Abstract
AICHE Conference

Optical Remote Sensing and Its Application to Emission Factor development for the Fertilizer Industry

R.L. Spellicy
Radian Corporation

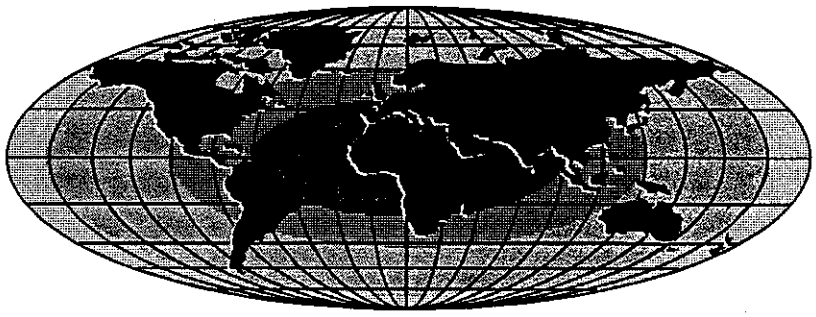
The U.S. EPA is actively developing emission factors for industries to be regulated under the Clean Air Act Amendments of 1990. These factors will be used to determine annual emissions of controlled compounds based upon process parameters. Because these factors will be used to regulate the industries involved, it is critical to those industries that the emission factors be accurate and that they truly represent the industry.

The fertilizer industry has both stationary (stack) and area (pond) sources. To assist the industry in establishing their emissions levels from these sources, Radian Corporation was contracted by The Fertilizer Institute (TFI) to perform emission measurements at several plants in Florida. The particular compounds of concern to the fertilizer industry (HF, SiF_4, etc.) and the types of sources involved make measurements by conventional methods both difficult and uncertain. Radian has therefore applied a new technique, optical remote sensing, to the problem. Optical remote sensing operates by propagating an infrared or ultraviolet light beam through the region to be monitored, capturing this beam after passing through the region, and analyzing the received light to evaluate what compounds are present and at what concentrations. This paper will

- Outline the principles of operation of these systems,
- Show typical instrumentation,
- Present data collected from representative plants, and
- Show methods used to estimate emission factors from the data.

This technology has also been used for continuous fence-line and in-stack monitoring at a variety of industrial sites. The output of the monitors is made available to the plant manager and environmental/safety officer in real time. Software displays of actual data will be presented showing how emissions can be assessed and how the origin of certain emissions can determined.

Technology at Work℠



RADIAN CORPORATION

Outline

- Why Remote Sensing?
- Basic operational principles of remote sensing systems
- Applications of remote sensing systems
- Examples of data and user interfaces - current systems
- Details of Analytical Methods

Why Remote Sensing?

- Many monitoring requirements emerging from the Clean Air Act cannot be adequately met with current technology
  - Real time monitoring of multiple HAPS compounds in stacks or at the fence-line (MACT effectiveness)
  - Assessment of total emissions from distributed or area sources
  - Establishment of realistic emissions factors for industrial sources

Why Remote Sensing?

- Remote sensing systems provide measurements on multiple compounds from industrial sources on a minute-to-minute basis.
  - Continuous in-stack monitoring of multiple compounds simultaneously
  - Fence-line monitoring of fugitive emissions
  - Monitoring of accidental releases in-stack or in the open air
  - Monitoring of public exposure to fugitive or accidental releases

The HRM Demonstration Test
Sponsored by HRM, Exxon, Radian

The HRM/Exxon Demonstration Program (1991)

- A Demonstrations of IR and UV technology in an industrial environment
- Conclusions of the HRM test
  - Technologies mature enough for industrial monitoring today.
  - Systems capable of stand-alone operation although some refinements desirable.
  - Detection limits for most compounds of interest adequate - however some improvements desireable.
  - Data presentation to user needs development

Developments since 1991

- **Focus has been on IR systems because of their ability to detect both criteria and VOC compounds.**

- **Rugged IR systems have been designed and developed specifically for industrial use.**

- **Refined analysis methods have been developed reducing detection levels to low ppb level for most compounds.**

