Introduction

Benzene, toluene, ethylbenzene, and the three xylene isomers, collectively known as BTEX, are commonly found in industrial processes: burning coal or oil, motor vehicle exhaust, or leaking underground storage tanks. Exposure to these compounds may have adverse health effects; therefore chronic (1 year or longer) inhalation exposure limits have been established.

Compound	Exposure Limit (ppbv)
benzene	3
toluene	60
ethylbenzene	80
xylenes	50

Table 1: Agency for Toxic Substances and Disease Registry Chronic Exposure Limits

Objective

Continuous monitoring of these compounds is important to alert personnel to the possibility of escalating emissions. Frequent BTEX monitoring of air is necessary to ensure a safe working environment.

Figure 1: CMS5000 configured for continuous air monitoring

Materials & Methods

A fully automated, quantitative method was developed for the INFICON CMS5000 Continuous Monitoring System to monitor BTEX levels in air.

- **Air Sampling**
  Air is introduced to the instrument through a screened vessel or direct plumb (< 1 atm.) and then drawn into the instrument using a sample pump.
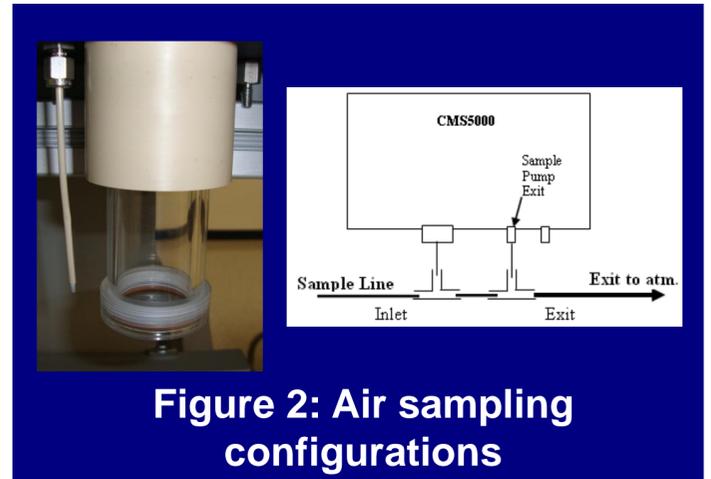

Figure 2: Air sampling configurations

- **Tri-Bed Carbon Concentrator**
  A three bed carbon packed concentrator collects the volatile sample for a method specific period of time. Heat is applied to the concentrator to desorb the sample. The sample is then diverted to the GC column module.

- **GC Column Module**
  The sample is separated using a 30 m, 0.32 mm ID, 4.0 µm df GC column with a DB-1 stationary phase and argon carrier gas.

- **Micro Argon Ionization Detector (MAID)**
  The MAID is sensitive to organic compounds having an ionization potential of 11.7 eV or lower. When argon flows over a Ni-63 source, argon atoms are energized to an excited, metastable state. Organic molecules enter the detector and collide with the metastable argon, becoming charged and releasing electrons. High voltage applied across the detector produces a current, which is amplified and measured to produce a chromatogram.

Ar → Ar* (energized to excited state, exciton)
Ar* (exciton) + R (organic molecule) → Ar + R⁺ + e⁻

