



**IEC Automation INDIA Week 2018
15 to 17 November 2018, Mumbai**

Automation INDIA Week 2018

AMETEK Overview

- Global manufacturer of high-technology products with 15,000+ employees
- Serve a diverse set of niche markets and applications
- Annual sales of approximately \$4 billion, with over 50% of sales outside U.S.
- Component of S&P 500 Index; listed on NYSE (symbol: AME)
- Long track record of creating significant value for shareholders through execution of Four Growth Strategies
- Proven ability to deploy capital on value-enhancing acquisitions
- Strong, experienced management team

Electronic Instruments Group			Electromechanical Group	
<u>Process</u> 	<u>Power & Industrial</u> 	<u>Aerospace</u> 	<u>Differentiated</u> 	<u>Floorcare & Specialty Motors</u> 

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Electronic Instruments Group (EIG)

Worldwide leader in the design and manufacture of advanced monitoring, testing, and calibrating instruments

Markets served include:

- Energy
- Aerospace
- Power
- Research
- Medical
- Industrial



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Electromechanical Group (EMG)

A differentiated supplier of electrical interconnects, precision motion control solutions, specialty metals, thermal management systems and electric motors for specialty applications

Markets served include:

- Aerospace & Defense, Medical, Industrial, Energy, Semiconductor, and Food & Beverage



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AMETEK – Value and Culture

Manufactures world-class products and services at competitive prices

Provides shareholders a consistent, superior return on investments

Remains committed to the highest standards of corporate responsibility and ethical business behavior



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AMETEK – Socially Responsible

promotes diversity and fosters cultures and work environments based on respect and empowerment. It supports programs, via the AMETEK Foundation, that focus on education, health and welfare, and civic and social needs in communities where it has businesses.



AMETEK
Foundation, Inc.

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AMETEK Process Instruments

Moisture measurement in Refineries

What makes the measurement of Trace Moisture Measurement in Refineries special

C Automation INDIA Week 2018

enda

History

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Applications

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Conclusions

C Automation INDIA Week 2018 History

roduction

hout the water circulation system on earth, no life could be possible. However, in industrial processes, water is not always desirable.

cessive moisture content

can cause corrosion and ice at low temperatures in instrument air systems used to control pneumatic tools;

can destroy catalysts in hydrocarbon processing;

causes oxidation of metal surfaces during certain heat treating processes;

can cause high voltage discharge in oil filled transformers or high power switches filled with blanket gases and

causes corrosion in natural gas pipelines.

Moisture measurement can be utilized to control plant efficiency, save energy, control product quality and improve health and safety.

C Automation INDIA Week 2018 History

Manual chilled mirror instruments were the first widely used process moisture monitors

Their output is the temperature at which dew or frost forms: the water dewpoint

- **What happens when the process gas liquefies before the water vapor condenses?**

In the mid-50's, DuPont needed a new technology to measure the water concentration in gases that liquefy at high temperature (Freons)

Invented the electrolytic moisture analyzer (P_2O_5) which measures ppm (concentration)

C Automation INDIA Week 2018 History

Aluminum oxide moisture sensors were developed mid-1950's, by the Torry Research Station, Aberdeen Scotland

- first used to measure moisture in fish-drying oven*
- first widely used to measure humidity on weather balloons*

Quartz crystal moisture sensors were developed, mid-1960's by ESSO Research & Development

- first used to monitor moisture in catalytic reformer's hydrogen recycle gas*

Laser-based moisture analyzers were developed mid-1980's by Bell Labs

- first used to monitor semiconductor production gases*
- first models were very expensive*

C Automation INDIA Week 2018 History

As electronic sensors gradually replaced chilled mirror instruments in the '60's and '70's, most were programmed to permit them to display dewpoint, though none actually measure that property

Dewpoint is a nonlinear scale that allows accuracy claims to be manipulated

For first time unit conversion (ppm/dewpoint) becomes a problem

Automation INDIA Week 2018 Facts

Reality of Process Moisture Measurement

There are only two basic classes of moisture measurement

• *'Physical state': measurement of the temperature at which water vapor in a process gas changes physical state (condensation or freezing), called the 'dew point' or 'frost point'*

• *'Quantity': measurement of how much water is in the process gas*

- **ppm(v/w): parts per million by volume or weight of process gas**
- **ng/nm³, pounds per million standard cubic feet: mass of water per standard volume of process gas**
- **partial pressure: pressure exerted by water vapor in a gas mixture**

Automation INDIA Week 2018 Terms and Definitions

Relative Humidity

Absolute Humidity

Dew Point Temperature

Water Vapor Pressure

Moisture Concentration

C Automation INDIA Week 2018 Terms and Definitions

■ Moisture Concentration (ppm_v)

- *The moisture concentration is defined as the ratio of the volume the water vapor occupies to the total volume of the gas. For high water concentration, the unit could be volume by percent. However, in the range of trace moisture, parts per million by volume (ppm_v) is preferred.*
- *The moisture concentration is independent of temperature, type of gas, and pressure. If moist gas of a specific volume is compressed, the partial water vapor pressure and the partial pressures of the dry gases increase by the same proportion. (Dalton's Law)*

C Automation INDIA Week 2018 Terms and Definitions

Converting Dewpoint and Quantity (Concentration)

There is no formula for non-ideal gases

Experiments have been conducted at various
national and industrial labs for years

- *The most complete data is for CO₂-free air from NIST down to -100°C*
- *Institute of Gas Technology (in Research Bulletin #8) has produced data for natural gas to -40°C*

The accuracy of converting one to the other is no
better than the data available

- *Every electronic instrument that displays dewpoints of natural gas below -40°C is guessing...even AMETEK*

C Automation INDIA Week 2018 Terms and Definitions

ce more for emphasis...

very electronic instrument that displays dewpoint
natural gas below -40°C is 'guessing', by
extrapolating conversion data down from -40°C

ach manufacturer uses different mathematics to
less

specs like " -150°C dew point" are physically
meaningless on many process streams, because
components in the stream would be liquid at these
temperatures

is better to restate such specifications in ppm(v)

Automation INDIA Week 2018 Terms and Definitions

Summary

Dew point temperature, water vapor pressure, and moisture concentration are absolute moisture units. Relative humidity is not and requires the measurement of two parameters, water vapor pressure and temperature.

The dependence on both water vapor pressure and temperature limits the use of relative humidity as a measurement unit.

Nearly all units can be transferred to each other by using special equations or literature data.

30°C dew point \Leftrightarrow 0,38 mbar vapor pressure \Leftrightarrow 375 ppm_v \Leftrightarrow 301 mg/Nm³)

Automation INDIA Week 2018 Applications

Why Measure Moisture ?

Moisture in a process gas stream causes trouble in manufacturing operations and quality control procedures.

Moisture affects the physical, chemical and electrical property of virtually everything.

If goes undetected, moisture can affect product quality and lead to process downtime.

Moisture analysis in process gas is critical.

Automation INDIA Week 2018 Applications

Maintaining Optimum Level of Moisture

- Minimizes pipeline equipment corrosion.

- Minimizes line freezing.

- Improves process yields.

- Improves product quality.

- Lowers plant operating costs.

- Slows down catalyst degradation.

C Automation INDIA Week 2018 Applications

Natural gas pipelines and gas processing plants (Gas processing)

Recycle H₂ gas moisture in catalytic reformer (refinery)

Feedstock monitoring in alkylation unit (refinery)

Cracked gas monitoring in Olefin plant

Instrument air systems

Custody transfer points

Inert gas in Nuclear Plants

Turboexpander application in Natural gas application.

