



# Practical methodology for estimating occupational exposure to hand-arm vibrations according to CEN/TR 15350:2013



F. Brocal<sup>a,\*</sup>, C. González<sup>b</sup>, M.A. Sebastián<sup>b</sup>

<sup>a</sup> Department of Physics, Systems Engineering and Sign Theory, Universidad de Alicante, Alicante, Spain

<sup>b</sup> Department of Manufacturing Engineering, Universidad Nacional de Educación a Distancia (UNED), Madrid, Spain

## ARTICLE INFO

### Keywords:

Acceleration

Uncertainty

Instruction manual

Risk

Hand-arm vibration

## ABSTRACT

Directive 2002/44/EC, regarding exposure of workers to vibrations, distinguishes between vibrations transmitted to the hand-arm system (HAV) and vibrations transmitted to the whole body (WBV). In both cases, the employer must perform an assessment of the level of exposure to mechanical vibration. To do so, the employer may observe the specific working methods and refer to the information provided by the manufacturer. This operation is not the same as measuring, which requires the use of specific equipment, along with a suitable methodology.

When using the information provided by the manufacturer with the aim of approximately estimating the level of risk of the worker's exposure to HAV, the CEN/TR 15350:2013 Technical Report includes the guidelines to do so, according to the requirements laid down by Directive 2002/44/EC.

Nevertheless, the procedure set out in CEN/TR 15350:2013 considers problems of practical application that may hinder decision-making in terms of the risk assessment process. These problems are mainly linked to the following factors: limitations and conditions for application of the procedure; determining the correction factor; determining the undeclared uncertainty; and determining the declared vibration emission value.

In order to resolve these problems, this paper seeks to develop a methodology that facilitates practical application of the procedure to estimate the HAV exposure according to CEN/TR 15350:2013 using the information provided in the instruction manuals from the tool manufacturers.

Thus, the procedure set out in Annex B to CEN/TR 15350:2013, and other related standards, has been analysed. The results obtained were included in the procedure of said Annex B, thus shaping the methodology sought after in this paper. This methodology has been applied to a practical example based on actual data.

All of this shows that although the methodology developed facilitates the practical application of the procedure in Annex B to CEN/TR 15350:2013, its implementation requires very thorough studies, the results of which cannot be considered anything more than an estimation with a high degree of uncertainty.

## 1. Introduction

At present, the European regulatory framework regarding occupational risk prevention (ORP) is highly developed. These regulations are based on what is known as the Framework Directive (Directive 89/391 EEC), which guarantees minimum requirements in terms of ORP throughout the whole European Union and, at the same time, allows the Member States to keep these minimum requirements or establish more restrictive measures.

Among the set of specific directives on ORP is Directive 2002/44/EC regarding the exposure of workers to vibrations. Over recent years, the administrations of the European Union (EU) have carried out work in this area regarding control and prevention relating to the harm caused

by exposure to vibrations (Álvarez, 2014). However, according to what is stated in the Sixth European Working Conditions Survey (6th EWCS), 20% of workers in the EU are exposed to vibrations from tools or machinery (Eurofound, 2015).

The aforementioned Directive 2002/44/EC distinguishes between vibrations transmitted to the hand-arm system (HAV) and vibrations transmitted to the whole body (WBV). HAV is vibration that, when transmitted to the human hand and arm system, entails risks to the health and safety of workers, in particular vascular, bone, joint, neurological or muscular disorders. WBV is 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.

Continuing with Directive 2002/44/EC, it states that in both cases

\* Corresponding author.

E-mail address: [francisco.brocal@ua.es](mailto:francisco.brocal@ua.es) (F. Brocal).

(HAV and WBV) the employer must perform an assessment and, where necessary, measure the levels of mechanical vibrations to which the workers are exposed. The risk assessment regarding the exposure to mechanical vibrations should be performed by firstly determining parameter value A(8).

In order to evaluate the level of exposure to mechanical vibration, the employer may observe specific working practices and refer to relevant information on the probable magnitude of the vibration corresponding to the equipment or the types of equipment used in the particular conditions of use, including the information provided by the manufacturer of the equipment. This operation is not the same as measuring, which requires the use of specific equipment, along with a suitable methodology.

When using the information provided by the manufacturer with the aim of approximately estimating the level of risk of the worker's exposure to HAV, the CEN/TR 15350:2013 Technical Report includes the guidelines to do so, according to the requirements laid down by Directive 2002/44/EC.

Nevertheless, as indicated by Brocal et al. (2016), regarding the application of the guidelines set out in CEN/TR 15350:2013, there are unresolved aspects regarding how the uncertainty of the data is to be dealt with. Essentially, these problems are due to the difficulties relating to interpreting and determining the vibration emission values declared by the manufacturer (acceleration and associated uncertainty).