Figure 3: GC Column Module

Figure 4: MAID detector assembly

Method Calibration

Five concentrations of a liquid BTEX standard were prepared in nitrogen and then analyzed. The concentration range was 1.5 ppbv to 123 ppbv, depending on the molecular weight of each analyte. Sample was collected onto the Tri-Bed concentrator for 2 minutes. The analysis time is ~15 minutes.
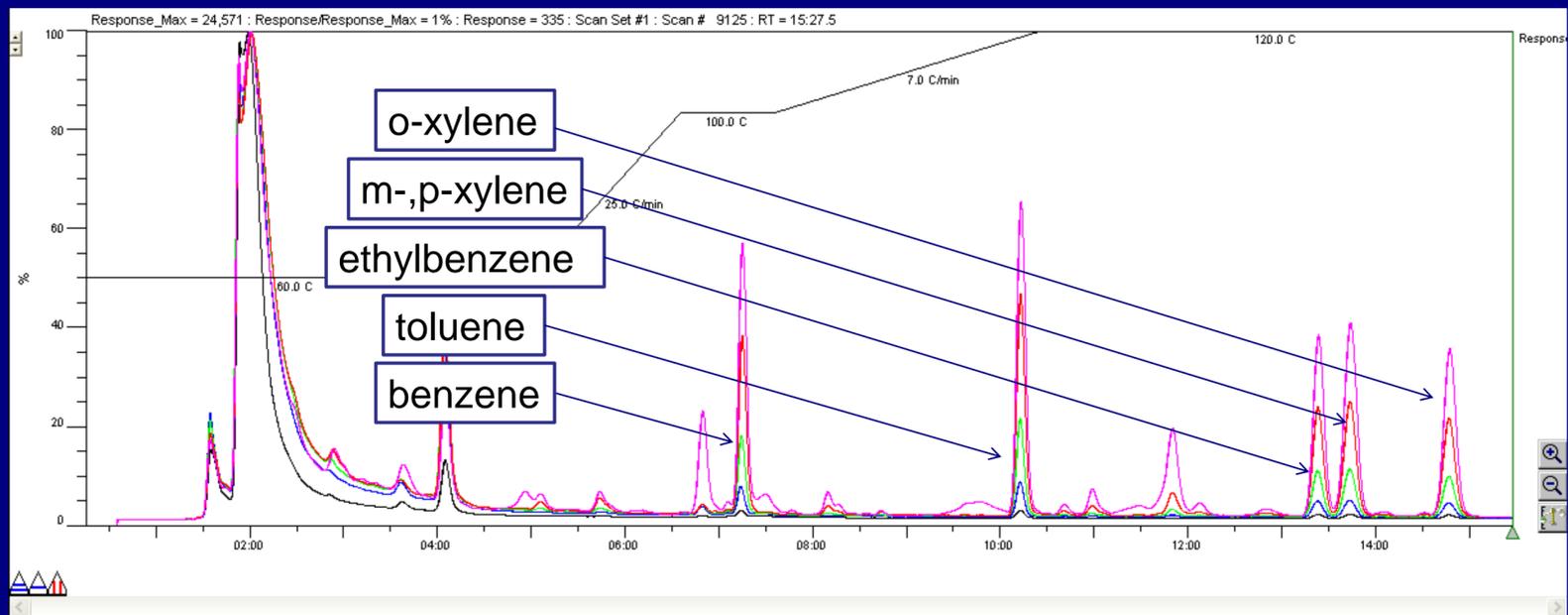

Figure 5: Chromatogram overlay of the 5-point calibration showing the programmable temperature profile – 60 ⁰C (hold 5 min) to 100 ⁰C at 25 ⁰C / min (hold 1 min) to 120 ⁰C at 7 ⁰C / min

Quadratic Calibration Fit

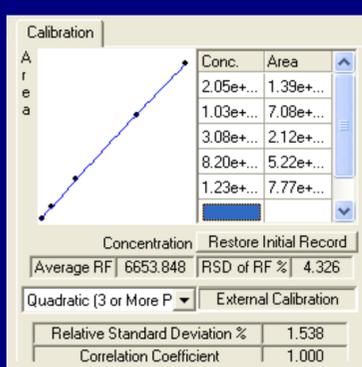The instrument produces calibration curves which follow a quadratic fit pattern.
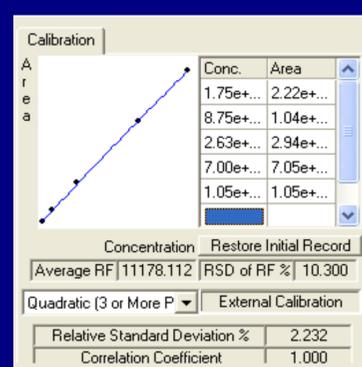

Figure 6: Benzene calibration curve
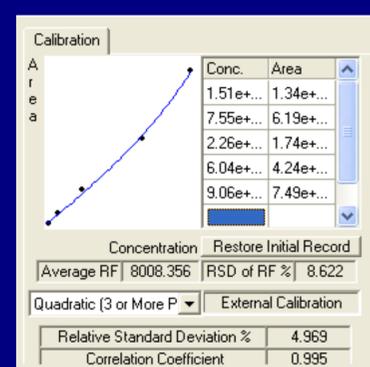

Figure 7: Toluene calibration curve

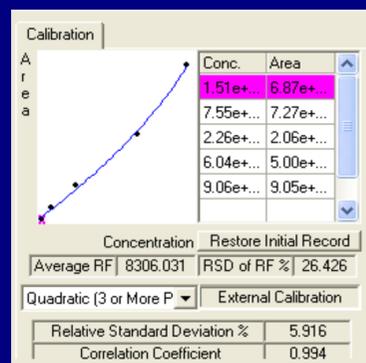**Figure 8: Ethylbenzene calibration curve**

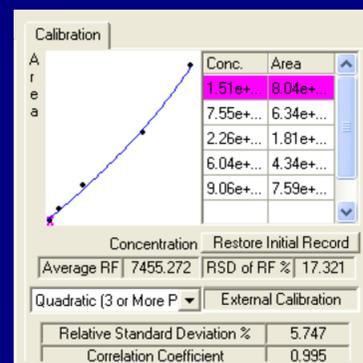**Figure 9: Meta-, para- xylene calibration curve**

