WHOLE-BODY VIBRATION INDICATORS IN AGRICULTURAL TRACTORS

Adolfsson, N[1]

[1]JTI-Swedish Institute of Agricultural and Environmental Engineering
P.O. Box 7033, SE-750 07 Uppsala, Sweden
E-mail: niklas.adolfsson@jti.se

The main objective of this study was to evaluate if a feed-back system, vibration indicators, could help the tractor driver to lower the exposure of whole-body vibrations. In the first step a literature study were carried out and in the next step a field study, where the vibration indicator was evaluated. The tasks carried out were spraying, sowing, rolling and manure spreading. The literature study indicated that similar studies haven't been performed earlier and that there are very few whole-body vibration measurements made on agricultural tractors. The interviews with the drivers showed that they found the vibration indicator user-friendly, but difficult to adopt.

Keywords: Agriculture, Tractors, Whole-Body Vibration

1 Introduction

Adolfsson (2006) made a literature study in the field of Whole-Body Vibrations (WBV), in which common disorders were found in the literature. It is often the lower back, the neck, shoulders and the hips that are affected negatively by WBV from mobile working machines such as an agricultural tractor. This over time can lead to musculoskeletal disorders in those areas (Burström, 2001; Wikström et al., 1994; Bovenzi et al., 1994; Boshuizen et al., 1990a & b). These disorders can in turn result in pain and fatigue (Wikström et al, 1994; Sjaastad & Bakketeig, 2002). Jönsson (2005) describes in his doctoral thesis how transient vibrations can affect the driver and result in discomfort.

According to the European Directive on WBV, there are two exposure values, standardized to an eight-hour reference period, that indicate the risk for musculoskeletal disorders. The daily exposure action value is 0,5 m/s² and the daily exposure limit value is 1,15 m/s² (2002/44/EG). However, the Swedish daily exposure limit value is set to 1,1 m/s² (AFS 2005:15).

Farmers mean annual tractor-driving time is 472 hours according to a ten year old Swedish study (Torén et al, 2002). The most common working tasks are ploughing, forage harvesting, working with a front loader, manure and fertiliser spreading. However, the general development in Swedish agriculture is that the farms are getting fewer but bigger with larger areas of arable land to cultivate and a greater animal production. In consequence, more work is performed with the help of different kinds of machines, such as the agricultural tractor, exposing the farmer to WBV to a greater extent, then before.

Since the new European directive (2002/44/EG) on vibration including WBV came, different kinds of solutions to reduce high vibration exposures in mobile working machines have been presented. One technique is the vibration indicator, which let the driver now how much vibration he or she is exposed to during the driving. Other techniques, however not studied any further in this paper, are different kinds of interventions that can reduce perceptions of vibration discomfort and risks for musculoskeletal disorders, such as levelling and low frequency suspended seats.

2 Objectives

The main objective was to evaluate if a feed-back system, a vibration indicator, could help the tractor driver to lower the exposure to WBV. The objective was also to measure the exposure to WBV in order to gather more data in this particular working environment.

3 Methods

The project was carried out in two steps. A literature study in the first step, to find data on previews, measurements and similar projects. A few literature databases were covered and summarised. In next step a field study was performed, where the use of a vibration indicator (CVK VibIndicator™) was evaluated.

Seven tractor drivers participated in the field study and two measurements were made for each driver. The tasks carried out were spraying, sowing, rolling and manure spreading. The first measurement was made without the indicator and the second with it. After the measurements each driver answered a few questions about the indicator and if they were influenced in any way. The questions also covered how user-friendly the vibration indicator system was.

The vibration indicator system contains a rubber seat pad, a wireless HealthVib WBV-measurement unit and wireless a Vibindicator WBV-presentation and storage unit (fig 1).