Consequently, the procedure set out in CEN/TR 15350:2013 considers problems of application which may hinder decision-making in terms of the risk management process.

In order to resolve the problems indicated while interpreting and determining the vibration emission values declared by the manufacturer, this paper seeks to develop a methodology that facilitates practical application of the procedure set out in Annex B to CEN/TR 15350:2013. This procedure is that which should generally be applied when the parameter A(8) is estimated, using the emission values declared by the manufacturer for this purpose.

Thus, this paper is structured as described below. Firstly, an explanation is given of the analysis method used based on legal-technical criteria in line with the foundations of the Framework Directive (Directive 89/391 EEC) and Directive 2002/44/EC on the exposure of workers to vibrations.

Secondly, by means of the method indicated, the procedure set out in Annex B to CEN/TR 15350:2013 is analysed. The following variables are then studied with this analysis: (i) the correction factor (c); (ii) the undeclared uncertainty (K); and (iii) the declared vibration emission value ( $a_d$ ).

Thirdly, the results of this analysis were included in the procedure of said Annex B, thus shaping the methodology sought after in this paper. This methodology has been applied to a practical example based on actual data. Finally, the results obtained as a whole have been widely discussed, obtaining a number of conclusions.

## 2. Method

In order to fulfil the objective of this paper, the CEN/TR 15350:2013 Technical Report is analysed. This analysis is based on the risk assessment procedure set out in Article 5.3 of RD 39/1997, by virtue of which the Regulations for Prevention Services were approved in Spain.

RD 39/1997 fulfils the legal mandate set out in directive 89/391/EEC regarding the risk assessment procedures for workers' health and the forms of organisation, operation and control of the prevention services.

In this way, the aforementioned Article 5.3 indicates that when the assessment requires measurements, analyses or tests to be performed and the regulations do not indicate or specify the methods to be used, or when the assessment criteria set out in said regulations have to be

interpreted or specified in light of other criteria of a technical nature, the methods or criteria set out in standards, where applicable, may be used.

Considering the criteria above, for the interpretation of what is indicated in Directive 2002/44/EC regarding the evaluation of the level of exposure to HAV by means of observing the specific working practices and obtaining suitable information on the probable magnitude of the vibration corresponding to the equipment, the CEN/TR 15350:2013 may be used in the first instance.

However, as stated in the introduction, the technical report in question poses several problems of interpretation which, in order to be clarified, require the analysis of two additional standards: EN 12096:1997 and EN ISO 20643:2008.

## 3. Analysis of the procedure to estimate exposure to HAV set out in the CEN/TR 15350:2013 Technical Report

Prior to the analysis of the CEN/TR 15350:2013 Technical Report itself, it is a good idea to describe, on the one hand, the conceptual framework for determining the levels of exposure according to the provisions of Directive 2002/44/EC and, on the other, the procedure set out in Annex B to CEN/TR 15350:2013, along with its limitations and conditions of application.

These brief and applicative descriptions provide the theoretical base required to define a comprehensible guiding principle between Directive 2002/44/EC, CEN/TR 15350:2013 and the other technical documents subject to analysis.

After said descriptions, the analysis itself of the procedure in Annex B to CEN/TR 15350:2013 is addressed. For these purposes, the following variables considered in the procedure are analysed and need to be interpreted in light of other criteria of a technical nature: (i) the correction factor (c); (ii) the undeclared uncertainty (K); and (iii) the declared vibration emission value ( $a_d$ ).

### 3.1. Determining exposure levels

According to the provisions of Directive 2002/44/EC, the risk assessment regarding the exposure to mechanical vibrations should be performed by firstly determining parameter value A(8) according to the Eq. (1), which represents the value of daily exposure for a period of 8 h, according to what is stated in standard EN ISO 5349-1:2001.

$$A(8) = a_{hv} \cdot \sqrt{\frac{T}{8}} \quad (1)$$

where  $a_{hv}$  is the total equivalent value of vibration in  $m/s^2$  and T the duration of exposure in h.

Throughout the working day, a worker's total daily exposure to vibrations may consist of several tasks or operations with different magnitudes of vibration (different machines and/or different conditions with one or more machines), such that the parameter A(8) can be calculated according to the Eq. (2).

$$A(8) = \sqrt{\frac{1}{8} \sum_{i=1}^n a_{hvi}^2 T_i} \quad (2)$$

Thus, in each case (i) the acceleration and duration of exposure relating to each operation will need to be determined.

Once parameter A(8) has been calculated, it should be compared with the levels of exposure set in Directive 2002/44/EC itself and which are set out in Table 1.

### 3.2. Procedure for estimating parameter A(8)

The CEN/TR 15350:2013 Technical Report sets out in its Annex B the procedure that should generally be applied when the daily vibration exposure is estimated in the workplace, that is to say, parameter A(8),

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