- **User interfaces developed providing data display for plant managers and safety officers.**

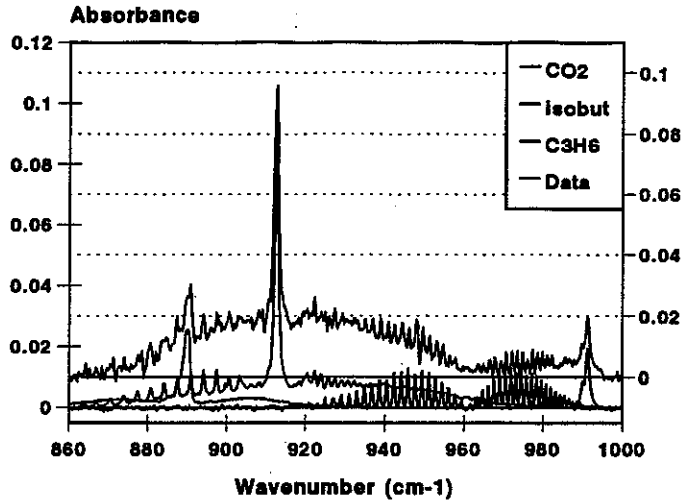
Basic Concepts of Remote Sensing

Open-path and Extractive Monitoring
Classical Least Squares - IR/UV

Linear Least Squares Regions and components

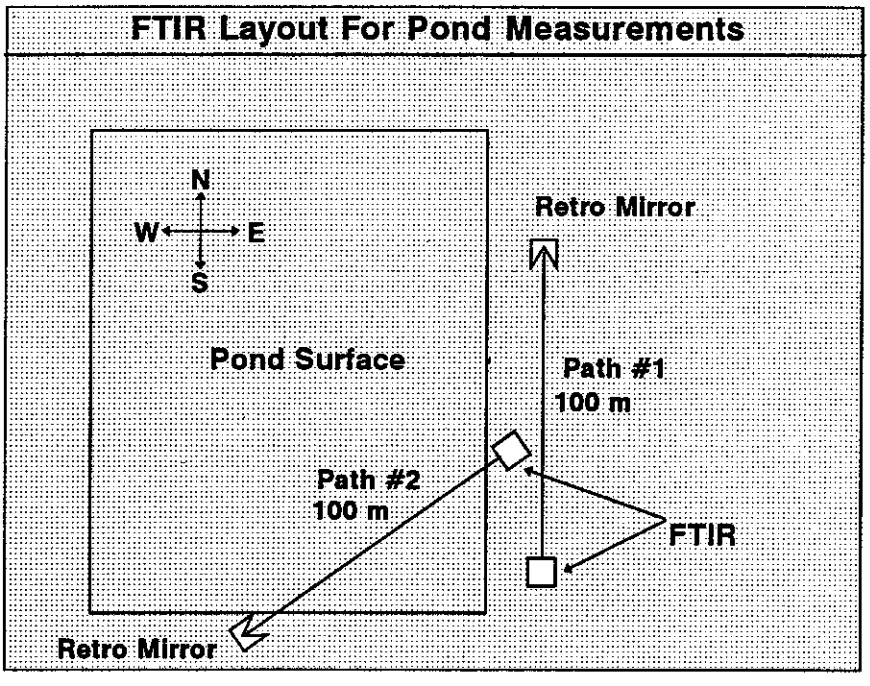
Region	H_2O	CO	CO_2	NH_3	CH_4	C_2H_4	C_3H_6	H_2CO	CH_3OH	C_6H_6	C_7H_8	ISBUT	13BUT	MXYL	MTBE	HCL	CH_3CL	N_2O	NO	SO_2
743.50	I	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-
766.25	I	-	I	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-
889.50	I	-	-	I	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-
937.50	S	-	I	S	-	S	S	-	-	-	-	S	-	-	-	-	-	-	-	-
1009.00	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	S	-	-	-
1035.50	I	-	I	I	-	-	-	-	S	S	S	-	-	-	-	-	I	-	-	-
1095.00	I	-	-	I	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-
1148.00	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S
1900.00	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S	-
2138.50	I	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2207.50	I	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S	-	-
2787.00	I	-	-	-	I	-	-	S	I	-	-	-	-	-	-	S	-	-	-	-
2932.50	I	-	-	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Difference Spectrum
Reference File Overlays

