How to reduce wind noise and vibration

By Chris Woolf

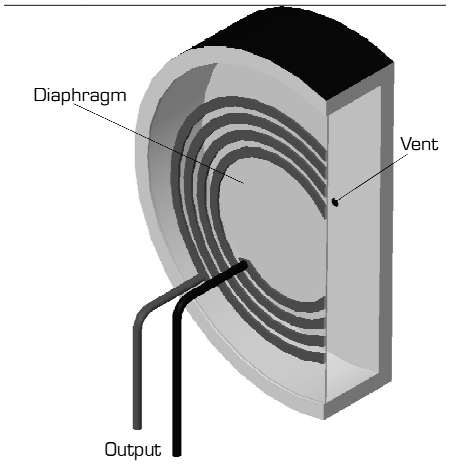
Wind and handling noise

Everyone who reads this article will know that sound is normally transmitted to our ears as tiny changes in air pressure and that microphones operate by sensing these brief changes and converting them into an electrical signal. Classically a sound source will generate the variation in pressure – the sound wave – which is then sensed by a very light diaphragm in the microphone. The pressure change will displace this with respect to the stationary body of the microphone and the movement will generate a small current either directly by electromagnetic means or indirectly by modifying an electrical parameter such as capacitance.

There are two implicit assumptions in this description. Firstly that the only variations in air pressure that the microphone senses are due to the original sound source and secondly that the microphone body is truly static. In practice both rarely hold true and the unfortunate results are lumped together somewhat indiscriminately as wind and handling noise. The effects are indeed intimately bound together and difficult to tease apart but understanding the separate causes and what can reasonably be expected of the cures is worth some effort.

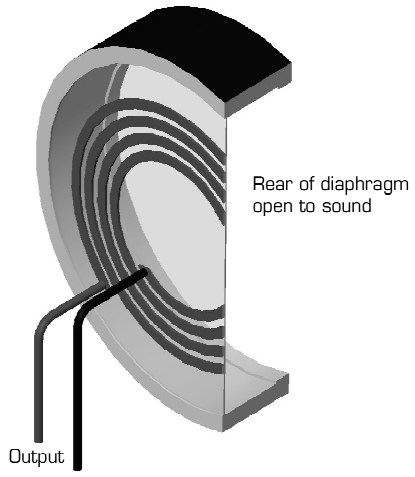
Operating principles

Microphones can be categorised according to two basic operating principles. Firstly there are the pressure transducers that measure changes in absolute air pressure. These are effectively a closed box with a diaphragm across one side and as the air pressure increases so the diaphragm bends inwards. To prevent drastic variation in performance as the weather changes a small controlled leak allows a slow equalisation of pressure between the closed box and the environment. Having only one face exposed to the sound wave – a single port –



Pressure transducer – single port

they are effectively omnidirectional in pattern. Secondly there are the microphones that respond to pressure gradients. These allow the sound wave to have access to both sides of the diaphragm. Since the wave is a series of compressions and rarefactions at any one instant there will be a different pressure on



Pressure-gradient transducer – two port

each side of the diaphragm which will displace it. The gradient of pressure is not very large, particularly at long wavelengths (low frequencies), and so the diaphragm has to be quite loosely tensioned. With the use of two ports, one to each face of the diaphragm,

the transducer inherently becomes directional. However, just to confuse, some microphones with an omni pattern may use multiple pressure-gradient (directional) elements.

Before this becomes too frighteningly academic let's look back at one of those key assumptions – that the body of the microphone stays still and it is the diaphragm that moves. Although this is the normal state of affairs what happens when you knock, move or rub the microphone body? The elastically suspended diaphragm will initially stay still due both to its own finite (even if very small) mass and that of the air next to it. After a moment the elastic forces that tension the membrane will restore the diaphragm's position relative to the (moved) microphone body. This temporary displacement is identical to that caused by a sound wave and produces the same electrical signal.

