MODEL 3050-OLV Process Moisture Analyzer

AMETEK®
PROCESS INSTRUMENTS

Welcome to the new world of process moisture analysis

The Model 3050-OLV measures trace levels of moisture in a gas through the use of a quartz-crystal oscillator sample cell. AMETEK is the leader in quartz-crystal technology, which for thirty years has offered significant advantages over other measurement techniques:

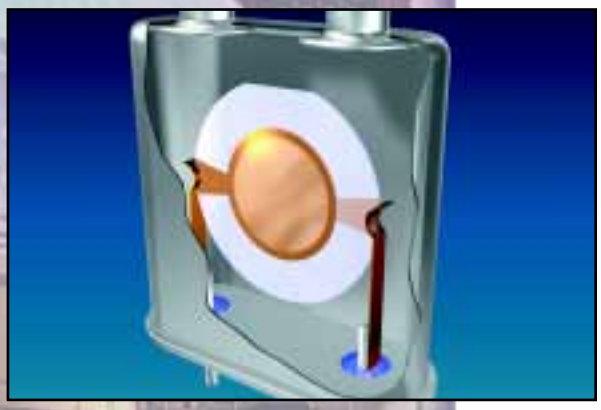
- *It is the most accurate trace moisture measurement technology available*
- *It responds far faster to both increasing and decreasing moisture levels*
- *It is specific to moisture in most applications*
- *It provides a much more rugged sensor*

Because of these advantages, the quartz-crystal oscillator has become the industry standard for applications ranging from ultrahigh purity semiconductor gases to natural gas streams containing 30% H_2S. Now, the 3050-OLV brings the benefits of quartz-crystal technology to a broad spectrum of moisture measurement applications.

Humidity measurement vs. moisture measurement

Most process moisture sensors measure relative or absolute humidity, with the data commonly expressed as dew point. But, absolute humidity is a function of not only moisture concentration, but also the pressure of the gas. Relative humidity varies with both pressure and temperature. Humidity sensors, therefore, require pressure and temperature compensation to convert their readings to true moisture concentration.

The Model 3050-OLV measures moisture concentration directly, in parts per million by volume, parts per million by weight, or mass of water per standard volume. There is no need for pressure or temperature compensation because the true moisture concentration is totally independent of these parameters.



Quartz-crystal oscillator,
the heart of the 3050-OLV analyzer

The quartz-crystal oscillator

The heart of the 3050-OLV analyzer is a quartz-crystal microbalance (QCM) sensor and sampling system developed by AMETEK specifically for highly accurate moisture measurements. The sensor consists of a pair of electrodes which support the QCM sensor. When voltage is applied to the sensor a very stable oscillation occurs.

The faces of the oscillator are covered with a hygroscopic polymer. As the amount of moisture sorbed onto the polymer varies, the mass of the QCM changes, producing a corresponding change in the frequency of oscillation.

Unique sampling system

The sampling system in the 3050-OLV provides three operating modes: **gas saver, sensor saver,** and **high speed**.

Under normal conditions, the analyzer operates in the high speed mode. Process gas and dry reference gas alternately pass through the sensor for short, equal intervals of time. In this mode, the analyzer delivers a speed of response that's far superior to other analyzers while consuming just over one SLPM of sample gas.

If the analyzer is connected to the process through a long length of tubing, the apparent response time will be affected by the time it takes the moisture event to travel the length of the tubing. For these applications, the high speed mode will provide the fastest response to

process changes available from any process moisture analyzer. In some processes, the sample gas is very valuable, in which case the sample gas consumption of the 3050-OLV can be reduced to a mere 150 sccm by activating GAS SAVER mode.

In process applications where the sample contains liquid contaminants such as glycol, compressor oils or high boiling point hydrocarbons, the 3050-OLV should be operated in its sensor saver mode. Here, the sensor sees the process sample for a shorter period and the reference gas for a longer period. Therefore, the sensor is exposed to less contamination and the dry gas has a longer period to strip volatile contaminants from the sensor. These two factors work together to provide a longer cell life.

