



July 2023

Monitoring solutions for better air quality & health!

Blue - Gas emissions measurement solutions

- **Blue analysers monitor in real time critical gas molecules**

- 1) Regulated **environmental** pollutants emissions (eg. chimney) continuous **compliance** monitoring, quantification of SBTi targets
- 2) Gas **exposure** in workshops, labs: mapping & continuous monitoring for **HSE** purposes
- 3) **Continuous** monitoring of gas streams in **production processes** (eg. drying step or new process development)



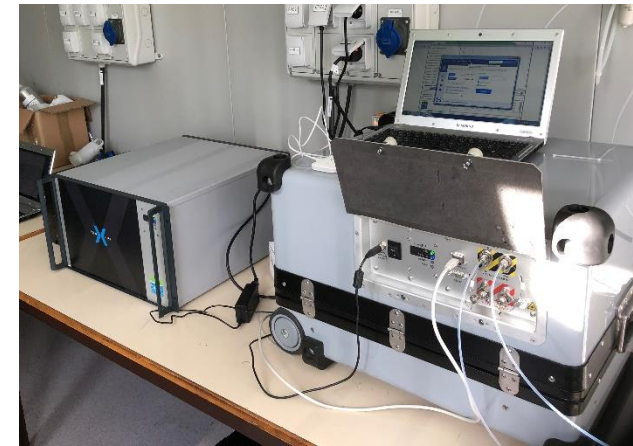
- **Differentiated and patented technology, the world's first Broadly Tunable Laser (BTL)**

- **Continuous** monitoring round the clock 24h/24; **500+** molecules
- Low **quantification** level (ppb to ppm) and wide dynamic range (up to %)
- **Simultaneous** & stable measurement of **multiple** gas molecules
 - Broad spectral range of 800 cm⁻¹ covering wide range of VOCs molecules
- **Molecule identification** capabilities
- **Easy to use** and low maintenance costs
- **Sampling** system (extraction) adapted to measurement objective
 - Multiple sampling points and dilution module
 - Sampling **in vacuum**



Use case Example n°1: Continuous environmental control of gas emissions

- **Site:** Pharmaceuticals (APIs) factory
 - **Requirements:** Continuous monitoring of critical pollutants emissions & cost management of activated carbon filters replacements
 - **Target pollutants:** Bromopropane, Toluene, Isopropanol, Propene, Ammonia, TVOCs ...
 - **Range:** 100 ppb – 300 ppm
- **Blue's gas analyzers are able to monitor all pollutants before and after activated carbon filters**



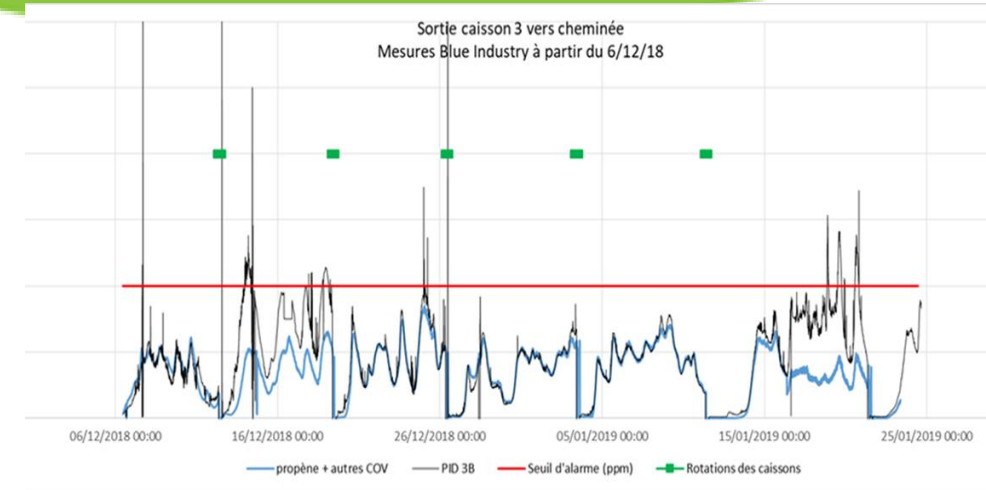
Use case Example n°1: Continuous environmental control of gas emissions

