24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017-2565
VIBRATION'S IMPACT ON WORKER WHEN USING INDUSTRIAL MACHINE

Hélio Augusto Goulart Diniz
Jane de Souza Ramos
Pontifícia Universidade Católica de Minas Gerais, Mechanical Engineering Department, 30140100, Belo Horizonte, MG, Brazil
helioufmg@gmail.com
janesramoss@gmail.com

Bruno Alysson Lopes Martins Pereira
Centro Federal de Educação Tecnológica de Minas Gerais, Mechanical Engineering Department, 30421169, Belo Horizonte, MG, Brazil
brunoalysson@hotmail.com

Leandro de Souza Pinto
Pontifícia Universidade Católica de Minas Gerais, Mechanical Engineering Department, 30140100, Belo Horizonte, MG, Brazil
leandrosp1982@yahoo.com.br

Julio Cesar de Jesus
Centro Federal de Educação Tecnológica de Minas Gerais, Mechanical Engineering Department, 30421169, Belo Horizonte, MG, Brazil
juliocric21@gmail.com

Abstract. *Diverse industrial sectors are used motorized manual tools, which generate hands and arms vibration (HAV's) on operators, and forklift transport equipment, which expose the worker to whole body vibration. For these situations is necessary to evaluate whether the exposure limit vibrations has been exceeded, as there may be damage to the human body and occupational health of operators. This article was aimed at evaluating the occupational exposure of some workers to physical agent vibration. The study was founded basis the Brazilian standardisation, responsible for regulating and vibration control, based on the data collect from a boiler making company. The analysis on the located vibration exposure in hands and arms, measurements were done on angle grinders of different working levels. The whole body vibration analysis was done by measuring vibration on a forklift. During the use of almost all sanders, the workers had the exposure limits to accelerations exceeded, requiring immediate corrective actions. Already when used the forklift, the vibration exposure was between the exposure limit and level of action, requiring only taken preventative actions. The study increased our awareness about the need to preserve the occupational workers's health about vibrations exposure and also advise the company the importance of mitigating these impacts releasing the company of additional unhealthy provided in standard NR-15-Annex 8.*

Keywords: *Hands and arms vibrations (HAV), whole body vibration, angle grinders, forklift, unhealthy.*

1. INTRODUCTION

The motorized manual tools are widely used in a many sectors of manufacture, because they perform work with greater speed and accuracy, saving the workers of the repetitive efforts. However, all these handle tools generate vibration on operators, and consequently may be harmful to the human body if the exposure limit be exceeded. Some manual tools commonly used resulting on hands and arms vibration are: drills, Angle grinders, screwdrivers, pulleys, chainsaws, hammers, among others.

According to Gonçalves (2015), the transmission of vibration to human could result in discomfort and loss of efficiency, and may constitute a potential risk for workers, once the vibrations may iniciate neurological or muscular disturbances, vascular and Ósteo lesions, in the case of vibrations transmitted to the hand-arm system and pathologies in the lumbar region and lesions of the spine, in the case of vibrations transmitted to the whole body.

The vibration's effects in the human body depend of several factors, in particular the vibration intensity, values of frequency, direction, contact point, , as well as the time in which the professional has been submitting to exposure. According to Gonçalves (2015), studies show a higher prevalence on workers who manipulate equipment that emits such a vibratory energy and consequently are subjected to more frequent exposure and higher values.

The vibration related work with the use of a vibratory equipment was resulted from a mechanical vibration source (unbalanced element of the equipment) that focuses act on the organism, being in the whole body or in the hands. In the first case (ISO 2631-1/1997), there is a surface that vibrates, support the human body standing, sitting or laying down, being this form of exposure to which occurs in all modes of transportation. In the second case (ISO 5349-1/2001), exposure occurs when handling vibratory equipment, which is seen in industrial workers, farmers, miners, dentists professionals and construction workers, among other professionals.

Faced with this situation, the objetive of the present aticle is measure the worker's exposure during the exercises of his activities, during the use of angle grinders and forklift operation in a heavy steel conformation company. Since the evaluation of the occupational vibration, in cases where values higher the threshold of tolerance and the level of action were detected, in accordance with the standards set out in paragraph 15 Annex 8, mitigating measures were presented aiming for good health of the worker.

2. CONTEXTUALIZATION

The norms related to this study exhibit greater detailing of the types of vibrations targeted at this work and the measuring equipment used to collect the data needed to perform the calculations and evaluation of vibration.

2.1 Linked norms

In 2013, Fundacentro presented the work safety professionals the NHO 09/2013 (related the occupational exposure to whole body vibrations) and NHO 10/2013 (related the occupational exposure of hands and arms vibration).

