

Remote Chemical Sensing Review

Airborne Chemical Detection Insights

Perspectives and Emerging Applications in Operational Environment

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Welcome to the **Remote Chemical Sensing Review No. 2**, a publication dedicated to developments in airborne chemical detection and remote analytical technologies.

In this second issue, we continue exploring how remote and airborne sensing technologies are reshaping the way chemical information is collected outside the laboratory. As environmental challenges, emergency response needs, and industrial monitoring demands grow, the ability to detect and analyze chemicals from a distance is becoming an increasingly important capability. From conceptual discussions about the meaning of field chemical analysis to practical examples of airborne monitoring, this issue highlights both the scientific foundations and the emerging real-world applications of remote chemical sensing.

The editor/MS. [Read more...](#)

In this issue:

- **Perspective – What Do We Mean by Field Chemical Analysis?**

An analysis on how the concept of field chemical analysis is evolving in the era of mobile and remote sensing technologies.

- **Application – Field Calibration and Training for Chemical Detection Teams Using Controlled Vapor sources**

The use of field calibration also improves operational readiness by allowing teams to test equipment before deployment. Instruments such as IMS detectors, field mass spectrometers or GC-PID and PID detectors can be evaluated for sensitivity, selectivity, and response time under real atmospheric conditions.

- **Emerging Application – Airborne Monitoring of Ports Air Quality**

A look at how airborne platforms can provide new insights into air quality and emissions in complex port environments.

- **Emerging Application – Airborne Monitoring of Forest Fire Smoke**

An exploration of the role of airborne chemical sensing systems in tracking and analysing smoke from forest fires, supporting both environmental monitoring and public health protection.

Together, these contributions illustrate the growing scope of remote chemical sensing—from conceptual frameworks to operational applications in some of the most demanding environments.

The editor/MS



PERSPECTIVE

What Do We Mean by Field Chemical Analysis?

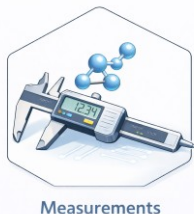
Field Chemical Analysis refers to the process of measuring the type and concentration of chemical compounds as they vary in space and time. In this context, the term “field” reflects the spatial and/or temporal dimension in which measurements are performed. [Read more...](#)

Spatial measurements may be carried out in horizontally or vertically depending on the nature of the environment or the source under investigation. Temporal measurements, on the other hand, are associated with monitoring. These may occur at fixed locations, such as a point emission source or an industrial stack, or may be performed while the measurement platform is in motion. Temporal measurements can be either discrete or continuous.

Field Chemical Analysis therefore produces information derived from spatial measurements, temporal monitoring, or from combined variations in both space and time. **Field screening** represents a specific category of Field Chemical Analysis designed for rapid sorting, separation, or preliminary selection of samples or signals requiring further investigation.

In practice, **Field Chemical Analysis encompasses analytical chemical methods, operational procedures, and the technological devices or systems used to implement them.** Modern field technologies integrate multiple instrumental analytical techniques together with information and communication technologies for data acquisition, processing, and transmission.

In this sense, **Field Chemical Analysis** should be viewed not simply as a measurement activity, but as an **integrated analytical practice combining chemistry, instrumentation, and information communication systems in real-world environments.**



APPLICATION

Field Calibration and Training for Chemical Detection Teams Using Controlled Vapor Sources

Reliable chemical detection in operational environments requires instruments that remain accurate outside controlled laboratory conditions. Field teams responding to hazardous materials incidents or CBRN threats depend on portable analytical devices such as Ion Mobility Spectrometers (IMS), field mass spectrometers, with or without gas chromatographs photoionization detectors (GC-PID). Ensuring the accuracy and proper response of these instruments in real operational settings is therefore essential. [Read more...](#)