This spurious output – handling noise – from a mechanically coupled vibration is common to all microphones but for the pressure type with a tightly suspended diaphragm the restoring force will be high and the displacement quite small. For a pressure-gradient transducer the restoring force will usually be a lot lower and the membrane will be able to flap more easily and thus generate a much larger spurious output. It is wise to anticipate that a directional pressure-gradient microphone will be more prone to handling noise than a pressure one.

Suspensions

The idea of mounting the transducer in some form of suspension that isolates it from external influences is both obvious and effective and the trick can be accomplished in a wide variety of ways. Handheld microphones usually isolate the fixed part of the transducer completely from the cosmetic case by seating it in an elastomeric bushing. Larger studio versions may put most of the isolation in a 'cat's cradle' mount outside the casing, while rifle microphones are commonly fitted into hoop-and-band structures mounted onto pistol grips or boom poles. All of these can work moderately well but have limitations, governed partly by mechanical constraints and also by the fundamentals of physics. Essentially all suspensions involve a mass (the microphone), which can be displaced, and a restoring force which tries to bring it back to its rest position. Such a device can oscillate at its natural (resonant) frequency at which moment it is completely worthless as a suspension – it will enhance rather than reduce movement. At about three times its resonant frequency the mount starts to function usefully. The aim is therefore to make the resonance as low as possible and to try to damp any oscillation very heavily.

For frequencies of perhaps 100Hz and above this approach is quite easy to achieve but many microphones have a response far lower than this. Most users have a very reasonable urge to keep as much low frequency content as possible in a recording. However to make a mechanism that can satisfactorily isolate 20Hz – a signal with an acoustic wavelength of about 17m – may involve not simply suspending the microphone but several kilograms of stand and very probably the entire studio. The magnitude of the problem doubles with every extra octave of LF and is not helped by the inability of many monitoring systems to reveal the results accurately, if at all.

The need to define the lowest useable frequency and to cut out anything below with a high-pass filter is rarely underlined as it should be. For microphones mounted on boom poles this is a particular problem since the LF and infrasonic signals produced by movement can easily be large enough to overload the entire audio chain. It is over-optimistic to imagine that even the most magical of microphone suspensions can do anything to alleviate this and improbable that headphone monitoring will report the failure until it becomes total.

Over the frequency range that an external microphone suspension can be expected to operate well it should, of course, be completely silent. It should not creak or groan or rasp and this can be checked very easily by listening critically to the output of the microphone while 'exercising' the possible movements. You also need to be aware that cables are designed for

toughness and longevity and have no useful elastomeric qualities. They therefore need to be chosen carefully, and dressed and anchored so that they do not negate the function of the suspension.

Wind noise

We should also have a look at that other assumption – that the only variations in air pressure that the microphone senses are due to the original sound source. This is, of course, false too. Anyone who has held a microphone in the wind or even just breathed at one will know what wind noise is and that it is a most unwanted addition to the sound source.

Air is a much more turbulent and knotty fluid than we usually imagine it to be. In a screaming gale it is possible to feel the enormous pressure variations that are taking place but thermal currents or the action of someone moving in a room are sufficient to set up eddies and local changes of pressure which may be comparable with those due to a sound source. The draught across the cold stone floor of a quiet church may produce more serious 'wind noise' than the gentle breeze outside. For now I will term all such air movements – even those caused by a performer's breath – as wind.

