/44/EC and ISO 2631-1:1997, will be presented more than others.

2. OHS LAWS RELATED TO WBV

This chapter will give several most important OHS laws concerning whole body vibration.

2.1. European union OHS laws related to WBV

In European Union, the legal framework for the implementation of precaution concerning exposure to vibration health risks is based on Directive 2002/44/EC, so called European Vibration Directive [1]. Numerous provisions of this so called European Vibration Directive derive from the provisions of Council Directive 89/391/EEC that provides measures for raising the operaters' safety level at workplaces.

Most of the EU member states introduced this Directive directly to their legal systems as early as in 2005, whereas some countries did that with their special local laws which are, in some cases, even more favourable for workers than it is provided by the Directive itself.

According to the Directive, whole body vibration is mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine.

The Directive establishes several requirements for the protection of workers from vibration, including:

- employers must conduct risk assessments for vibration hazards (this requires the employer to measure vibration levels of tools, machinery and equipment that can expose workers to vibration and determine worker exposure)
- limits for maximum permissible vibration exposures
- requirements for employers to reduce worker exposures through control measures
- recommendations for the health surveillance of workers at significant risk of vibration exposure

The Directive sets the limit values of daily exposure of workers to whole body vibration:

- daily exposure limit value-ELV which must not be exceeded in professional working conditions and is 1,15 m/s^2 standardized to an eight-hour reference period (or, vibration dose value of 21 $m/s^{1.75}$),
- daily exposure action value-EAV, above which employers must control risks coming from vibrations and is 0,5 m/s^2 standardized to an eight-hour reference period (or, vibration dose value of 9.1 $m/s^{1.75}$)

The Directive provides duties of employers related to risk estimation, measures for reducing and avoiding the critical exposure and elaborates practices for training and educating the operaters.

2.2. Other OHS laws related to WBV

In 2006, the United Kingdom passed The Control of Vibration at Work Regulations 2005, based on the Directive. It requires employers to: assess vibration exposure risks, determine if workers are likely to be exposed above the daily exposure action value, provide health surveillance to workers who continue to be regularly exposed above the action value or otherwise continue to be at risk, provide information and training to workers about health risks and actions to control vibration exposure risks, keep a record of risk assessments, control actions, and health surveillance records for vibration exposed workers and periodically review and update the risk assessment. The legislated maximum permissible vibration exposure limits are the same as those specified in the Directive 2002/44/EC.

In 1977, the International Labour Organization held the “The Convention Concerning the Protection of Workers against Occupational Hazards in the Working Environment Due to Air Pollution, Noise and Vibration” (ILO No. 148, 1977). This event focused on the protection of workers from vibration.

The United States federal and state occupational health and safety laws establish general duties for employers to protect the health and safety of workers. However, except in California, there are no specific requirements on vibration exposure hazards.

3. STANDARDS RELATED TO WBV

This chapter will give short information about non-regulated and voluntary standards relating to vibration exposure limits, vibration measurement techniques, minimizing vibration through design and fabrication, and vibration control methods.

3.1. ISO Standards related to WBV

The matter of whole body vibration is covered by many ISO (International organization for standardization) standards. A few of them have basic name 2631.

The first International Standard ISO 2631, for measuring and evaluating of human exposure to whole body vibration was outlined in 1966, and was published in 1974. Following a few amendments, this standard was published again in 1985, under the new name ISO 2631-1:1985 Evaluation of human exposure to whole-body vibration - Part 1: General requirements [2]. Because of some shortcomings, the standard from

1985. was additionally developed and published in 1987 under the name ISO 2631-1:1997 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements [3]. This standard is stil in effect and is one of thye most important documents in studying whole body vibration. In comparison to previous 1985 standard, this standard includes revised frequency weightings, calculation of a single overall root mean square (RMS) acceleration and the introduction of methods for assessment of WBV containing shocks.

ISO 2631-1:1997 is a standard that:

- incorporates assessment methods for both steady state and shock type whole body vibration, and
- provides guidance for acceptable workplace vibration exposures.

The standard classifies vibration exposures into three categories or "zones":

- likely health risk zone (RMS – 0,86 m/s^2 ili VDV – 17 m/s$^{1.75}$), where vibration exposure is likely to be a risk to health (in Directive it is daily exposure limit value)
- caution zone (RMS – 0,43 m/s^2 ili VDV – 8,5 m/s$^{1.75}$), where vibration exposure is a potential risk to health (in Directive it is daily exposure action value)
- below the caution zone, where the vibration exposure level is considered acceptable and unlikely to be a risk to health.

