ORS-Based Air Monitoring During An MGP Site Cleanup




By **Stuart P. Schulz Jr, Timothy R. Minnich, Robert L. Scotto,** and **Stephen H. Perry**

Dallas-based Atmos Energy Corporation recently completed a removal action at a former manufactured gas plant (MGP) site in Tennessee, removing approximately 1,200 tons of coal tar and impacted soils from two tar wells and a spray pond area. The site is located in the historic downtown center of Bristol, adjacent to the county courthouse. Development of an effective ambient air monitoring program was necessary to ensure safe ambient air quality for the downwind community at all times during the cleanup.

Having completed two other MGP site cleanups, Atmos Energy was familiar with traditional point monitoring but was interested in a technology that could offer improved data quality and real-time data capabilities. Therefore, Atmos Energy began researching alternative monitoring approaches which were simple, unobtrusive, and able to acquire real-time data, and which had increased sensitivity and the capability to analyze many compounds simultaneously. Optical remote sensing (ORS) addressed all of these needs.

Optical Remote Sensing — "The Eye That Never Sleeps"

ORS uses energy within the ultraviolet and mid-infrared portions of the electromagnetic spectrum to detect and measure contaminants in situ. ORS technologies include open-path Fourier-transform infrared (FTIR) and ultraviolet (UV) spectroscopy, and tunable diode laser (TDL) spectroscopy.

ORS has been dubbed "the eye that never sleeps" because, in theory, once positioned along the downwind site perimeter, any gaseous compound which passes through the beam of light can be detected and measured - even when the monitoring equipment is unattended. Ultimately, Atmos Energy selected open-path FTIR based on the technology's ability to measure the contaminants of concern and because of its legal status as a U.S. EPA-approved ORS method (Compendium Method TO-16).

Open-Path FTIR Monitoring System

A typical open-path FTIR monitoring system consists of an infrared (IR) transmitter/receiver and a retro reflector which are placed inside the fence line, downwind of the emissions-affecting activity. The collimated IR radiation is transmitted through the atmosphere (and target compounds) to the retro reflector which reflects the light back to the detector. The detector measures the absorption over a range of wavelengths, and each target compound is identified and quantified by comparing, via a classical least squares fitting routine, the measured intensity spectra to the compound's known library spectra.

An EDO Corporation RAM2000 open-path FTIR spectrometer was used to measure 14 volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs), approximately 1.5 meters above grade.

Target gaseous compounds are presented in Table 1.

Table 1: Target Gaseous Compounds

Compound	Compound
ammonia	phenol
benzene	styrene
m-cresol	toluene
o-cresol	1,2,4-trimethylbenzene
p-cresol	m-xylene
ethyl benzene	o-xylene
naphthalene	p-xylene

Continuous, real-time meteorological monitoring was performed to assist interpretation of the open-path FTIR data as well as to document atmospheric transport for evidencing proper FTIR-monitoring configurations. A Climatronics TACMET Weather Sensor was equipped to monitor, at a height of three meters, wind speed, wind direction, and sigma-theta (standard deviation of the horizontal wind direction) — a parameter calculated from individual, once-per-second, wind direction measurements.

Offsite Action Levels

Site-specific offsite action levels (ALs) were developed for all target compounds. For each compound, an ambient air acceptable concentration (AAAC) was defined for exposure durations of one hour and eight hours per day during the removal action (conservatively assumed to be six weeks). Results of a risk assessment showed there would be no potential adverse health impacts to the downwind community if the average ambient air levels did not exceed these concentrations during these time periods.

A one-hour exposure duration was applied to the general population at the site perimeter and addressed the exposure scenario of people parking their cars and walking to and from the nearby county courthouse. An eight-hour exposure duration was applied to the general population inside the courthouse and addressed the exposure scenario of courthouse employees or visitors being present for a normal eight-hour day inside the building.

Action levels were established for all target compounds to ensure the AAACs were maintained. An AL exceedance alerted onsite personnel that implementation of some type of mitigative measure might be necessary in order to keep ambient air concentrations within these acceptable ranges.

All ALs were defined as 10-minute-averaged values, and all "monitoring events" were precisely 10 minutes in duration. This time period was chosen based on statistical considerations in establishing representative sigma-theta values for subsequent use in the meas-

urement of plume width.

Given that 10 minutes affords ample opportunity to initiate mitigative measures, there was no need to set the AL concentrations any higher or more conservative than the AAACs. For simplicity, the AL concentrations were set equal to the AAACs.

This approach to removal-action monitoring is in contrast to programs based on typically employed, traditional point techniques, where sample readings can take hours. Further, this approach obviates the need for regulatory agencies to apply a "safety factor" to account for data-quality uncertainties.

Table 2 presents the 10-minute ALs based on the one- and eight-hour exposure scenarios.

Table 2: 10-Minute Action Levels

Target Compound	Fence line 10-Minute Action Level (mg/m_3)	Sensitive-Receptor 10-Minute Action Level (mg/m_3)
ammonia	18.0	18.0
benzene	1.6	1.6
m-cresol	22.0	22.0
o-cresol	22.0	22.0
p-cresol	22.0	22.0
ethyl benzene	435.0	435.0
naphthalene	0.90	0.21
phenol	19.0	19.0
styrene	85.0	85.0
toluene	188.0	188.0
1,2,4-trimethylbenzene	125.0	125.0
m-xylene	435.0	435.0
o-xylene	435.0	435.0
p-xylene	435.0	435.0

Cross-Sector-Averaging Technique

The cross-sector-averaging technique was used in conjunction with open-path FTIR monitoring for the direct assessment of offsite contaminant exposure. Conceived of and employed by U.S. EPA Region 7, this technique involves collecting path-integrated, crosswind contaminant measurement data downwind of the source (concentration units of parts per million times meter, ppm-m, or milligrams per square meter, mg/m_2), and then dividing each concentration by the plume width (m) to yield a representative maximum impact along the FTIR beam (ppm or mg/m_3). This technique provides a conservative methodology for assessing the maximum

10-minute averaged concentration at any downwind location.

