The Ferret is noisy

Using a 52N sound meter, I measured the sound pressure levels in decibels within the driving compartment of the Mk 2/3 Ferret with the hatches open, and in a typical modern small hatchback car. The car registered 70-75 dB_A, whereas the Ferret registered 80-95 dB_A, about 2-4 times as loud. The Ferret idling value was 80 dB_A compared to a car (with the interior insulated from the engine compartment) of an idling value of 55 dB_A.

According to the World Health Organisation Guidelines (Sliwinska-Kowalska & Zaborowski, 2017) 5% of the population have a hearing impairment. Apart from age-related hearing loss, excessive noise exposure is the most common form of acquired hearing impairment, often accompanied by tinnitus (the phantom perception of sound). It is thus extremely important to protect your ears whilst driving or riding in the Ferret. In the turreted Mk 2/3 Ferret it is the driver who is at most risk, for he sits between the two forward drive-shafts and very near the sound focal point created in the fighting compartment by the reflections off the bell-shaped interior of the hull. The top-commander is removed from this, sitting externally in the turret and exposed to the outside environment. However, one study of motorcyclists (McCombe, 2003) records wind noise of 90dB_A at 40 mph, rising to 110 dB_A at 100 mph.

Noise-induced hearing loss develops very slowly over years of exposure without us being aware. Various studies (e.g. Marron *et al*, 2014) indicate the critical exposure limit for use of personal listening devices is **8 hours at 80 dB_A**. For every 5 dB increase in volume, the maximum exposure time is halved: At 85 dB, hearing damage will occur after 8 hours; at 100 dB damage is after 15 minutes. 120 dB is the pain threshold, with permanent damage after a few minutes (see the decibel scale at the end of this article).

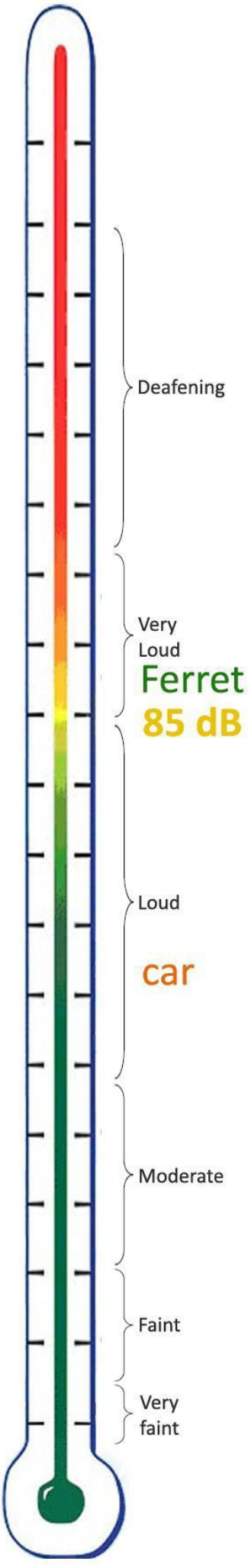
The reference level for such measurements is I_0 = the intensity for the standard threshold of hearing at 1,000 Hz = 10^{-16} watts/cm^2, the standard reference sound pressure of 20 Pa or 20 x 10^{-6} Pa in air (= 0 dB). The threshold of pain is about 10^{13} I_0 or 130 decibels. Normal music is 40 dB - 100 dB and conversational speech about 50-70 dB. The response of the ear to sound is dependent on the frequency of the sound, hence a weighted (dB_A) scale is used to record sound pressure levels. Humans can normally hear sounds with frequencies between 20Hz and 20,000Hz (20kHz) with a peak response between 2.5 – 3.0 kHz and a relatively low response at low frequencies. For the human ear in air, the quietest noises we hear are around 10 dB whereas sounds of 130 dB are considered painful.

Noise is a very subjective term. It can refer to any unwanted sound but is more correctly used to describe sound that isn't rhythmic or pure. Sound pressure levels, measured in dB is a physical quantity, whereas loudness is a perceived quantity (measured by the phon and sone) related to the sound pressure level of intensity (SPL), frequency content and duration of a sound. Most subjects report a doubling of loudness for each increase in sound level of approximately 10 dB_A.

When sensorineural hearing loss (damage to the cochlea or in the brain) is present, the perception of loudness is altered. Sounds at low levels (often perceived by those without hearing loss as relatively quiet) are no longer audible to the hearing impaired, but sounds at high levels often are perceived as having the same loudness as they would for an unimpaired listener. Some listeners with sensorineural hearing loss may hear an elevated loudness at their threshold. To achieve full sentence intelligibility for listeners with normal hearing, the signal to noise ratio – the difference between the speech level and the sound level of the interfering noise – should be at least 15 dB_A.

