GE Measurement & Control

- Moisture Measurement Tutorial
- Instruments
- Application Overview

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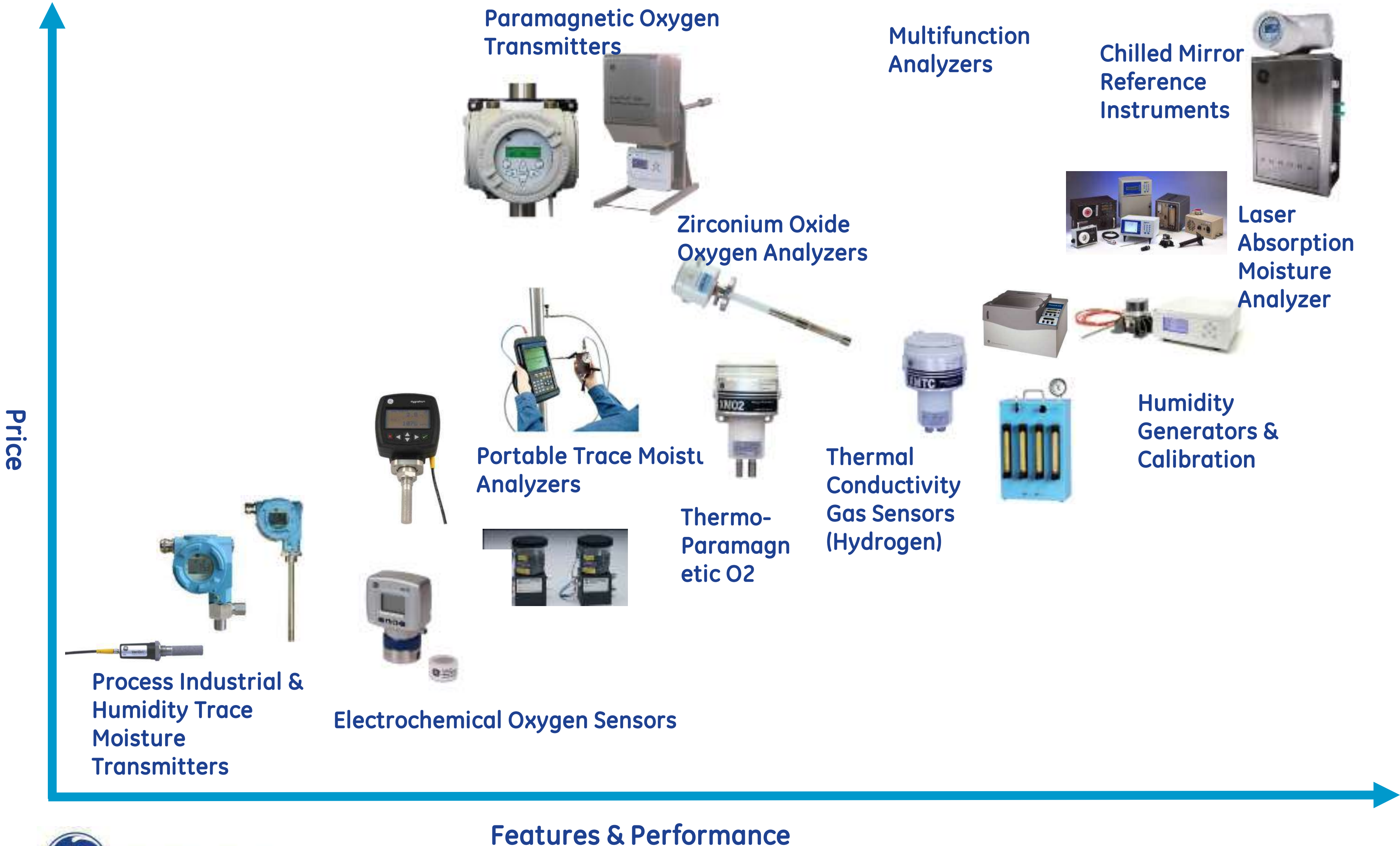
GE Process Moisture & Gas Instruments Overview



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Moisture & Humidity Measurement Fundamentals

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Composition of Dry Air

Gas	% Volume	Pressure KPa
Nitrogen	78.08	79.09504
Oxygen	20.95	21.22235
Argon	0.93	0.94209
Carbon Dioxide	0.031	0.031403
Neon	0.002	0.002026
Helium	0.0005	0.0005065
Methane	0.000015	0.000015195
Sulfur Dioxide	0.0001	0.0001013
Hydrogen	0.00005	0.00005065
Other Noble Gases	0.0002	0.0002026
Total	99.993865	101.2937852

Each component gas exerts a "partial pressure" directly proportional to it's volume (Dalton's Law)

When water vapor is added to dry air it also exerts a partial pressure proportional to it's volume

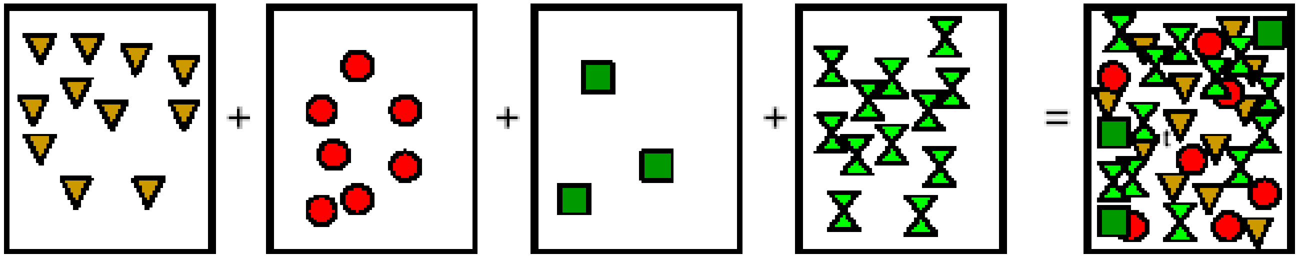
At typical summertime ambient conditions the concentration of water in air is about 1-1.5% by volume

Dalton's Law

The sum of the partial pressures of all the component gases of a gas mixture is equal to the total pressure.

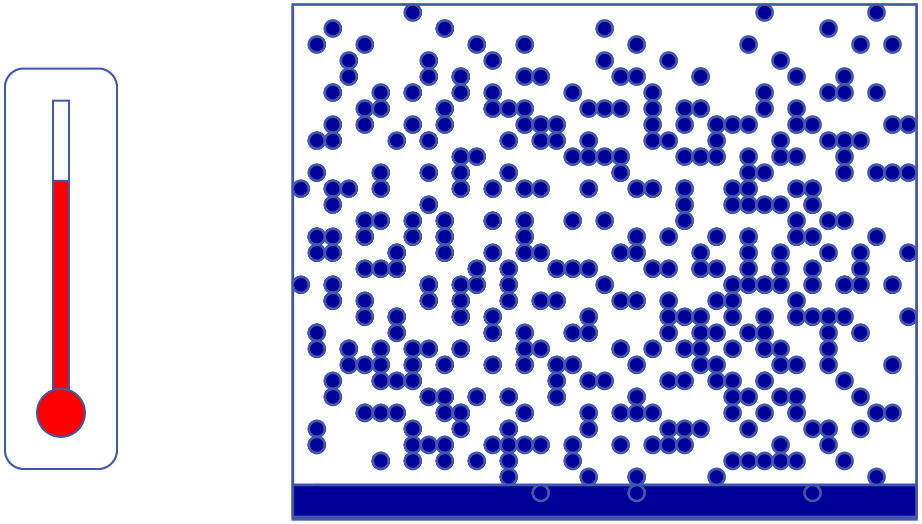
The concentration of any component gas in a mixture is directly proportional to it's the partial pressure.

$$P_1 + P_2 + P_3 + P_4 \ldots = P_T$$



Each component gas obeys the Ideal gas law PV = nRT

Water Vapor Saturation



In a closed system at given temperature and pressure, water (liquid or ice) will establish an equilibrium with gaseous water (water vapor) in the “head space”.

At a given temperature, the maximum amount of water that can be held in the gas phase is finite. When a space is holding the maximum amount of water vapor at a given temperature, the water vapor exerts a finite partial pressure called the “saturation vapor pressure”.

Increasing the temperature increases the saturation vapor pressure.

At the boiling point the vapor pressure is equal to the atmospheric pressure (100°C at sea level)

Saturation Water Vapor Pressure

When water vapor is at the saturation point, the space has reached the maximum capacity to hold water in the gas phase.

At the saturation point the water vapor exerts a specific "saturation water vapor pressure"

Any water vapor in excess of the saturation point will be converted to the liquid or solid.

$$e_s(\text{water}) = K_w \bullet 6.1121\exp\left(\frac{17.502t}{240.97+t}\right) \qquad K_w = 1.0007 + 3.46x10^{-6}P$$

$$e_s(\text{ice}) = K_i \bullet 6.1115\exp\left(\frac{22.452t}{272.55+t}\right) \qquad K_i = 1.0003 + 4.18x10^{-6}P$$

e_s = Saturation Water Vapor Pressure in mBars

P = Pressure in mBar

t = Temperature in °C

Ref: A.L. Buck. *Equations for the Saturation Water Vapor Pressure Over Water & Ice*

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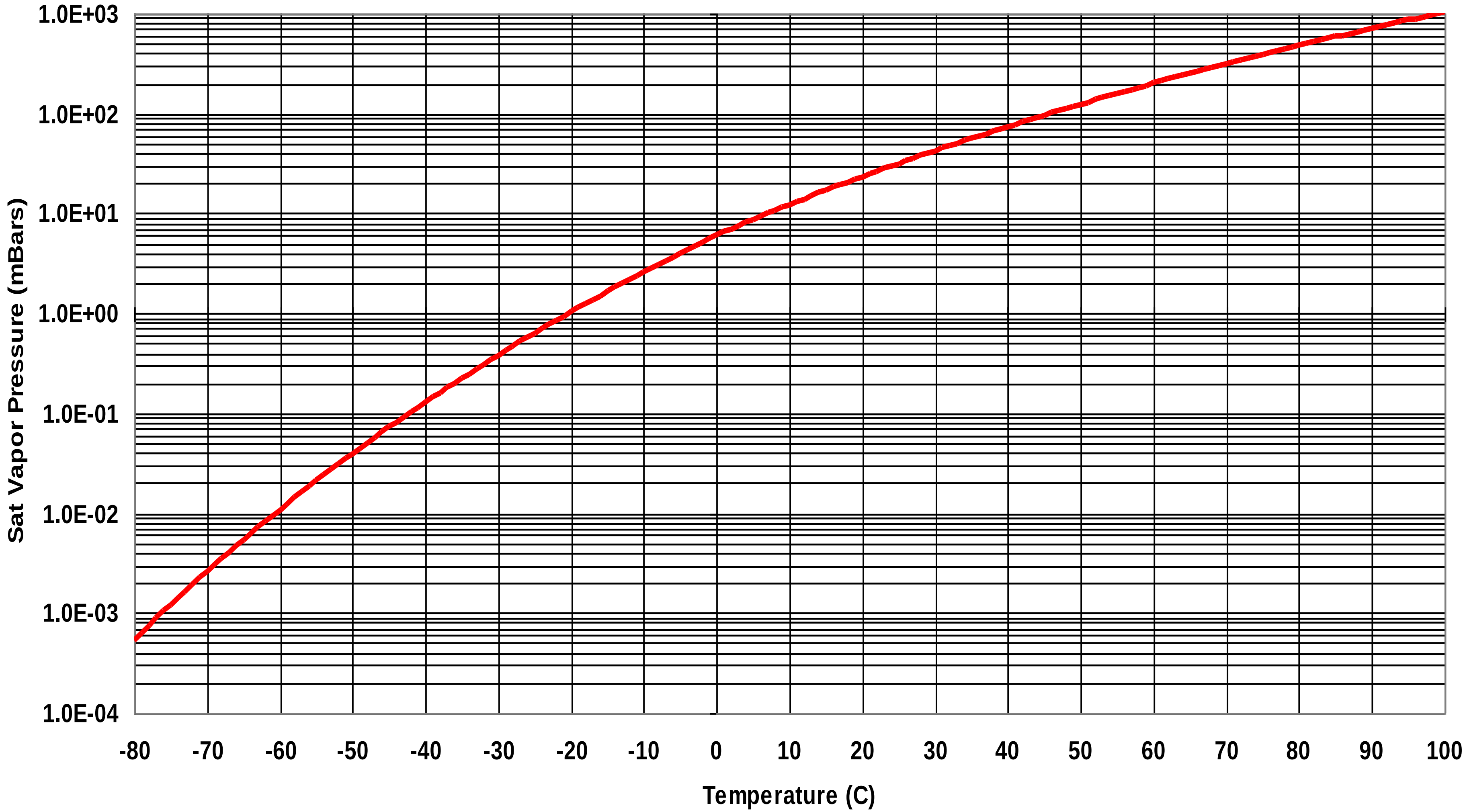
Saturation Water Vapor Pressure



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Dew/Frost Point Temperature

The dew point or frost point temperature (T_d) is defined as the maximum temperature at a given pressure where the gas will be saturated with water vapor.

At the dew point decreasing the temperature, increasing the pressure or the water vapor concentration will cause water vapor to condense as liquid water or ice.

$$T_{dew} = \frac{240.97 \cdot \ln\left(\frac{e}{6.1121}\right)}{17.502 - \ln\left(\frac{e}{6.1121}\right)}$$

T_{dew} = Dew Point Temperature in °C

T_{frost} = Frost Point Temperature in °C

e = Water vapor pressure in mBars

Relative Humidity (%RH)

The ratio of the partial pressure of water vapor to the saturation water vapor pressure at a given temperature multiplied by 100.

$$\%RH = \frac{e}{e_s} \bullet 100$$

%RH = Relative Humidity

e = Existing partial pressure of water vapor

$\mathbf{e_s}$ = Saturation water vapor pressure (referenced to the prevailing temperature)

The relative humidity is an indication of how much water vapor is in a space compared to how much the space can hold at at the prevailing temperature .

Absolute Humidity (AH)

The ratio of the mass of water vapor to volume of air or gas.