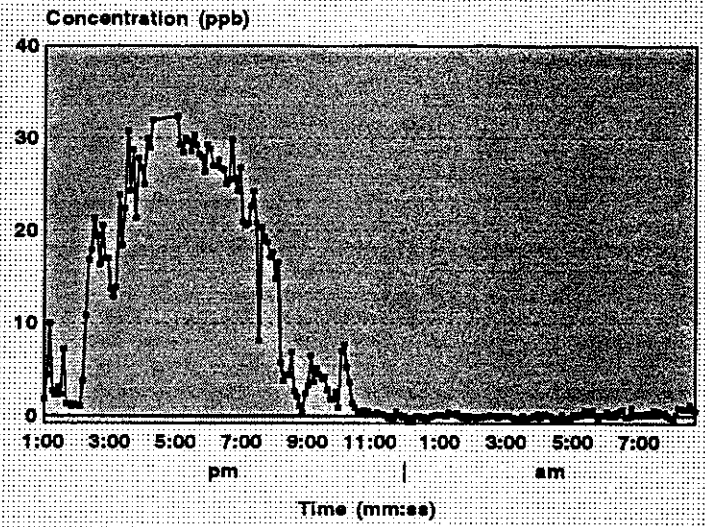


0.5 cm-1 resolution

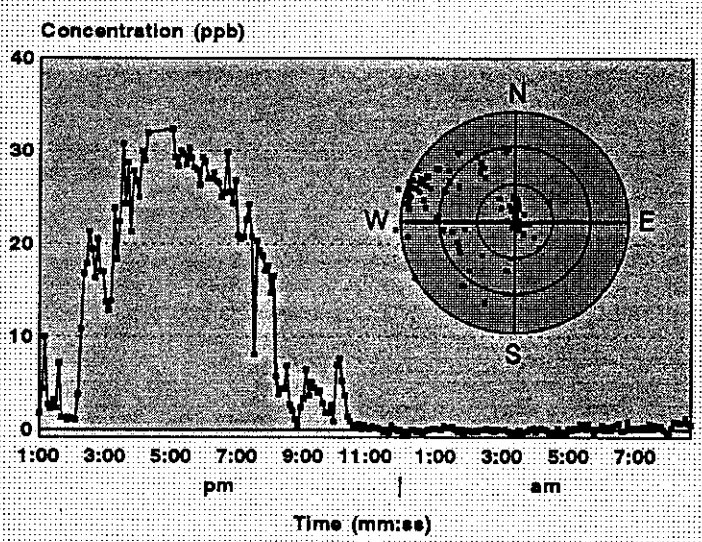
Representative Data
--
Open-air Pond Measurements
Industrial Stack Monitoring



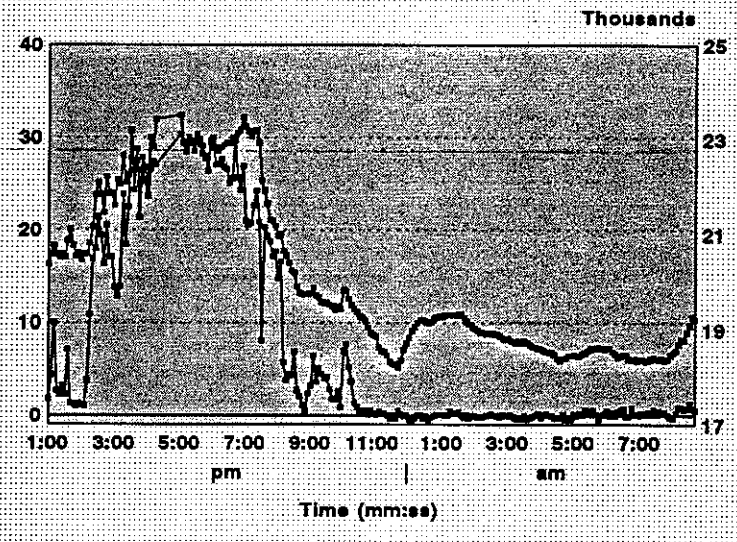
HF Vapor Concentrations
Adjacent to Gypsum Pond 02/21/94



