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Noise Generated by Construction Power Tools

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Introduction

It is generally widely known and accepted that hearing capacity is diminished with exposure to elevated sound levels over a period of time. This is an issue that should be a major concern to every employer who has employees who are exposed to elevated sound levels in the workplace. This is especially true in the construction industry where there are numerous sources of elevated sound, included heavy equipment, power tools, generators, air compressors, and motors of various types. While this is a concern that is addressed by some construction firms, the area of hearing conservation is one in which most construction firms have not devised specific plans.

Elevated sound levels can permanently damage hearing if the exposure is of sufficient duration. Elevated sound levels are commonly referred to as noise and noise is generally regarded as unwanted or undesirable sound. In the context as it is used here, noise will refer to elevated sound levels that can do harm to human hearing.

To develop a hearing conservation plan, it is important to understand the various sources of elevated sound levels or noise and their relative magnitudes. It is also important to understand some of the basic principles of sound. In the study being described here, the focus was on the measurement of the noise propagation of selected construction power tools under varying conditions. The objective was to provide some basic information on sound propagation that occurs on many construction sites.

Properties of Sound

In its most basic form, sound can be described as a wave that is created by a change in the pressure in the atmosphere from some type of vibration or turbulence. The human ear detects two aspects of these pressure waves, namely the amplitude or peak intensity of the wave and the frequency in which the pressure peaks occur. The frequency, the number of times that a sound wave is created per second, is measured in hertz. The human ear can normally detect or hear sound in the range of approximately 20 to 20,000 hertz. To humans, the frequency is detected as the pitch of the sound.

The focus of the research being described here was not on the frequency of the pressure wave, but the intensity or strength of the pressure wave as measured in decibels. To the human ear, a sound of high intensity is perceived as loudness of the sound. Sound intensify is measured by the use of a sound meter. In the absence of any physical encumbrances, sound emanates outward in a radial pattern from the source. As the distance from the source increases, the sound level is diminished. This is depicted in Figure 1.

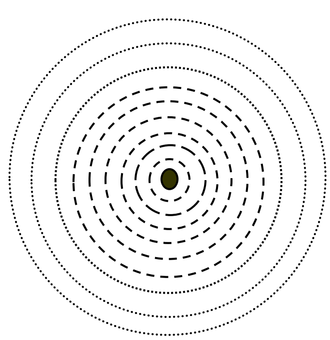

Figure1. Sound intensity diminishes with distance from the source

The decrease in the sound intensity with distance from the source can be computed for ideal conditions. This is computed with the following equation:

$$\Delta_{db} = 20 * \log (d_1/d_2)$$

Where: d_1 is the first measured distance from the source of the sound
d_2 is the second measured distance from the source of the sound
Δ_{db} is the change in the decibel reading from d1 to d2
(negative values imply a decline in sound intensity)

In this equation, a negative change in the decibels will indicate that the sound is less intense, and conversely, a positive change would indicate that the sound is more intense. Thus, when d_1 is less than d_2, there will be a negative value as the sound level will decrease with distance from the source. A general rule that is commonly noted is that as the distance from the source is doubled, the drop in the decibel reading will be about six decibels. This is true for readings that would be noted for 10 and 20 meters from the source as well as 50 and 100 meters from the source. Conversely, as one reduces the distance to the source to one half, the sound intensity will increase by six decibels. Noise is unwanted sound and when the decibel readings are in an acceptable range the sound will no longer be regarded as noise.

On construction sites, it is common to observe multiple sources of sound. There have been studies of sound that have examined the cumulative effect of more than one source of sound. This has resulted in the formulation of information on the impact of having two sources of sound, instead of one. The information shown in Table 1 helps to illustrate the impact of having two sources of sound.

From this information, it is apparent that the cumulative effect of having two sound sources with the same sound level will result in an elevation of the sound level by three decibels. When the differences between the sound levels of two sources increase, the additive effect of the source with the lower sound level is diminished. It would appear that the sound intensity of adding a second source of sound does not have a major or significant impact on the sound intensity. However, it must be recognized that the sound intensity is measured on a logarithmic scale, meaning that the intensity of adding a second source of sound has a sizable impact on increasing the noise level, especially when both sources are at the same sound level.