Phase 1 - Process qualification phase:

- Measurements at chimney exit (emissions monitoring - compliance)
- Measurements at inbound of filtering solution (qualification of the filter provider)
- Measurements at exit of filter n°1 (process control – monitoring when the filter is saturated)

Phase 2 - Permanent monitoring:

- Continuous measurement of each molecule concentration at exit of filter 1 and chimney exit
- Integrated in the factory digital control system



Use case Example n°1: Continuous environmental control of gas emissions

Benefits for the customer

- **Continuous monitoring** enables to measure in **real-time** consequences of actions or events in the process
 - Not only punctual measures at a given time, not representative of emission profile evolution !
- **Better environmental control**
 - Continuous monitoring
 - Costs of **regulatory control decreased**
- **Lower rate of activated carbon filter regeneration**
 - **Higher productivity**
 - **Reduced costs**

Use case n°1: Other examples of environmental pollutant monitoring

- **Site:** API factory in Hungary
 - **Requirements:**
 - Continuously measure DCM emissions after cryogenic treatment and after activated carbon filters to monitor critical gas abatement rate
 - **Target molecules:**
 - DCM (Dichloromethane) and other solvents
 - **Range:**
 - 0,3 ppm - 1% (emission limit 5,75 ppm - 20mg/ m3)
 - Assessment of **abatement rate** of filtering system with 3-point sampling including dilution system for high concentration emissions
 - Implementation of a **continuous monitoring** system integrated in the factory digital control system.
- **Blue's gas analysers enable assessment of abatement system performance, continuously measure compliance to regulatory emission limits**



Use case n°1: Other examples of environmental pollutant monitoring

- **Site:** Acrylates polymers production unit
- **Requirements:** Dynamically quantify process emissions during a polymerisation for process and emissions tracking.
- **Target molecules:** Acrylates (methyl + ethyl), methyl chloride, alcohols & solvent mixtures
- **Range:** 1ppm - 1200ppm
- **Blue's gas analysers measure continuously target molecules, enable identification of unknown molecules and allow process and filtering solution optimization**

- **Site:** HMD production unit (Hexamethylenediamine)
- **Requirements:** quantify atmospheric emissions.
- **Target molecules:** HMD and derivatives
- **Range:** <1ppm - 200ppm
- **Blue's gas analysers continuously measure target molecules**



Use case Example n°2: Mapping of pollutants within a factory

- **Site:** API Factory in France
- **Requirements:**
 - Real-time quantification of critical pollutants – measure emissions at various places within the factory
- **Target pollutants:**
 - HCN, chloroform, diisopropyl ether, THF, methanol, DCM
- **Range:**
 - 100 ppb – 300 ppm

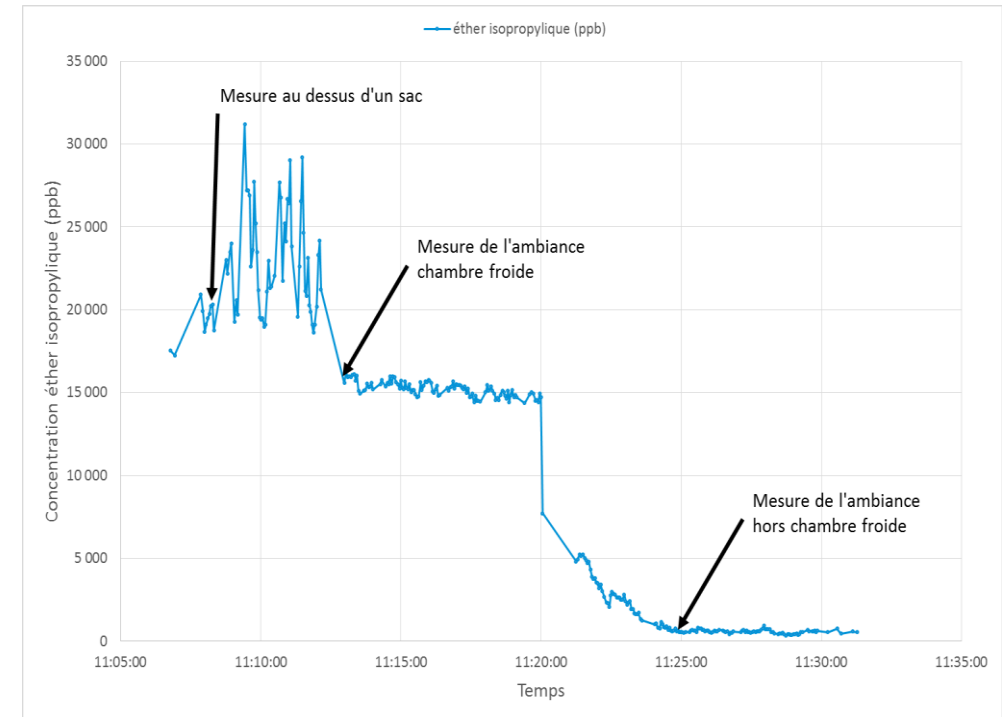
➤ **Blue's gas analyzers are able to monitor all pollutants emissions in real-time**



