The reverberant sound intensity ($I_R$) is then:

$I_R = W(1 - \alpha)/S\alpha$ where S is the total surface area of the room and

$I_R = W/R$ where R is the room constant = $S\alpha/(1 - \alpha)$

It can be shown that the intensity in a reverberant field for a given sound pressure is a quarter of the intensity measured in a free field (pressure is a scalar quantity, intensity is a vector) which leads to the expression:

$L_p = L_w + 10 \log( Q/4\pi r^2 + 4/R)$

If the reverberant field is dominant we can make an approximation that all the energy goes directly into the reverberant field. Then $W_R = W/\alpha$ and:

$Lp = Lw + 10 \log (4/A)$ where A ( the absorption area) = $S\alpha$

The reduction in sound level by introduction of further absorption area in dB
= 10 log(A'/A) where A' is the new absorption area.
Note that substantial reductions in room sound level can be obtained if the amount of absorption is initially small and is a useful means of reducing overall noise levels in noisy reverberant factory spaces.

The formulae above apply to spaces with similar dimensions. Spaces which are long and low (e.g. some factory units) do not allow uniform reverberant fields to develop. There is a continual reduction in noise level as the distance from the source increases, and the flexing of a typical low bay factory roofs can cause absorption of the sound at mid frequencies and increased attenuation. Absorbers hanging from or applied to the roof can also increase the sound attenuation with distance from the source. For example in a factory space 75m x 39m x 8m high made of sheet steel the reduction in sound level may be 3.5dBA per doubling of distance without absorber and 5.6 dBA with 80% roof coverage of 50mm mineral wool slab with an overall sound reduction of about 7-8 dBA.

## Outdoor Noise Propagation and Environmental Noise.

In the preceding section it was indicted that the sound pressure level in a free field was inversely proportional to the square of the distance from a sound source - the inverse square law. Expressed logarithmically as decibels this means the sound level decreases 6 dB with doubling of distance. This applies to a point source of sound. If the source is uniform and linear then the decrease is only 3 dB per doubling of distance. For a large area source there is no decrease with distance.

Rathe ( ref 9) has shown that for a building of elevation dimensions a and b the building will behave as an area source until the distance d from the building $> a/\pi$ or $b/\pi$ and then as a linear source until $a/\pi$ and $b/\pi < d$ after which a point source can be assumed.

Air absorption is important over large distances at high frequencies, depends on humidity but is typically about 40 dB/km @ 4000Hz. Note that traffic noise frequencies are mainly mid/low and will be unaffected below 200m.

Wind

Sound propagation is affected by wind gradient rather than the wind itself. Ground causes such a gradient. Sound propagating upwind is refracted upwards creating a sound shadow and downwind refracted towards the ground producing a slight increase in sound level over calm isothermal conditions.

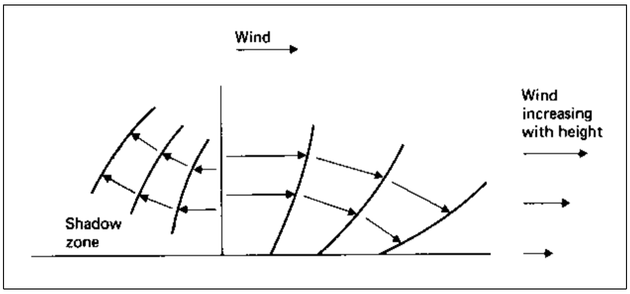

Fig 10 ( Source
ref 10) The effect of wind on wavefront

Temperature Gradient

The velocity of sound is inversely proportional to the temperature so a temperature gradient produces a velocity gradient and refraction of the sound. Under most conditions temperature decreases with height and the sound is refracted upwards.

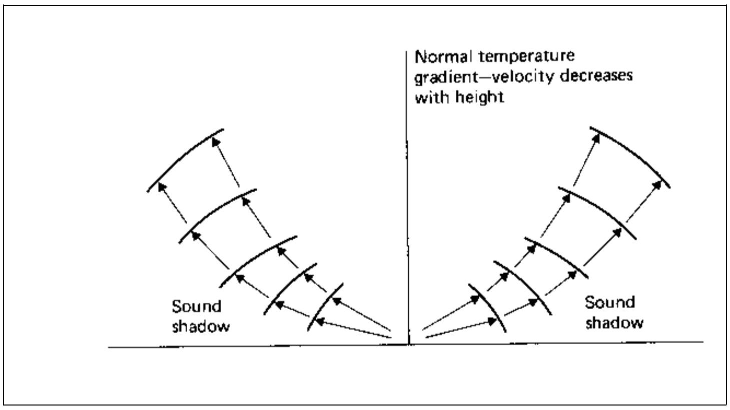

Fig 11 (
Source ref 10) Normal Temperture Gradient effect

Under temperature inversion conditions the sound is refracted downwards and can cause noise to travel over large distance. It can be particularly noticeable when an aeroplane moves through the temperature inversion layer. Sometimes focussing can