HF Vapor Concentrations
Adjacent to Gypsum Pond 02/21/94

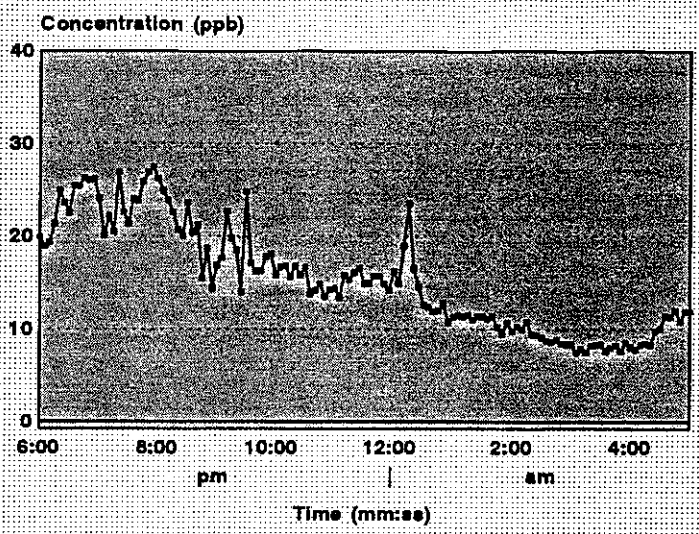


HF Vapor Concentrations
Adjacent to Gypsum Pond 02/21/94



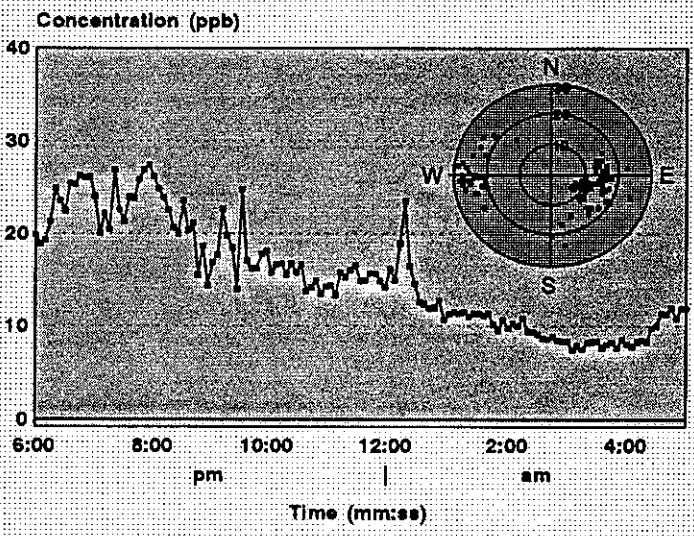
HF Concentrations

Immediately Above Pond Surface 02/22/94



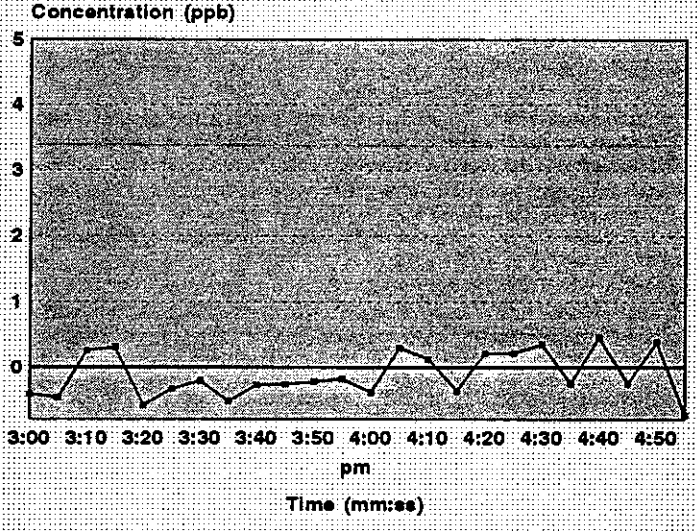
