Home Interior Air Sampling Suite

Indoor Air Quality Project (2015)

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# \\fs1.cee.wsu.edu\students$\home\pokeeffe\Desktop\2015 IAQ photos\Jobson_01.jpgOverview

The home interior air sampling suite is composed of scientific-grade trace gas and particulate analyzers, a data-logging computer, and communications equipment.

In addition to continuously monitoring the air in its vicinity, the indoor sampling suite serves as Internet gateway to the wireless environmental sensor (CO2/T/P) network and outdoor air sampling suite.

Instrumentation includes, from top to bottom (Figure 1):

* Air quality monitor  
  *Dylos Corp (DC1100)*   
  Provides 1-minute average measurements of small (≥1µm) and large (≥5µm) particle abundance.   
  [Black with triangle logo, top left]
* Ultraportable greenhouse gas analyzer  
  *Los Gatos Research Inc (UGGA; Model 915-0011)*  
  Provides real-time measurements of methane (CH4), carbon dioxide (CO2), and water vapor (H2O) concentrations, as well as ambient temperature and internal parameters, such as sample cell pressure.   
  [Yellow, on top of cabinet]

Figure . Indoor sampling suite

* Ozone monitor  
  *2B Tech (Model 205)*   
  Provides near real-time measurements of ozone (O3) concentration and sampling cell temperature and pressure.  
  [Blue, upper-right cabinet interior]
* Area aerosol monitor  
  *TSI Inc (Model 8530; DustTrak II)*   
  Provides real-time aerosol mass measurements (2.5µm impactor used).   
  [Dark blue, mid-level cabinet interior]
* NO2/NO/NOx monitor  
  *2B Tech (Model 405 nm)*   
  Provides 1-minute average measurements of nitrogen dioxide (NO2), nitric oxide (NO), combined NOX and a variety of internal parameters, such as sample cell flow.   
  [Blue/silver, bottom cabinet interior]
* ~~CO~~~~2~~~~/H~~~~2~~~~O monitor~~*~~LI-COR Biosciences (LI-840A)~~*  ~~Provides real-time measurements of carbon dioxide (CO2), water vapor (H2O), and sampling cell temperature and pressure.~~   
  [Not pictured; unavailable for integration]

Supporting hardware found in the instrument cabinet includes:

* Datalogger and control system  
  *Campbell Scientific (CR3000)*Aggregates sensor data streams, generates temporal averages, records data to files, reports sensor data to secure, central monitoring server, etc.
* 3G cellular modem  
  *Sierra Wireless (LS300G)*  
  Provides secure, non-intrusive Internet access to devices, which is necessary for reliable distributed time-keeping, data telemetry, and remote diagnostics.
* Wireless router  
  *TP-Link (TL-WR841ND)*  
  Provides network access to environmental sensors and data-logging computers. A directional Wi-Fi antenna, mounted outside the cabinet on an articulating arm, establishes a link with the outdoor air sampling suite.
* Uninterruptible power supply (UPS)  
  *CyberPower (OR500LCDRM1U)*  
  Protects instrumentation from power surges or brief outages; and allows the instrument cabinet to be repositioned in the home without disrupting sampling.

# Operational Details

## Gas sampling

Instruments draw sample air through a pair of inverted snorkels:

* 1/4” O.D. (0.047” wall) PFA tubing for gas analyzers
* 3/8” O.D. (0.035” wall) 316SS tubing for the area aerosol monitor

Snorkel inlets are co-located above the instrument cabinet at roughly the height of an adult human’s head. The PFA line is protected from dust with a 47mm Ø, 1-2µm PTFE membrane filter and the 316SS sampling line has a ½” brass mud dauber to prevent bug ingress.

Gas flow through the sampling tubes is several Liters per minute – **do not block the snorkel inlets.**

Within the cabinet, more PFA tubing and PFA fittings are used to deliver sample air to gas analyzers while rubber conductive tubing connects the aerosol mass monitor to the 316SS snorkel.

The single exception, the Dylos particulate monitor, continually flushes its sampling volume through vents on the rear of the device with an internal fan.

## Data Acquisition

Each instrument has an acquisition rate in the range of 1 second to 1 minute. The datalogger continuously monitors sensors at their own rate and records a snapshot of values at the start of each new minute. Half-hour means of the minutely values are calculated as well.

* The Dylos particulate monitor transmits 1-minute mean values, despite updating values on its LCD display in real-time.
* The ozone monitor is configured to output 1-minute mean values, but its inherent measurement rate is approximately every 2 seconds.
* The NOX monitor is configured to output 1-minute mean values, but its inherent measurement rate is approximately every 20 seconds.
* The TSI aerosol mass monitor performs measurements at 1 Hz, but its numeric display is configured to use a 60-sec time constant.
* The CH4 analyzer performs measurements at 1Hz, its inherent rate.

These two data sets – minutely and half-hourly – are retained to a CompactFlash memory card. The card has sufficient capacity for several months of data.

## Remote Monitoring

A third data set, not stored to memory card, is used strictly for remote monitoring. 5-minute mean values of minutely data are sent via secure HTTPS connection to a server in LAR’s Technology Lab. The ScadaBR instance run on this server allows research technicians to rapidly detect malfunctioning equipment and other system failures.

Copies of the previous day’s minutely and half-hourly data files are also sent daily to a private mailing list monitored by research technicians at WSU.

Table . Instrumentation summary

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measurement | Method | Physical  Layer | Data  Layer | Power  (W) | Make | Model | Serial  Number | Last Calibration |
| Particle abundance, ≥1µm & ≥5µm | Laser photometer | TTL serial | ASCII text | < 1 | Dylos | DC1100 | ? | n/a |
| Aerosol mass concentration, 2.5µm | Laser photometer, 90º | 0-1.000 mg/m3  over 0-5Vdc | | ? | TSI | 8530 | 8530152108 | 2015-05-27 |
| O3 | UV absorbance (254nm) | TTL serial | ASCII text | 5 | 2B Tech | 205 | ? | ? |
| NO2, NO, NOx | NO2: Visible absorbance (405nm), NO: same, after conversion to NO2 using O3 | TTL serial | ASCII text | 26 | 2B Tech | 405 nm | 1016 | 2015-06-10 |
| CO2, H2O | single path, dual wavelength non-dispersive infrared (NDIR) | TTL serial | ASCII text | max 14  typ 3.6 | Licor | LI-840A | HGA-2573 | 2015-01-12 |
| CH4, CO2, H2O | laser-based off-axis integrated-cavity output spectroscopy (ICOS) | TTL serial | ASCII text | 80 | LGR | UGGA /  915-0011 | 15-0056 | 2015-03-30 |

# Nomenclature

|  |  |
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| 316SS | Stainless steel, grade 316 |
| PFA | Fluoropolymer (perfluoroalkoxy alkane) with similar properties to PTFE |
| PTFE | Fluoropolymer best known under its brand name, Teflon® |
| TTL serial | serial data signal conforming to TTL-logic voltage levels (typ. 0/5 or 0/3.3v); specified in contrast to RS-232 (±12V) |
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# Appendix I. Standard Units

Incoming values are scaled as necessary to satisfy the following unit conventions.

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| Scalar | Units | As string |
| Temperature | degrees Celsius | degC |
| Pressure | millibars | mbar |
| Speed | meters per second | m/s |
| Density (of anything) | *whatever* per cubic meter | *whatever*/m^3 |
| Flow (of anything) | *whatever* per minute | *whatever*/min |