

# ICAD NO<sub>2</sub> / NO<sub>x</sub> / NO Analyzer

## SERIES 200 - High Grade Version

NO<sub>x</sub> / NO MEASUREMENT VIA O<sub>3</sub> TITRATION CONVERTER (OPTIONAL)

PATENTED, DIRECT NO<sub>2</sub> DETECTION



Figure 1 ICAD-NOx-200DL series featuring 19" rack housing and OLED display.

The ICAD (*I*terative *C*avity enhanced *D*OAS) NO<sub>2</sub>/NO<sub>x</sub>/NO measurement system uses direct optical absorption spectroscopy in the spectral range between 430 to 465 nm. In contrast to the ICAD 200 series, the “L” series features an enhanced sensitivity by using a longer absorption cell and increased reflectivity mirrors. By measuring the absorption spectrum and applying the ICAD algorithm, the unique and characteristic absorption structure of NO<sub>2</sub> is directly identified and separated from other overlapping absorptions like water vapour (H<sub>2</sub>O) or Glyoxal (C<sub>2</sub>H<sub>2</sub>O<sub>2</sub>). This gives the advantage of direct NO<sub>2</sub> measurements (in comparison to CLD) without interferences to other substances or the need of drying mechanism which introduce new interferences (e.g., CLD, CRD, CAPS).

As the ICAD system relies not on absolute intensities, but rather characteristic differential absorption structures, it has no absolute zero-point drift and is insensitive to temperature variations, vibrations and light source degradation like other optical instruments. An internal converter for NO to NO<sub>2</sub> (optional) with a NO<sub>x</sub> free O<sub>3</sub> source allows measuring also NO<sub>x</sub>/NO with the same system (patented). The operation is simple as no consumable gases are required. Data display is directly available with any WiFi or LAN device or over the RS232 interface. Patents: DE102015000423; EP3329251; US15/748,923; China ZL201680057099.6

### SPECIFICATIONS

|  |  |                          |   |
|--|--|--------------------------|---|
| Measurement range* <sup>1</sup>            | 0 - 2000 ppb   | Power consumption        | Less than 30 W at 12 V (typ.)   |
| Time resolution                            | 2s to 60s (1s with post processing possible)   | Dimensions               | 19" Rack housing      13.2 x 43.8 x 61 cm   |
| Limit of Detection (at 2 s) * <sup>1</sup> | 0.2 ppb, 12 ppt at 1800 s  | Start-up time            | Less than 1 min (typ.)  |
| Precision (1σ at 2 s)                      | 0.1 ppb or 2%  | Temp. range of operation | -10 to +25°C (+40°C with cooling option)  |
| Detection of NO <sub>2</sub>               | Direct spectroscopic measurement   | Temperature sensitivity  | Less than 0.01 ppb/°C   |
| Detection of NO <sub>x</sub> / NO          | By conversion to NO <sub>2</sub>   | Cross sensitivity        | No significant cross sensitivity <sup>5</sup>   |
| Response Time (10% to 90%)* <sup>2</sup>   | 2s at 1 l/min or 1s at 2 l/min   | Weight                   | Less than 11.7 kg (depending on config)   |
| Zero Drift                                 | Less than 0.1 ppb/month <sup>3</sup>   | Consumable gases         | No gases needed for operation   |
| Sample flow                                | 1 to 2.5 l/min   | Other detectable gases   | Glyoxal, CO <sub>2</sub> (optional NDIR sensor)                                       |
| Calibration                                | NO <sub>2</sub> calibration gas not needed <sup>4</sup> ;<br>NO gas for converter calibration (only for high NO <sub>x</sub> measurements) | Data communication       | LAN/WiFi/RS232/M2M/OPCUA; Bayern-Hessen Protocol; Voltage/Current Output (on request) |
| Path length characterization               | Helium gas (1 to 2 years interval)   | Processing unit          | Internal embedded PC, with data analysis and measurement software                     |
| Mechanical stability                       | Insensitive to vibrations  |                          |   |

\*<sup>1</sup> Custom specifications with different measurement range are possible. By reducing the measurement range better precision and LOD can be achieved.

\*<sup>2</sup> Response: Different measurement cell types are available, allowing different response times. Smaller measurement cells allow a much faster response time, but result typically in a lower precision.

\*<sup>3</sup> Upper limit. Drift is negligible due to regularly automated reference measurements.