Most commonly expressed as grains (1 grain = 1/7000 of a pound) per cubic foot (gr/Ft^3, grams per cubic meter g/m^3 or pounds per million cubic feet (lbs/MMSCF… used for natural gas).

$$\frac{g}{m^3} = \frac{216.7e}{T + 273.16}$$

e = Partial pressure of water vapor
T = Temperature in °C

Reference to atmospheric pressure

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Volume Ratio & Specific Volume

Volume Ratio: The ratio of the volume of water vapor to the volume of the carrier gas. Usually expressed as PPMv (Parts per Million by Volume) or %. Also called volume mixing ratio

$$V_m = \frac{e}{P - e}$$

e = Partial pressure of water vapor
P = Pressure

Specific Volume: The ratio of the volume of water vapor to volume total gas mixture. Usually expressed as PPMv (Parts per Million by Volume) or percent

$$V_s = \frac{e}{P}$$

$$\text{PPMv} = V_s \times 10^6$$

Mass Ratio & Specific Humidity

Mass Mixing Ratio: The ratio of the mass of water vapor to the mass of carrier gas. Usually expressed as grains per pound, milligrams per kilogram or PPMw.

$$W_m = \left(\frac{e}{P - e}\right) \bullet \frac{18}{MW_{cg}}$$

Specific Mass: The ratio of the mass of water vapor to mass of the gas mixture. Usually expressed as PPMw (Parts per Million by Volume) or % (Percent)

$$W_s = \frac{e}{P} \bullet \frac{18}{MW_{cg}}$$

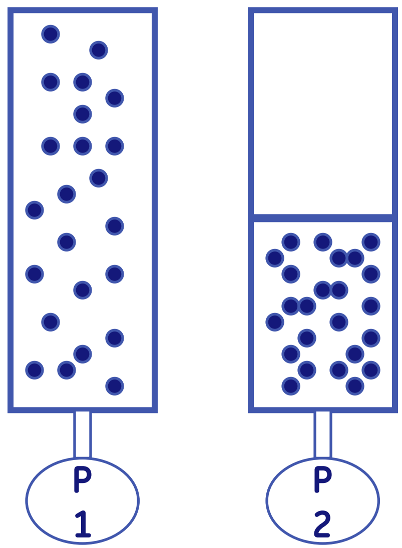
e = Partial pressure of water vapor
P = Pressure
18= Molecular Weight of Water
MWcg = Molecular Weight of the Carrier Gas

Pressure & The Effect on Water Vapor Pressure

If a gas mixture is expanded or compressed, the saturation water vapor pressure will change directly proportional to the ratio of the change in absolute pressure.

$$\frac{e_2}{e_1} = \frac{P_2}{P_1} \bullet \frac{K_2}{K_1}$$

If a gas containing water vapor is compressed, this is equivalent concentrating the water vapor in a smaller volume. The partial pressure of water increases directly proportional to the system pressure



At elevated pressures water vapor deviates from the "ideal gas law".

The "K" enhancement factors are used to compensate for the deviation from the ideal gas law

Kw = Enhancement Factor for water
Ki = Enhancement Factor for ice
P = Pressure in mBar

$$K_w = 1.0007 + 3.46x10^{-6}P$$

$$K_i = 1.0003 + 4.18x10^{-6}P$$

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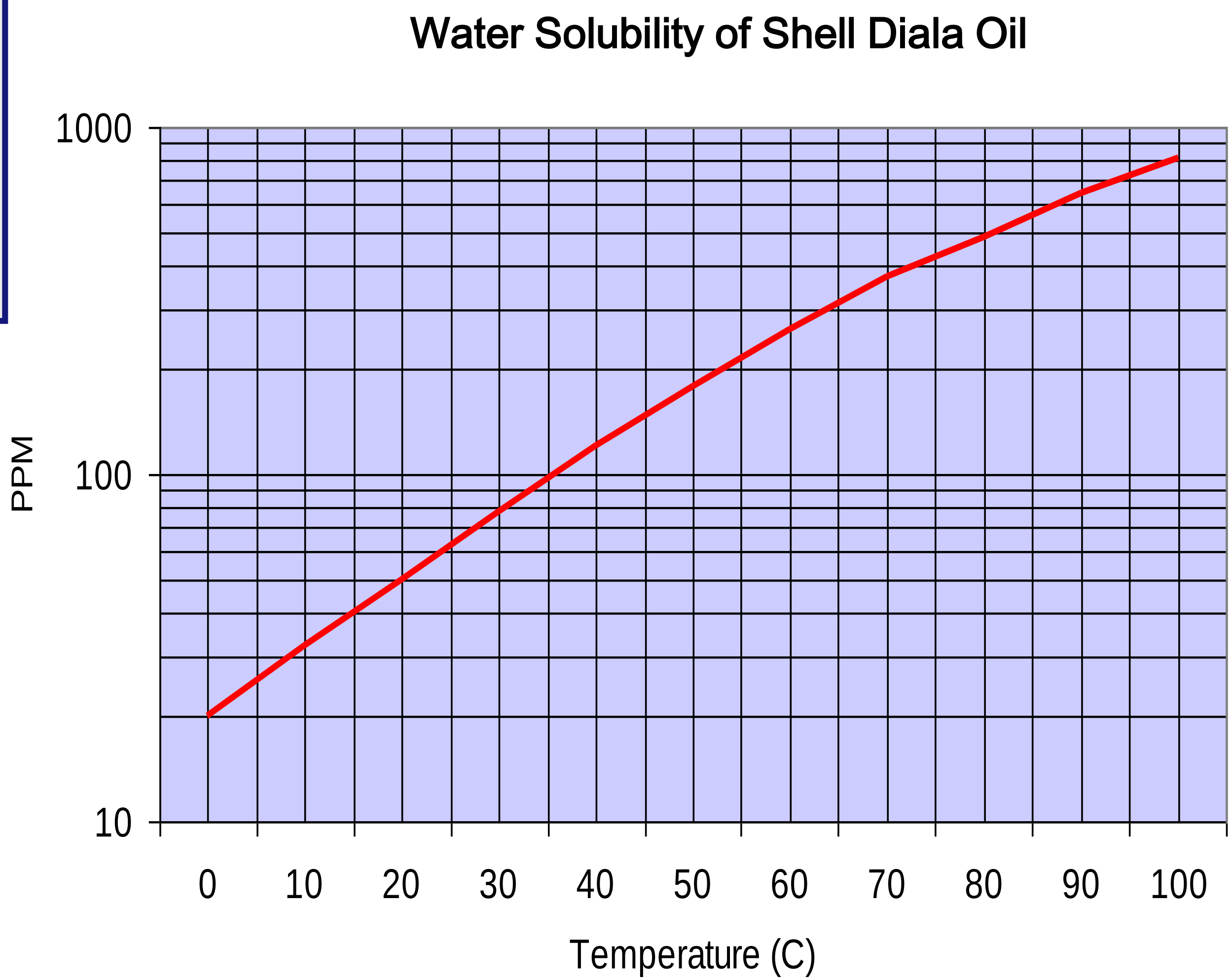
Moisture in Organic Liquids

Henry's Law:

The amount of a gas that dissolves in a liquid is proportional to the partial pressure of the gas over the liquid

Direct insertion Aluminum Oxide sensors (trace levels) and polymer %RH sensors (higher levels) may be used to measure the moisture concentration (PPMw) in "non-miscible" liquids

Water saturation concentration (PPMw) vs. temperature tables are stored in the analyzer



Instruments

- Chilled Mirror
- Aluminum Oxide
- Polymer
- TDLAS

GE Sensing Humidity Industrial & Process Humidity Sensors










Dew/Frost Point

-110°C -80 °C -60 °C -40 °C 0 °C +20°C +40°C +60 °C +85 °C +150 °C

Trace Moisture

- Aluminum Oxide Sensors
- Aurora TDLAS
- 4&5 Stage Chilled Mirrors

Mid-Range

- Polymer Capacitive Sensors
- 1&2 Stage Chilled Mirrors

High Humidity

- Polymer Capacitive Sensor
- Heated Chilled Mirror

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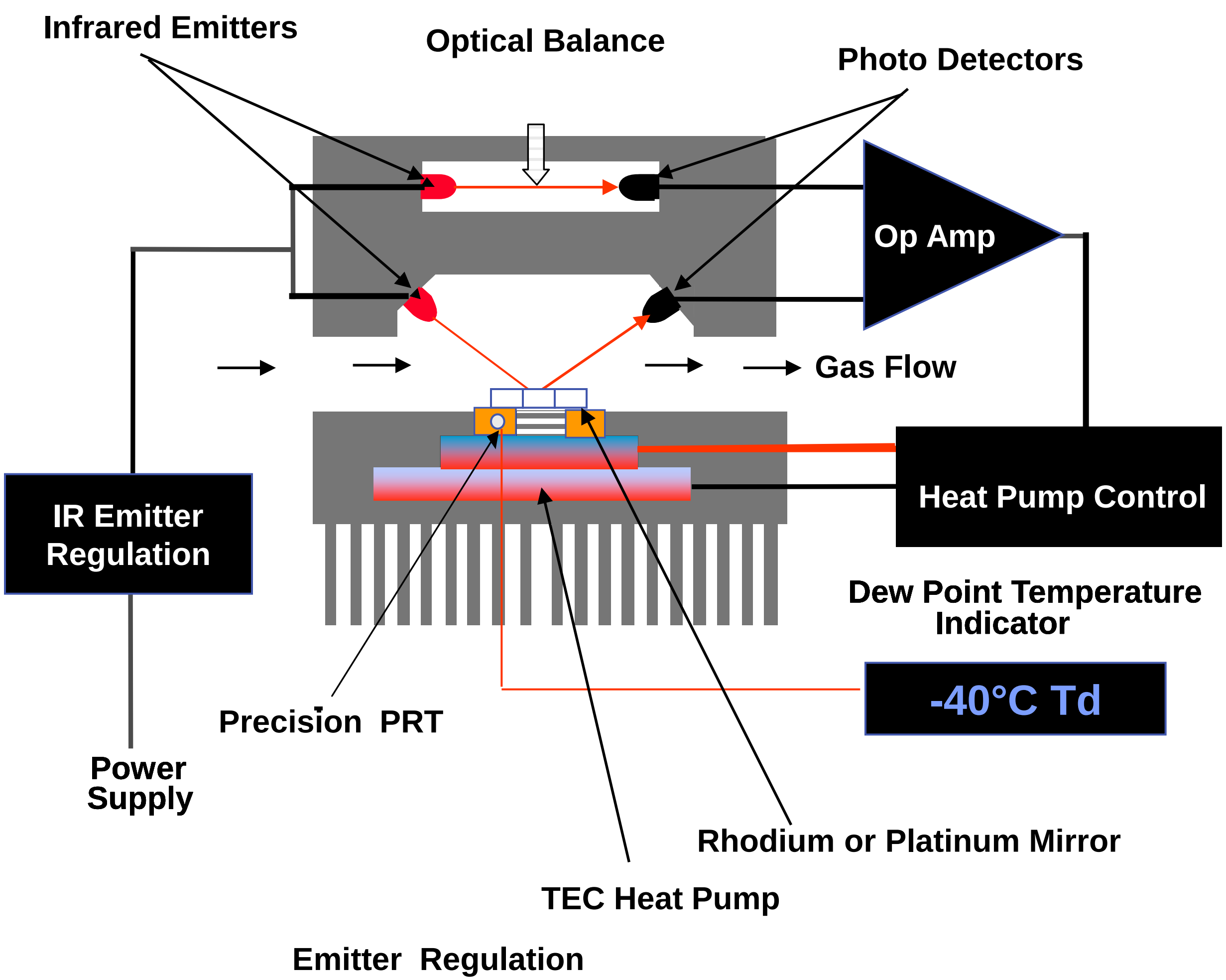
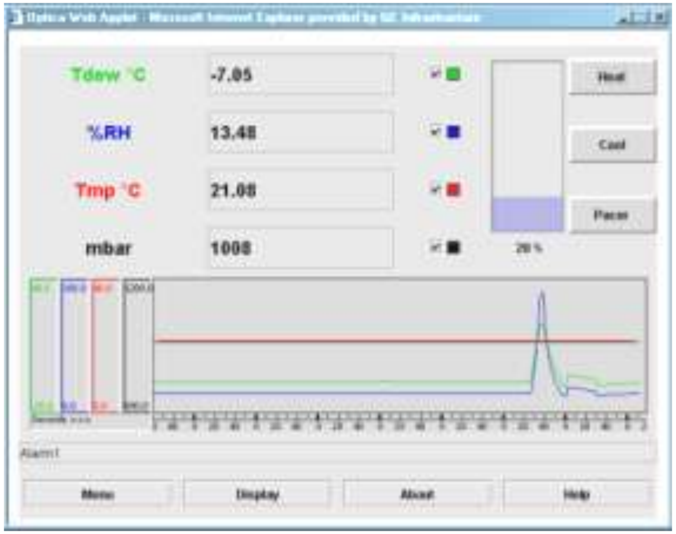
Chilled Mirror Principle of Operation



Chilled Mirror Hygrometers



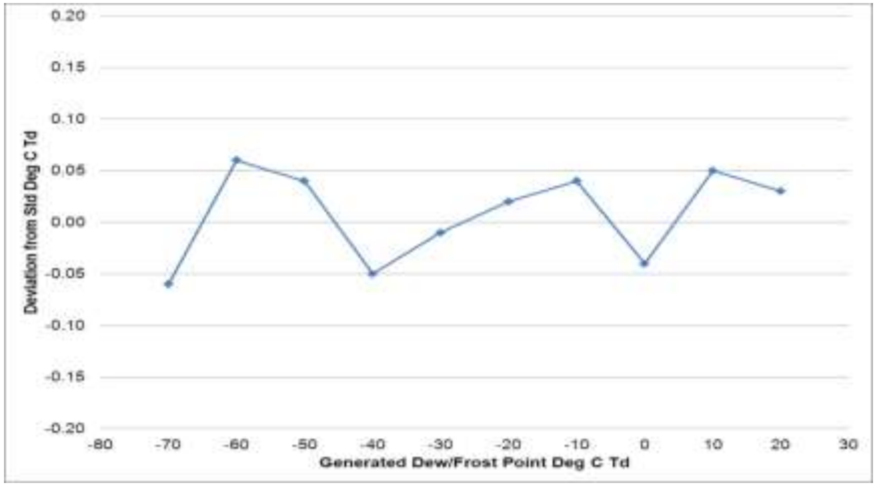
- Primary reference standard used for calibrating other humidity sensors
- Digital telemetry (Serial & Ethernet) & data logging
- Access data via internet
- Benchtop Calibration Chamber
- Traceable to NIST and other National Standards Labs
- Used In R+D & Mission Critical applications

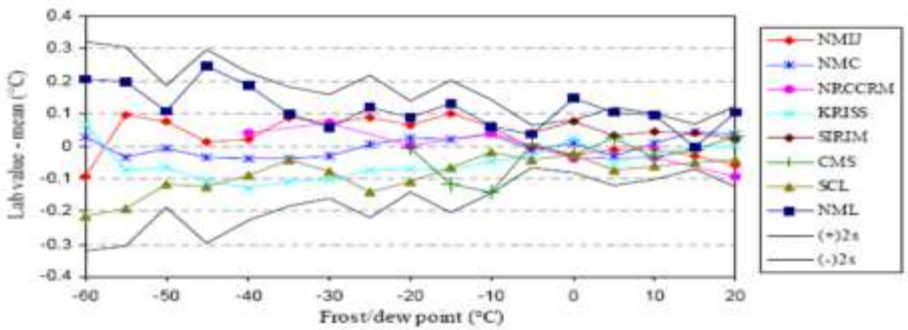
Primary Chilled Mirror Standard

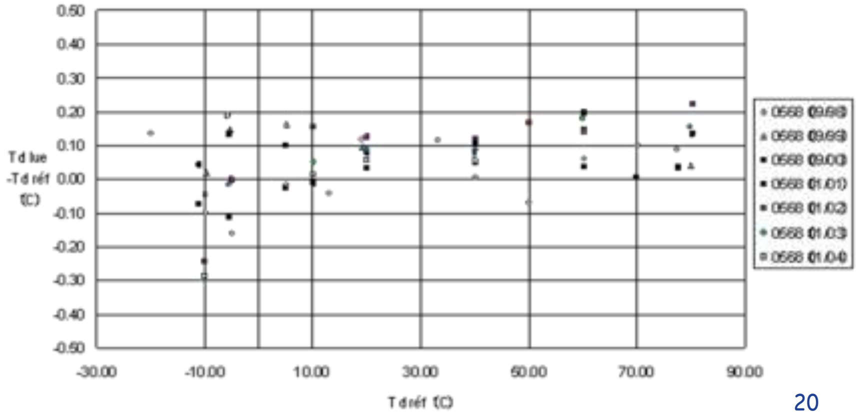
GE Sensing's Chilled Mirrors are calibrated at National Standards Laboratories such as NIST (USA), NPL (UK), AIST (Japan), CETIAT (France) etc.

