A Review of Psychological Assessment of Noise from Engines

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Abstract: *Noise is defined as 'unwanted sounds', while sound is a term used for sensation that the brain receives when pressure variations in the air are detected by the ear. What is sound to one person can very well be noise to somebody else, but anyone who is exposed to noise is potentially at risk. The higher the level of noise and the longer individuals are exposed to it, the more risk they have of suffering harm from it. Millions of workers worldwide are exposed to noise levels that put their hearing at risk. Excessive noise is an occupational hazard with many adverse effects, not only to the workers involved with noisy operations but also to those around them.*

Keywords: *Noise, psychological assessment*

1. Introduction

Its effects can lead to temporary or permanent hearing damage and can impair workers' efficiency. Individuals suffering from poor hearing, whether it is due to their age or illness, can have their problems made worse by exposure to higher levels of noise at work. It can also lead to accidents due to limited speech communication, misunderstanding oral instructions and masking the sounds of approaching danger or warnings.

2. Main sources of noise at work

Noise is a common hazard and is present to some extent in almost all workplaces. It is the most common health hazard in industries such as entertainment, manufacturing, agriculture, ship-building, textiles, mining and quarrying, food and drink, woodworking, metal working and construction. Some common sources of noise are:

- loud music
- the use of heavy machinery
- workplace transport
- electrical tools such as circular saws and cutter heads
- production lines
- pneumatic tools such as drills, grinders and riveting guns
- electrical motors and generators
- engineering processes such as metal fabrication
- Plant rooms where ventilation equipment has to run continuously.
- General signs of hearing loss

It is important to spot hearing loss as soon as possible because early signs can help to identify the problem quickly. Early signs of hearing loss can include:

- ringing in the ears
- inability to hear soft and high-pitched sounds
- muffling of speech and other sounds
- trouble understanding conversations at a distance or in a crowd
- listening to music or watching television with the volume higher than other people need
- difficulty hearing the telephone or doorbell
- finding it difficult to tell which direction noise is coming from
- regularly feeling tired or stressed, from having to concentrate while listening
- answering or responding inappropriately in conversations
- reading lips or more intently watching people's faces during conversations
- feeling annoyed at other people because of not understanding them
- feeling nervous about trying to hear and understand others.

Research suggests it takes 10 years from the time someone notices they have hearing loss before they do anything about it.

3. Occupational noise burden

Excessive noise is a global occupational health hazard with considerable social and physiological impacts. Exposure to loud noise from all sources accounts for about 20 per cent of adult-onset hearing loss, while 16 per cent of the disabling hearing loss in adults is attributed to occupational noise. Noise-induced hearing loss is considered the 15th most serious health problem in the world.

Noise-induced hearing loss is the most common reported occupational disease in Europe. Twenty per cent of Europe's workers have to raise their voices to be heard for at least half of the time that they are at work, while seven per cent suffer from hearing difficulties. In 2000, 29 per cent of workers in the EU15 and 35 per cent in the new member states reported being exposed to high-level noise at least one quarter of the time and 11 per cent all the time.

In the United Kingdom, it is estimated that there are more than 10 million individuals (about 1 in 6) with some degree of hearing impairment or deafness. Over one million workers are exposed to levels of noise that put their hearing at risk, with 17 per cent suffering hearing loss, tinnitus or other hearing-related conditions as a result of exposure to excessive noise at work.

4. Health effects of noise

When individuals are exposed to high levels of noise in the workplace, they can suffer from various adverse health effects. These health effects can be caused by a single exposure to a very loud noise or by exposure to raised levels of noise over a prolonged period of time.

The effects of noise on hearing depend on:

- noise intensity or sound pressure

- frequency or pitch of sound
- exposure time
- distance from source
- individual susceptibility
- other factors (life-style, age, disease, genetics and so on).

The most well-known effect of occupational noise is hearing impairment. However, it can also exacerbate other health conditions. Some individuals are more sensitive to noise than others are and will suffer harm more readily through noise exposure. The main health effects include the following:

Tinnitus

Tinnitus (ringing in the ears) is the early sign of hearing damage. Excessive exposure to noise increases the risk of tinnitus. If the noise is impulsive, the risk can rise substantially. Tinnitus can be a very distressing condition and can lead to disturbed sleep and affected speech. There is no effective cure for this condition but there is treatment available for easing the symptoms. More information on Tinnitus is available from the UK's National Health Service.

Noise-induced hearing loss

Noise-induced hearing loss occurs because excessive noise damages the delicate hearing mechanism of the inner ear. It is the most common preventable occupational health condition across the world. The level of noise that is likely to damage hearing varies depending on the individual's characteristics and the duration for which they are exposed to the noise.

Hearing loss is a common health problem that often develops with age (presbycusis). It is linked with genetic inheritance and other illnesses, and is also caused by exposure to excessive noise. Hearing loss is not always gradual: it can occur when an individual is exposed to very intense or loud noise for a short period of time such as a loud explosion. This condition is known as acoustic trauma.

Furthermore, the ear's sensitivity level decreases as a measure of protection against exposure to noise. This process is known as a shift in the threshold of hearing, meaning that only sounds louder than a certain level will be heard. The shift may be temporary or permanent. Short-term hearing loss can be experienced as a temporary threshold shift. It may occur suddenly after exposure to intense and/or loud noise, a situation most individuals have experienced at some point in their lives. Temporary threshold shift results in temporary hearing loss. However, repeated exposure to such intense or loud noise normally transforms this into a permanent loss, or permanent threshold shift.