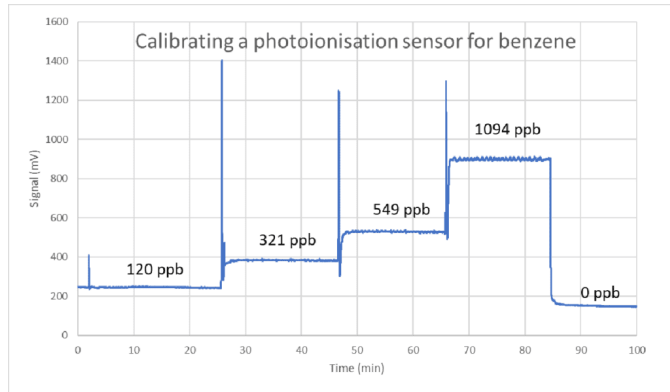
Field calibration systems such as the **T4i FemtoMachine**[®] provide a practical solution for generating controlled concentrations of chemical vapors directly in the field. The system is designed to produce stable and reproducible vapor levels from e.g. solvents and selected CWA simulants, allowing detectors to be tested and calibrated under realistic environmental conditions.

Such capability is particularly valuable for training CBRN response units and hazardous materials teams. During training exercises, the controlled release of trace vapors enables operators to verify instrument response, understand detection thresholds, and become familiar with the behaviour of different sensing technologies.

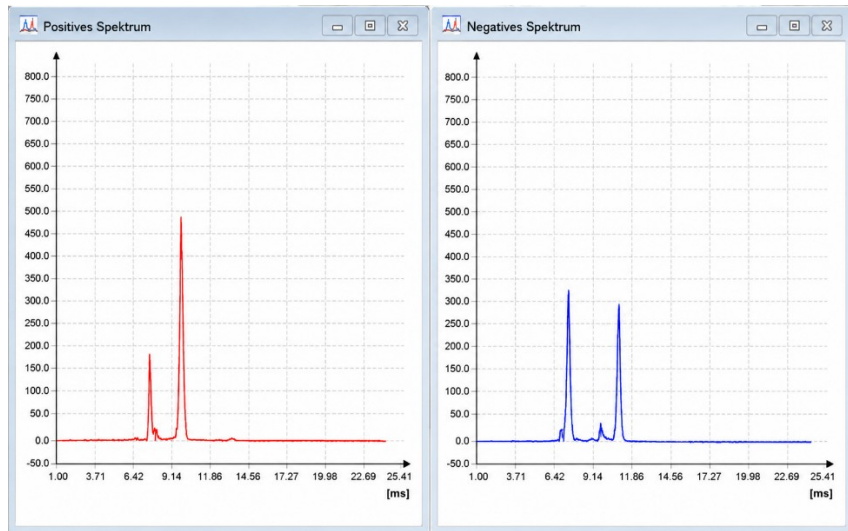
The use of field calibration also improves operational readiness by allowing teams to test equipment before deployment. Instruments such as IMS detectors, field mass spectrometers or GC-PID and PID detectors can be evaluated for sensitivity, selectivity, and response time under real atmospheric conditions.

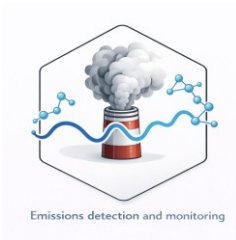
Beyond calibration, the system can support field simulation exercises where teams practice locating the source of chemical emissions. By generating stable vapor plumes, responders can train in plume tracking, source identification, and coordinated detection strategies using multiple sensors.

This approach bridges the gap between laboratory calibration and operational deployment. By providing realistic vapor sources in controlled concentrations, field calibration technologies enhance both instrument reliability and the practical training of teams responsible for responding to chemical hazards.



MSA vapor (simulant)
Calibrator: T4i FemtoMachine® generating 20 ppb concentration
Detector: IMS at 40°C





EMERGING APPLICATION

Airborne monitoring of ports air quality

Ports represent complex emission environments where ship exhaust, cargo handling equipment, trucks, and nearby industries combine to produce significant air pollution. Major pollutants include nitrogen oxides (NO_x), sulphur oxides (SO_x), particulate matter ($\text{PM}_{2.5}$ and PM_{10}), and greenhouse gases originating from maritime fuel combustion and port operations. In many European port cities, shipping emissions can, significantly, influence local air quality, sometimes increasing nearby urban concentrations of NO_2 and particulate matter depending on wind conditions.