They are used as "transfer standards" for the calibration of many types of humidity sensors and instruments.

This technology is noted for it's precision, long-term stability and repeatability







Automated Chilled Mirror Calibration System

Most of GE Sensing's chilled mirrors are calibrated in a completely automated process. An automated dew point generator and data acquisition system documents the performance of the units and provides NIST traceability.

Each unit under test (UUT) is referenced to a master chilled mirror which is directly traceable to NIST

Many of the instruments we service are 20+ years old

GE's Boston Center is Accredited to ISO/IEC-17025 By NVLAP

NVLAP® National Voluntary Laboratory Accreditation Program

CALIBRATION LABORATORIES

NVLAP LAB CODE 200803-0
Scope Revised: 2012-08-10

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

GE Sensing 1100 Technology Park Drive Billerica, MA 01821 Mr. Stephen Rehn Phone: 978-437-1000 Fax: 502-479-6722 E-mail: stephen.rehn@ge.com URL: www.gesensing.com	**Parameter(s) of Accreditation** Thermodynamic

CALIBRATION AND MEASUREMENT CAPABILITIES (CMC) Notes 1,2

Measured Parameter or Device Calibrated	Range	Uncertainty (k=2) Note 3	Remarks
THERMODYNAMIC			
NVLAP Code: 20/T02 **HUMIDITY** Humidity Generation			
Relative Humidity	24 % to 86 % RH	1.1 % RH	Generated in RH chamber at 25 °C
Dew/Frost Point Temperature	-80 °C to 20 °C	0.15 °C	
NVLAP Code: 20/T05 **PRESSURE** Pneumatic Pressure by Comparison to Piston Gage	-100 kPa to -1.38 kPa	0.0020 % (not less than 0.07 Pa)	Gage Mode
	1.38 kPa to 689 kPa	0.0020 % (not less than 0.07 Pa)	
	689 kPa to 7 MPa	0.0031%	
	7 MPa to 21 MPa	0.0033%	
	1.38 kPa to 689 kPa	0.0020 % (not less than 1.35 Pa)	Absolute Mode
	689 kPa to 7 MPa	0.0031%	
Pneumatic Pressure by Comparison to Precision Transducer	-100 kPa to 0 kPa	0.0075 % (not less than 3.45 Pa)	Gauge Mode
	0 kPa to 2 MPa	0.0075 % (not less than 3.45 Pa)	Gage or Absolute Mode

2012-04-01 through 2013-03-31
Effective dates

For the National Institute of Standards and Technology

Page 1 of 2

NVLAP-02S (REV. 2011-08-18)

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 200803-0

GE Sensing
Billerica, MA

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

CALIBRATION LABORATORIES

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated January 2009).

2012-04-01 through 2013-03-31
Effective dates

David F. Alderman
For the National Institute of Standards and Technology

NVLAP-01C (REV. 2009-01-28)

Parameter	Range	Uncertainty (95% Confidence)
Relative Humidity	24-86% RH	1.1% RH
Dew/Frost Point	-80 to +20°C Td	0.15°C Td

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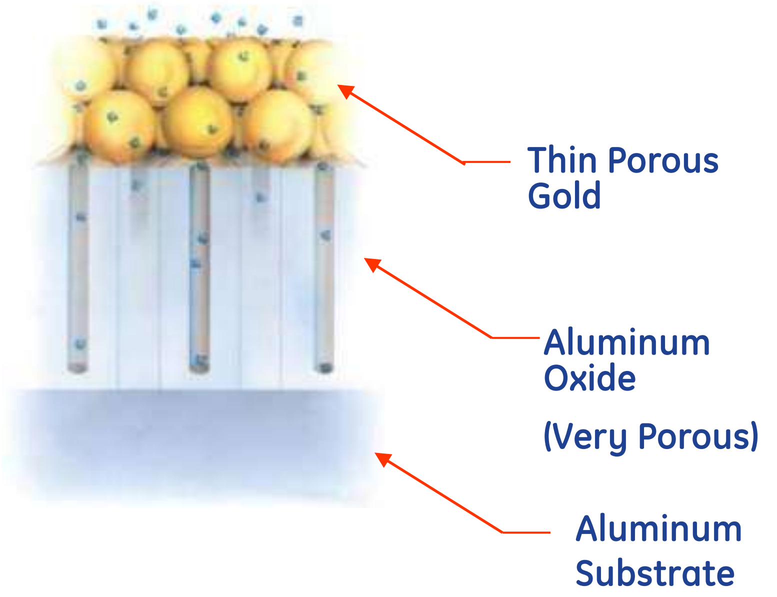
Aluminum Oxide – Trace Humidity Sensors



Range: -110°C frost point to +20°C Dew Point (parts per billion to parts per thousand)

The oxide layer is porous and under dry conditions the pores are filled with air or gas with a low dielectric (air and N_2 are ≈ 1)

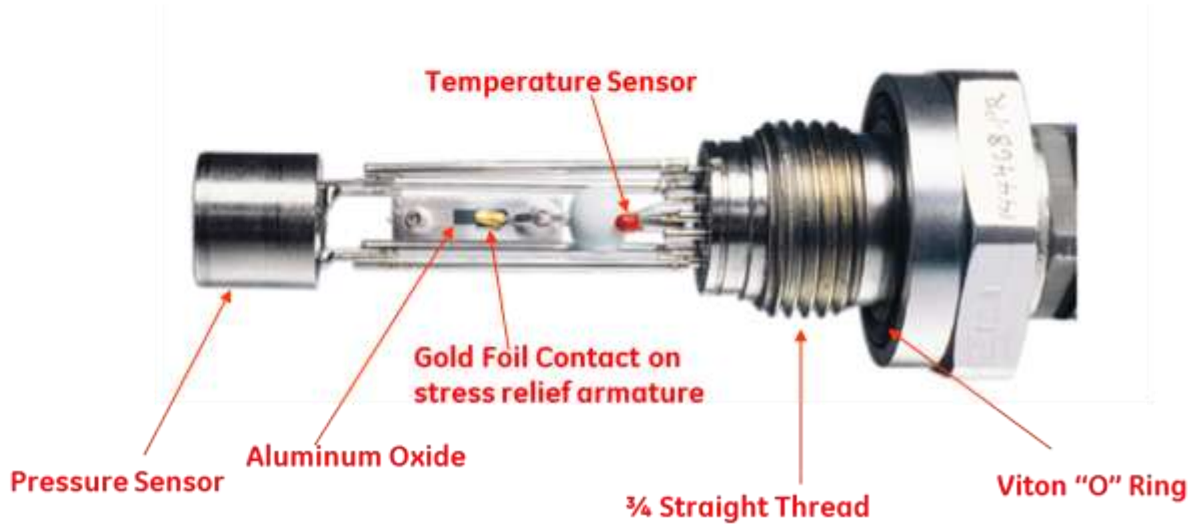
Water has a dielectric constant of approximately ≈ 80

When exposed to water, microcondensation occurs in the pores increasing the capacitance between the substrate and upper electrode.

The sensor's impedance is calibrated against a dew point reference standard

Aluminum Oxide sensors are also be used to measure trace moisture in organic (non-polar) and non-miscible liquids.

Panametrics Al_2O_3 Sensor

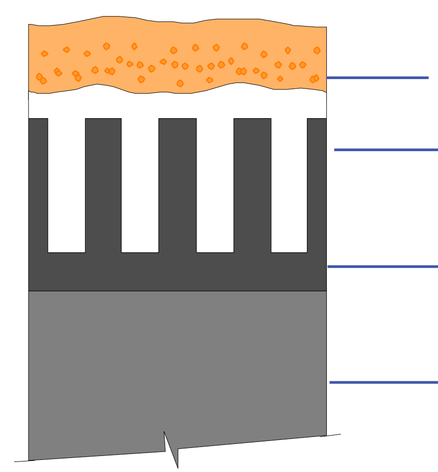


Water vapor rapidly transports through the gold layer and equilibrates to the pore walls of the aluminum oxide layer.

The number of water molecules adsorbed onto the pore walls determines the conductivity of the pore wall.

The sensor is calibrated by measuring the "impedance" (MH or FH Values) against a dew/frost point standard at multiple points.

Each sensor is calibrated a minimum of 2 times



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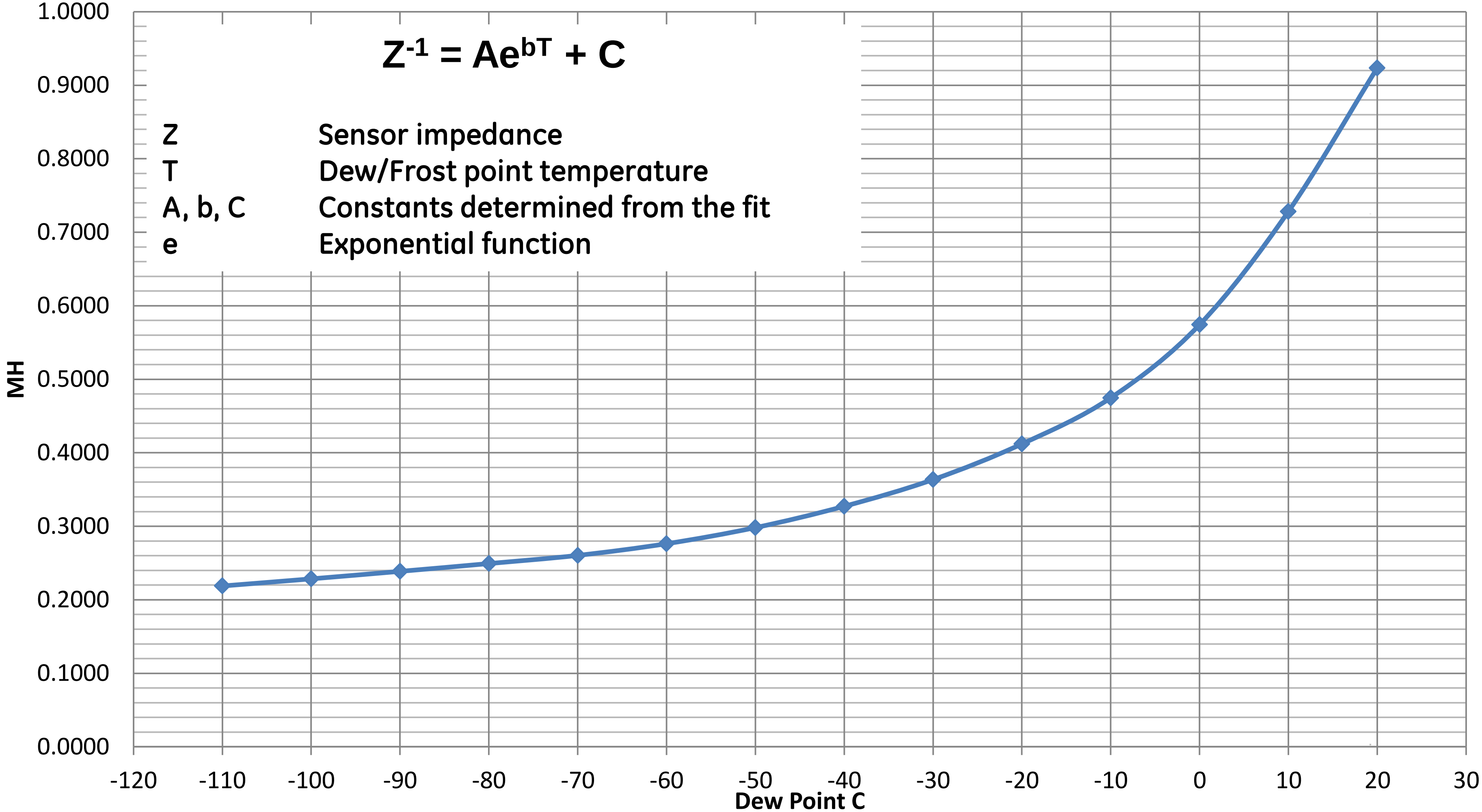
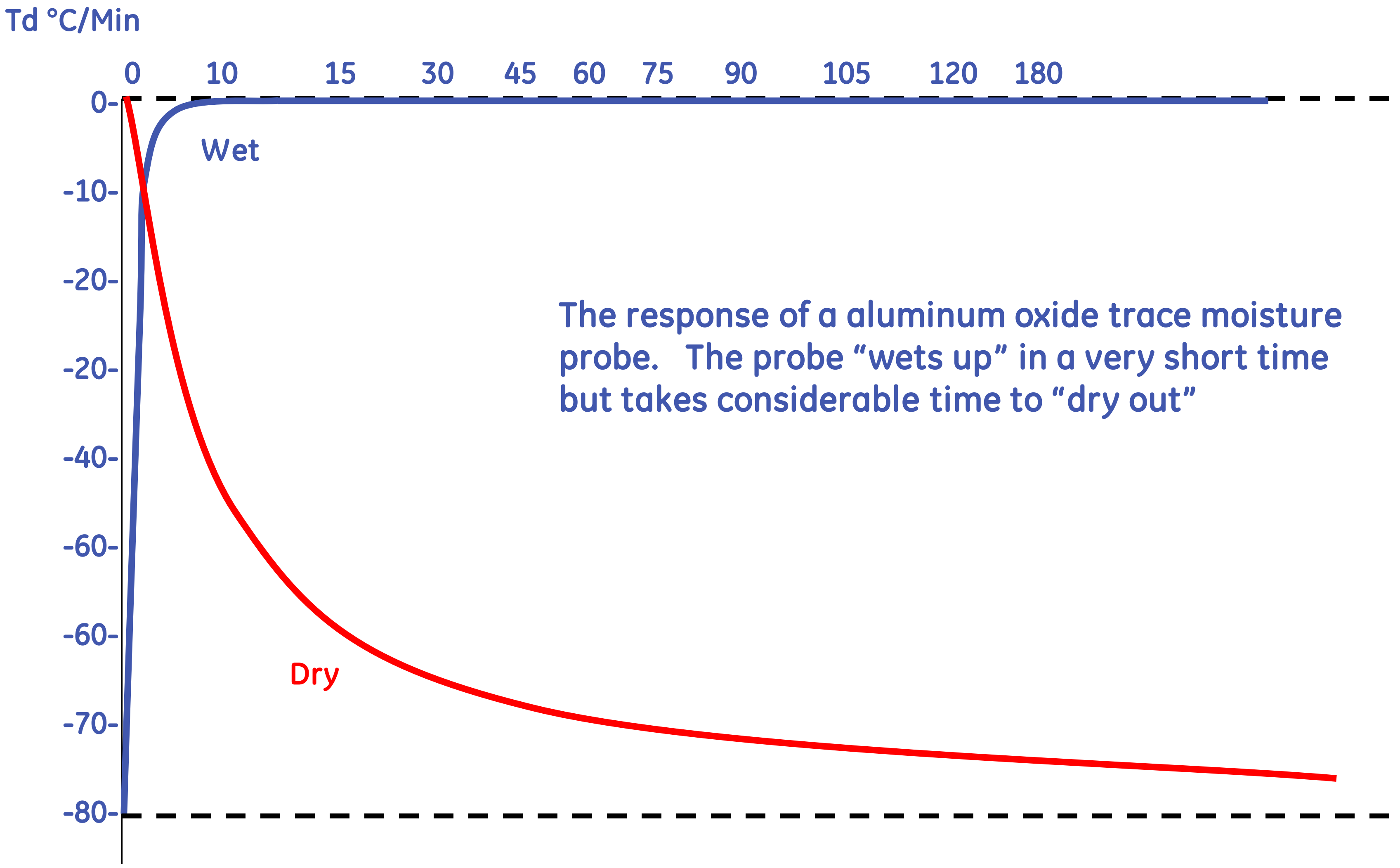
Calibration Curve for AlOx Sensors



