The Proper Mechanism for Field Validating Moisture Analyzers

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Abstract

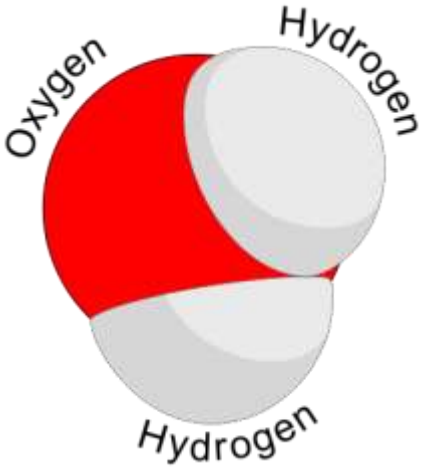
Field verification of moisture analyzer calibrations mitigates the need to return the analyzer to the vendor for a traceable calibration.

Analyzer companies have introduced newer measurement technologies to improve speed of response and accuracy. The same level of innovation has not yet occurred in field verification techniques, which would need to be more accurate than the measurement they are validating.

Let’s investigate how a plant can implement and maintain proper field validation techniques that allow for the highest level of accuracy for on-line trace moisture measurement.

Water Vapor as a Contaminant

Water vapor is a contaminant in natural gas applications. The measurement of water vapor in these gases offers challenges not typically found in the measurement of other process contaminants.



Water molecules adsorb onto metallic surfaces and accumulate

- in dead legs,
- on soft wetted materials such as fittings and gaskets, and
- in filter elements.

Changes in process conditions such as an increase in temperature will lead to off-gassing of these water molecules into the process gas or will impact the measurement at the sensor.

The Need to Measure Moisture

Moisture measurement is critical to indicate process upsets, trends, and end-use product quality specification.

Example: water is a contaminant in the natural gas, as it

- dilutes the heating value,
- enables corrosion,
- contributes to ice and hydrate formation.

Could field validation of a moisture measurement have prevented the ice formation shown here? What was the cost?

The Challenges in Measuring Moisture

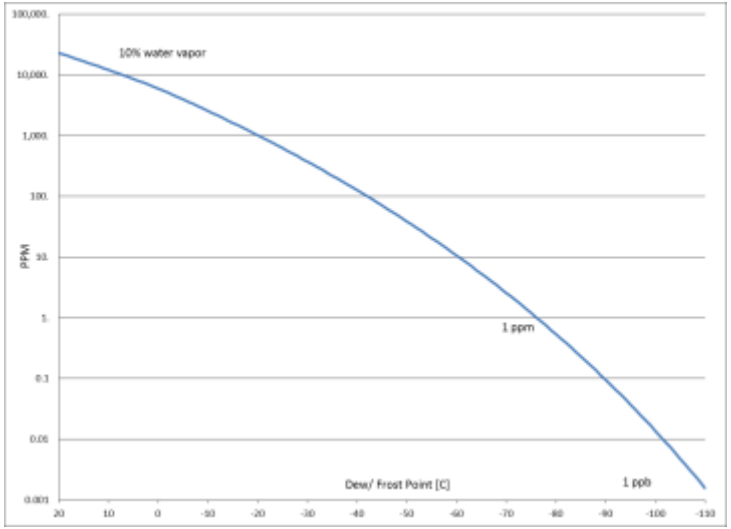
Seeing the full spectrum of measurement

The measurement system and the process are at a moisture content at or near ambient conditions (+10 °C dew point or 10,000 ppmv) at start-up.

For many process applications, the moisture content needs to be below 1 ppmv

Process operators would like to see the moisture content of the system dry down from ambient, through the alarm point, to the equilibrium moisture content.

Maintaining accuracy from 10,000 to 0.1 ppm, or lower, is a challenge.



Measurement Technologies

Metal Oxide Sensor/Analyzer

The most versatile moisture analyzer technologies offer a very wide range of moisture measurement, allowing the operator to see the analyzer dry down from ambient moisture to the measurement point of interest. Metal oxide analyzers meet this measurement challenge: ambient to ppb.

