Trace Moisture Measurement with Aluminum Oxide Sensor in X-STREAM Process Gas Analyzers

With an Aluminum Oxide sensor, the X-STREAM Process Gas Analyzer family is capable of measuring trace moisture in many challenging applications. Key features include:

- -100 °C (-148 °F) to -10 °C (14 °F) dew point
- In combination with other measurements in one housing
- Factory calibrated / no field calibration needed
- Cryogenic Gases, Natural Gas (LNG), Utility Power Generators, Heat Treating

The sensor measures water in the range from -100 °C (-148 °F) to -10 °C (14 °F) dew point with an accuracy of +/-2 °C. A ppm sensor is also available with corresponding water concentrations of 0–100 ... 3000 ppm. Each sensor comes with a factory calibration.

X-STREAM Process Gas Analyzers

Trace Moisture

The moisture sensor can be combined with any other X-STREAM Analyzer technology, including: non-dispersive infrared, ultraviolet, and visible photometry (NDIR/UV/VIS), paramagnetic and electrochemical oxygen (pO_2 / eO_2), thermal conductivity (TCD) sensor and trace oxygen (tO_2). If combined with other measurements in series, the moisture sensor is always first in the series and completely tubed with stainless steel to avoid any diffusion of ambient air moisture to the sensor. A calibration exchange program (annual interval) is available. The sensor can be used in various background gases such as CO, CO_2 and natural gas.

	Trace Moisture (tH_2O)
Measurement range Measurement accuracy Repeatability	-100 to -10 °C dew point (0–100 ... 3000 ppm) ±2 °C dew point 0.5 °C dew point
Response time (t_{95}) Operating humidity Sensor operating temperature	5 min (dry to wet) 0 to 100 % r.h. -40 to +60 °C
Temperature coefficient Operating pressure	Temperature compensated across operating temperature range Depending on sequential measurement system, see analyzer specification (1) max. 1500 hPa abs / 7 psig
Flow rate	Depending on sequential measurement system, see analyzer specification (1) 0.2 to 1.5 l/min

**NOTE: 1psi = 68.95 hPa*

(1) If installed in series to another measurement system, e. g. IR channel

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Natural Gas Production/Transmission

Natural gas is found in vast underground wells and is often a petroleum byproduct. Ethylene Glycol (anti-freeze) dehydrators are used to dry the gas. In some special applications, molecular sieve may be used. The gas industry uses a particular terminology when measuring water vapor in the gas stream. It is specified in lbs/mmft^3 (pounds of H_2O/million cubic foot of gas) at 15.5 °C (60 °F). This is an absolute measurement such as dew point or ppm. The normal transfer specification is 7 lbs/mmft^3. This is equivalent to -38.5 °C dew point, -37 °F dew point or 150 ppm. Should the moisture level increase, the BTU (British Thermal Unit) value of the gas drops and the potential for corrosion increases. In LNG plants, the trace moisture sensor is often used to monitor moisture levels at the dehydrators for mercury removal.

Notes: Gas lines can be high pressure. Glycol carryover is possible. The sensor should be protected by a coalescing element.

Example: Combining trace H_2O, pO_2 and CO_2 measurements in Natural Gas in one flameproof analyzer

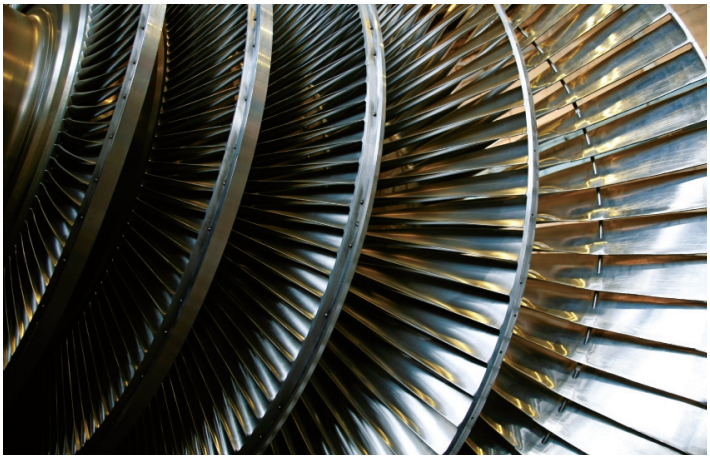
Cryogenic Gases

Cryogenic gases are normal atmospheric components which have been liquefied, separated and purified. Although they may be supplied as a high pressure gas, most are shipped to the customer in a liquid state and vaporized on site. The primary cryogenics are O_2, N_2 and Ar. H_2 and He are supplied in much smaller quantities.