In Brazil, regulatory norm NR-15-Annex 8 provides that "activities and operations that expose workers without adequate protection to localized or whole body vibrations will be characterized as unhealthy through expertise carried out in the workplace". This assessment should be based on exposure limits determined by ISO 2631-1/1997 and ISO 5349-1/2001.

Brazilian legislation also determines that the expert reports must necessarily include the following items: the criterion adopted; instrumentation used; the evaluation methodology; the working description; conditions work; exposure time to vibrations; the quantitative assessment results; and actions to elimination and/or neutralisation the unhealthy when there is.

When there is unhealthy, it will be labeled as médium grade, ensuring the worker receives the additional 20% incident on minimum wage.

This article has based on the abovementioned standards seeking to apply its equations and reference tables to an empirical analysis of the company in question.

2.2 Localized vibrations

According to Saliba (2014), vibrations are classified as follows: whole body vibration (sitting or standing) and localized vibrations (hands and arms). Localized vibrations, also known as hands and arms vibrations, extremities vibrations or segmental vibration, relate the vibrations that affect primarily hands and arms when using manual vibrating tools, such as, for example, Manual compactors, chainsaws, crushers, hammers, etc.

According to Saliba (2014), the vibration levels found resulting from the use of these tools for a prolonged period are considerably high and can cause damage to blood vessels, tendon of flexors, decalcification and serious circulation problems. Case of high exposure levels, problems can occur such as gangrene or Raynaud's disease (white finger syndrome).

The ISO standard 5349-1/2001 specifies general methods for measuring and evaluating the risk of vibration exposure on the hands using three orthogonal axes for the bands of 1/3 Octave and an octave, frequently from 6.3 Hz to 1,250 kHz.

The risks that the machinery vibrations offer the worker depend on the intensity of the vibration, the exposure time, the exposure pattern, the direction, the hand postion, the frequency spectrum and the machine type.

The main unit used to describe the intensity of vibration is acceleration. For measuring of hands and arms vibration, the total acceleration A_t, in m/s², or, sum of the axes, gives the application of the Eq. (1).

$$A_t = \sqrt{a_{whx}^2 + a_{why}^2 + a_{whz}^2} \tag{1}$$

Where a_{whx}, a_{why} e a_{whz}, is in m/s², are weighted speed up r.m.s as the respective axes orthogonal X, Y and Z.

Having different exposure in two or more periods of the workday, the resulting equivalent acceleration *Are* should be considered, according to Eq. (2).

$$\text{Are} = \sqrt[2]{\frac{a_1{}^2 t_1 + a_2{}^2 t_2 + \cdots a_n{}^2 t_n}{t_1 + t_2 \ldots t_n}} \quad (2)$$

Where a_n, in m/s², is the value of the acceleration obtained and t_n is the duration of the measurement for that exposure to acceleration a_n.

It can be calculated the resulting acceleration of standard exposure *Aren*, m/s², by NHO 10/2013, applying the Eq. (3).

$$\text{Aren} = \text{Are}\sqrt{\frac{T}{T_0}} \quad (3)$$

Where T is the labor day duration expressed in hours or minutes. As a standardized journey, it adopts T_0 = 8 hours or 480 minutes.

To guide the judgement and decision selection, the NHO 10/2013 shown on the Table 1 presents technical considerations and the recommended performance in the function of the *Aren.*

Table 1. Judgement criterion and decision-making based on NHO 10. Source: Fundacentro – NHO 10 (2013)

Aren (m/s²)	Tecnical considerations	Recomendation
Aren < 2.5	Aceptable	Minimum condition mantuence
2.5 < *Aren* < 3.5	Higher action level	Minimum adoption of preventative actions
3.5 < *Aren* < 5.0	Uncertainty	Adoption preventative and corrective actions, focus in reducing the daily exposition
Aren > 5.0	Exposition limit exceeded	Adoption imediate corrective ations

Moreover, according to ISO 5349, the daily exposure value of acceleration *Aren* induce Raynaud's syndrome development of in 10% of exposed workers, can be modelled through a correlation involving daily exposure acceleration presented by EQ. (4).

$$D_y = 31.8\,[\text{Aren}]^{1.06} \quad (4)$$

Where D_y is the total duration, in years, of the exposure necessary for the occurrence of discoloured appearance of fingers.

