Stability of Zero Calibration Technical Bulletin

Introduction:

A customer has asked if running a “Tune” (zero calibration) repeatedly will show different values with a Tiger Optics CW-CRDS (Continuous Wave Cavity Ring-Down Spectroscopy) analyzer.

Background:

Tiger Optics’ analyzers do not require traditional field calibration. In fact, our laser-locked CW-CRDS analyzers are self-calibrating. Because they are based on fundamental chemical principles, they require no external calibration gases; they need no built-in zero calibration purifiers; and they do not require permeation tubes. Tiger Optics analyzers are therefore very reliable and simple to operate. In addition, our analyzers do not have the maintenance requirements, down-time, or costs associated with the calibration techniques required by our competitors’ devices.

Tiger Optics’ CW-CRDS analyzers measure the time (in microseconds) for light to decay (“ring down”) inside an optical cavity. When the laser is cut off, the light travels back and forth between two mirrors up to 100,000 times in less than one second. The optical losses in the cavity reduce the amount of light with each pass, allowing us to measure a “ring-down time.” When the target molecules are present in the gas flowing through the cavity, they absorb light. Thus, the optical losses will increase (per the Beer-Lambert law). Therefore the ring-down time will be shorter.

“Tau” is the ring-down time measured in the cavity when there is an absorbing species in the sample gas (H_2O in N_2, for example), and the laser is emitting light at a wavelength where those molecules will absorb light. “Tau empty” describes the ring-down time when the laser is emitting light at a wavelength where *no* light is absorbed by the molecules present. Our analyzers compare the difference between the Tau and Tau empty values to determine target gas concentrations at very high accuracy; and with LDL’s down to a fraction of a ppb.

Tau empty is measured each time the analyzer is “Tuned”. A Tune will change the wavelength of the laser to a value where the molecule (e.g., H_2O) *does not* absorb light – the system will *see* a cavity with no H_2O. At this wavelength, the ring-down time gives us the new Tau empty value. When the Tune is complete, the wavelength is returned to that point where the H_2O *does* absorb light. Then, concentration measurements are resumed.

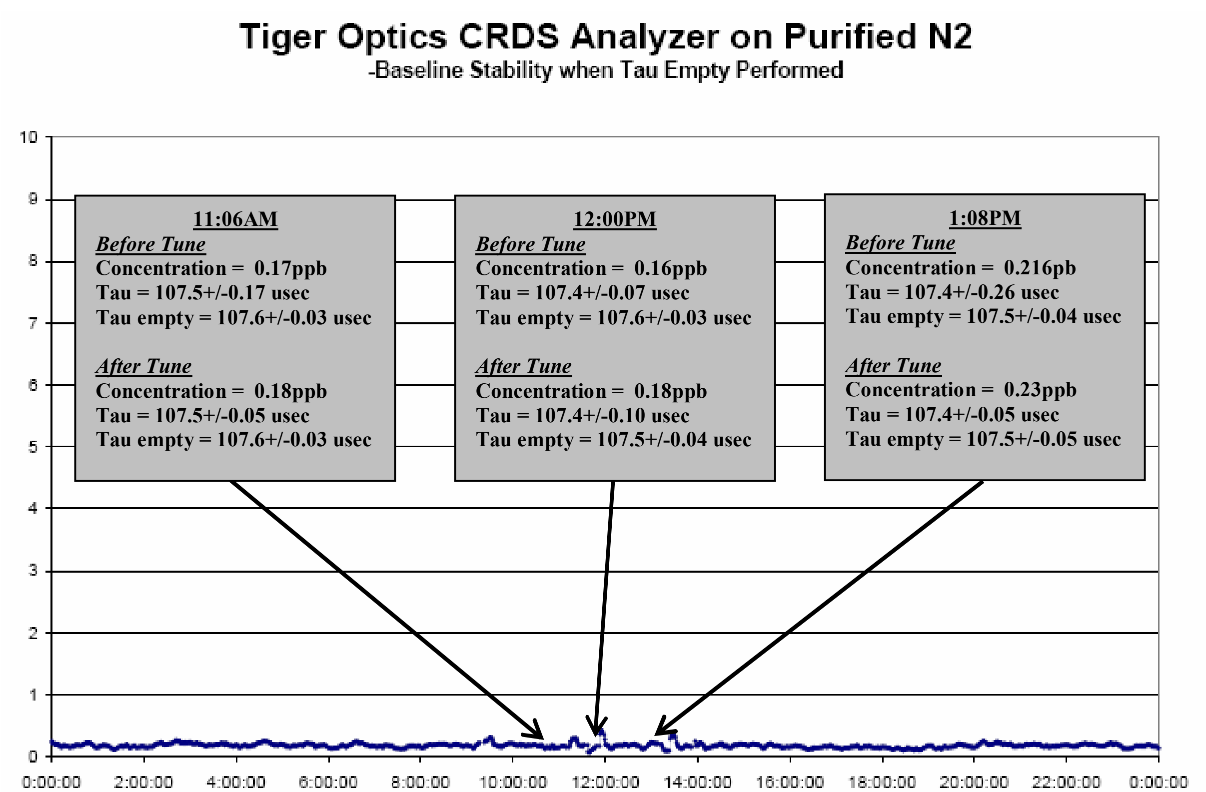
Performing a Tune is very simple. It starts by pushing a button on the touch-screen (or sending the computer the appropriate command electronically), and is completed in less than 90 seconds -- virtually eliminating calibration downtime. Users can also program their Tiger Optics analyzer to perform a Tune *automatically* at daily, weekly or monthly intervals. In addition, our software will *automatically* determine Tau empty *while measuring* at very low concentrations (for example, < 10 ppb for H_2O) to maintain the accuracy of measurements.

In most clean gas applications (like high-purity gas analysis) there is no, or very little, change in measured Tau empty values over time. We nonetheless recommend that users Tune their Tiger Optics analyzers periodically to always ensure the highest accuracy from their system.

Internal Testing:

A Tiger Optics analyzer was run on purified N_2 for a 24-hour period. Figure 1 shows the concentration of H_2O (in ppb) vs. time. The analyzer was tuned at three different times during the period: 11:06AM, 12:00PM and 1:08PM. The H_2O concentration, Tau and Tau empty values were recorded before and after each Tune (shown in the gray text boxes of Figure 1 below).

FIGURE 1:



Discussion of Results:

Figure 1 gives conclusive evidence that the concentration readings and Tau empty values remain very stable. The results are well within the accuracy specification of the analyzer.

You might ask, "Why would these Tau empty values change?" One possibility: if the analyzer has been contaminated. This can occur in specialty gas or process tool monitoring applications, where solid particles, deposition gases or condensates can deposit on optical surfaces, despite the particle filter built into the analyzer inlet. (Mirror contamination is not an issue in the vast majority of applications.)

If an analyzer were to become contaminated, the optical cavity would become less reflective. Thus, the Tau empty value (after a Tune) would drop significantly, and the standard deviation would increase. If a user were to repeatedly Tune an instrument that has become contaminated, the measured Tau empty value after each Tune could fall within the range of the standard deviation. Therefore, when the standard deviation of Tau empty is high, repeated Tunes may produce changing values of Tau empty. **This will only happen if the analyzer is contaminated.**

Conclusion:

The Tiger Optics Research and Development Team has selected our Tune method for system verification/calibration because of its accuracy, repeatability and simplicity. This gives a significant advantage to our users, especially when compared to our competitors' analyzers that use other zero calibration methods. The "self-verification" of our laser-locked CW-CRDS analyzers is one of the many reasons why nine National Laboratories have adopted our *absolute* technology.

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