HF Concentrations

Immediately Above Pond Surface 02/22/94



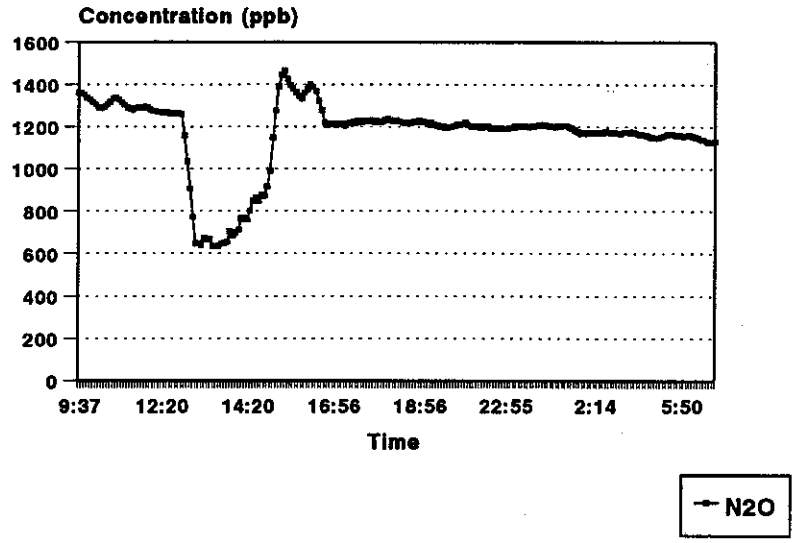
SIF4 Vapor Concentrations

Immediately Above Pond Surface 02/22/94

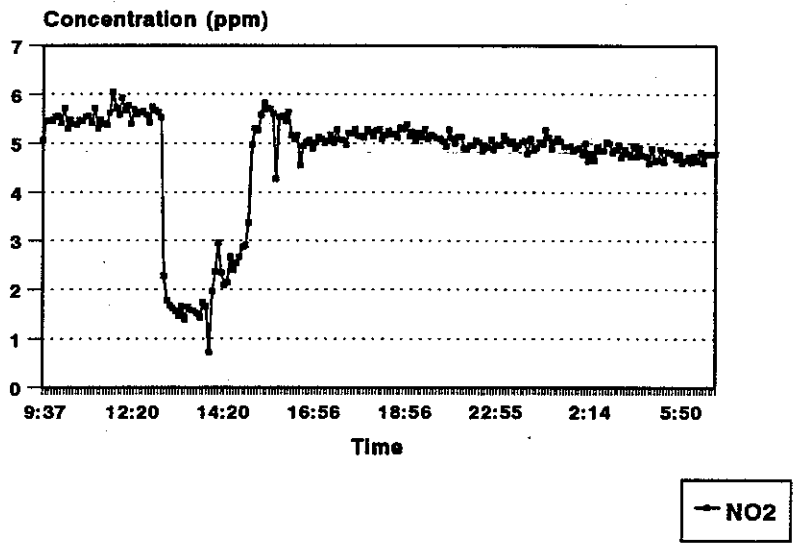


Extractive Monitoring
--
Industrial Stacks/Vents