2.3 Whole body vibration

They are whole body vibrations those transmitted simultaneously to the total body surface and/or some part of it when the worker makes use of equipment such as trucks, tractors, platforms, etc. in the sitting position (reclined or not), standing or lying down. The vibration transmission occur through the supporting surfaces, for example, if the person is standing up, the vibration is transmitted by the feet, if the person is sitting, the vibration is transmitted by the feet, the buttocks and the back and the supporting surfaces for a leaning or lying down person.

A person exposed to high limits of vibration is subject to headaches, back aches, muscle fatigue, tremors, insomnia, joint injuries, and can develop with the passing of time, diseases such as problems in the spine, loss of equilibrium, Labyrinthitis and Visual disturbances, and can also severely compromise the dorsal and lumbar region, and cause changes in the reproductive system.

Depending on the affected region, the human body reacts to vibrations differently, thus, according to ISO 2631/1997 standard, it is necessary to measure vibration in the structure or at the point where it will be transmitted to the entire body. The ISO standard 2631/1997, lays down criteria for vibration on the human body in the frequency range from 0.5 to 80 Hz for health, comfort and perception and from 0.1 to 0.5 Hz for seasickness. The region of greater sensitivity of the human being is in the longitudinal axis z, 4 to 8 Hz and in the transverse axes X and Y, from 1 to 2 Hz.

As well as in evaluating the effects of hands and arms vibration, in the analysis for the whole body, the values of the acceleration found on the three axes and obtain a total acceleration at m/s², but in this case, applies to Eq. (5).

$$A_t = \sqrt{K_x^2 a_{wx}^2 + K_y^2 a_{wy}^2 + K_z^2 a_{wz}^2} \tag{5}$$

Where K_x, K_y and K_z are multiplication factors of respective orthogonal axes X, Y and Z. K values, for health purposes for standing up or sitting people are $k_x = 1.4$; $K_y = 1.4$ and $K_z = 1.0$. Moreover, AWX, a_{wx}, a_{wy} and a_{wz}, in m/s², are weighted R.M. accelerations with the respective orthogonal axes X, Y and Z.

As well in the analysis of vibration of hands and arms, if vibration exposure is different in two or more periods of the labor, it should be considered the acceleration exposure resulting *Are* in m/s² according to EQ. (6).

$$Are = \sqrt[2]{\frac{{a_1}^2 t_1 + {a_2}^2 t_2 + \cdots {a_n}^2 t_n}{t_1 + t_2 \ldots t_n}} \tag{6}$$

Where a_n, in m/s², is the value of the acceleration obtained and t_n is the time measurement duration for that exposure to acceleration.

To standard acceleration exposure, *Aren*, in m/s² the Eq (7) is used:

$$Aren = Are\sqrt{\frac{T}{T_0}} \tag{7}$$

Where T is the duration of the daily work journey expressed in hours or minutes. As a standardized journey, it adopts T_0 = 8 hours or 480 minutes.

The acceleration value investigation can be found by the basic method can underestimate the exposure. This can occur when the transmitted vibration is short-lived. In this situation, when the crest factor is greater than 9.1 $m/s^{1.75}$, you can calculate the value of the vibration ratio *VDV*, in $m/s^{1.75}$, according to Eq. (8).

$$VDV = \left\{\int_0^T [a_w(t)]^4 \, dt\right\}^{\frac{1}{4}} \tag{8}$$

Where $a_w(t)$, in m/s², is the instantaneous weighted acceleration and t, is given in seconds, is the time measurement duration.

The vibration exposure also can occurs in two or more periods presenting different vibration magnitudes, in these situations, you can calculate the VDV_{total} resulting or equivalent, according to Eq. (9).

$$VDV_{total} = \sqrt[4]{\sum VDV_i^4} \tag{9}$$

Where VDV_i, in $m/s^{1.75}$, is the vibration dose VDV_i due to exposure to acceleration in its given period of timekeeping.

According to NHO 09/2013, corrective actions will be necessary aiming at controlling the vibration exposure, where the resulting values are: *Aren*, value greater than 1.1 m/s^2; and *VDVR*, high to 21 $m/s^{1.75}$.

To guide the judgement and decision-making, the NHO 09/2013 presents in Table 2 technical considerations and the recommended performance in the function of *Aren* and *VDVR*.

Table 2. Judgement criterion and decision-making based on NHO 09. Source: Fundacentro – NHO 09/2013

Aren (m/s²)	*VDVR* ($m/s^{1.75}$)	Tecnical considerations	Recomendation
Aren < 0.5	*VDVR* < 9.1	Aceptable	Minimum condition mantuence
0.5 < *Aren* < 0.9	9.1 < *VDVR* < 16.4	Higher action level	Minimum adoption of preventative actions
0.9 < *Aren* < 1.1	16.4 < *VDVR* < 21	Uncertainty	Adoption preventative and corrective actions, focus in reducing the daily exposition
Aren > 1.1	*VDVR* > 21	Exposition limit exceeded	Adoption imediate corrective ations

2.4 Measuring equipment

For the vibration measurement performance, is used a system consists of a vibration sensor (accelerometer), an integrator that transforms the measurement into an electrical signal and an amplifier.