EU maritime transport: progress made, but environmental, sustainability challenges persist (Press release Published 04 Feb 2025). [Read more...](#)

Recent European environmental policy developments are placing greater emphasis on monitoring these emissions. The revised EU Ambient Air Quality Directive introduces stricter standards for pollutants such as $\text{PM}_{2.5}$, PM_{10} and NO_2 and identifies ports as potential air-quality hotspots requiring targeted monitoring and assessment.

Airborne monitoring platforms—such as drones, aircraft, or satellite-based systems—offer unique advantages in these environments. They can rapidly map pollution chemical plumes over large port areas, identify emission sources from individual ships or terminals, and capture spatial variability that fixed monitoring stations may miss.

Such capabilities are increasingly relevant as new European regulations take effect. Measures including sulphur emission control areas, the FuelEU Maritime framework, and stricter monitoring and reporting of maritime energy use are driving the need for improved environmental oversight in ports.

Airborne chemical sensing technologies therefore provide an important complementary tool to traditional monitoring networks. By enabling near-real-time mapping of pollutants and supporting compliance verification, these systems can help port authorities and regulators to perform effective surveillance and better understand emission patterns and guide mitigation strategies. As regulatory

requirements tighten toward the EU's 2030 air-quality targets and long-term decarbonization goals, airborne monitoring is likely to become an increasingly valuable component of environmental management in port regions.



EMERGING APPLICATION

Airborne Monitoring of Forest Fire Smoke: Real-Time Chemical Mapping of Wildfire Emissions

Forest fires release large quantities of gases and particulate matter that significantly affect air quality, climate, public health and firemen. Smoke plumes contain a complex mixture of pollutants including carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), particulate matter (e.g. PM_{2.5}), and a wide range of hazardous volatile organic compounds (VOCs). These emissions can travel long distances and influence atmospheric chemistry far beyond the fire zone. [Read more...](#)

Airborne monitoring platforms such as drones equipped with chemical analyzers/detectors provide an effective means of characterizing wildfire smoke in real time. By flying through, next or above smoke plumes, airborne chemical sensors can measure gas concentrations, aerosol properties, and plume dispersion patterns. Instruments such as electrochemical gas and VOCs analyzers, and particle counters, allow detailed characterization of smoke composition.

From a scientific perspective, airborne measurements help quantify emission factors for different types of vegetation and burning conditions. Such information improves atmospheric models used to predict pollutant transport and assess climate impacts. These measurements also help distinguish between wildfire smoke and other pollution sources affecting regional air quality.

Operationally, airborne chemical monitoring supports emergency response and civil protection authorities during wildfire events. Real-time mapping of smoke plumes can guide evacuation decisions, identify areas of high exposure, and assist firefighting teams in understanding plume behaviour under changing meteorological conditions. Drone-based monitoring can also be deployed close to active fire fronts where ground measurements are difficult or dangerous.

Within the European context, monitoring wildfire smoke contributes to the objectives of the EU Ambient Air Quality Directive (Directive (EU) 2024/2881), which aims to protect public health from harmful air pollutants. It also supports activities coordinated under the EU Civil Protection Mechanism, which facilitates cross-border response to large-scale wildfires.

As climate change increases the frequency and intensity of forest fires across Europe and other regions, airborne monitoring technologies are becoming an increasingly important tool for both scientific understanding and operational management of wildfire smoke and its environmental impacts.

If you would like to discuss any of the topics in this Remote Chemical Sensing review, we look forward to hearing from you at RCS@t4ieng.com .



Offices:
Ergaton Typou 10, 16346,
Athens, Greece
LinkedIn: [T4i engineering](#)

Loughborough University Science
and Enterprise Park
5 Oakwood Drive, Loughborough Leicestershire,
LE11 3QF UK

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