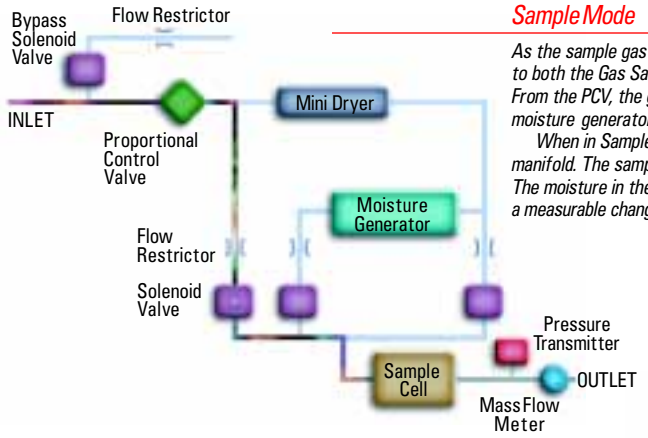
Sophisticated system diagnostics

Using an integral moisture generator that is NIST-traceable, the Model 3050-OLV verifies the accuracy of its measurements. This verification can be programmed at regular intervals, or accomplished by a manual command at any time. During the verification process, the 3050-OLV can make any necessary small corrections to its calibration automatically. If a severe calibration problem exists, the analyzer will provide an alarm.

This analyzer also monitors the baseline performance of the QCM sensor. If contaminants begin to foul the sensor, the analyzer will automatically change its operating mode to the sensor saver mode and provide an alarm. This self-preservation capability enables the 3050-OLV to continue to deliver accurate moisture measurements while extending cell life.

The sampling system

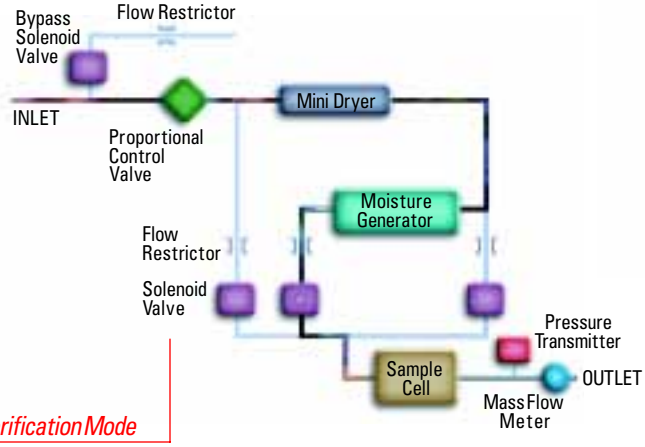
The unique AMETEK sampling system in the Model 3050-OLV provides superior accuracy, repeatability, and speed of response compared to other moisture analyzers. And, the analyzer's On-Line Verification capability gives you data you can count on while completely eliminating the need for periodic recalibration of probes.



Sample Mode

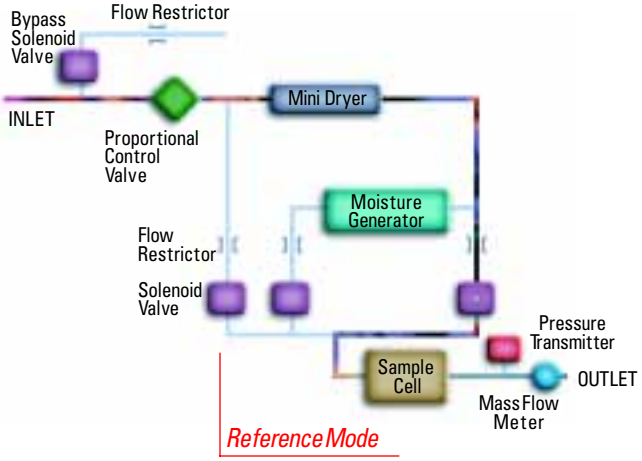
As the sample gas enters the Model 3050-OLV, it enters the input manifold. Here the gas will flow to both the Gas Saver bypass control valve and the analyzer's proportional control valve (PCV). From the PCV, the gas will flow through three distinct paths: sample path, reference path, and moisture generator path.

When in Sample Mode, the sample gas flows directly to the sample solenoid valve on the cell manifold. The sample solenoid valve activates, thereby directing the sample gas to the sample cell. The moisture in the process sample is deposited on the surface of the crystal oscillator, producing a measurable change in the frequency of oscillation.



