Environmental Changes: Temperature, Pressure, Humidity

This Application Note explains the effects of ambient temperature and pressure, and humidity transients on sensor performance. Read Application Note AAN 106 for guidance on long term sensor performance changes from use in high and low humidities. Read AAN 010 for guidance on pressure and flow transients.

Temperature Effects

Electrochemical gas sensors are sensitive to ambient temperature. The sensitivity (expressed as nA/ ppm) changes by typically +0.1 to +0.3%/K, while the zero current is effectively constant at temperatures below 30°C.

Figure 1 below shows the temperature dependence for different sensor types. This graph is an average for each type and should not be used for programming temperature compensation- consult Alphasense for specific temperature correction data.

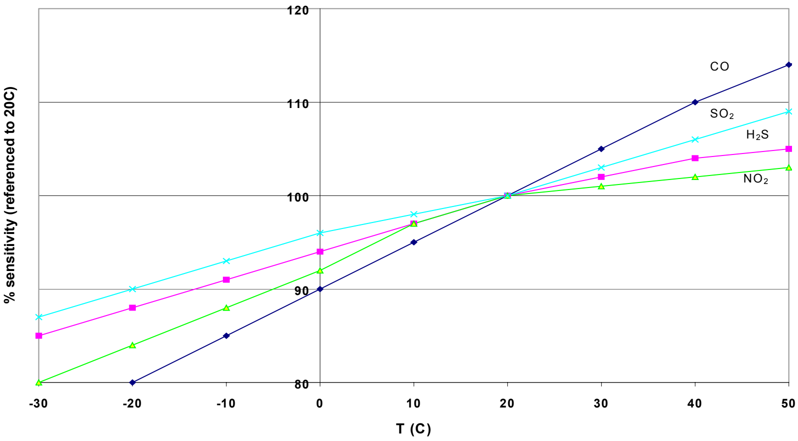

Figure 1. Sensitivity temperature dependence of four toxic gas sensor types.

Repeatability of Temperature Dependence

Whilst it is simple to correct for the average temperature dependence, one must also know the variability both between sensors in a batch and between different batches of sensors. Calibrating temperature dependence for each sensor is onerous and fortunately unnecessary. Figure 2 graphs the 95% confidence interval for the sensitivity of 15 batches of H2S-A2 sensors at -30°C. Whilst the limits are typically ±5%, in the worst case the error could be as much as 10%, when calibrated at 20°C. Considering that this 10% error is at a temperature difference of 50°C, this corresponds to a worst case error of ±0.2%/K, with more typically a 95% confidence of ±0.1%/K.

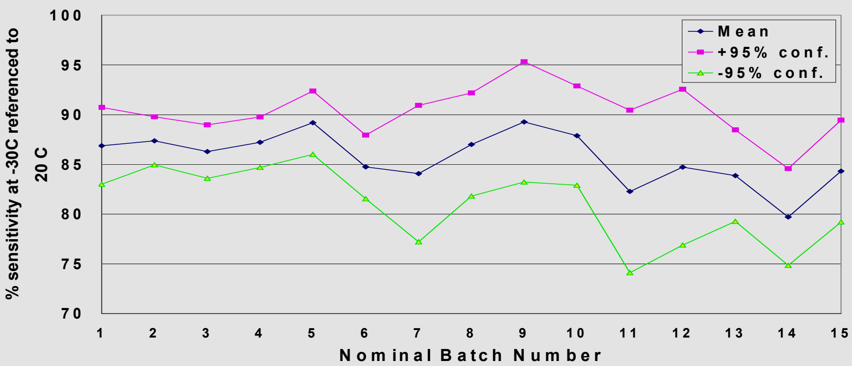

Figure 2. Mean and 95% confidence intervals for sensitivity (referenced to sensitivity at 20°C) for 15 batches of H2S-A2 sensors at -30°C.

Likewise, different batches of CO-AF sensors show the same variability at 50°C; this time the temperature difference is only 30°C and the 95% confidence intervals are correspondingly tighter.