C Automation INDIA Week 2018 Applications

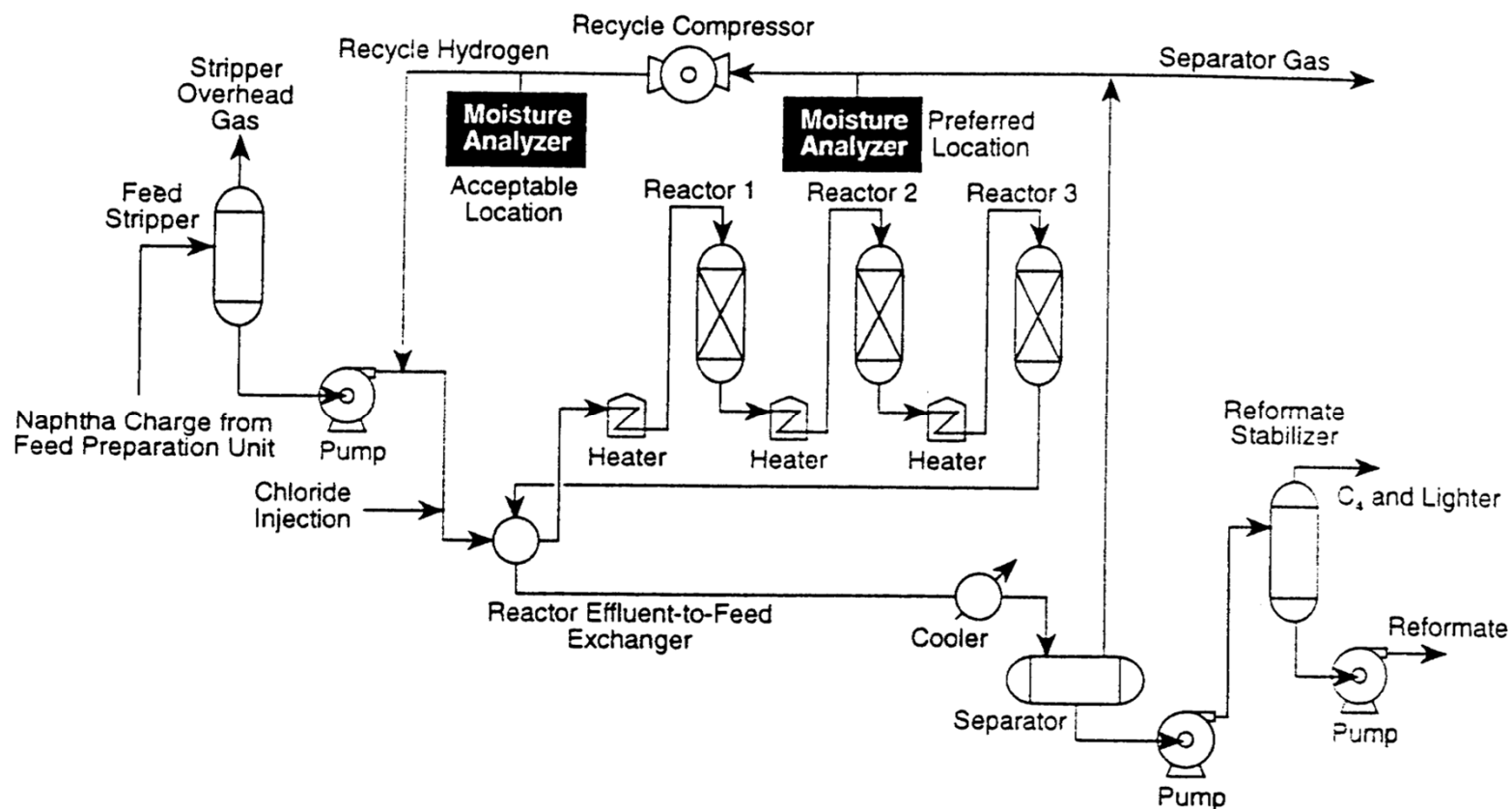
■ To illustrate the importance of monitoring moisture in the process gas, the following applications are reviewed:

- *Catalytic reformer recycle gas*
- *Alkylation unit feedstock*
- *Olefin plant cracked gas*
- *Natural gas*

C Automation INDIA Week 2018 Applications

Catalytic reforming is a vapor phase process where the 'Octane' number of the feed naphtha is increased. Hydrogen, a by-product gas, is compressed and recycled to the feed. Hydrogen reacts with the coke precursors to prevent carbon deposit on the reformer catalyst. Naphtha, a chloride chemical (acid catalyst) and water are the other feeds. Proper moisture balance in the feedstock is required to optimize product yield and catalyst life.

C Automation INDIA Week 2018 Applications



C Automation INDIA Week 2018 Applications

Why Measure Moisture in Recycle Gas?

In addition to water in the feedstock, oxygenation of hydrocarbons produce water in the reactor. Approximately 4 to 5 ppm wt water is injected in the feed to maintain a moisture content of 10 to 20 ppm in the recycle gas. Measuring moisture in the recycle gas gives a good measure of the moisture balance in the feedstock that is essential to high yield and long catalyst life.

C Automation INDIA Week 2018 Applications

y Measuring Moisture Reliably on a Continuous Basis is Difficult

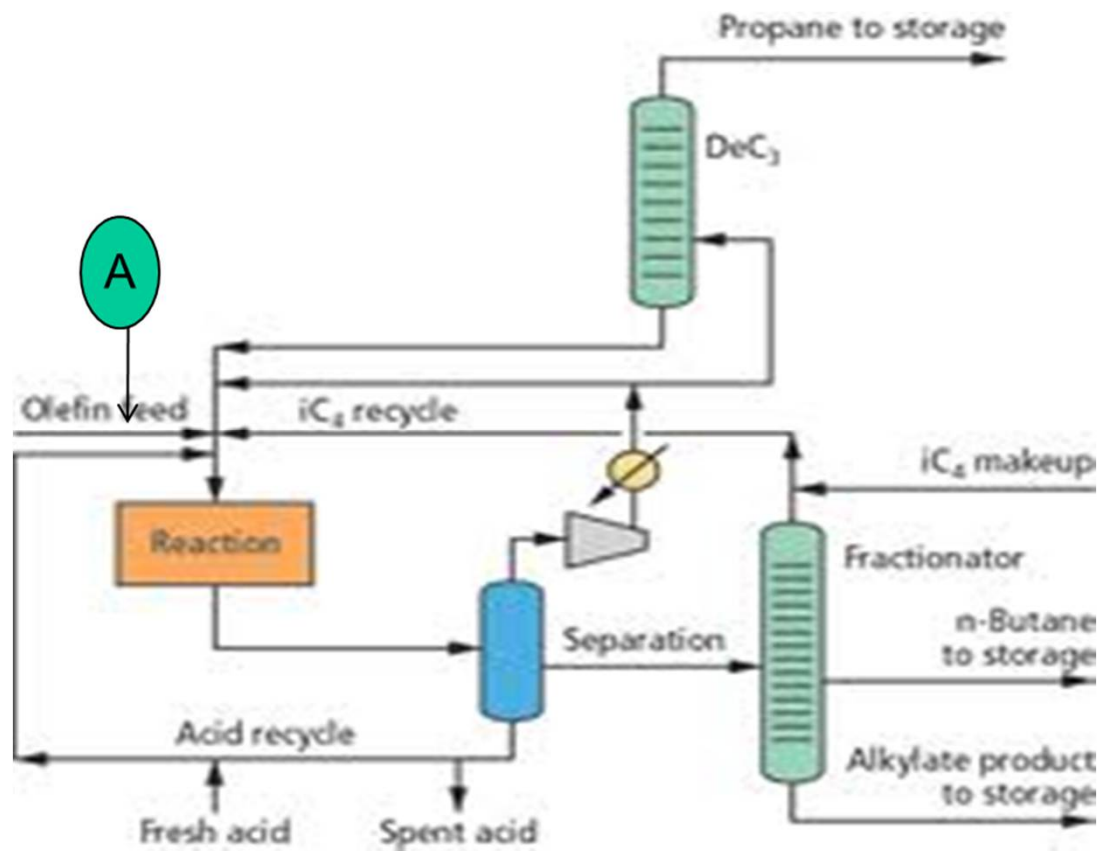
- The following contaminants in recycle gas foul and damage sensors.
 - *Entrained compressor oil.*
 - *High levels of wet HCl during reactor regeneration.*
- Problem - 'Failed' or de-sensitized sensors, calibration drift, process downtime.

C Automation INDIA Week 2018 Applications

e Alkylation Process

Alkylation is the reaction of light olefins (mixture of propylene and butylene) with isobutane to form an iso-paraffin, called an alkylate which is basically a high octane gasoline blending stock. The alkylation process uses sulfuric acid or hydrofluoric acid as the catalyst. The olefins from the FCCU, isobutane, and the acid are mixed and allowed to react in a reactor. The yield is an alkylate.

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C Automation INDIA Week 2018 Applications

Benefits of Moisture Measurement in Alkylation Feedstock

The acid catalyst is corrosive in the presence of moisture. Therefore, feedstock must be dry.

Heat generated in the exothermic process varies with the moisture content in the feedstock. High temperatures cause polymerization. Low temperatures are needed for good quality alkylate yield.

Optimum consumption of acid.

Lowering of cooling costs.

Automation INDIA Week 2018 Applications

Why Measuring Moisture Reliably on a Continuous Basis is Difficult

The feedstock can not have more than 2 to 3 ppm of moisture and therefore monitoring the moisture at that low level and verification of the analyzer performance is critical. The effect of prolonged exposure to contaminants will degrade sensor functionality.

Problem - 'Failed' or de-sensitized sensors, calibration drift, process downtime.