Verification Mode

With its on-line verification capability, the 3050-OLV provides a level of confidence that doesn't exist with other moisture analyzers. Part of the dry reference gas passes through a precision moisture source which introduces a known, repeatable moisture concentration to produce a moisture calibration gas. This calibration gas is routed to the sensor, on a programmed schedule, or on manual command. The analyzer compares its measurement with this NIST-traceable value and alerts you if its reading is out of specification.



Reference Mode

Some of the sample gas exiting the PCV flows to the dryer that produces a reference gas with a low ppb moisture content. Note that the reference gas is the actual process gas being measured. The moisture that was previously deposited on the surface of the crystal oscillator during the sample mode is swept away by the dry reference gas, producing a measurable change in the frequency of oscillation.

Inherently better accuracy that you can verify right in your process

When a moisture analyzer is used to protect a catalyst bed, you are concerned about the true concentration of water molecules in the process gas, not the humidity of the process. When filling gas cylinders, the data you need is the volume concentration of water as an impurity. In drier beds, it's the volume of water the drier bed can absorb before it needs to be regenerated. And, in natural gas applications, it's the volume of water per standard cubic measure that is the real measurement needed.

A moisture analyzer that measures humidity is a compromise in process applications. Now, it's a compromise you no longer have to make. The Model 3050-OLV gives you a direct measurement of moisture concentration. And, it gives it to you with a degree of accuracy and confidence that other analyzers just can't provide.

Consider the basic accuracy specification of the 3050-OLV: ±10% *of reading*, from 1 to 2500 ppm by volume. Compare this to the accuracy of a humidity analyzer that is typically listed as dew point. The typical specification is $\pm 2^0$ C and $\pm 3^0$ C dewpoint for gases drier than -65^0 C dewpoint. Which analyzer provides you with more accurate data?

Let's look at a process stream with a true moisture content of 1000 parts per million by volume. Under these conditions, the dew point (at one atmosphere) is approximately -20^0 C. In this situation, the humidity analyzer has an accuracy of $\pm 2^0$ C, so its readings can vary from -18.2^0 C to -22.2^0 C. A dew point of -18.2^0 C indicates a true moisture level of 1210 ppmv. That's a possible error of +210 ppmv, which translates to an accuracy of only +21%. At the opposite extreme, a dewpoint measurement of -22.2^0 C indicates a true moisture level of 824 ppm. Now the humidity analyzer's allowable error is −176 ppmv and the corresponding accuracy is −18%. With its accuracy of ±10% of reading, data from the 3050-OLV could only range from 900 to 1100 ppmv.

With humidity analyzers, drier gas results in bigger errors. With a gas stream containing a true moisture concentration of 1.0 ppmv, the 3050-OLV gives you a reading from 0.90 to 1.1 ppmv. The typical humidity analyzer is now in its $\pm 3^0$ C dew point accuracy range. Therefore, the data of a brand new humidity sensor can be in error by as much as +60%/-38% of the actual moisture level.

Drift is another major concern

While the inherent inaccuracy of humidity analyzers is a major obstacle to obtaining accurate moisture measurements, the drift of aluminum oxide probes may be an even bigger problem. Manufacturers of these probes typically warrant the calibration of the probe for only six months and recommend that they be returned for recalibration on a regular schedule.

Pulling probes out of a process for shipment back to the manufacturer is certainly an inconvenience. It's also a cost consideration, since a spare probe must be available during the time it takes for recalibration.

Of even greater concern is the time uncertainty of when the probe begins to drift. Did it occur just minutes before the probe was replaced? Or, did it occur minutes after the probe was first installed?

