Electret microphones in the field; care and the effects of the environment and damage

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In the last issue, effects of specific physical damage to a microphone capsule were presented where it was seen that capsules can carry on performing surprisingly well despite near complete destruction of the membrane. In this article, we consider the effect of the measurement environment itself upon the immediate performance of a pre-polarised electret condenser microphone, as typically used on the vast majority of sound level metering equipment.

Environmental effects on capsule performance

Barometric pressure

The small fluctuations expected by standard atmospheric pressures have minimal effect; Zuckerwar[1] reports 0.001dB/mbar changes to be typical for a 1-inch capsule. If the capsule were to be used in near-vacuum environments, the matter changes entirely; damping reduces significantly and the resonant frequency shifts, giving a very peaky response. Fortunately, such effects are only to be seen well below 100mbar; clearly, nowhere on Earth's surface presents a concern!

Humidity

Historically, humidity presented a major concern to the measurement microphone before the advent of the electret condenser. An increase in humidity within the membrane-backplate gap increases the conductivity of the air and thus the chances of arcing between the 200V polarised backplate and the membrane. With a pre-polarised electret capsule, humidity has very little effect. Strictly, the density of air changes with humidity, thus affecting the compliance (damping) of the backplate-membrane air layer and of the back chamber. This would allow for higher maximum deflections around resonance and alter the resonant frequency, but this change is very negligible. Certainly, from a measurement perspective, the effects are so far within stipulated measurement uncertainty tolerances that humidity is relatively ignorable. The only concern for an operator of an SLM is that the dew point has not been reached; condensation on the membrane would increase the moving mass and, as the membrane mass is extremely small (less than 2mg), quite drastically affect the measurements; typically the response will drop overall and even more so at higher frequencies.

Temperature

Capsules are supplied as being capable of measurements within standard atmospheric conditions; operation to the required tolerances within the temperature range -10°C to 50°C is stipulated by the standard for working microphones EN 61094-4:1995. Interestingly, by careful use of similar materials within manufacture, the design of the condenser microphone is reasonably resilient to drastic fluctuations in response and sensitivity due to temperature. Increasing temperature decreases the tension in the membrane by an increase in ductility, which would lead to a higher maximum displacement and consequentially a higher sensitivity. However, this is partly counteracted by the thermal expansion of the ring to which the membrane is attached. In fact, thermal expansion of all the capsule components causes the backplate/membrane air gap distance to increase, thus reducing sensitivity and part-compensating the change in tension. As with changes in humidity, the viscous damping of the backplate/membrane gap is also affected due to the change in air density with temperature.

Using newly-developed equipment, which is the focus of upcoming publication from research at Cirrus, measurements of the change in the frequency response of a MK224 microphone capsule have been made recently; here presented in figure 1.