Due to the nature of all oxide sensors, these change in calibration with time and can be contaminated to read wetter or drier than true readings.

It is not practical to calibrate these analyzers with one or two calibration gases, as the technologies are not linear enough throughout the required measurement range.

Attributes:

- Measure moisture from ambient moisture down to sub-ppm levels.
- Can be installed at process pressures, allowing for equilibrium process dew/frost point measurement.
- Calibration is independent of process fluid.
- Can measure moisture in hydrocarbon process fluids in the liquid phase without the need for vaporization.

Measurement Technologies

Quartz Crystal Microbalance

Technologies such as quartz crystal microbalance require constant adjustment to their calibration and thus come equipped with an integral permeation tube-based, one- or two-point calibration schema. The permeation tube requires that the process gas be dried below the calibration point to be generated. This is accomplished by using a desiccant.

There is no practical method to check the integrity of the desiccant and thus there could be reason to doubt the integrity of the calibration schema and thus the measurement based on it.

Attributes:

- Upper range of the analyzer is limited by the range of interest. A sub-ppm analyzer may not provide accurate readings near ambient.
- Measurement is made at near-atmospheric pressure. Sample system needs to account for this pressure drop.
- Measurements are made in the vapor phase. The sample system will need to vaporize hydrocarbon liquids.

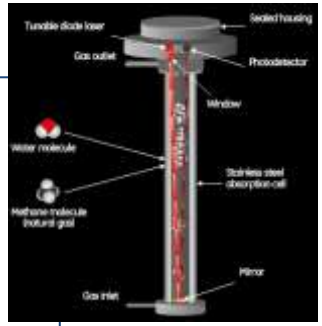
Measurement Technologies

Tunable Diode Lasers

Laser-based moisture analyzer technologies can offer an analyzer that has negligible change in calibration with time. Many of these are immune to measurements errors due to contamination.

Changes in background gas can impact the moisture reading, if the background gas compensation algorithm is not sufficient. The cost of sending these back to the vendor's plant can be expensive, due to the size of the analyzer.

It is not practical to keep a spare analyzer on hand, when return to the factory is necessary.



Attributes:

- Laser emitter and receiver are not in contact with the process fluid. Only the measurement cell is wetted, minimizing dry-down and wet-up times.
- Typically requires no factory calibration.
- Measurement is made at near-atmospheric pressure. Sample system needs to account for this pressure drop.
- Measurements are made in the vapor phase. The sample system will need to vaporize hydrocarbon liquids.

Calibration

Metal Oxide Sensor/Analyzer

For the highest level of calibration integrity, recommend practice is that these be sent to the manufacturer for periodic calibration or characterization.

Very few manufacturers have made the investment in regional and/or certified calibration systems, operated by the vendor that can guarantee the calibration.

Calibration QCM & TDL

Quartz crystal microbalance and tunable diode laser analyzers either self-calibrate or change insignificantly in calibration.

There is significant expense in sending these back to the factory, should repair or calibration be required.

Unlike oxide sensors, it may not be practical to maintain a spare QCM or TDL analyzer on-site.

This is a key driver for the need for field validation of the moisture analyzer!

Reasons for Field Validation

Protecting Assets

The investment in a moisture analyzer is made based on the value in knowing the amount of water vapor in the application. The measurement may be protecting catalyst in a reformer. In natural gas it is protecting the pipeline and ensuring the heating value of the product.

Purchasing the appropriate analyzer fit for purpose is the first step.

Installing it in a fashion that will allow it to perform to its specification is also vitally important.

Ensuring that it is working properly is priceless.

Reasons for Field Validation

Managing expectations

When the moisture readings are in the expected range and are changing with process conditions, the operator is less likely to want or need to validate the measurement.

If an analyzer is reporting a constant moisture content, with little or no change, the operator may question if the analyzer is responding to changes in moisture content.

Abnormally low moisture readings may indicate that the analyzer has changed in calibration.

The largest driving force for field validation is when the moisture readings are approaching or are above the alarm point.

