Product Information – UVSentry
Real-Time Multi-gas Open Path DOAS

Cerex Monitoring Solutions is pleased to provide the following Information regarding the UVSentry Open Path gas analyzer. The system is suitable for permanent or portable applications which require real-time analysis of airborne VOC’s. The system can achieve very low detection limits for many hazardous pollutants such as Benzene, Naphthalene, Toluene, H2S, Ammonia, as well as EPA “Criteria” pollutants NOx, SOx, and Ozone.

Real-time detection and quantification for multiple gases including;

- BTEX,
- Naphthalene
- Butadiene
- SO2, NO,
- NO2, Ozone,
- and more….

The UVSentry system represents the most cost effective, yet technically capable solution for monitoring a variety of ambient and toxic gases on a real-time basis. A single system deployed along a 50-200 meter fenceline can identify gas releases ranging from ppb to ppm levels, quantify the amount, log and report the concentration data. The system response time is very fast, yielding near real-time results. The system is extremely lightweight and portable, and can be quickly moved to accommodate rapidly changing local meteorological conditions.
Summary Elements of CEREX UVSentry DOAS Air Monitoring System

- **System Cost**
  Complete turnkey system includes emitter, receiver, calibration system, gas spectral library, and analysis software. No additional analytical costs!

- **Current Spectral Library**
  Simultaneous real-time measurements of Napthalene, Ozone, Benzene, Toluene, NO, NO2, SO2, and many other gases

- **Low Detection limits**
  MDL’s in the 5.0 ppb range or less for many compounds. Below the community health exposure limits.

- **Regulatory Uses**
  EPA’s Office of Enforcement has provided guidance on operational and QA procedures to insure legally defensible data. System in use by USEPA.

- **Long term maintenance**
  Because there are no moving parts, the only routine maintenance cost is the replacement of the UV light source (rated at 2000+ hours).

- **Portable**
  System can be installed and producing data in 10 minutes. Weighs less than 30 lbs.

- **Internet Ready**
  Real-time data can be posted to an internet site. Secure (password, encrypted) access, or open access.

- **Reliable**
  Over 40,000 spectrometers sold for non-air monitoring purposes

*With UVSentry, There’s No Guesswork About What’s in the Air!*

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**Chalmette Air Monitoring (SO2)**

![Chart showing SO2 measurements](image)

*UVSentry measures SO2 at such low MDL’s that a good comparison against the 10 minute, 24 hour, and annual health exposure limits can be examined very carefully. Here, data is taken from the back yard of a refinery neighbor.*
* Cerex will provide a complete UVDOAS Monitoring System. The base system is supplied, capable of monitoring all gases in the library. Realistically, a chosen subset of target gases is chosen. Software is supplied which allows for both real time, and post processing of data to check for the presence of other compounds. The transmitter and receiver modules, are provided. Optional items provided include such equipment as tripod mounts, laptop pc (or internal SBC single board controller), and calibration cell.

UV Sentry is a “bi-static” system whereby the UV emitter is located at one end of the path, and the receiver is located at the other end of the path.

UVSentry utilizes advanced CCD-array detector technology. There is no requirement to cool this detector to improve performance. This eliminates the costly cooling systems required by other systems available on the market, and the no-moving-parts design improves the mean time to failure (MTTF), and overall reliability. This no moving parts system provides measurement stability under the ambient temperature variations experienced in the field. The system is high reliability, maintenance free, and requires no consumables such as LN2.

The output of the system is both raw spectroscopic, and also computer-aided analysis (concentration value) data.

