MATERIALS

The Importance of the Four Diaphragms

Dave Robinson 12 August 2014

Aston Fearon writes…

Although our role as sound engineers focuses heavily on using the latest advancements in digital technology, it is all with the aim to mould, shape and deliver the invisible artefact that we know and sense as sound to our audiences. The fact that we are effecting this unseen medium which has real, measurable (but complex) results is obviously what lends to the engineering half of our title.

Like heat and light, sound changes as it passes through varying mediums before reaching its destination (the listener), and as sound engineers our job is to understand and implement the physics and mechanics of these crucial points along its path. By crucial points here, I am talking about the role of each diaphragm: each piece of membrane-like material well-suited for oscillating backwards and forwards affecting the air around it – and the basis of all physics for sound reinforcement.

1 The Acoustic Source

The final mix that hits the listener's ears begins as a variety of sources: vocals and instruments. The diaphragm is crucial in the projection of the human voice, just as all acoustic instruments also create some kind of vibration.

These are sources and not channels, sounds and not audio. This distinction is important because we need to remember that sounds propagate and interact with the environment, reflections and other sounds before a microphone is ever involved. The best way to deliver a good mix is if all of the sources are working well, and are well- tuned on stage before they enter the PA. Electronic instruments obviously skip this acoustic stage but they still imitate diaphragm oscillation – in the form of synthesised waveforms, which are electronic oscillations.

2 The Microphone

As the diaphragm of the microphone is designed to convert the acoustic vibrations of a source into a corresponding electronic voltage, the size and shape of the mic and the characteristics of its diaphragm greatly affect its ability to capture the source faithfully – and therefore the said source's impact in the mix.

The appropriate transient response for the required frequency of the instrument is crucial well before touching any kind of EQ at the desk. Taking good care of microphones by monitoring and controlling their exposure to dust, humidity, high temperatures, saliva and dampness etc ensures that the diaphragm is well looked after and fit for purpose.

Capturing a good signal tonally is just as important as achieving good signal strength and gain before feedback. Trying to add what isn't captured at this stage is a futile exercise when it comes to signal-to-noise ratio.

3 The Loudspeaker

In this third phase the driver of a single loudspeaker is essentially doing the exact same thing as the human diaphragm: oscillating back and forth instead of up and down and projecting out of the horn instead of the mouth.

The better the transient response of the loudspeaker, the greater the dynamic range of the music being performed onstage can be reproduced.

This event is the point at which everything increases in scale. What was once an acoustic source that was only able to intelligibly travel a moderate distance can now travel 100 metres and more with the aid of a PA system. In essence a modern line array is a series of cabinets all acting as a single quasi-diaphragm. When a manufacturer says that their various speaker models all have similar 'voicing', they are touching on this parallel of function to the human respiratory system.

4 The Eardrum

The fourth and final diaphragm is the eardrum, which is often forgotten in the engineering process. The mechanical response of the eardrum is important. It's all too easy to forget that the ear is not flat in its response. Because the ear responds to sound in such a logarithmic fashion, any measurements conducted (for loudness etc) need to take our ears' frequency reponse into account. ('A-weighting' curves are applied to measure sound levels in order to account for the relative loudness perceived by the human ear.)

Pink noise is better than white noise for performing such measurements and grey noise is also a good alternative to matching the ear's logarithmic curve. If we take into consideration the processing performed by our brains as it converts acoustic energy to a (neural) electronic signal we notice that what is happening in the environment is different to what the brain is perceiving. If we factor this phenomenon into our calculations we can see more accuracy with the changes that we make.

Understanding the anatomy, motion and effects of a diaphragm is very important, as all sound is the vibration and movement of air molecules at varying amplitudes, frequencies and timings.

All the other elements in between are important to prepare the integrity of the audio for its next stage, but the four diaphragms themselves are key points in the chain as they accurately (when used correctly) translate sound from one medium to the next.

We talk a lot about A-D and D-A conversion but we spend less time talking about the crucial stages of acoustic to electrical, electrical to mechanical, mechanical to acoustic and acoustic to psychoacoustic signals. Our job is to ensure the faithful preservation and transfer of energy from one medium to the next, making sure that nothing integral gets lost and nothing undesirable is added at each stage – whether from electronics or mechanical design. Our understanding of how sound passes through each of the four diaphragms, one after the other, is key if we want to do this well.

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