Cryogenic gases are purchased for their particular properties. They may be used as an inert blanket, in chemical reactions or to protect a catalyst. Due to this wide range of usage, they are sold in various degrees of purity. Moisture (H_2O) is obviously an impurity, although on a very small scale. Typically, moisture levels are in the 0–5 ppm range.

Notes: The sensor should be in a bypass after the vaporizer and not directly in the flow. This will warm the sample and insure that the flow past the sensor is not excessive.

Example: With X-STREAM and MLT analyzer Emerson Process Management is able to provide complete analytical solutions for Air Separation Unit (ASU)



Utility Power Generation

Generator windings are cooled with hydrogen gas (H_2). Hydrogen is used due to the large heat absorption capacity, approximately 2.7 times that of ambient air. This gas must be kept moderately dry for several reasons. First, generators with a steel retaining ring having a composition of 18 % Chromium (Cr) and 5 % Manganese (Mn), are susceptible to stress failure in a high moisture environment. In this case, the problem can be solved by an expensive ring replacement (these rings are 18 % Cr and 18 % Mn, and are claimed to be resistant to high moisture levels) or by monitoring and drying the gas. Second, high moisture levels are suspected in the formation of lead carbonate. The lead is present in solder joints in the generator. Lead carbonate is hygroscopic and may provide a potential for arcing.

Notes: Due to the potential for oil carryover, all in-line, continuous systems should be filtered with a good coalescer. In the event of significant oil vapor, an activated carbon bed should be installed after the filter and before the sensor.

Example: The moisture measurement can be combined with the H_2 purity measurement (Utility Application) in one flameproof housing.

Utility Power Transmission

Utility transformers are periodically taken out of service for maintenance. These transformers are filled with an insulating oil, then topped off with a pressurized nitrogen blanket. Prior to refilling, the transformers must be purged with dry nitrogen for a period of time, until the moisture inside the transformer windings has been removed. The nitrogen source must be verified as dry, then the transformer exhaust must be monitored until a certain dryness has been achieved.

Notes: Sampling N_2 from transformers fueled with oil can lead to carry over. A coalescing filter may be required.

Dry Compressed Air

There are different qualities of compressed air with different moisture levels:

- Deliquescent (typically 20 °F depression from ambient)
- Refrigerated (with approx. 2 °C (35 °F) dew point)
- Desiccant (-40 to -73 °C (-40 to -100 °F) dew point)
- CDA (-73 °C (-100 °F) dew point)

Compressed air must remain dry to avoid pneumatic failure and winter freeze-up. CDA (compressed dry air) must remain below 2–3 ppm to avoid semiconductor manufacturing defects.

Notes: Although compressed air is one of the easiest applications, there can be some problems. In several instances -40 °C (-40 °F) dryers with wide dew point swings were found to spike during changeover up to 10 °C to 21 °C (50 °F to 70 °F). If the air temperature drops below this temperature, condensate can form in the pipe. This is especially troublesome with refrigerated air lines outside in winter. For these applications, special sampling techniques utilizing sample systems or heated sample cells may be required.

Heat Treating Furnaces

Heat treating furnaces may be found in numerous industries. They are used by manufacturers of semiconductors, electronic parts, aircraft and aerospace components, metal products, glass products, ceramics and various types of hermetic seals. In a typical application, the product moves down a belt into the oven. Depending on the requirements, one or more of the following gases may be present: N_2, Ar, O_2, H_2. The dew point may range from ultra-dry -73 °C (-100 °F) or lower to wet 20 °C (+68 °F), possibly greater in some situations. The goal is to have a conditioning atmosphere which has an effect on the product surface (i.e., formation of, or reduction of an oxide layer, etc...).