"MH" is a function of the sensor's "impedance" at a specific excitation voltage & frequency

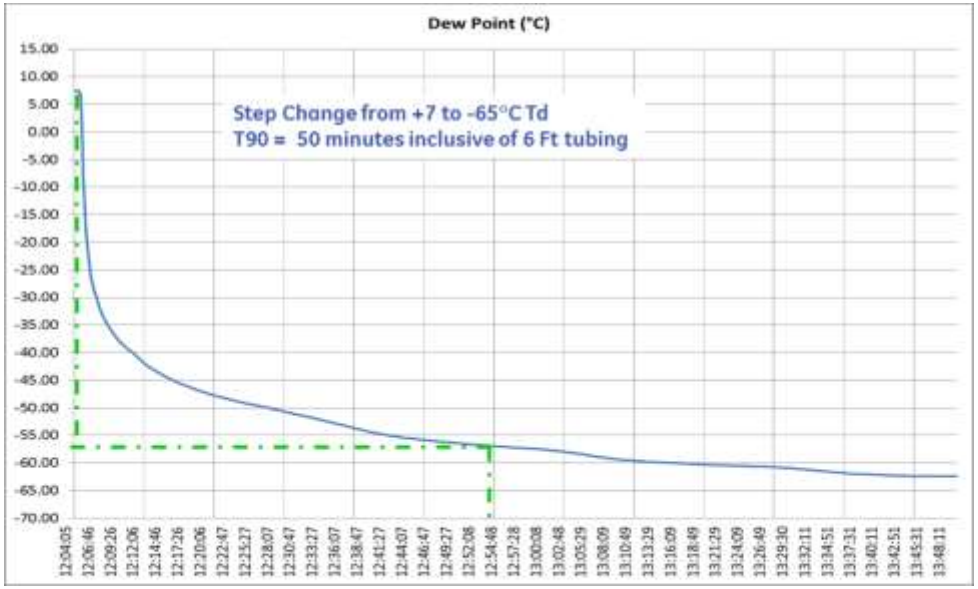
The calibration process is automated and traceable to NIST or other national standards.

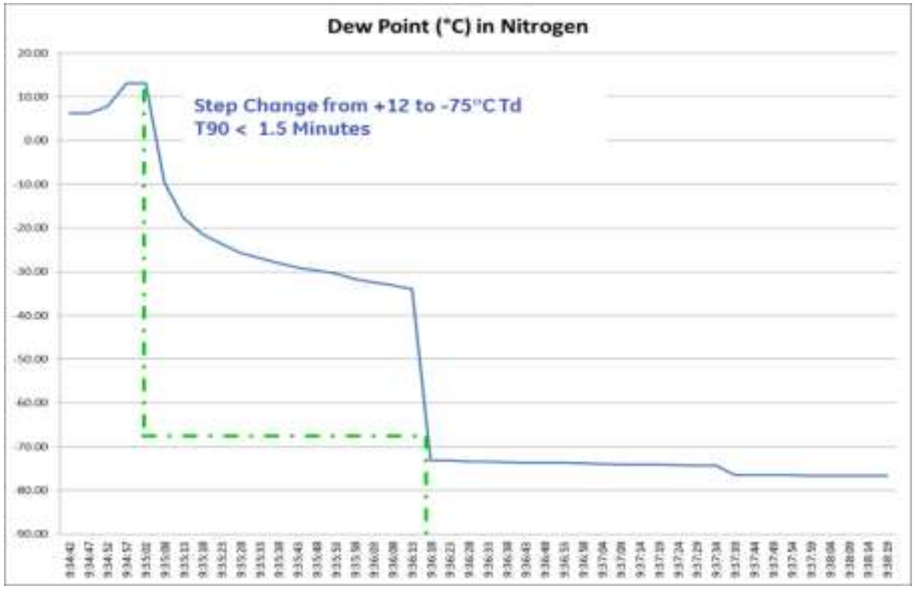
Response of Aluminum Oxide Trace Moisture Sensors



The response of a aluminum oxide trace moisture probe. The probe “wets up” in a very short time but takes considerable time to “dry out”

CER – Enhanced Response



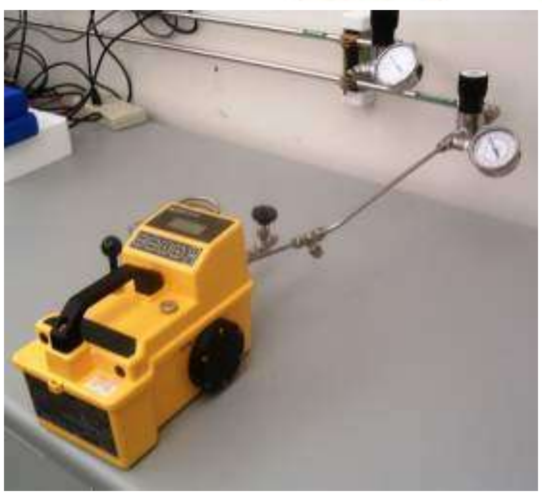


By measuring the rate of change (slope) the instrument is effectively able to "predict" moisture content faster than by conventional means.

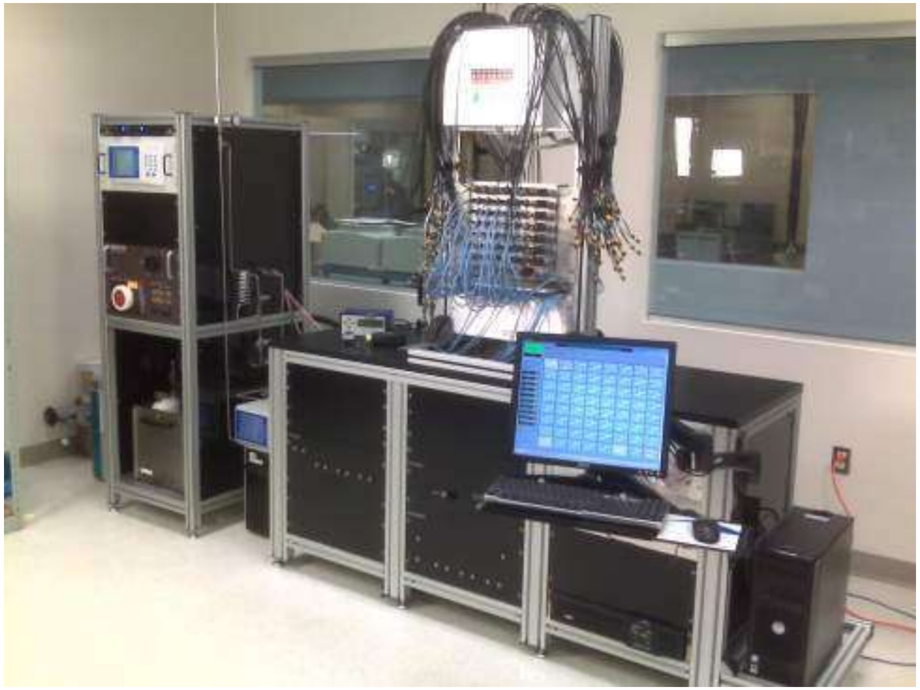
In the example above the a 90% step change from from ambient humidity to <1 ppmv was improved from 50 minutes to <1.5 minutes.

CER is useful when you have a large ΔTd

GE Sensing Trace Moisture Instruments



Low Frost Point Calibration for Aluminum Oxide Sensors



Dry nitrogen is mixed in precise proportions with nitrogen saturated with water vapor to produce test gas at stable dew/frost points. Mass flow controllers are used to control precise volumetric mixing ratios.

A chilled mirror functions as the reference standard to -80°C Td (500 ppbv)

The system is fully automated and utilizes Labview to control the system, collect data and produce calibration reports.

The system is used at GE's global moisture calibration centers

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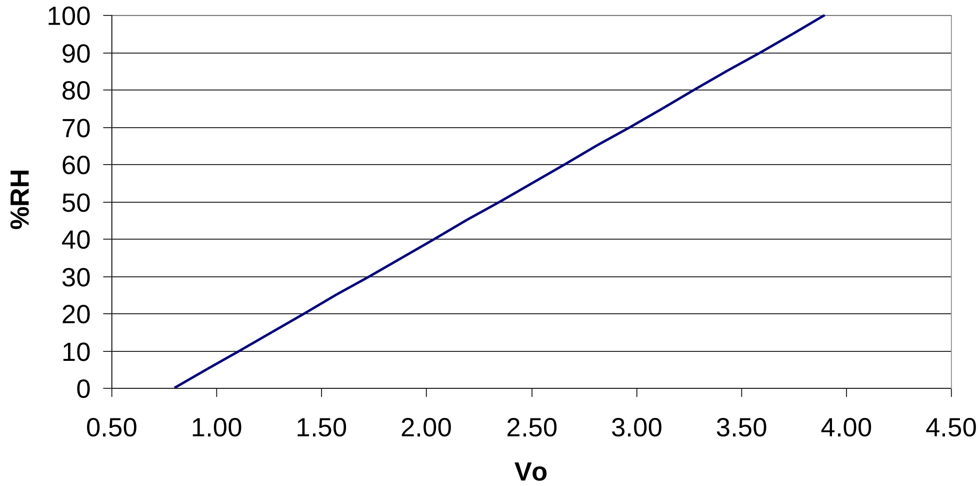
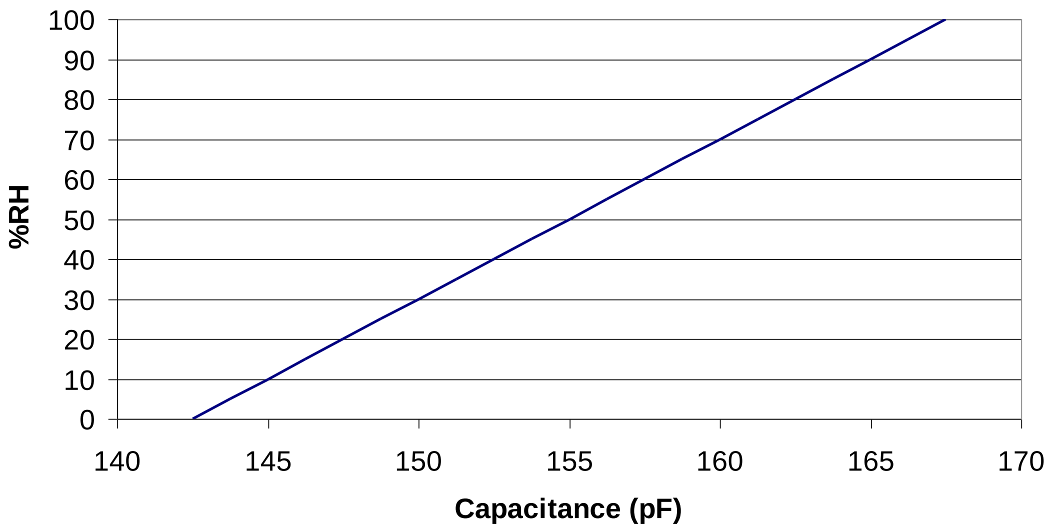
Polymer Capacitive Humidity Sensors for Industrial Instruments



MMR-31 & MDR-3

Proprietary capacitive polymer %RH sensor. TO type can houses %RH & Temperature Sensor (RTD) sensors. CMOS signal conditioning circuit provides voltage output. Equipped with sintered metal filter.



MMR-101

High Temperature proprietary capacitive polymer %RH Sensor. Passive element has separate signal conditioning circuit & temperature sensor.