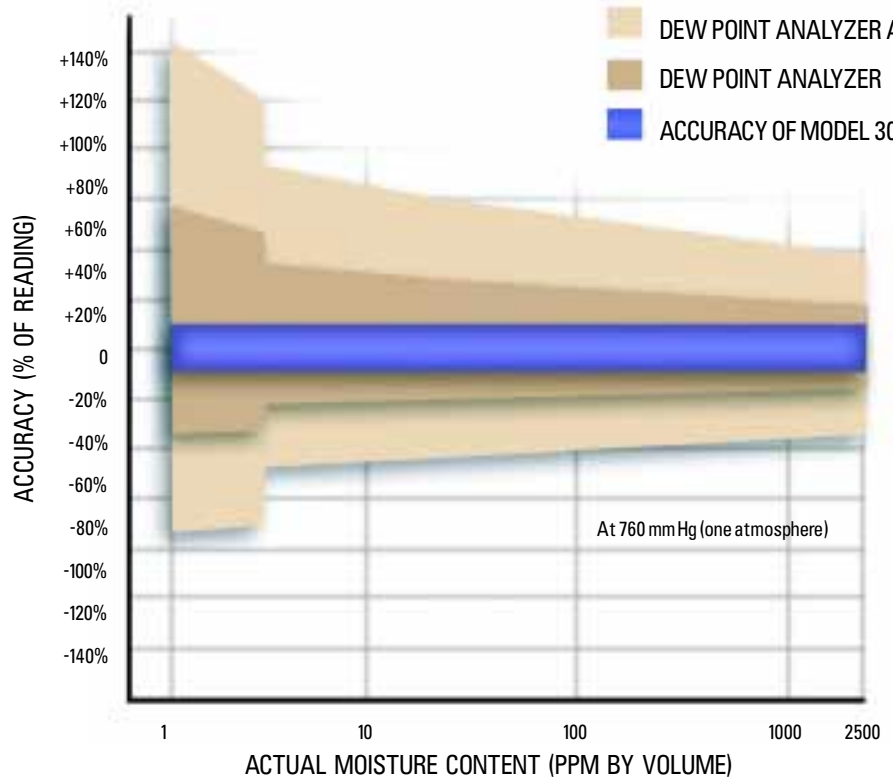
While an exact specification on drift is often difficult to determine, a change of 3^0 C to 4^0 C between calibrations is fairly common. Going back to our hypothetical example of a process stream with 1000 ppmv moisture at one atmosphere, a drift of ±3^0 C produces a moisture measurement error of +400/-209 ppm. That's an additional inaccuracy of +40%/-21% on top of the basic accuracy specification. Therefore the combined error due to basic accuracy and drift under these conditions could be +61%/-39%.

Once again, the lower the actual moisture content of the sample, the worse the situation becomes. For an actual moisture concentration of 1 ppm, the sum of the base and drift errors for a humidity analyzer could be +152%/-62%.

Perform On-line verification of humidity sensors using the 3050-OLV

With its internal moisture source, the 3050-OLV gives you data you can have confidence in. On a programmed schedule, or whenever you feel it's necessary, you can route your process gas through the 3050-OLV's internal moisture source, giving you a calibration standard based on the actual process gas. The 3050-OLV automatically compares its measurement with this NIST-traceable known value. The analyzer can then make any necessary small corrections to its calibration automatically. If a severe calibration problem exists, the analyzer will provide an alarm.

You can also use the 3050-OLV to verify the performance of sensors that previously had to be returned to the manufacturer for recalibration. Simply include a slipstream into the sampling system for the other moisture sensor. Connect the 3050-OLV to the slipstream and command it to self-verify; then, compare the 3050-OLV's data to the other moisture sensor. With this approach, you can eliminate "measuring" out of specification gas with an out of calibration sensor. And, you can eliminate the cost of returning sensors for recalibration when it's not needed.



ACCURACY OF MODEL 3050-OLV AND DEW POINT ANALYZER

Because it measures moisture concentration directly rather than humidity, the Model 3050-OLV provides significantly greater accuracy over its entire operating range. At moisture levels below about 5 ppm (-65^0 C dew point), the accuracy of the humidity analyzer degrades even further.

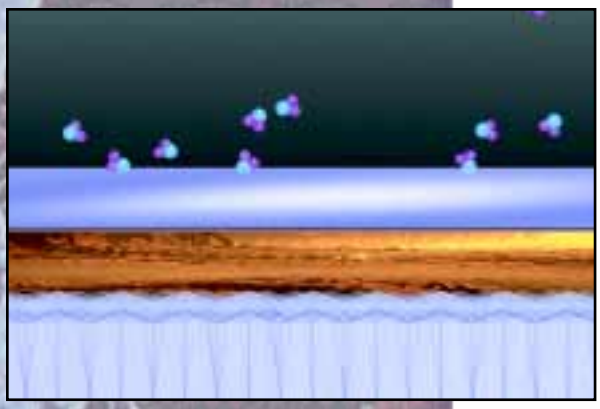
COMPARE ACCURACY PLUS DRIFT OF MODEL 3050-OLV AND COMPETITION

This graph shows the sum of the errors for a dew point sensor that drifts ±3^0 C between calibrations. The on-board verification feature of the 3050-OLV can check for drift errors and provide automatic compensation.