Vibration transducers of type acceleration, known as accelerometers are used to measure exposure to vibration and can be of type piezoresistive (whole body) working at low frequency and piezoelectric (hands and arms) working at higher frequencies. However, it is more common to use piezoelectric transducers in both cases.

For the correct equipment setup, follow the guidelines of the standard NHO 10/2013 corresponding to hands and arms and the NHO 09/2013 referring to whole body.

3. METHODOLOGY

As already contextualized, this work aims to evaluate the occupational exposure of some workers to the physical agent vibration, due to the contact with industrial equipment inherent in their daily work activities. The vibration levels have been determined to which workers are exposed and, from the results of analyses, measures have been proposed to minimise the impacts on health of them, and to ensure that their productivity is maintained. This situation was the case study of this work and was based on following Brazilian normalisation responsible for regulating and controlling the vibration agent.

Brazilian legislation provides through the regulatory norm NR – 15-Annex 08, that activities and operations that expose workers without adequate safeguards to localized and whole body vibrations will be characterized as unhealthy through quantitative evaluations. This context was promoted by a human vibration assessment in some sectors of the company and the survey of quantitative data was conducted for the calculation of the vibration agent, serving as a diagnosis of the working environment of these collaborators.

The procedures used in the data collect and analyses were based on the Norms NHO 09 and NHO 10 of the Fundacentro. These two standards are based on the ISO 2631/97 and 5349/01 standards. They deal with the whole body vibration and localized and both cases are analyzed in this work from the quantitative assessment of this agent in cargo transport and manufacturing process equipment. For the vibration results, which are higher the limit according to the abovementioned standards, preventative and corrective actions are cited to revert the unhealthy framework by providing the developer with better working conditions and labor health.

3.1 Industrial equipment, study targets and vibration types analyzed

The human vibration was analyzed in some company collaborators, who routinely work with angle grinders in finishing activities of manufactured parts, and forklift, responsible for transportation of material in the industrial area.

3.1.1 Localized Vibration

The analysis of the localized vibration exposure (hands and arms) was carried out through measurements of the accelerations in the hands of workers using four differents angle grinders. The first of them applied 4 inches disc diameter, and is employed in workpiece finishing activity. The second used 9 inches disc diameter is applied to grinder some pieces. The third with 7 inches disc diameter is applied in the finishing for mounting preparation. The fourth and last angle grinder is of the high frequency type applied in the sanding of parts for painting preparation. The composition material of the parts that machining processes (cutting and grinder) by the angle grinder was the same, aiming to create a standard of mechanical resistance offered by the material of the parts during the operations of the aforementioned equipment. Figure 1 show collaborators using the angle grinders in study.

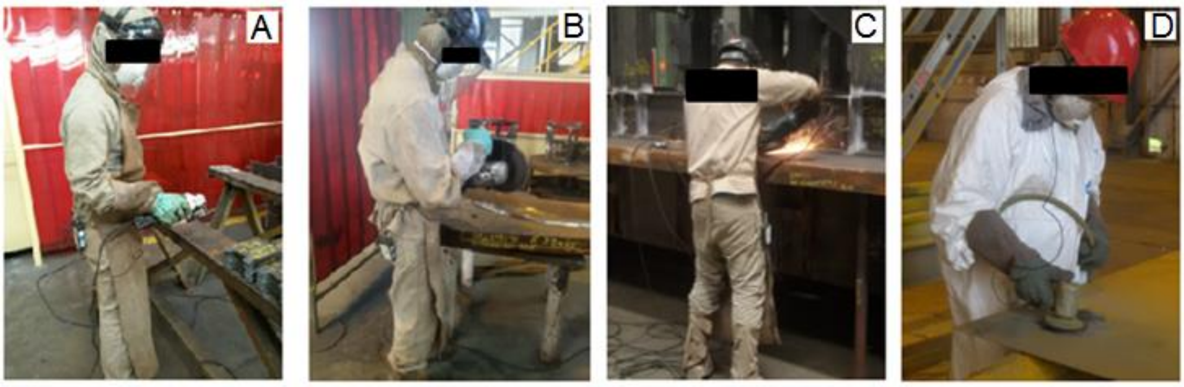

Figure 1. Angle grinders’s study (A) 4”, (B) 9”, (C) 7” and (D) high frequency

All angle grinders are in good conditions (conservation and maintenance), and approximated 1 to 2 years used in work. About the wokers work jorney, they all use approximately 05:20 hours (320 minutes) per daily work handling these equipment. The total work jorney of these workers is 08:00 hours (480 minutes) daily, they develop other complementary activities beyond the typical task, in which they are exposed to the localized vibration. The work is usual type and intermittent, standing up and with relative physical effort. Moreover, none of the collaborators had registered complaints and medical background until the time related to vibration as the everyday operation of the equipment.

