Broadband Sound

The 'Noiseless'* Alarm with safety & environmental benefits

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"Calling **noise** a **nuisance** is like calling **smog** an **inconvenience**"

Dr William H Stewart, former Surgeon General of USA

* Webster Dictionary Noise; “any sound that is undesired or interferes with one’s hearing of something”. The sound from a correctly selected and installed broadband alarm is heard only in and near the danger area - where it is meant to be heard.

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Introduction

Field trials of bbs-tek® backup alarms, scientific research and evacuation trials confirm that broadband sound is very effective at giving away the location of a sound source. In 2002 the American Council for the Blind called for the use of locatable sound saying current alarms “serve more to disorient people who are blind and visually impaired than to assist them[1]”. Additonally, there is a significant reduction in extraneous sound beyond the danger area - behind the reversing vehicle.

In comparison to the conventional backup alarm, the bbs-tek® Broadband alarm is equally as loud and as effective at alerting the listener to the presence of the reversing vehicle. In contrast to conventional backup alarms to the bbs-tek® is little heard outside the danger area.

Locatable Sound

The American Council for the Blind reported at their 2002 annual Conference in Houston, Texas, that conventional alarms serve more to confuse blind people than to assist them and called for the use instead of locatable sound.

Instant location of a sound-source is a part of Nature’s survival mechanism. An animal in imminent danger of being attacked promptly locates the sound of the stalking predator. Naturally occurring broadband sounds such as the crack of a breaking twig or the rustle of leaves accurately reveal the approach direction of the danger.

To locate a sound source, three parts of the frequency spectrum must be heard simultaneously, as a single sound:

1. Low Frequencies; about 1KHz and below. With low frequencies the brain can process the time difference between the sounds arrival at one ear then the other.
2. Mid frequencies; about 3KHz and above. At frequencies above 3KHz (approx) the brain senses the intensity difference of the sund at each ear, i.e. the sound is more intense at the ear closest to the source than at the shadow ear (further away from the source). With this frequency range we can determine if the sound is to the left or right. For single frequencies the timing and intensity differences are the same at equal distances from the ear. These leave a ‘cone of confusion’ as illustrated in figure 1 below.
3. Higher Frequencies; about 5KHz and above. Due to our outer ear shape and body shape, higher frequencies are modified before entering the ear canal. This is an individual response and is known as the HRTF (head related transfer function). This phenomenon is a learned skill and allows the brain to resolve the ‘cone of confusion’ and identify the exact location of the sound.

[1] American Council for the Blind resolution ACB 2002-22.

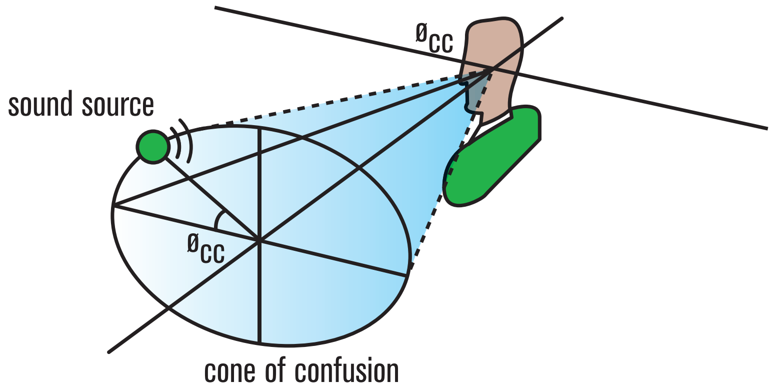

Figure 1

With a large section of each of these frequency ranges the brain can locate the direction of the sound source. The more the better, and with broadband the accuracy for instant locatability is around 5 degrees.

We can locate the source of pure tones but usually after a much longer delay by rotating or moving the head and sometimes only with simultaneous sight cues.

Assuming a person hearing a narrowband alarm is not desensitised by the alarm's ubiquitous nature, and reacts to it, the vehicle posing the hazard may bwell have travelled several metres by the time the person locates it!

Sound Localised within Hazard Area

Sound is localised to and near the hazard area, this:

1. removes noise complaints from those that neither need nor want to hear the warnings and
2. makes those exposed to the danger more responsive, because when a broadband alarm is heard the hearer knows they are in or close to a hazard area.

How is this achieved?