Figure 10: Ortho-xylene calibration curve

Internal Check Standard

The instrument contains an on-board toluene permeation tube, which emits toluene at a consistent rate. Each check standard run establishes a correction factor, which is applied to subsequent data, to compensate for slight instrument drift.
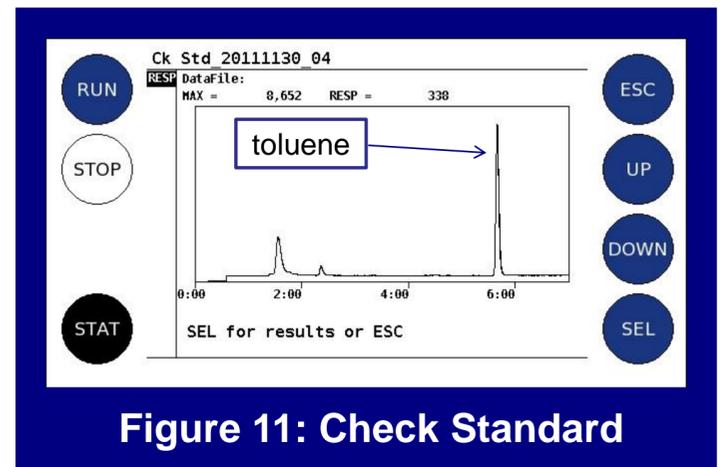

Figure 11: Check Standard

Results

Instrument accuracy is ± 20%. A quantitative report is accessible through the software and instrument front panel.
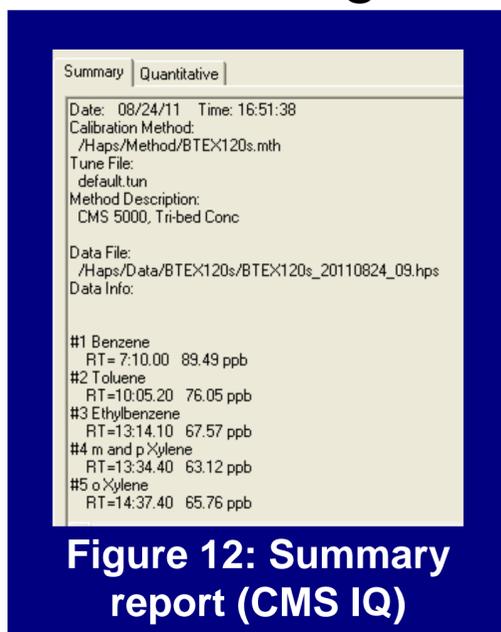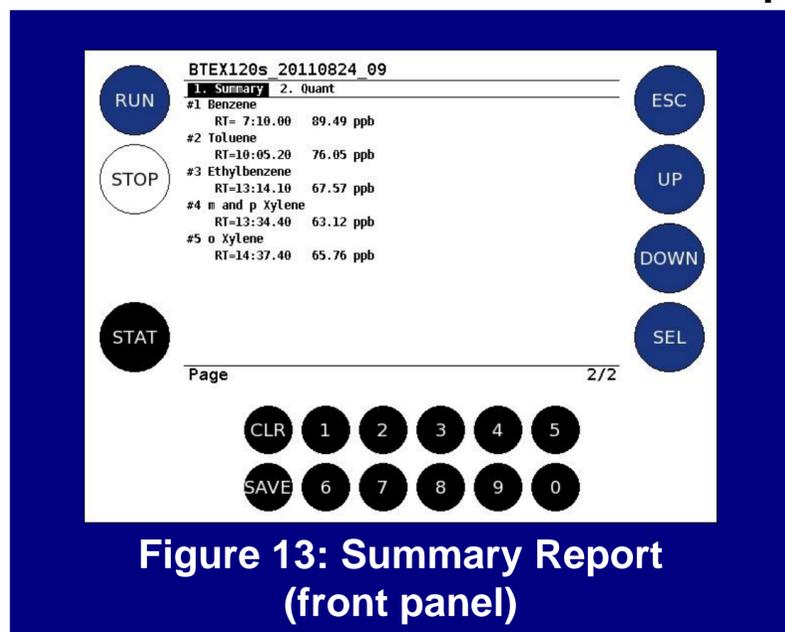

Figure 12: Summary report (CMS IQ)

Figure 13: Summary Report (front panel)

Compound	Expected (ppbv)	Actual (ppbv)	Recovery (%)
benzene	92	89	96.7
toluene	78	76	97.4
ethylbenzene	68	68	100
meta-, para-xylene	68	63	92.6
ortho-xylene	68	66	97.1

Table 2: Analyte Recovery – 93 to 110%

Conclusion

The INFICON CMS5000 has the ability to collect, analyze, quantify, and report BTEX concentrations in air – multiple times per day, over an extended period of time with virtually no human intervention. The instrument is an excellent option for continuous on-site monitoring of BTEX levels in air. Continually monitoring air to be certain BTEX levels are within acceptable limits will help to ensure the safety of workers and the environment.