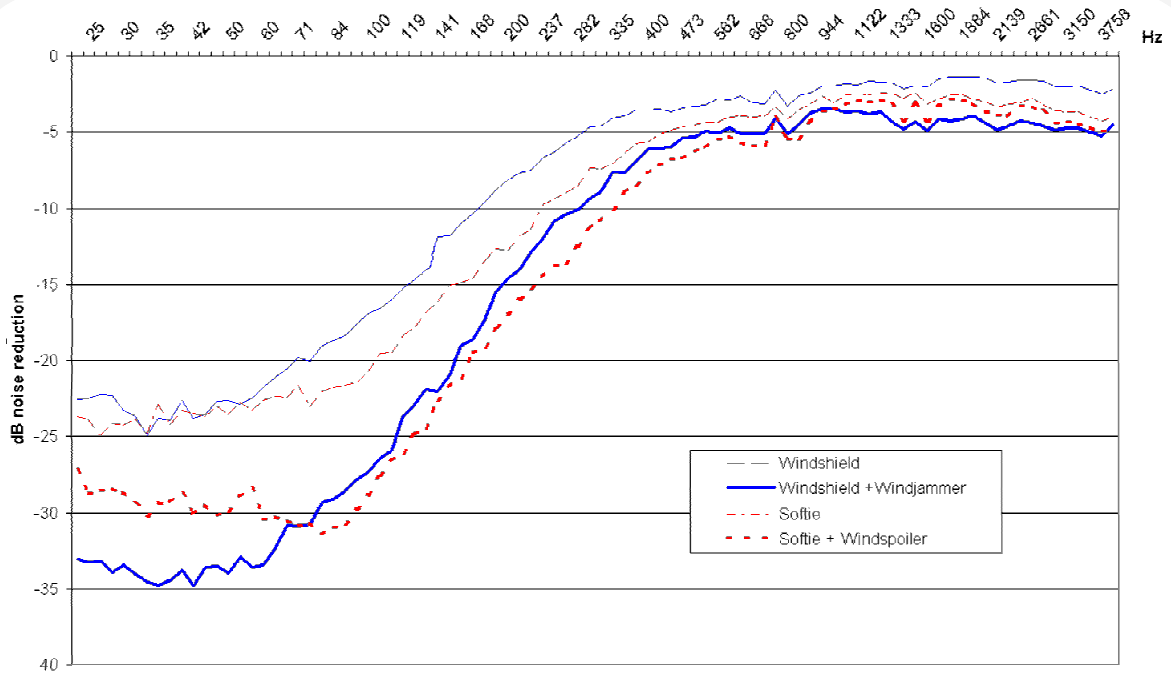
With a single-port microphone the wind pressure is simply added to the soundwave pressure to give a composite signal. Unless the wind is very strong its contribution to the total signal will not dominate. However with a two-port transducer the local difference in wind pressure at each port can easily exceed the rather small difference due to the sound wave. Thus a pressure-gradient microphone is invariably more sensitive to wind noise than a pressure one. Pressure transducers do have one area of weakness though. If used where there may be a sudden step change in air pressure – perhaps inside a car when a door is slammed – the diaphragm may be forced against the back plate and the device will mute until the internal and external pressure can be equalised again.

It is possible to counteract wind noise by several different means. Firstly wind noise has a spectral content that is heavily tilted towards LF. Cutting out the extreme bass – as is so often required for removing rumble and infrasonic noise – is also an effective method of cutting down wind noise. Secondly wind has a fairly high airspeed in comparison to sound waves. Fitting a screen of very fine mesh in the path of the wind will dissipate the energy in the faster air stream to a much greater extent than the slower one.

Almost every microphone adds at least one layer of mesh to protect the capsule. The mesh must have a very fine pore size and so is usually a fine wire or fabric gauze. These have little mechanical strength so they need stretching across a framework or supporting on a coarser grid. Foams and sintered metal are possible substitutes. Rigidity and stiffness are important because the material must not flap or rattle or vibrate even when buffeted by the wind. Adding extra nested layers gives improved performance – the disc pop-screen that intercepts the unidirectional breath-stream of a performer comes into this category – but there are some penalties. Each new layer or element will need an additional structure to hold it and these are likely to cause some damage to the polar pattern of the microphone.

There are some other important factors to keep in mind. Actual acoustic noise is generated at the attenuating surface by turbulence so if this can be kept to a minimum and the surface kept as far away from the microphone as possible the noise reduction will be improved. This dictates that a windshield (or windscreen – the terms are interchangeable) should be aerodynamic and as large as possible, bearing in mind the need for it to be structurally rigid. For any two shields of comparable quality and design the larger one will be more efficient at reducing wind noise.