Apart from ISO 2631-1:1997, ISO 2631-5:2004 is also important. Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration – Part 5: Method for evaluation of vibration containing multiple shocks [4]. The purpose of ISO 2631-5:2004 is to define a method for analyzing the effect of multiple shocks in relation to human health. This standard provides guidance for the assessment of health effects in the lumbar spine relating to long-term exposure to whole body vibration containing multiple shocks. It is the first time a standard in this field has directly attributed a specific degenerative health effect to whole body vibration and shock. Previous standards generalized the human response as simply adverse health effects consisting mainly of problems in the "lumbar" region.

The set of standards ISO 2631 also includes ISO 2631-4:2001 Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed-guideway transport systems. These guidelines establish methods for the evaluation of relative comfort between systems, as opposed to absolute levels of comfort.

Another important standard among ISO standards is ISO 8041:2005 Human response to vibration – Measuring instrumentation. The first issue of this standard was published in 1990, whereas the standard was changed and published again in 2005. Standard contains not only specifications but also detailed instructions for performance testing on different levels.

There are numerous standards addressing measuring and evaluating of vibration at the seat of vehicles and machines such as agricultural tractors, railroad cars or constructional machinery for work with soil:

- ISO 10326-1:1992 Mechanical vibration – Laboratory method for evaluating vehicle seat vibration – Part 1: Basic requirements

- ISO 10326-2:2001 Mechanical vibration-Laboratory method for evaluating vehicle seat vibration – Part 2: Application to railway vehicles
- ISO 7096:2000 Earth-moving machinery – laboratory evaluation of operator seat vibration
- ISO 5007:2003 Agricultural wheeled tractors - Operator's seat – Laboratory measurement of transmitted vibration.

3.2. European Standards (EN) related to WBV

European Committee for standardization (CEN) has developed and published several important standards addressing the whole body vibration and vibrations in general.

- EN 13490:2001 Mechanical vibration – Industrial trucks – Laboratory evaluation and specification of operator seat vibration.

This European Standard specifies, in accordance with EN 30326-1, a laboratory method for measuring and evaluating the effectiveness of the seat suspension in reducing the vertical whole body vibration transmitted to the operator of industrial trucks at frequencies between 1Hz and 20Hz.

- EN 14253:2003 Mechanical vibration — Measurement and calculation of occupational exposure to whole-body vibration with reference to health — Practical guidance.

This European Standard describes the precautions to be taken to make representative vibration measurements and to determine the daily exposure time for each operation in order to calculate the daily exposure value standardized to an 8-h reference period. Also, standard provides a means to determine the relevant operations that should be taken into account when determining the vibration exposure.

- CEN/TR 15172-1:2005 Whole-body vibration - Guidelines for vibration hazards reduction - Part 1: Engineering methods by design of machinery.

This Technical Report provides best practices and methods available for limiting the effects of mechanical whole-body vibration on operators positions. The guidelines given outline practical ways in which whole body vibration hazards associated with mobile machinery can be reduced by machinery design.

3.3. National Standards (BS, ANSI, VDI...)

Most of local standards are taken from international regulations and is based on ISO 2631-1:1997.

Although accepted internationally, the United Kingdom voted against ISO 2631 as a full standard. British Standards Institution releasing their own standard in 1987 BS 6841.This standard differs from the earlier International Standards in some areas. A methodology for the measurement and evaluation of vibration containing shocks, called the Vibration Dose Value (VDV), was introduced. This quantity is a single value representing vibration in each axis using frequency weightings, and assessment of the fourth power of acceleration between 0.5 and 80 Hz. Frequency weightings in BS 6841 differ from the early International Standards, and in part were implemented to eliminate the need for multiplying factors in the horizontal axes.

In the U.S., American National Standards Institute published in 2002 ANSI S3.18:2002, which relies entirely on ISO 2631-1:1997 while the American Conference

of Governmental Industrial Hygienists Threshold Limit Value given in 1996 ACGIH-TLV 1996 which is based on the ISO 2631-1:1985.

In Germany, one of the most important standards in this field is VDI 2057-1:2002 Human Exposure To Mechanical Vibrations – Whole-body Vibration.

4. CONCLUSION

In careful consideration and studying of WBV effets on workers, laws and standards are of great importance. The strength of the standards is that they are internationally recognized and applied. However, many industrial WBV exposures will fall into a caution zone between categories, providing uncertainty to the user, which is a weakness. Other weaknesses of the standards are the absence of a single measurement and assessment methodology and the ambiguities in the current methods. Possible improvements include definition of acceptable short-term exposures and guidelines outlining acceptable measurement durations and data certainty. Some of these are not possible based on current knowledge.

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