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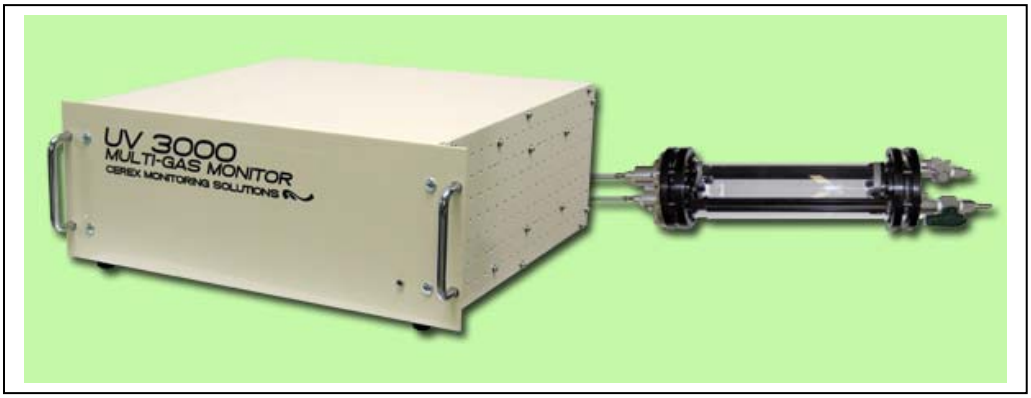
Product Information – UV3000
Multi-gas Stack/Process Monitor System

Cerex Monitoring Solutions is pleased to submit the following technical information for our UV3000 Stack Gas Analyzer. The system is available to meet a variety of stack monitoring methods, ranging from extractive, to in-situ, utilizing optical methods of gas detection. For process monitoring, a closed cell is used, and either process pressure, or a pump is used to transport the sample into the optical cell.



Many clients, including industry, researchers, University, and EPA have a requirement to perform a wide array of air monitoring projects. The applications might include ambient monitoring, stack monitoring, process monitoring, on a fixed or mobile platform. The clients usually end up purchasing several sets of expensive equipment, just to enable their capability to meet these varied project needs. The Cerex UV3000 system is designed with the flexibility to accommodate these needs within a single analyzer.

The construction and features of the UV3000 system are such that a single, core system, coupled with modular sampling accessories, allows multiple applications to be explored without having to purchase multiple monitoring systems.

Cerex has developed two technologies that allow this to be possible. UV spectrophotometer hardware and software allow multi-gas measuring flexibility. Second, Cerex has perfected multi-pass, long-path gas cells that provide for very low minimum detection capabilities; often down to parts per trillion or low ppb levels.

When attempting to match a monitor to an application, a primary issue is the concentration range of the gases that will be detected. In ambient applications, the concentration limits usually begin in low ppb levels. Stack monitoring applications typically can have gas concentrations ranging from ppm even up to pp-thousand, or even percent levels. Process applications can span the entire range.

The Cerex UV3 monitor allows the user to adapt to these various concentration levels by selectively varying the pathlength of the UV beam that intercepts the gas stream. In the case of ambient gases, the pathlength of 30meters or more is used. We gain this path by utilizing a multipass cell.

For short path, stack or process applications, we utilize a short path multipass cell, or even a single pass cell ranging in the length of centimeters.

Cerex has developed our analyzer system such that various cells are "plug and play" and coupled to the main analyzer via fiber optic cables. This enables the user to customize the system to his specific project application needs.

Summary of UV3000 Features

- High Resolution 2048 element UV spectrometer
- Operates on principle of UV/Vis DOAS
- Stabilized UV Source (Deuterium or Xenon)
- Continuous, Real-Time Concentration Data
- Raw Data is Logged
- Easy On-Site Calibration Checks
- Stack Extractive options allow paths from 1cm to 30+meters
- Cross-Stack, In-Situ method is offered
- In-Stack In-Situ method is offered
- Gas concentrations from pptrillion to percent
- Optional Alarm outputs (trip-level is user selectable in software)
- Optional 4-20 mA outputs corresponding to measuring range
- Long-life deuterium UV Source (guaranteed 2000 hours, 4000 typical)
- Fiber optic-coupled, Temperature stabilized UV Source
- Cell or other Probe connected to main analyzer using only fiber optic
- Advanced real-time software utilizing CLS or optional PLS
- External laptop connects to analyzer via USB
- Or user can select a internal Single Board Controller (SBC)
- Optional local display on the analyzer case
- Automatically takes clean air backgrounds (auto re-zero function)
- Internet/wireless connectivity
- Operation in extreme temperatures with optional heating/cooling package
- Optional Thermostatically controlled heated Cell to eliminate condensation effect
- Provided with the capability of the full Cerex UV library of compounds
- Sample cell can be remoted to keep personnel away from hazardous gases.