\*<sup>4</sup> Literature absorption data for NO<sub>x</sub> is used for gas quantification.

\*<sup>5</sup> No significant spectroscopic cross sensitivity with respect to: Carbon oxides, Methane, H<sub>2</sub>CO, Hydrogen, Sulphide, Sulphur Dioxide, Chlorine, Chlorine Dioxide, Hydrogen Cyanide, Hydrogen Chloride, Phosphine, Hydrogen, Ammonia, Acetylene, Nitromethane, Ethylene, Ethanol, Methyl Mercaptan, Ethyl Mercaptan

## APPLICATIONS

- High precision NO<sub>2</sub> / NO<sub>x</sub> measurements (science, research, background air pollution monitoring)
- Urban air quality monitoring (outdoor, streets, tunnels, street canyons, mobile measurements)
- Indoor air quality and workplace monitoring
- Quick & precise NO<sub>2</sub> / NO<sub>x</sub> pollution study, personal exposure studies e.g., for workspace, pedestrians etc.
- Emission monitoring (e.g., stacks)
- Real Driving Emission Measurement of vehicles (RDE): requires extra CO<sub>2</sub> option to derive NO<sub>x</sub> / NO<sub>2</sub> per km or kWh

## THEORY OF OPERATION

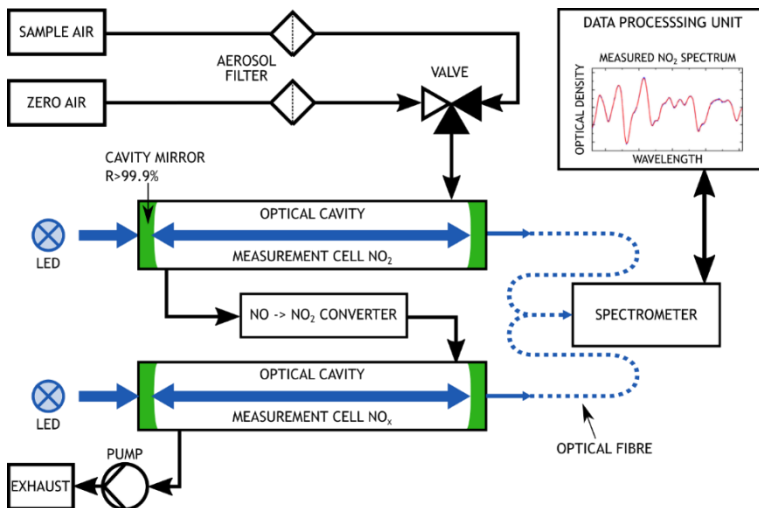


Figure 2: Flow scheme and Measurement Principle of the ICAD NO<sub>2</sub> / NO<sub>x</sub> / NO measurement system (incl. additional NO to NO<sub>2</sub> converter for NO<sub>x</sub> measurement).

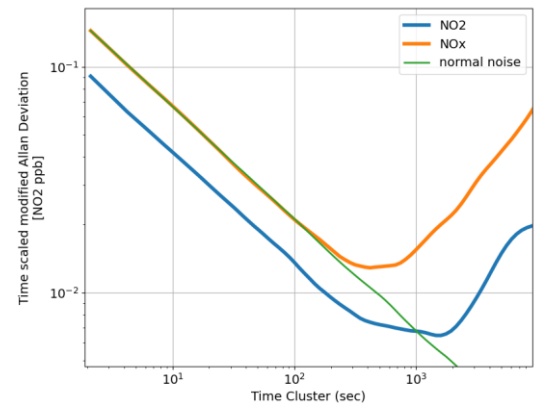


Figure 3: Time scaled modified Allan deviation for NO<sub>2</sub> and NO<sub>x</sub> measurements.

## ADVANTAGES

### BENEFITS

#### High measurement accuracy

- Direct NO<sub>2</sub> measurement
- High sensitivity, low measurement error
- No zero-point or calibration drift, 100% reproducibility
- No interferences
- No water dryer needed

#### Favourable initial and operating costs

- Parallel NO-Measurement (with converter)
- Simple and robust setup
- No consumable gases needed
- Long lifetime
- Fast response within seconds

#### Simple operation

- No calibration with NO<sub>2</sub> gas required
- High stability (not sensitive to shocks, vibration, temperature)
- Light weight
- Low power consumption and 12V operation
- Multiple Interfaces: WiFi, LAN, Machine2Machine, RS232, Analogue Volt./Cur.

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