Monitoring and Mitigating Methane, Benzene and other VOC Emissions at the site level in Refineries: Strategies for a Cleaner Future

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Aeromon

Monitoring and Mitigating Methane, Benzene and other VOC Emissions at the site level in Refineries

- Aeromon briefly
- Measurement technologies – what can we apply and what are the limitations
- Emission plumes – the fiction and the fact.
- Methodologies – how do we approach measurements?
- How to assess the site level quantification result uncertainty?

Aeromon Ltd. holds ISO/IEC 17025:2017 test laboratory accreditation for environmental testing with scope for:

1. Mass flow rate quantification,
2. Source localization,
3. Concentration measurements and
4. Flare combustion and CH_4 destruction efficiency analysis.

FINAS
Finnish Accreditation Service
T362 (EN ISO/IEC 17025)

Aeromon Ltd. is a testing laboratory No. T362 accredited by FINAS Finnish Accreditation Service, accreditation requirement SFS-EN ISO/IEC 17025.

Aeromon quality management system has ISO 9001:2015 certification.

ISO
9001:2015

Emission Awareness

Understanding of fugitive emission locations, sources, and concentration levels

Spreading & Dilution

Visualised and layered information on the emission dispersion

Leak Detection

Site-level (top-down) information on leakage locations and volumes

Process Monitoring

Continuous and real-time measurements to support process improvements

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EU Regulation

Top-down emission mass-flow measurement EU 2024:1787.

EN 17628:2022

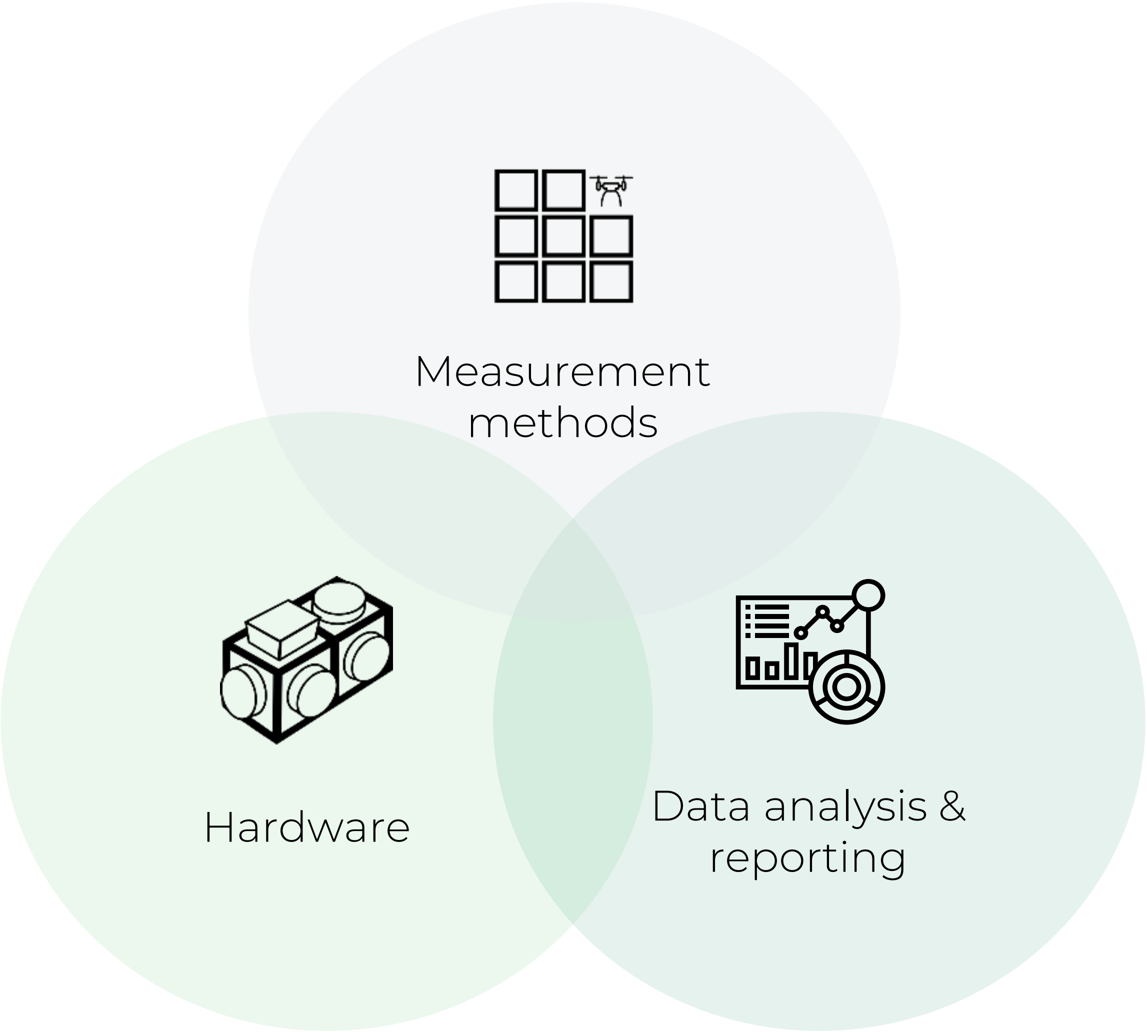
Emission mass-flow measurement compliant with EN 17628:2022.

OGMP2.0 Level-5

Site level measurement as part of the OGMP2.0 Level-5.