Response Time in Process Gases is Critical

Two response speeds: fast and faster

Compared to other process instruments, moisture analyzers have the reputation for slow response times. When a rapid change in moisture concentration occurs, conventional humidity sensors require a long period of time before they can report the new humidity level accurately. This problem is particularly acute with sudden decreases in moisture levels that require the sensor to dry down.



During the reference gas cycle, the water molecules are swept off the surface of the sensor by the dry gas flow

Aluminum-oxide sensors calculate dew point based on the water that has permeated through the metallic electrode and been absorbed by the dielectric material. These sensors can only provide an accurate representation of the process gas after the moisture within the sensor has reached equilibrium with the moisture in the process gas.

When the moisture content of the process gas decreases, the problems of aluminum-oxide sensors become more pronounced. Moisture molecules already in the sensor matrix are bound by weak physical bonds; therefore it takes longer to get moisture out than it took to get it in. If the sensor needs protection in the form of a sintered metal cap, the cap has to dry before the sensor can even begin to move toward equilibrium with the process gas.

The Model 3050-OLV employs "non-equilibrium" sensing technology, pioneered and refined in over thirty years of practical applications. The fundamental difference between the 3050-OLV and other technologies, is that the 3050-OLV does not need to measure the absolute value of moisture. So, there's no need to wait for equilibrium between the sensor and process.

The analyzer cycles between the actual process gas and the dried reference gas. During the process gas cycle, moisture molecules accumulate on the surface of the QCM sensor. During the reference gas cycle, these water molecules are swept off the surface of the sensor by the dry gas flow.

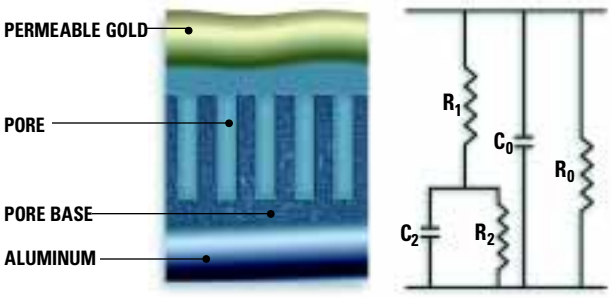
The number of water molecules that accumulate on the surface of the sensor is a function of the difference in moisture between the process gas and reference gas. The analyzer compares the process gas with the known, dry reference as opposed to trying to measure an absolute value that only occurs once equilibrium has been achieved. When a high moisture event occurs, the 3050-OLV responds quickly to alert you to the problem. After the high moisture event passes, the non-equilibrium nature of the 3050-OLV means that no long dry down period is ever needed before you get accurate low ppmv measurements.

High speed mode provides even faster response

If any moisture analyzer is connected to the process through a length of tubing, the apparent response time of the analyzer will be affected by the time required for the moisture event to travel through the tubing and actually reach the sensor. In situations where the tubing is particularly lengthy, or if the inside diameter is rough, a noticeable degradation in response time can occur.

When operating in its gas-saver mode, the 3050-OLV consumes just 150 sccm of process gas. For situations requiring long runs of sample tubing, or any time an even faster response time is desired, the 3050-OLV can be placed in high speed mode by activating the gas saver function. The flow rate through the analyzer will be increased by one to two liters per minute, increasing flow through the sample tubing by at least a factor of eight, so any moisture event will be detected much faster.