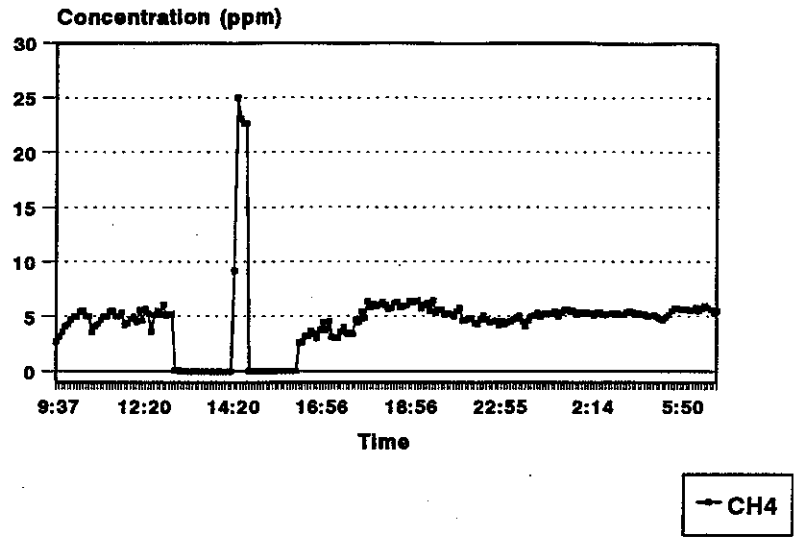
Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



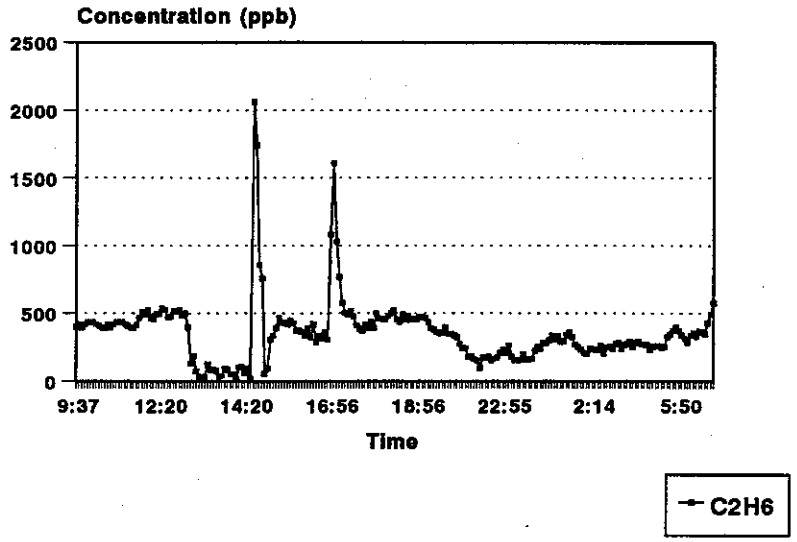
Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



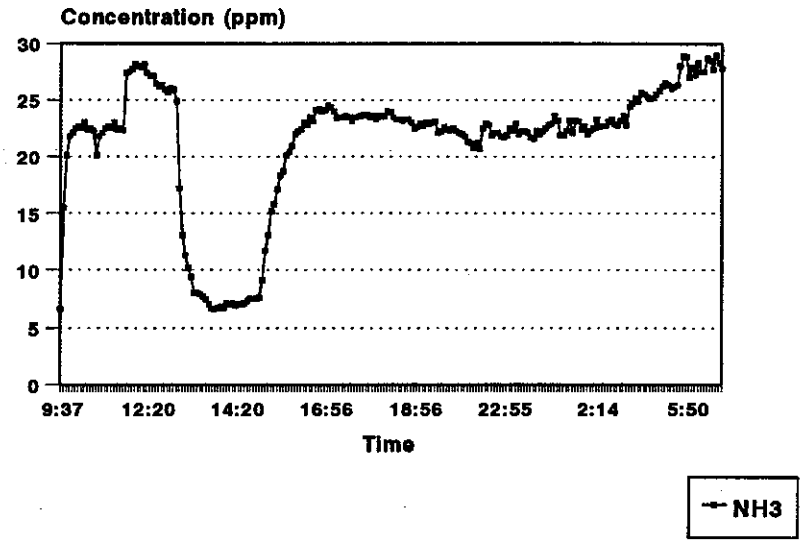
Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