There is an additional method of reducing wind noise that is specific to pressure-gradient transducers. The cavity windshield is typically a plastic mesh basket (often termed a zeppelin) that totally encloses the microphone and traps still air inside. Provided that the wavelength of a sound is much longer than the windshield – it has a low frequency - it will squeeze it



Wind noise reduction options - Sennheiser MKH60 under real wind conditions (means of 20 readings)

uniformly. With no pressure difference at the two ports of the transducer – called correlation – the diaphragm does not move and thus there is no output. At higher frequencies – shorter wavelengths – the pressure chamber effect ceases to operate. This technique therefore neatly exploits the LF skewed spectrum of wind noise and the only drawback is a reduction in LF sensitivity since audio waves are also affected.

Of the other materials used for windshielding open-cell foam is popular since it can combine a fine pore size with some structural strength. Cavity windshields can be made using it but the most usual types are the simple push-on foam 'hats'. Foam shields still need to be aerodynamic in shape but the trade-off in size also involves the path length through the foam which must be short enough to avoid too much loss of high frequencies.

Another special-case material is fur. This is invariably an artificial fibre fixed to a fabric mesh backing and works by absorbing turbulence energy. The efficiency is very high and provided that the fibres are not allowed to matt up can reduce airspeed in a virtual 'shell' around the shield. The fur itself contributes no noise as it absorbs energy and any signal attenuation is largely a property of the backing material. This is a long list and many of the various techniques can be used in combination. Fur can fit around a basket windshield and foam 'gags' can be fitted over the mesh screen of a capsule, but foam inside a zeppelin will have a decorrelating effect and so will worsen performance. Since all attenuating layers tend to affect high frequencies more than low ones the greater the number of layers or depth of material the poorer the HF response will be. The least covering necessary is always the best choice, but a small and equalisable loss of HF may be a small price to pay for 30–40dB reduction of wind noise.

A note of caution in comparing such figures is worth adding here. In calm conditions a windshield will have no useful effect at all – it will merely add some attenuation, hopefully small and probably only to frequencies above 10kHz. If you use a laboratory wind generator to blow air at the microphone the shield starts to have a noticeable effect up to a measurable maximum. If you take a wide-spectrum noise figure and add a weighting factor (perhaps the familiar A-type) to give an approximation of what the ear would hear then you can produce a single figure for comparison. However, wind machines are not

the part of the real world, and measurement results with them may be slightly ambiguous. Where a figure is published for wind noise reduction it should be taken as a guide rather than an absolute and comparisons between differently measured or quoted figures are most unwise.

Confusion

I have explained handling and wind noise as if they are were unrelated but that is through necessity rather than accuracy. The turbulence of wind does not just rattle the grille of a microphone but also all the rest of its casing and the cable plugged into it as well. This is the same path that mechanically coupled handling noise follows, although it may also be possible for wind to leak through holes cut for switches and generate noise inside the body too. Thus at least some wind noise will be inextricably linked with handling noise.

The reverse also holds. All the wind protection layers that may surround a microphone will have a degree of acoustic opacity – they will be able to push air and thus be able to act as small loudspeakers, albeit very inefficiently. This is also true of their supporting structures and the static parts of suspensions. If any of these can be forced to vibrate they will radiate some acoustic noise and thus couple the sound to the transducer through the air. This is an effective short-circuit around any suspension system, internal or external, and is a significant source of handling noise that is hard to eradicate since it follows the same acoustic path as the wanted sound. For directional microphones the problem is roughly proportional to the pick-up angle – least for a narrow rifle pattern and particularly severe for stereo versions.

The range of handling or wind-related noise problems that users will meet are as great and varied as the solutions. Not every technique that is helpful with large-diaphragm capacitor microphones in a music studio is necessarily of value for a handheld dynamic used by a singer in a club, any more than the windshielding on a rifle microphone can be used with a lavalier. But the sound itself, the analysis of the problem and the underlying physics are common.

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