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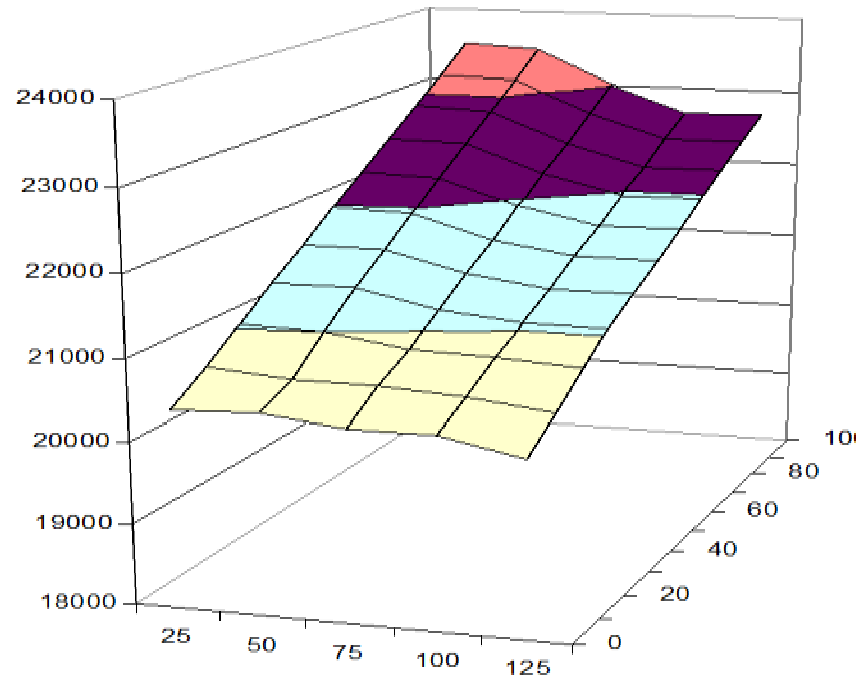
Industrial Humidity Calibration System



A Two-Pressure generator is used to produce the target relative humidity.

The chamber is monitored with a chilled mirror hygrometer (standard)

For lower temperature instruments a two point calibration is performed and those instruments use a temperature compensation formula

For high temperature applications the transmitters are calibrated at five humidity values at three exclusive temperatures and the data matrix stored in the instruments memory as a look up table.

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Industrial Humidity Transmitters



- Commercial Refrigeration
- Food Processing
- Clean Rooms
- Process Drying
- Paper & Pulp
- Nuclear Plants
- Blast Furnace
- Coal Gasification

- Thin-film polymer capacitive humidity sensor and RTD. Microprocessor based signal conditioner. Stores calibration data for sensor.
- Transmitters and Analyzers with remote probes – Programmable 4-20mA Signals – Local Display
- May be programmed for: Relative Humidity, Dew Point, Mass/Vol, Vol/Vol, Mass/Mass
- Ability to measure up to 150°C
- Stainless steel insertion probes
- Explosion Proof rating

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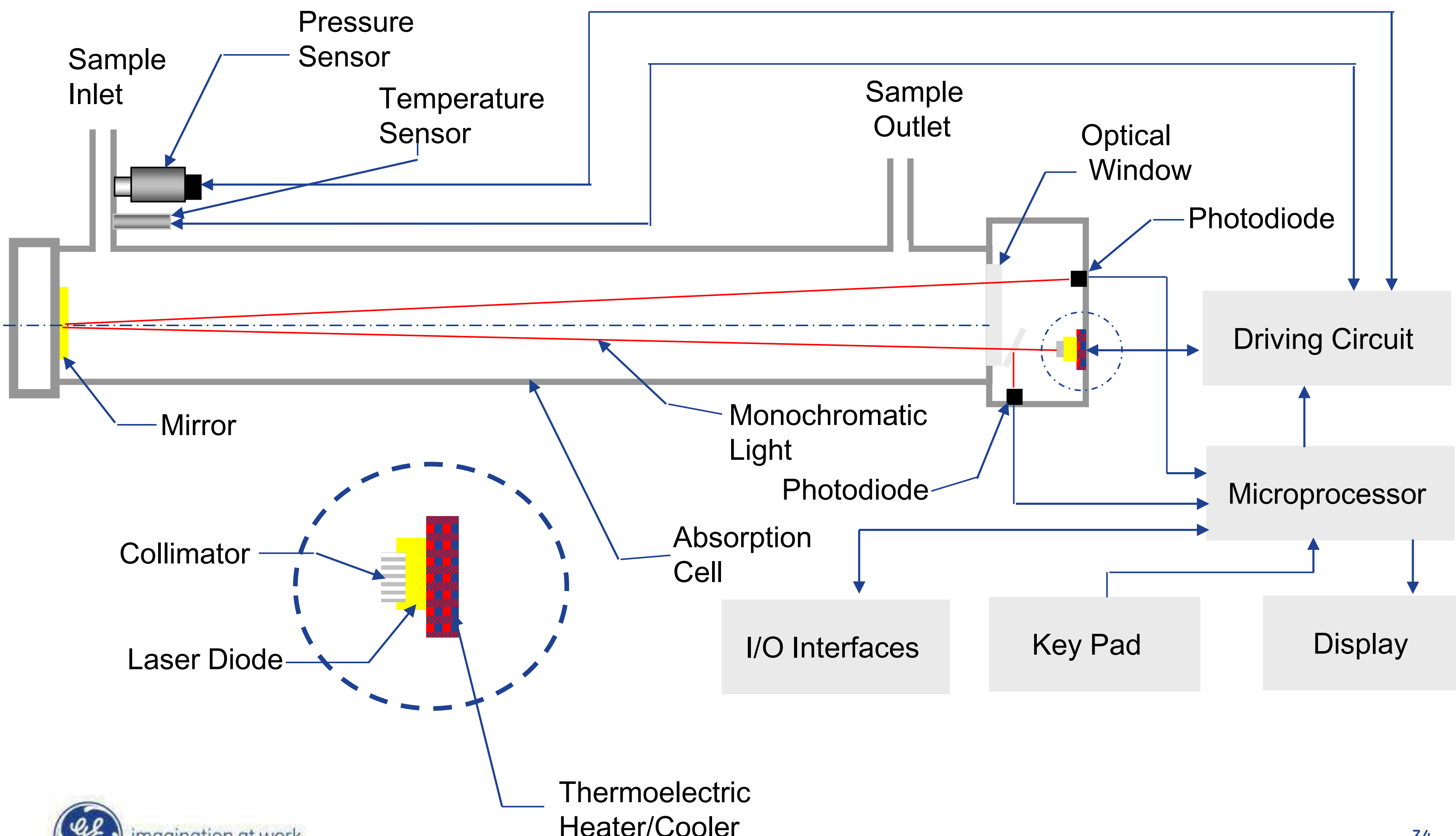
Aurora TDLAS Hygrometer

- Designed for Moisture in Natural Gas
- Tunable Diode Laser Absorption Spectroscopy
- Fast Response 2 second once absorption cell is purged
- NEC/CSA Class 1, Div 1 XP (ATEX Equivalent)
- Magnetic Induction Keypad – may be field programmed w/o “Hot Permit”
- Turnkey sampling system for natural gas
- (3) 4-20mA Signals, (2) RS-485/232 with Modbus protocol
- Supplied with software for remote data acquisition, trend graphing, alarms and spectral scans

GE Aurora TDLAS Moisture Analyzer Schematic



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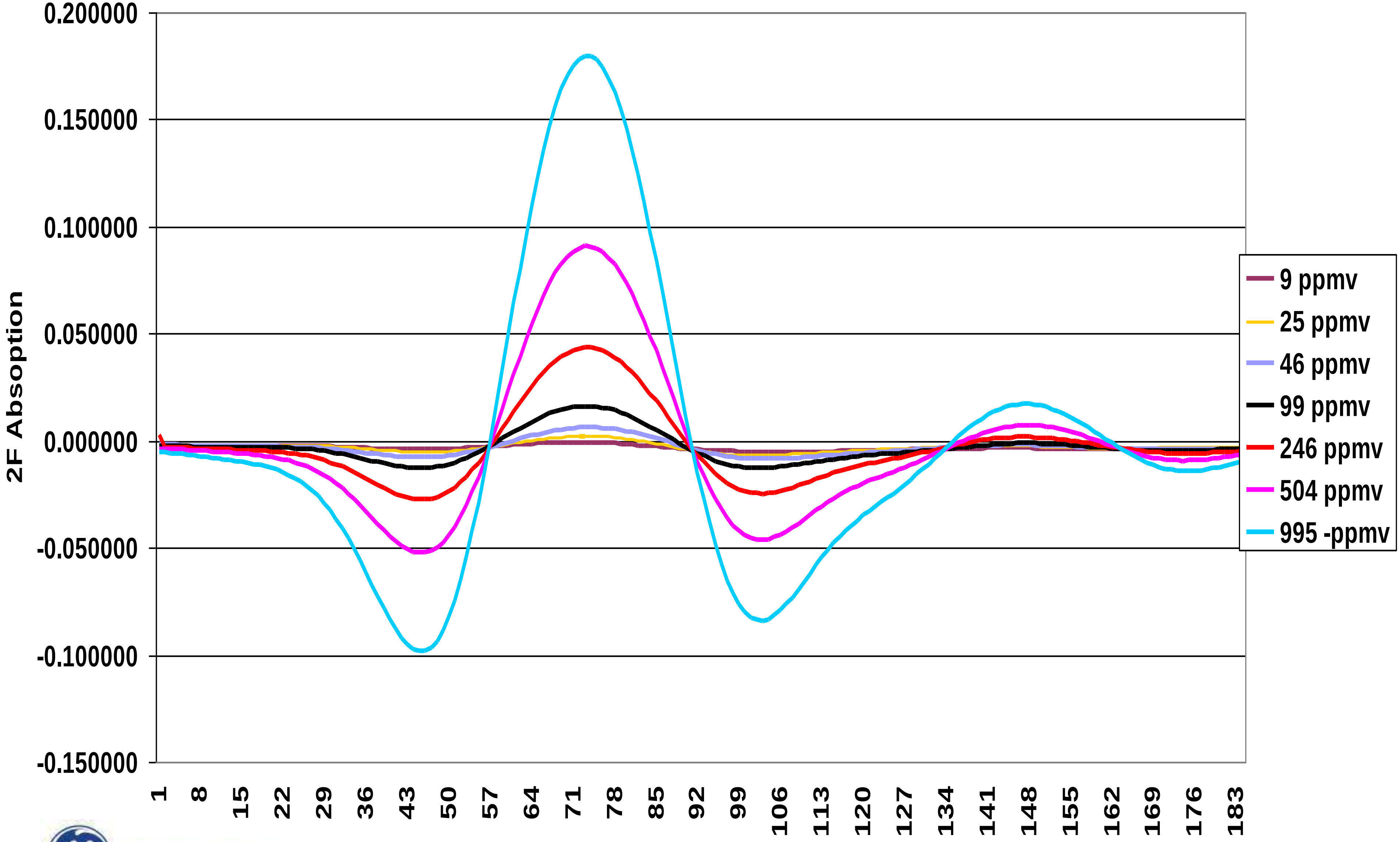
2F Absorption at Various Concentrations of Water



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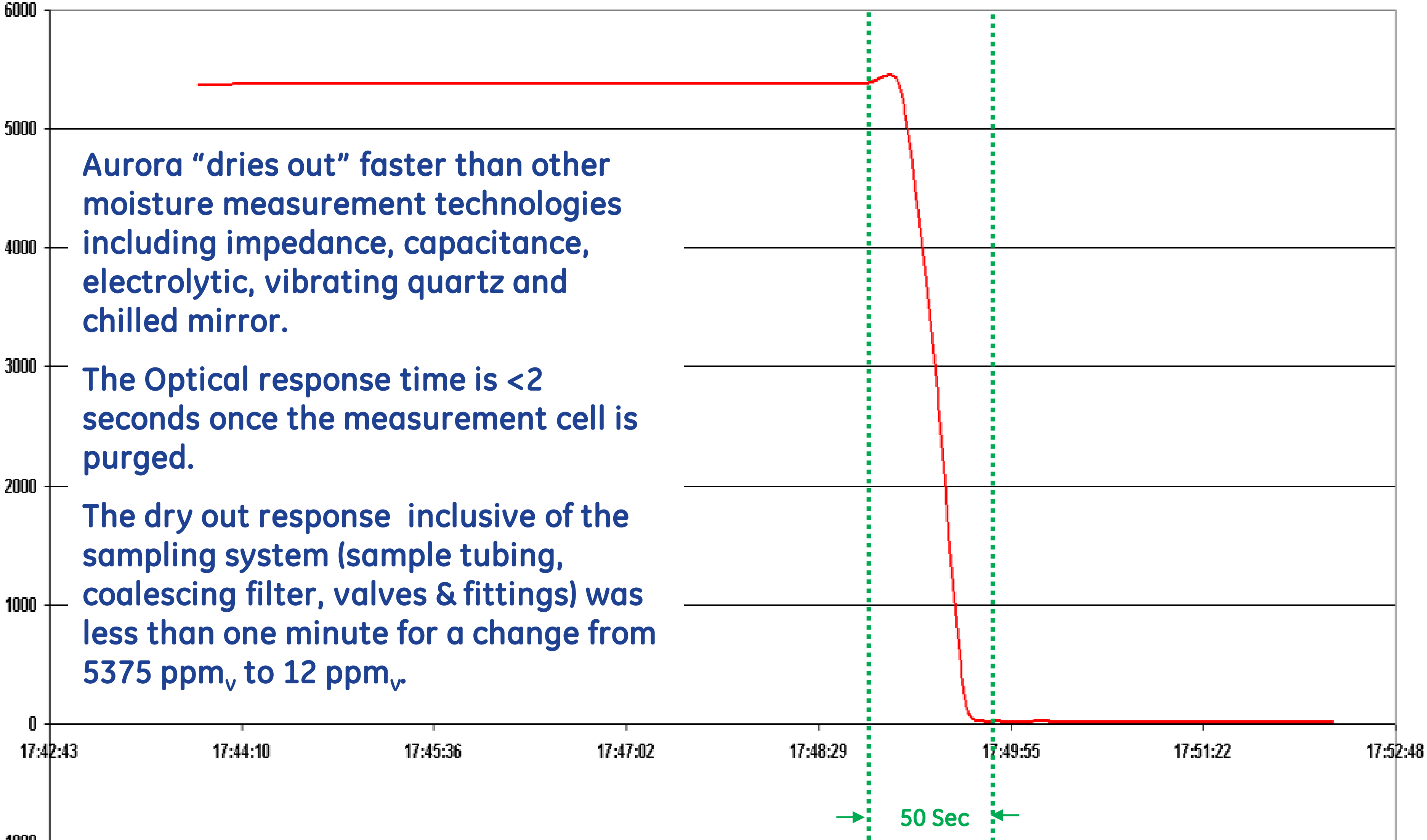
System Response Time of Aurora - Dry Down