Temperatures experienced at standard atmospheric P22

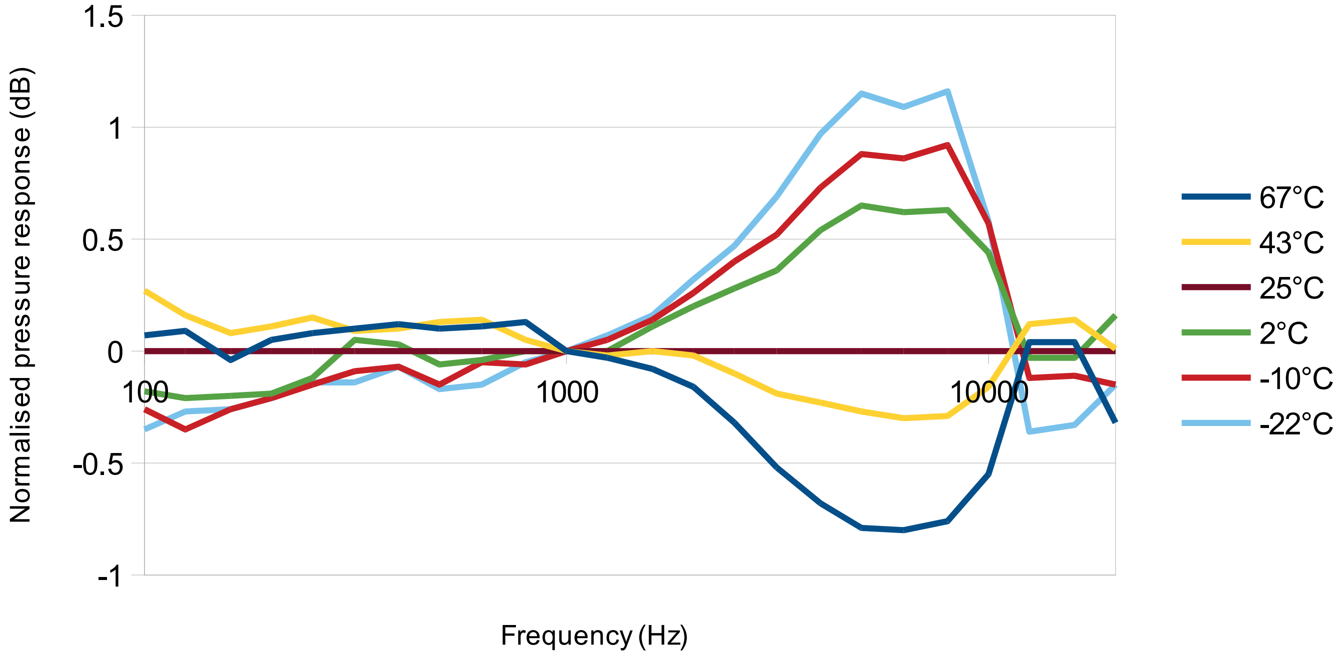

Figure 1: Variation in response with temperature

◄P20 conditions can therefore contribute to a measurement difference of over 1dB at high frequencies. While this is one of the major components of uncertainty, it is allowed for by the IEC measurement standard, and is unlikely to push the boundary of even Class 1 metering.

Effect of temperature cycling on capsules

Within this same document, it is stated that "*Large or rapid temperature changes (temperature shock) can lead to a permanent change of microphone sensitivity*". Despite this, recent investigations at Cirrus have indicated capsules to be considerably resilient to such conditions. Figure 2 is of a capsule that was cycled repeatedly from -20°C to 65°C as quickly as equipment would allow (approximately ten minutes) over a period of one week, removed for testing at daily intervals.

Whilst a very slight change could be suggested, the sensitivity would appear to have increased, which could be explained by a slight loss of membrane tension. This is far within the uncertainty of the measurement system used to perform the tests and a conclusion as such would be unfounded. Future testing is intended to incorporate far more rapid temperature changes to ascertain the limits at which permanent damage occurs.

In very extreme cases very high temperatures can completely destroy a polarised microphone capsule. Temperatures reaching 100°C cause the charge upon the electret to begin to dissipate at an increasing rate until 170°C where the charge will be entirely lost. Partial loss of charge (which occurs naturally at ambient levels as the capsule ages) results in a drop in sensitivity without a huge effect upon the characteristic frequency response, which can be compensated for by the standard calibration of a SLM, but near-to-complete loss of charge renders a capsule due for replacement. This worst case appears highly unlikely, but considering industrial processes that are likely to be in operation in areas requiring noise level assessment, exposure to such high temperatures is not impossible. It is also important to consider that sources of some infra-red radiation, such as that from heat lamps, are able to heat metals to very high temperatures from a fair distance. This effect was also investigated within the recent work, as shown in figure 3.

It is interesting that the frequency response flattened as the capsule underwent the tests; the response was originally poor (hence choosing this capsule for such testing!). Such effects would be typical of an upward change in diaphragm tension. Strikingly, the capsule stood up to higher temperatures than were expected before charge was completely lost, and would have been able to make valid measurements even after the 180°C bake.

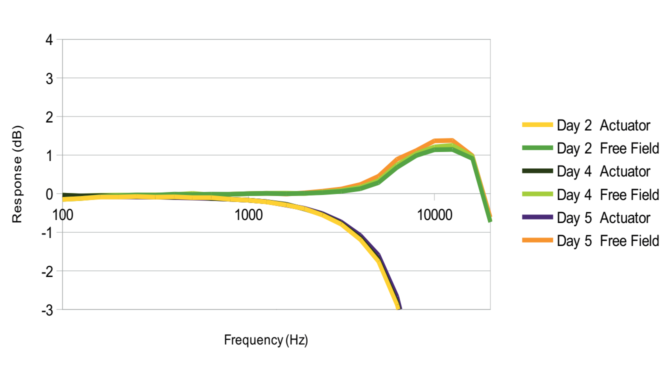

Figure 2: Temperature shock testing of an MK224 microphone capsule – measured on an electrostatic actuator microphone measurement system