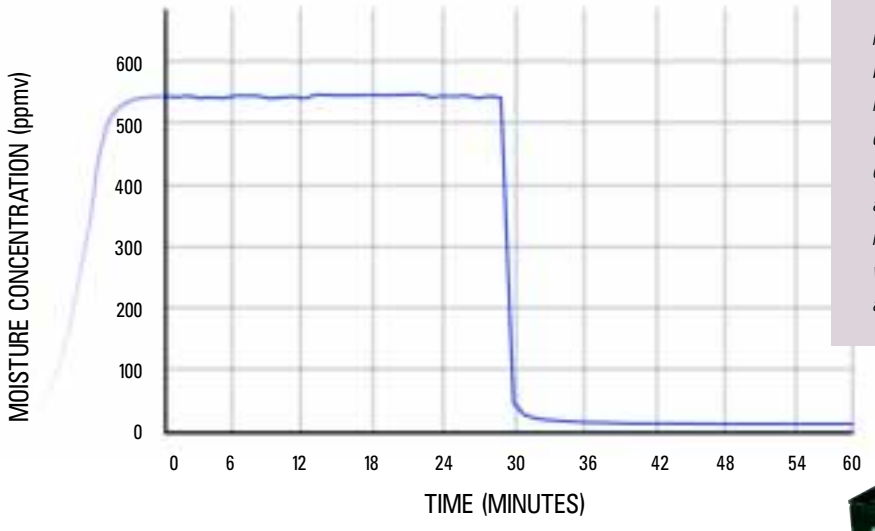
Aluminum-Oxide Moisture Sensor Process



C_0 = Capacitance of oxide layer
R_1 = Pore-side resistance
R_2 = Pore-base resistance
C_2 = Pore-base resistance
R_0 = Resistance of aluminum oxide

With an aluminum-oxide sensor, moisture molecules in the process gas must permeate through a layer of gold before being absorbed by an oxide structure which is the dielectric of a capacitor. How quickly moisture molecules can enter and leave the sensor determine its speed of response. With the QCM sensor, moisture molecules are deposited only on the surface of the sensor. The mass of these molecules causes a small but measurable difference in frequency of oscillation.

Response Time of Model 3050-OLV Analyzer



With the quartz-crystal microbalance method, the sensor is periodically cycled between the process gas and the dried reference gas. During the reference gas cycle, the water molecules are swept off the sensor. This cycling action allows the 3050-OLV to respond to high moisture events, and then "dry down" within minutes, not hours or days like aluminum-oxide sensors.

AMETEK's Model 3050-OLV Process Moisture Analyzer responds quickly to alert you to high moisture problems and has no long dry-down periods so that you get accurate data quickly

Performance under real world process conditions

Contaminants in the process stream can have a major impact on the performance of moisture sensors. This impact can range from a degradation in accuracy and response time, to a sensor that "dies in place," becoming completely unresponsive to changes in moisture concentration and leaving your process completely unprotected.

For a given level of contamination, the technology and design of the sensor and the amount of time it is exposed to the contaminants will determine how badly sensor performance is degraded.

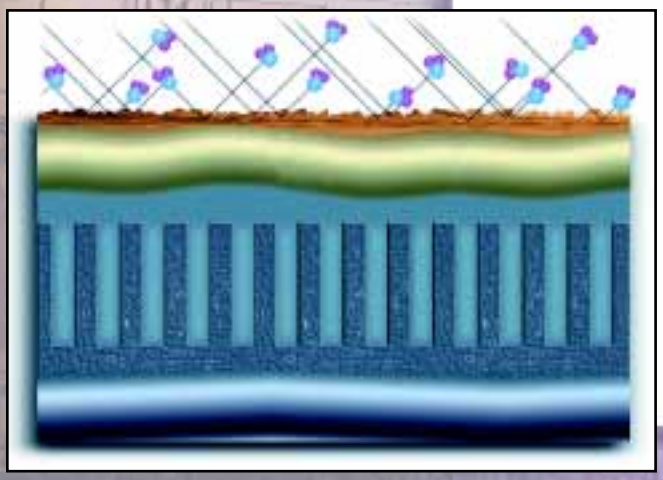
With aluminum-oxide sensors, moisture must permeate through a gold electrode before it can be measured. If contaminants are deposited on the electrode, they change the rate of permeation, further slowing its response time or even making the probe unresponsive to moisture. If the contaminant is conductive, it can form a short circuit on the probe, rendering it completely inoperative. Most moisture probes normally include a sintered metal cap for protection. This cap provides another surface for contaminant collection that can degrade sensor performance. And, since the probe is continually exposed to the contaminated process stream, there is maximum opportunity for sensor fouling.