3.1.2 Whole-body vibration

The whole body vibration analysis was performed on a woker while he used a forklift to transportation a material, as well as loading and unloading. The floor where the machine was moving is built of type small bloclks outside of the shed (origin of the material to be transported) and built of machined concrete inside of the shed (where the material is stored). The equipment provides vibrational effect throughout the worker's body, so a case in which the whole body vibration applies very well. Figure 2 introduces the forklift when performing tasks by the operator.

Figure 2. Forklift used in case study

The forklift, target of the case study, was utilized for approximately nine years by the company. It has good conservation and maintenance. The daily jorney by worker operating this machine is approximately 05:20 hours (320 minutes). The total time of the working journey of this worker is 08:00 hours (480 minutes) daily, i.e., develops other complementary activities beyond the typical task in which it is exposed to whole body vibration.

The work is usual type and intermittent, sitting without relative physical efforts. Moreover, the operator had never registered any complaints and medical background due operation of the equipment.

3.2 Data collection for case study

The vibration samples in equipments abovementioned were collected in November 2016, for a one week period. A specialized company has been responsible for collecting and processing the data and generate a technical report, in which this present work was based.

A vibration dosimeter VIB were used for measurements of occupational vibrations of hands and arms. This instrument is in accordance with ISO 5349, Fundacentro (NHO 10), European Directive and ACGIH (American Conference of Governametal Industrial Higienists), i.e. the weighting curve for hands and arms is already embedded in the calculations. The dosimeter VIB is portable, ergonomic and lightweight type to perform the measurement of data captured by the accelerometers, signal treatment and the transfer of stored data. This equipment collects levels of vibrations captured by the Tri-Axial accelerometer on the X, Y and Z axes and performs the calculation of the daily dose of exposure *Aren*. The dosimeter counts on a program that assists in the transfer, analysis and emission of measurement results. With the use of a notebook, the data was collected and analyzed in the said program. Important to highlight that the measuring instrument was within the calibration validity period.

3.2.1 Collecting methodology for localized vibration

The hands and arm evaluation was done with tri-axial accelerometers were mounted on an adapter and positioned at the point where the energy is transmitted to the hands. This mounting scheme allowed the collection of acceleration data for employees who operated the four types of angle grinders presented.

The data collection carried out through the dosimeter followed the standards of ISO 5349/2001, which establishes vibration measurement for hands and arms on the octave frequencies of eighths between 6.3 and 1,250 Hz. The instrument through its internal system weighs the accelerations in the respective frequencies within the range of 5 to 1500 Hz, i.e., given the abovementioned standard. Moreover, the dosimeter presents the global weighted acceleration that presents the corrected values as a function of sensitivity, and are precisely these values of acceleration measured on the X, Y and Z axes that were used to calculate the *Are* and *Aren.* It is also assessed the estimate of time in years so that 10% of the workers exposed to the vibration acquire the Raynoud syndrome (white finger).

3.2.2 Collection methodology for full body vibration

The whole body vibration was measurement using a seat accelerometer mounted on the bench where the operator stays seated when using the equipment. This assembly scheme allowed the collection of acceleration data for the developer who operated the forklift.

Figure 3 show tri-axial accelerometers similar to those used for hand and arm vibration, and the seat accelerometer similar to what was used on whole body vibration case study.