There are a number of factors that contribute to this benefit.

1. Lower dB(A) output! Figure 2 below illustrates a narrowband alarm and a broadband alarm that both measure 100dB(A) using a conventional sound meter to IEC 60651:1979 Class 2 or better. The maximum dB(A) output from the black-line narrowband alarm is 100dB(A) whereas the maximum dB(A) output from any of the red-line broadband frequencies is about 10dB(A) lower! The distance a sound travels is dependant upon the peak frequency dB(A) output - not the conventional SPL meter reading!

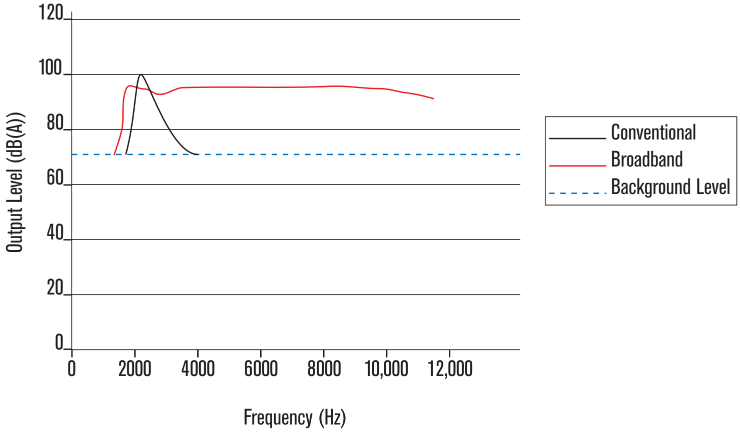

Figure 2

Dissipation off-axis. Whereas a narrowband is omni-directional, broadband is focused into the danger area. The schematic at figure 3 below by Hanson Aggregates, is typical of several studies reviewing dB(A) dissipation off the rearward axis. While there is negligible sound dissipation in the danger area, there is typically around 10 dB(A) loss away from the danger area at 90 degrees to the side of the vehicle.

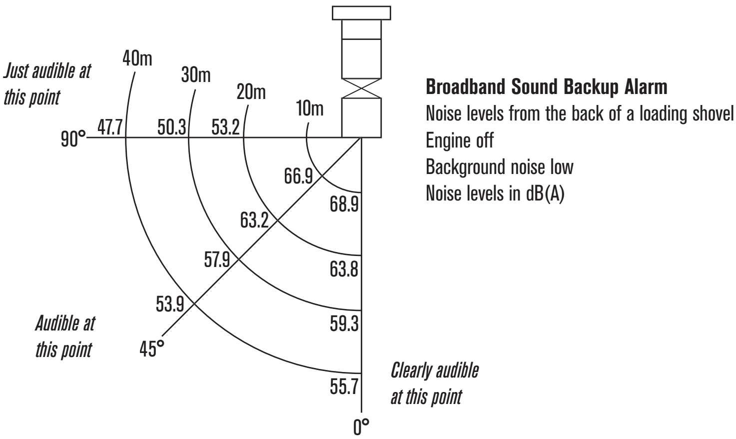

Figure 3

3. Lower dB(A) rating. Anecdotally, numerous site evaluations have revealed a broadband travel alarm to be equally effective at 5dB(A) lower SPL than a conventional narrowband

alarm (Refer Fig 1 above) - the broadband alarm has peak frequencies about 10dB(A) lower, making a total dB(A) reduction of around 15dB(A).

Net Effect of These Factors

Aggregating these three factors reveals broadband's full potential as a noise-abater. Roughly speaking, a 6dB(A) reduction yeilds a halving of the sound travel distance. The schematic at Figure 4 below shows:

1. Black Outer Circle, the range of noise impact of a narrowband alarm 'X'.
2. Blue disc, sound impact area of a broadband alarm with the same dB(A) output to 'X' if it did not have the off-axis, away from the danger area, localised characteristic.
3. Mauve disc, alarm zone of broadband with same dB(A) rating as narrowband alarm 'X'.
4. Red Area, the alarm zone should the narrowband alarm 'X' be replaced by a 5dB(A) lower broadband alarm.