Common examples of contaminants in process streams that have a major impact on traditional moisture sensors include:

- *compressor oil that coats the sensor and/or its protective cap*
- *olefins that polymerize on the sensor and form an impenetrable plastic barrier*
- *mercury that amalgamates with the gold electrode, again forming an impenetrable barrier to moisture*
- *glycol carryover that partially short circuits the sensor*
- *methanol that the sensor misinterprets as moisture in the process*

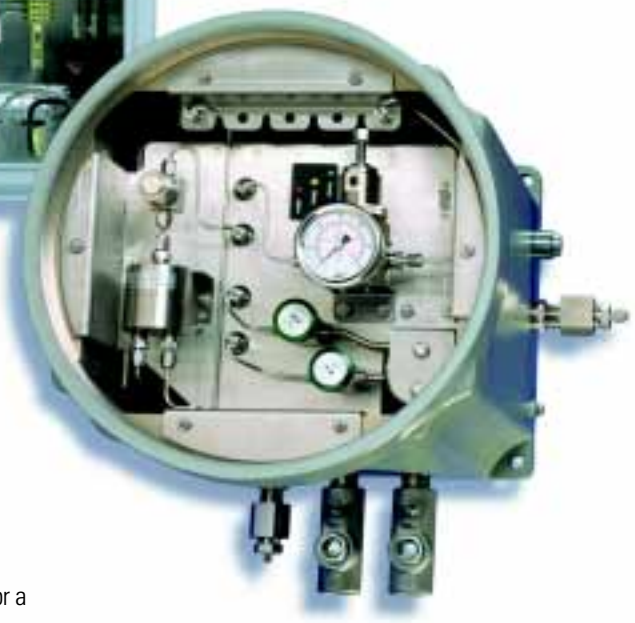
Less sensitivity plus less exposure to contaminants

The first major difference with the 3050-OLV is that the sensor itself is less sensitive to contamination. Quartz is non-reactive to almost all process contaminants and the hygroscopic coating has no pores. The hygroscopic coating on the oscillator is virtually specific to moisture. Unsaturated hydrocarbons don't polymerize on it and there's no exposed metallic electrodes to be affected by mercury or glycol.



A typical aluminum oxide probe can accumulate contaminants such as compressor oils, polymerized olefins, and glycols that prohibit moisture molecules from penetrating the protective cap and electrode, further slowing response time. In worst cases, the contaminant can be conductive, causing a short cuircuit and rendering the probe totally useless.

NEMA 4X weather-proof enclosure for Model 3050-OLV Process Moisture Analyzer



NEC Class 1, Division 1/CENELEC Zone 1 explosion-proof enclosure for Model 3050-OLV Process Moisture Analyzer

The analyzer's sampling system reduces exposure to contamination. In the normal high speed mode of operation, the QCM sensor is exposed to process gas for 50% of the measurement cycle and clean, dry reference gas for the other 50%. In this situation, the QCM sensor sees only half the contaminants of other sensors. If an extreme contamination event occurs, the 3050-OLV will automatically change over to its sensor saver mode. In this mode, the QCM sensor typically monitors the process gas for a short time followed by a longer period of reference gas flow. This reduces the QCM sensor's exposure to contaminants even further; thereby minimizing the effects of any contaminants. When monitoring process gas that is known to contain contaminants, operating the analyzer in the sensor saver mode maximizes cell life.

AMETEK's years of experience with moisture analyzers have resulted in the development of several of the world's most advanced calibration facilities. AMETEK has invested over a half a million dollars in its NIST-traceable moisture calibration facilities. These leading-edge-technology systems are capable of generating calibration gases with an accuracy of a single ppb. These systems are routinely rechecked and verified via mass balance to ensure the accuracy of every calibration. No other company has more accurate or advanced calibration facilities.

Performance specifications

Technology: Quartz-Crystal Microbalance

Range: Calibrated from 0.1 to 2500 parts per million by volume (ppmv). Readout capability in ppmw, lb/mmscf, mg/Nm^3, and dew point in ^{o}C or ^{o}F (requires process pressure as an input)

Reference Gas: Continuously produced using actual sample gas

On-Line Verification: Internal moisture source with NIST-traceable calibration enables on-demand verification of analyzer accuracy and responsiveness without uninstalling the analyzer

Accuracy: 10% of reading from 1 to 2500 ppmv with standard calibration; special calibration ranges not required

Reproducibility: 5.0% of reading from 1 to 2500 ppmv

Limits of Detection: 0.1 ppmv

A/D Resolution: 16 bit (0.0015%)

