Evaluation ergonomic in agricultural Tractors

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Abstract— *Agricultural mechanization is of extreme importance to high current agricultural demand. The increased production needs associated with the decrease in available area growth imply in the improvement and mechanization of techniques, being necessary to analyze all variables of the mechanization. As an example, exposure of workers to noise produced by agricultural tractors, which can be harmful to your health, to be occur a productive growth without affecting the minimum conditions imposed by Brazilian law. Excessive noise is a factor that affects the operators. This study aims at evaluating the levels and vibration and noise emitted by agricultural tractors with different powers, comparing the results with existing regulations in Brazil. The tractors studied were: Tractor A (engine power of 86 cv at 2200 rpm, manufactured in the year 2005, 4050,5 hours worked), Tractor B (engine power of 120 cv at 2200 rpm, manufactured in the year 2005, 3800,0 hours worked), Tractor C (engine power of 173 cv at 2200 rpm, manufactured in the year 1997, 7472, 9 hours worked), and Tractor D (engine power of 110 cv at 2200 rpm manufactured in the year 2011, 907 hours worked), crowded in Campus Hall Administrative USP Pirassununga.*

Keywords— ***noise, vibration, level.***

I. INTRODUCTION

The use of tractors in agriculture took place shortly after the Second World War and the beginning of 1950 were offered to the market wide variety of brands and models, but featuring configuration and rough appearance compared to what is observed today. In Brazil, 1960, was observed the beginning of concerning with ergonomic aspects, with emphasis on occupational safety and operator comfort, at which time the tractor industry in Brazil was installed.

Recently, the projects of agricultural tractors centered on maximizing efficiency in detriment to the human factor. However, due to the increased rigor of safety standards at work, there has been a tendency to seek improvements in terms of ergonomics and operator safety, to improve working conditions (ALVES et al . 2011).

Agricultural tractors have evolved in recent years, highlighting the best distribution and organization of items related to ergonomics in the design of operating stations have contributed substantially to improve the comfort and safety of the operator, but there are few studies developed for the parameter assessment and occupational health implications (ANTONUCCI et al 2012; . CUNHA et al 2012.). The main ergonomic concern is the human element, in order to satisfy the employee, it was understood that the increased production and improved quality of products are the result of an adequate interaction between man and the production system (FILIP & CANDALE 2012).

Regarding the security items, security devices and systems under the regulatory norm, they must integrate the machines since its manufacturing and cannot be considered optional items for any purpose. However, it is known that there is no machine inspection obligation in Brazil on the occasion of their marketing, complicating the items standardization.

1.1 Noise in agricultural machinery

Among the ergonomic factors that impair machine operators, noise is a major, but there are few studies developed for the evaluation of this parameter and its implications for occupational health. The changes caused by noise are not immediate and, yes, cumulative effects and will be deploying with time: hearing loss, mental imbalances and degenerative physical illnesses (Noronha et al 2005.).

Vitória (2000) noted that in rural areas it is common the use of personal protective equipment (PPE) to prevent phytosanitary contamination. However, little attention is paid to prevention of noise effects.

Souza (2001) evaluated the levels of noise emitted by a tractor-harvester set of beans, concluding that in general, the noise levels obtained in threshing cylinder at 540 rpm rotation were higher than those obtained at 420 rpm. The noise level at the

operator's ear in his working day is one of the factors that must be evaluated in production systems that use machinery intensively.

Rinaldi et al. (2008) inspected 29 tractors, concluded that noise levels were issued above the maximum allowed by regulatory norms. They can cause hearing loss, irritability and loss of concentration, with the increased possibility of accidents.

Analyzing noise tractors, Cunha et al. (2012) stated that even with technological advances in the production of agricultural machinery, the noise level is still above permitted for a journey of eight hours of work on tractors without cab protection, so it is necessary the use of hearing protection.

The decibel scale is used in most of evaluation, verification and quantification of noise and the measurements of noise level should be made with an electronic compensation circuit of the type "A".

The maximum permissible daily exposures, according to Norm (NR 15) of the Ministry of Labor and Employment are shown in Table 1.

TABLE 1
MAXIMUM PERMISSIBLE DAILY EXPOSURE AND NOISE LEVEL

Noise level dB(A)	Maximum permissible daily exposure
85	8 h
86	7 h
87	6 h
88	5 h
90	4 h
92	3 h
95	2 h
100	1 h
105	30 min
110	15 min
115	7 min

Source: Norm (NR 15) of the Ministry of Labor and Employment.

II. OBJECTIVE

2.1 General Objective

This work has as general objective evaluate the vibration and noise level that came from different models of agricultural tractors (based on power) and work time, in comparison with the Brazilian legislation.

2.2 Specific Objectives

Determine the maximum daily exposure time to allowed noise level, according to Regulatory Standard (NR 15) of Brazilian Ministry of Labor and Employment;

III. MATERIALS AND METHODS

The work has been realized at Faculty of Animal Sciences and Food Engineering (FZEA) from University of São Paulo located at Pirassununga County, in area conceded by the Prefecture of the Campus. The geographic location of the campus is 21º59' south latitude and 47º26' west longitude, and average height as 653 meters. The region weather is type Cwa in Köppen classification, and the average annual temperature is 20,8ºC, with average annual rainfall as 1298 mm.

3.1 Studied tractors

The experiments were performed with four tractors, with different power and manufactory year: Tractor A (engine power of 86 cv at 2200 rpm, manufactured in the year 2005, 4050,5 hours worked), Tractor B (engine power of 120 cv at 2200 rpm, manufactured in the year 2005, 3800,0 hours worked), Tractor C (engine power of 173 cv at 2200 rpm, manufactured in the year 1997, 7472,9 hours worked), and Tractor D (engine power of 110 cv at 2200 rpm manufactured in the year 2011, 907 hours worked). All tractors are from the Prefecture of Pirassununga Campus.