UV3000 Main Analyzer

The system is separated into two parts, the primary UV3000 analyzer, and the optical "probe". This probe can be a closed cell, or an open path optical system. The optical half of the system connects to the primary analyzer via optical cabling. Therefore, if the user elects to remote the optical half in a separate area, this entire half of the system is now intrinsically-safe. The main analyzer is available in a 19-inch rackmount enclosure, or an optional outdoor-rated NEMA enclosure.

Cerex Reference Spectra

Each Cerex system comes standard with our core group of compounds. There is no need to pay extra to monitor for additional compounds. Please see the attached Appendix "A" for a sample listing of core compounds provided, and also a statement on detection limits.

Create New Reference Spectra Onsite

Using the standard Short Path Linear Flow Cell, the user can create certified library references onsite, without the need to purchase these from Cerex or another outside source. This is typically accomplished via 3 methods;

- Obtain a cylinder of target gas containing a certified concentration (lab analysis)
- Dilute a liquid sample into a known volume of carrier gas
- Obtain a standard, certified permeation tube, and use these with a calibrated oven.

The quantitative sample is flowed into the stabilized cell of known pathlength. From this the absorption spectra is acquired and saved in a format that is compatible with the Cerex CMS real-time analysis software.

UV Light Source

The main UV3000 Analyzer is available with a choice of light sources.

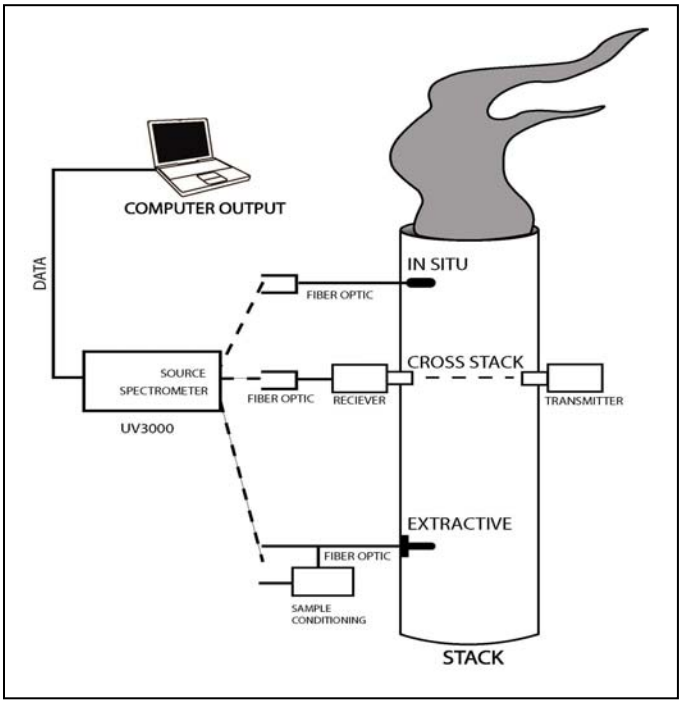
UV3000-X Xenon- A more powerful beam that allows for longer paths, or paths heavy in particulate matter. The downside is that there is a subset of "deep-uv" absorbing compounds that may not be available

UV3000-D Deuterium – A less powerful optical beam, but enables monitoring of several deep-uv compounds, including H2S.

See separate Cerex document for details on uv source intercomparison.

Enclosure – The UV3000 primary analyzer comes standard built into a 19" rack-mount enclosure.
A variety of other enclosure options are available to accommodate a variety of environments. These range from sealed enclosures that are suitable for mounting in outdoor environments, including hazardous locations.

