LABORATORY AND FIELD MEASUREMENTS OF NAIL GUNS' NOISE EMISSION

MESURES LABORATOIRE ET TERRAIN DE L'ÉMISSION SONORE DES CLOUEUSES

Marc-André Gaudreau[*1], Frédéric Laville[†1], Pierre Marcotte[‡2], Jérôme Boutin[2]**
[1] ÉTS, 1100 Notre-Dame Ouest, Montréal, QC, H3C 1K3, CANADA
[2] IRSST, 505 Boul. de Maisonneuve Ouest, Montréal, QC, H3A 3C2, CANADA

1 Introduction

Nail guns are heavily used in the construction industry by carpenters and roofers. These hand-held power tools expose their users to impulse noise and hand-arm vibration that are difficult to mitigate due to the user's proximity to the tool. Thus, the choice of low noise and low vibration power tools seems to be a good strategy in order to reduce workers' exposure to such noise and vibration. However, among the very few studies on the noise and vibration levels of nail guns found in the literature, only one made by the Health and Safety Executive in England is quite exhaustive. It is presented in two reports [1, 2]. In the present study, 10 nail guns were tested (8 framing and 2 roofing nailers). Both noise and vibration were studied, but only the noise aspect will be discussed in this paper (vibration results can be found in a paper presented at the 6th American conference on human vibration [3]). The goal of this paper is to present field measurements and laboratory measurements using EN 12549 [4].

2 Field Measurements

Six of the eight framing nailers were first tested on a construction site with two carpenters operating each of the six nailers for the construction of a building wall (see Fig. 1). The two roofing nailers were tested on asphalt shingle installation and were also operated by two roofers each (see Fig. 1).

Figure 1. Field measurement for framing nailers (left) and for roofing nailers (right).

The measurement rig consisted of a 6 input Wi-Fi B&K acquisition card that was relaying to a base PC: a triax 5000g accelerometer (i, ii, iii) fixed on the handle of the gun, the static pressure at the inlet of the gun (iv) and the acoustic pressure at the worker's ears (v, iv), via a microphone fixed to the center of each earmuff. The rig was held in a small comfortable backpack and even if the sensors were wired to the acquisition card, the worker could work without obstruction. Between 8 and 12 trials of 10 impacts were recorded for each nailer/worker combination.

3 Laboratory Measurements

Eight framing nailers and two roofing nailers were tested in the laboratory under controlled conditions as per the EN 12549 standard. From this standard, three operators were required to perform five trials of 10 nails each, with each trial lasting a period of 30 seconds (1 nail each 3 second). The nails were sunk in a standardized piece of wood (sawn pine wood, clear of knots) buried in a sandbox (see Fig. 2). The measures were performed in a semi anechoic room where both the sound power and the sound pressure level at the worker's ear were measured. The sound power was measured using a 9 microphones cubic grid as per ISO 3744 [5], embedded in EN 12549.

Figure 2. Laboratory measurement rig.

4 Results

For each measurement (both lab and field measurements), a one second equivalent sound pressure level (SPL), A-weighed, of a single impact was calculated using the following formula :

$$L_{pA,1s} = L_{pA_{eq}T} + 10\log_{10}\left(\frac{T}{T_0}\right) - 10\log_{10}(N) \quad \text{, Eq. 1}$$

[*] marc-andre.gaudreau@cegepdrummond.ca
[†] frederic.laville@etsmtl.ca
[‡] pierre.marcotte@irsst.qc.ca
[**] jerome.boutin@irsst.qc.ca

where $L_{pA_{eq}T}$ is the equivalent pressure level for a given period (T), T_0 is 1 second and N is the number of impacts during the period T. The sound power $L_{wA_{eq}T}$ (SWL) was only available in laboratory measurements and the equivalent acoustic power level, A-weighed, of a single impact $L_{wA,1s}$ was calculated using :

$$L_{wA,1s} = L_{wA_{eq}T} + 10\log_{10}\left(\frac{T}{T_0}\right) - 10\log_{10}(N) \quad \text{, Eq. 2}$$