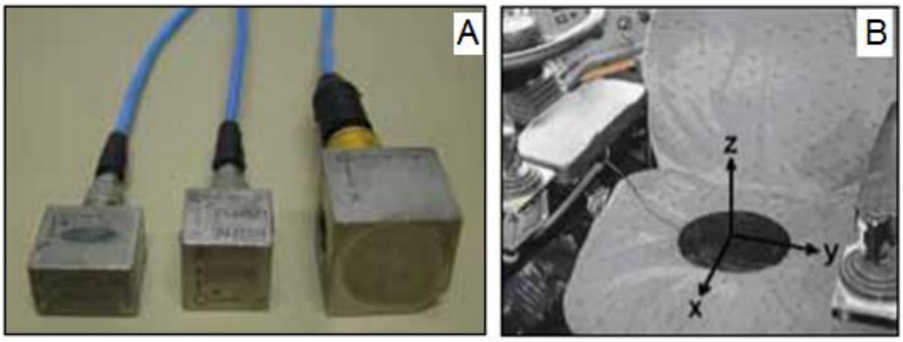

Figure 3. (A) Tri-axial accelerometers and (B) accelerometer seat. Source: Fundacentro-NHO 10/2013

In the entire body evaluation the frequency range analyzed was 0.5 to 80 Hz according to ISO 2631/2010, and the area of the highest sensitivity of the human being is 4 to 8 Hz for the longitudinal axis Z and 1 to 2 Hz for the transverse axes X and Y.

During vibration measurement, the dosimeter multiplies the acceleration by weighting corresponding to each frequency, as the human body response to vibration is not linear on all frequencies. This is justified because it is necessary to correct the sensitivity responses in the different frequencies. The effect evaluation of the vibration on health should be done independently on each axis, and should be considered the highest value of the weighted accelerations in the frequencies measured on the three axes of the seat. Then, of the data collected from the accelerations on the X, Y and Z axes, the weighted accelerations are used, which are used for the calculations of the *Are* and *Aren*. It also analyses the crest factor of the accelerations for determining the value of the vibration dose *VDV*.

4. RESULTS AND DISCUSSION

The results of the vibration analyses are presented in this section for the two situations addressed.

4.1 Result for localized vibration

Vibration measurements were carried out on three axes for the use of the four types of angle grinders. Figure 4 show the program's vibration record screen along the measurements interval for the three axes in the case of the high-frequency angle grinder.

The instantaneous variation of vibrations can be noted every instant of time and the identification of the weighted accelerations on the three axes are required. The program used by vibration measuring equipment store data and calculate the weighted accelerations on the three axes. The data collected from the weighted accelerations were crucial for the calculations of the parameters for quantitative evaluation of the vibration effect on the worker. This same procedure were repeated for others angle grinders.

The weighted accelerations and measurement times where the vibration information collected for all angle grinders are shown in Table 3. This data allowed the realization of the calculations of the vibration analysis parameters. In the case of the calculation of the *Aren* it uses the information of the exposure time to the vibration of 05:20 hours for a daily work day of 08:00 hours.

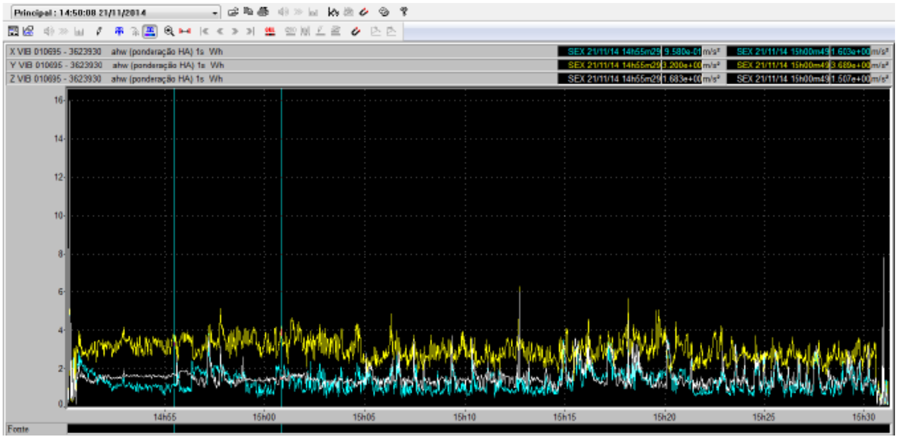

Figure 4. The three-axis acceleration log screen for the high frequency angle grinder

Table 3. Localized vibration measurements results

Equipment	Weighted acceleration (m/s²)			Measure time (minutes)	Total acceleration (m/s²)	*Are* (m/s²)	*Aren* (m/s²)	Maximum exposure time (minutes)	D_y (years)
	X	Y	Z						
Angle grinder 4"	12.44	9.60	15.40	42.60	22.00	22.00	17.96	24.79	1.49
Angle grinder a 7"	3.49	6.70	5.00	28.00	9.06	9.06	7.40	146.22	3.81
Angle grinder 9"	5.70	6.88	4.71	46.45	10.10	10.10	8.25	117.64	3.40
High frequence sander	1.48	3.02	1.64	41.12	3.74	3.74	3.06	857.12	9.73