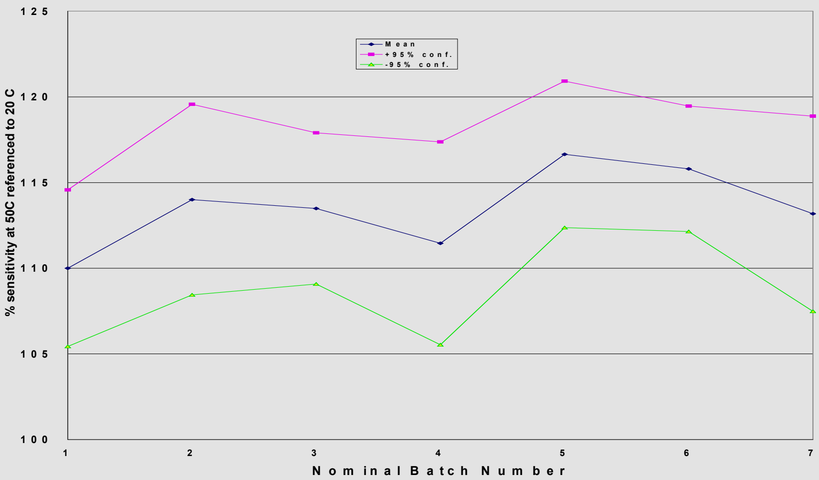

Figure 3. Mean and 95% confidence intervals for sensitivity (referenced to sensitivity at 20°C) for 7 batches of CO-AF sensors at 50°C.

Although the CO sensors are only specified for use to 50°C, tests have shown that their temperature sensitivity is well behaved up to 70°C, as shown in figure 4.

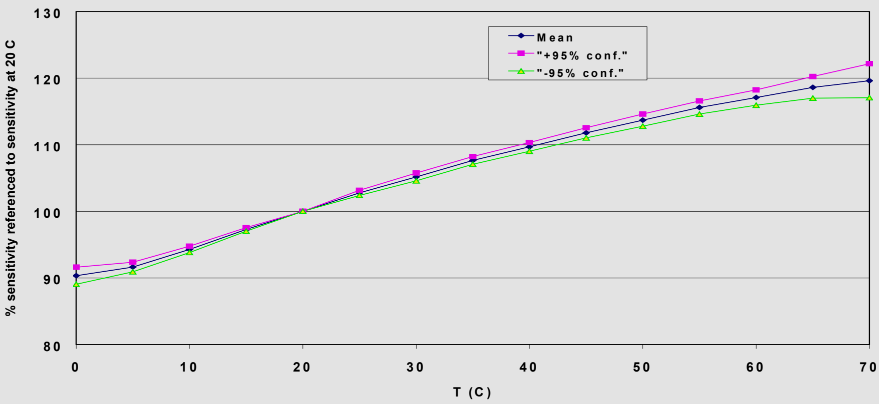

Figure 4. Mean and 95% confidence intervals for sensitivity (referenced to sensitivity at 20°C) for CO-BF sensors from 0 to 70°C.

Zero Temperature Dependence

The zero current shows little temperature dependence at low temperatures. This offset error can normally be ignored except in some environmental measurements where the lower limits of resolution and accuracy are exploited. Figure 5 shows the average zero current, expressed as equivalent ppm, for different sensor types. Note that the zero current begins to deviate from zero at higher temperatures- similar to CMOS components.

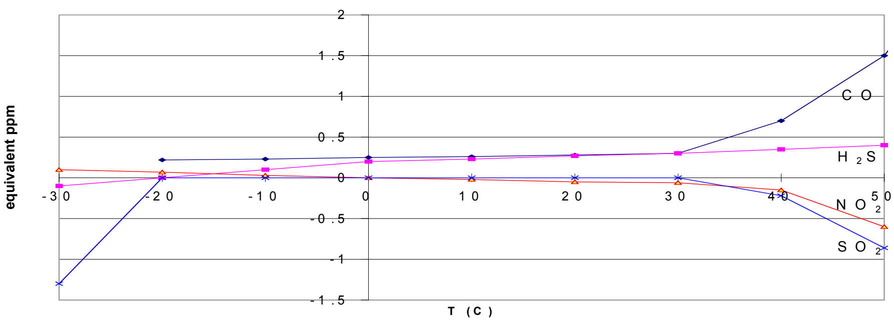

Figure 5. Average zero current (expressed as equivalent ppm) of four sensor types.

This rapid increase at high temperatures can be seen for CO-BF sensors- note the rapid increase above 40°C in figure 6 below.

