



## PROTECTION FROM EXTENDED-RANGE LOW AND HIGH FREQUENCIES

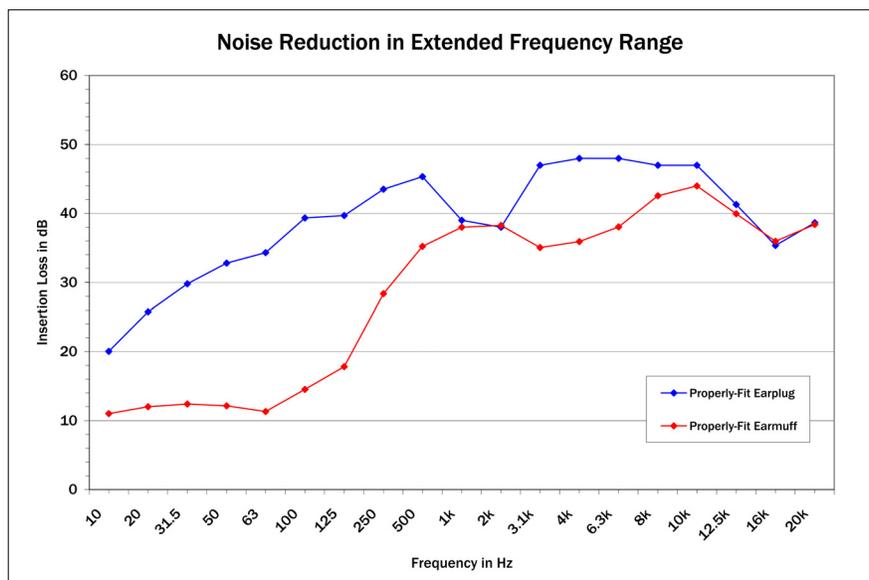
### ***Do earplugs and earmuffs offer protection from audible noise in the extreme low and high frequencies?***

While human hearing is generally defined as spanning the frequency range from 20 to 20,000 Hertz [Hz], most industrial noise falls closer to the mid-range of those extremes. There are some specialized pieces of machinery, however, that emit noise levels near the lower and upper limits of the audible range – the low-frequency rumbling of some turbines or mining equipment, for example, in the frequencies below 100 Hz, or the piercing high-frequency noise of an ultrasonic welder emitting 15,000-20,000 Hz.

The attenuation of hearing protectors is tested in the range from 125-8000 Hz, and these results are printed on the box or package of the protector. But what about the frequencies beyond that test range – below 125 Hz or above 8,000 Hz? Do earplugs and earmuffs offer adequate protection in those extreme ranges?

Fortunately, there is some built-in protection to these low-and high-frequency noises in the human ear. Our best sensitivity is in the range of about 2,000 Hz [where much of speech and conversation is heard], but our hearing sensitivity drops off dramatically in the low and high frequencies. A 100 dB sound at 100 Hz will sound much softer than a 100 dB sound at 1,000 Hz, because the ear's sensitivity in the low frequencies is about 20 dB lower.

Beyond this “built-in” protection, earplugs and earmuffs can also provide good blocking of noise in the extremes of the frequency range. Even though the attenuation levels printed on packaging show 125 Hz as the lowest and 8000 Hz as the highest frequency, actual protection extends far beyond those limits. Figure 1 shows attenuation of noise in the extended frequency range for a sampling of typical earplugs and earmuffs.



**Figure 1. Attenuation of a properly-fit earplug and earmuff across an extended range of frequencies**  
*[Data from the Howard Leight Acoustical Laboratory, San Diego, CA]*

In the extended high frequencies, nearly any well-fit earplug or earmuff will offer good protection – about 35 dB. But in the extended low-frequency range, hearing protectors have a harder job to block incoming sound, offering 10-25 dB of protection in the lowest audible frequencies.

Due to the ear's decreased sensitivity to extreme low and high frequency noise, noise-induced hearing loss may not be the biggest concern with these extended-range noises. Other complaints may be more common – notably, complaints of annoyance and discomfort, headaches and fatigue. There is quite a bit of individual variability in human sensitivity to extended-range frequencies, so some workers may not be bothered by the noise at all, while others feel like the noise is piercing their head.

In low-frequency noise, workers often feel the noise as a vibration more easily than they hear it. Low-frequency waves travel farther, and are often structure-borne, making them more noticeable indoors. Another feature of low-frequency noise is the annoying “beat pattern” caused by competing frequencies. This repetitive throbbing can cause fatigue and annoyance at noise levels far below those that would damage hearing.

High-frequency noise, on the other hand, is usually very directional and easily blocked with partitions or panels. Our sensitivity to high-frequency noise drops off sharply in adulthood, an effect that has now been capitalized by innovators who market a high-frequency noise emitter intended to break up groups of loitering teens with its annoying shrill pitch, apparently unheard by adults.

For workers exposed to significant noise levels in the extended low-and high-frequency range, the best protection [from hearing loss as well as annoyance and discomfort] still comes from a well-fit earplug. But because the ear already has some built-in protection in these frequency ranges, hearing is rarely at risk in these ranges, and any quality earplug or earmuff will offer some relief from the annoyance and discomfort.

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