MiQ compatible

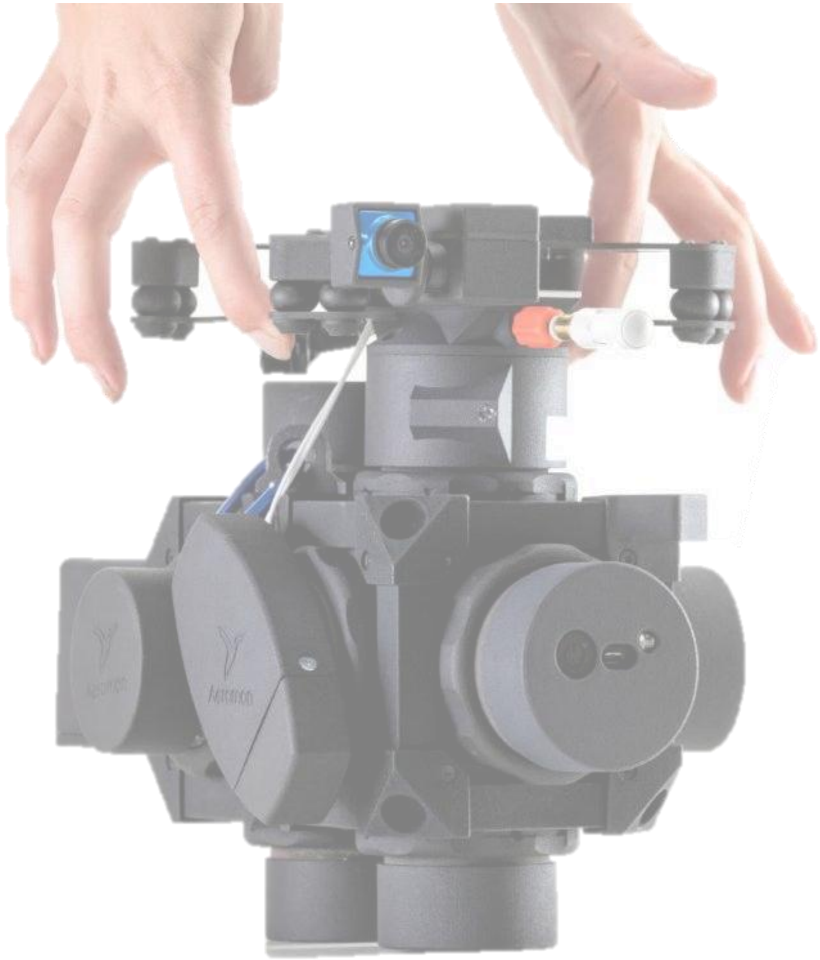
MiQ facility scale inspection and Source level inspection