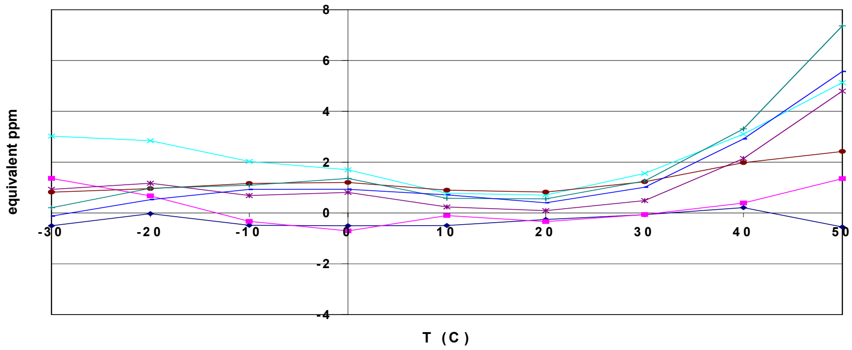

Figure 6. Temperature dependence of zero current for CO-BF sensors from 0 to 70°C.

Unlike sensitivity, the zero current varies between each sensor and hence a zero current correction cannot be universally programmed into the instrument or detector. Figure 7 shows the variability of zero current for a set of eight CO-AF sensors.

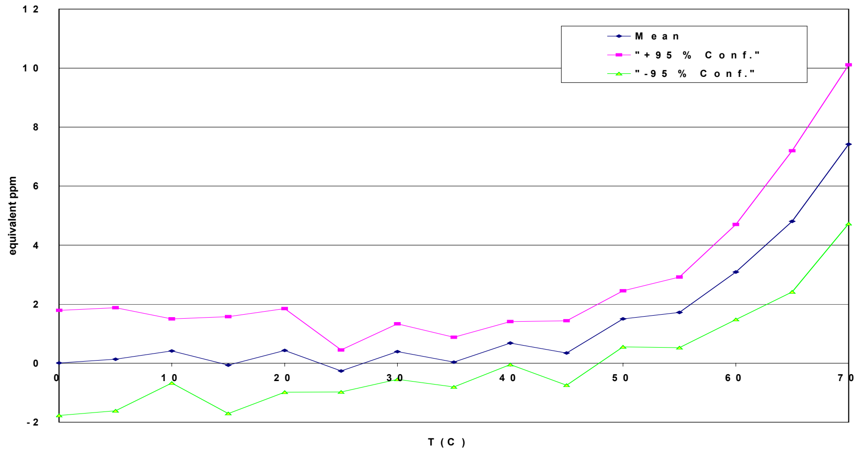

Figure 7. Variability of zero current for eight CO-AF sensors from −20 to 50°C.

Response Time Also Changes With Temperature

All Alphasense toxic gas sensors are tested for response time (specified as t90). This response time is independent of temperature from 10 to 50°C, but below 10°C the response time increases as shown in figure 8. This effect is expected and repeatable. Contact Alphasense Technical Sales for applications where response time in freezing environments is critical.

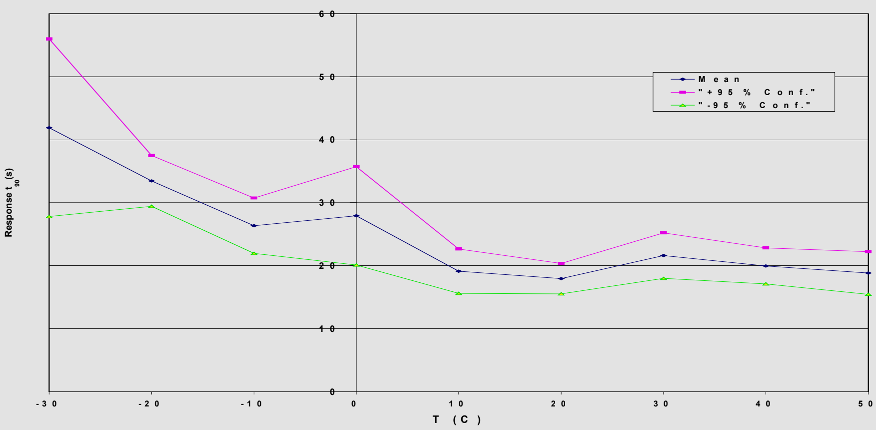

Figure 8. Mean and 95% confidence intervals of the temperature dependence for t_{90} of H2S-A1 sensors.

Temperature Transients are Important

When the ambient temperature changes then both the electrochemistry and sensor dimensions change. This can lead to transient currents, which may cause a false alarm. Alphasense has reduced this effect, as shown in figure 9 below. This trace shows eight CO-AF sensors as they are first cooled to -20°C, then heated in 10°C steps to 50°C. As sensors pass through 0°C, a small transient can be observed.