The technical considerations shown on Table 1, Norm NHO 10, the maximum value of *Aren* for the vibration exposure to fit within acceptable values is up to 2.5 m/s², if higher it requires that preventative actions should be taken. Already the exposure rate limit value is 5 m/s², i.e. higher that is considered unsanitary condition and there is immediate need to take corrective actions. It is concluded that in the angle grinder of 4, 7 and 9 inches the collaborators have exhibited accelerations higher the exposure limit rate of the abovementioned norm, requiring immediate corrective actions, being the case of the 4-inch angle grinder the most critical of all. In the case of the high-frequency angle grinder the vibration exposure, although lower the exposure limit rate, was higher the level of action, requiring taken preventative measures.

In relation the data analysis shown in Table 3, the maximum daily exposure time of the employees was estimated to operate each of the angle grinder in the conditions of exposure of current and work-day vibrations. It is concluded that the current working time of the collaborators exposed to vibration (320 minutes) for angle grinder 4, 7 and 9 inches is above the calculated permitted time (24 minutes, 146 minutes and 117 minutes respectively). Therefore, the vibration value is higher the exposure limit rate for 4, 7 and 9 inches Angle grinders, primarily for workers using the 4-inch angle grinder, which features greater vibration exposure criticality (could operate this equipment for only 24 minutes. Analyzing the case of high-frequency angle grinder, the daily operating time of the equipment is the only one that could be greater than the current working time (320 minutes). Next the worker could operate the equipment for a longer time than usual (up to 857 minutes) without being in an unhealthy situation by vibration, attentive to the realization of preventative measures for the employee's Labor health.

Second analysis of the value of the *Aren* applied the estimate of producing white finger syndrome in 10% of people exposed to vibration for a given time in years is also presented in table 3. It is noted that in less than 4 years of exposure This estimate will occur on three of the Angle grinders, except the high frequency, which takes about almost 10 years.

4.2 Result for full-body vibration

Vibration measurements were carried out on three axes for the use of the forklift. Figure 5 show the DB Maestro's software vibration records screen along the measurements interval for the three axes.

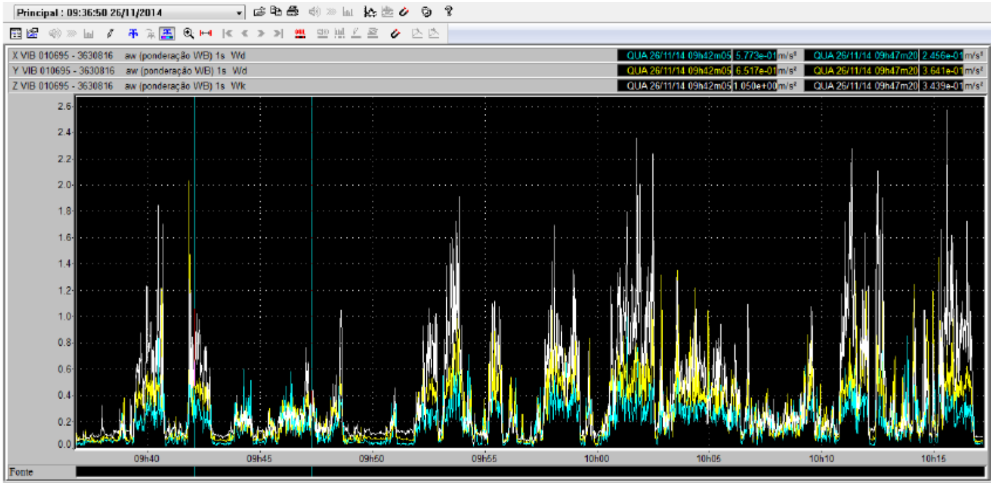

Figure 5. Acceleration log screen on three axes for forklift

The weighted accelerations and timekeeping, in which the collection of vibration information for the forklift, shown in Table 4. This data allowed the realization of the calculations of the vibration analysis parameters. In the case of the calculation of the *Aren*, the information of the exposure time to the vibration of 05:20 hours is usedfor a daily work day of 08:00 hours.

Table 4. Results of full-body vibration measurements

Equipment	weighted acceleration (m/s²)			Measure time (minutes)	Total acceleration (m/s²)	*Are* (m/s²)	*Aren* (m/s²)	Maximum exposure time (minutes)
	X	Y	Z					
Forklift	0.25	0.35	0.53	40.38	0.80	0.80	0.65	902.56

The technical considerations of standard NHO 09 shown in Table 2, the maximum value of *Aren* for the vibration exposure to fit within acceptable values is up to 0.5 m/s², if higher it requires that preventative actions should be taken. Already with regard to the exposure limit, the value is 1.1 m/s², i.e. higher that is considered unhealthy condition and immediate need for corrective actions. By analyzing the results calculations, the vibration exposure in the use of the forklift, although lowe the exposure limit, is higher the level of action, requiring be taken preventative actions.

