APPLIED ANALYTICS™

OMA
Continuous Emissions Monitor

Scalable next-generation emissions monitoring.

- UV-Vis full-spectrum nova II™ spectrophotometer w/ integrated MicroSpec™ modules
- Solid state with no moving parts
- Optional "close-coupled" system mounted directly on the stack with easy service access
- True readings for NO_X ($NO + NO_2$) and SO_X ($SO_2 + SO_3$)
- Fiber optic cables transmit signal to/from sample cell
- Xenon light source with 5 years average lifespan
- Outdoor installation — no shelter necessary
- Automatic data logging & reporting options
- Redefine concentration ranges and add new measurement benches at any time

Available Measurements:

NO	NO_2	N_2O	NO_X	SO_2	SO_3
SO_X	CO	CO_2	O_2	H_2S	Cl_2

Applied Analytics™ [AAI] is a global manufacturer of industrial process analysis instruments.

Our systems are used primarily to measure real-time chemical concentrations in liquid or gas process streams, as well as physical parameters like color, calorific value, and purity.

AAI's mission is to provide a true window into your process via an elegant and automated solution.

Applied Analytics was incorporated in 1994. All of our systems are manufactured in the USA.

Global Support & Installation Services

AAI's specialized role as a manufacturer of process analysis instruments means that 100% of our focus and resources are permanently dedicated to the long-term performance of our solutions. Our certified field engineers proudly ensure that your AAI systems deliver decades of reliable process monitoring.

We maintain a comprehensive global support network. Our service commitment spans from rigorous pre-build application research to expedient start-up, followed by fast support for the lifetime of your AAI systems.

- On-site installation assistance, commissioning, and system service by certified, experienced field engineers
- Technical support by phone and email for the lifetime of your Applied Analytics systems
- Equipment training at our facility or your site

Continuous Emissions Monitoring (CEM)

Modern industrial plants are typically required by law to measure and report the quantities of certain chemicals that they release to the atmosphere. As environmental regulations become increasingly stringent and ubiquitous, more plants worldwide will need adequate process analysis to guarantee compliance.

Government agencies such as the EPA and EEA have rigid criteria for Continuous Emissions Monitoring (CEM) systems. Stipulations include the mandatory monitoring of emissions of SO_2, NO_X (generic term for nitrogen oxides including NO and NO_2), CO, CO_2, and O_2, as well as strictly regulated reporting of these chemicals' concentrations.

While reducing emissions is a pressing environmental issue, it typically poses no direct financial benefit for the plant yet requires purchasing and servicing expensive equipment. Clearly, an ideal CEM system provides reliable compliance at minimal cost.

The OMA Continuous Emissions Monitor is a fully integrated powerhouse, monitoring dynamic concentrations of various emitted chemicals with a single system. While this solution leads its class in multi-component accuracy, it remains cost-effective by virtue of low-maintenance solid state design, competitive pricing, and high scalability for your exact analysis needs.

The painless, economical route to environmental compliance and public social responsibility begins as soon as your OMA emissions monitoring solution is installed.

What makes an ideal CEM solution?

- Accurate multi-component accuracy for 10 or more measured gas components
- Suitability for large periods of unattended opreation
- Customizable, reliable data logging and reporting packages
- Intelligent sampling design
- Low cost of maintenance and consumables
- Flexibility for redefinition of measurement ranges and addition of new measurements as process evolves
- Field-proven track record

In the subsequent pages, we will demonstrate how the OMA Continuous Emissions Monitor fulfills all of these criteria.

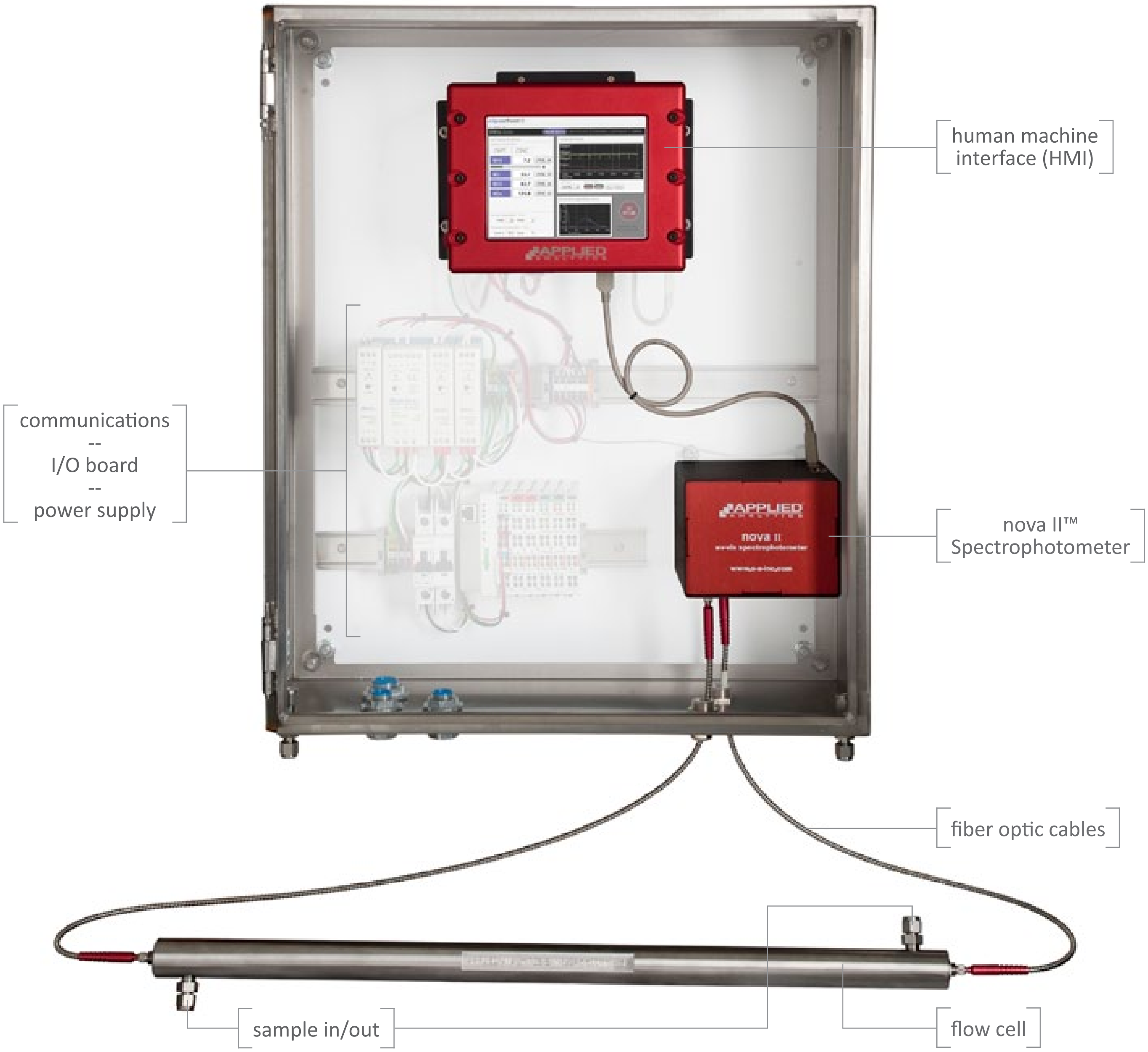
What is Absorbance Spectroscopy?

Light interacts with matter in numerous ways, one of which is absorption. A molecule will absorb specific wavelengths of light primarily as a function of its electronic and molecular structures, which are unique to each chemical; the energies (wavelengths) of light that are absorbed by the molecule match the energy quanta that are required to move that specific molecule between two quantum mechanical states.

This phenomenon of absorption is quantified as **absorbance**, or the difference between incident light intensity (the light entering the mixture) and transmitted light intensity (the light exiting the sample). Plotting absorbance against wavelength creates an absorbance **spectrum**, which allows us to observe the unique curve (shape) of the absorbance. Each chemical therefore has a natural identifier in its absorbance curve, which can be detected like a footprint within the total absorbance of a mixture.

This is the basic premise for every analyzer that Applied Analytics manufactures. We believe solid state spectroscopic technology is the definite future of industrial process analysis.

The OMA System Overview



nova II™ Spectrophotometer

The core component of the OMA system is the nova II™. This device connects to the sample flow cell via fiber optic cables, continuously pulsing a white light signal through the sample fluid and measuring absorbance in the returned signal.

Human Machine Interface

The OMA system is controlled by an industrial computer operating on the proprietary ECLIPSE™ runtime software. The touch-screen LCD displays real-time H_2S concentration and any additional measured parameters with access to system settings.

Custom Communication Electronics & Power Supply

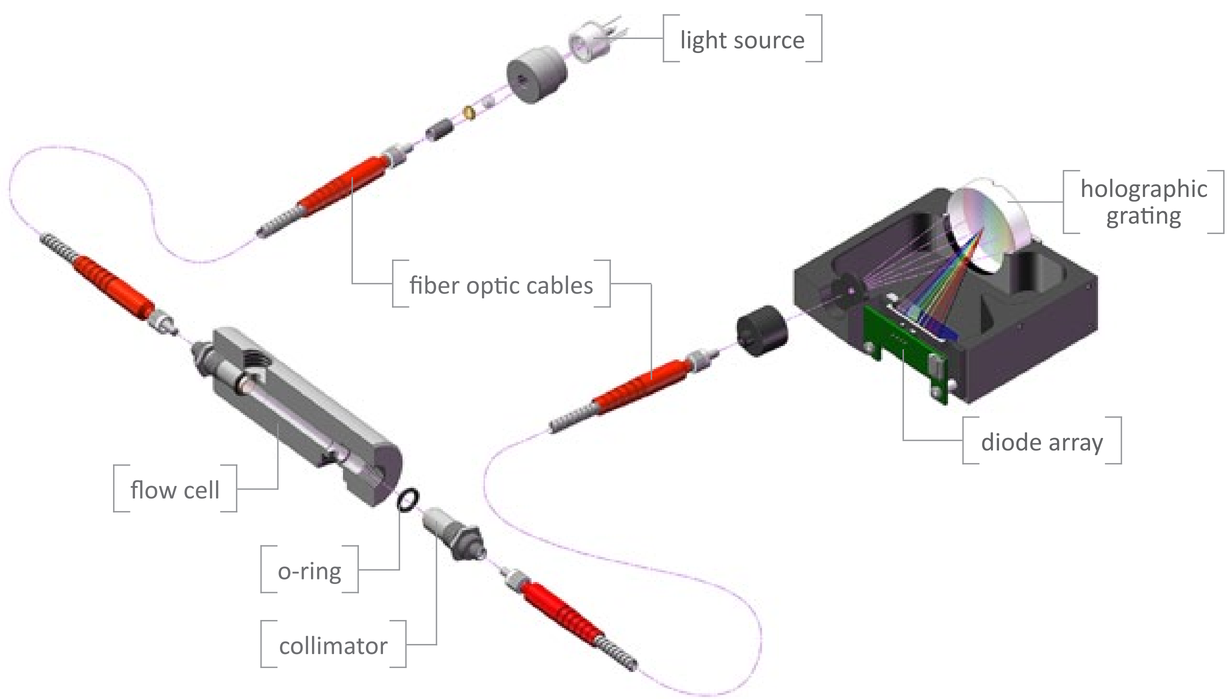
The standard OMA system is equipped with 1 galvanically isolated 4-20 mA analog output per measurement and 3 digital outputs. Additional communication protocols can be specified by the customer (inquire for available options).

Flow Cell & Fiber Optics

The continuously drawn process sample circulates through the flow cell as the fiber optic cables transmit the light signal through the flow cell path length and back to the nova II Spectrophotometer.

Optical Assembly & Principle of Operation

The nova II Spectrophotometer measures the absorbance in the sample. This device is normally mounted inside the OMA analyzer enclosure and transmits a light signal to and from the sample flow cell via fiber optic cables. The nova II housing contains the light source as well as the detector hardware.



The nova II measurement cycle is virtually instantaneous thanks to the speed of light. For explanatory purposes, it helps to break the cycle into stages:

(1) The white light signal originates in the pulsed Xe lamp that functions as the light source.

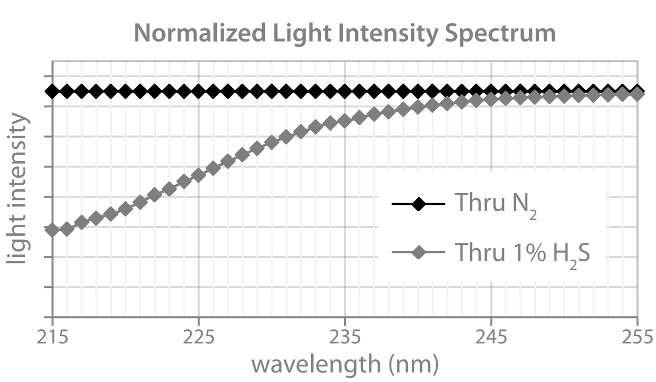
(2) The signal travels via fiber optic cable to the flow cell. A collimator narrows the light beam.

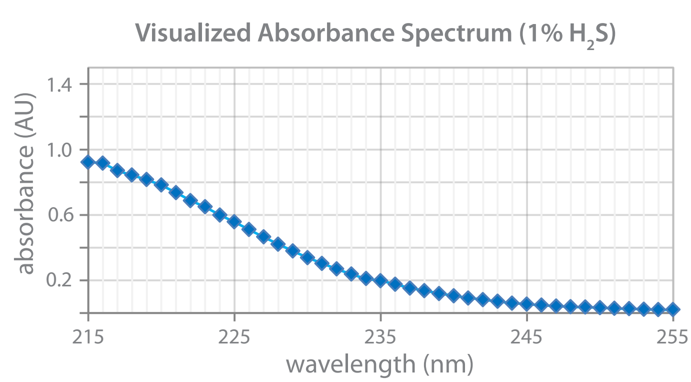
(3) The signal travels directly across the length of the flow cell, interacting with the continuously drawn process sample.

(4) The signal exits the flow cell through a collimator, now containing the distinct absorbance imprint of the current chemical composition of the sample.

(5) The signal travels via fiber optic cable to the nova II.

(6) The signal is dispersed by the holographic grating. Each differentiated wavelength is focused onto a designated photodiode within the diode array. Much like sensors in a digital camera, each diode records the light intensity at its assigned wavelength. The nova II provides this rich data to the HMI for real-time visualization of the absorbance spectrum:



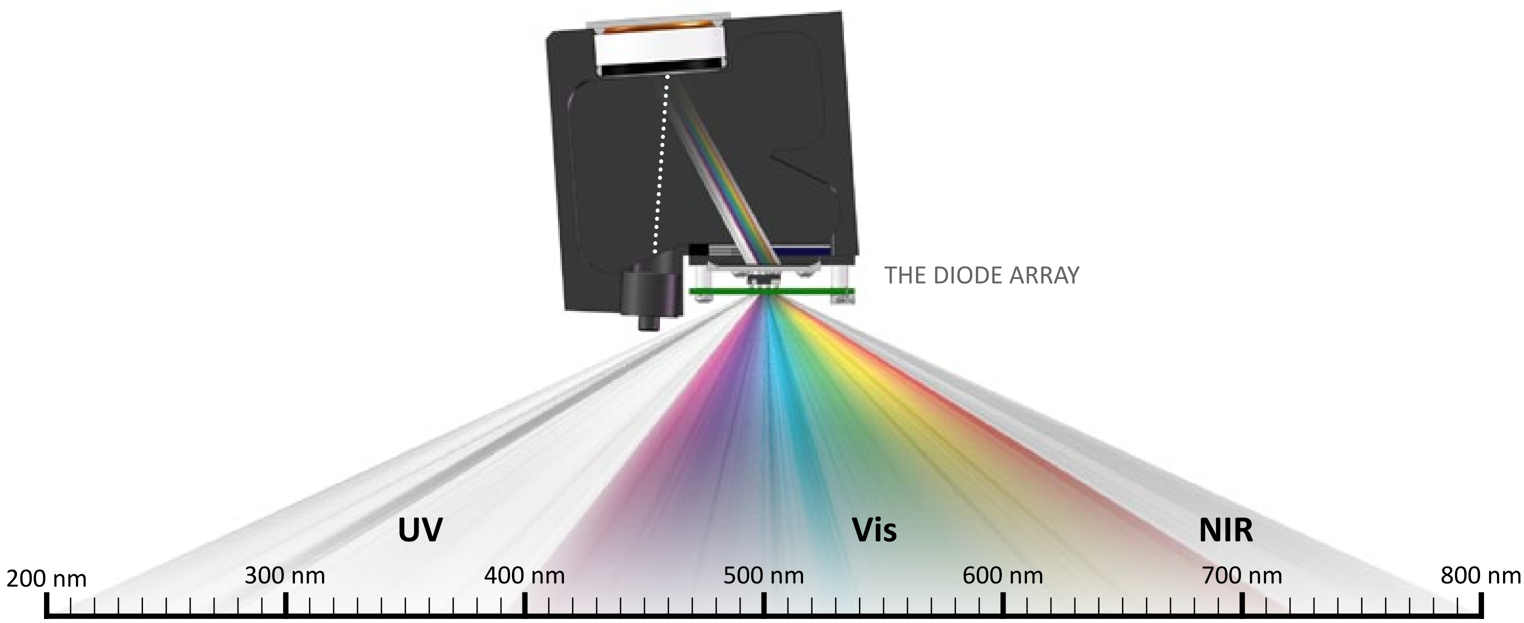


Normal Photometer vs. **nova II Spectrophotometer**

A conventional photometer measures a chemical's absorbance at one pre-selected wavelength with **one photodiode**. This is known as 'non-dispersive' spectroscopy because it uses an optical filter or line source lamp to remove all wavelengths but the pre-selected measurement wavelength.

The nova II Spectrophotometer acquires a full absorbance spectrum using an **array of 1,024 photodiodes**. Each one of these diodes is assigned by the firmware to register light intensity at one specific energy (wavelength). This is known as 'dispersive' spectroscopy because each wavelength of light is measured individually and no data destruction occurs.

In the nova II, a full 200-800 nm UV-Vis absorbance spectrum is produced at 1 nm resolution:



NOTE: Some applications require the SW-NIR version of the nova II depending on analytes and concentrations. This device is virtually identical to the UV-Vis nova II, except that it uses an alternate light source (tungsten) and assigns the diode array to a spectral range of 400-1100 nm.

nova II Overview

- Broad UV-Vis spectral response: 200-800 nanometers
- 1,024 photodiode array producing ~1nm resolution full spectrum
- Long-lifespan xenon light source with average 5 years b/w replacement
- CMOS analog circuitry for low noise and low power consumption
- Solid state device (no moving parts) for maximum stability
- Excellent performance in the low UV region
- No mirrors or filters used, minimizing stray light
- Ethernet interface for remote access

The Advantages of **Full-Spectrum** Analysis

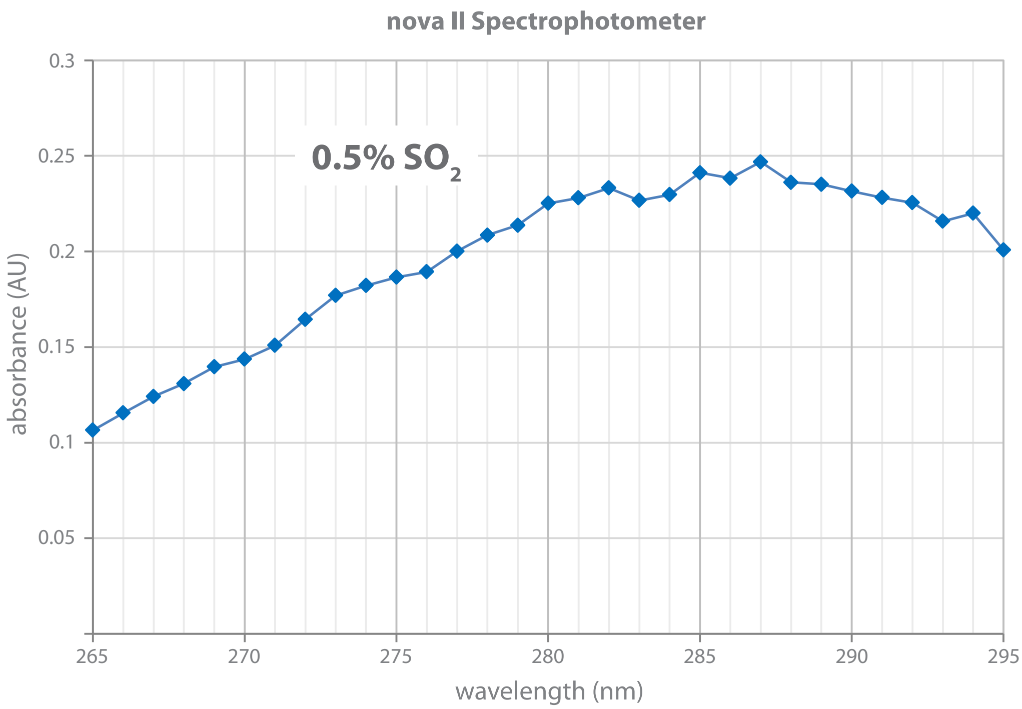
Dispersive, full-spectrum acquisition gives the OMA critical advantages in accuracy, dynamic range, and multi-component measurement, as detailed below.

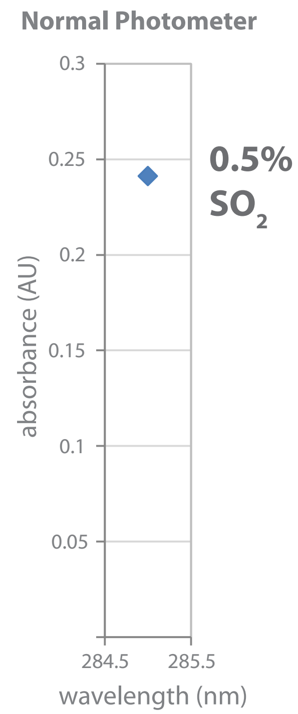
Collateral Data

Any single photodiode measurement is vulnerable to noise, signal saturation, or unexpected interference. This susceptibility to error makes a lone photodiode data point an unreliable indicator of one chemical's absorbance.

As accepted in the lab community for decades, the best way to neutralize this type of error is to use collateral data in the form of 'confirmation wavelengths,' i.e. many data points at many wavelengths instead of a single wavelength.

Consider the example of measuring SO_2 with either system:





In the figures above, each diamond represents a single photodiode and data point. The nova II registers absorbance at each integer wavelength within the 265-295 nm measurement range and produces an SO_2 absorbance curve. After being calibrated on a full spectrum of pure SO_2, the OMA knows the absorbance-concentration correlation for each measurement wavelength; the system can average the modeled concentration value from each wavelength to completely eradicate the effect of noise at any single photodiode.

The OMA visualizes the SO_2 absorbance curve in this manner and knows the expected relation of each data point to the others in terms of the curve's structure. This curve analysis enables the system to automatically detect erroneous results at specific wavelengths, such as when a single photodiode is saturated with light. The normal photometer, with a single data point, is completely incapable of internally verifying its measurement.

Huge Dynamic Range

[In spectroscopy, 'dynamic range' refers to how well the measuring instrument sustains accuracy in the event of large, rapid changes in concentration.]

Dynamic range is extremely limited for the typical photometer:

» If analyte concentration rises above the calibrated range, the absorbance at the measurement wavelength will be so strong that the photodiode will detect no light; the system has zero accuracy above this threshold.

» If analyte concentration becomes lower than expected, there will be no absorbance at the measurement wavelength and the photodiode may experience light saturation (just like an overexposed camera sensor) and lose sensitivity.

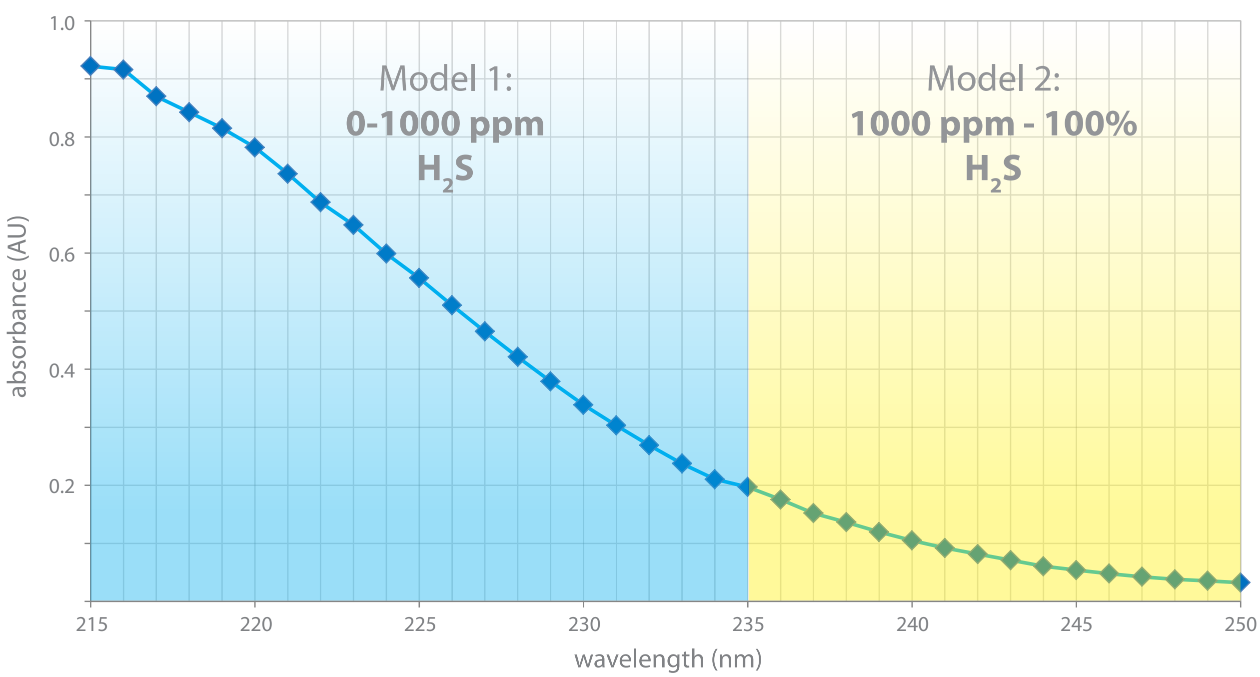
Photometers are not designed to remain accurate during unexpected process conditions, e.g. upset or overload — their performance is limited to ideal conditions.

The nova II Spectrophotometer intelligently exploits the diode array to establish huge dynamic range. This is done using parallel analysis models with different wavelength ranges, a unique capability of the ECLIPSE software.

For example, let's say you are measuring 0-1,000 ppm H_2S in natural gas. Your system is calibrated to use the 215-235 nm range of measurement wavelengths, the highest absorbing region in the H_2S UV spectrum. This wavelength range is excellent for low level H_2S because the strong absorbance is easily detected.

However, you notice that the H_2S concentration in the process periodically spikes up above the 1,000 ppm limit. The concentration is rising so high that no light is reaching the photodiodes scanning the 215-235 nm wavelengths — the absorbance here is too strong when H_2S is unexpectedly high.

In the ECLIPSE software, you add a second H_2S analysis model which uses the 235-250 nm range of measurement wavelengths. H_2S has much weaker absorbance in this region, but this is ideal for high level H_2S since over-absorbance will kill the signal. The two parallel analysis models are illustrated below:



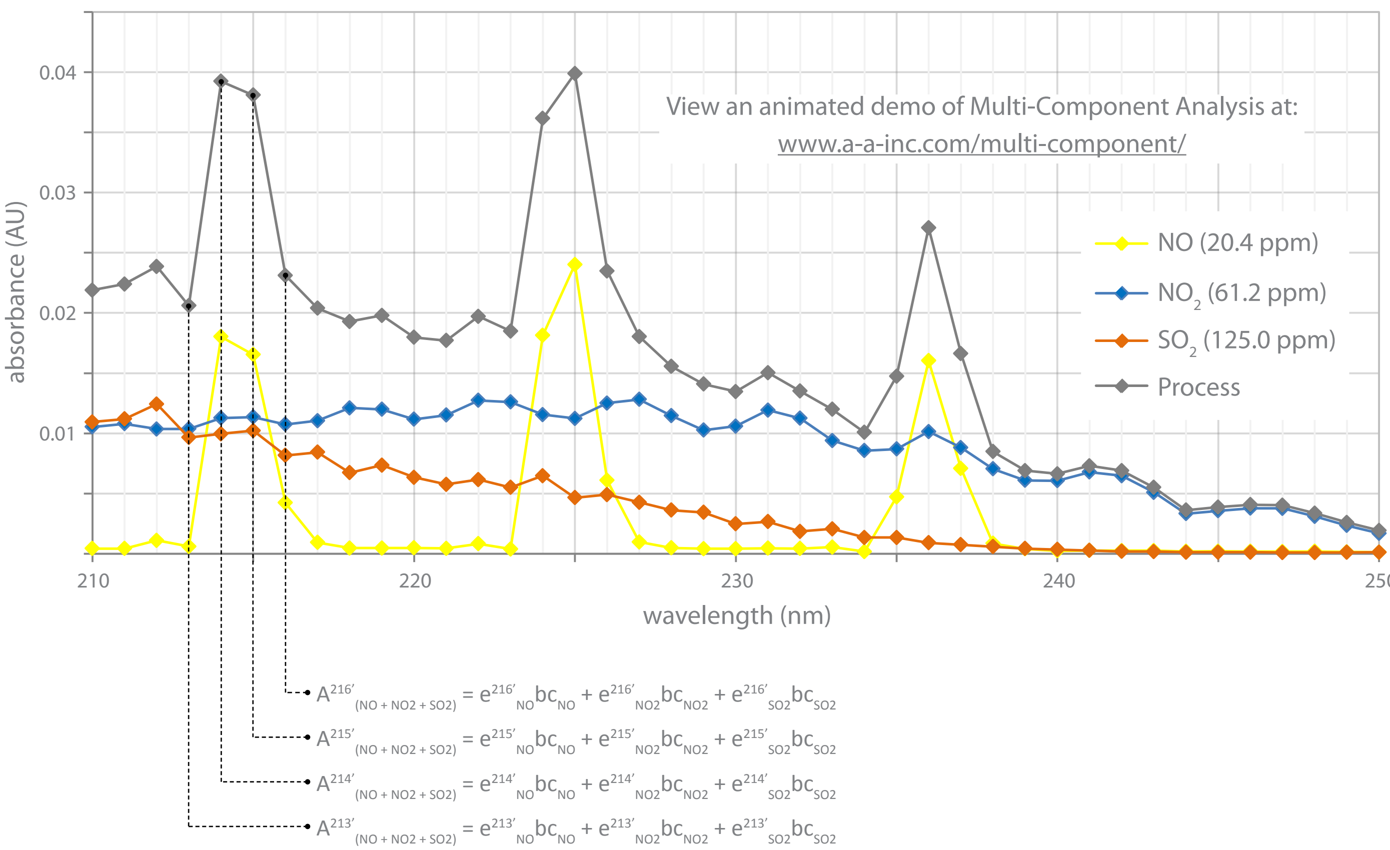
Both analysis models run simultaneously, and ECLIPSE uses conditional logic to determine which model reports to the DCS based on the current H_2S concentration. Due to this capability, the same OMA system can be used to measure any H_2S range from 0-10 ppm to 0-100%. Unlike the photometer, which has an "application lock" for a specific concentration range, you can adjust the measured concentration range(s) of the OMA at any time via this quick software procedure.

Multi-Component Analysis

The nova II Spectrophotometer does not depend on physical wavelength isolation or any other data-destructive method; filters are applied virtually by telling the software which measurement wavelengths to utilize. There is no "application lock" due to specialized filters/lamps, so the OMA can be repurposed easily as your process evolves.

All multi-component spectroscopy depends on the principle of additivity: according to Beer's law, the absorbance at any wavelength of a mixture is equal to the sum of the absorbance of each chemical in the mixture at that wavelength. A multiwave photometer measuring 2 chemicals will perform a rudimentary "2 equations, 2 unknowns" calculation using 2 measurement wavelengths to output the separate absorbance/concentration of each chemical.

Advancing from this crude algebra, the nova II Spectrophotometer uses robust collateral data and statistical averaging to perform far more accurate multi-component measurement. Consider the example of the nova II measuring SO_2 and NO_x simultaneously:



As illustrated above, the ECLIPSE software uses the full spectrum to de-convolute the total sample absorbance curve and isolate each chemical's absorbance. The OMA continuously solves a matrix of equations, where each equation is supplied by a single photodiode for its assigned wavelength in the form:

$$A'_{(x+y)} = A'_x + A'_y = e'_x bc_x + e'_y bc_y$$

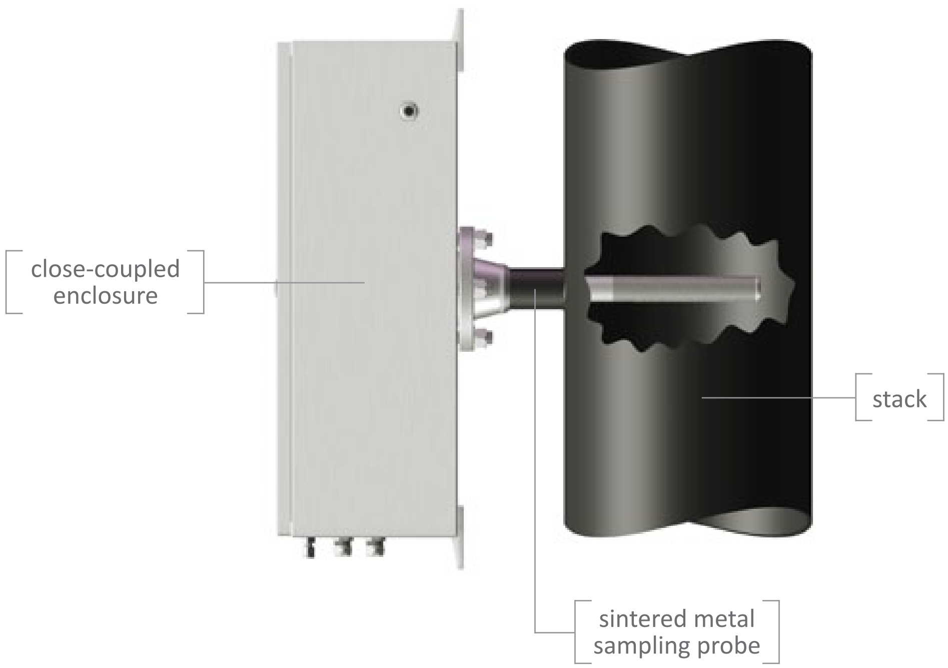
where *A'* is the absorbance at wavelength *'*, *e'* is the molar absorptivity coefficient at wavelength *'*, *c* is concentration, and *b* is the path length of the flow cell. In the image above, four such equations (at 213nm, 214nm, 215nm, and 216nm) are shown. In reality, the matrix includes one equation from every single integer wavelength in the measurement wavelength range.

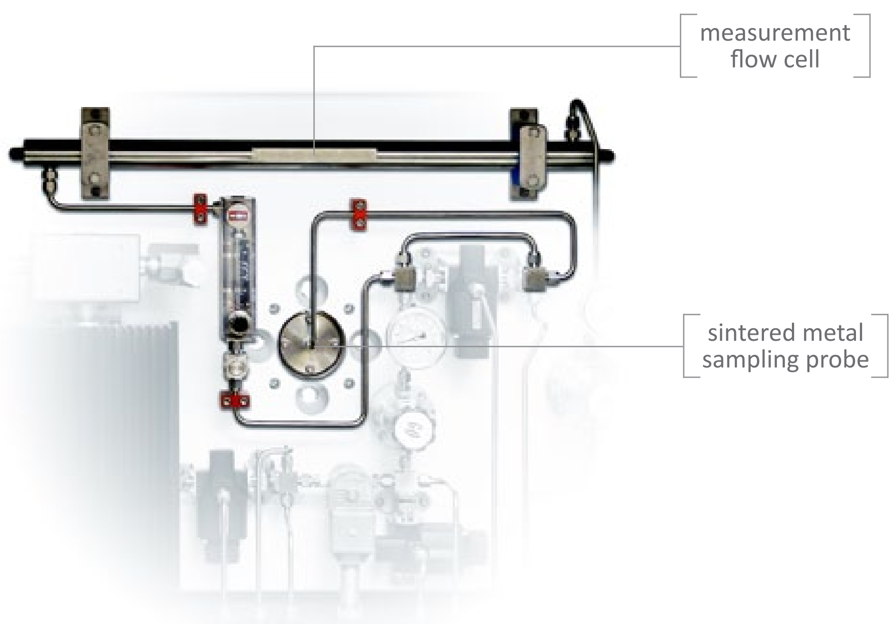
This robust calculation, performed with each reading, uses the power of confirmation wavelengths and statistical averaging to achieve much higher accuracy in multi-component measurement.

The **Close-Coupled** Design

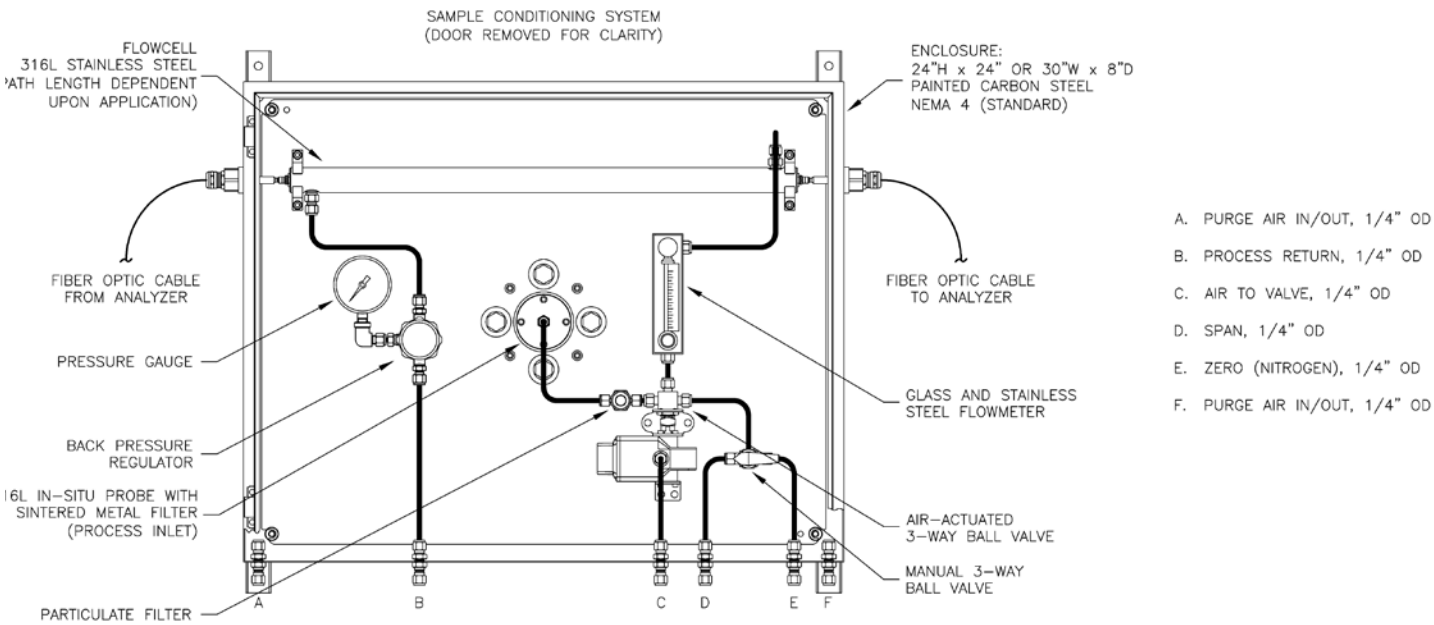
When it comes to sampling from flue gas streams, traditional cross-stack (in situ) and extractive methods each have their unique strengths and pitfalls. While cross-stack sampling is superior to extractive methods in response time and sample integrity, it has some serious drawbacks including the inability to verify the measurement with span gas and the difficult installation. Extractive sampling is easy to install and maintain, but has slow response and often provides a low-integrity sample.

As an attractive option, Applied Analytics offers a close-coupled CEM system — conceptually a hybrid between cross-stack and extractive sampling designs. In close-coupling, the sintered metal sampling probe enters the stack through a weld neck and draws a continuous sample by means of an enclosed aspirator. The sample conditioning system is mounted directly on this probe.





Close-Coupled Sample Conditioner Technical Drawing



Technical Comparison

	Cross-Stack Design	Extractive Design	**Close-Coupled Design**
Response time?	**FAST** No sample lines.	**SLOW** Long sample lines = sample lag.	**FAST** No sample lines. Sample cell is located very close to the stack.
Sample integrity?	**HIGH** No sample conditioning possible.	**LOW** Drying and dilution introduce signficant measurement error.	**HIGH** Direct analysis of hot, wet sample in mounted enclosure.
Span checks and verification using calibration gases?	**DIFFICULT/IMPOSSIBLE** The stack itself cannot be filled with calibration gas, and all workarounds ultimately calibrate using non-representative path lengths.	**SIMPLE BUT SLOW** Performed externally, but long sample lines increase procedure duration and downtime.	**SIMPLE AND FAST** Auto Zero and Auto Span are performed on user-set schedule on the same analysis path length. The procedure is brief due to minimal sample route.
Maintenance regimen?	**INTENSIVE** Aside from the difficulty of cleaning coated optics inside a stack, the instrumentation is subject to heat and corrosion from the flue gas. Service often require disassembly and downtime.	**INTENSIVE** Long sample lines suffer from cold spot plugging.	**MILD** No sample lines to maintain. Optics are easily accessible in mounted enclosure for a monthly cleaning. A shut-off valve allows for hot tapping.
Ease of installation?	**DIFFICULT** Aligning optics across the stack is a complex task. The height of the installation poses a documented human risk.	**DIFFICULT** Sample lines require expensive heat tracing.	**EASY** The SCS is mounted directly on the stack and connected to the analyzer with custom length fiber optic cables.

The OMA Series

The OMA platform — comprising the spectrophotometer, HMI, runtime software, fiber optics, flow cell, and I/O board — can be packaged with various form factors, enclosures, explosion proofing, and communication protocols to perfectly meet your requirements.

standard

OMA-300 w/ standard white carbon steel enclosure

ultra corrosion-proof

OMA-300 w/ NEMA 4X fiberglass enclosure

explosion-proof (Ex p)

OMA-300 Ex p w/ Z-Purge & NEMA 4X SS316 enclosure

explosion-proof (Ex d)

OMA-300 Ex d w/ cast-aluminum enclosure

portable

OMA-206 Portable w/ unbreakable copolymer suitcase

rack-mount

OMA-406 Rackmount w/ standard 19" form

freestanding

OMA-300 w/ free-standing structure

cabinet

OMA-300 w/ cabinet & highly custom integration

Communication Protocols

- 1 galvanically isolated 4-20 mA analog output per measured component; 2 digital ouputs for fault/relay control
- Customizable alarms for high/low concentration
- Optional: Modbus TCP/IP, RS-232, Fieldbus, Profibus, HART, and more

Available Hazardous Area Certifications

- CSA Class I Division 1
- CSA Class I Division 2
- ATEX Exp II 2(2) GD
- Gosstandart Pattern Approval
- All European directives
- Other certifications available — please inquire

User Experience

The OMA system only requires a one-time calibration during installation. Designed for unattended operation, the OMA only requires Auto Zero to maintain accuracy. Spanning is not required, but the OMA does include an Auto Span option.

ECLIPSE normal runtime display

ECLIPSE Auto Zero

Auto Zero

The OMA is self-maintained by periodically normalizing the spectrophotometer on a zero-absorbance fluid (e.g. nitrogen, air) in order to "zero" (i.e. blank) the analyzer. The ECLIPSE Auto Zero function automates this task by operating the SCS valves via relays to purge the flow cell with zero fluid and save a new zero spectrum. Auto Zero can be run on-demand or at a scheduled frequency.

In a typical usage profile, Auto Zero is set to run every 8 hours. The task requires approximately 120 seconds during which the measurement output is frozen. Under these settings, the OMA can provide greater than 99.5% analyzer uptime.

Integrating Required Non UV-Vis Measurements

Some chemicals do not absorb radiation in the UV-Vis / SW-NIR range and therefore cannot be analyzed by the nova II Spectrophotometer. Some of these measurements are often required in CEMS and are easily incorporated into the OMA system using integrated MicroSpec™ series analysis modules. These compact, single-analyte analyzers integrate directly into the OMA interface.

MicroSpec MCP-200 Module

Integrated Measurements

carbon monoxide — CO
carbon dioxide — CO_2
oxygen — O_2
water — H_2O
methane equivalency — CH_4
ethylene — C_2H_4

OMA-300-CEM Specifications

Note: All performance specifications herein are subject to the assumption that all design for integration and sample conditioning is first approved by Applied Analytics.

<table>
<tr><td>Detection Method</td><td colspan="4">nova-II™ UV-Vis diode array spectrophotometer
MicroSpec™ NDIR Analysis Modules
MicroSpec™ TDL Analysis Modules</td></tr>
<tr><td>Light Source</td><td colspan="4">UV-Vis: Pulsed xenon lamp (average 5 year lifespan)
NDIR: Tungsten black-body source
TDL: VCSEL</td></tr>
<tr><td>Fiber Optic Cables</td><td colspan="4">Standard: 1.8 meter 600 μm core fibers (qty=2)
Longer lengths available.</td></tr>
<tr><td>Sampling Design</td><td colspan="4">Standard: close-coupled sample conditioning system
Alternative designs available.</td></tr>
<tr><td rowspan="9">Accuracy & Repeatability</td><td colspan="4">Example ranges below; custom ranges available. Inquire directly for other accuracy specifications.</td></tr>
<tr><td>Analyte / Parameter</td><td>Example Range</td><td>Accuracy</td><td>Repeatability</td></tr>
<tr><td>SO_2</td><td>0-1,000 ppm</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>NO</td><td>0-1,000 ppm</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>NO_2</td><td>0-1,000 ppm</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>NO_x</td><td>0-2,000 ppm</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>CO</td><td>0-500 ppm</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>CO_2</td><td>0-20%</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>O_2</td><td>0-25%</td><td>±1% of measurement</td><td>±1.0%</td></tr>
<tr><td>Response Time (T_{10} - T_{90})</td><td colspan="4">10 seconds</td></tr>
<tr><td>Zero Drift</td><td colspan="4">±0.1% after 1hr warm-up, measured over 24hrs at constant ambient temperature</td></tr>
<tr><td>Sensitivity</td><td colspan="4">±0.1% full scale</td></tr>
<tr><td>Noise</td><td colspan="4">±0.004 AU at 220 nm</td></tr>
<tr><td>Analyzer Calibration</td><td colspan="4">One-time calibration at factory or site with certified calibration gas (never requires re-calibration)</td></tr>
<tr><td>Verification</td><td colspan="4">Simple verification with samples or neutral density filters</td></tr>
<tr><td>Ambient Temperature</td><td colspan="4">Low Range (<1000 ppm): 0 to 40 °C (32 to 104 °F)
High Range (>1000 ppm): 0 to 55 °C (32 to 131 °F)
w/ Temperature Control: -20 to 55 °C (-4 to 131 °F)</td></tr>
<tr><td>Environment</td><td colspan="4">Indoor/Outdoor — no shelter required</td></tr>
<tr><td>Wetted Materials</td><td colspan="4">Various custom materials available.
Standard: K7 glass, Viton, stainless steel 316L</td></tr>
<tr><td>Analyzer Enclosure</td><td colspan="4">Standard: NEMA 4 painted carbon steel enclosure
Other enclosures available.</td></tr>
<tr><td>Size</td><td colspan="4">Analyzer: 24”” H x 20”” W x 8”” D (610mm H x 508mm W x 203mm D)</td></tr>
<tr><td>Weight</td><td colspan="4">Analyzer: 32 lbs. (15 kg)</td></tr>
<tr><td>Electrical Requirements</td><td colspan="4">100 to 240 VAC 47 to 63 Hz</td></tr>
<tr><td>Power Consumption</td><td colspan="4">60 watts</td></tr>
<tr><td>Human Machine Interface</td><td colspan="4">Touch-screen industrial controller with 640x480 LCD</td></tr>
<tr><td>Storage</td><td colspan="4">32GB Solid State Drive</td></tr>
<tr><td>Software</td><td colspan="4">ECLIPSE™ Runtime Software</td></tr>
<tr><td>Standard Outputs</td><td colspan="4">1 galvanically isolated 4-20mA output per measurement
2 digital outputs for fault and SCS control</td></tr>
<tr><td>Optional Outputs</td><td colspan="4">Modbus TCP/IP; RS-232; Fieldbus; Profibus; HART;</td></tr>
<tr><td>Instrument Air Requirement</td><td colspan="4">70 psig (-40 °C dew point)</td></tr>
<tr><td>Certifications</td><td colspan="4">Class I, Division 2
Class I, Division 1 — optional
ATEX Exp II 2(2) GD — optional
Any other certification — please inquire</td></tr>
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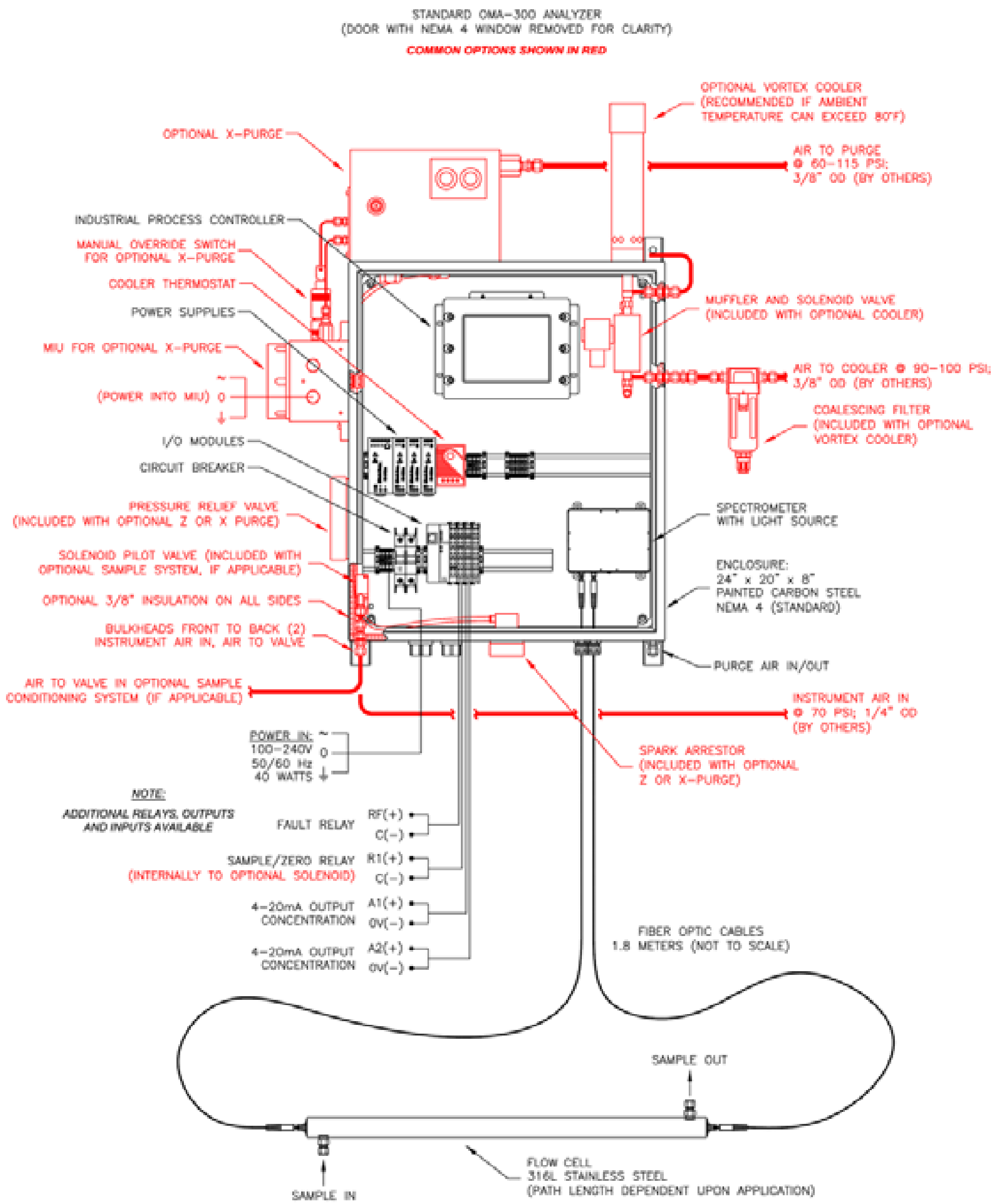

MADE IN THE USA

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Headquarters + Manufacturing
Applied Analytics, Inc.
Burlington, MA, USA | sales@a-a-inc.com

North America Sales
Applied Analytics North America, Ltd.
Houston, TX, USA | sales@appliedanalytics.us

Europe Sales
Applied Analytics Europe, SpA
Milan, Italy | sales@appliedanalytics.eu

Asia Pacific Sales
Applied Analytics Asia Pte. Ltd.
Singapore | sales@appliedanalytics.com.sg

Middle East Sales
Applied Analytics Middle East (FZE)
Sharjah, UAE | sales@appliedanalytics.ae

India Sales
Applied Analytics (India) Pte. Ltd.
Mumbai, India | sales@appliedanalytics.in

Brazil Sales
Applied Analytics do Brasil
Rio de Janeiro, Brazil | sales@aadbl.com.br