Measurement methods
Hardware
Data analysis & reporting

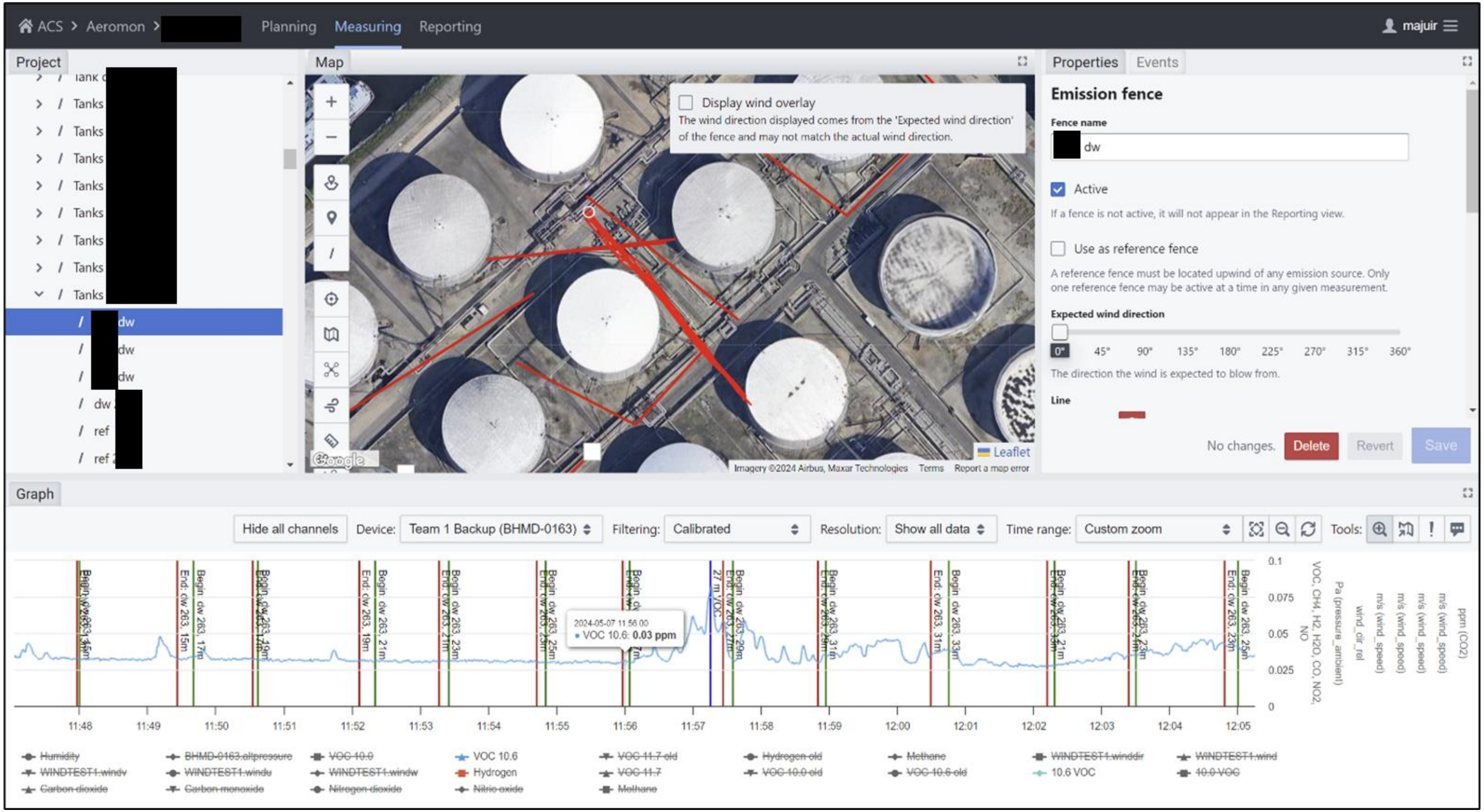
Drone

Handheld

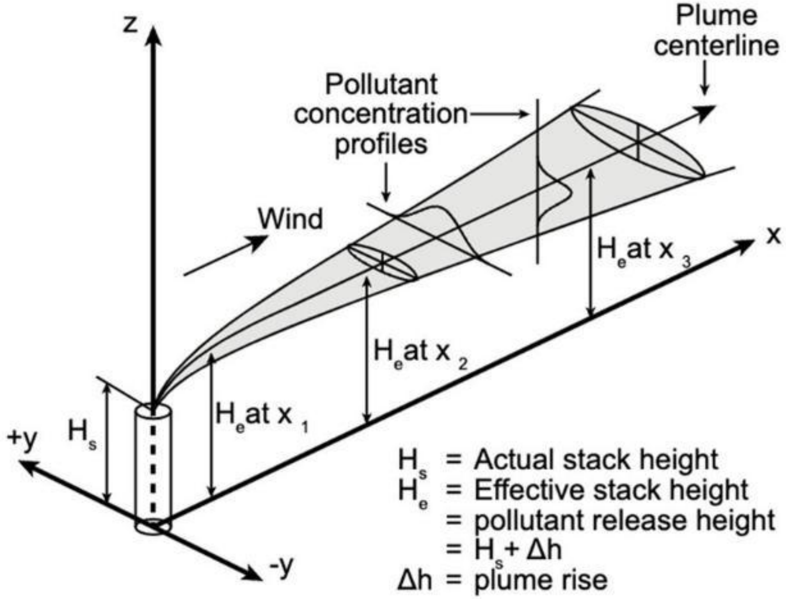
Fixed

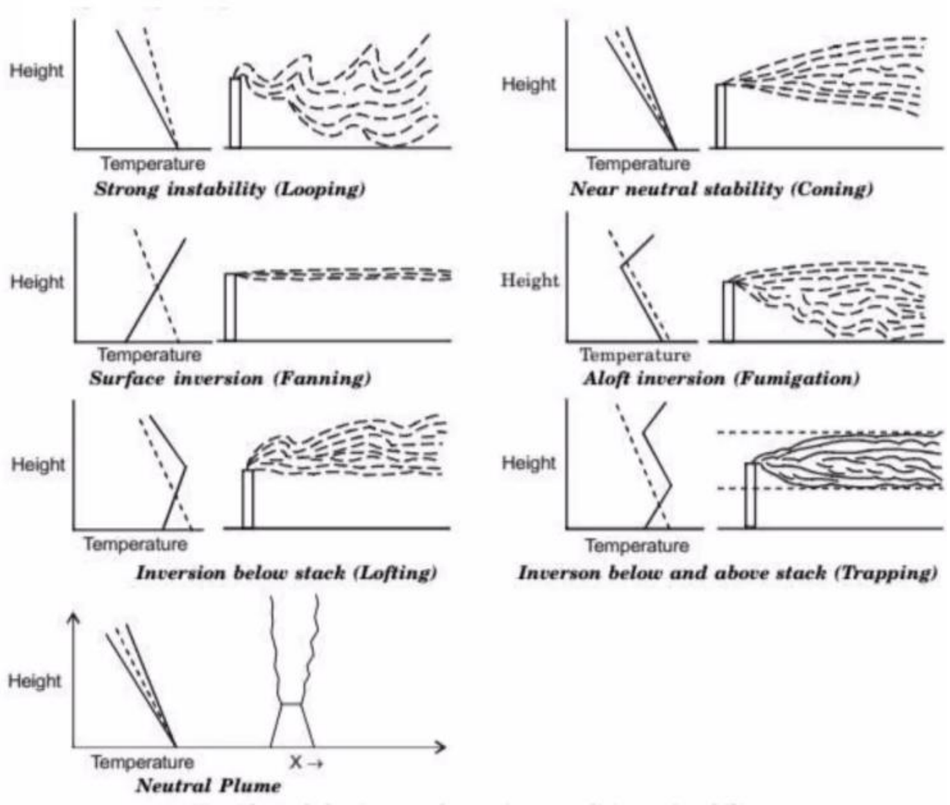


PARAMETERS	MEASUREMENT RANGES
Ammonia NH_3	< 100 ppm
Benzene C_6H_6	< 100 ppm
Carbon dioxide CO_2	< 10 000 ppm
Carbon monoxide CO	< 500 ppm
Dimethyl sulfide $(CH_4)_2S$	< 10 ppm
Hydrogen, H_2	< 1 000 ppm
Hydrogen sulfide H_2S	< 50 ppm
Methane CH_4	< 40 000 ppm
Methyl mercaptan CH_4S	< 14 ppm
Nitrous oxide N_2O	< 1 000 ppm
Nitrogen dioxide NO_2	< 20 ppm
Nitric oxide NO	< 250 ppm
Oxygen O_2	< 25%
Ozone O_3	< 5 ppm
Refrigerants, e.g., R134A, R410A	< 2 000 ppm, < 5 000 ppm
Sulfur dioxide SO_2	< 50 ppm
Non-Methane Volatile Organic Compounds, NMVOC	< 10 000 ppm isobutylene equivalent
Particulate matter, PM	PM1, PM2.5, PM10
Noise	30 - 135 dB (A-, C-, Z- and octave bands)
Wind speed and direction	< 15 m/s (with drone) , 0-360°