In relation the data analysis shown in Table 4, the maximum daily exposure time of the workers was estimated to operate the forklift in the current vibration exposure conditions and the workday. It is concluded that the time allowed, i.e., which would be lowe the exposure limit rate, could be greater than the current working time exposed to vibration. Next the worker could operate the equipment for a longer time than usual, without being in an unhealthy situation by vibration, meeting in the realization of preventive actions for the employee's Labor health.

The analysis of the crest factor of accelerations for determining of the vibration dose value *VDV*, calculated by the dosimeter software, a value of a crest factor was obtained from less than 9.1 $m/s^{1.75}$ where it is in the acceptable technical range. Table 5 presents the results found for the crest values.

Table 5: Results for Crest factor

Equipment	Crest factor ($m/s^{1.75}$)			Maximum value ($m/s^{1.75}$)
	X	Y	Z	
Forklift	6.38	4.78	5.50	6.38

As the maximum value of the crest factor is lower than the exposure limit rate, there is no need to consider the vibration dose value *VDV*, because according to the evaluation criterion of Table 2, Norm NHO 09, the value of the acceleration aforementioned is within the acceptable range.

4.3 Actions adptions

The localized vibration situations discussed, for cases of use of three angle grinders (4, 7 and 9 inches) is necessary to take immediate corrective actions, as the vibration levels in which the workers are exposed higher the tolerance limit. Already for the high-frequency angle grinder, as well as for the forklift, it is necessary to adopt preventive actiond to improve the labour health of workers operating such equipment, as the analyses of vibrations indicated exposure to values higher the level of action and lower the exposure limit rate. Preventative and corrective actions were suggested to provide extension of the occupational health of the company's collaborators subject to the vibration of these equipment in study.

4.4 Preventative actions

- Education;
- Periodic monitoring of exposure performing;
- Training on the risks arising from vibration exposure to and the correct use the of equipments, minimizing the exposed to vibrations;
- Surveillance focusing on the effects of vibration exposure;
- In the localized vibrations exposures should be established for adequate work practices that allow the hands to keep warm;
- Elaboration work procedures and alternative methods to reduce vibration exposure;
- Medical monitoring on workers exposed to vibration as determined NR-07-Medical Occupational Health control program.

4.5 Corrective actions

- Carry out maintenance on the sector equipments and machines;
- Improve studies for improvement of the processes and equipments;
- Reduce the exposure time vibration by promoting job rotation and pauses;
- The forklift tyre calibration contributes to reducing vibrations transmitted;
- Wear anti vibration gloves for use of the angle grinders.

5. CONCLUSIONS

The development of this work, show the importance of monitoring the worker's exposure to the physical agent vibration, since it provokes undesirable effects on the human body when exceded the limits set on the rules responsible for the vibration regulation, such as white finger syndrome for hands and arms exposure. Therefore, the control of this agent is extremely important to maintaining the quality of life and occupational health of workers involved in activities that inevitably be subjected to vibration.

The occupational vibration evaluetion on workers, it was found that with the use of the angle grinders of 4, 7 and 9 inches, the workers presented exposure to accelerations limit exceded compared the exposure limit of standard NR 15-Annex 8, requiring be taken corrective actions as soon as possible, being the 4-inch angle grinder the most critical scenario. Some corrective actions proposed were: maintenance on existing equipment in the sector, reducing the exposure time to vibration by promoting rotations and pauses, working procedure and alternative methods to reduce exposure to vibrations, among others action. In the case of the high-frequency angle grinder the vibration exposure, although unexceded the exposure limit, is higher the level of action, requiring taken preventative actions.

In relation to the analysis of the calculated results for the use of the forklift, it has been contacted that vibration, albeit unexceded the exposure limit, is higher the level of action, requiring taken of preventative actions, among them: periodic monitoring of the exposure, training about risks arising from exposure to vibration and medical control of workers.

It is important to emphasize that when the vibration exposure limit is respected, the company is unobliged to pay additional unhealthy to the employees involved in the activities that have exposure to that kind of physical agent. Therefore, the study also portrays the necessity to optimize expenditure by the company with the payment of additional unhealthy to employees who operate higher the threshold regulated by the norms, generating economy and greater profitability by the company.

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7. RESPONSIBILITY NOTICE

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