The Cell accessory options are also available mounted in enclosures, or sold individually for use in customer-determined applications, including research and general laboratory use.



Stack Monitoring Options

Gnerally, the Cerex UV3000 has the ability to accommodate 3 types of Stack Sampling Scenarios; A single UV3000 system has the capability to adapt to each of these 3 scenarios with the purchase of optional sampling equipment.

In addition to stack sampling, the system can then easily be adapted to process monitoring, or even ambient (closed or open path) monitoring.

Extractive - In this method, the gas sample is removed from the stack and transported to the analyzer for analysis. However, in most cases some **conditioning** of the sample is required to remove water vapor and particulate matter. A variety of different pathlength **cells** are available, and the selection of what cell to use is a function of the gas and concentration range found in the stack.
In the case of Cerex Cells, each of these opto/mechanical assemblies is fiber-optically linked to the main UV3000 analyzer.

Cross Stack – This method represents a form of "in-situ" monitoring, as the sample never leaves the stack. In effect, this is also remote sensing, because the sample never touches any sampling apparatus. An optical beam passes across the stack diameter, and that optical beam is the absorption path which enables the analysis.

In-Situ – A gas probe is inserted into the wall of the stack. An optical beam is contained within the probe. This optical beam represents the absorption path which enables the analysis. The sample is drawn into the probe, but remains at the conditions found in the stack. The sample is never removed or extracted from the stack.

In each case, the UV3000 connects via fiber optic to the opto-mechanical hardware that is utilized under each method. The gas absorption is monitored, and continuous, real-time indications of concentration are reported and logged.

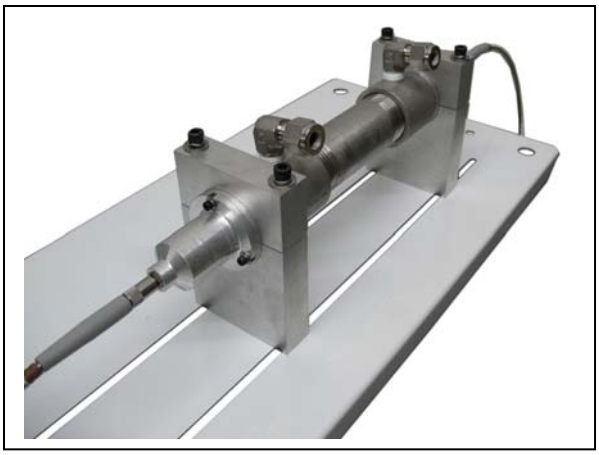
Next we will describe the specific options that are available with each stack monitoring method;

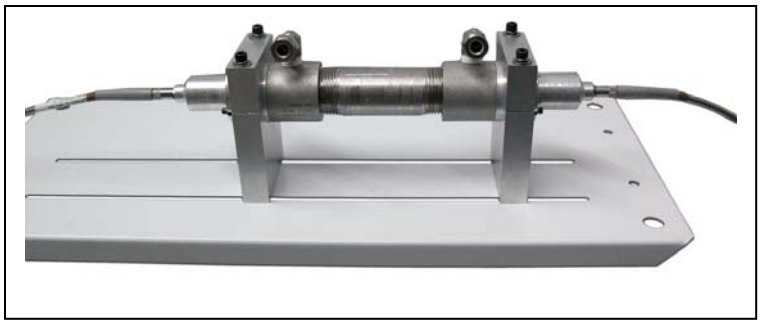
EXTRACTIVE

Short Path Linear Flow-Through Cells

The Cerex Short Path linear cells are designed with several unique features that make them very user-friendly in applications that require flexibility in pathlength;

- Cells are offered in a wide variety of materials to adapt in harsh chemical or temperature conditions
- Cells easily disassemble in the event cleaning is required
- The path length is User-Selectable. The center section of the cell is constructed of standard stainless-steel pipe with standard NPT threads. Any standard pipe "nipple" can be used as the body of the cell. This enables the user to choose any standard off-the-shelf size, or even create a custom-length cell.
- Heater can easily be added
- Paths of up to 1.5 meter are recommended (using Xenon)
- Paths of up to 0.5 meters are recommended (using D2)
- Standard Compression fittings for Gas Inlet and Outlet