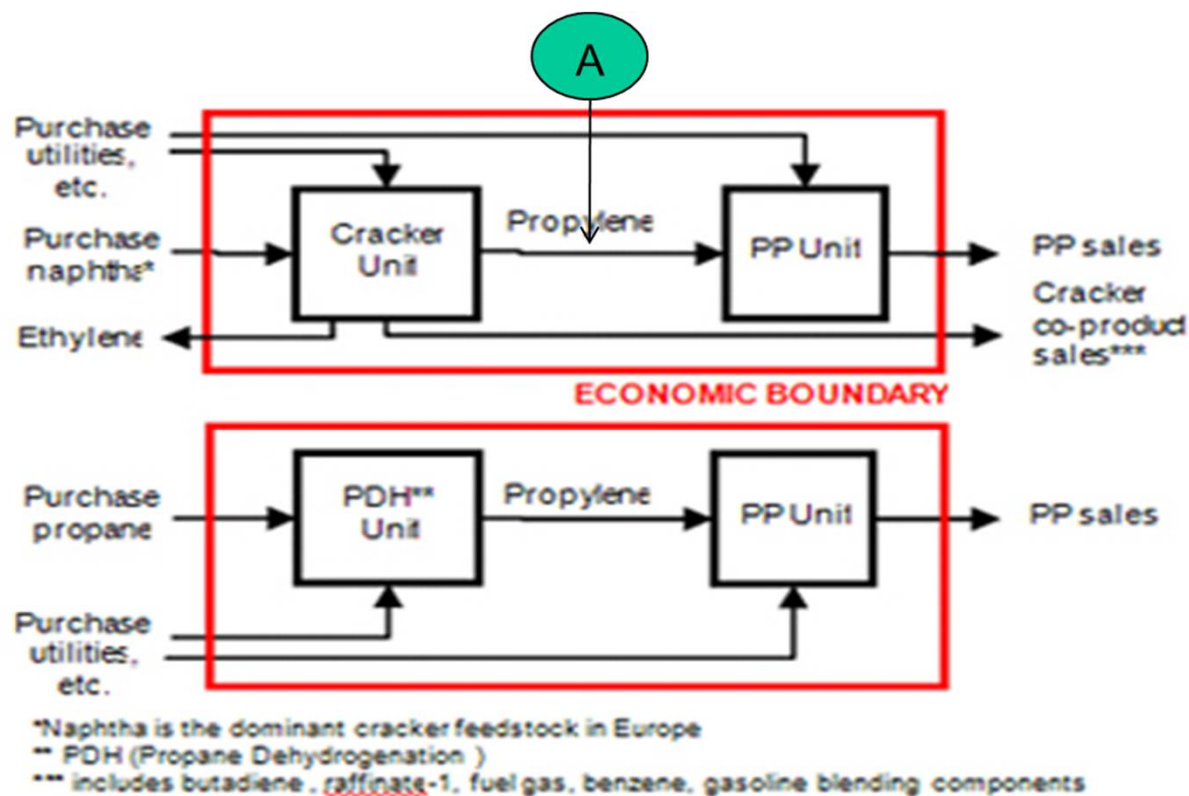
C Automation INDIA Week 2018 Applications

Olefins – Petrochemical Plants

Olefin is a generic term for chemicals such as ethylene, propylene, butylene and benzene. Olefins are manufactured by cracking complex hydrocarbon molecules. Olefins are the building blocks for the Petrochemical industry. Moisture measurement is critical in the manufacture, storage, and distribution of olefins.

C Automation INDIA Week 2018 Applications

in feedstock monitoring



C Automation INDIA Week 2018 Applications

Benefits of Moisture Measurement in Olefins Feedstock

- At the outlet of the drier, prior to the cold box, moisture must be held to 1 to 2 ppm to prevent freezing within the cold box. Excessive moisture leads to plugged flow or split cold box due to water expansion as it freezes.
- At every metering point moisture content is a quality specification.
- At the inlet and outlet of ethylene and propylene towers monitoring of moisture as a product specification.
- At every pressure reduction point. Olefins are excellent refrigerants and water freezing can lead to plugged valves.
- Moisture poisons catalyst in the polymerization plant.

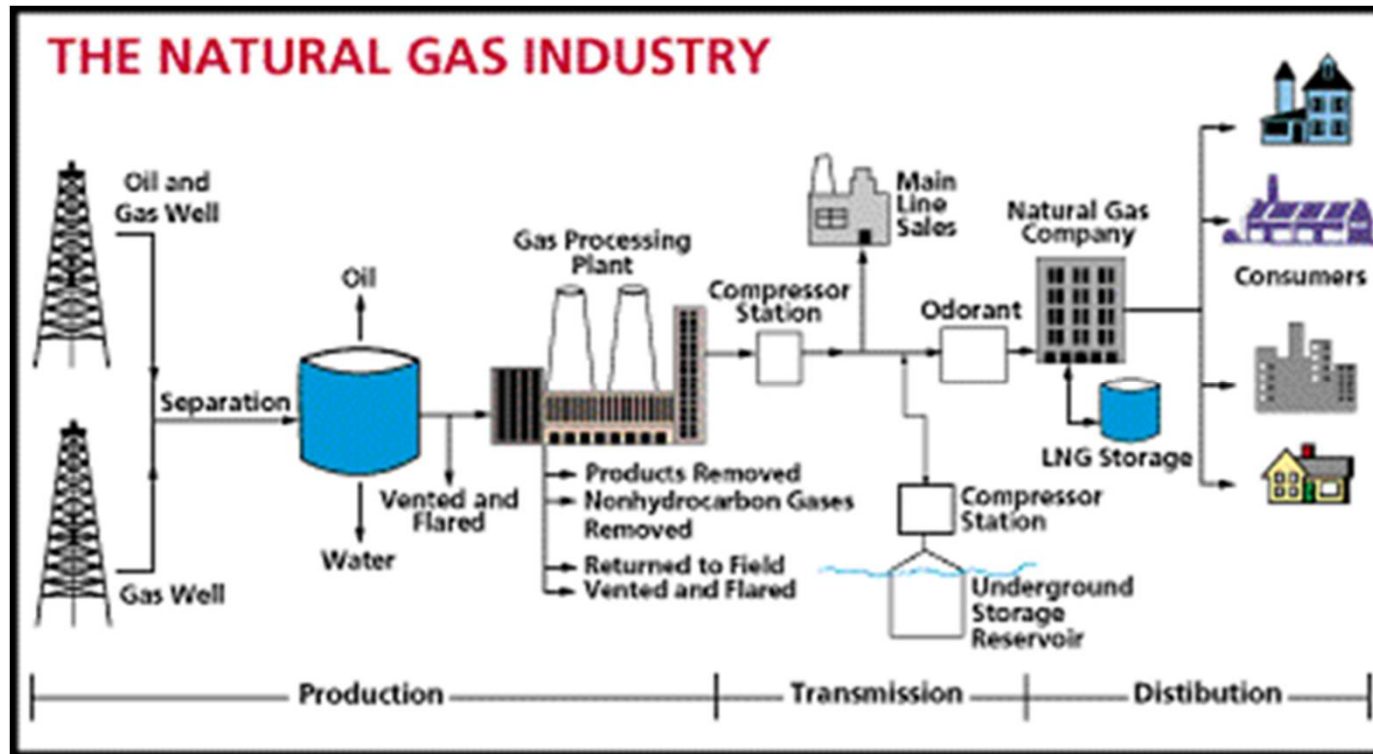
C Automation INDIA Week 2018 Applications

Why Measuring Moisture Reliably on a Continuous Basis is Difficult

The olefins can not have more than 2 to 3 ppm of moisture and therefore monitoring the moisture at that low level and being in a position to verify the analyzer operation is critical. The effect of prolonged exposure to contaminants will degrade sensor functionality.

