Blasted Microphones

CHRIS WOOLF MIBS explains the science and the compromises behind keeping wind out of microphones.

Although the form of windshields for microphones varies quite a bit, the science behind them doesn't. The rules are well known, but applying this mixture of simple acoustics and thoroughly practical mechanics inevitably involves dancing round some compromises.

Wind – large-scale air movement – is, in itself, silent. But as soon as the air mass hits an object it will make it shake, twitch or vibrate in some way and thus create noise. In return the object will make the air change direction and thus generate turbulence and chaotic flow. Given that sound levels reduce very rapidly with distance, microphone windshields are designed to place any noise-producing surface as far away as possible from the capsule so that it basks in a local environment of still, quiet air. The direct result is that efficient windshields are inevitably large.

Figure 1 shows an excellent experimental example. Figure 1a is the response of a teardrop-shaped windshield (green trace), which has a larger maximum diameter than the cylindrical control version (blue trace). As you can see, the wind noise attenuation of the teardrop shape is significantly better. However, moving the microphone forward in the tear-drop so that the diameter of the windshield surrounding the capsule is the same as that of the control windshield (Fig 1b) shows a reduction of the amount of noise attenuation to an identical level. Physics says this will happen, and it does.

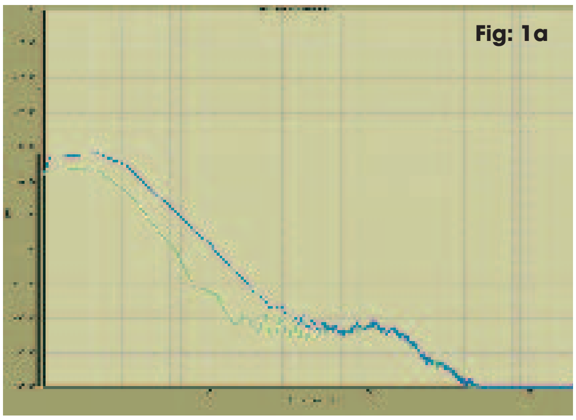
Fig: 1a

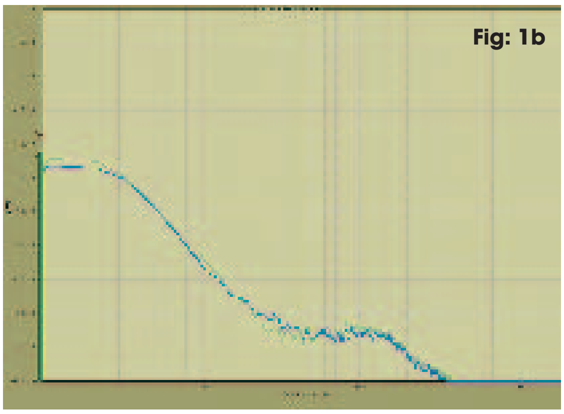
Fig: 1b

Bigger is Better?

The practical size of windshields is governed by three factors. What can be made rigid and strong; what can be held still in the wind; and what the customer will accept. The last cannot be ignored because wind-shielded microphones have to be used in awkward places, and the common 100mm diameter version was arrived at long ago as the most requested compromise.

Rigidity and strength matter because the shield must not, itself, move relative to the microphone. If it does it will generate noise. Consequently, cloth coverings have to be anchored exceptionally well to prevent flapping in high winds, and the windshield shape must be sufficiently aerodynamic that it doesn't create excessive lift, drag or large-scale turbulence. If the entire windshield shakes in the wind, the microphone will also be shaken (noisily), irrespective of any internal suspension system because none can isolate at extreme LF. This need for functional streamlining explains why spheres and zeppelins predominate – pointy nose-cones only work in wind tunnels and on rockets.

Rude Mechanicals

The mechanical aspects of windshield design also affect simple matters like balance. Most users imagine this in terms of centre of mass and how the microphone 'hangs' on a pole. However, in high winds the aerodynamic balance can be just as important. For example, if the windshield were supported at one end, pointing it in a strong wind would be virtually impossible since it would constantly try to 'windmill' in the direction of any gusts.