- If the moisture readings are correct, the plant personnel would need to tak the appropriate action, based on the high levels of moisture to protect their product, process, or safety.
- If the analyzer is incorrect, the instrument engineers will need to take corrective action to bring this analyzer, or another, back on-line to ensure measurement integrity.

Reasons for Field Validation

Why not *Trust* the analyzer…

Contaminants and other environmental factors may result in any technology to read in error.

- Filters could be plugged and may now be off-gassing moisture into the process with changes in pressure or temperature.
- Moisture from a leak in the sample system may result in false high readings.
- An aluminum oxide sensor may be covered with a contaminant, making it appear unresponsive.
- Unexpected changes in background gas may be impacting a TDL analyzer.
- A spent purifier in the QCM analyzer is resulting in an artificially low moisture reading.

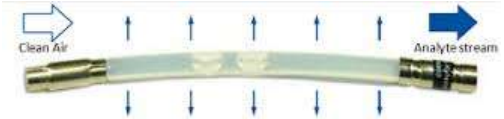
Trust evaporates as

- the criticality of the moisture measurement increases,
- the further from the expected moisture content the analyzer is reporting, and/or
- as the measurement approaches the alarm point.

Validation Techniques

External & Integrated Verification Systems

Manufacturers of any moisture measurement technology may offer external or integrated permeation tube-based or cylinder gas-based calibration or verification systems. There is no practical method to check the integrity of the purifier that feeds dry gas to the permeation tube and thus there could be reason to doubt the integrity of the calibration schema and thus the measurement based on it.



One must use great care in the use of calibration cylinders. Even when properly prepared with known moisture contents, typically no lower than 1 ppm, the quality of the gas can be subject to the ambient temperature, the length of time the cylinder has been stagnant, and the amount of gas remaining in the cylinder.

Validation Techniques

Practical considerations

The above techniques can validate the analyzer at a specific moisture content, but may not be able to validate the analyzer at the measurement it is currently reading or meant to read.

- Moisture analyzer reports 5 ppmw liquid butane. Expected moisture is 1 ppmw. Will a calibration cylinder of 1 ppmv in nitrogen validate his moisture analyzer?
- Moisture analyzer reports 5 ppmv in a H2/N2 mix. Expected moisture is 1 ppmv. Should we order a 1 ppmv standard, a 5 ppmv standard, or both?
- An aluminum oxide sensor is reporting 10 ppmv at 1000 psig (-24 °C frost point). Will a 10 ppmv cylinder at 100 psig validate the analyzer (-44 °C frost point), or should we use a 500 ppmv cylinder at atmospheric pressure (-27 °C frost point)?

Validation Techniques

Redundant sensors

The value of the moisture measurement might be such that redundant sensors are a practical method for validating a moisture measurement.

These can be in series, to expose them to the same fluid, process conditions and upsets continuously. These should be on the same calibration cycle, to mitigate differences in reading based on off-cycle rate of change in calibration.

One may choose to display the readings from all sensors at the same time, implementing an averaging and/or polling routine. One might choose to display the readings of one sensor, only displaying the redundant sensor(s) when questions arise.

Validation Techniques

Multiple technologies

Mixing technologies may also offer an advantage. One example might be to have an aluminum oxide sensor mounted on the outlet of a TDL analyzer. Although there may be an accuracy mismatch, most often, it is large differences in moisture reading expectation that drive questions.

Having multiple technologies offers the advantage that an upset or contaminant that may impact one technology and not the other, pointing to where the source of reading discrepancy.

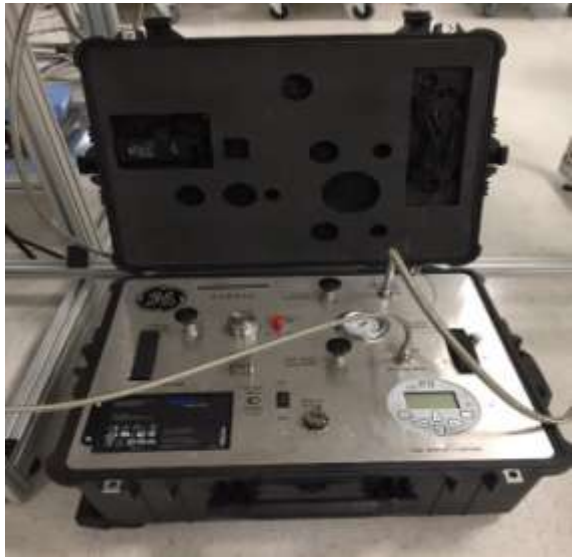
Validation Techniques

Portable Analyzer

A portable moisture analyzer can answer questions that a calibration standard is unable to.

