Refineries and Natural Gas Processing

Pick the right moisture sensing technology

Moisture is a critical contaminant for both natural gas storage and processing as well as petrochemical refining applications. There are many analysers and technologies – but not all options are appropriate in all situations.

At Michell we offer three technologies for moisture measurements suitable for refineries and natural gas which means we can offer unbiased, factual advice on the pros and cons for each technology for a given application.

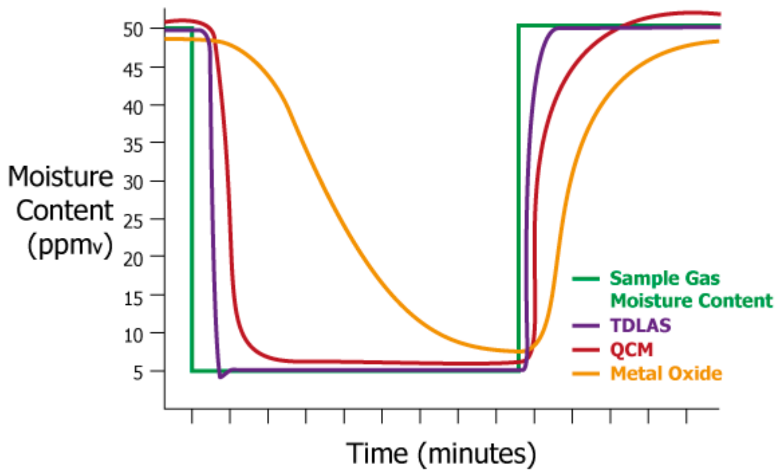
Sampling and conditioning are just as critical to the success of an installation as the specific analyser or technology chosen. We have been creating sampling systems and analyser houses for our customers to meet the challenges of some of the most extreme conditions on the planet - from the heat of the sub-Sahara to the extreme cold of Siberia.

This guide gives a short overview of each technology, its strengths for each application, and when you might want to choose it. It doesn't replace expert advice – our sales engineers are happy to help you with questions and advise on your specific application.

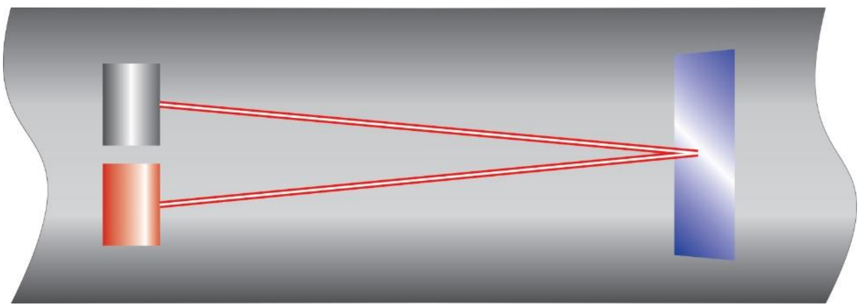
Comparison of process moisture sensing technologies

	TDLAS (single reflection optical cell)	**QCM**	**Metal-oxide**
Sensing principle	Fundamental photometric gas absorption spectroscopy with narrow band NIR TDL source	Cyclic changes in oscillating frequency relating to mass of hygroscopic polymer- coated crystal	Capacitance sensor with metal-oxide hygroscopic dielectric porous to polarized moisture molecules
Primary measurement	Moisture content	Moisture content	Dew point temperature
Range, ppm$_v$	1 or 2 - 1,000	From 0.01 - 100 up to 1 - 2,000	<0.01 - >20,000 (<-100 to >+20C dew point)
Accuracy, % of reading	±1 or 2 (or 1 or 2 ppm$_v$ at less than 100 ppm$_v$)	±10 (or ± LDL ppm$_v$ value, whichever is greater)	±10 - 20 ±20 - 30 at less than 10 ppm$_v$
Lower Detection Limit, ppm$_v$	1 or 2	0.01, 0.03 or 0.1 dependent on model range	<0.01
Repeatability	< 1 ppm$_v$	±5% of reading	±5 to 10% of reading
Calibration maintenance	Periodic field verification. Major service after typically 5 years.	Integral auto-calibration. Periodic replacement of reference drier and moisture generator.	Annual sensor re-calibration, by exchange scheme or spares rotation.

Comparison of response to a step change in moisture content



Tunable Diode Laser Spectroscopy (TDLAS)



Tunable diode laser spectroscopy (TDLAS) has become a very popular technology for measuring moisture in the natural gas industry, particularly in North America. To a typical end-user of hygrometers, the advantages of the technology are immediately apparent: a prime example being its superior accuracy. A single-path TDLAS analyzer is accurate to ±2% of the reading and offers a detection limit of 5ppmv. The most recent models can achieve measurements as low as 1 ppmv with an accuracy of ±1% of the reading: these accuracy results outperform other process moisture sensing methods.