Rigidity is important for an entirely different aspect of physics. Pressure gradient microphones have twin sound entry ports, and the directional behaviour is governed by the differential signal at these points. This can be exploited because windshield covers have a degree of acoustic impedance which prevents air moving quickly into and out of a windshield. At LF (long wavelength) pressure changes tend to squeeze the entire shield like an aneroid barometer sensor. Consequently, the pressure at all points inside the windshield will vary by the same amount, and with no net pressure difference between its ports the microphone's output is zero. Although this effect is only apparent at very low frequencies, the spectrum of wind noise is heavily tilted in this direction. This explains why flexible shields – including foam – are less effective unless a steep high pass filter is used.

Particle Velocity

Yet another strand of physics that comes into play is particle velocity. The speed at which an oscillating molecule or particle of air moves is obviously governed by how loud the sound is, the frequency, and the phase angle – but would not often exceed 0.001metre per second. With wind, however, the particle velocity is essentially the mean speed of the air itself. Any decent draught would be 2-3 orders of magnitude greater and a hurricane is typically more than 33m/s (120km/hr or 74mph).

It is not too hard to find a material that will have both a low acoustic impedance to low particle velocity sound and a much higher one to fast-moving wind. Single or multiple layers of cloth, open cell foam and wire mesh all have a rôle to play in forming these differential barriers that are almost transparent to sound but mostly opaque to wind.

The backing of a fur covering will have a measurable impedance to audio but the fur layer (if well-brushed) has very little. Yet fur is very lossy for high particle velocity flows and dissipates turbulence by randomising it to the point where the net vortex energy in any direction is almost nil. Fig 2a shows a typical LF spectrum of wind noise (3m/s), and Fig 2b shows the attenuation due to a fur-covered windshield.

Almost all open-pore materials can hold water by capillary action and many fabrics also absorb it. Hydrophobic coatings can help but rarely eradicate the problem, so performance will change with weather conditions – and saturated windshields sound like the closed boxes that they become because the almost impervious walls reflect sound back to the microphone.

Even dry windshield coverings and structures will couple some wind noise (and handling noise) back into a microphone acoustically. The amount is dependent on the tension in the fabric, the degree of support, and the amount of damping provided. Integrally damped and structurally self-supporting foam, of course, is largely immune to this problem – but then to make a 'large' windshield it also ends up 'thick' with a high degree of HF attenuation. As you can see, the compromises play an endless, 'unsquarable' dance. ibs

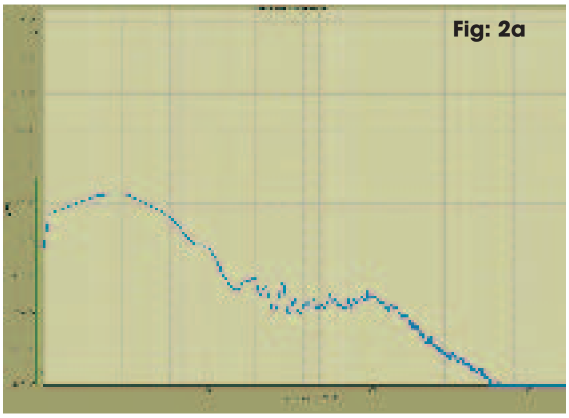
Fig: 2a

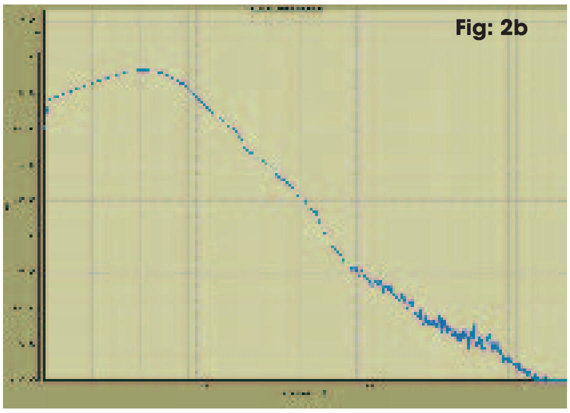
Fig: 2b