Use case Example n°2: Mapping of pollutants within a factory

Measurements performed:

- Measurement of **HCN** concentrations during the transfer of an intermediate product from a storage bag to a reactor
- Measurement of **chloroform** during an analytical procedure in the laboratory (thin layer chromatography, TLC)
- Cold storage of **diisopropyl ether**: Measurement of diisopropyl ether on the surface of a compound storage bag, measurement of the storage environment and external environment (see figure)
- Measurement of several solvents (**DCM**, **THF**, **Methanol**) at a dispatching station equipped with a suction bar to measure the efficiency of the solvent aspiration.
- Measurement of **HCN** and **methanol** concentration on the surface of mini bags



Diisopropyl ether measurements in and around a refrigeration chamber

Use case Example n°3: Continuous monitoring of harmful pollutants in a workshop

- **Site:** API Factory in Germany
- **Requirements:**
 - Real-time quantification of harmful pollutant with alarm reporting to the plant monitoring system
- **Target pollutant:**
 - Diborane, with very low alarm threshold at 50 ppb
- Analyzer provides **specific alerts** if concentration of **pollutant** reaches 50ppb in workshop ambient air
 - Multiple sampling points in different areas of a workshop
 - Fast loop sampling (Blue Gas Rack) allowing real-time measurement

➤ **Blue's gas analyzers allows safe operation of a process for plant operators**



Mapping and continuous monitoring of pollutants within a factory

Benefits

- **Easy to use** and mobile analyzers enable real-time measurements to **map the pollutants**:
 - Where, at what time and at which concentrations are potentially harmful pollutants emitted !
- Precise corrective actions can be taken to improve **workers' protection**:
 - Training to adapt technical gestures
 - Fine tuning of air extraction devices
 - Recommendations on personal protective equipment (PPE)
- Continuous monitoring of very critical pollutants can be implemented with **alerts over specific thresholds**
 - Real-time alarms enable safe operation
 - Multiple sampling lines in different areas of the workshops



Use case Example n°4: Continuous monitoring of gas streams in production processes

- **Site:** Fine chemicals and API factory
- **Requirements:**
 - Continuous quantification of molecules in the gas stream of a drying step, to be able to stop the process just-in-time
- **Target molecules:** MEK, Isopropanol, Toluene
- Blue analyzer performs **continuous measurement** directly in the dryer:
 - Vacuum at 20mbar abs
 - Multiple molecules measured
 - Range: 0,1 - 1000 ppm
- **Blue's gas analyzers allow better control of the drying process**
 - **Improved productivity & reproducibility**



Use case Example n°5: Continuous monitoring for process development (lab or pilot phase)

- **Site:** Fine chemicals factory
- **Requirements:**
 - Continuous quantification of various critical molecules at lab pilot stage, to have a first assessment of emissions
- **Target molecules:** acetone, ammonia, HCN
- Blue analyzer performs **continuous measurement** directly in the **pilot reactor**:
 - Reduced sampling volume, non-destructive measurement: adapted to small volumes typically available at lab pilot phase
 - Multiple molecules measured
 - Continuous dilution sampler for high concentrations (%)
 - Sampling in vacuum available

