INFRARED GAS ANALYZER CALIBRATION PROTOCOL (CO_2 AND H_2O)

The protocol is suitable for gas analyzers using NDIR spectroscopy.

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AMERIFLUX

Protocol purpose:
The purpose of calibrating a LICOR LI-IRGA is to establish a known relationship between the sensor's response and the actual concentration of the gas being measured. Over time, sensors can drift or degrade, leading to inaccuracies in measurements. Calibration corrects for these deviations and ensures that the instrument provides consistent and accurate readings.

PREPARATION

- Turn off any HVAC systems to minimize temperature fluctuations. Ideal conditions would be a stable temperature between $20–30°C$.
- Connect IRGA sensor heads to the analyzer interface unit (AIU). Connect power and communication cables (Ethernet) on the analyzer interface unit. For the LI-7500, check the o-rings on the calibration sleeve, then connect the calibration sleeve connectors to the AIU.
- Power on IRGAs and allow IRGAs to reach temperature equilibrium for a couple of hours. Note that optics takes about 30 minutes to reach equilibrium before calibration.
- Clean optics of IRGAs. For LI-7500, clean windows. For LI-7200, remove the sample cell, swab the inside of the cell, and clean the windows.
- Ensure that a 'pig-tail' (≈ 1 foot) is on the outlet of both IRGAs to prevent back diffusion.
- Prepare dew point generator. Check and fill the water level of the condenser block using the 'ruler' on the fill tube. When empty, requires $20–25\,ml$ of deionized water (DI). Slowly inject the water with one syringe into the fill tube to remove any trapped air bubbles. Check and fill the fluid level of the radiator. When empty, the radiator takes approximately $200\,ml$ of water. Turn on and adjust the dew point set point to $3–5°C$ below ambient air temperature to avoid condensation. The dew point generator should be allowed to run for 30 minutes before use.
- Begin filling out the calibration spreadsheet's relevant sections (e.g., date/time/location, serial numbers, pre-cal coefficients, ambient temperature, and signal strengths).
- Connect all plumbing (Bev-a-line) for calibration. IRGAs can be calibrated in parallel (except for the H2O span) with the zero/span gas split from the source and distributed to each IRGA. Use flow meters to adjust the flow rate to each IRGA. Check that the signal strength did not change on the LI-7500 when the calibration sleeve was inserted.

EQUIPMENT

- LI-COR 7500 open path analyzer
- LI-COR 7200 enclosed path analyzer
- N_2 tank
- CO_2 tanks (span and check)
- Dew-point generator
- Deionized water
- Paper tissues

CHEMICALS

- N_2
- CO_2
- H_2O

DANGERS

Chemicals
Physical
Environmental

PROTECTIVE GEAR

- Safety glasses

LAB CALIBRATION

Step 1

Inspect zero for CO_2 and H_2O

- Use compressed nitrogen or zero air. A pump and a two-stage scrubber/drier can generate CO_2 and H_2O free gas. To check both IRGAs simultaneously, flow calibration gas to each in parallel. The flow rate through each IRGA should be between 0.5–$1\,\mathrm{LPM}$ (using two flow meters). Alternatively, IRGAs can be checked separately.
- Using IRGA software, plot the time series of molar density ($\mathrm{mmol\,m^{-3}}$) for both CO_2 and H_2O. Wait for stable readings. For CO_2, stable values are changes of less than $0.025\,\mathrm{mmol\,m^{-3}}$ over 5 minutes, and for H_2O, a change of less than $0.4\,\mathrm{mmol\,m^{-3}}$ over 5 minutes. Once readings are stable, record average values, CO_2 should be $\pm 0.1\,\mathrm{mmol\,m^{-3}}$, and H_2O should be $\pm 5.0\,\mathrm{mmol\,m^{-3}}$. If out-of-spec, conduct a zero for the respective species for that IRGA.

Step 2

Inspect CO_2 span

- Pass CO_2-span gas through both IRGAs at a 0.5–$1\,\mathrm{LPM}$ flow rate. Wait for stable readings from both IRGAs using the above criteria (change of less than $0.025\,\mathrm{mmol\,m^{-3}}$ over 5 minutes). Record average stable reading. If the reading is $\pm 2\,\mathrm{ppm}$ from the stated value, IRGA will require a zero followed by a CO_2 span. If the IRGA was previously zeroed, proceed directly to span the IRGA.

Step 3

Inspect the H_2O span using the dew point generator

- Pass outlet from dew point generator to both IRGAs at a flow rate of 0.5–$1\,\mathrm{LPM}$. Wait for stable readings from both IRGAs using the change criteria of less than $1.2\,\mathrm{mmol\,m^{-3}}$ over 5 minutes. Record average stable reading. If the reading is $\pm 0.2^{\circ}\mathrm{C}$ from the dew point set point value, IRGA will require a zero followed by an H_2O span. If the IRGA was previously zeroed, proceed directly to span the IRGA.

Step 4

Verify CO_2 calibration by running a 'check' gas through IRGAs

- Wait for stable readings from both IRGAs (change of less than $0.025\,\mathrm{mmol\,m^{-3}}$ over 5 minutes). Record average stable reading. If the reading is $\pm 2\,\mathrm{ppm}$ from the stated value, repeat the procedure from step 2.

Step 5

Verify H_2O calibration by flowing a lower dew-point through the IRGAs

- Wait for stable readings from both IRGAs (change of less than $1.2\,\mathrm{mmol\,m^{-3}}$ over 5 minutes). Record average stable reading. If the reading is $\pm 0.2^{\circ}\mathrm{C}$ from the stated value, repeat the procedure from step 2.

Step 6

Record post-calibration coefficients on the calibration spreadsheet

ANNUAL SERVICE

LI-COR factory calibrations recalculate the IRGA polynomial coefficients for CO_2 and H_2O using $10+$ test points. A fifth-order polynomial is used for CO_2, and a third-order polynomial is used for H_2O. When IRGAs are sent for maintenance at LI-COR, request an O-ring replacement for the scrubber/desiccant bottle.

If used, the inline scrubber/desiccant chemicals for 'zero gas' in the calibration should be replaced regularly (e.g., annually or more frequently, depending on usage). Empty and properly dispose of or regenerate old chemicals: refill scrubber/desiccant tube. Note the flow direction such that the scrubber is upstream of the desiccant.

SOURCES

References

- *LI-7200 and LI-7200RS Enclosed CO2/H2O Analyzer Instruction Manual* (2023). LI-COR Biosciences. URL: `https://licor.app.boxenterprise.net/s/k8b90wiwdhietarx04qd`.
- *LI-7500A and LI-7500RS Open Path CO2/H2O Gas Analyzer Instruction Manual* (2023). LI-COR Biosciences. URL: `https://licor.app.boxenterprise.net/s/c7tyf0czqn9ezkq1ki3b`.
- *EC150 CO2/H2O Open-Path Gas Analyzer Manual* (2021). Campbell Scientific, Inc. URL: `https://s.campbellsci.com/documents/us/manuals/ec150.pdf`.
- *EC155 CO2/H2O Closed-Path Gas Analyzer Manual* (2021). Campbell Scientific, Inc. URL: `https://s.campbellsci.com/documents/us/manuals/ec155.pdf`.

NOTES

CONTACTS

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