Permanent threshold shift occurs when individuals have been regularly exposed to high levels of noise over a long period of time. It also occurs when exposed to noise repeatedly without sufficient time between exposures to allow recovery of normal hearing, resulting in permanent hearing damage. The UK's National Health Service provides more information on hearing loss.

Loss of hearing can have a huge impact on an individual's personal and work life. Once hearing has been damaged, there is currently no known cure or effective treatment.

Effect on pregnancy-Exposure of pregnant workers to high noise levels can affect the unborn child. Research suggests that prolonged exposure of the unborn child to high noise levels during

pregnancy may have an effect on a child's later hearing and that low frequencies have a greater potential for causing harm.

Physiological effects-Noise can have an effect on the cardiovascular system, resulting in an increase in blood pressure and the release of catecholamines in the blood. An increased level of catecholamines in the blood is associated with stress.

Occupational stress-Occupational stress rarely has a single cause and often arises from the interaction of several risk factors. Persistent noise in the work environment can be a stressor even at quite low levels.

An individual's performance in tasks demanding continuous attention (safety-critical tasks) may be affected by noise as it can distract them, resulting in poor judgements and decision-making process.

The noise, vibration and harness analysis of diesel engines has been an active topic of research during past few decades. This work has tried to deal with some of the important aspects of this issue. There are many key areas in which further work can be done [1].

Some of these include:

1. Quantification of various noise emissions.

A) Subjective approach -Some possible indices used for this purpose may include:

- Ranking-Various subjects may be asked to rank sound emissions from engine according to annoyance in a scale of 1to10. However, number of samples must be kept low to avoid complexity [2, 3, 4].
- Comparison in pairs-In this method various subjects may be asked to evaluate relative judgments on the basis of pairs, however this method can be exhaustive as number of pairs can be large[5, 6].

B) Objective approach-Various psychoacoustic indices that can be used for evaluation include:

I) Loudness-It is a parameter used for evaluation of noise intensity and has unit of phon or sone. Loudness level of 1 phon is SPL of a pure tone plane wave of 1kHz frequency as perceived by human ears in frontal direction [7].

II) Sharpness-A 60dB sound wave of 1kHz frequency has sharpness of 1 acum. Sharpness of a soundwave can be lowered either by adding low frequency components or by decreasing high frequency components [8].

III) Roughness-This parameter takes into account modulation of waves. Its standard unit is asper.1 asper is roughness of a tone of 1kHz frequency at 60dB which is modulated by 70Hz frequency with degree of modulation equal to unity [9].

IV) Impulsiveness- It represents the amplitude and frequency of occurrence of peaks in SPL. Its unit is Kurt and is most significant during ideal running of engines [8].

2. Motion of gudgeon pin inside pin hole

Piston pin is held inside hole either by a full floating system or by a semi floating one. For case of full floating system, both pin and connecting rod may be made of same material, whereas in case of semi floating system, piston may be made of aluminium alloy and pin of steel. Hence, a semi floating system is subjected to more noise due to differences in thermal expansion coefficients of different materials used. It has been observed that pin rotates counter clockwise inside its hole before striking the wall of piston vertically in crank angle duration 20ºBTDC- 30ºBTDC[10].Further movements of oil inside pin hole can be visualized by particle tracking velocimetry(PTV).

3. Use of gap sensors/Telemeter device to study piston secondary motion using different skirt profiles.

Frictional power losses for various skirt profiles can be evaluated using suitable motion gap sensors. Skirt profile having recess at top and bottom part of skirt has shown minimum frictional forces as it has better lubrication load bearing surface [11,12].

4. Use of AVL EXITE for modelling of piston motion.

This approach takes into account thermal distortions of liner using GUID (piston-liner guidance) and EPIL (elastic piston liner contact) approaches [13].Surface velocities may be analyzed both in time and frequency domains at thrust as well as anti-thrust side. At higher speeds, in conjunction with higher inertial forces, piston secondary motion was decreased. Hence, both approaches have shown almost same results [14].

5. Investigation into effects of bubble formations, mist and cavitation of lubrication oil during secondary motion of piston.

Formation of bubbles takes place in lubrication oil film as local pressure drops below ambient pressure particularly in convergent-divergent interfaces like contact between rings and liner [15]. It has been proved that under these conditions, Reynolds equation may yield different pressure profiles [16].

6. Use of different types of injections or use of exhaust gas recirculation (EGR)| and turbocharging.

a) Effects of post injection-specific consumption of fuel and various emissions can be controlled by use of post injection methodology. However, noise emissions were found to remain unaffected by post injection [17].

b) Effects of EGR-EGR has been found to reduce combustion noise above 300Hz range; however, excessive use of EGR may lower the thermal efficiency and increase various emissions [18].

c) Effects of turbocharging-Noise emission during transient conditions from a turbocharged diesel engine have been found to be up to 3 dBA higher as compared to steady state conditions. This has been attributed to turbocharger lag [19].

7. Use of Blind Source Separation (BSS) and Independent Component Analysis (ICA) methods for effective noise source separation.

A BSS algorithm based on least mean square method has been applied to separate piston slapping noise from other noise emissions [20]. ICA has also been used to analyze fuel injection signals, which would otherwise get suppressed by various high energy events or get corrupted by the background noise [20].

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