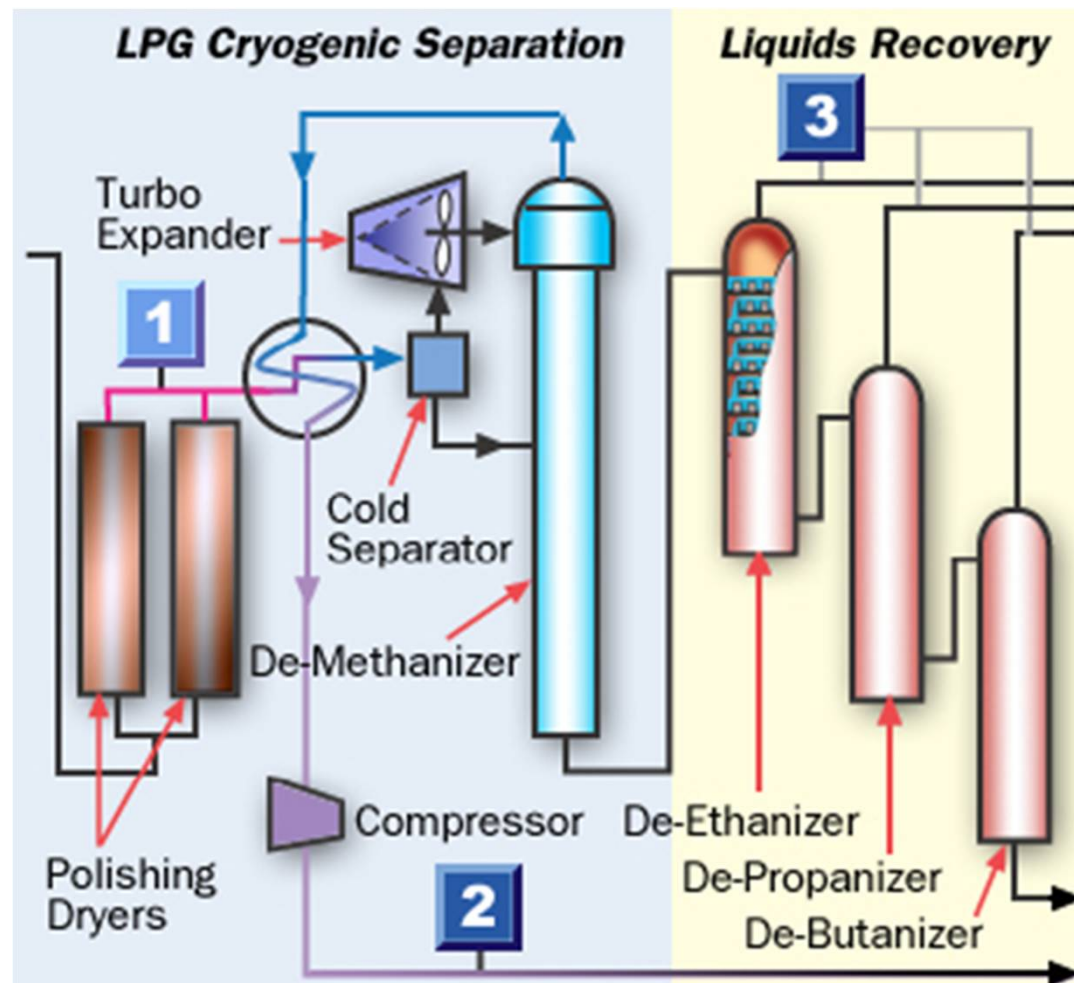
Problem - 'Failed' or de-sensitized sensors, calibration drift, process downtime.

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C Automation INDIA Week 2018 Applications

oo Expander Process



Moisture Measurement Techniques

Dew Point Analyzer*

Capacitive Analyzer

Electrolytic Analyzer*

Fiber Optical Analyzer

Quartz Crystal Analyzer*

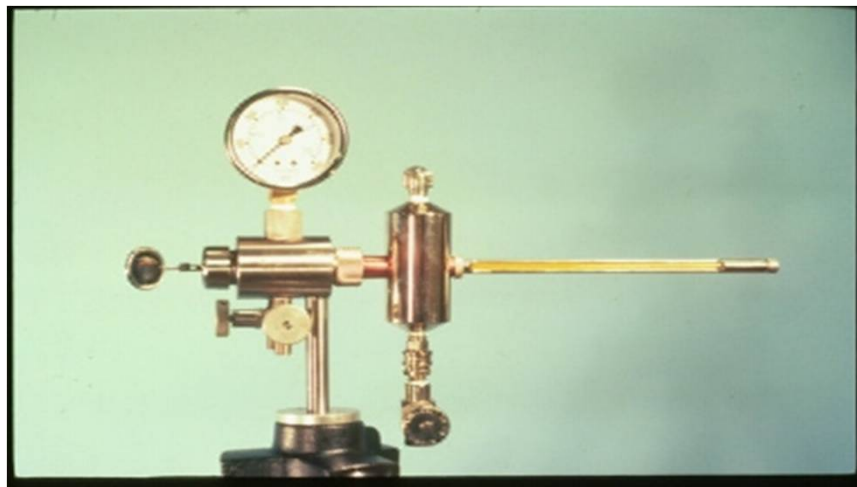
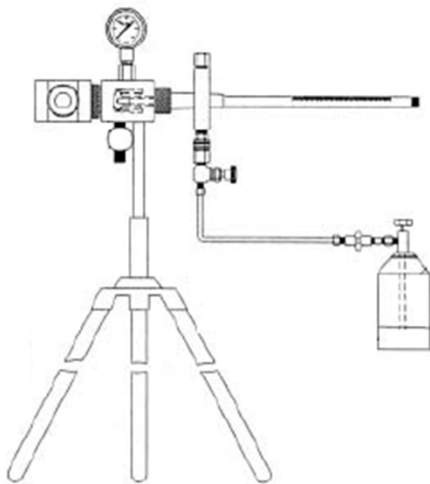
FDLAS Analyzer*

Offered by AMETEK Process Instruments

Moisture Measurement Techniques

Dew Point Analyzer (portable)

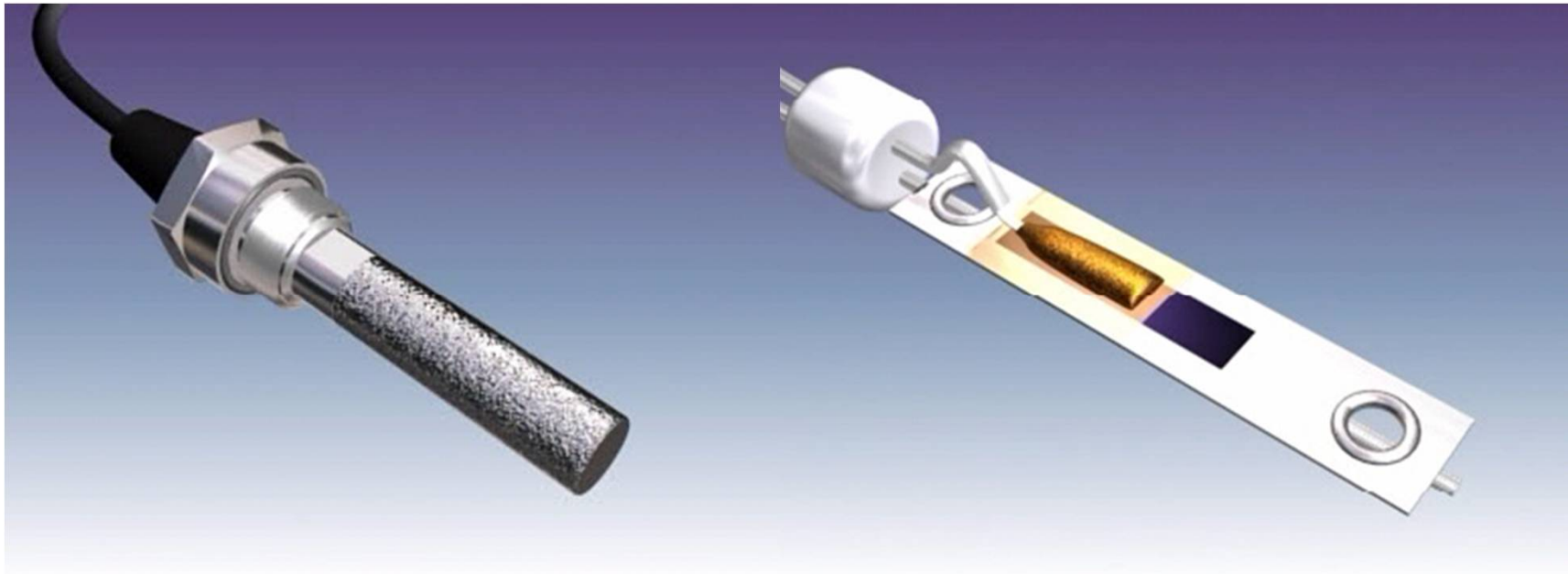
- This method consists of accurately measuring the temperature at which condensate forms on a chilled surface that is in the presence of the gas. The formation of the condensates on the chilled mirror is identified visually. Once the condensate has formed at the dew point, the sample pressure and the temperature of the mirror are accurately measured. The moisture content is then determined from published tables.