Notes: Most heat treating is performed on metals, or metal products. Prior to treatment, they may have been welded or machined, then cleaned. Most cleaning and degreasing compounds contain chlorides. During heat treating, these may be given off as Cl_2, HCl or Cl - radicals. All are highly aggressive and will attack an aluminum oxide sensor. Also, the treating gases themselves may combine to form NH_3 (if N_2 and H_2 are used) or they may combine with chemicals given off by the metals and degreasers to form other aggressive compounds. Heat treating is done at very high temperatures, possibly up to 2000 °C (3632 °F). This temperature must be reduced for sampling. Therefore, a cooling coil or appropriate length of tubing should be installed before the sample cell. Also, due to the low process pressures, a vacuum pump may be required.

Glove Boxes

Glove boxes are used to perform manual manufacturing processes where exposure to the components may be harmful to personnel, or exposure to the room atmosphere may be harmful to the product. Glove boxes, generally, are purged with N_2, Ar or CDA (see Dry Compressed Air application) to form an inert boundary. They are widely used in the semiconductor/electronic component metalworking, nuclear and crystal manufacturing industries.

Notes: Gases and residual products can produce aggressive chemicals.

Example: Combination of trace H_2O and trace O_2 in one analyzer is a smart solution for glove boxes.

Hopper Desiccant Dryers

Used for drying hygroscopic and non-hygroscopic plastic resins, twin tower hopper dryers operate in the following way: a fan circulates dry air through the hopper containing plastic resins at slightly above atmospheric pressures. The moisture laden air is then sent through a desiccant bed where the moisture is absorbed from the air stream by the desiccant. An external heater then takes the -40 °C (-40 °F) dry air and raises the temperature as high as 230 °C (450 °F). This air is sent back through the hopper of resin to remove additional moisture in a closed loop.

The quality of the dry air is monitored by a dew point sensor set as required for the desired degree of drying. When the moisture absorbing capacity of the desiccant reaches its limit, the air flow is automatically switched to a second desiccant chamber to maintain the drying process. Meanwhile the first desiccant chamber is regenerated by heating it to remove moisture and then cooling it so it can resume absorbing water.

Notes: Excessive temperatures may reach the sensor. The use of a cooling coil can bring this temperature close to ambient. Second, many polymers give off chemical vapors when heated. One family of compounds are acetaldehydes. These are aggressive and will attack the moisture sensor. However, dryer desiccant removes most of these compounds. Therefore, return (wet) leg sampling cannot be recommended on a continuous basis.

www.RosemountAnalytical.com

EUROPE
Emerson Process Management GmbH & Co. OHG
Rosemount Analytical
Process Gas Analyzer Center of Excellence
Industriestrasse 1
63594 Hasselroth, Germany
T +49 6055 884 0
F +49 6055 884 209
www.RosemountAnalytical.com

AMERICAS
Emerson Process Management
Rosemount Analytical
Gas Chromatograph Center of Excellence
10241 West Little York, Suite 200
Houston, TX 77040 USA
Toll Free 866 422 3683
T +1 713 396 8880 (North America)
T +1 713 396 8759 (Latin America)
F +1 713 466 8175
gc.csc@emerson.com

ASIA-PACIFIC
Emerson Process Management
Asia Pacific Private Limited
1 Pandan Crescent
Singapore 128461
Republic of Singapore
T +65 6 777 8211
F +65 6 777 0947
analytical@ap.emersonprocess.com
www.RosemountAnalytical.com

MIDDLE EAST AND AFRICA
Emerson Process Management
Emerson FZE
P.O Box 17033
Jebel Ali Free Zone
Dubai, United Arab Emirates
T +971 4 811 8100
F +971 4 886 5465
analytical@ap.emersonprocess.com
www.RosemountAnalytical.com

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