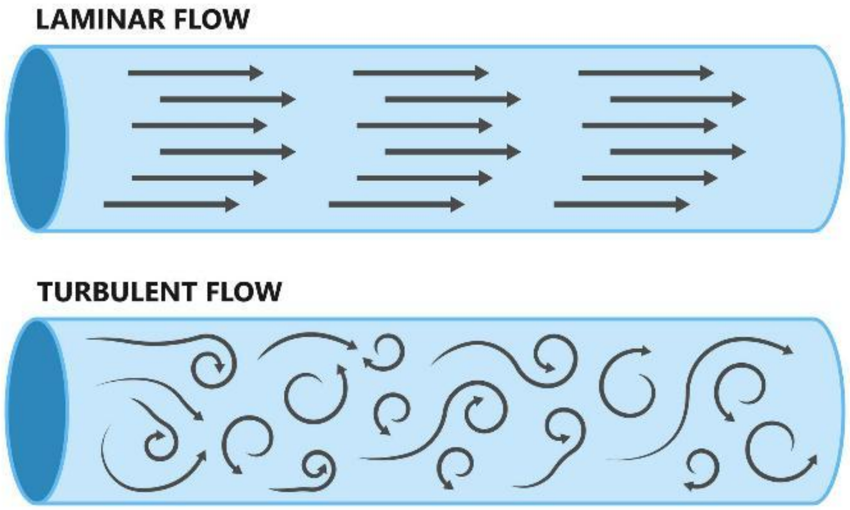

ACS > Aeromon > [redacted]
Planning
Measuring
Reporting
majuir
Project
Tanks [redacted]
dw
ref
Map
Display wind overlay
The wind direction displayed comes from the 'Expected wind direction' of the fence and may not match the actual wind direction.
Leaflet
Imagery ©2024 Airbus, Maxar Technologies
Terms
Report a map error
Properties
Events
Emission fence
Fence name
[redacted] dw
Active
If a fence is not active, it will not appear in the Reporting view.
Use as reference fence
A reference fence must be located upwind of any emission source. Only one reference fence may be active at a time in any given measurement.
Expected wind direction
0° 45° 90° 135° 180° 225° 270° 315° 360°
The direction the wind is expected to blow from.
Line
No changes.
Delete
Revert
Save
Graph
Hide all channels
Device: Team 1 Backup (BHMD-0163)
Filtering: Calibrated
Resolution: Show all data
Time range: Custom zoom
Tools:
2024-05-07 11:56:00
VOC 10.6: 0.03 ppm
11:48 11:49 11:50 11:51 11:52 11:53 11:54 11:55 11:56 11:57 11:58 11:59 12:00 12:01 12:02 12:03 12:04 12:05
0.1 0.075 0.05 0.025 0
VOC, CH4, H2, H2O, CO, NO2, NO
Pa (pressure_ambient)
wind_dir_rel
m/s (wind_speed)
ppm (CO2)
Humidity
BHMD-0163.altpressure
VOC 10.0
VOC 10.6
VOC 11.7 old
Hydrogen old
Methane
WINDTEST1.winddir
WINDTEST1.wind
WINDTEST1.windv
WINDTEST1.windu
WINDTEST1.windw
Hydrogen
VOC 11.7
VOC 10.0 old
VOC 10.6 old
10.6 VOC
10.0 VOC
Carbon dioxide
Carbon monoxide
Nitrogen dioxide
Nitric oxide
Methane

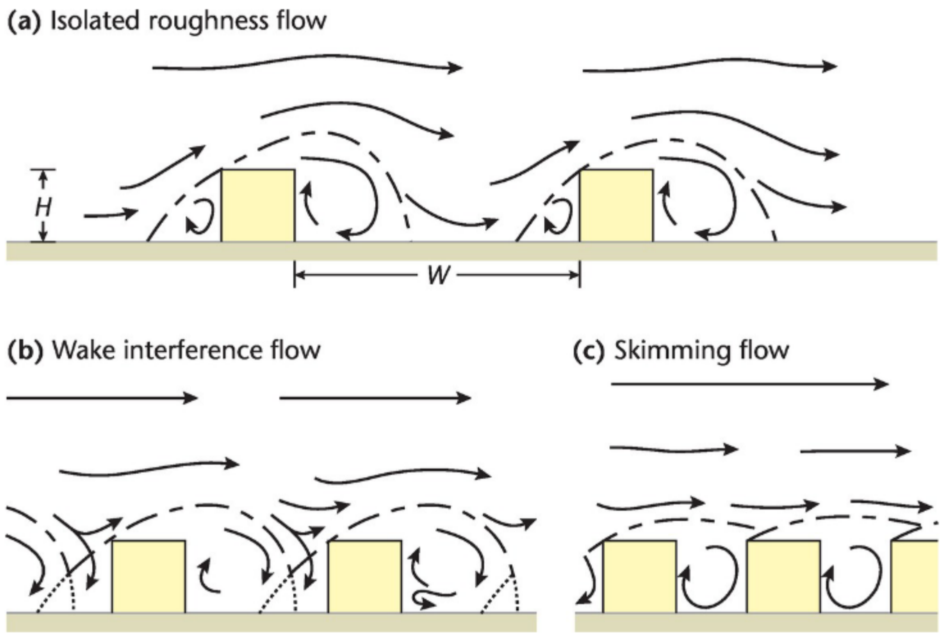
Emission plumes – theoretical plume shapes