Table 1. Change in sound intensity when a second sound source is provided

Difference in the decibel readings of two sound sources	Amount of added sound intensity with the second source of sound (in decibels)
0	3.0
1	2.6
2	2.1
3	1.8
4	1.4
5	1.2
6	1.0
7	0.8
8	0.6

9	0.5
10	0.4

Safety Regulations Related to Noise Exposure

The amount of hearing loss suffered by industrial workers in the United States is considerable. One of the possible explanations for the widespread level of hearing loss is that workers generally do not have a good understanding about the sound level intensity. To compensate for this limited knowledge in the construction workforce, prescriptive standards were developed for hearing conservation. Specifically, the permissible exposure level of workers to noise is addressed by the Occupational Safety and Health Administration (OSHA) regulations. These regulations state the amount of time that workers are allowed to be subjected to certain noise levels (see Table 2). If workers are exposed to excessive noise, they are to be removed from the noise exposure. Of course, the practical solution is simply to wear hearing protection (ear plugs or head phones) so that the exposure remains under control.

From observations made on various construction sites, it is apparent that most construction firms do not have aggressive hearing conservation programs. In fact, most of firms do not have the necessary equipment with which to take accurate measurements of the sound levels being generated in the workplace. From these observations, it is generally concluded that construction firms are frequently in non-compliance with the hearing regulations.

Table 2 Permissible Noise Levels of Construction Workers

Duration of Exposure to Noise Permitted in an 8-hour day	Sound Intensity Level (decibels)
8 hours	90
6 hours	92
4 hours	95
3 hours	97
2 hours	100
1 ½ hours	102
1 hour	105
½ hour	110
¼ hour or less	115

Research Methodology

While the theory about sound is relatively straight forward, there is little published information on the types or extent of noise encountered on construction projects. The specific focus of this research was to measure the sound intensify of selected power tools commonly used on construction projects. Measurements were taken indoors and outdoors, at different distances from the tools being operated, and under differing conditions. For example, outdoor measurements were taken next a masonry wall, as most construction work is performed where there are usually numerous encumbrances. Indoor measurements were also taken under differing conditions.

Sound intensity measurements were taken with a sound level meter that was set to take a weighted reading. Readings were taken at several locations. When measurements were taken, three separate readings were taken for each location. The readings from these three measurements were averaged. Readings were taken initially with the tools operating at maximum speed. Readings were also taken with the tools operating at maximum speed when cutting or operating on wood. The readings that are reported are those where the tool was not cutting or operating on wood, unless this is specifically noted.

Results

The initial sound readings that were taken consisted of sound measurements taken 0.6 meters from the tool being operated. This distance was selected as it was assumed to be roughly the distance from the tool to the operator's ear. Some typical sound level readings were as follows:

- Belt Sander 108db
- Router 103db
- Circular Saw 101db
- Reciprocating Saw 97db

From these measurements, it is evident that the operation of these tools should be limited when the operator does not wear hearing protection. Good practice would suggest that hearing protection be used whenever these tools are operated. This is especially true of the belt sander that operates at a level of 108db. Note that various other tools were also used in this research, but only selected information is provided here to keep the scope of information to a level that can be readily comprehended.

Sound level measurements were taken at varying distances from the tools. Most measurements were taken indoors with a concrete floor. These measurements are shown in Figure 2. The pattern of the decline in sound intensity with distance from the tool was reasonably consistent for the four tools, but this pattern of sound level decline was not as predicted by the equation. For example, the rate of decline was predicted to be approximately twice that which actually was measured. Evidently, the walls (primarily painted concrete block) and the steel-trowel finished concrete floor contributed to the elevated sound levels at the varying distances. Note the theoretical decline in sound intensity that would be predicted for a tool with a 95db level of sound intensity at 0.15m.