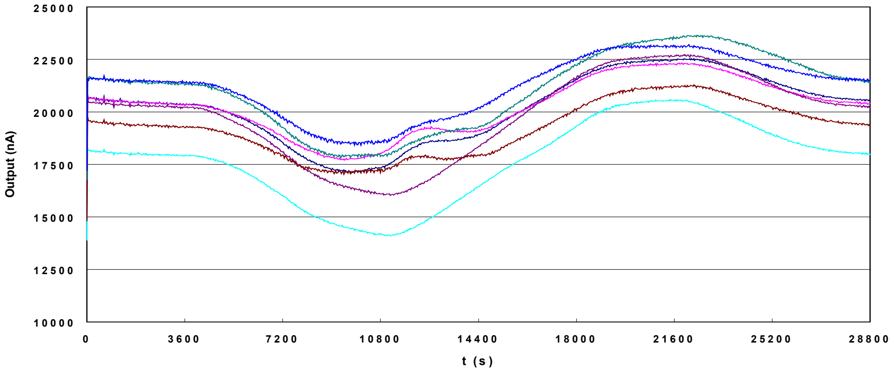

Figure 9. CO-AF response to thermal staircase test, starting at +20°C, then cooling to –20°C, followed by 10°C steps to 50°C; finally sensors are cooled to starting temperature.

Pressure Effects

When exposed to a pressure change, toxic sensors show a rapid positive current spike, then settle quickly to a constant output. Although Alphasense toxic sensors are only warranted for use at ambient pressures ±20 kPa, tests up to ±60 kPa show that sensors behave normally, with a small change of sensitivity, as shown in figure 10. Do not attempt to automatically compensate for this pressure effect: sensors should be calibrated at the usage pressure.

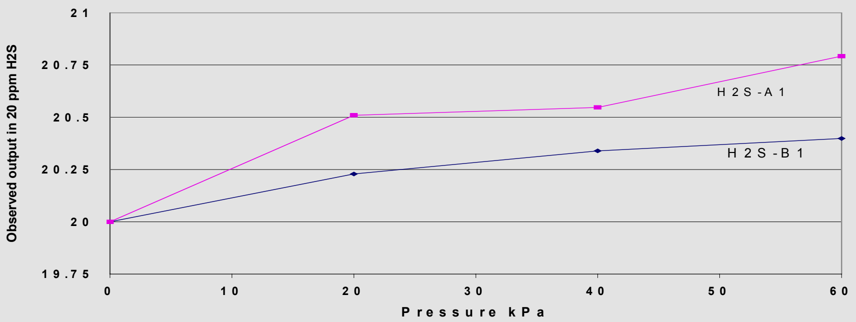

Figure 10. Effect of ambient pressure on sensitivity of H_2S sensors.

Humidity Transients

Like pressure, humidity transients cause current spikes, which decay in about 10 minutes. Figure 11 shows these spikes for NO2-B1 sensors. Note that the spikes are first positive then negative with a humidity decrease, and first negative then positive with a humidity increase.

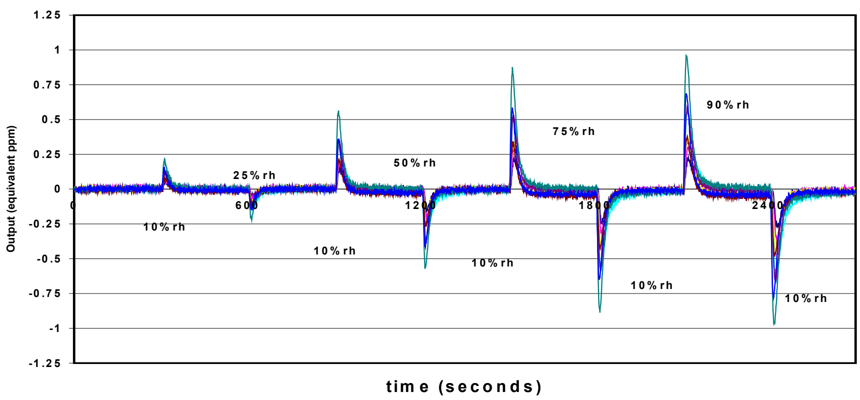

Figure 11. Effect of humidity transients on NO2-B1 sensors.