Cerex is supplying this equipment because it directly meets the intended goals and objectives often required in a wide array of possible monitoring scenarios;
- low minimum detection levels for the compounds specified
- quality, traceable, legally defensible data
- advanced, automated software, thus reducing or eliminating the costs associated with post-data analysis
- low initial cost to purchase when compared to other technologies
- negligible cost-of-ownership due to low maintenance, no consumables, inexpensive replacement parts
- minimal training due to easy user-interface
- extremely lightweight and portable…can be set up and taking data in under 10 minutes

**P/N 50000 – UV Sentry DOAS** - A complete automated air monitor system is provided: The following components and accessories are included in the package;

- UV (Deuterium) Optical Transmitter Unit (10 to >200 meter recommended range) *or*
- UV (Xenon) Optical Transmitter Unit (10 to >1000 meter range)
- UV Integrated Spectrometer Optical Receiver Unit
- 2 (ea) 120 VAC power cable,
- 1 (ea) USB signal cable
- 2 (ea) Detachable alignment scopes
- UV Sentry Continuous Monitor Software
- Internally-mountable sealed calibration cell containing a mix of benzene and sulfur dioxide gases
- Spectral Library allowing real-time detection, quantification, and continuous monitoring.
- Mounting tripods
- Computer (usually internal) used to run the control software, and log data. *or*
- Laptop PC may also be used
### Sample of Spectral Library

**Minimum Detection Limits for Cerex’s UVSentry UV DOAS Open Path Monitor**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Detection Limits (ppm-m)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>1.59</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.267</td>
</tr>
<tr>
<td>Chlorine</td>
<td>5.0</td>
</tr>
<tr>
<td>Carbon Disulfide</td>
<td>13.31</td>
</tr>
<tr>
<td>Napthalene</td>
<td>0.200</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>3.2</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.500</td>
</tr>
<tr>
<td>Nitrogen Oxide (NO)</td>
<td>.292</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO2)</td>
<td>4.0</td>
</tr>
<tr>
<td>Ozone</td>
<td>2.00</td>
</tr>
<tr>
<td>o-xylene</td>
<td>3.77</td>
</tr>
<tr>
<td>m-xylene</td>
<td>0.350</td>
</tr>
<tr>
<td>p-xylene</td>
<td>0.237</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>0.320</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.838</td>
</tr>
<tr>
<td>1,3 Butadiene</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*and more*

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* Currently there are a number of definitions of “detection limits” used to characterize the performance of air monitoring systems. A common definition of is the magnitude of the absorbance spectra that is twice the system noise. The Environmental Protection Agency’s “Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition Compendium Method TO-16 Long-Path Open-Path Fourier Transform Infrared Monitoring Of Atmospheric Gases” defines detection limits as the following:

The detection limit of the UVSentry systems is a dynamic quantity that will change as the atmospheric conditions change. The variability of the target gas, and all of the other interfering species concentrations contributes to the variability of this measurement. The detection limit as determined in this procedure is the result of a calculation using a set of 15 individual absorption spectra. The 16 individual single beam spectra used for this determination are acquired in 5-min intervals and no time is allowed to elapse between them. The absorption spectra are then created by using the first and the second single beam spectra, the second and the third, and the third and the fourth, and so on until the 15 absorption spectra are obtained. These absorption spectra are analyzed in exactly the same way that all field spectra are to be analyzed and over the same wave number region. The analysis should result in a set of numbers that are very close to zero because most of the effects of the gas variability have been removed. The numerical results should be both positive and negative and for a very large set of data should average to zero. Three times the standard deviation of this calculated set of concentrations is defined to be the detection limit.

Although Method TO-16 was written for open path FTIR, the Cerex UVSentry system is unique among Open path UV systems in that the raw data is essentially identical to an FTIR “Single beam” file. Hence the direct correlation drawn to TO-16. Using the detection limit definition described in TO-16, CEREX developed the detection limits that are listed above. However it should be noted that the actual detection limits achieved in the field will vary. This is primarily due to the fact that variations in interfering species will result in variability in detection limits. Cerex considers the detection limits listed to be a very conservative estimate. The end-user of the equipment will likely achieve much better results in the field. Cerex believes it is a good policy to not oversell a capability to our potential customers.
The CEREX UVSentry air monitoring system represents the most up-to-date, state-of-the-art open-path air monitor on the market. The system uses an off the shelf spectrometer (over 40,000 have been sold for non air monitoring purposes) that can easily identify spectral features of gases commonly seen at petroleum refineries, chemical plants, concentrated animal feeding operations, and other industrial facilities. The miniature spectrometer has no moving parts (hi reliability), and weighs less than 16 ounces. With no moving parts, long-term maintenance costs typically are limited to the replacement of the UV source every six months (a low dollar item). By utilizing the sealed cell gas system (included with the system) for Quality Assurance, costs associated with QA and calibration are eliminated. The cells have been known to remain stable for over five years (depending on the gas) and cell is included in the purchase price of the system.