Because of their non–contact, optical measurements the TDLAS instruments are highly resistant to potential corrosion from sour gases, allowing them to achieve highly stable, drift free moisture measurements in applications where other methods give disappointing results. Glycol and methanol additives, which are commonly found in upstream natural gas, do not interfere with the TDLAS principle, unlike surface adsorption sensing technologies.

The optical detection method of TDLAS instruments gives them a fast speed of response. This feature is especially welcomed by users in natural gas storage, where conformance with specifications for network quality must be determined swiftly to fulfil peak demands for gas. Furthermore, TDLAS technology has been promoted as having a very low cost of ownership.

Coupled with the high initial investment, there are characteristics which make TDLAS less suitable for certain applications. Despite the outstanding stability and accuracy, the sensing principle prevents it from coping with composition changes in the background gas: a common situation in many petrochemical as well as in an increasing numbers of unconventional natural gas applications. Only recently-developed products have done much to mitigate this weakness by incorporating automatic background gas compensation.

Also, despite their operational robustness and resistance to drift, TDLAS instruments need to be installed and commissioned with care to avoid damage to the laser and mirror configuration. Further attention is required to ensure that the sample handling conforms to the needs of the spectroscopic principle. The sample must be close to atmospheric pressure, since any significant back-pressure on the measurement cell leads to a broadening of the absorption peaks that reduce the accuracy and sensitivity of the measurement.

While the early models of TDLAS analyzer were promoted as being free from the need to have climate control to cope with changes in temperature, on-site experience with the technology told a different story. Just as with other moisture analyzers, TDLAS instruments need climate control in extreme conditions of heat or cold to ensure reliable measurements. Selecting the correct sampling system for the analyzer, with effective sample gas conditioning to suit the intended application, is crucial to ensuring the successful measurements.

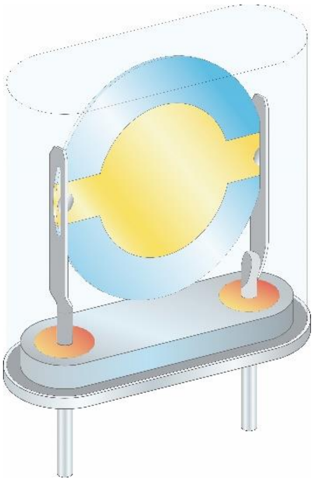
TDLAS – recommended applications

- Because of its resistance to contamination, fast response and – with newer models – ability to cope with changes in background gas composition, TDLAS analyzers are well suited to monitoring moisture in gas storage facilities.
- Monitoring natural gas glycol dehydration
- Natural gas custody transfer and transmission facilities – confirming moisture levels in the gas conform to international quality guidelines
- Export metering packages – combined with an HCDP analyzer – to confirm quality of gas
- Moisture in N2 monitoring

Watch out for:

- Claims of ‘no maintenance’ required: all instrumentation needs regular maintenance and re-calibration.
- Despite the low overall cost of ownership, initial purchase and installation costs are high.
- Ensure your supplier is able to provide suitable sample conditioning for your application.

Quartz Crystal Microbalance (QCM)



For refineries and petrochemical plants, where low detection levels often are of importance, the preferred technology for moisture measurement is still Quartz Crystal Microbalance (QCM). While not as accurate as TDLAS, QCM analyzers compensate by reliably detecting lower amounts of moisture. A typical example where moisture measurements benefit from the use of a QCM analyzer is LNG production. To avoid ice formation within the cryogenic process it requires moisture measurement in the region of <0.1 ppm_V after molecular sieve dehydration columns.

In addition to the high measurement sensitivity of QCM analyzers, users in hydrocarbon process industries value the built-in automatic calibration. It provides a periodic verification of the instrument automatically adjusting it to changes that may be caused by any gradual changes in detection sensitivity, the variation of the process gas or another parameter. The self-verification capability of Quartz Crystal Analyzers is particularly important to maintain user confidence where challenging single-digit or sub-ppm measurements are critical to the process, such as gas liquefaction, NGL extraction cryogenic separation plants, or in refinery reformer recycle gas where traces of highly aggressive hydrochloric acid vapour are present and may lead to sensor deterioration if left unchecked.