300-100 (10cm) – Fiber Optically Coupled 10-Centimeter path Flow Cell – General Purpose, Light Duty

Long Path Multipass Cells

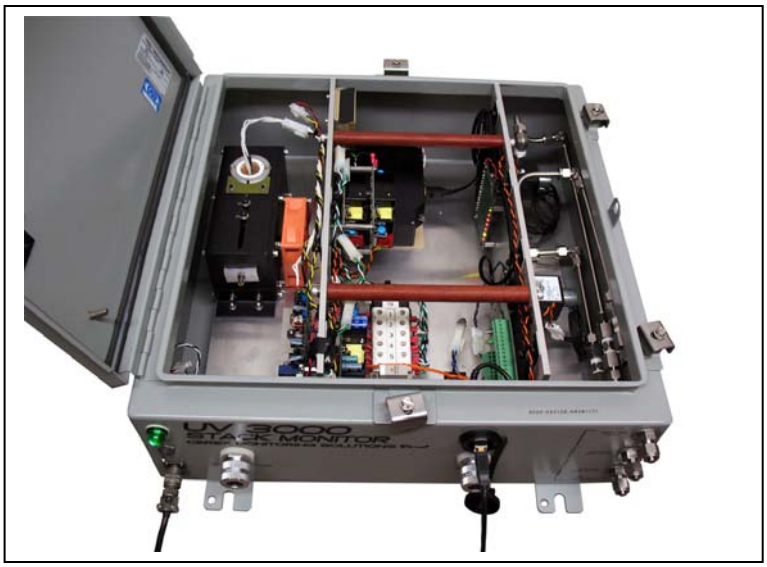
5 meter path – Low volume

Gas inlet and outlet valves are shown on the right side of the cell. The left side of the cell supports the optical input and output ports.

20 meter path – Larger Volume

Shown right are the relative size comparisons of the 20 meter cell, 5 meter cell, and UV3000 Primary Analyzer built into the 19” Rackmount Configuration.

Cerex UV3000 Analyzer Shown Configured in an outdoor NEMA enclosure.



Cerex UV3000 Analyzer Internal View.

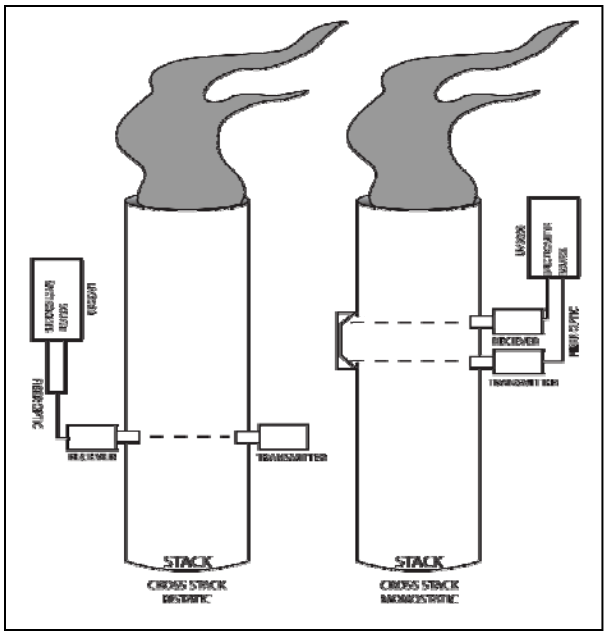
Cerex UV3000 Analyzer
10-Meter Multipass Cell
Complete with Heating and Enclosure.

Extractive Probe, with complete Sample Conditioning

Specifications are attached in a separate document found under **appendix "B"**.
The SPP-100 system comes complete with a sample extraction probe, and all of the hardware required to condition the stack sample prior to the gas entering the gas Cell for analysis.

SPP-100 Sample Extraction System with Conditioning

Cross-Stack Monitoring Optical System



Shown above – The optical telescope "head" used in the cross-stack method of the UV3000 stack analyzer

The cross stack optical system is typically built custom for every application. This is due to the fact that the diameter of the stack at the measuring height is different in every case. In addition the available size of the access port also is a limitation in some applications.