The nature of speech sounds determines the mechanism of loss of speech intelligibility. Vowels and consonants convey different sound energy. Consonants are spoken more softly than vowels, and tend to get drowned out in noisy environments. The average level of consonants is 10-12 dB lower than the level of vowels. A normal person can understand speech without extra contextual information if 30% is heard, providing no masking noise is present or the speech being below the audibility threshold.

Sources	Distance	SPL $_{20\mu Pa}$
Artillery	10 m	190 dB
Slap on ear	0 m	170 dB
Small arms	0.5 m	170 dB
12-gauge shotgun	1 m	165 dB
Airbag deployment	0.3 m	160 dB
Jet engine	1 m	150 dB
Rifle	1 m	140 dB
Trumpet	0.5 m	130 dB
Loud clapping	1 m	130 dB
Whistle	1 m	120 dB
Loudest human voice	0 m	120 dB
Risk of hearing loss	0 m	120 dB
Pain Threshold	1 m	120 dB
Plane taking off	10 m	115 dB
Chainsaw	0 m	110 dB
Siren	10 m	110 dB
Disco/loudspeakers	0-1 m	110 dB
Music headphones	0 m	105 dB
Car horn	3 m	100 dB
Electric drill	2 m	95 dB
Circular saw	1 m	95 dB
Angle grinder	1 m	90 dB
Hearing damage	0 m	85 dB
Work exposure limit	-	80 dB
Street traffic	10 m	80 dB
Inside car, 60 mph	0-1 m	80 dB
max. Shouted speech	1 m	80 dB
Inside car, 60 mph window closed	0-1 m	75 dB
Wind noise (cycling)	0-1 m	75 dB
Restaurant	0-1 m	75 dB
Idling truck	7-10 m	72 dB
Passing car	10 m	70 dB
Harm threshold	0 m	70 dB
Passing car, 30 mph	10 m	65 dB
Loud speech	0-1 m	60 dB
Office environment	1-10 m	55 dB
Vacuum cleaner	10 m	55 dB
Talking/TV set	1-10 m	50 dB
Hearing impairment threshold	1 m	50 dB
Low vol. TV/radio	1 m	50 dB
Normal living	10 m	45 dB
Rainfall	10 m	40 dB
Quiet rural area	1-10 m	30 dB
Whisper in ear	0 m	25 dB
Normal breathing	1 m	20 dB
Hearing threshold	0 m	0 dB
Anechoic chamber	0 m	-10 dB



SPL values in dB are measured with respect to the threshold of hearing, taken to be 2 x 10^{-5} Pa.

Decibels are measured on a logarithmic scale, sound pressure increases by a factor of 10 for every 10 dB increase, for which we *perceive* an approximate doubling in loudness. Smaller SPL changes than +3 dB (a doubling of sound pressure intensity are generally not perceptible). However, the 3 dB change does not take account of range, or distance.

+6 dB equates to an increase of four times the power and thus (inverse square law) halving the range. The SPL of a point source of noise diminishes by 6 dB for each doubling in distance, or range, due to geometrical divergence. For example, an idling truck at 50 feet measures 66 dB_A SPL, then at 25 feet, the value will be 72 dB, and at 100 feet 60 dB, and 200 feet 54 dB.

Wind, or aerodynamic noise is due to displacement of air by the passage of the vehicle. At lower speeds, the traction noise of the engine, drivetrain and roadwheels dominates.

Along a road sound is generated as a line source, which attenuate their sound at 3-4.5 dB according to the sound reflectivity of the ground, soft ground absorbing sound better. Obviously, other factors such as walls, vegetation, berms, buildings further reduce the SPL reaching the ear. Higher frequencies always attenuate faster than lower frequencies.

The ear perceives different frequencies at the same SPL intensity as different loudness values. The perception of loudness is related to SPL, frequency content and duration of a sound.

When sensorineural hearing loss is present, the perception of loudness is altered. Sounds at low levels (often perceived by those without hearing loss as relatively quiet) are no longer audible to the hearing impaired, but sounds at high levels often are perceived as having the same loudness as they would for an unimpaired listener. There is a good correlation between A-weighted sound level (dBA) and hearing damage, as well as speech interference.

Two phone apps Soundprint 2.0 and Decibel X (which only measures dBZ in the free version) are available.