Moisture Measurement Techniques

Capacitive Analyzer

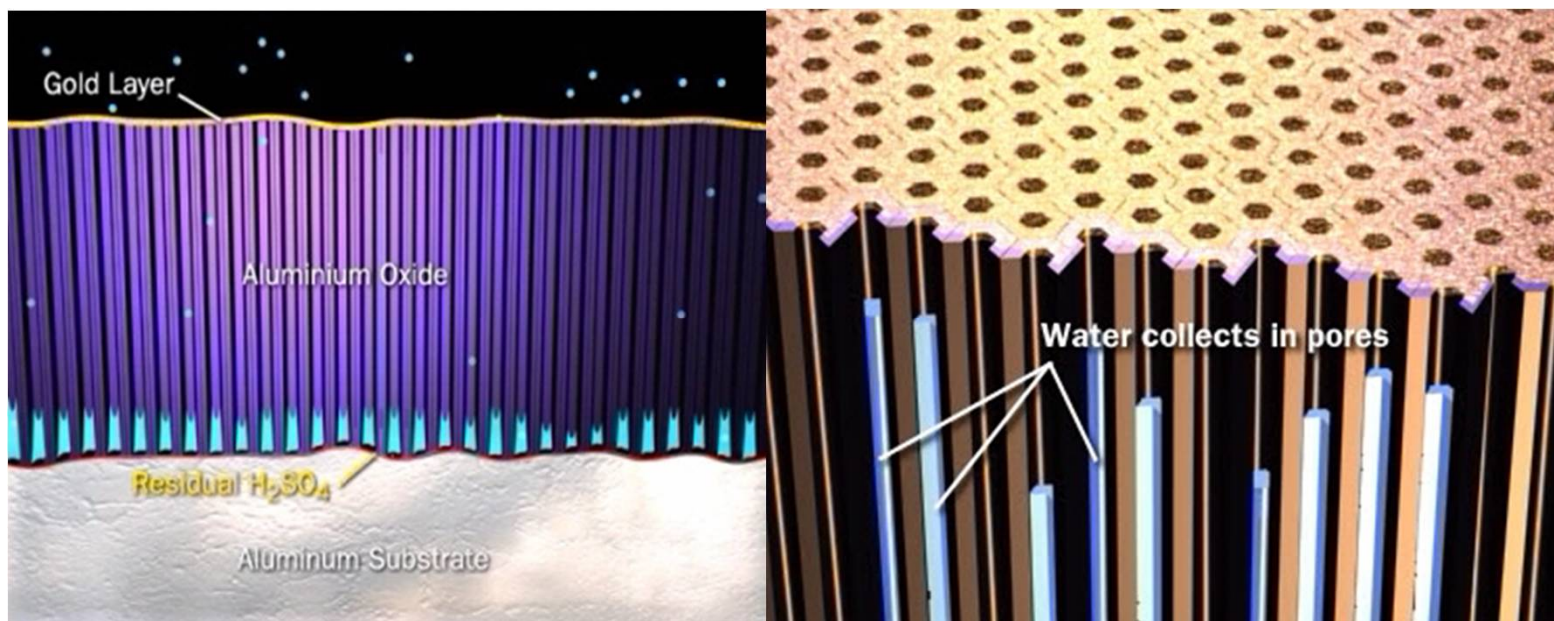
This method uses a capacitive cell in which the cell capacitance is proportional to the amount of moisture in the gas.



Moisture Measurement Techniques

Capacitive Analyzer

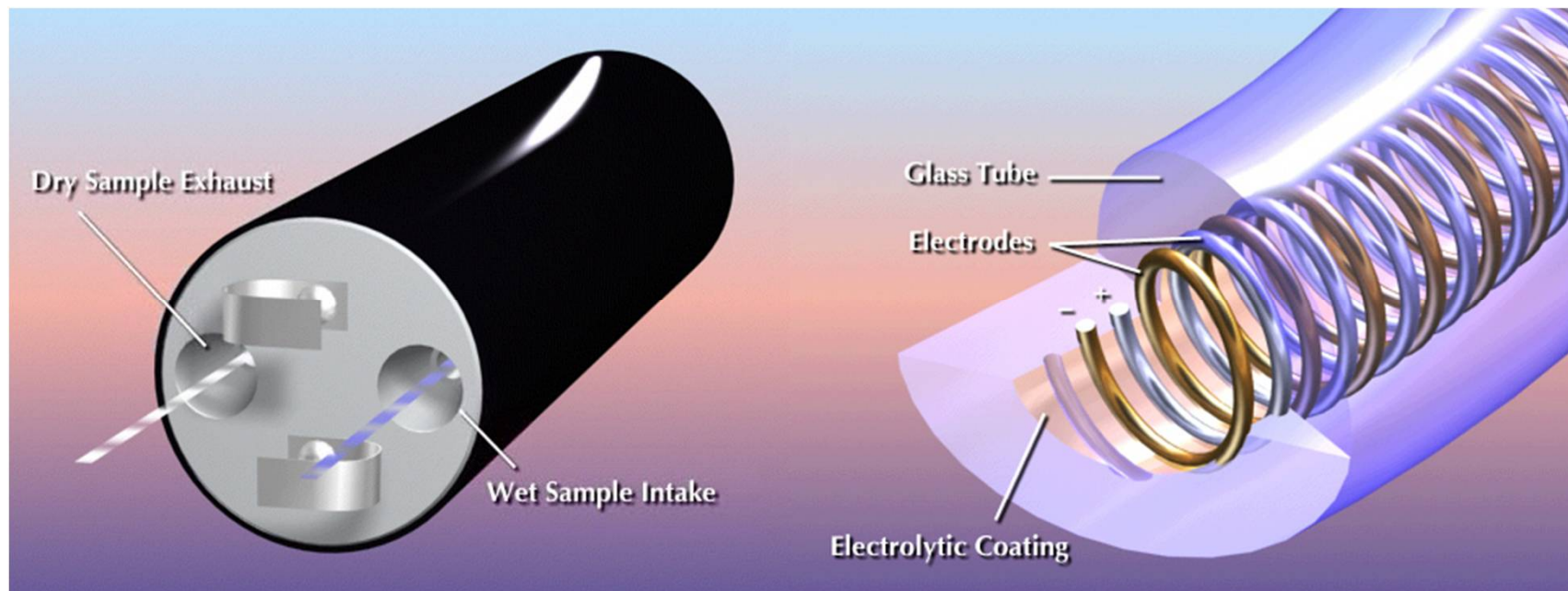
The sensor is made from pure aluminum. An aluminum strip is anodized in sulfuric acid resulting in a layer of porous aluminum oxide on its surface. Then a layer of a precious metal, typically gold, is thinly evaporated over the aluminum oxide so that it too is porous. This “sandwich” of three compounds is essentially a capacitor with the aluminum oxide layer being the dielectric.



Moisture Measurement Techniques

Electrolytic Sensor

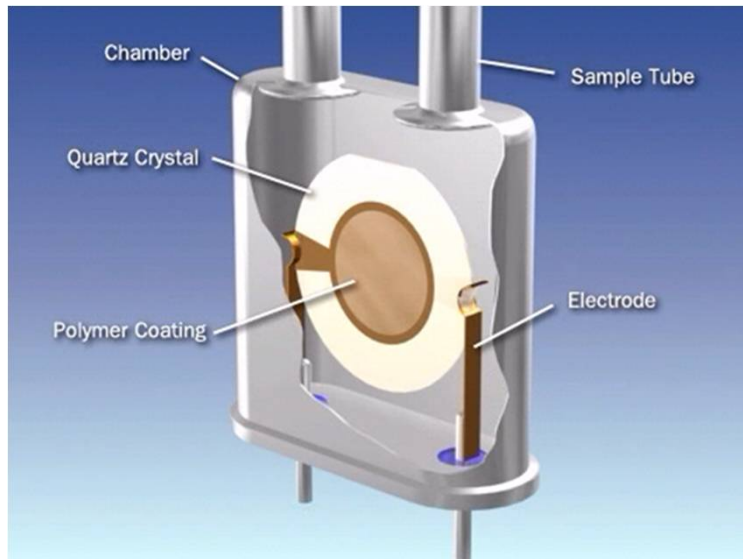
This method uses an electrolytic cell to produce an electrical current that is proportional to the amount of moisture in the natural gas.



Moisture Measurement Techniques

Quartz Crystal

A quartz crystal with a hygroscopic polymer vibrates at a baseline frequency. Absorption of water vapour causes increase of mass and decrease of frequency. The frequency change is a measure of the moisture concentration.



$$\Delta F_{Beat} = \frac{-2,3.10^6 * F^2 * \Delta M}{A}$$

Hence :

ΔF_{Beat} = Frequency difference (dry / wet)