The system has been used by the US Government, industry, federal and local regulators and citizen groups to quantify ambient concentrations around oil refineries, chemical plants and CAFOs. With assistance from the US EPA’s Office of Regulatory Enforcement, CEREX has developed QA plans and SOPs, that ensures the data meets the criteria as being “legally defensible”.

The system is extremely lightweight (30 pounds) and portable, with easy tripod mounting. The data acquisition speed is near instantaneous, with single scan data acquisition of approximately .1 to .5 seconds per scan.

**Principle of Operation - UVSentry DOAS**

Telescope optics are used to project a 6-inch collimated beam of light through the sample path and to the receiver. The receiver has similar telescope optics which capture the incoming light, and focus the energy into a fiber optic cable. Here the light is routed to a high resolution uv spectrometer for analysis.

During the time that the UV light passed through the atmosphere, there may have been gases present in the beampath. If any of these gases are UV-compatible (see the compound list), a portion of the radiation is absorbed. It is this loss of light due to absorption that is collected into the spectrometer for analysis.

It is known that every gas has a unique spectral fingerprint. In our laboratory, Cerex characterizes each gas by obtaining a quantitative sample and recording the unique spectral fingerprint. These “quantitative library references” are saved within the computer to aid in the analysis of the target gas in the DOAS beampath. When the gas becomes present in the beampath, the spectral fingerprints are compared to the stored library references using a pattern-matching classical least squares regression analysis. The results are presented to the user as a real time concentration number. In addition, there are “goodness of fit” qualifiers that are also presented, so that the quality of the data can be assessed in each measurement. Since the software utilizes a differential method of analysis, the calibration is inherent in the reference library spectra. There is no need to perform a recalibration on a periodic basis. However, as calibration verification is a requirement in most applications due to procedures written around older technologies, Cerex provides the provision to conduct a calibration and re-zero of the system, either in a manual, or automatic mode.
**Technology Description:**

The heart of the CEREX UV3000 process monitoring system is a sensitive spectrometer based on charge capacitor diode array (CCD) technology. The fundamental of system operation is simple. First, ultra-violet light is generated from a UV source; usually either a deuterium or xenon lamp. The light is projected through the cell, and interacts with the sample gas. The exiting collected light then passes through an input lens into the spectrometer via a fiber optic coupling. Once inside the spectrometer, the light is broken out into its various wavelengths by sending it through a holographic grating. The light then hits the CCD array which in turn charges the capacitors. The capacitors are discharged at a sample rate set by the user and the light signal at each light frequency is proportional to the total charge of each capacitor. Finally, a graphical representation of the UV spectra is produced by measuring the electrical charge of each capacitor at each given wavelength (signal intensity vs. wavelength).

The beauty of the CEREX UV open-path air monitor lies its size, simplicity of design and ease of use. These three factors enable the system to have the flexibility to meet many different monitoring applications. For example the system has been operated using both a deuterium and xenon sources. Deuterium sources have a lower noise and higher UV spectral component than traditional xenon lamps. The systems have also been operated at both long (850 meters, with xenon) and short pathlengths (10 meters).

The graph below shows some typical situations where the system detected, quantified and displayed ambient gas concentrations on a real-time basis.
UVSentry monitors the air at a CAFO for ammonia. Although the Opsis and UVSentry track very closely, the faster system response of the UVSentry affords a much more detailed look at what is really going on, with greater chance of catching dynamic concentrated plumes. This may allow for quicker response time – hence reducing health concerns in the local environment.

Computer Controller and Software

The UVSentry is provided with a computer controller. Two options are available, and the customer should specific which at the time of order;

- **External Laptop PC** - The UVSentry connects to the laptop via USB connection.