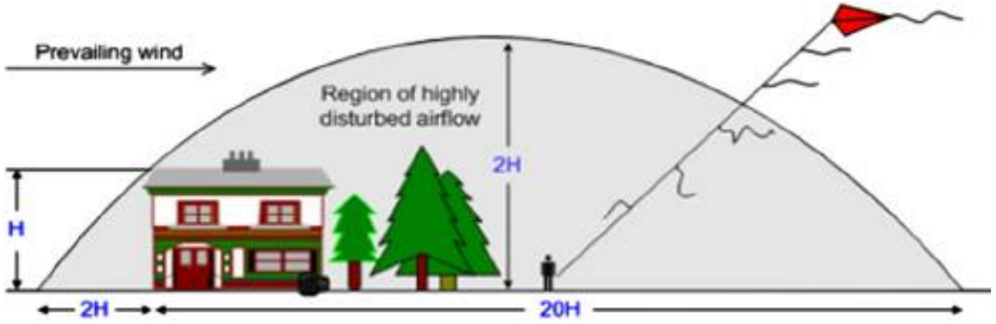




Emission plumes – turbulent mixing

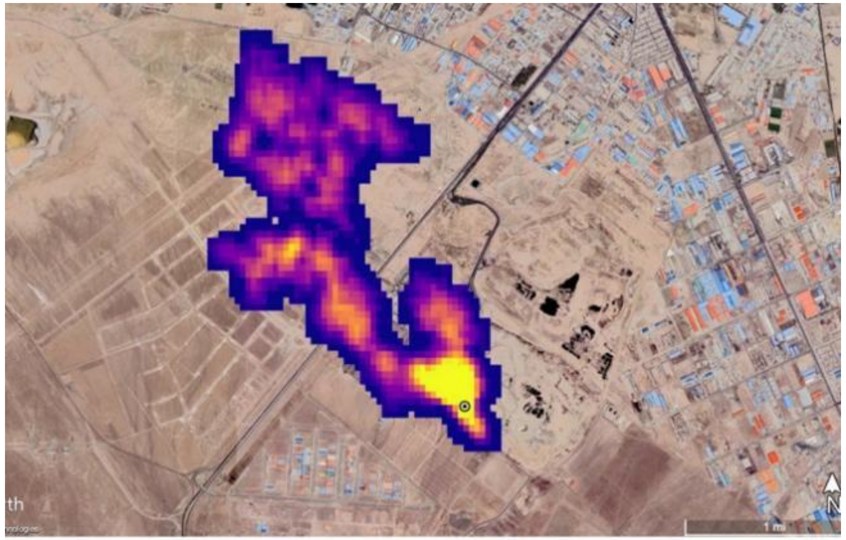






https://www.researchgate.net/publication/263048982_Advances_in_wind_energy_resource_exploitation_in_urban_environment_A_review

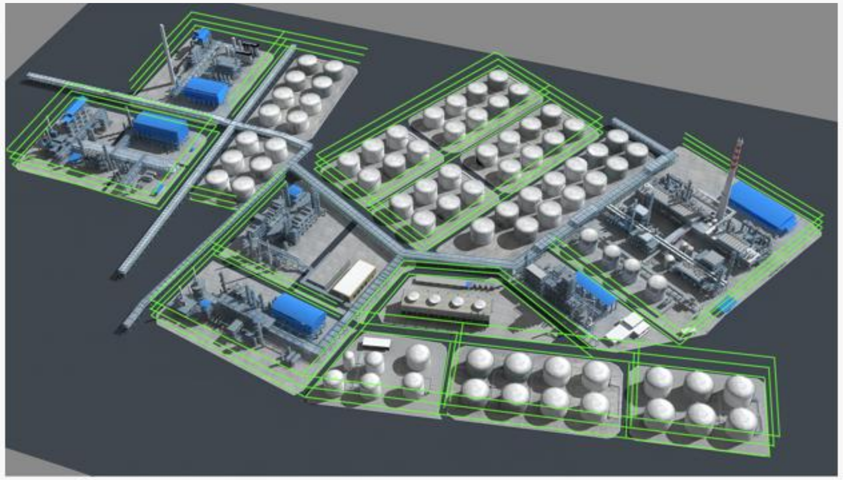
Emission plumes – real plumes



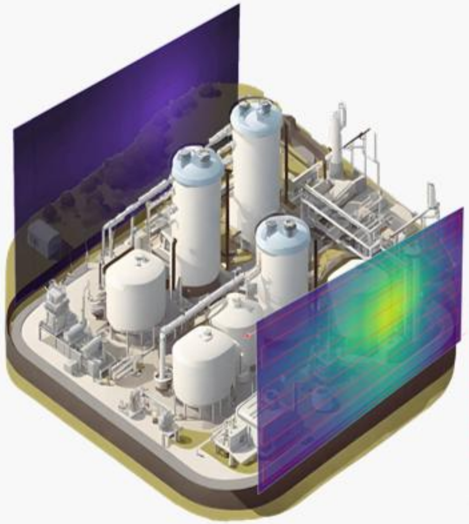
Methodologies - how can we approach refinery measurements?

Measurement approaches for refineries

Emission Mapping



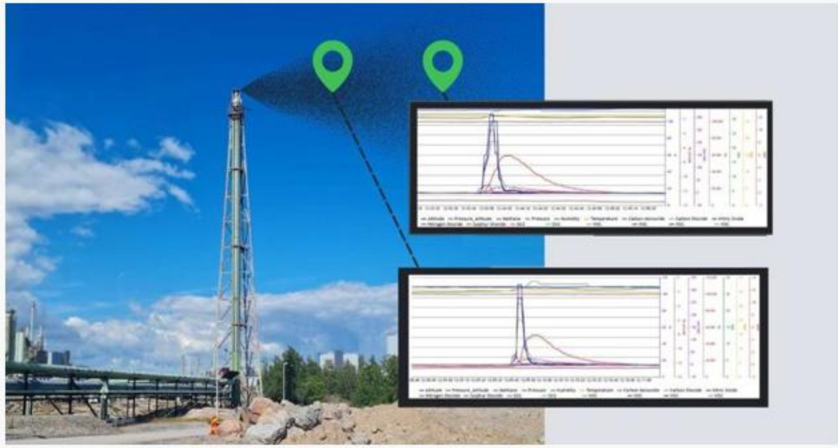
Emission Fenceline Monitoring



Measurement point	SO_2 [ppm]	tVOC [ppm]	NO [ppm]	NH_3 [ppm]
1	0	0.06 ± 0.02	0	0
2	0	0	0	0
3	0	0.10 ± 0.03	0	0
4	0	0.22 ± 0.05	0	0
5*	43 ± 7	0.42 ± 0.09	0	2.7 ± 0.4
6	0	0.07 ± 0.02	0	0
7	0	0.09 ± 0.02	0	0