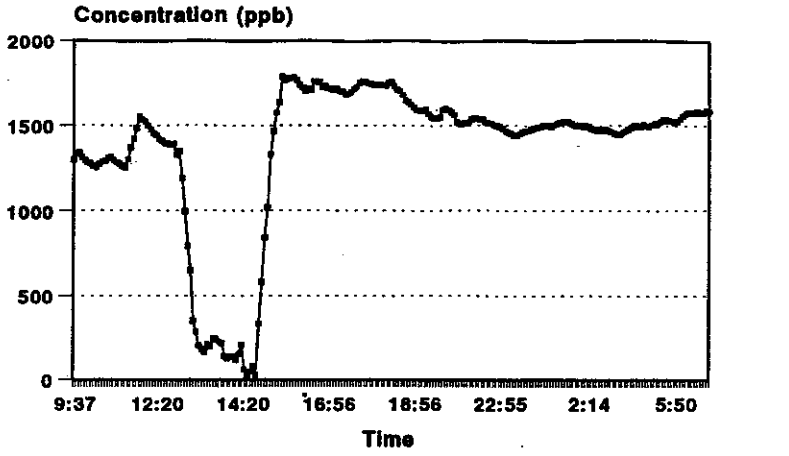
Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



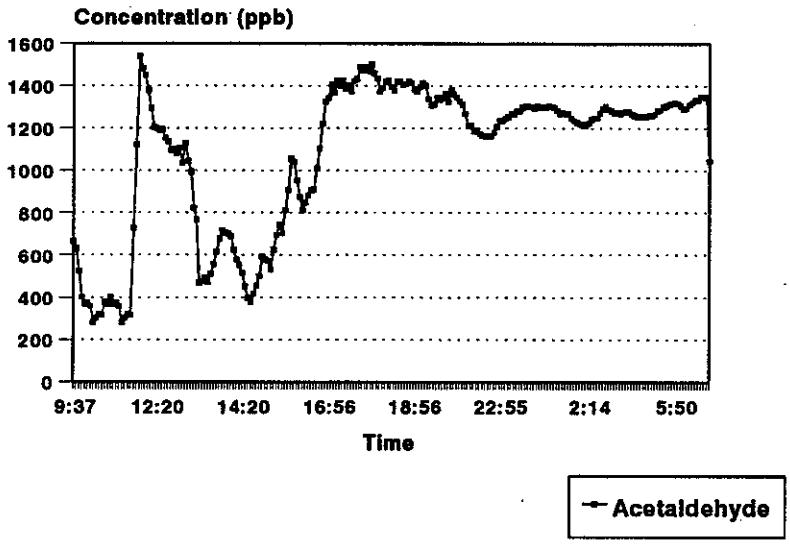
Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



Extractive FTIR Gas Concentrations
Typical Industrial Exhaust Stack (100 C)



Conclusions

Acceptance of Optical Systems In The United States

- FT-IR is in use by EPA for inventory and superfund applications and protocols are being developed for its use in extractive and open-air applications
- FT-IR has been tested for certain compounds as an in-stack CEM monitor and has been accepted by EPA
- State agencies are beginning to use these systems and some agencies are ordering portable systems for regulatory use
- Industry is installing fence-line and stack systems and ordering portable systems for mobile measurements at their facilities

Conclusions Regarding Utility of IR and UV Systems

- FTIR, UV-DOAS and GFC Systems are now developed and tested to the point that they are seeing more regular use in the U.S. for:

- - Extractive and In-situ Stationary Source Measurements
  CEM
  Emission factor and emission inventory development

- - Open-path air measurements
  Continuous fence-line monitoring
  Accidental release detection/emergency response
  Mobile wide-area spot monitoring
  Urban air monitoring

CONFIGURATION CONTROL TRAVELER

Part Number _____ Serial Number _____

Description _____

Status: Awaiting Parts ☐

List missing parts and status.

_____

_____

_____

_____

Completed ☐ Date _____ Initials _____

Deviations: Describe all deviations or modifications made to this item and list all affected parts.

_____

_____

_____

_____

Testing: Completed ☐ Date _____ Initials _____

Describe all failures or discrepancies. Describe any corrective action or rework required.

_____

_____

_____

Quality Control:

Inspection - Pass ☐ Fail ☐ Date _____ Initials _____

Final Inspection - Pass ☐ Fail ☐ Date _____ Initials _____

Describe reason for failure. Describe any corrective action required.

_____

_____

_____

Please use the back of this form for any additional entry.