The concentration of measurable gases within the stack also determine whether the optical pathlength achieved by the system is indeed large enough to allow enough absorption to detect the compounds at the required minimum detectable limit (MDL). In addition, if the concentrations range very high, and the path is too long, then so much absorption could occur that certain spectral regions of analysis could be rendered useless due to complete loss of available uv light.

Monostatic system

The monostatic configuration consists of a Transmitter and Receiver located side-by-side. The beam path is completed at the opposite end of the stack with a retro-reflector or mirrored transfer optic. This design offers the following benefits;

- Double path through the stack achieves lower detections of gases
- Only a reflector is required at one end of the path – easier installation details

Bistatic System

The bistatic configuration consists of a Transmitter located at one end of the path, and the Receiver located at the opposite end. The beam passes through the sample one time

In both designed, the optical system is fiber-optically coupled to the main UV3000 analyzer. Depending on the gases to be analyzed, and the amount of particulates within the stack, the appropriate UV source (Deuterium or Xenon) is chosen. Xenon has the benefit of higher optical power to cut through heavy particulate scattering. Deuterium has the benefit of enabling the monitoring of the deep-uv subset of compounds.

For the purposes of this proposal, the two optional optical systems are simply identified as " Cross Stack – Short Path" and "Cross-Stack – Long Path.

P/N 300-250 Cross Stack – Short Path

Used on Stacks of 1 meter diameter or less

Available in monostatic or bistatic optical designs

Please specify length of fiber to interconnect the optics and main UV3000 analyzer

P/N 300-350 Cross Stack – Long Path
Used on stacks with diameter greater than 1 meter.
Available in monostatic or bistatic designs
Please specify length of fiber to interconnect the optics and main UV3000 analyzer

In-Situ Stack Probe

In Situ Probes are normally custom-specified and priced according to the effective pathlength of the probe. The concentration of measurable gases within the stack determine whether the optical pathlength achieved by the system is indeed large enough to allow enough absorption to detect the compounds at the required minimum detectable limit (MDL). In addition, if the concentrations range very high, and the path is too long, then so much absorption could occur that certain spectral regions of analysis could be rendered useless due to complete loss of available uv light.

Shown Left – The in-situ probe has a maximum pathlength of 2 meters. (Physical length is 1 meter).
Sections of the probe can be removed to reduce the pathlength for higher-concentration gas sampling

In-Situ probes are available in a variety of paths ranging from a few millimeters up to 2 meters.
Each probe is fiber-optically coupled back to the primary UV3000 Analyzer

Most models that we offer have the provision built-in to inject a zero gas or calibration gas ahead of the sample stream.

300-420 Probes up to pathlength of 20mm
300-430 Probes from 20mm up to 1 meter

Extractive Probe, with complete Sample Conditioning

Specifications are attached in a separate document.
The SPP-100 system comes complete with a sample extraction probe, and all of the hardware required to condition the stack sample prior to the gas entering the gas Cell for analysis.