*50% mixture, station was restarted after a 30 min break

Site Level Quantification



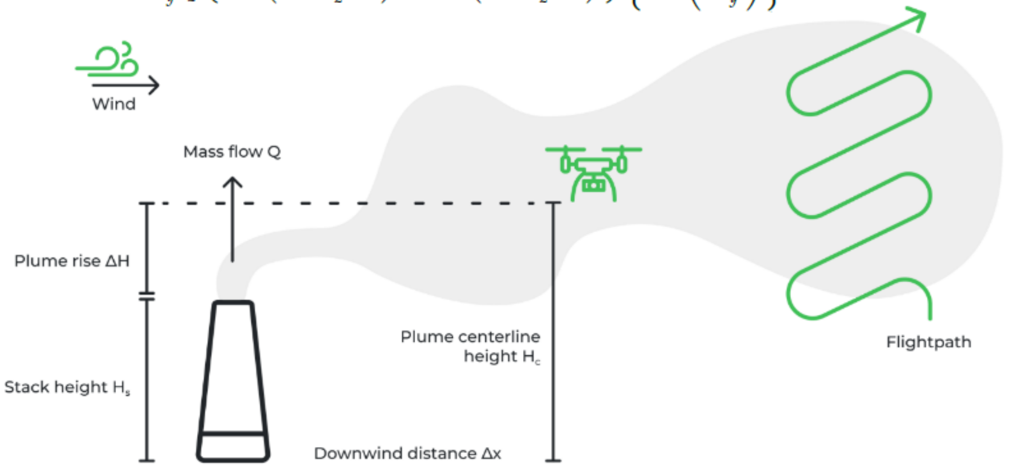
Flare Efficiency Monitoring

Quantification methodologies

Reverse Dispersion Modelling

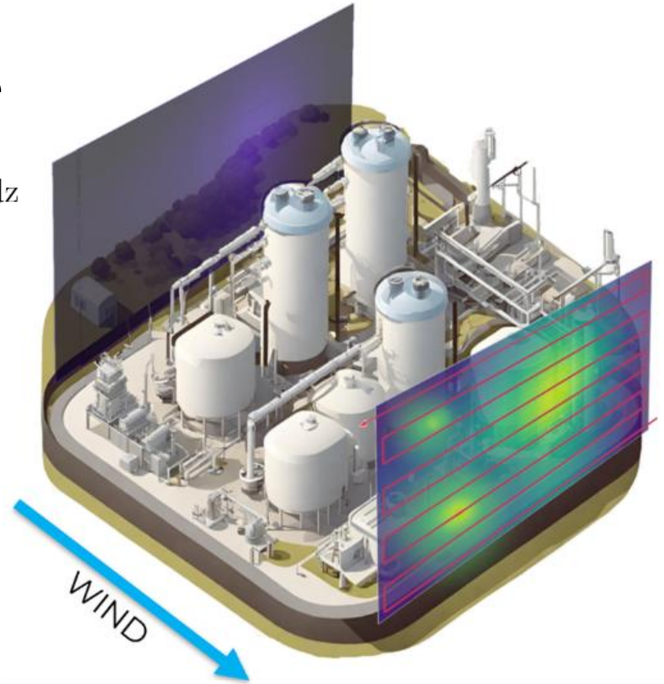
$$Q = \frac{C(x,y,z)}{\beta}$$

$$\beta = \frac{1}{2\pi u \sigma_y \sigma_z}\left\{exp\left(\frac{-(z-h)^2}{2\sigma_z^2}\right) + exp\left(\frac{-(z+h)^2}{2\sigma_z^2}\right)\right\}\left\{exp\left(\frac{-y^2}{2\sigma_y^2}\right)\right\}$$

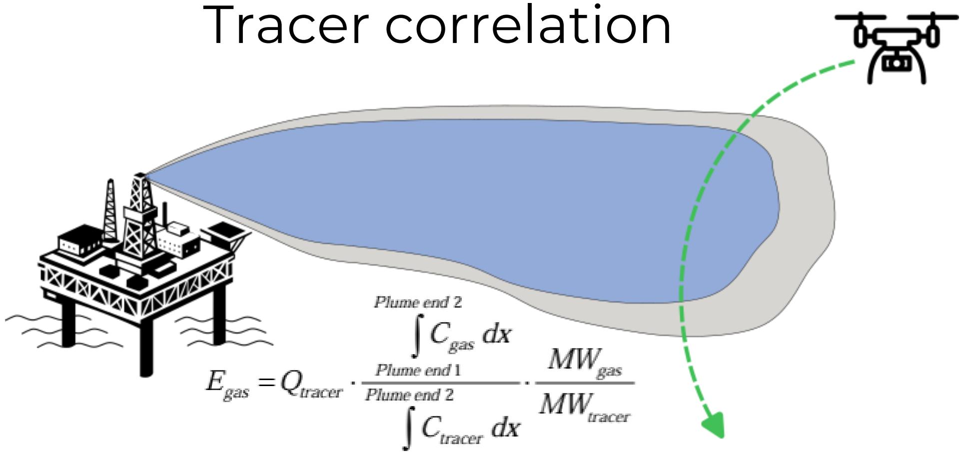


Mass Balance

$$F = \int_{z_1}^{z_2}\int_{x_1}^{x_2}(C - C_b)U_{\perp}\mathrm{dxdz}$$



Tracer correlation



$$E_{gas} = Q_{tracer} \cdot \frac{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{gas}\, dx}{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{tracer}\, dx} \cdot \frac{MW_{gas}}{MW_{tracer}}$$

Flare efficiency analysis

	Measurement	Result
Aeromon	CH_4 mass flow rate measurement from flare	CH_4 mass flow rate result from flare
Customer	CH_4 mass flow into flare (process data).	CH_4 destruction efficiency result from flare
Aeromon	CH_4 and CO_2 (possibly CO and NMVOC) concentration measurement from flare plume.	Flare combustion efficiency result

The CH_4 mass flow rate measurement from flare goes to both the CH_4 mass flow rate result from flare and the CH_4 destruction efficiency result from flare.