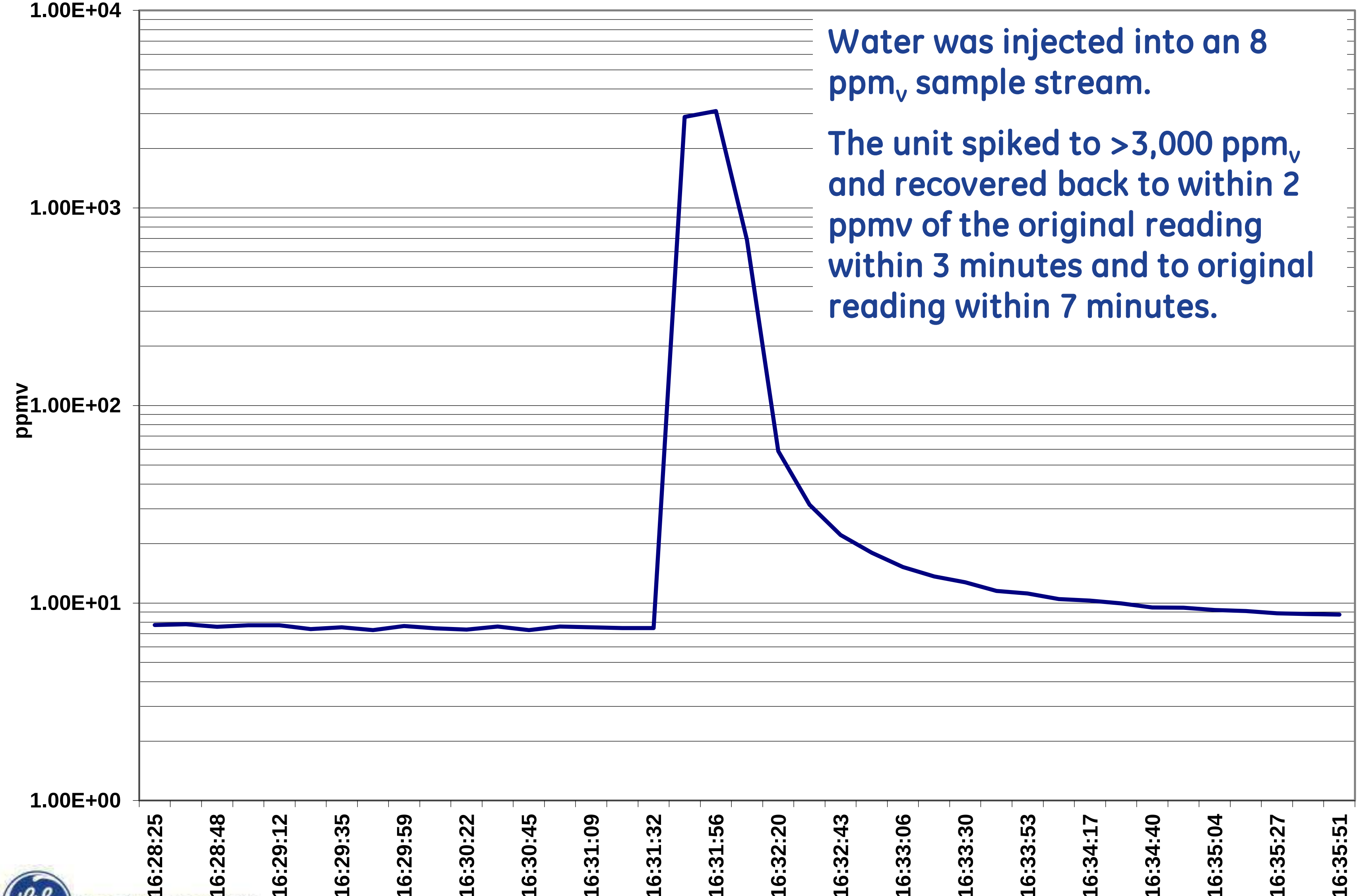
Aurora "dries out" faster than other moisture measurement technologies including impedance, capacitance, electrolytic, vibrating quartz and chilled mirror.

The Optical response time is <2 seconds once the measurement cell is purged.

The dry out response inclusive of the sampling system (sample tubing, coalescing filter, valves & fittings) was less than one minute for a change from 5375 ppm_v to 12 ppm_v.



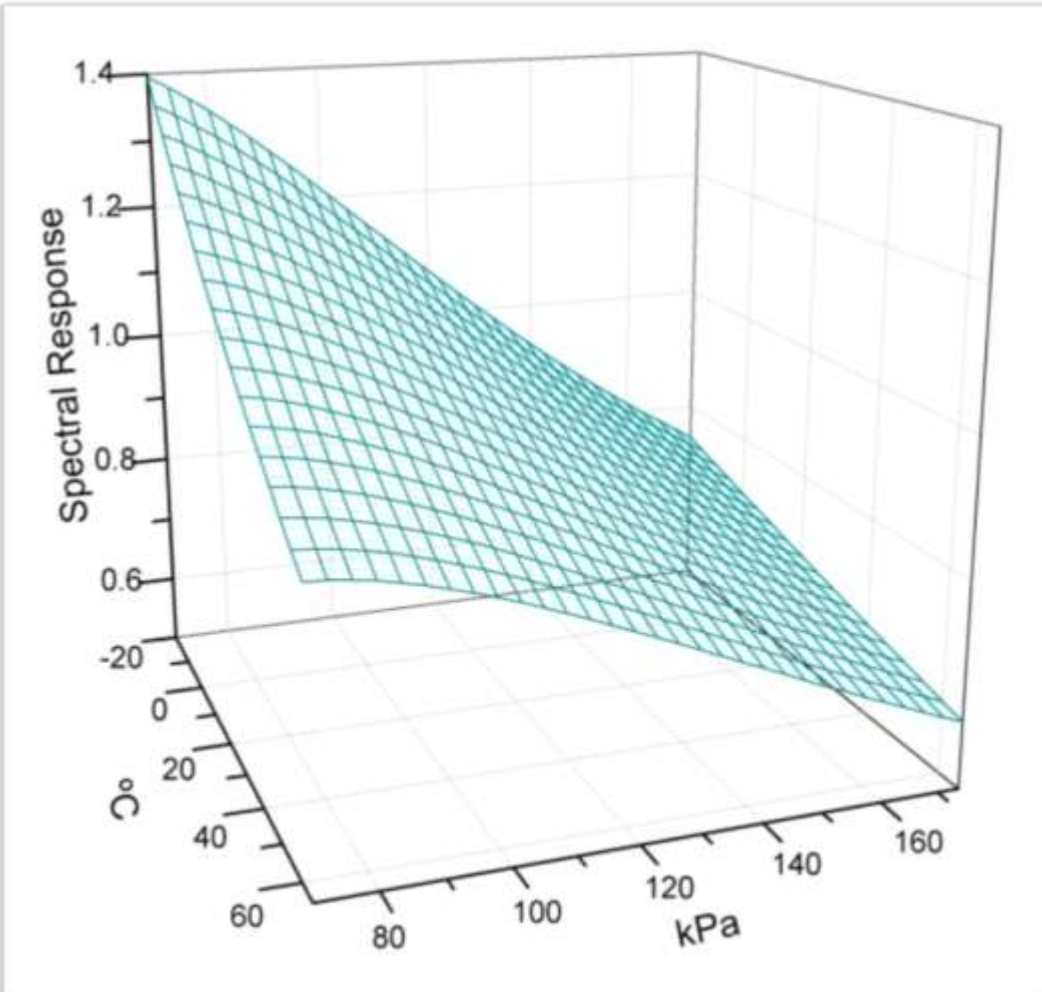
Aurora Recovery From Process Upset



Water was injected into an 8 ppm_v sample stream.

The unit spiked to >3,000 ppm_v and recovered back to within 2 ppmv of the original reading within 3 minutes and to original reading within 7 minutes.

Pressure & Temperature Compensation



At constant water concentration and increase in pressure and temperature reduces the 2F absorption peak.

This is due to more interactions between water as well other molecules in the carrier gas (collision broadening)

By varying the pressure and temperature calibration data can be stored in the analyzer's memory and used for compensation

(US Patent 7,943,915 *Method of Calibrating a Wavelength – Modulation Spectroscopy Apparatus)*

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Aurora-Trace Features

- HDLAS – High Definition Laser Absorption Spectroscopy
- Measurement Range: 0-400 ppm_v calibrated & 400-1000 ppm_v trending.
- Accuracy: ±2% or ±50 ppb_v includes linearity, hysteresis and repeatability.
- Utilizes many of the same design features of the Aurora-H20
- cFMus Class 1 Div1 certification for the USA & Canada, ATEX & IEC Ex for Europe and other global localities
- Three Programmable 4-20mA signals.
- (2) RS-232/485 digital interface ports with Modbus RTU
- Optional Ethernet TCP/IP or Foundation Fieldbus
- AuroraView – Utility software for remote set up, trend graphing & diagnostics
- Optional calibration system – may be programmed to run on demand

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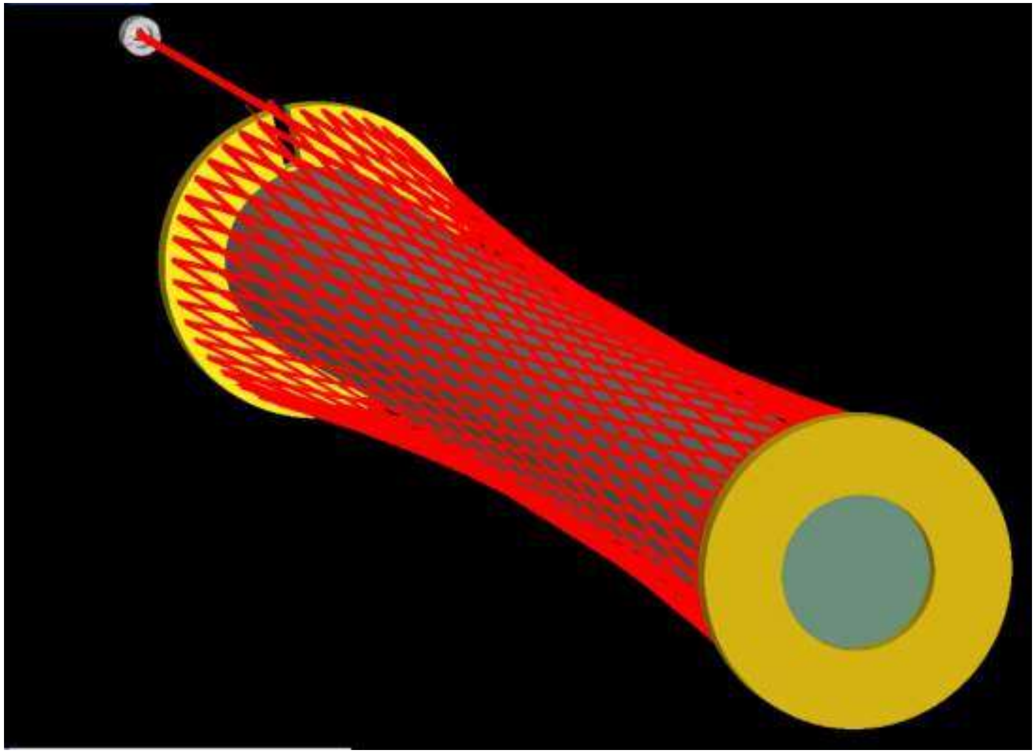
Multi-Pass Absorption Cell



- In order to measure trace levels of moisture (<5 ppmv) a long path length is required. In the Aurora Trace the path-length is 30 meters vs. 1 meter for Aurora H2O resulting in 30X the sensitivity.
- This is achieved in the Aurora Trace by using a “multi pass optical cell”. The cell utilizes specially curved mirrors to bounce the laser light back & forth