SPP-100 Sample Extraction System with Conditioning

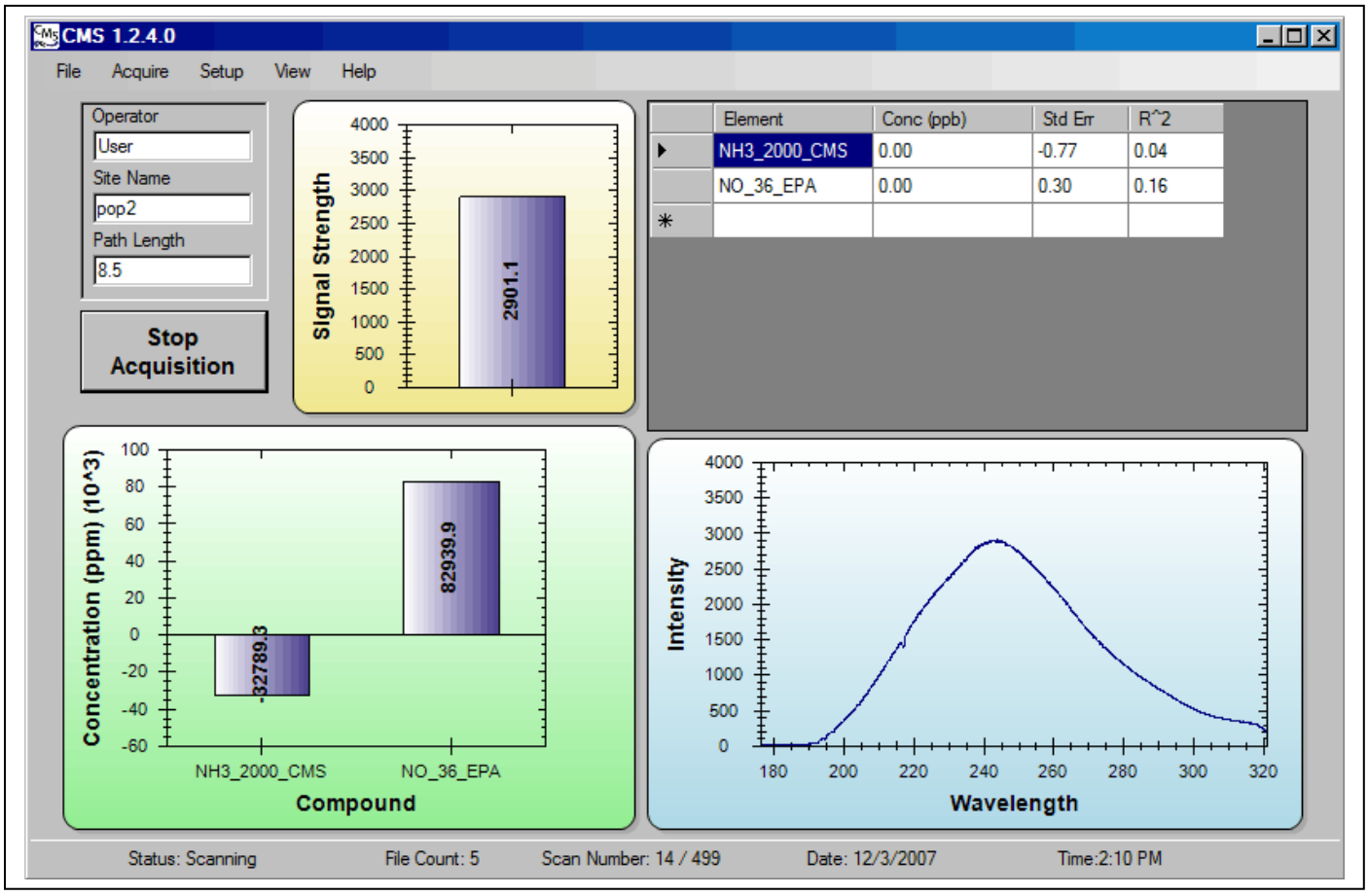
Computer Controller and Software

The UV3000 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 UV3000 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 UV3000 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.

CMS – Cerex Continuous Monitoring Software and Data Logging



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)

Hardware Control

- Solenoid valve activation to control the injection of zero or calibration gas into the cell
- Auto-cal, Auto-background function

Calibration

Generally, the calibration of the UV Spectrometer is fixed and inherent in the quality of the library reference spectrum.
However, Cerex does offer the provision to challenge every configuration with a calibration gas.

* Cerex offers a small sealed calibration cell that can be inserted within the uv beam path. A limited number of gases are stable, long-term in these sealed cells. Cerex recommends that these only be left in the beam path for short periods of time

* For absolute calibration, Cerex offers 1 cm path flow cells that allow calibration gas from a certified cylinder to be flowed.

* In the case of UV3000 systems utilizing linear, or multipass cells, provision is offered to flow a calibration gas from a certified cylinder.

* In the case of UV3000 systems utilizing a in-situ probe, provision exists to flow calibration gas ahead of the stack gas.

* In the case of the Cross-Stack system, a large flow-cell, with precision glass windows is provided. The cell is manually inserted into the beampath (external to the stack). Gas from a certified cylinder is flowed through the cell for verification purposes.