➤ **Blue's gas analyzers allow early characterization of emissions at process development phase**



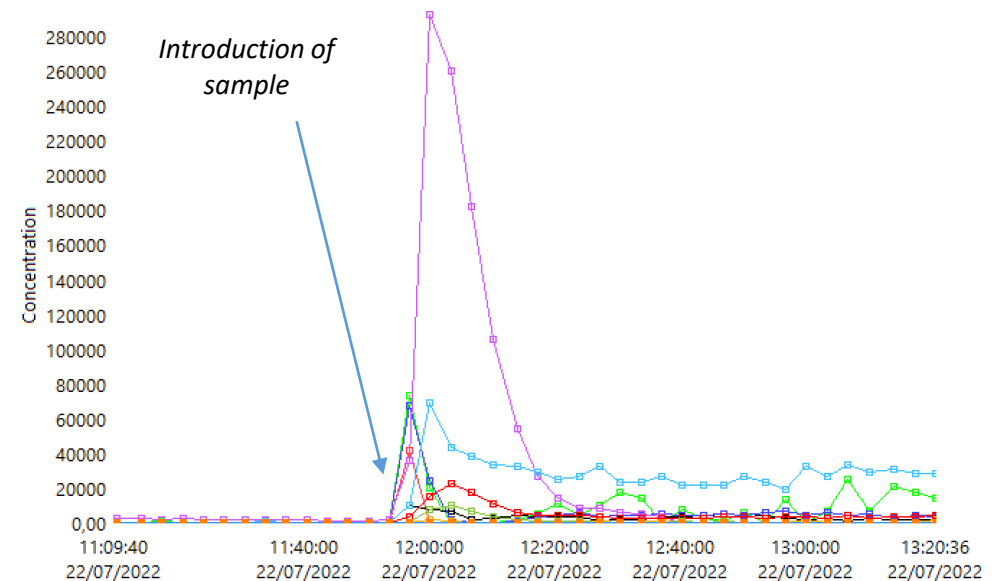
Use case Example n°6: Process optimization and Quality Control

- **Site:** Silicones derivatives production unit
 - **Requirements:**
 - Measurement of gas concentrations evolution at the « surface » of the process (reactors, blenders, silos ...) and at the vents to monitor quality trackers for different batch conditions
 - **Target molecules:**
 - Siloxanes D4 & D5, methanol, methane
 - **Range:**
 - 1ppm - 2500ppm
- **Blue's gas analyser measures continuously at process « surface » and enables finished products quality improvement**



Use case Example n°7: Dynamic monitoring of fugitive emissions (perfumes)

- **Site:** Flavors and fragrances R&D department, Switzerland
 - **Requirements:**
 - Measurement of blooming gas dynamic evolution in air of a complex perfume formulation
 - **Target molecules:**
 - d-Limonene, benzyl alcohol, 3-Carene, Guaiacol, Geraniol...
 - **Range:**
 - 0,1ppm - 50ppm
- **Blue's gas analyser measures continuously in ambient air and enables to provide quantitative dynamic measurements that can be compared with human sensorial assessment**



Use case Example n°8: SBTi assessment of VOC emissions

- **Site:** Chemical factory, France
 - **Requirements:**
 - Measurement of precise emission flow output of the plant for base reference of SBTi reduction commitment
 - **Target molecules:**
 - 1,3-Butadiene, Cyclohexanes, Styrene, etc emissions from processes or storage tanks
 - **Range:**
 - 0,001 – 20g/m³
- **Blue's gas analyser measures continuously at emission to provide quantitative basis measurement**



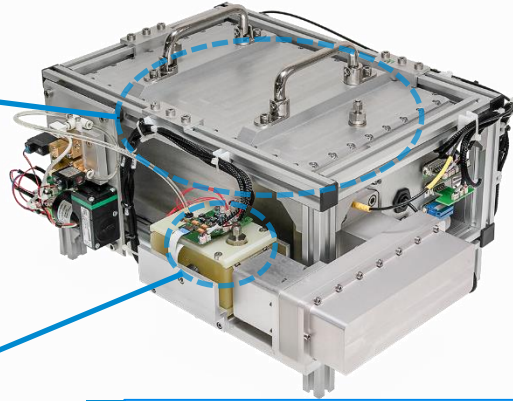
Technology: an advanced laser-based gas analyzer