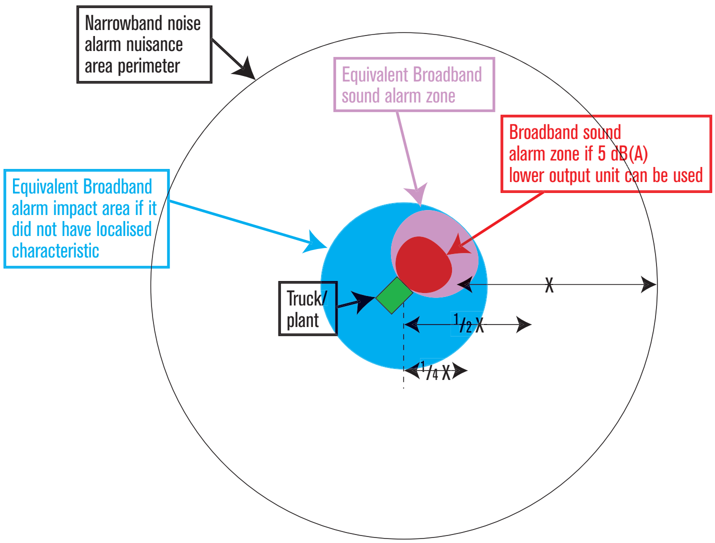

Figure 4

Audible through Ear Defenders (Ear Protection)

Low frequencies more readily penetrate solid objects. When music is played very loud in a building or car with windows and doors shut, it is the low frequencies boom-boom noises that are heard. The frequencies can travel through the body and are heard through many ear defenders. Fog horns use low frequencies because they travel long distances, round corners and penetrate solids such as windows, walls etc.

Reduced Risk of Alarm Sound Being Masked

Narrowband travel alarms are at risk of being masked by similar frequency background noise. Broadband almost entirely eliminates this risk.

Rapid Sound Dissipation

Broadband's massive frequency spectrum enables lower overall SPL. While it's low frequencies travel further they are more benign whearas the less tolerable high frequencies are more readily absorbed by air. As a result the overall sound pressure reduces more quickly with distance from source.

Less Irritating

Narrowband alarms are more strident and irritating than broadband frequencies. (See Technical Stuff; Psychoacoustics & Tonal Aspect sections below).

End to Intentional Disconnects

many companies suffer increased danger, breached regulations and repair costs following sabotage of narrowband alarms. They are comfortable to work with and their extra safety benefits are respected too.

Reduced Risk of Hearing Damage

With lower frequencies the risk of hearing damage is greatly reduced.

The cochlea (inner ear) is a long 'string' of receptors, akin to a ticker tape. Each receptor receives within a narrow frequency range. Hearing impairment is generally restricted to those receptors which are damaged.

Figure 5 below shows the cochlea receptor frequencies aligned with the travel alarm frequencies. In this case, the damaged receptors correspond with the whole of the narrowband alarm's frequency band which is therefore unheard. Conversely, all the other frequencies of the broadband are heard perfectly well.

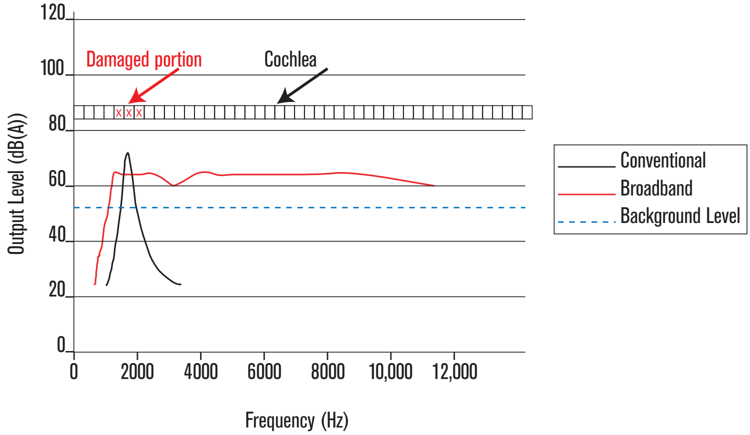

Figure 5

Reduce Heart Risk due to 'Startle'

ISO-7731 states; "Reactions due to fright (e.g. more than 30dB in 0,5 s) may be caused by using too high a sound-pressure level." We would add "these can also delay, or even prevent escape from danger due to 'freezing'.

The risk of Shock/Startle is much less likely using broadband travel alarms with their lower SPLs and multi-frequencies.