Conclusions

Environmental effects are a major cause for the levels of uncertainty in SLM measurements made to IEC 61072-1:2003. Fortunately, for the user of metering equipment all such effects are taken into account by equipment design. Most effects of the environment can be discounted, but temperature certainly plays a part in the care of a capsule to ensure maximum product life. By the temperature tests performed, it is fair to say that the MK224 microphone capsule is resilient against quite rapid changes in temperature. While the very high temperatures required to destroy a capsule in a matter of minutes are highly unlikely, users need to remember that a capsule's sensitivity will decay at an increasing rate with any increase in temperature, so remember; we cook expensive electret microphone capsules so you don't have to...!

References

1. 1. Zuckerwar, A.(1995), "*Principles of Operation of Condenser Microphones*", AIP Press, NY.

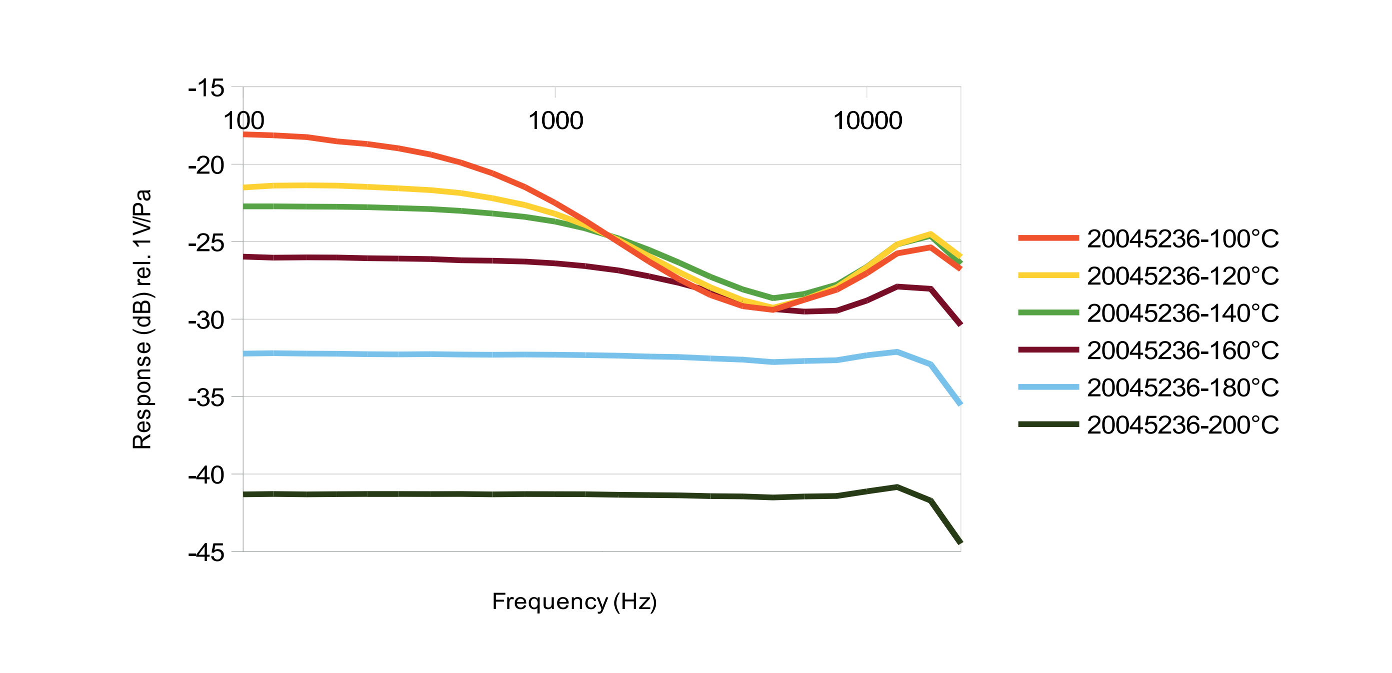

Figure 3: Effect of successive 15 minute intervals at increasing extreme temperatures upon MK224 capsule performance