Key components

Optical source

- Broadly Tunable Laser
- Wavelength control
- Patented
- Fully industrialized by Blue

1



Photoacoustic Detection

- Patented, fully developed and qualified
- Plug and play assembly

2

3

Software

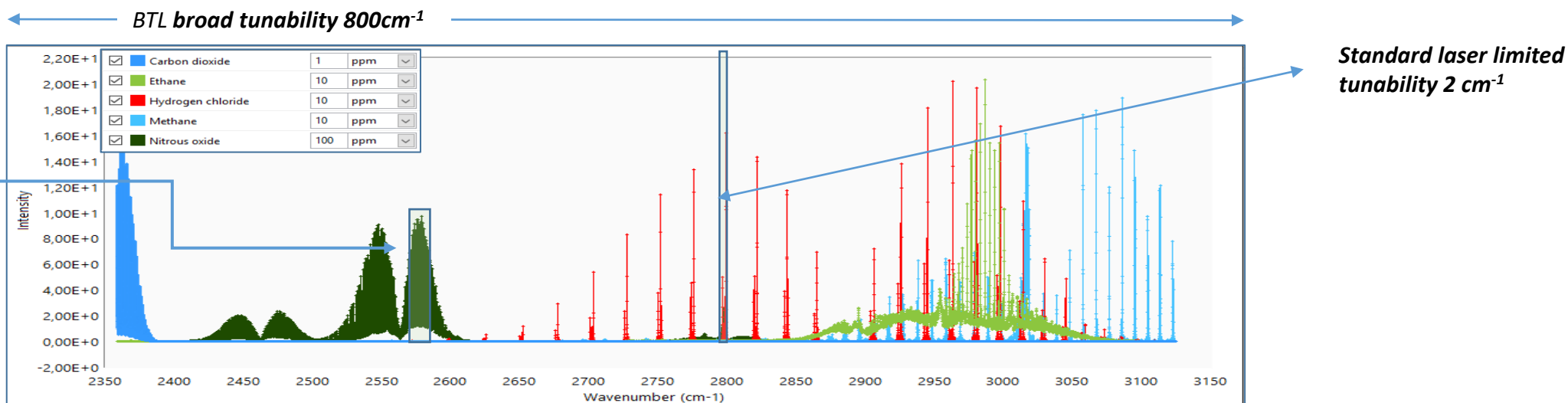
- Blue's advanced suite of tools
- Customizable

The first gas analyzer based on a broadly tunable laser (BTL)

1. The BTL optical source is the heart of the analyzer. It includes 2 proprietary patented modules :
 - A special design, Doubly-Resonant Optical Parametric Oscillator (OPO)
 - A wavelength control unit, that ensures the proper **spectral resolution (up to 0,01 cm⁻¹)**
 - Broad tunability: **spectral range of 800 cm⁻¹**
2. The detection is a photoacoustic cell adapted to the BTL source. Provides trace detection capabilities
 - Measurement at **atmospheric pressure and 50°C** (heating controller in analyzer)
3. A full suite of software for simulation, control-command, maintenance
 - **500+** molecules spectrum catalogue
 - Methods downloaded depending of the applications



Blue's innovative Broadly Tunable Laser (BTL) technology has an extended tunability, equivalent to 400 "standard" lasers !