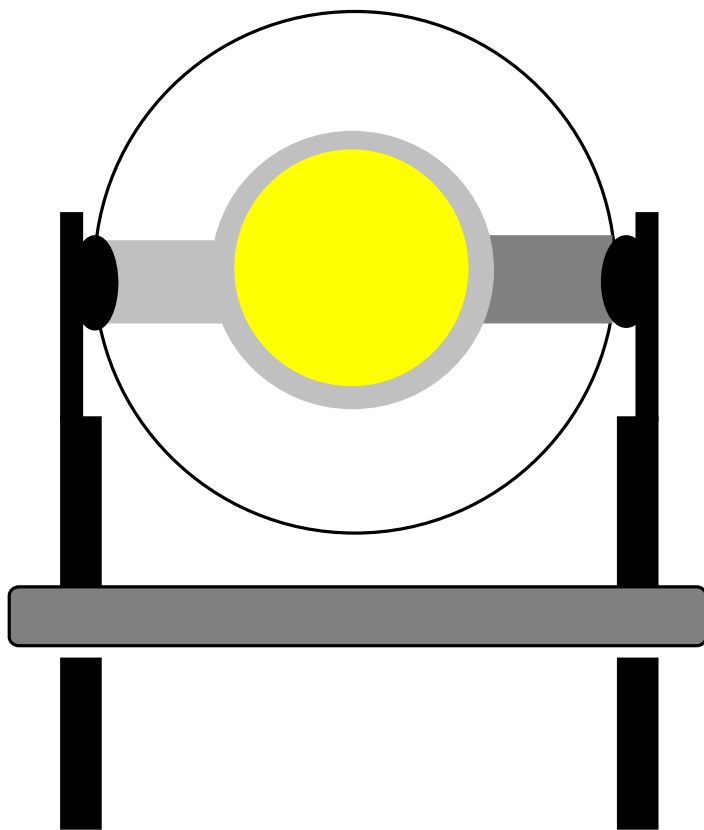
F = Fundamental frequency crystal

ΔM = mass change

A = polymer surface

Moisture Measurement Techniques

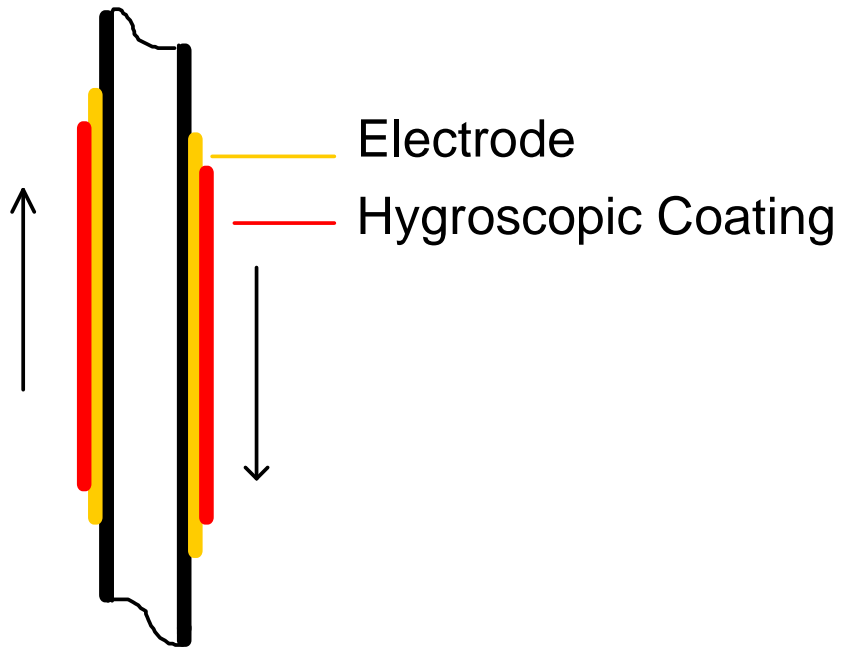
Quartz Crystal



- AT-Cut Quartz Crystal.
- Thickness-Shear Mode of Oscillation.
- Operation at 9 MHz.
- Electrode Surfaces Are Coated With Hygroscopic Material.

Moisture Measurement Techniques

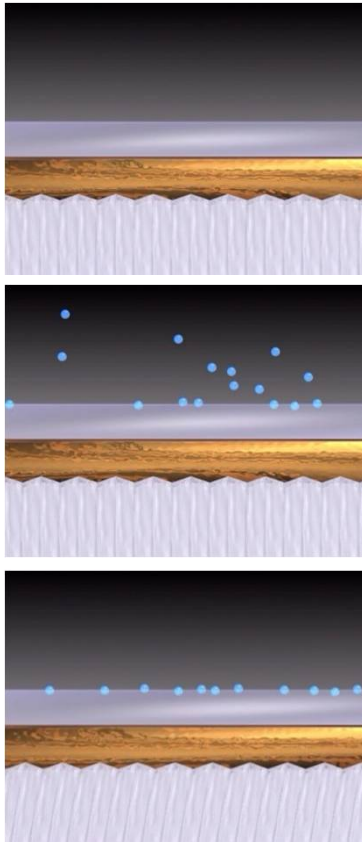
Quartz Crystal



- The moisture concentration is measured as a change in the oscillation frequency of the crystal.

Moisture Measurement Techniques

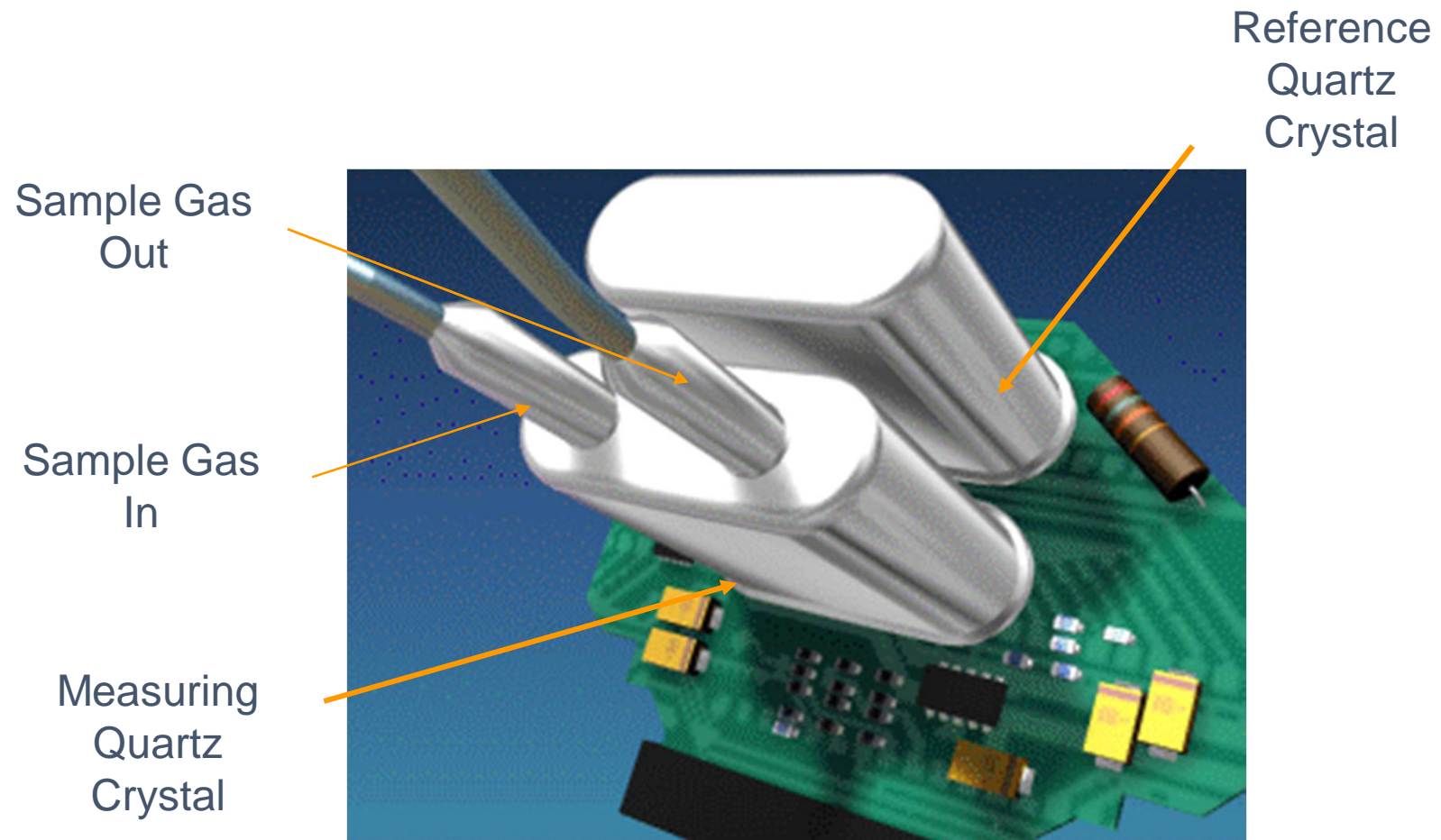
Quartz Crystal



- High Affinity for Sorbing Water Molecules from a Sample Gas.
- High Selectivity for Water Molecules.
- Sorption Process is Reversible at the same rate in either direction.