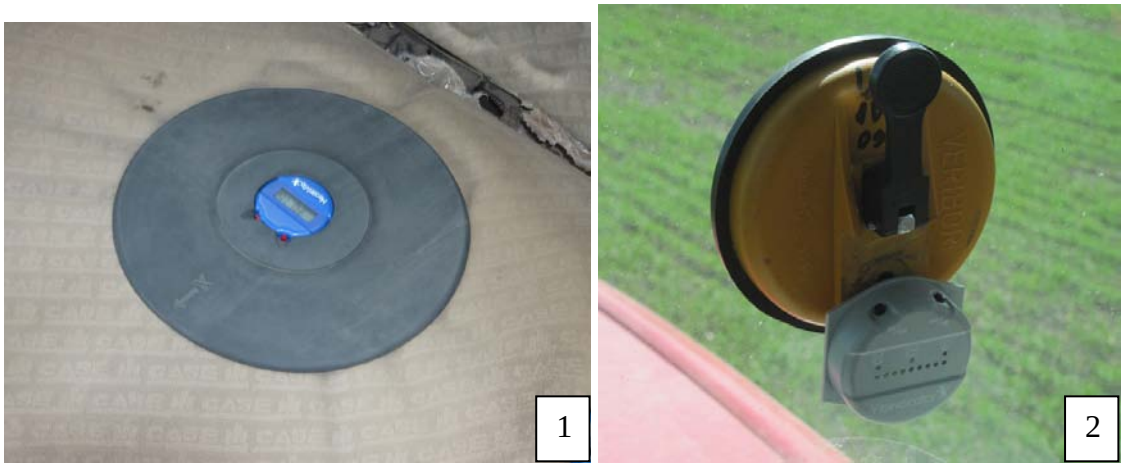


Figure 1 and 2. The vibration measurement unit and rubber pad to the left and the presentation and storage unit to the right.

The presentation and storage unit was mounted onto the lower part of the windscreen on the tractor with a suction cap (figure 2). The driver is informed by the system on the

presentation and storage unit through a total of nine lights, four green lights indicating vibration exposures below the action value, three yellow lights indicating vibration exposures above the action value and two red lights indicating vibration exposures over the limit value.

The measurement unit, HealthVib WBV, measured whole body vibrations in the three X-, Y- and Z-directions according to guidance in ISO-2631 and EU-directive 2002/44/EG (figure 3). According to these standards the exposure value of importance is the highest one of the three axes X, Y and Z.

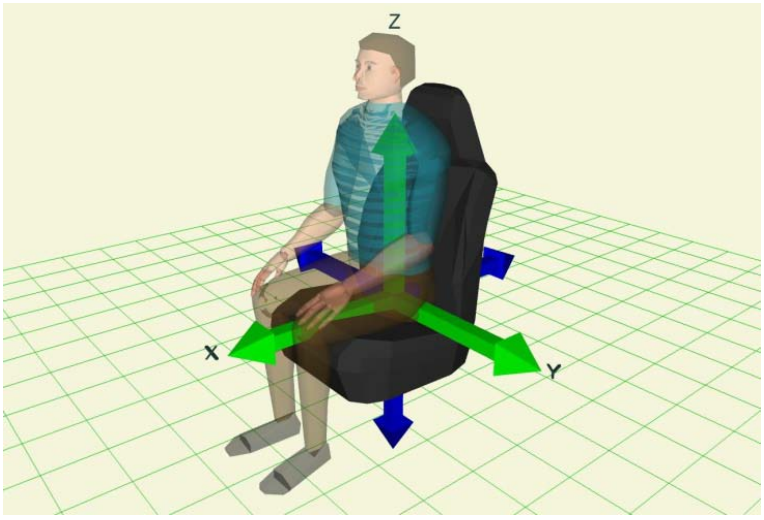


Figure 3. Illustration of the three axes X, Y and Z.

4 Results

4.1 Literature study

The results of the literature study indicated that a similar study hasn't been performed earlier in the agricultural sector. According to the results there are very few WBV measurements that have been made in agricultural tractors. Table 1 shows a few examples from a study by Adolfsson (2009).

Table 1. Example of measurements from an earlier study (Adolfsson, 2009).

Working task	Vibration exposure (m/s²), ISO 2631-1
Plowing (3 measurements)	0,79 – 1,08
Disc cultivating	0,62
Transport, full liquid manure spreader	0,71
Transport, empty liquid manure spreader	0,64
Spreading liquid manure	0,27

4.2 Field study

The measurements of the WBV, standardised to an eight-hour reference period, showed that the tasks spraying and sowing had the lowest exposure values, below the daily exposure action value (table 2). Manure spreading (table 3) and rolling (table 2) had exposure values between the action value and the limit value. Table 2 and 3 contains the

collected vibration data during the working tasks including measuring time, tractors and implements used by the driver.

Table 2. Measurements of spraying, rolling and sowing. Different drivers performed every work task.