- **Benefits:** Similar performance to **Infra Red lasers** : stable, robust, easy to use, low maintenance costs, no consumables, continuous measurements
- **Extra benefits of BTL vs "standard" TDL/QCL lasers:**
 - **Hundreds of molecules** with only one laser source, "light" and "heavy" molecules monitored
 - Alcohols, alkanes, alkenes, amines, aromatics, halogenated & sulfur/nitrogen/chlorine compounds, esters, siloxanes....
 - Ability to be **specific** in a **complex matrix** or facing changing conditions
 - **Methods** can be adapted easily depending of **species & concentrations**
 - **Identification** capabilities of non expected molecules

An increasing catalogue of 500+ molecules that can be monitored

<https://www.blueindustryandscience.com/molecules/>

- **Alcohols:** Methanol, Ethanol, PEG, Isopropanol, Cyclohexanol, Phenol...
- **Hydrocarbons:** Linear and cyclic alkanes, alkenes, terpenes, methane...
- **Aromatics:** Benzene, Xylenes, Toluene, Styrene, Naphtalene...
- **Mercaptans:** Ethyl, methyl, tert-butyl...
- **Amines:** TEA, TMA, Aniline, DEA ...
- **Chlorine compounds:** Dichloromethane, Chloroethane, Chlorobutane, 1-Chlorobutane...
- **Acrylates:** Ethyl Acrylate, Methyl Acrylate, Methyl Methacrylate...
- **Esters:** Ethyl Benzoate, Propyl Acetate, Isobutyl acetate...
- **Ethers:** Diethyl Ether, Dipropyl Ether, Ethyl Vinyl Ether, Ethylene Oxide, Propylene Oxide...
- **Fluorine Compounds:** Difluoromethane, Pentafluoroethane, Fluoroacetone, Allyl Fluoride...
- **Non-organics Compounds:** H₂O, CO₂, NO₂, N₂O, SO₂, HCl, HBr, Diborane, Phosphine, ...

New molecules can be added to the catalogue on-demand

Adapted sampling & remote equipments are provided by Blue

- **Extractive sampling, continuous flow** (50 to 200 ml/min), non destructive
- The sampling system ensures that sample conditions at entry point of the analyzer are met:
 - 1bar, $T^{\circ} < 50^{\circ}\text{C}$, sample integrity
- Sampling in reactor **under vacuum** available

Multi-point sampler

- **Multi-point** automatic sampling solutions
 - **Fast-loop** for rapid multipoint sampling
 - **Auto-switch** mode or manual override



Continuous diluter

- For measurements of **high concentrations**
- **Adapted** to measure gas streams with ppb to % concentrations



Blue « mobile » BOX

- All in one box containing **analyzer, air con and remote connection**
- Easily **installed** (non ATEX zone) and **ready to use**



Description of a « standard » Blue measurement campaign

1. Set-up by Blue of analyzer & sampling (2-4h max)

- Employees certified for working in chemical hazards environment
- Installation of analyzer, sampling and remote connection equipment
 - Functional tests and launch of measurements
 - **To be prepared on the customer side:**
 - Intervention plan/work permit(s)
 - Adapted room for installation of active equipment (not ATEX) - **Blue BOX** available on demand
 - Sampling points to be identified prior campaign

2. Remote monitoring:

- Continuous measurements of target molecules, measurement methods adjusted remotely
- Daily reports on measurement to customer

3. At the end of the measurement campaign:

- Dismantling of equipment (2h max)
- Debriefing meeting (within 1 week)
- Submission of the complete report of measurements

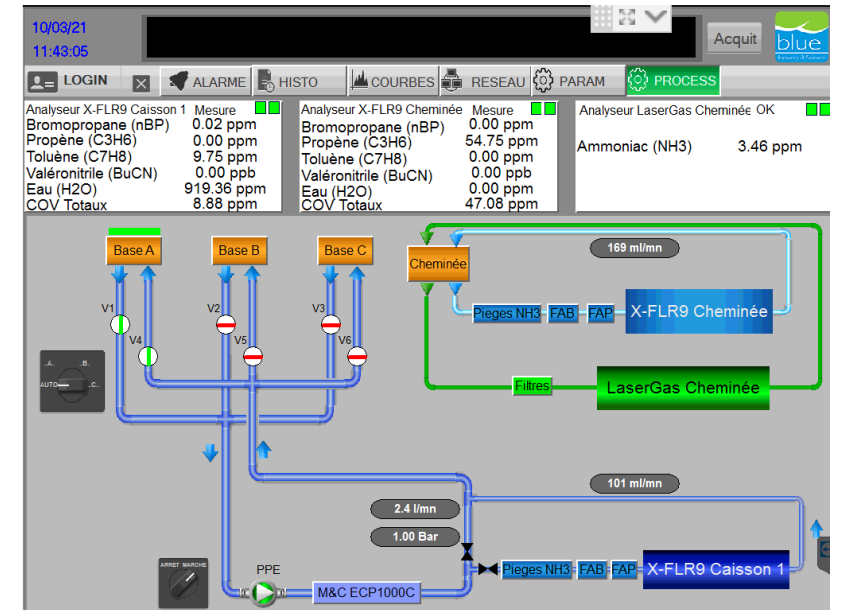
Data Integration solutions provided with analyzers