Humidity Measurement Techniques

Quartz Crystal



Moisture Measurement Techniques

Quartz Crystal Analyzer

Specific Features

Ranges from 1 ppbv to 2.500 ppmv

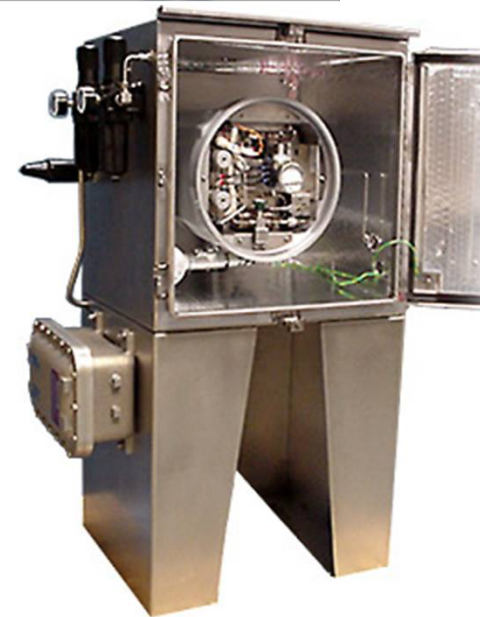
High accuracy for the whole range

Fast response even in ppbv ranges

Online calibration with integrated moisture generator

Diagnostic functions via referenz quartz

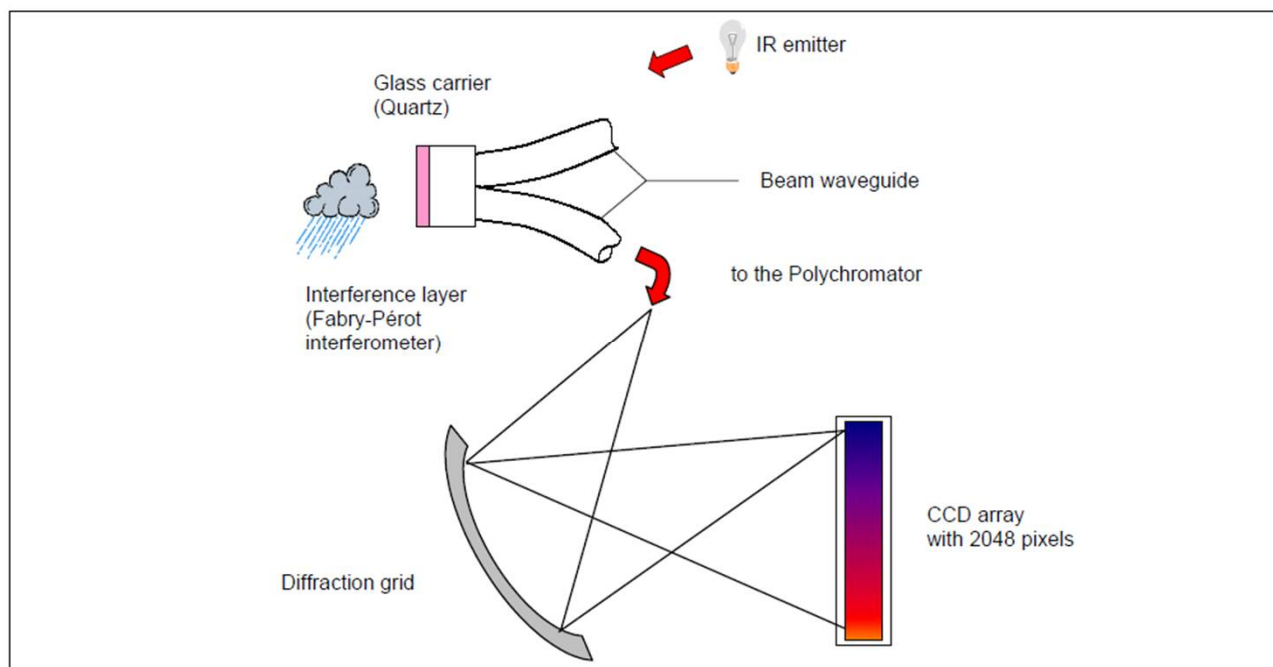
Dew point temperature based on GERG equation



Moisture Measurement Techniques

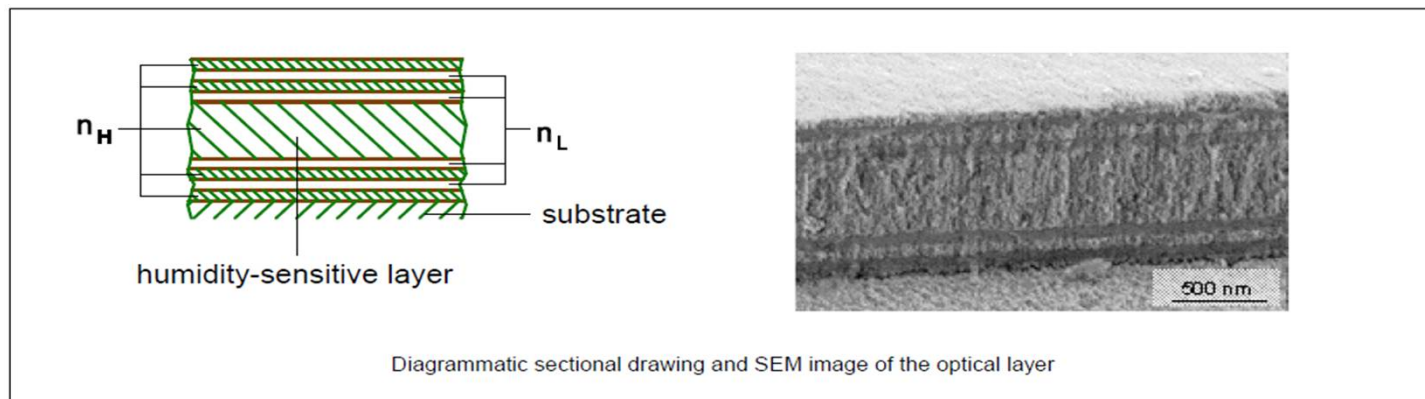
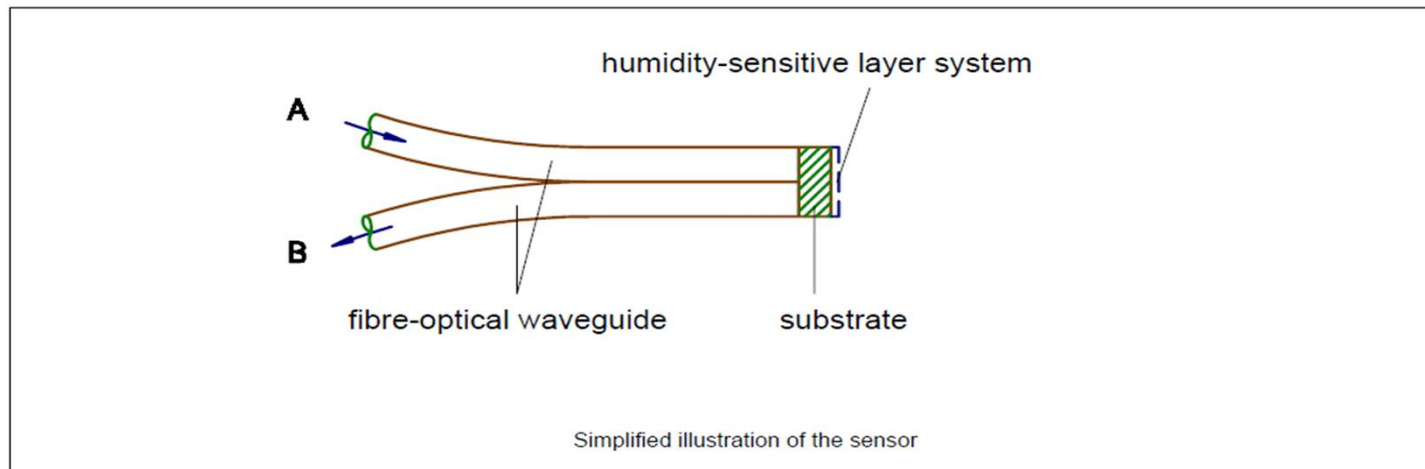
Fiber Optical Sensor

- Measures the change of the refractive index on a multilayer sensor with fiber optics