A "dilution factor" is applied to the maximum beam impact in order to account for the increasing amount of contaminant "loss" due to atmospheric dispersion as the plume is advected toward the downwind receptor(s). The dilution factor is based on previously performed dispersion modeling.

Identification of an appropriate plume width depends on three factors: (a) various properties of the plume as it is transported along the mean wind direction; (b) the distance between the source and the FTIR beam; and (c) the width of the source, in this case the excavation area.

The above approach was applicable even when there were two or more simultaneously emitting sources, as was generally the case. Because each measured path-integrated concentration reflected the combined impact of all sources impacting the beam, the sources furthest from the site perimeter were conservatively considered to be superimposed upon the closest source.

Field Data Management

Excel-based input and output forms were used for each monitoring event. Upon entry of the data into a computerized data-management system, the program automatically calculated the maximum fence line and offsite exposure during each event.

Responsible field project personnel were immediately notified whenever the concentration of a given target compound exceeded its AL. When two such exceedances occurred during any moving one-hour period, appropriate measures were initiated. Such measures included covering the contaminated soils and coal-tar materials with tarps and odor suppressing foam, reducing the rate of lime addition, and slowing or temporarily suspending removal-action activities. Air monitoring continued and removal work was not resumed until two consecutive acceptable monitoring events occurred.

Monitoring Configurations

Continuous wind-direction forecasting was provided in order to assist onsite decision-making with respect to the open-path FTIR monitoring configurations. Optimal configurations were employed to ensure protection of any individuals who might potentially be present in the downwind direction.

During calm conditions and when the wind was light and variable, the monitoring configurations were always protective of the occupants of the County Court House. This meant that one of the spectrometer's beam path segments was always oriented along the easternmost site perimeter. A flat mirror was employed to "bend" the FTIR beam so that two adjacent sides of the site perimeter could be monitored during a given monitoring event.

Results

Results of the removal-action monitoring clearly demonstrated that the safety of all offsite individuals was maintained at all times. A total of 326 open-path FTIR monitoring events were performed over the course of the nine-day removal action. In accordance with the work plan, at least four monitoring events were performed each hour of removal-action activity. Out of 4,564 measurements, there were 3,954 non-detects, 610 detects, 29 detects above a fence line AL (0.64% frequency), and 6 detects above an offsite AL (0.13% frequency).

Naphthalene was the most frequently detected target compound (193) followed by ammonia (157). Benzene was detected a total of 16 times.

Naphthalene (24) and benzene (5) were responsible for the 29 fence line AL exceedances, and naphthalene for all six offsite AL exceedances. Most exceedances occurred during in situ coal-tar conditioning and stockpiling, while others occurred during truck loading for offsite disposal and during maintenance of stockpiled materials. There were no AL exceedances of either type during excavation of overburden or during removal of underground structures and debris.

Precision & Accuracy

Precision and accuracy were assessed for all open-path FTIR data collected. For each monitoring event, carbon tetrafluoride (CF4) was introduced into the spectrometer's flow-through cell from a cylinder traceable to the National Institute of Standards and Technology (NIST) and measured for precision. Accuracy was assessed at the beginning and end of each day by measuring sulfur hexafluoride (SF6), also introduced into the flow-through cell from a NIST-traceable cylinder.

Excellent precision and accuracy were noted during each monitoring day - well within the project measurement quality objectives (MQOs). The average precision achieved for all of the FTIR data was +1.56% and the average accuracy was 5.72%.

Conclusions

The main objective was achieved, ensuring safe ambient-air conditions were maintained at all times, as was the secondary objective of supporting onsite mitigative decision-making. Applica-tion of the cross-sector-averaging technique proved to be particularly straightforward for meeting these objectives.

The monitoring program design enabled the AAACs to be directly assessed, without applying "safety factors" to account for data-quality uncertainties.

Offsite contaminant transport during calm conditions or when the wind was light and variable — typically problematic with more traditional approaches — was effectively addressed, as conservative meteorological defaults were employed and the entire site perimeter segment between the emission sources and the nearest receptors was monitored during such times.

Based on the bids received, the ORS approach was about 25% less costly to

implement than the traditional point-monitoring approach. This is even more significant when one considers the effectiveness of the ORS approach in meeting the program objectives. ***P&GJ***

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Timothy R. Minnich *is a meteorologist and atmospheric scientist with over 25 years experience specializing in the design and implementation of air toxics investigations. Since 1988, he has designed and managed more than 25 ORS-based field investigations, most of which were performed for regulatory application. He is the principal developer of the cross-sector-averaging technique as applied to open-path spectroscopic data for the real-time assessment of offsite AL compliance.*

Robert L. Scotto *is a meteorologist and atmospheric scientist with over 25 years experience in the design, management, and execution of a variety of air quality investigations. He is expert in a broad range of CERCLA-related QA/QC issues. Scotto was the principal developer of Minnich and Scotto's proprietary computer-based, real-time data-management software package employing open-path spectroscopic data and coincident meteorological data to facilitate real-time assessment of action-level compliance.*

Stephen H. Perry *is a bio-resource engineer with more than 10 years experience in the operation of open-path FTIR spectrometers and ancillary measurement equipment. He has full responsibility for servicing all of EDO's permanent, open-path FTIR monitoring networks at chemical plants throughout the United States and South America.*