TECHNICAL BULLETIN 2007-06

CALIBRATION AND TIGER OPTICS' CONTINUOUS WAVE CAVITY RING-DOWN SPECTROSCOPY (CW CRDS) ANALYZERS

Question: "How do I calibrate my Tiger Optics CW CRDS analyzer?"

Answer: Tiger's CW CRDS analyzers have a built-in spectroscopic reference standard based on fundamental molecular characteristics as published in the High-resolution Transmission Molecular Absorption (HITRAN) database. The procedure to verify the unit's operation using this reference standard is called "Tune". You simply push a button to run a Tune at any time, even while on-line. It is completed in less than 90 seconds, virtually eliminating calibration downtime. You can also schedule *automatic* Tunes at monthly, weekly, or daily intervals. Each "Tune" can be documented for use in audits and to track routine maintenance.

Technical Background: Every molecule has its own optical fingerprint. CW CRDS measures the target molecule's absorption of laser light shot into an optical cavity. By briefly blocking the laser from the cavity the photons built-up inside it decay, or "ring down". The time for this decay is the "ring-down time". While the sample is flowing through the cavity, ring-downs are taken continuously, with the laser emitting light at a wavelength corresponding to a known absorption peak for the analyte. Higher concentrations result in shorter ring-down times due to absorption of light by the analyte.

We measure the "off peak" ring-down time by adjusting the laser to emit light at a wavelength where the analyte does not absorb light. Hence the light takes longer to decay. The *difference* between the inverse of the ring-down time off peak (called Tau zero) and that of the ring-down time on peak (Tau measure) accurately determines the optical absorption by the analyte inside the cell. That, in turn, is related by a known molecular absorption strength to the concentration of the analyte. The resultant measurement is therefore a function of time. The Tune process adjusts the laser to the wavelength for Tau zero and measures the off-peak ring-down time, before returning to on-peak measurements.

Key Points: There are four principles underlying the calculation of concentration.

1. The spectroscopic characteristics (line strength and pressure broadening coefficient) of the analyte are known physical properties. These are published in refereed sources, including the HITRAN database cited above. Any modifications we make are based on acceptance by recognized authorities, including the United States National Institute of Standards and Technology (NIST), the National Physical Laboratory (NPL) in the UK, or the National Institute of Advanced Industrial Science and Technology (AIST) in Japan.
2. The laser is operating at the required wavelength. Our analyzers include internal verification and an automatic adjustment to maintain the correct laser wavelength.
3. Tiger Optics ensures the mirror loss is stable with both time and wavelength. The Tau zero scans provide on-going verification of any changes. Factory pre-qualification of each unit assures the system is operating within specification.
4. The matrix gas is known and its constituents are defined as stable. Gas matrices in the libraries of our analyzers have been tested to ensure they do not absorb light at the same wavelength as the target analyte. Any uncommon gases and mixtures not included in the unit's library are tested for spectroscopic features prior to analysis. For gas mixtures, the values must be the weighted average (by partial pressure) of the components of the gas. Trace impurities (<1%) are insignificant to this calculation.

Validation: Tiger Optics' technology is based on an absolute principle, the Beer-Lambert Law. Tiger's analyzers are used as a transfer standard by the world's leading national laboratories, including NIST, the NPL, and AIST. In addition, Tiger's performance is verified from 5 to 1000 ppb by the low frost-point generator at NIST, a primary moisture concentration standard.

For more detailed information, please access our website at **www.tigeroptics.com** or call us at (215) 343-6600. You may also email **service@tigeroptics.com**