- **Custom HMI (Human Machine Interface):**

- Integrates data from multiple sources (analysers, flowmeters, process)
- Adapts data presentation according to customer specifications (average, units, frequency, ...)

- **Communication:**

- Analog ports to transmit data to factory Digital Control System (Emerson - Delta V)
 - Measurement information - concentrations
 - System status - alarms
- Dry contact to receive information from factory
 - Switching position for sampling



Powerful solutions for process qualifications and monitoring!

- **Blue provides complete gas measurement solutions**
 - Sampling + Measurement 24h/24 (ppb to %) + Data display & Daily reports
- **For industries with specific gas molecules monitoring needs**
 - Examples: amines, aromatics, chlorine compounds, acrylates, N₂O, H₂O, CH₄.....
 - 500+ molecules catalogue (<https://www.blueindustryandscience.com/molecules/>)
- **Made for continuous monitoring...**
 - No consumables, no recurring calibrations, stable & easy to use, versatile
 - Process monitoring of single or multiple productions
 - Ambient air monitoring of harmful pollutants emissions, HSE mapping
- **... and investigations!**
 - Molecules identification capabilities
 - Process qualification at development stage & process optimization
- **Our offer!**
 - **Measurement services**
 - Rental service with remote support for continuous measurements
 - **Hardware sales**
 - Installation of a unit for continuous monitoring 365 days/yr on a specific gas emission – Long term maintenance contract





THANK YOU

www.blueindustryandscience.com

https://www.youtube.com/channel/UCdLUVI_XjFiWCIX49OY1nEQ/featured



Application example in industrial air emission compliance

EU directive 2017/2398

✓ Characterization of gas emissions and exposures to adapt workers' protection

- Our mobile analyzers can be deployed on an industrial site to continuously quantify the target gas molecules and map out emissions
- Measurements can be sampled precisely, for example close to the most hazardous operations (e.g. loading/unloading operations, transfers...)
- **Benefit** : by linking these measurements to steps in the production process, the site benefits from objective criteria to **characterize exposures and adapt workers' protection (PPEs) to local conditions**

✓ Continuous monitoring of exposure

- Where needed, our fixed analyzers can provide a continuous and permanent monitoring of the target CMR agents
- Multiple sampling points can be monitored by the same analyzer
- **Benefits:**
 - 1- the measurements can feed an alarm system to provide **further safety protection**
 - 2- change in local conditions can be **detected and dealt** with in time

CMR agent	CAS	Exposure limit value (ppm)	Detection limit Blue X-FLR9 gas analyzer (ppm)
Benzene	71-43-2	1	0,039
Vinyl Chloride monomer	75-01-4	1	0,250
Ethylene oxide	75-21-8	1	0,003
1,2 epoxypropane	75-56-9	1	0,025
2-nitropropane	79-46-9	5	0,037
o-Toluidine	95-53-4	0,1	0,044
1,3 Butadiene	106-99-0	1	0,079
Bromoethylene	593-60-2	1	0,330

EU Directive 2017/2398 provides for the protection of workers from exposure to CMR compounds and lists limit values for occupational exposure to 14 CMR agents, of which 10 gas molecules.

What's new in the Blue X-FLR9 Series

Improved technologies

- New crystal design and integration in the OPO.
 - Patented
 - Eliminates T° as an adjusting parameter of wavelengths
 - Fully reproducible
- New wavelength control unit
 - Patented
 - 100 times faster



« Wide scan » operational
Heavy molecules measurement



New architecture

- Modular
- Robustness
- Maintainability
- Industrialized/ ready for scale-up
- Fully reproducible