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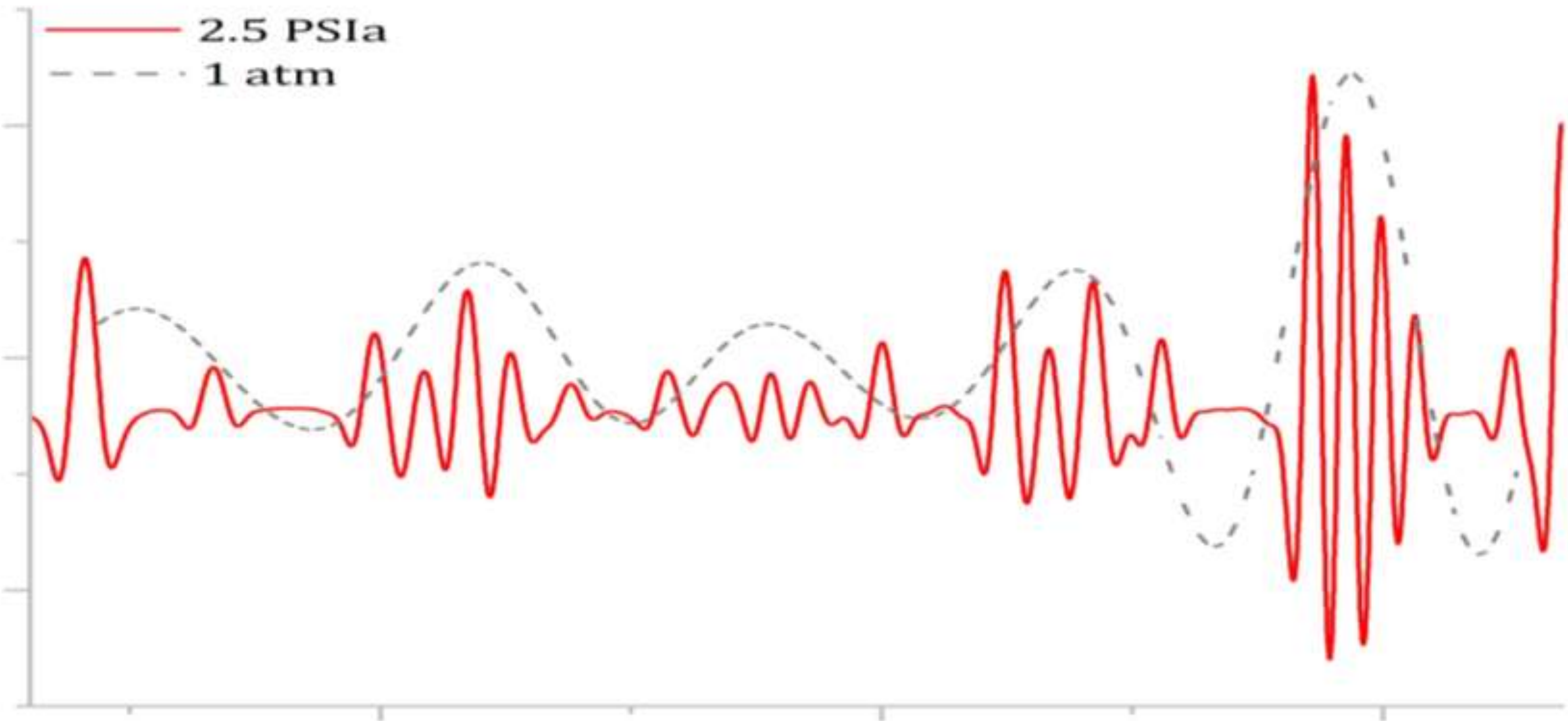
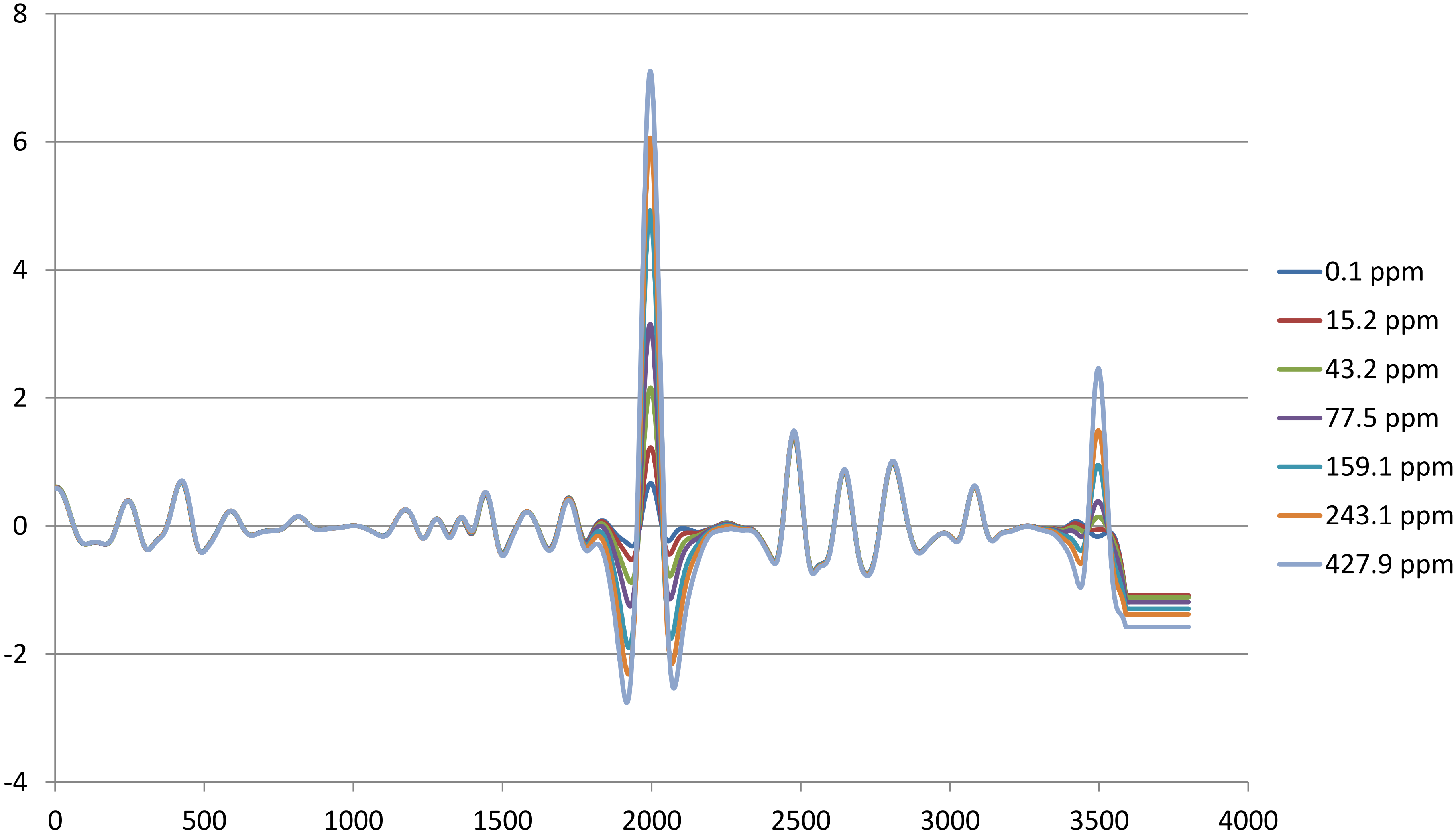
Spectrum of 5 PPMv H_20 in Methane – Vacuum vs Atmospheric Pressure



By applying a vacuum, better resolution is achieved than at atmospheric pressure. Absorption peaks are seen that were formerly "masked" by methane & other hydrocarbons

Spectrum of H2O in Methane at Various Concentrations



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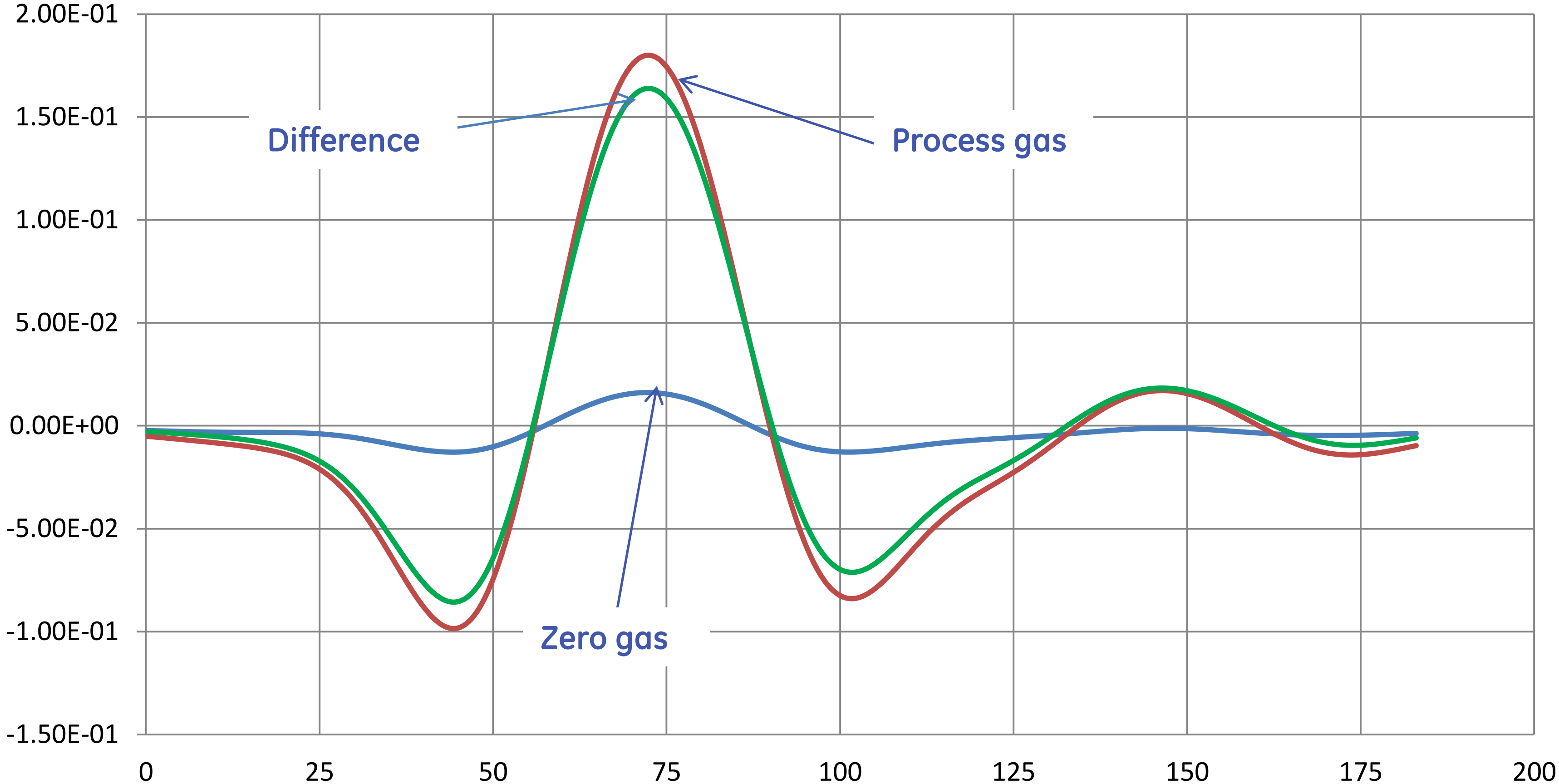
Differential Spectroscopy



The differential method relies on the production of a "zero gas". The zero gas signal is subtracted from the process gas signal. The small peak in the zero gas is due to co-absorbing background gases. This method relies on the production of zero gas from a finite purifier (an consumable component).

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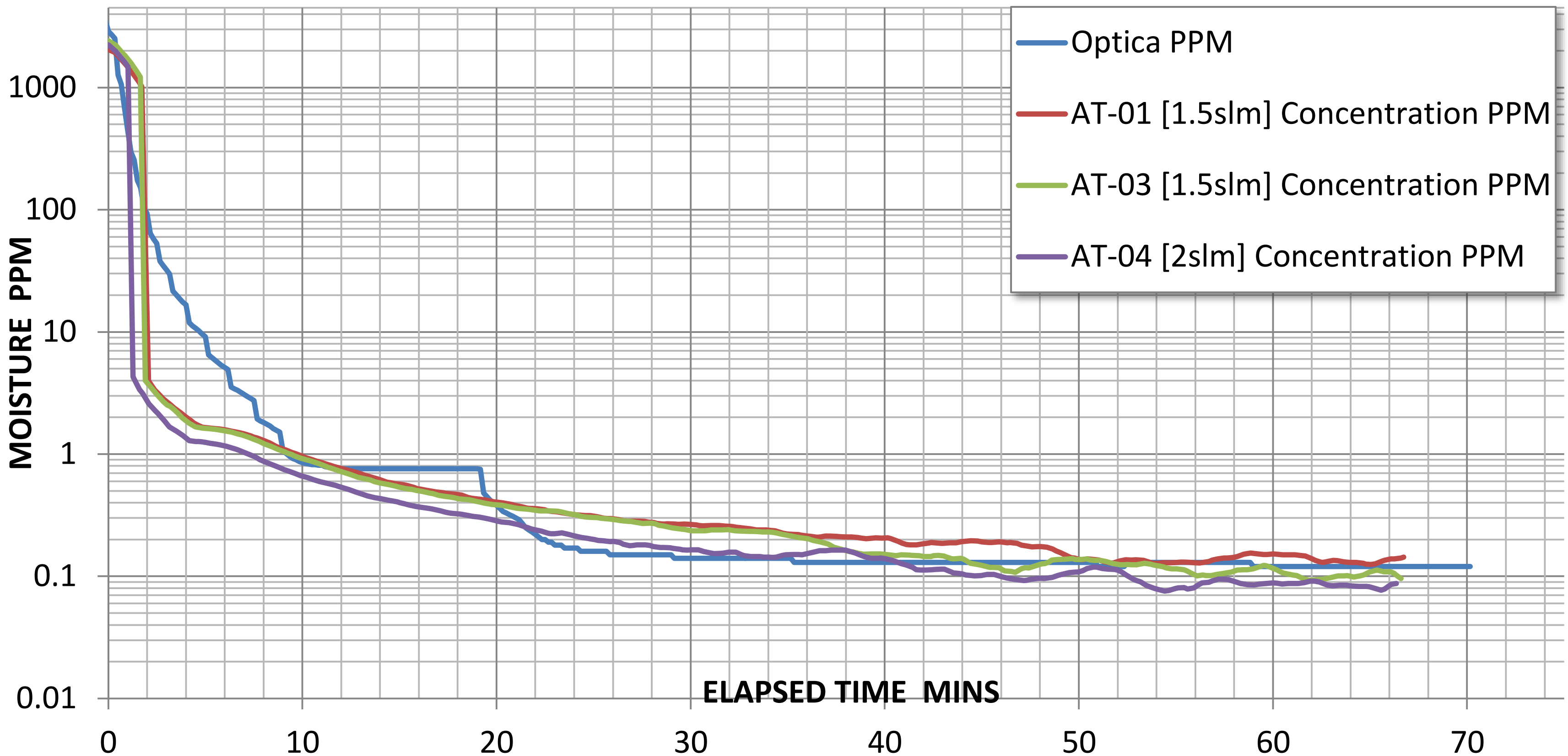
Response Time - Dry Down



Step change from 2500 ppmv to 0.1 ppmv

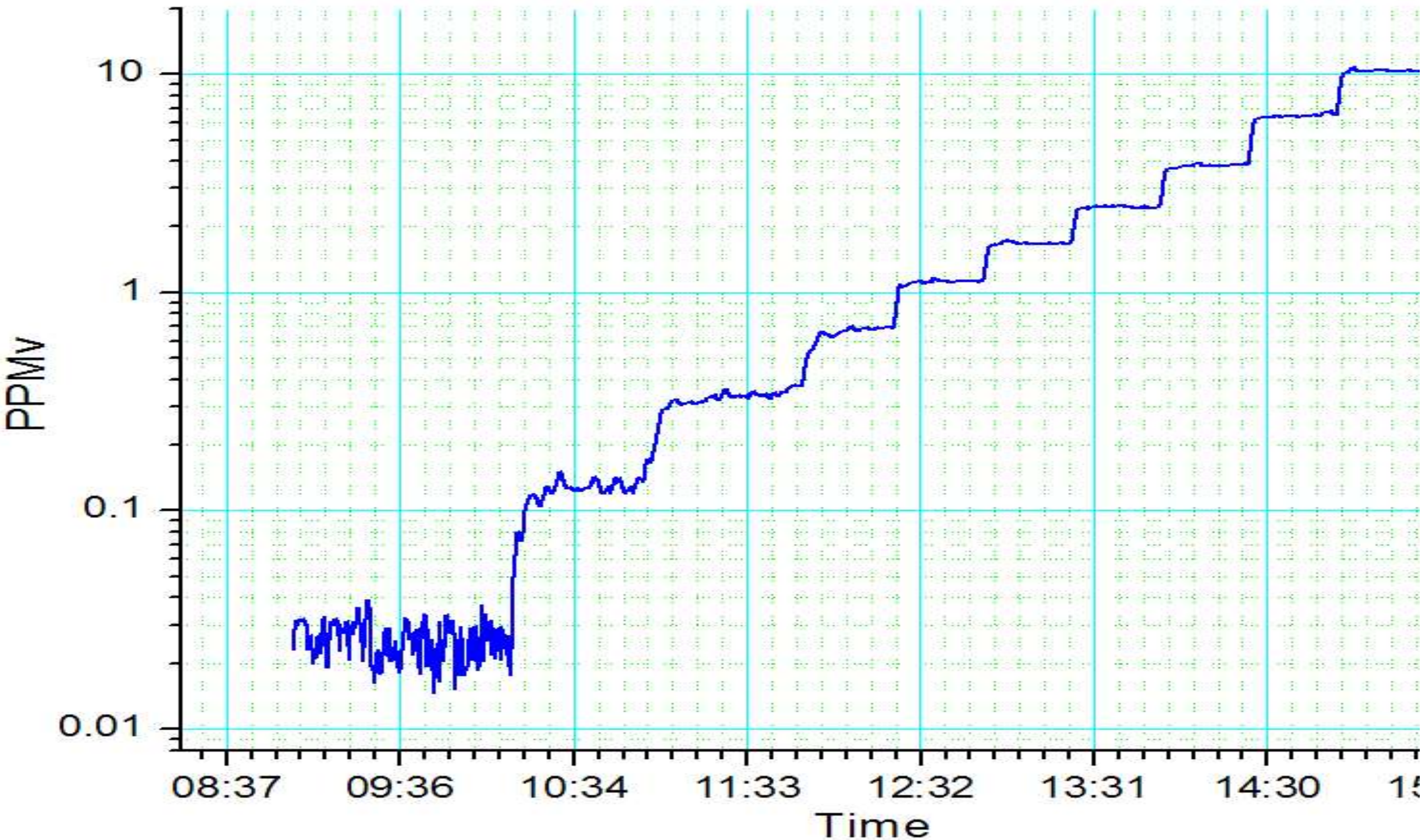
Optica = Chilled Mirror Reference AT-01, AT-02 & AT-03 are three test units

T_{90} < 2 min

Total Change ≈ 60 min

These are system response times inclusive of purging the sampling system

Aurora Trace – Step Change Response



Calibration System for Aurora TDLAS Hygrometer

A chilled mirror is used as the reference standard for calibrating laser based hygrometers used for continuous moisture measurement in natural gas.