Users of earlier generations QCM based analyzers for moisture often cite the relatively high cost of routine maintenance. In reaction to this, QCM manufacturers designed their latest models not only for simplicity and ease of operation but also to extend maintenance periods. Thanks to a modular design, routine maintenance is far easier and faster (and therefore cheaper). Buyers of the latest generations of QCM analyzers discovered that "There's life in the old dog yet" and that they can sleep peacefully with it monitoring the process.

QCM – recommended applications

- Applications include Molecular sieve or glycol dehydration of natural gas
- Natural gas transmission and storage, refinery catalytic reforming — recycle gas monitoring
- Ethylene product quality monitoring

Watch out for...

- High service and parts costs on older models

Metal Oxide Moisture Sensors

For low cost of initial investment and ownership, coupled with high-tolerance for composition changes in the gas stream, metal-oxide sensors offer many advantages. It is the oldest and most established process moisture measurement technology – backed by a wealth of field experience.

Of all the many types of metal-oxide moisture sensors aluminium-oxide is the most recognised. They provide a wide measurement range, coupled with a low cost, for both dew point and moisture content.

Just as with the QCM technology, there have been constant developments and improvements. The metal-oxide sensors of today are very different in terms of accuracy and reliability compared to those of twenty years ago. Previous generations of the sensors suffered from drift, lack of temperature compensation or were mechanically damaged by sudden pressure changes in the system; faults which are not encountered in the of sensors currently produced.

A host of different designs, specifications and materials help to confuse users' perceptions. Not all sensors with a threaded sample connection are based on metal oxide technology. Both metal oxide and capacitive polymer sensors can provide readings of dew point and it can be easy to confuse the actual range capabilities of each.

Among all technologies available for measurement of moisture in hydrocarbon processes metal oxide sensors are by far the most versatile ones. No other existing technology covers a range that starts from around 23,000 ppm_V (+20°Cdp) on the wet side and goes down to less than ten parts per billion on the dry side (-100°Cdp). This means a dynamic measurement over 9 orders of magnitude is possible with just one sensor. A TDLAS or QCM analyzer often measures in a well-defined, but relatively narrow range: for example 0-100ppm_V to 0-500ppm_V.

Due to their design and extensive dynamic range, metal-oxide sensors do take longer to make a measurement than the other technologies discussed here. However, they have two unique advantages that make them attractive for many users. Firstly, is the ability to measure moisture in liquids – such as monitoring trace levels of dissolved moisture in naphtha feedstock into refinery isomerisation catalyst and other processes in aromatics, polymer and synthetic rubber where the high fluid boiling point prevents vapour phase measurement by TDLAS or QCM.

Secondly, unlike TDLAS and QCM, metal-oxide sensors are able to measure dew point at line pressure. This is an advantage for natural gas pipelines in regions where contractual specifications stipulate a permissible limit in terms of dew point at line pressure, rather in terms of moisture content.

A recent innovation that differentiates ceramic sensors (a later generation of metal-oxide technology) from earlier versions is an improved resistance to sudden changes in pressure. In older sensors a drop from high to atmospheric pressure would often result in sensor element damage causing the gold foil connection to separate from the sensing element. Despite the improved durability, metal-oxide film technologies still suffer from undue prejudice in the hydrocarbon process community. The longevity of the technology, with sensors as old as 20 years still in service, also allows critics to say that it is old-or-out of date, despite the fact that the current generation is actively temperature-compensated and show less drift than sensors manufactured in the 1980s.

Another myth is the lack of clarity about the true cost of ownership. Compared to TDLAS and QCM, metal oxide moisture sensors have the lowest capital cost to purchase. They are capable of accuracies of ±1 or ±2°C dew point: perfectly acceptable for many hydrocarbon processes. The simplicity of the installation and operation also contribute to the comparatively low cost of ownership.

In addition, maintenance costs can be kept to a minimum with various actively managed service programs offered by manufacturers. These so called 'sensor exchange programmes' guarantee a simple, easy and inexpensive annual recalibration. It is in effect a lifetime guarantee to any customer subscribing to the service. Once this is taken into account, the cost of maintenance over 10 years is below that of either a QCM or TDLAS analyzer.

Metal oxide – recommended applications

Moisture in gases:

- Moisture measurements for quality in natural gas production and processing
- Pipeline drying
- LNG production processing and receiving terminals

Moisture in liquids:

- Naphtha dehydration into refinery isomerisation catalyst
- 1,3 Butadiene and styrene feed stock into synthetic rubber co-polymerisation

Watch out for...

- Regular calibration is essential for metal oxide sensors, but this can mean downtime for processes. Look out for calibration exchange schemes that will allow for regular calibration with minimum disruption to the process.