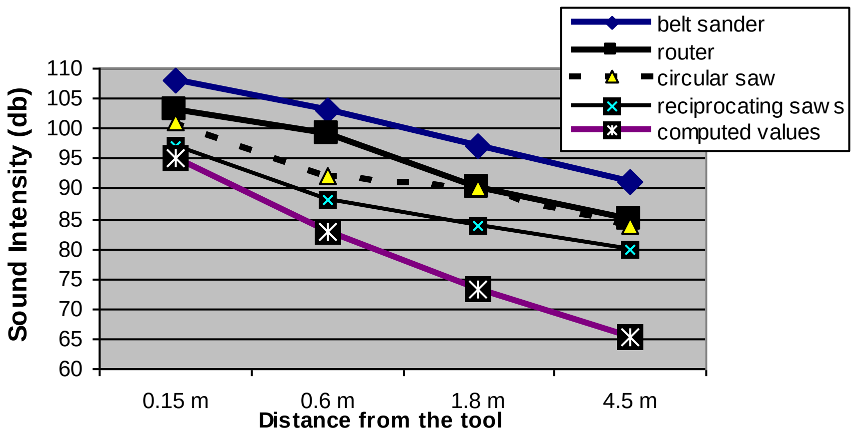

Figure 2 Decline in sound intensity with distance from the source

To demonstrate the impact of a wall on the effect on the degradation of sound with distance from the source of the sound, measurements were taken with a tool operated in the corner of an inside space. Measurements were taken at a distance of 0.15m from the tool, at 0.6m from the tool, at three locations that were 1.8m from the tool and at three locations that were 4.5m from the tool. These distances and relative positions of these readings are shown in Figure 3. The figure depicts the corner of a room, the operator, the location of the tool, and the various associated sound level readings that were taken. Note that the tool (a circular saw in this instance) produced a sound of 103.3db intensity at a distance of 0.15m. At the 0.6m distance the sound intensity was 99.3 db, where the computed intensity of the sound at 0.6m would be about 91.3db. It would appear that the presence of the sound reflective properties of the two walls making up the corner contributed to maintaining an elevated sound level with distance from the tool.

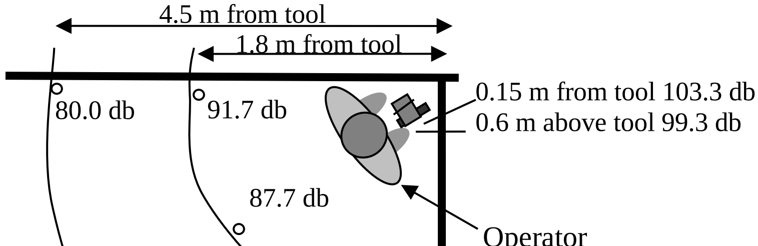

Figure 3. Noise measurements taken at varying distances from a circular saw operated in an interior corner

The additional readings also proved enlightening. Note that the sound measurements 1.8m from the source are also somewhat different. This is especially true of the sound reading (87.8 db) taken directly behind the operator, where the operator's body essentially shielded the area directly behind the operator.

The sound intensity of the tools has been presented, but those figures represented the sound intensity of the tools when operating at their highest operating speeds. Measurements were then taken with the same tools when they were actually used to cut wood. It was noted that the sound intensity levels were quite different when the tools were cutting wood. For example, the sound intensity of the circular saw increased an average of 3.5 decibels when wood was being cut. Some individual readings increased as much as 15 decibels when wood was being cut. This variability may be due in part to the variation that occurs naturally in the properties of wood. While most tool manufacturers do not disclose the noise level of their tools when operated, if such information was provided it might still understate the true noise level as the cutting of wood with the tool will generally increase the noise level. In a few rare instances (as was found with some measurements with the reciprocating saw) the noise level actually declined when the tool was cutting wood.

Since most construction projects are constructed with the involvement of many trades and many different tools, it is common for numerous sources of sound to exist on construction projects. Measurements were taken when there were two similar tools being operated. One saw was measured to operate at 94.8 db and the second saw operated at 93.8 db. The predicted sound level of both saws operating at the same time was 97.4 db, but the actual measured sound level of both saws was 99.7 db. It is unclear why this difference exists, but the reflecting sound from the concrete floor may have contributed to this measurement. Note that such conditions are common on construction projects. This information is summarized below:

- Sound level of saw #1 94.8db
- Sound level of saw #2 93.8db
- Sound level of both saws (measured) 99.7db
- Computed sound level of 2 saws 97.4db

Conclusions

Several conclusions could be drawn from the findings of this research. First of all, most power tools utilized on construction projects operate at a sound level that has the potential of damaging the hearing of workers. While computations can be made of the decrease of sound levels with distance from the source of the sound, jobsite conditions will generally be such that these computations will far understate the true noise levels in the workplace.

Sound level readings must be taken with care. The relative position of the source of the sound and the location of the sound level meter should be carefully selected. It is suggested that a variety of readings be taken at varying locations so as to more accurately profile the noise levels in the work area. Sound level readings should also be taken when the tools are operating at maximum sound intensity, including when the tools are actually cutting wood or when working with other materials.

Recommendations

It is recommended that employers become more familiar with the extent of noise that their employees are exposed to in the workplace. Relatively inexpensive sound level meters can provide valuable insights about work noise. If such sound level readings are not taken on a regular basis, it would be most prudent to implement a program where all employees who work near power tools, heavy equipment, air compressors, generators, or other sources of noise be equipped with and properly wear hearing protection.

Very limited research has been conducted on the sound levels encountered on construction sites. Research should be continued in this area so that the level of understanding about construction noise will increase. It is also important that this information be disseminated so the construction community can benefit from the research.

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