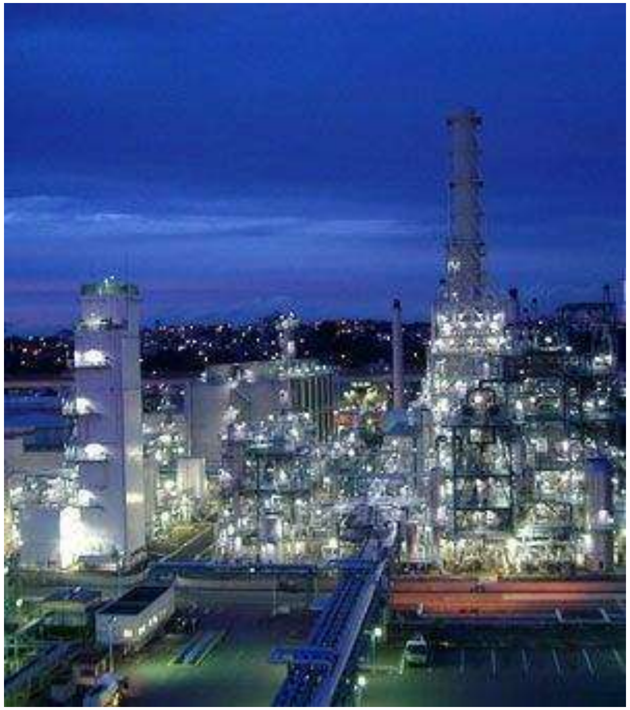
Up to 6 units are calibrated simultaneously. The units are first calibrated using nitrogen as the carrier gas then methane

The system is automated using Labview to control a two-pressure/two temperature frost point generator and to collect the raw data from each unit.

The data is also archived in an enterprise server.

Applications

Refinery & Petrochemical Processing & Feedstocks



- Moisture even in trace amounts is a contaminant in organic chemical feed stocks
- Oil Refineries: Trace moisture measurement in H_2 recycle, cat cracking (CCR), ethlyene production, alkylation, isomerization, etc
- Ethylene & Polyethylene production
- Engineered sensors and sampling systems provide turnkey online monitoring

Sampling Systems for Liquids

Hazardous Area

Feedstock 1

Aluminum Oxide Sensors may be used for hydrocarbon liquids or gases

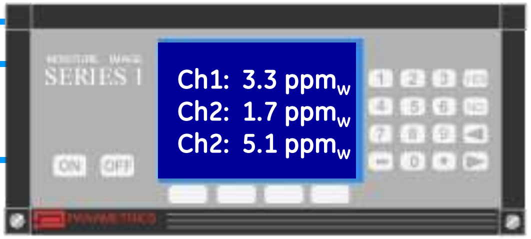
Feedstock 2

Other analyzers such as electrolytic and quartz are for gas only… liquids have to be vaporized

Feedstock 3

Built –In IS Barrier

Safe Zone



- GE Sensing offers a Complete Solution for moisture monitoring in petrochemical liquid feedstocks
- Sensor + Sampling System + Muliti-Channel Analyzer (up to 6 Moisture Probes) + optional pressure, temperature & oxygen
- For determine ppm_w (parts per million by weight) in liquid feed stock, the solubility data for each liquid is programmed into the analyzer
- Hot liquids are cooled to the operating range of the sensor by a "liquid to liquid" heat exchanger (stainless steel tube in copper tube)
- For gases typically dew point or ppm_v or is the measurement of choice

Air Separation

Composition of Dry Air	
Gas	% Volume
Nitrogen	78.08
Oxygen	20.95
Argon	0.93
Carbon Dioxide	0.031
Neon	0.002
Helium	0.0005
Methane	0.000015
Sulfur Dioxide	0.0001
Hydrogen	0.00005
Other Noble Gases	0.0002
Total	99.993865

Air separation plants use compression and cooling to liquefy air and "boil off" the various components to separate them. The requirement is often for very pure gases.

Moisture is a contaminant in pure gases

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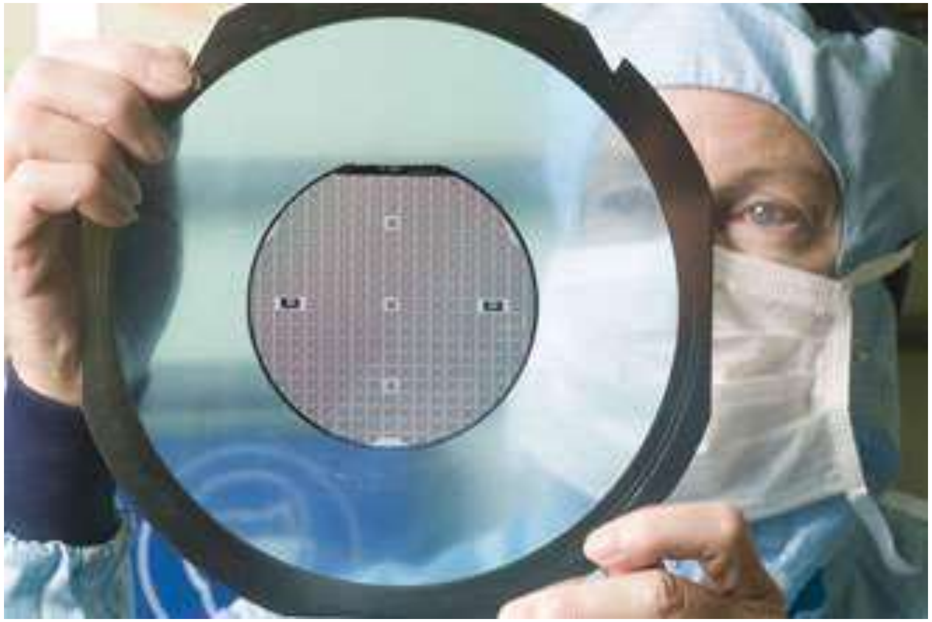
Semiconductor and Electronic



- PPB levels for Process Carrier Gases
- Clean Rooms
- Product Testing
- Environmental Chambers
- HALT/HASS Testing
- Fiber Optic Splicing
- CRT/Plasma Screen Coating

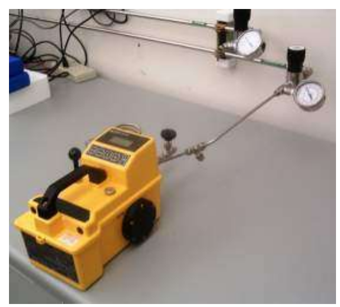
Natural Gas

- Maximum water for Natural Gas in USA content for USA is 7lbs/MMSCF (approximately -38°C frost point)
- Custody Transfer and Contractual Specifications
- Water in NG = corrosion, costs more to transport in pipelines
- Eliminate ice & methane-hydrates
- Moisture in LNG (Liquefied Natural Gas) processing
- Compressor stations
- Calibration Systems

Power Generation

- Gas Turbines – Power Augmentation, Anti-Icing, Emissions Controls
- Fuel Quality for Gas Turbines
- Hydrogen Cooled Generators
- Weather Telemetry
- Oil Filled Transformers
- SF_6 Switchgear
- Nuclear Containment Testing
- Calibration Labs

Pharmaceutical Process Control & Testing



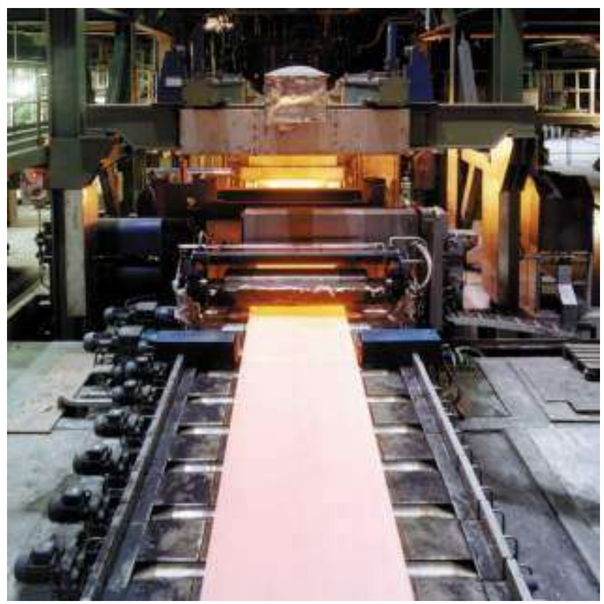
- Tablet Coating
- ETO Sterilization,
- Gel Caps
- Mixing
- Compounding,
- Fluid Bed Processors
- Freeze Drying
- Inerting
- Storage
- Product Testing
- Facility Monitoring
- Validation Chambers
- Medical Compressed Air

Compressed Air

- Instrument Air
- Breathing Air
- Painting & Coating
- Robotics
- Pneumatic Tools
- Packaging
- Airveying
- Inerting
- Testing & Verification of Drying Systems

Metals Processing & Heat Treating

- Blast Furnaces
- Atmosphere Controlled Furnaces
- Annealing
- Sintering
- Carburization,
- Welding (Shield Gas)
- Nitriding & Carbonitriding
- Galvanization
- Brazing



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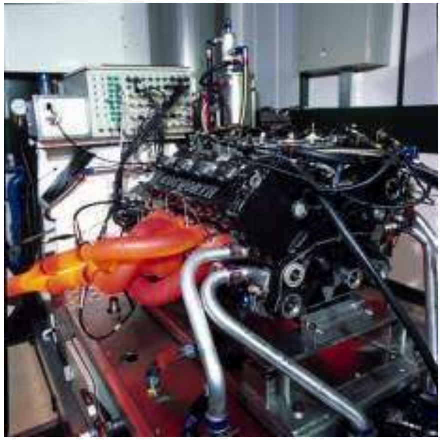
Plastics Manufacturing

- Blow Molding
- Injection Molding
- Composites
- Sufficiently drying many plastic resins prevents bubbles, splay and increased scrap rates

Automotive & Engine Power & Emissions Testing



- Inlet Combustion Mass Ratio
- Dynamometers
- Wind Tunnels
- Automotive
- Aerospace
- Marine
- Diesel
- Fuel Cells
- Climatic Chambers
- Gas Turbine Wet Compression
- Deicing & Ice Prevention

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Aerospace

- Engine Testing
- Avionics
- Antennas & Waveguides
- Deicing & Ice Prevention
- Rocket Fuel Purge
- Aerospace HVAC

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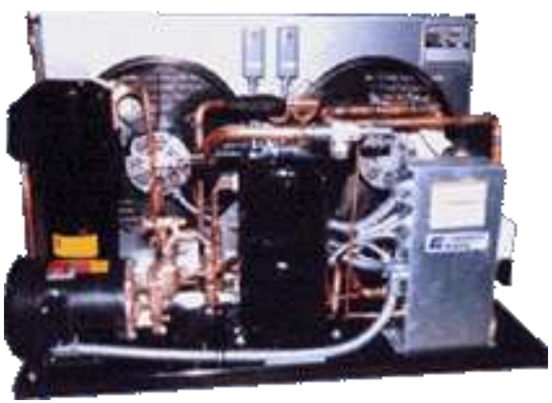
Refrigeration, Heat Exchanger & HVAC Component Testing

The performance of refrigeration and air-conditioning components used for residential, commercial, automotive and industrial systems is validated and tested by GE Sensing's chilled mirror analyzers



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Environmental Test Chambers

- Electronic components
- Building Materials
- Clothing
- HASS & HALT
- Incubators
- Plant Growth
- Pharmaceutical Validation
- Refrigeration Systems
- Sample Preconditioning for fire & smoke testing

Sampling Systems

Sampling systems are an integral part of the integrity of process and industrial humidity and trace moisture measurements.

Gas samples are temperature conditioned and filtered (without adding or removing water or the desired gas).   The flow rate and pressure is also regulated by the sampling system

GE Sensing Humidity & Trace Moisture Calibration

GE Sensing is the global leader in automated humidity & moisture instrument calibration

Global service centers – NIST and other NMI traceable calibrations

Web based archive enables customers to access calibration data and plan instrument cal cycles

Onsite training and start up assistance as well as classroom training

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Product Training

GE Sensing offers onsite training as well as training in a classroom environment at our global training centers.

The classes cover theory, product operation as well as practical "hands on" training.

GE Sensing
Certificate of Training

James T. Kirk
The United Federation of Planets

Successfully Completed GE Measurement & Control Solutions Training Courses
Humidity Measurement Fundamentals
Optica Chilled Mirror Hygrometer

Thirty-Six Hours – Completed January 1, 2011

Instructor
Ken Soleyn, Product Manager
Humidity Test & Calibration Instruments