3.2 Noise level evaluation

The noise levels have been determined by a digital decibel meter, ICEL brand, model DL-4020, in fast answer circuits and "A" equalization, expressed in dB(A). All measurements were made with wind protector.

The readings have been taken close to operator ear in each removal radius, 1 to 10 m, collected 1 in 1 meter, directed to right, left, rear and front parts of the tractor. Three readings were realized in each point and under each condition. During the test, the tractor was in rotation as 540 RPM in PTO (Power take-off).

The evaluations have been based in the method described in NBR-9999 (ABNT, 1987). At the position and time for noise level measurement, the temperature was between -5 and 30ºC and wind velocity was under 5,0 $m.s^{-1}$, being satisfactory at the evaluation time according to this standard.

For the study of noise level variation in function of the removal radius, regression equations have been adjusted for the tested group. By this mean, it was possible to determine the noise level that operators, and workers close to the machinery also, were exposed.

IV. RESULTS AND DISCUSSION

Table 2 shows the average values of the noise levels obtained close to the operator's ear and every ray of distance from 1 to 10 meters, taken each one meter, targeted for the right and left side, rear and front parts of each tractor

TABLE 2
AVERAGE VALUES OF THE NOISE LEVELS OBTAINED CLOSE TO THE OPERATOR'S EAR AND EVERY RAY OF DISTANCE OF 1 TO 10 METERS TAKEN FROM A ONE PER ONE METER, TARGETED FOR THE RIGHT AND LEFT SIDE, REAR AND FRONT PARTS OF EACH TRACTOR

Ray of distance (m)											
Position	0	1	2	3	4	5	6	7	8	9	10
TRACTOR A											
Front	-	91,6	88,4	84,4	81,6	79,8	78,4	77,1	76,4	74,6	74,0
Right	89,0	87,9	84,7	82,1	79,9	78,5	76,6	75,6	74,1	72,9	72,3
Left	92,7	89,4	86,8	84,5	83,0	82,0	80,2	79,3	78,1	77,1	76,3
Rear	-	84,6	82,8	79,4	77,9	76,6	75,6	74,4	73,4	72,4	71,3
TRACTOR B											
Front	-	90,8	87,8	84,8	82,6	81,4	79,6	78,6	77,6	76,5	75,6
Right	90,3	92,8	88,6	85,6	83,5	81,7	80,1	79,2	78,2	76,5	76,4
Left	89,8	90,5	87,8	85,5	83,6	81,5	80,2	79,3	78,5	77,3	76,5
Rear	-	83,4	80,6	78,6	77,3	75,7	73,6	72,8	72,7	71,4	71,2
TRACTOR C											
Front	-	94,7	89,4	86,9	85,1	83,8	82,9	81,2	80,8	79,9	78,8
Right	88,0	95,1	90,4	88,2	85,8	84,0	82,3	80,8	79,7	78,7	77,8
Left	88,9	93,8	89,9	87,3	84,6	82,9	81,7	80,6	79,1	78,3	77,8
Rear	-	83,8	81,8	80,5	78,6	77,1	76,1	75,7	74,0	73,5	72,4
TRACTOR D											
Front	-	92,7	87,0	85,0	83,1	81,7	81,0	79,7	79,2	78,5	77,1
Right	90,0	93,9	90,6	86,7	84,5	82,5	81,2	80,1	78,8	77,9	76,4
Left	89,3	94,1	90,7	87,5	85,6	83,7	81,8	80,4	79,3	78,5	77,3
Rear	-	86,3	84,4	81,3	78,5	76,6	75,1	74,2	72,5	71,8	70,8

The noise levels obtained close to the operator's right ear were 89.0; 90.3; 88.0 and 90.0 dB (A) respectively for the Tractor A, Tractor B, Tractor C and Tractor D tractors. Noise level above the maximum allowed for the work day of 8 hours was observed in all tractors studied, according to the regulatory standards of the Brazilian Ministry of Labor and Employment (NR 15). The use of hearing protection is required. Similar results were observed by Alves et al. (2011), where the level of noise in static condition and dynamic of a Valtra Model 785 TDA (75 hp) tractor was evaluated, and concluded that the levels of noise near the operator in terms of field were higher than those established by the rules for maximum daily 8-hour exposure, without the use of hearing protection.

In relation to the ray of distance the highest values generally occur up to 4 m away, for people who are in a distance of up to 4 m of the tractor during his workday the use personal protective equipment is required.

Pimenta Junior et al. (2012) determined in 5 meters the compulsory use of protective equipment in routine operations with tractors, both for operators and other employees working in its proximity.

Applying linear regression of the mean values of noise on the right side of the tractor in function of the ray of distance, the following equations were found: -1,7418D + 88,127 (R^2 = 0,9705); -1,6509D + 91,255 (R^2 = 0,9375); -1,5882D + 92,209 (R^2 = 0,8595) and -1,6718D + 92,232 (R^2 = 0,9254), respectively for the Tractor A, Tractor B, Tractor C and Tractor D.

Applying the same principle of the left side of the tractor to the following equations are found-1,5500D + 90,423 (R^2 = 0,9574); -1,4818D + 90,282 (R^2 = 0,9648); -1,5109D + 91,636 (R^2 = 0,8990) and -1,5873D + 92,318 (R^2 = 0,9137), respectively for the Tractor A, Tractor B, Tractor C and Tractor D.

The results in the left side of the operator are similar to those on the right. Therefore the use of protective equipment for people in a shorter distance than 4 meters is required for all tractors.

V. CONCLUSION

The structures of the seat were able to absorb the impact and creating a good working condition for the machine operator.

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