OTHER OPTIONS

Heating Option for Cells
Heaters and a temperature sensor are attached to the body of the cell. A separate temperature controller is adjusted to allow the cell to maintain a fixed temperature setting. This is very useful for eliminating condensation effects from unconditioned samples. This also reduces the effect of polar molecules sticking to the internal cell walls.

Please specify your desired setpoint temperature

P/N 300-727 Heating Option for Cells

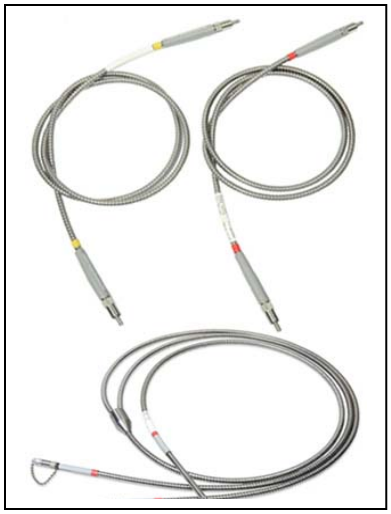
Enclosure for External Cells
The cells, and optional heaters and controllers are built into a sealed steel enclosure.

- AC power is accessible on the outside (for heater power).
- 2 bulkhead fiber ports are provided as the optical interface to the internal cell
- Sections of fiber are also provided on the internal side of the enclosure.
- Bulkhead compression fittings are provided as the gas inlet and outlet ports.

P/N 300-757 Enclosure for External Cells

Fiber Optic Cables

Used to connect optical sampling accessories to the main UV3000 analyzer
Specify Length when ordering. Typically 2, equal length fibers are required.



300-121 1.0 meter
300-122 2.0 meter
300-123 3.0 meters
300-124 5.0 meters
300-125 **10.0 meters**

Auto Purge / Background system

Auto Zero / Background- We can add the option to auto-background (zero) the system. The solenoid shuts off the sample flow from the stack, and opens the valve to allow clean air (N2, O2, Factory air, Ambient air...from cylinder or local supply lines) to purge the cell. When the timing cycle of the purge is reached, then a new instrument background is taken. Afterwards, normal stack monitoring resumes. Background acquisition frequency is software selectable.

POWER

The system is powered by 115VAC/15A/60Hz Standard North American connection.
As an option 220VAC/ 50-60Hz is also available. (Please specify at the time of ordering)

Maintenance Items

P/N 02004 - UV Deuterium Source (replacement bulb)

P/N 02002 - UV Xenon Source (replacement bulb)

APPENDIX "A"

Guidelines - Minimum Detection Limits for Cerex's UV3000 UV DOAS Monitor

Compound	Detection Limits (ppm-m)*
Ammonia	1.59
Benzene	0.267
Chlorine	5.0
Carbon Disulfide	13.31
Napthalene	0.200
Formaldehyde	3.2
Hydrogen Sulfide	.500
Nitrogen Oxide (NO)	.34
Nitrogen Dioxide (NO2)	2.0
Ozone	2.00
o-xylene	3.77
m-xylene	0.350
p-xylene	0.237
Sulfur Dioxide	0.320
Toluene	0.838
1,3 Butadiene	0.20

....and more

* 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 UV3000 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 UV3000 system is unique among 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.

APPENDIX "B"

Detailed Literature on the SPP-100 Sample Conditioning System

SPP-100

Stack Permeation probe system

The easily way to stack sampling solution

ETG PERMEATION PROBE

ETG PERMEATION sample conditioning systems are designed to prepare hot gas sample streams for high flow, high performance gas monitoring applications. The ETG PERMEATION system will remove particulates, mists & water vapor from a gas stream without the loss of analyte gasses.

Gas conditioning is accomplished by filtering the sample and then removing water vapor with a Nafion® membrane gas dryer. The dryer is installed downstream of the filter. When the sample enters the dryer it will remove water vapor from the hot sample before it cools down and condenses. This is a distinct advantage over chiller systems, which exposes the sample to condensate in the drying process, allowing water soluble analytes to be lost.