QCM Response Time: Near real time. Computer enhanced response, which may lead to errors, is not required to obtain quick wet-up or dry-down response

Sensitivity: 0.1 ppmv or 1% of reading, whichever is greater

Allowable Inlet Pressure: 1.3 to 3.3 Bar (20 to 50 psi); up to 200 Bar (3000 psi) with optional pressure reducer; analyzer performance is independent of process pressure

Exhaust Pressure: 0 to 1 Bar (0 to 15 psi)

Sample Gas Temperature: 0 to 100^{o}C (32 to 212^{o}F); analyzer performance is immune to changes in sample gas temperature

Gas Flow Requirements: Approximately 150 sccm. Approximately 1.0 slpm bypass flow for increased speed of response

Outputs: Isolated 4 to 20 mA analog signal, keyboard selectable; 12 bit (0.025%) resolution, RS-232 and RS-485 serial communication ports

Alarms: Three contact closures; system, data valid, and concentration alarms

Ambient Temperature Limits

Analyzer: 5 to 50^{o}C (41 to 122^{o}F)

Enclosed analyzer with sample system: –20 to 50^{o}C (–4 to 122^{o}F)

Voltage/Power Requirements

Analyzer: 24 VDC, 50 watts

Analyzer with sample system: 120 ±10% VAC, 50/60 Hz, 150 W maximum
230 ±10% VAC, 50/60 Hz, 150 W maximum

Approvals and certifications:

UL/CSA/CE

Class I, Division 2, Groups A, B, C, D, T4 with optional Class I, Division 1, Groups B, C, D, T6 and EEx d IIC T6X ATEX

GOST 1ExdIICT6 X
GOST Pattern Approval

Also complies with European EMC, LV, ATEX, and PE Directives

Additional sample system components:

In order to derive the full advantages of the Model 3050-OLV, a well-designed sampling system is necessary. AMETEK can supply a complete sampling system to include:

- Filters: In-line or bypass filters to remove particulate from gas or liquid sample streams and small amounts of oil or other condensables from gas streams.
- Contaminant Trap: Activated charcoal trap protects the reference gas dryer by removing contaminants from the reference stream.
- Pressure Reducer: Required if sample sources are at pressures higher than 3.3 Bar (50 psi). Maximum input pressure is 200 Bar (3000 psi).
- Heated Pressure Reducer: Designed to prevent condensation of gases upon pressure reduction or to vaporize liquefied gas streams with boiling points not exceeding 40^{o}C (104^{o}F). Maximum input pressure is 200 Bar (3000 psi).

Suitable for NEC/CEC Class I, Division 1, Groups B,C,D, and CENELEC IIC T3 areas.

Analyzers for specialized applications

While these moisture analyzers utilize the same quartz-crystal technology and provide the same on-line verification capabilities as the Model 3050-OLV, they are optimized for specific applications.

The Model 3050-SLR
Enhanced accuracy at very low ranges for process applications

Using its self-verify accuracy and sensitivity, the 3050-SLR is optimized to provide increased accuracy in the super low range of zero to one ppmv. This explosion-proof moisture analyzer is for use with flammable gases and in hazardous locations where very low moisture concentrations are required. The analyzer has an accuracy of ±0.03 ppmv.

The Model 3050-DO
For monitoring the outlet of mole sieve dryers

The 3050-DO will accurately monitor the very low concentrations of gases exiting mole sieve dryers. By minimizing the need for regenerating the bed, it will reduce costs and increase plant uptime. Suitable for outdoor installation, the 3050-DO has a range of 0.02 to 2500 ppmv with an accuracy of ±0.02 ppmv or 10% of reading.

The Model 3050-TE
For monitoring natural gas into a turbo-expander or other cryogenic process

Even the smallest amount of moisture in natural gas feeding a turbo-expander can cause huge problems. The 3050-TE is designed to accurately measure sub-ppmv moisture levels and provide a rapid speed of response. It will help prevent damage from ice build up and increase the efficiency of heat exchangers. Designed for Zone 1, Division 1 applications, the 3050-TE has a measurement range of 0.01 to 100 ppmv with accuracy of ±0.01 ppmv or 10% of reading from 0.01 to 100 ppmv.

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