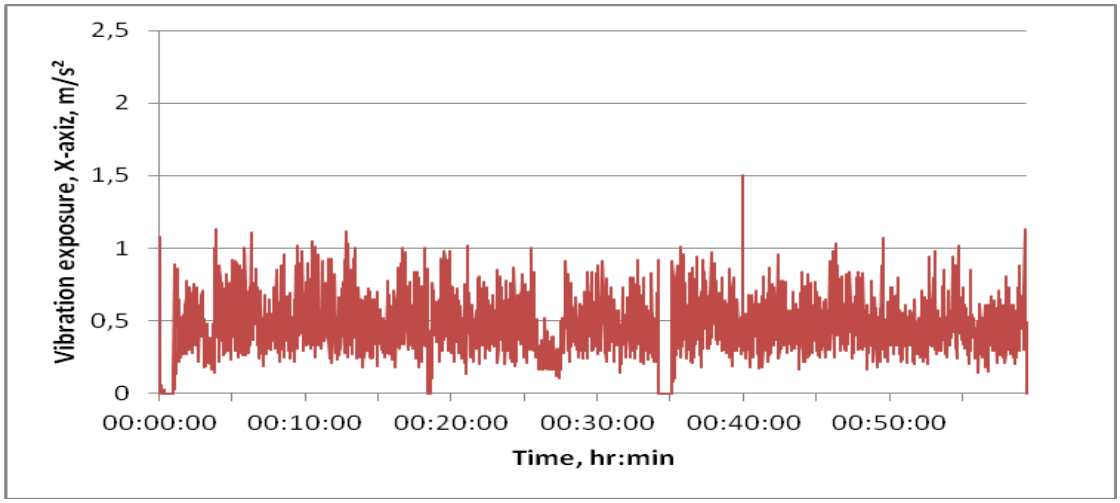
	Vibration exposure, m/s²	Time, hr:min	Tractor and implement model
Spraying, without indicator	0,35	1:16	Case IH CVX 150,
Spraying, with indicator	0,36	1:07	Danfoil, 24 m
Rolling, without indicator	0,52	1:02	Case IH CVX 210,
Rolling, with indicator	0,50	0:59	Väderstad Rollex 620
Sowing, without indicator	0,38	0:55	Case IH CVX 130,
Sowing, with indicator	0,46	1:54	System Cameleon, 8 m

Table 2. Measurements of liquid manure spreading, including filling of spreader and transport to/from the field. D=Driver.

	Vibration exposure, m/s²	Time, hr:min	Tractor and implement model
D1, without indicator	0,61	1:05	John Deere 8530, Samson 25 manure
D1, with indicator	0,64	1:06	spreader with injectors
D2, without indicator	0,64	0:42	Massey Ferguson 8480, Omas 18 manure
D2, with indicator	0,62	1:00	spreader with hoses*
D3, without indicator	0,67	1:28	John Deere 8530, Samson 20 manure
D3, with indicator	0,63	1:35	spreader with hoses
D4, without indicator	0,76	0:20	Massey Ferguson 8480, Omas 18 manure
D4, with indicator	0,61	0:53	spreader with hoses*

* Driver 2 and 4 used the same tractor and liquid manure spreader.

The interviews of the drivers showed that they could easily read the indicator with its lights and understand the meaning of them. However, even though a few drivers changed their driving behaviour to minimise the WHB, mostly by slowing the tractor down, they soon went back to their old habits. Figure 4 shows an example of this, where the driver slowed down after approximately 25 minutes during rolling and then increased the speed again after three minutes. The main reason was in most cases time related; they wanted to finish their working tasks as soon as possible.



Figur 4. Example of WBV exposure during rolling with a noticeable drop between 25 and 30 min.

Three drivers forgot about the vibration indicator a few times during manure spreading. The driver who did the spraying didn't have time to look at the indicator because he needed to be focused on the working task. Two drivers thought that this system should be a standard equipment in tractors.

5 Discussion and conclusions

The interviews showed that the farmers found the indicator user-friendly, but difficult to adopt. A vibration indicator is preferably used as an aid for consultants to inform about and to help tractor-drivers lowering their vibration exposure values. Because so few measurements have been made on tractors more measurements in different tractor-driving situations should be carried out. The main reason is that the working tasks that farmers carry out often have high vibration exposure values.

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