AN ADVANCED OPEN PATH ATMOSPHERIC POLLUTION MONITOR FOR LARGE AREAS[*]

L. Taylor (412) 256-1650
D. Suhre (412) 256-1649
N. Singh (412) 256-1469
J. Seidel (412) 256-1228
Northrop Grumman STC
1350 Beulah Road
Pittsburgh, PA 15235-5080

A. Anderson (412) 256-2183
Westinghouse STC
1310 Beulah Road
Pittsburgh, PA 15235

B. McVey (505) 665-5255
G. Busch (505) 665-1941
R. Nemzek (505) 665-3670
M. Schmitt (505) 665-7522
Los Alamos National Laboratory
CST-1, MS E543
Los Alamos, NM 87545

Abstract

Over 100 million gallons of radioactive and toxic waste materials generated in weapon materials production are stored in 322 tanks buried within large areas at DOE sites. Toxic vapors occur in the tank headspaces due to the solvents used and to chemical reactions within the tanks. To prevent flammable or explosive concentrations of volatile vapors, the headspace gases are vented, either manually or automatically, to the atmosphere when the headspace pressure exceeds preset values.

These underground storage tanks are grouped into "tank farms" which contain 2 to 18 closely spaced tanks in areas as large as 1 km^2. The objective of this program is to protect DOE personnel and the public by monitoring the atmosphere above these tank farms for Toxic Air Pollutants (TAPs) which could endanger personnel safety, as well as to be able to measure TAP concentrations in fugitive emissions wherever and whenever they may occur.

[*] Research sponsored by the U.S. Department of Energy's Federal Energy Technology Center, under contract DE-AR21-95MC32087 with Northrop Grumman STC, 1350 Beulah Road, Pittsburgh, PA 15235; fax: (412) 256-1661.

The concept being developed to monitor these large areas is the Thermal Emission, Laser Absorption (TELA) Atmospheric Pollution Monitor. The concept is based on a pulsed CO_2 laser tuned to a high absorbing line of each gas of interest and to wavelengths at which there is little absorption as the laser beam traverses the atmosphere. The returned intensities on the high absorbing and low absorbing lines are ratioed to determine the concentration of each gas. The laser lines are much narrower than the absorption lines, thereby providing high spectral selectivity in the 9-11 μm region, which is within the 8-14 μm "fingerprint" region where most large molecules have unique spectral absorption signatures.

The laser intensity is sufficiently low that the laser beam is eye-safe, even at the Monitor's exit window, but the intensity is sufficiently high that topological objects, e.g., trees or buildings, as far away as 4 km can be used as back-reflectors. Time-of-flight measurements give the distance to the topological reflector.

The wavelength-restricted laser system is augmented with an acousto-optic tunable filter (AOTF) which gives two beams separated by 10.6°: an unfiltered beam and a filtered beam. Each beam has its own HgCdTe detector cooled by a Split Stirling Closed-Cycle cooler. The unfiltered beam contains the reflected laser beam while the filtered beam contains the thermal emission spectra from the pollutants. The thermal emission beam is centered anywhere from 3 to 13 μm with a 3 cm^{-1} bandwidth. Path-averaged concentrations are determined from the AOTF-measured thermal emission intensity and the laser-determined range.

Sensitivity to narrow thermal emission lines masked by strong background radiation is enhanced orders of magnitude by wavelength-modulation spectroscopy in which the passband of the AOTF is repetitively stepped between two center wavelengths via the rf drive.

All data is digitized for high accuracy and the Monitor is completely computer controlled. Individual gas concentrations are determined from the data by the Partial Least Squares multivariant analysis software. The estimated concentrations are presented in easily read bar graphs which include nominal concentrations for normal atmospheric gases and danger levels for hazardous gases.

The Monitor must be mobile to be applicable to potential pollution sites miles apart and to have sufficient range to monitor DOE waste tank farms without becoming radioactive or contaminated. The Monitor has a monitoring range of 4 km. Its optics fit on a 4' x 8' optical bench and the entire Monitor will fit into a 26' Motorized Laboratory.

The major benefit of this design is that rapid open-path monitoring for dangerous vapors occurring within large areas is obtained from a completely computerized, self-contained instrument which is easily moved to different areas. The complete system is being assembled and will be laboratory tested by the end of the year.

Acknowledgments

We gratefully acknowledge the support of the Federal Energy Technology Center Contracting Officer's Representative, Maria Vargas.