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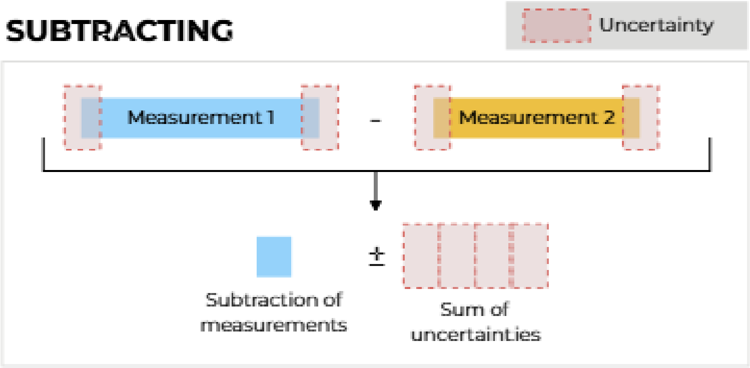
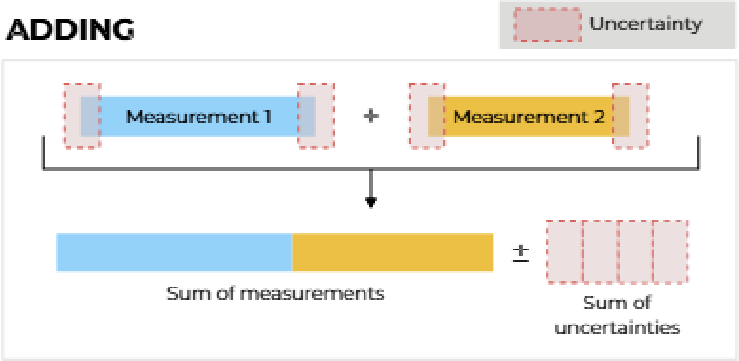
Site level uncertainty – Real world example

Source	Mass flow (kg/h)	Uncertainty ± (kg/h)	Uncertainty ± (%)
Area 1	0.64	0.33	52 %
Area 2	2.76	1.10	40 %
Area 3	1.46	0.59	40 %
Area 4	2.10	4.68	223 %
Areas combined (total site)	6.96	6.70	96 %
Total Site measured as whole	**6.92**	**1.78**	**26 %**

Result = Downwind - Upwind



Combined result = Area 1 + Area 2 + ...



Quantification is more accurate when large areas are quantified as whole, but only spatial granularity supports leak detection and repair effectively

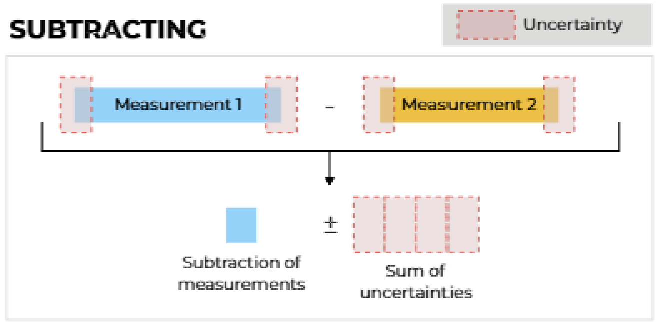
What factors affect the quantification result uncertainty?

Uncertainty analysis of mass flow rate is a combination of

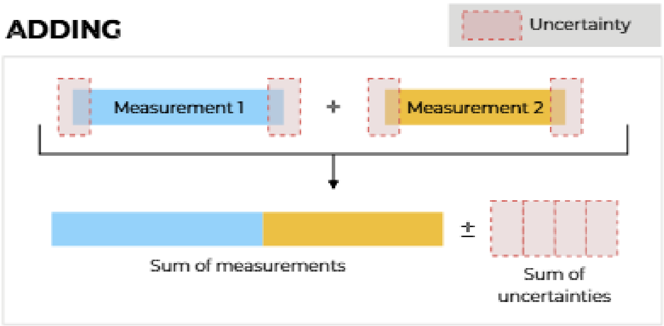
- Expanded sensor uncertainty (k=2) for all used sensors (CEN/TS 17660-1:2021),
- Detected concentration levels in relation to system detection limit (< determination limit),
- Number of repetitions for results,
- Repeatability of detections in data collection,
- Stability of weather conditions during data collection,
- Consistency/variability of emission rates at sources and
- Overlapping spread of emissions.

Each part of the measurements should be conducted in a traceable, validated and transparent way and dynamics of the uncertainty of each result should be known and shown.

Result = Downwind - Upwind

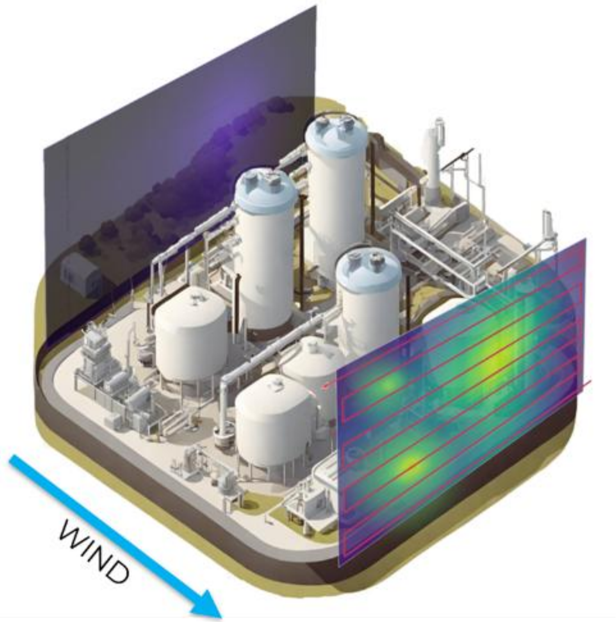


Combined result = Area 1 + Area 2 + ...