- **Internal Single Board Controller (SBC)** – The single board controller handles all the real time monitoring, data collection and archiving. The customer communicates and controls the UVSentry via a wireless or Ethernet link from another local PC or laptop (remote desktop connection). In the case that the SBC option is chosen, then Cerex also offers an optional LCD display that is front-mounted on the enclosure. The display provides the same visual information that is available on the laptop screen.
Shown above – Real-Time trend charts are displayed to show concentration vs. time. The output rate of the analyzer can be (user) selected to be as quick as a only a few seconds, or minutes. Here, the concentration data is plotted with the r-squared, or “data quality” indicator.

The CMS software is provided in several modules:

Instrumentation Control
This provides the interface with the basic spectrometer data acquisition controls
- Averaging
- Data Output Rate
- Alarms

Real Time Monitor
- Numerical concentration output for each of the compounds that have been user-selected
- Numerical representation of data quality. Each concentration result has this data-confidence attached
- Monitor of system light throughput, updated with each measurement
- Trend Chart with choice of all chemicals shown, or a user-selected subset

Smart-QA Software
* Software applet that guides the user through a simple, calibration verification utilizing the Cerex sealed calibration cells.

Raw Spectral Data is Saved
- Raw Single-Beam Intensity Spectra
- Data Summary file containing a complete log of
  - Time and date stamp
  - Concentration value for each individual gas chosen
  - Data quality value for each measurement
  - Record of signal strength
  - Record of what background file was utilized in the analysis to create the reported concentration

Post Processing Module
- Reprocess with an alternate background
- Reprocess to locate additional chemicals

Graphic/Report Summary Tools
* One-click data summary chart creator

Library Reference Generator
* Allows user-selection of spectral analysis regions
* Important when configuring the analysis for mixtures of gases
Algorithms

- **CLS** – Included in the basic analysis software
- **PLS** - Offered on a custom gas-mixture basis (additional charges apply)

**Data Output**

The UVSentry is capable of interfacing with existing data acquisition equipment through a variety of analog and digital formats. In most cases, the data will be stored locally on the pc.

As the real-time concentrations are displayed, all of the raw spectral data is saved. Each data collection is accompanied by saving the raw single beam spectrum. In addition, all the important monitoring details are saved to the data summary file.

![Excel spreadsheet](image)

*Shown above; Each data file is logged within the pc. This includes some information about the acquisition in the header of the file, and then the raw spectrum...intensity vs. wavelength.*
Below is the datasummary file. This is the compilation of all the detection and QA/QC results. This file is updated automatically with each new data collection.
Optional Meteorological Data (Wind speed and Direction)
An optional meteorological station is available to allow concurrent measurements of wind speed and wind direction. With this option, software is included to allow the meteorological data to be logged into the same database as the gas concentrations.

Optional Flow-Thru Calibration Cell

Some gases are not stable in sealed cells. The flow-through cell allows the user to connect a standard certified cylinder of gas to perform QA.

Training
Training is free at our factory in Atlanta. Typical training is one to two days. Training includes:

- System setup and operation
- Software operation
- Data QA/QC
- Maintenance

On-Site training is available.
Contact Cerex

See Real-Time data from your UVSentry on the Internet
Optional software is available to allow the gas concentration data to be sent, real-time, to an internet site. The site can be password secured, or opened to anyone with internet access. The data upload can be done via dsl line, phone line, or even wireless cellular modem for operation in remote or mobile locations. If you are interested in this option, please contact Cerex for current pricing.

Alarms Output
Optional software is available to allow alarms to be generated in the event of gas level exceedance or instrumentation malfunction. The alarms can be programmed to contact a designated person via email, pager, cell phone, etc. (onsite internet connection, or cellular modem account required). Contact us for current pricing.
**System Remote Access- Radio Modems**
Optional Software is available to allow remote access to the monitoring site. The instruments can be monitored remotely, raw data files downloaded, and instrument maintenance and QA functions checked while never having to travel to the actual site. Package includes two modems, plus a repeater. Directional Yagi antennae are also included. Range is up to 30 miles. Contact Cerex for exact specifications. Contact us for pricing.

*Shown above the Sentry receiver with remote fiber-coupled optics, main spectrometer unit (Mil-spec temperature, dust, moisture proof), on-board controller and radio communications equipped. (laptop shown only for sizing comparison)*