SPP 100 Stack Permeation Probe System

GASES OF INTEREST

Nafion is not only highly resistant to chemical attack, it also exhibits highly selective absorption. Only compounds that associate chemically with the sulfonic acid group within the Nafion tubing are removed. Gases of environmental interest such as carbon monoxide, carbon dioxide, nitrogen oxides, sulfur dioxide, and hydrogen chloride are totally retained within the sample. With the exception of ammonia, virtually all compounds routinely monitored in a CEMS application are totally retained within the sample stream.

Typical Installation on Stack

Perma Pure developed the first Nafion dryer more than twenty years ago. Today Perma Pure dryers are used throughout the world for gas sample conditioning prior to analysis by medical, scientific, and industrial instrumentation. ETG has incorporated this proven technology into the ETG PERMEATION system. With a wide range of filters, dryers, and other options available, the ETG PERMEATION system can be quickly and cost-effectively tailored to your specific needs.

SPP-100 Advantage against similar tecnique:

- Positive sample line pressure with more efficiency on remove water
- Rugged permeation element with improved sample flow
- Sample pump included

SPP 100 Stack Permeation Probe System

The first step in conditioning the sample is filtering out particulate and aerosols. The sample gas enters the ETG PERMEATION system through a bulkhead fitting or in the case of a heated sample line, a sealing fitting and then through the filter. After the filter pass trough an heated sample pump, in thys way the Membrane could work in positive pressure conditions enhancing his water removal capabilities. Depending upon your application, the filter can be run as either a coalescer and particulate or just as a particulate filter simply by switching the inlet and outlet ports. After pumping, the sample enters the Nafion dryer. Gases pass down the length of the tubing by means of a temperature gradient. Water vapor is selectively absorbed into and moves through the tubing walls driven by the difference in partial water vapor pressure on the opposing sides of the membrane. Dry purge gas entering the dryer at the *sample outlet* provides a medium for the water vapor removal from the sample to be carried away. It also cools the outlet of the dryer producing a temperature gradient which will result in both a rapid vapor removal and decreased final dew point temperature

TOTALLY RETAINED	
Atmospheric gasses	**Hydrocarbons**
N_2 O_2 H_2 Ar He	All simple hydrocarbons
Oxides	**Toxic gases**
CO CO_2 SO_2 SO_3 NO_x	HCN $COCL_2$ NOCL
Halogens	**Other Organics**
Cl_2 F_2 HCl HF HBr	Aldehydes, THF, Cyanides, Esters
Sulfur	**Inorganic acids**
H_2S COS Mercaptans	HNO_3 H_2SO_4
SOME LOSSES	
Polar Organics	**Other**
DMSO, Alcohols, Organic Acids, Ketones	NH_3 Amines

Table 1 Nafion dryers Selectivity

SPP 100 Stack Permeation Probe System

The purge gas stream should be –40° C dew point air, nitrogen or argon. If this is not available, ETG offers an air dryer generator as an option to dry the purge air supply. In addition to carrying away water vapor, the purge gas acts to cool the dryer. Purge gas enters the dryer at the sample outlet end, where the sample is almost at ambient temperature. As the purge gas is circulating counter-currently to the hot sample, it gradually comes to equilibrium. In this way, the purge gas helps establish a smooth temperature gradient along the length of the dryer. This temperature gradient ensures that the dryers operating as efficiently as possible. As the purge exits gas exits the dryer, it is at or very close to the sample temperature. The heated enclosure gas is monitored with a thermocouple located at the dryer purge gas exhaust port. Positioning the thermocouple at this point provides the most accurate indication of the sample gas temperature as it enters the dryer. The thermocouple is linked to a digital temperature controller which maintains the sample at a preset, adjustable temperature. Operating temperature is displayed on the digital LED readout on the front of the controller.

SPECIFICATIONS
Sample inlet
Maximum Temperature 120°C Maximum flow rate 2,5 lt/min Maximum water content: 90°C DP
Air Requirement
Purge Air Dew Point –40°C Recommended Flow rate: 7,5-10 lit/min Maximum flow rate: 10 lt/min Pressure: 0-4 bar
Sample Outlet
Ambient temperature Dew point well below 0°C

√ Removes only water vapor from gas stream

√ Dries continuously

√ Can process almost any gas up to 10 LPM

√ Easy to Install , reliable, low cost of ownership

www.etgrisorse.com

ETG RISORSE E TECNOLOGIA

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