Humidity Measurement Techniques

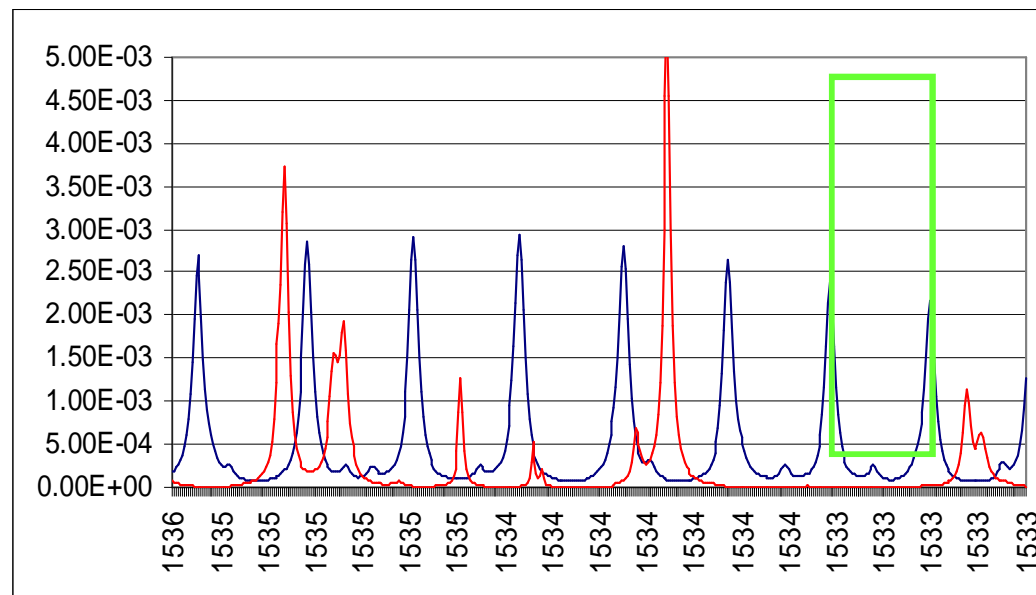
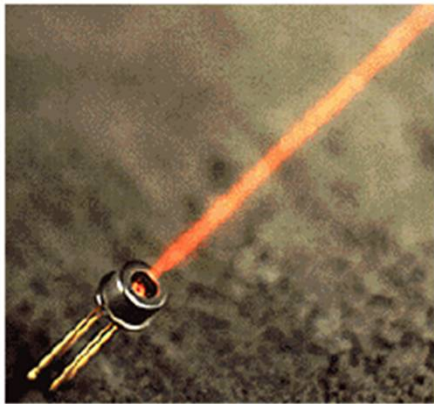
Fibre-Optical Sensor



Moisture Measurement Techniques

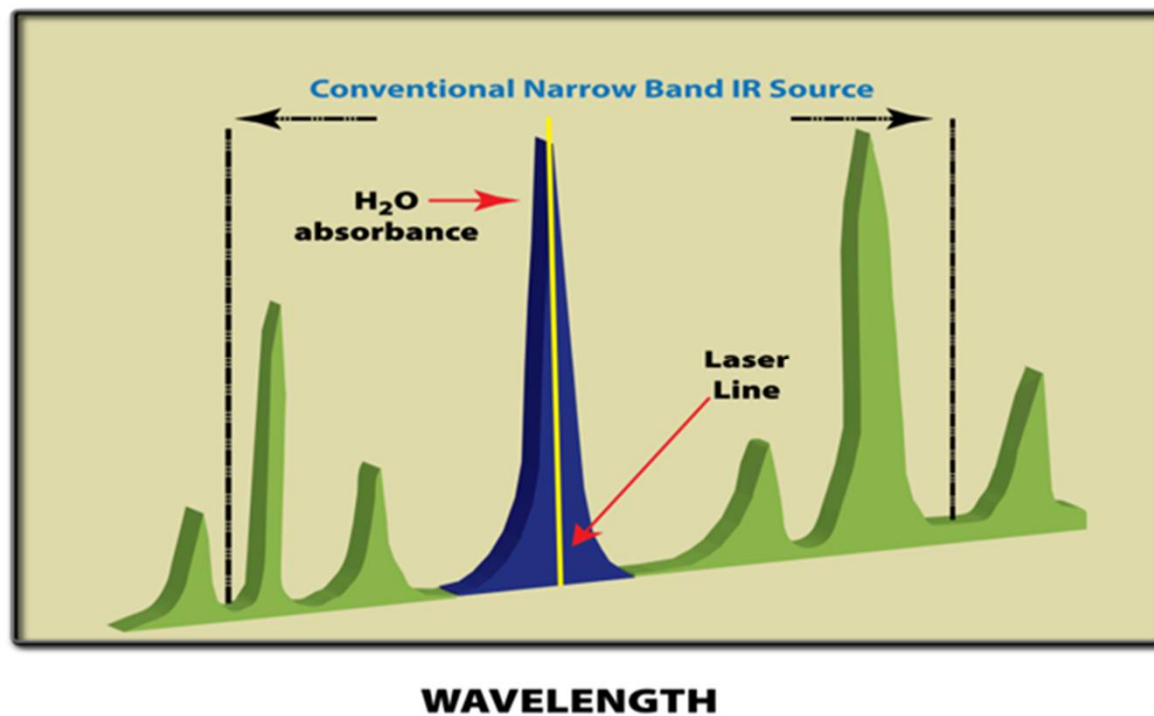
AS Analyzer

The tunable diode laser analyzer measures the moisture concentration in gases without cross interference. The compact unit includes a fully enclosed optics and sampling conditioning system as well as continuous on-board moisture verification.



Moisture Measurement Techniques

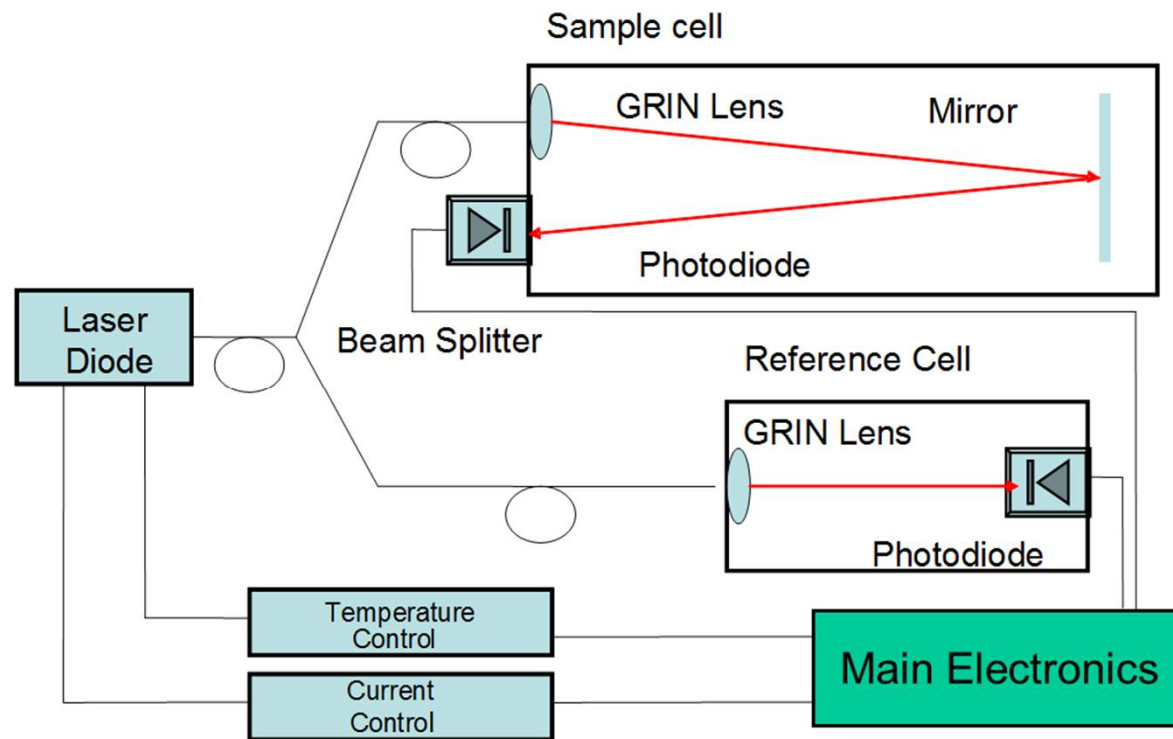
AS Analyzer



- Analyte, typical absorption linewidth 0.05 nm
- Laser scan range, typically 0.2 - 0.3 nm,
- Laser spectral line width is ca. 0.0001 nm
- Conventional optical filter bandwidth > 5 nm

Moisture Measurement Techniques

Reference Cell



Moisture Measurement Techniques

AS Analyzer

Specific Features

- *Ranges from 4 ppmv bis 2.500 ppmv*
- *Non-Contact Moisture Analyzer*
- *No interference from gas phase amines, glycol, methanol, H₂S and mercaptans*
- *Suitable for high corrosive gases*
- *Fast Response*
- *Laser line-lock verification using internal reference cell*
- *Web-Based Interface with diagnostic software*
- *Modbus, Fast Ethernet and analog connectivity*



Moisture Measurement Techniques

AS Analyzer

and accurate
measurements, free of
interferences

able

egrated sample
management panel

lock feature ensures
is analyzing at the
red wavelength

ardous area certified !!



C Automation INDIA Week 2018 Conclusions

- Trace Moisture measurement applications are important as it impacts product quality but also can impact process equipment (corrosion)
- The measurement is different then other process applications and therefore a different grate of attention must be given to the application .
- Not only the instrument technology is important the installation as a total must match the requirements of the specific application

C Automation INDIA Week 2018

Thank you very much for your attention
We are happy to answer your questions
Supporting team :

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Jochen Geiger Director Sales & Service EMEA / India
Anantha Kukkuvada Sales Manager India
Michael Gaura Global Product Manager