Technical Stuff

Equal SPL measurements and Spectral analysis

A reading of sound pressure on an SPL meter (as per ANSI S1.4 (or IEC 60651) - specification for sound level meters) will 'average' the sound pressure in each frequency band and present a consolidated single figure output - weighted as per the settings on the dB(A) meter.

It is the industry norm to measure SPL using the 'A' weighting dB(A) which adjusts the correct measurement of SPL to the actual response of the human ear. This 'A' weighting adds or subtracts a number of dB from the level reading from each of the frequency bands in order to simulate the non-linear output versus the frequency response of the ear.

The graph at Figure 6 below shows the SPLs which might be expected from a conventional travel alarm (when centred on 1250Hz) and a broadband travel alarm. Clearly the frequency content of broadband is much larger than narrowband, but always at a lower SPL. These SPLs could be read using a sound meter (and filter set) as per ANSI S1.4 & S1.11 (or IEC 60651 & 61260) set to the one third octave range.

Although the broadband shows lower SPLs in each one third octave band the added oeffect of these is equal to the narrowband travel alarm - 100dB(A) at 1m.

The summation of decibels is as follows:-

$$SPL=10x\log(10^{[spl1/10]}+10^{[spl2/10]}+10^{[spl3/10]}...)$$

where spl1, spl2, spl3 etc., are the individual one third octave band sound pressure levels.

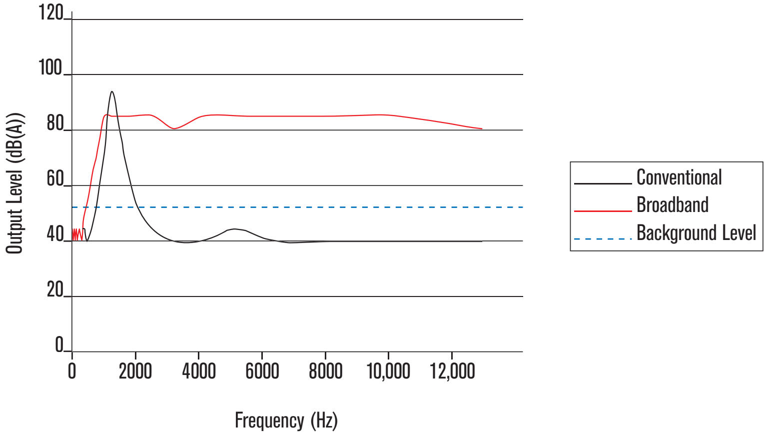

Figure 6

Sound versus Distance

In a free field (open 3D spherical space) sound dissipates from a point source according to an inverse square law and the reduction in dB is calculated as:-

$$SPL^{R}=10x\log\left[\frac{1}{r^2}\right]$$

Where 'r' is the distance of the listener from the source. This results in the well known 6dB drop for each doubling of distance from the soure. However, most sound sources are not 'ideal point sources' and hence have less than ideal sound distribution in every direction.

Hence, taking into account no other environmental factor the SPL will be about 36dB lower in each one third octave band for a listener 60m from the source. Ref. to the graph in Appendix 1 shows clearly that broadband SPLs have dropped almost to ambient SPLs whearas the narrowband travel alarm remains some 10dB(A) above ambient.

The rate of sound-absorbtion depends on numerous other features including frequency content. Air absorbs sound faster (i.e. more rapidly per doubling of distance) in the higher frequency ranges. Atmospheric conditions (humidity, temperature, wind direction and speed etc.) all affect the speed of sound. The rate of sound absorbtion by physical structures between source and listener (Buildings, fences, trees etc.) is also frequency dependant.

Psychoacoustics

The perception of sound is what is judges to be ‘pleasant’ or ‘intrusive’. Sensitivity is greater and sounds therefore seem louder in the 1KHz to 4KHz band (this forms the basis for the ‘A’ weighting system). Discrete narrowband alarm noise is intrusive even in high ambient noise levels.

Tonal Aspect

The ‘Tonal’ aspect is important enough for the Federal Aviation Administration to have made provision for the prescence of tones in aircraft noise in the Federal Regulation for Noise Standards on Aircraft. (Title 15 - Aeronautics and Space, Chapter 1, part 36.803 - Noise evalution and calculation).

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