It can report the moisture of the process.

If this is different than what the dedicated moisture analyzer is reporting, it can be used a troubleshooting tool to determine the cause of the discrepancy.



Measurement Verification

Interrogating the Measurement

The portable can be installed at the outlet of the analyzer system to interrogate the gas or liquid that is passing through the dedicated analyzer.

After equilibrium is reached, if the readings do not agree with one another, one has the choice to adjust the calibration of the dedicated analyzer (if this is recommended by the manufacturer) or to follow the manufacturer's procedure for calibration.

If the readings agree and if they agree with the operator's expectations for the moisture content, all is well and the dedicated meter was never taken off-line.

Measurement Verification

Moving Beyond the Analyzer

When the portable agrees with the analyzer, but are not reporting the expected moisture content, the portable offers the opportunity to interrogate the system as a whole. Readings can be taken prior to the filter, prior to any pressure drop, and at the inlet of the sample system.

The discrepancy in the measurement may be due to loose fittings, faulty pressure regulators, dirty filters, and/or issues with an integral calibration system.

If the analyzer and the portable continue to report the same reading with no fault found all the way back to the sample take-off probe, they are reporting the true moisture content.

Choosing a Portable Analyzer

Helpful Attributes

A portable analyzer that can make the measurement at process conditions will allow the operator to investigate the measurement system back to the point of measurement. A sensor that can make the measurement in both the liquid and vapor phase and at either process pressure or atmospheric pressure is most useful, especially when the dedicated analyzer uses a vaporizing regulator in liquid hydrocarbon applications.

There is a benefit for the operator to use a portable analyzer that doesn't use the same technology as the dedicated analyzer. If the portable and the dedicated analyzer agree, and they use two different technologies, there is little chance that they can both be wrong by the same amount.

Measurement Audits

People Make the Difference

Plants have fewer technicians and they need to be fluent in many analyzer measurements and techniques. Calling in an expert to verify the measurement offers benefits.

- Preventative maintenance is preferable to emergency call outs.
- Measurement audits can be planned and are typically less expensive that an emergency call to the manufacturer.
- The field service engineer is fluent in the use of the portable, can verify the entire installation, and can spot issues where none were known to exist.

The field service engineer would come out with a recently calibrated analyzer and then submit a report detailing his findings and any recommendations.

The Perfect Moisture Generator

R&D Group at Work

In the past several decades, analyzer companies have introduced newer measurement technologies to improve speed of response and accuracy.

The same level of innovation has not yet occurred in field verification techniques, which would need to be more accurate than the measurement they are validating.

The ideal moisture generator could use any background gas as the carrier, one would dial in the moisture content they would want to generate, and within minutes the generator would be able to provide the gas at the desired temperature and pressure. The accuracy would match the accuracy requirements of the analyzer in question.

The Proper Mechanism for Field Validation

In the Absence of Perfection: Piece of Mind

We promised the proper mechanism for field validating moisture analyzers.

- Calibration cylinders and moisture generators can be used to validate measurements.
- Redundant or multiple sensors offer benefit. Mixing technologies may provide insight as to the reason for a measurement discrepancy.
- Use of a portable moisture analyzer, in the absence of a perfect moisture generator, is the best available method for validating a dedicated moisture analyzer in the field. It can validate the moisture content of the process and point out where in the measurement system there may be a discrepancy.

The *proper* mechanism is that one that performs the validation quickly and with the highest level of confidence: piece of mind.

This may utilize any one of the above techniques or several in conjunction.

Thanks you……. any Questions?

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