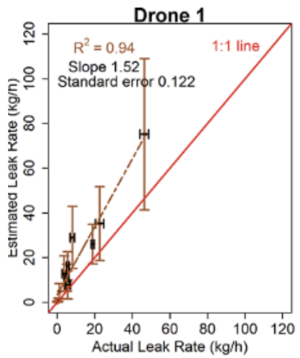


Quantification uncertainty

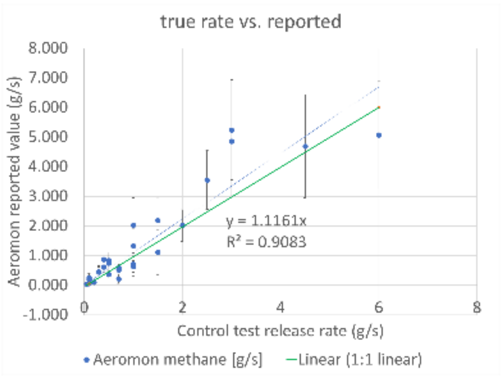
- Collaboration in research projects has been essential in building a traceable track of evidence for continuous improvement and reliable, metrologically traceable result provision with realistic uncertainty budget.
- Aeromon has an in-house team of experts and we're continuously improving our [ISO 17025:2017 test laboratory accredited]() methodologies and technology stack.



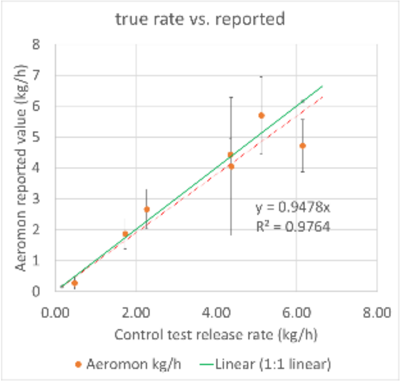
https://amt.copernicus.org/articles/17/1633/2024/



2021



2022



2024

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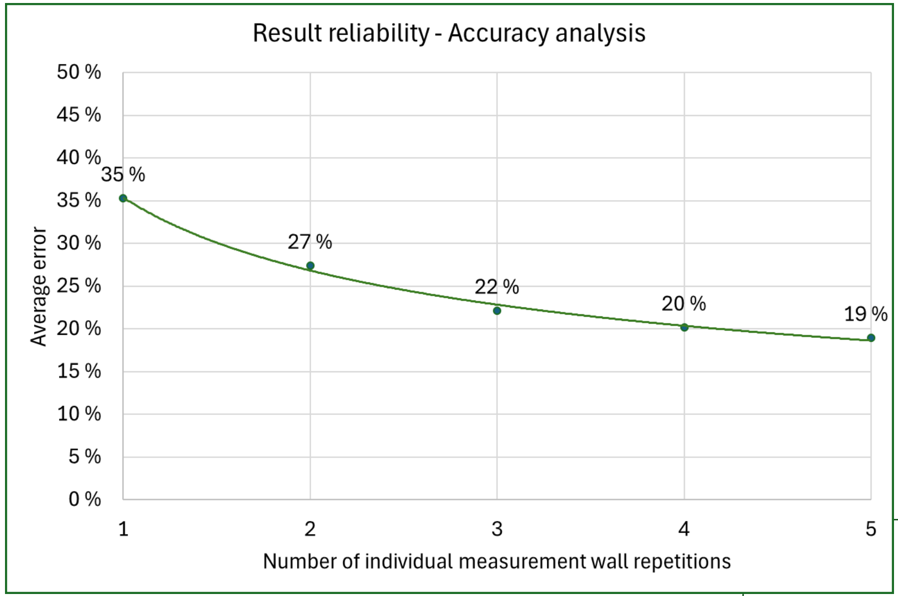
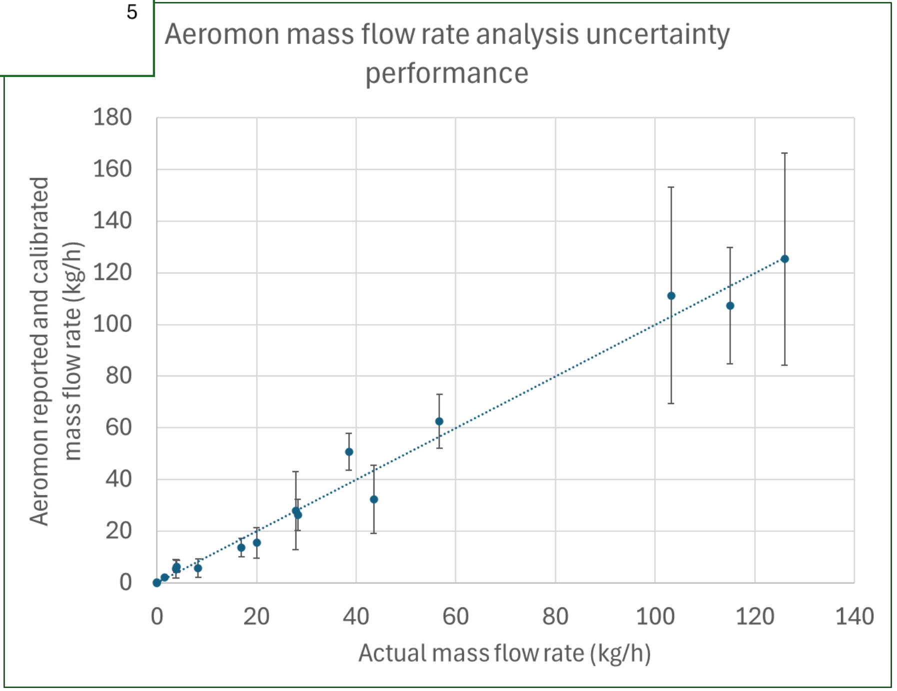
Result reliability – uncertainty and accuracy



NOTE: No filtering based on partial wall or suboptimal conditions



Results collected in blind control release study in multisource environment in TADI test centre in Lacq, France

Aeromon

The Standard in Emission Measurement Services

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