INFICON

TECHNICAL NOTE

Calculating Sensitivity for RGA Partial Pressures

To establish stability, compare readings from sensor to sensor, and make accurate partial pressure measurements using the INFICON Transpector® 2 Residual Gas Analyzers (RGAs), actual sensitivity value for the Faraday Cup or Electron Multiplier sensor must be known. **Sensitivity** is defined mathematically as the ratio of signal current (in amps) to pressure minus any background. Assuming the background is insignificant, the formula for sensitivity is:

$$S\ (\text{sensitivity}) = \frac{\text{Signal current (amps)}}{\text{Pressure (Torr)*}}$$

*This formula can also be calculated using mbar or Pascal.

Using nominal sensitivity values is not sufficient for operation in partial pressure mode. Also, a continued decrease in sensitivity, which will occur naturally over time due to aging of the sensor, can indicate the need for preventive maintenance or replacement of the sensor.

CALCULATING AND USING SENSITIVITY VALUES FOR ACCURATE GAS ANALYSIS MEASUREMENTS

Here are guidelines for operating an RGA for accurate data and sensitivity measurements:

- The background level of the system should be less than 10% of the signal where the sensitivity is measured. For example, for measuring in the 1E-5 Torr range, the background should be less than 1E-6 Torr.
- Due to the nature of the quadrupole sensor, sensitivity will be more linear at lower pressures. Optimum operating range for the RGA is 1E-6 to 1E-5 Torr.
- The vacuum system and sensor should be operating under typical process conditions. This allows any sensitivity measurements to be made in the operating pressure range of the process or where partial pressure values are important.
- To eliminate contamination and excessive background, routine bake out of the sensor should be part of normal operation.
- A calibrated vacuum gauge should be used as a reference.
- To achieve accurate results, the RGA should be warmed up for at least 30 minutes prior to operation.
- Be sure the sensor has been adjusted for peak position and resolution before any measurements are made.
- Pure, dry nitrogen is the preferred gas for making sensitivity measurements. However, other gases may be used, but gas type corrections on the gauging may be required in the calculations.

SENSITIVITY MEASUREMENT FOR FARADAY CUP SENSORS

Sensitivity should be calculated using nitrogen gas with a background pressure less than 3.0E-7 Torr. Add nitrogen gas to a pressure of 1E-5 Torr. From the Selected Peaks mode in the Transpector software, record the mass 28 current (in amps). Using the equation presented above, Faraday cup (FC) sensitivity will be calculated as:

$$\text{FC Sensitivity} = \frac{\text{Mass 28 Current (Amps)}}{\text{1E-5 Torr of nitrogen}}$$

This formula assumes the background current at mass 28 is insignificant. If this background is not less than 1% of the mass 28 current when the nitrogen is present, the formula should be:

$$\text{FC Sensitivity} = \frac{\text{Mass 28 Current (Amps)} - \text{Mass 28 Background Current}}{\text{1E-5 Torr of nitrogen}}$$

For example, if the mass 28 current reads 2.5E-9 Amps after adding 1E-5 Torr of nitrogen to the system, the sensitivity of this FC sensor with no significant background would be:

$$\text{FC Sensitivity} = \frac{\text{2.5E-9 Amps}}{\text{1E-5 Torr}} = \text{2.5E-4 Amps / Torr}$$

If the sensor does not meet the required sensitivity specifications, experienced users can make adjustments to the focus voltage to improve sensitivity. If sensitivity cannot be improved, baking of the sensor may be required (see INFICON Technical Note, "Heating jackets Can Improve RGA Performance.") If sensitivity still does not improve, preventive maintenance measures such as replacing the ion source or replacement of the sensor may be required.

SENSITIVITY MEASUREMENT FOR ELECTRON MULTIPLIER SENSORS

When measuring the sensitivity of electron multiplier sensors, first be sure that the background pressure is less than 3.0E-7 Torr. Add nitrogen gas to a pressure of 1E-5 Torr. Set the EM voltage to a value of 1.00 kV for a High Performance Transpector (650 v for a Compact version and Transpector XPR. Measure and record the current at mass 28 and also the current at mass 7. The mass 7 peak will be very small in comparison to the mass 28 peak. You can measure this small current from the Selected Peaks mode in the Transpector software.

For example, if at an EM voltage of 1.0 kV, at which the mass 28 current achieved was 4.3E-8 amps, the mass 7 current might be 3.2E-11 amps.

With these two current readings, the 28/7 Ratio can be calculated by the following formula:

$$\text{28/7 Ratio} = \frac{\text{Mass 28 Current}}{\text{Mass 7 Current}}$$

For our example, the 28/7 Ratio would be:

$$\text{28/7 Ratio} = \frac{\text{4.3E-8 amps}}{\text{3.2E-11 amps}} = 1344$$

Now, increase the EM voltage to 3.0 kV for a High Performance Transpector or 1150 for a Compact version or Transpector XPR (or lower if the mass 7 current reading exceeds 1E-6 Amps and thus, saturates the EM). Record the mass 7 current reading at 3.0 kV and calculate the EM sensitivity using the formula:

$$\text{EM Sensitivity} = \frac{\text{(Mass 7 Current) x 28/7 Ratio}}{\text{Pressure}}$$

In our example, after increasing the EM voltage to 3.0 kV, suppose that the mass 7 current now reads 2.1E-7 amps, this would make the EM sensitivity equal to:

$$\text{EM Sensitivity} = \frac{\text{(2.1E-7 amps) x 1344}}{\text{1.0E-5 Torr}} = \text{28.2 amps / Torr}$$

It is recommended that initial and periodic sensitivity measurements be made for each sensor. In some instances, it may be important for the user to maintain a sensitivity (and the corresponding ion current) for a given process pressure. If a change in sensitivity is noted for the same gas pressure, it may be necessary to adjust the voltage applied to the electron multiplier. If peaks that are normally visible for a particular process disappear or are only visible at increasingly higher gain ranges, the sensor may be contaminated, aging, or in need of preventive maintenance. Begin with baking the sensor according to the directions in the manual. If the sensitivity is still reduced, preventive maintenance or replacement of the sensor may be required.

For more information or technical support, contact us at +1.315.434.1100.

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