Even if EN 12549 requires a microphone measurement at the average worker's position to measure $L_{pA,1s}$, the acoustic power $L_{wA,1s}$ was preferred to compare the noise level of the nailers since the position of the test subject and the position of the exhaust on each nailer were found to cause major uncertainties in $L_{pA,1s}$ values. In order to compare the laboratory and the field measurements, an estimation of the pressure level ($\overline{L_{p,A,1s}}$) at the ear of the subject, made out of the SWL and the distance (r) between the nailer and the ear of the subject is made using :

$$\overline{L_{p,A,1s}} = L_{w,A,1s} - 10\log_{10}(2\,\Pi\, r^2) \quad \text{, Eq. 3}$$

Table 1: Framing nailer ranking using Laboratory (left) or Field (right) measurements.

Laboratory measurements			
Rank	Tool	SWL dB(A)	estimated SPL dB(A)
#1	S6**	95.6	92.1
#2	R2	101.7	98.2
#3	S2	102.6	99.1
#4	S3	103.0	99.5
#5	R1	105.1	101.6
#6	S5*	107.1	103.6

Field measurements		
Rank	Tool	SPL dB(A)
#1	S6**	91.7
#2	R1	98.2
#3	R2	98.4
#4	S3	98.7
#5	S5*	99.7
#6	S2	100.1

Table 1 presents the laboratory ranking of the framing nailers with $L_{wA,1s}$ and its estimated sound pressure $\overline{L_{p,A,1s}}$, using r = 0.6m (see figure 1). The nailers R1 and R2 are using coils while nailers S1 to S6 are using strips (S1 and S4 are not presented as they were not evaluated at the workplace). All nailers were pneumatic, except nailer S5 (identified by *) which is gas operated and nailer S6 (identified by **) which is battery operated.

Table 2: Roofing nailer ranking using Laboratory (left) or Field (right) measurements.

Laboratory measurements			
Rank	Tool	SWL dB(A)	estimated SPL dB(A)
#1	B2	97.9	97.9
#2	B1	99.9	99.9

Field measurements		
Rank	Tool	SPL dB(A)
#1	B2	97.7
#2	B1	99.5

Table 2 presents the ranking of the 2 roofing nailers for both the laboratory and the field measurements (same ranking). The lab estimated SPL values were calculated using r = 0.4m (see figure 1). The 2 roofing nailers are labeled B1 and B2.

5 Discussion

Firstly, concerning the field results, since the lab bench prescribed in EN 12549 is designed to reduce the acoustic radiation from the nailed piece of wood, it was expected that field results would be higher than those measured in lab. This has not been validated by this study. For framing nailers, the field results are, on the contrary, lower by 3 dB or more than the estimated SPL ($\overline{L_{p,A,1s}}$) from the lab SWL. For the roofing nailers, the field results are at the same level as the lab estimated SPL. Secondly, concerning the lab and field rankings, they are very similar. Thirdly the battery operated nailer (S6**) is considerably less noisy than all other tested nailers in both lab and field measurements.

6 Conclusion

Concerning the EN 12549 standard, it seems appropriate in order to perform representative workplace ranking of nailers following their sound power level values. Concerning the reduction of workers' noise exposure, the battery operated nailer (S6**) stands out as the best choice as its level is at least 6 dBs lower than any other tested nailer in both lab and field measurements.

Acknowledgements

The authors are grateful to IRSST for providing the financial support of this research project.

References

[1] E. Shanks, *Noise emission from fastener driving tools*, HSE, England, (2008).

[2] R. Heaton et al., *Correlation between vibration emission and vibration during real use*, HSE, England, (2008).

[3] P. Marcotte et al., Vibration emission values of nail guns measured at the workplace and in the laboratory as by the ISO 8662-11, proceedings of the 6th ACHV, Miliwaukee, WI (2016)

[4] AFNOR. (2008). Acoustique -- Code d'essai acoustique pour les machines à enfoncer les fixations -- Méthode d'expertise. Association Française de Normalisation, NF EN 12549+A1:2008

[5] ISO 3744 (2010), Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane