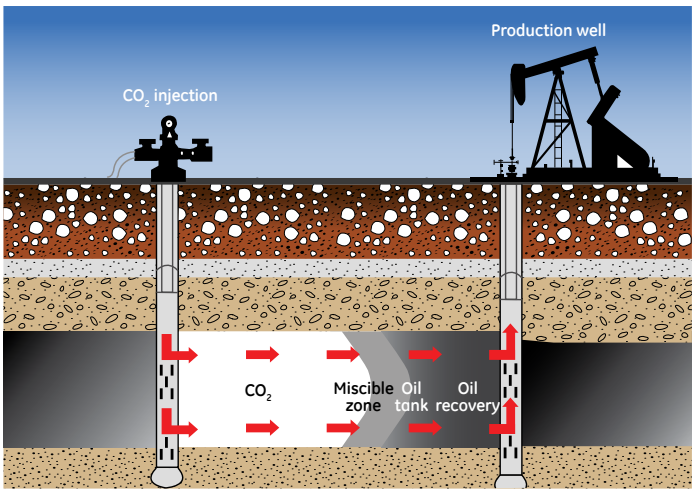
Aurora moisture analyzer

New light for moisture measurement in carbon dioxide

Panametrics Aurora analyzer uses tunable diode laser absorption spectroscopy (TDLAS) to rapidly and accurately measure moisture in CO_2. The analyzer is suitable for installation in hazardous areas and operates over a wide range of environmental conditions. Aurora's fast response immediately alerts when moisture concentrations are out of specification; once corrected, gas can be quickly cleared for re-entry to the process.

Enhanced oil recovery (EOR) is a generic term for techniques for increasing the amount of crude oil that can be extracted from an oil field. Using EOR, and additional 30 – 60%, of the reservoir's original oil can be extracted. Gas reinjection with carbon dioxide is presently the most commonly used approach to EOR. In addition, CO_2 can be sequestered in oil wells as opposed to being released into the atmosphere. Most global governments are supporting the development of EOR and carbon capture projects to reduce emissions and produce more energy.



The CO_2 used in this process must be dried to levels of -40°C dew point, about 130 ppmv, or lower. Panametrics Aurora offers the most reliable and fastest responding moisture analyzer for this application. The analyzer has no wetted moisture sensor and utilized a light energy to instantly measure the moisture content. The Aurora is designed to provide years of operation without user intervention or maintenance.

Panametrics experience in moisture measurement includes aluminum oxide, polymer capacitance and chilled mirror sensors. Panametrics heritage also includes the development of the first injection diode laser in 1962 by Dr. Robert Hall in Schenectady, NY. The compact and inexpensive diode laser made it possible for compact discs, laser printers and fiber optic telecommunications. The Aurora TDLAS hygrometer enables EOR and carbon sequestration facilities to monitor moisture content in real time with high precision and reliability.



Panametrics

Features and benefits

- Optical response <2 seconds
- Direct readout in lbs/mmscf, mg/m3, dew point or ppmv
- Turnkey sampling system for measurement integrity
- Hot permit not required with through-the-glass programming
- Analog and digital communications available
- AuroraView software enable remote service, trend graphing and diagnostics
- Five years of continuous, reliable service before first factory service
- Patented calibration process to meet variety of composition applications

Theory of operation

The Aurora TDLAS hygrometer fundamentally measures the partial pressure of water vapor (water in the gas state). With the simultaneous measurement of pressure and temperature, the Aurora provides all of the commonly used moisture units, including:

- Volume ratio in parts per million by volume (ppmv)
- Absolute humidity in lbs per million standard cubic feet (lbs/mmscf) or milligrams per cubic meter (mg/m3)
- Dew point temperature in °C or °F
- Pressure dew point in °C or °F

The fundamental water vapor pressure measurement is based on the Beer-Lambert Law:

$$A = ln\left(\frac{I_0}{I}\right) = SLN$$

A = Absorbance

Io = Incident light intensity

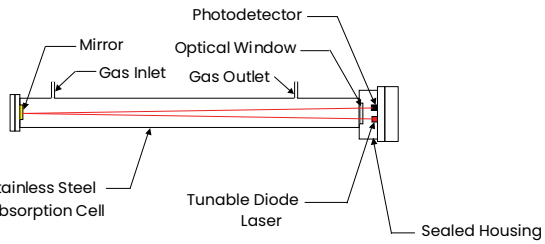
I = Light intensity transmitted through sample gas

S = Absorption coefficient†

L = Absorption path length (a constant)

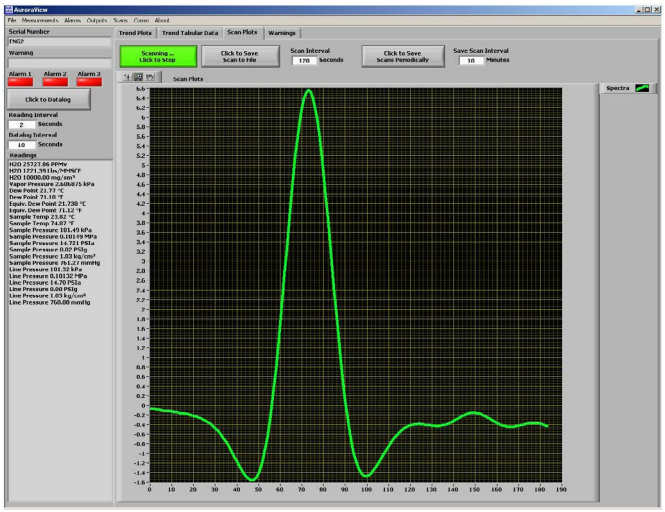
N = Concentration of water vapor (directly related to the ratio of the partial pressure of water and the total pressure)

†The absorption coefficient is a constant for a specific gas composition at a given pressure and temperature.



Cross-section of absorption cell

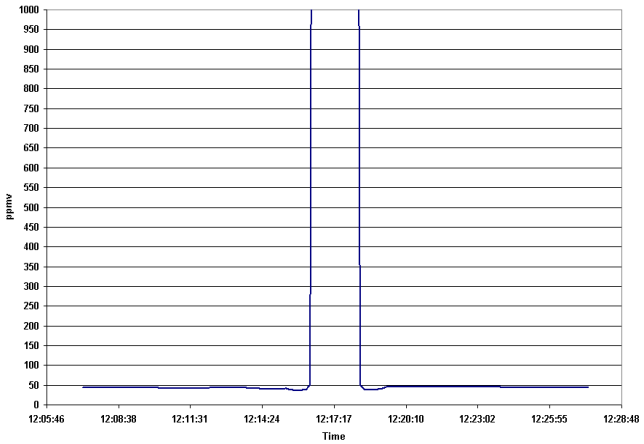
At certain specific frequencies the water molecule will absorb light energy, while at other frequencies the gas is practically transparent. At a given absorbing frequency, as the concentration of water vapor increases, the absorption also increases. Aurora utilizes a diode laser that is swept through a narrow frequency band in the near infrared spectrum. The laser is also modulated at high frequency. By measuring the laser light intensity with a photodetector, the Aurora is able to provide direct measurement of the partial pressure of water by correlation of laser light lost to the incident light. The light loss or absorption signal is reduced by looking at the second harmonic signal known as the 2F signal. The magnitude of the 2F signal is related to the partial pressure of water, which is divided by the total pressure and multiplied by 106 yields ppmv (parts per million by volume).



The location of the peak on the x-axis confirms the identity of water. The y-axis is related to the partial pressure of water and therefore the concentration. The system is equipped with AuroraView software, which enables users to capture the absorption spectrum and export it to other application programs such as ExcelTM.

Built to last

The absorption cell of the Aurora is constructed for proven reliability. The laser light is transmitted through an optical window made of proprietary material, reflected off a gold plated mirror, and then returned through the window where it is measured by a photo detector. Since only light comes in contact with the process gas and all wetted components are made of inert non-corrosive materials, this technology provides fast response without drift associated with sensor based hygrometers.



Example of Aurora's response time after a process upset. Water was injected into a sample of natural gas that had a concentration of 50 ppmv. Within a few seconds the Aurora indicated the increase. The Aurora recovered back to 50 ppmv within three minutes.

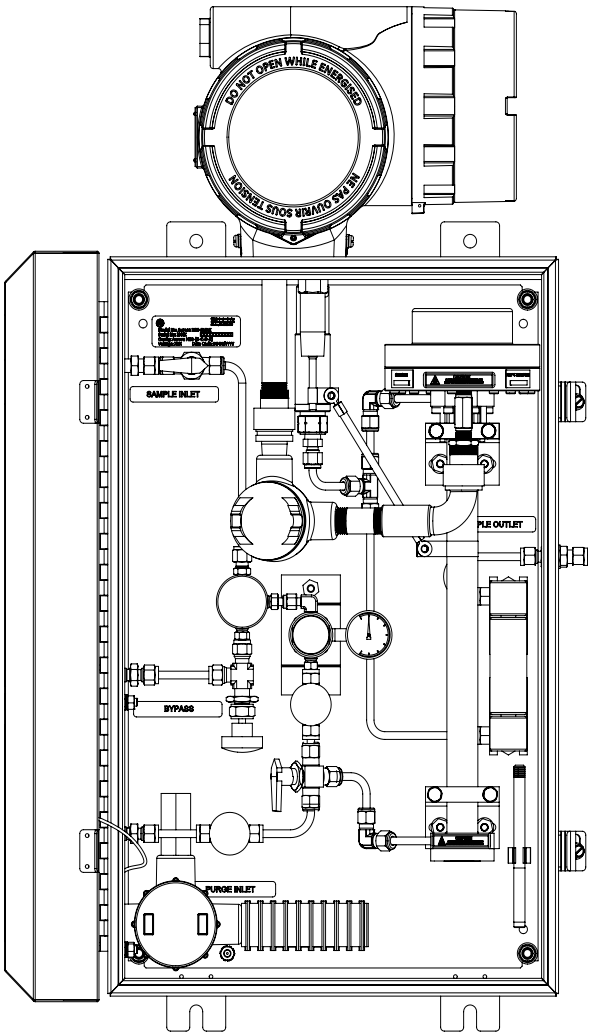
The complete system is certified for use in hazardous areas. The laser power supply, controller and digital signal conditioning circuitry are assembled in an explosion proof, flameproof enclosure. A backlit three parameter LCD provides direct readout of user-programmable parameters as well as indication of system status. The Aurora utilizes induction keys and a magnetic stylus eliminating the need for a hot permit to program or access the unit.



The Aurora is equipped with magnetic induction keys that enable "through-the-glass" programming. The unit may be operated in a hazardous area without the requirement for a "hot permit."

Aurora is equipped with three programmable analog outputs (0/4-20 mA), two digital RS485/232 ports and an optional ethernet port. The unit is equipped with an auxiliary 4-20 mA input channel for connection to a process pressure transmitter which enables real-time calculation of process dew/frost point. MODBUS RTU communication protocol makes the Aurora ideal for connection to a data acquisition system or SCADA system for long term monitoring of process moisture concentration.

An adequate sample system is critical for accurate moisture measurement. For high pressure applications, the Aurora can be equipped with heated pressure regulators and membrane/coalescing filters to drop the sample pressure over stages while also eliminating any liquid carryover from the sample gas. The flow rate of the sample is adjusted with needle valves. In cold climates, an optional heater may be installed in the enclosure to keep the sample in the gas phase. The Aurora sample system is 100% customizable; experienced Panametrics application engineers are committed to finding the best solution for every application.



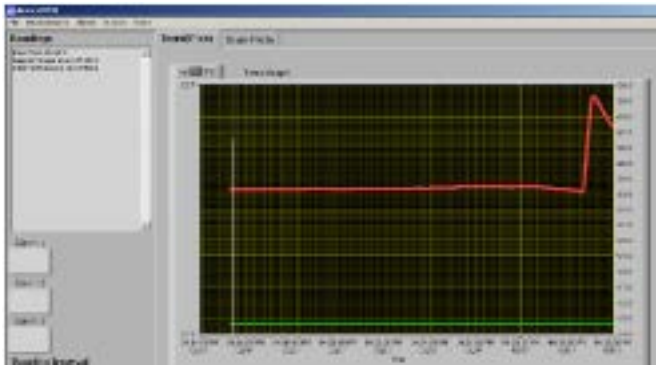
Sampling system—US and Canada

Each Aurora unit is calibrated against a NIST (or other national metrological institute) traceable moisture generator and reference hygrometer. A certificate of calibration with functional test data is supplied with every unit. Calibration is performed using nitrogen as the background gas, then verified by using carbon dioxide background gas. This innovation enables users to verify the Aurora using nitrogen with a known concentration of water.

AuroraView© PC software is supplied with every Aurora. The utility enables the simple interface to a remote computer. AuroraView enables remote configuration user selected parameters, trend graphing, diagnostics and capturing of spectral scans. Trend data and spectral scans can be saved as ASCII text files, facilitating the ability to export and share the data in other application software such as ExcelTM.

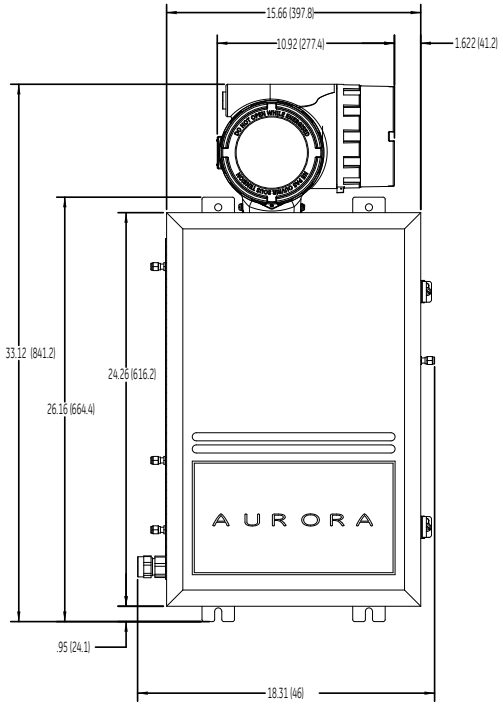


AuroraView has intuitive pull-down menus for setting up the parameters to be displayed, graphed and data logged.

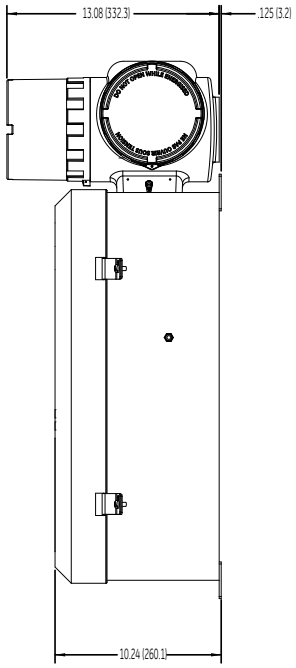


AuroraView software displays direct readings of moisture, temperature and pressure, as well as trend graphs. The data trends can be exported as ASCII text and opened in spreadsheet programs such as ExcelTM.

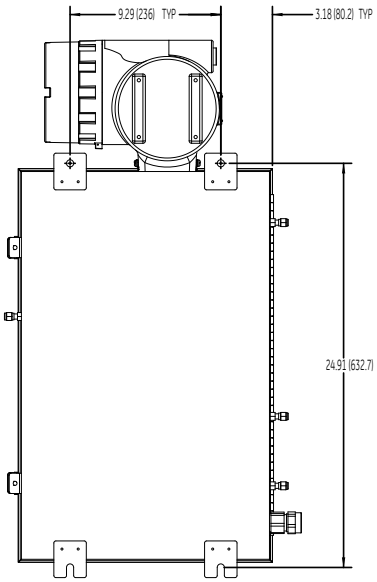
Dimensions



Front view



Side view



in (mm)

Specifications

Range	
Range	0 to 5000 ppm For CO_2 applications: 0 to 1000 ppm
Lower detection point	2 ppm For CO_2 applications: 20 ppm (-55.3°C)
Dew/frost point	-97° to 27.3°F (-71° to -2.6°C) frost point @ STP of 25°C, 14.696 psia
Process dew/frost point	Process or equivalent dew point/ frost point by calculation with process pressure signal (4-20 mA) or constant
Absolute humidity	0.095 to 237 lbs/MMSFC (1.52 to 3,803 mg/m^3)
Accuracy	
Moisture reading (parts per million by volume)	±1% of reading or ±2 ppm, whichever is greater; for > 1000 ppm, ±5% of reading For CO_2 applications: ±3% of reading or ±5 ppmv For H_2 recycle applications: ±1% of reading or ±2 ppmv (for up to ±5% H2 and ±1% C_2H_6 variation from nominal calibration composition) (Background conditions for individual instrument calibrated accuracy provided in Certificate of Conformance. Accuracy of other parameters derived from ppmv.)
Repeatability	±0.2 ppmv or ±0.1%, whichever is greater For CO_2 applications: ±1.0 ppmv or ±0.5%, whichever is greater
Calibration certification	NIST or equivalent NMI traceable certification
Calibration options	Nitrogen, standard natural gas and 3 customizable calibration curves
Response time	
Response time	Optical system <2 seconds
System response	The system response is dependent on the length of sample tubing, sample system components, flow rate and pressure, as well as the change in moisture concentration.
Pressure	
Operating sample cell pressure	10 to 25 psia (69 to 172 kPa)
Maximum pressure	200 psi (1380 kPa)
Process pressure	400 psig (2.76 MPa) [2500 psig (17.23 MPa) with heated pressure regulator option] *Higher pressure available with application of additional sampling system components.*

Flow rate	
Sample cell flow rate	10 to 60 SLH (0.4 to 2 SCFH); 30 SLH (1 SCFH) nominal
By-pass fast loop	5 to 10X of flow rate through sample cell
I/O	
Display	Backlit LCD. Three programable simultaneous parameters. Alphanumeric status and diagnostic display. LEDs for power, laser temperature stability, keypad lockout
Power	Analyzer: 100-240 VAC, 50-60 Hz, 24 VDC
Analog outputs	Three 0/4-20 mA DC (source) with 500 ohm load. User programmable for any parameter and scalable. Complies with NAMUR protocol for analog signals.
Analog input	Loop powered 4-20 mA input for remote pressure transmitter. Aurora supplies 24 VDC.
Digital interfaces	Two programmable digital communications ports: RS232, RS485 with multidrop capability and assignable address, MODBUS RTU protocol. One ethernet port: Modbus TCP/IP protocol
User interface	Programmable "through-the-glass" via magnetic stylus
Laser	Class 1 product. Conforms to IEC 60825-1. Edition 2.0 Safety of Laser Products
Enclosure	
Ingress protection	IP-66
Net weight	45 kg (100 lb)
Dimensions (H x L x W)	841.2 mm x 461 mm x 332.3 mm (33.12 in. x 18.31 in. x 13.08 in.)
Temperature	
Operating	-20 to 65°C (-4 to 149°F)
Storage	-20 to 70°C (-4 to 158°F)
Optional heater/ thermostat set point	20°C/68°F ±5°C/9°F for US/Canada, 10°C/50°F ±5°C/9°F EU and elsewhere
Hazardous area certification	
USA/Canada	Explosion-proof for Class I, Division 1, Groups B, C, D
EU and elsewhere	ATEX and IECEx: Ex de IIB+H2 T6 -20°C to +65°C Flameproof with increased safety compartment

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