Thank You for Attending Today's Webinar

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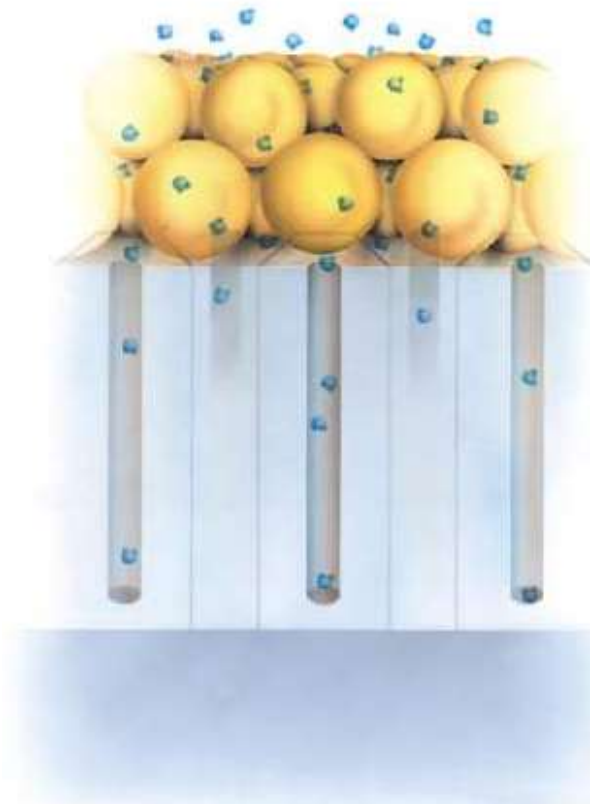
GE Measurement & Control

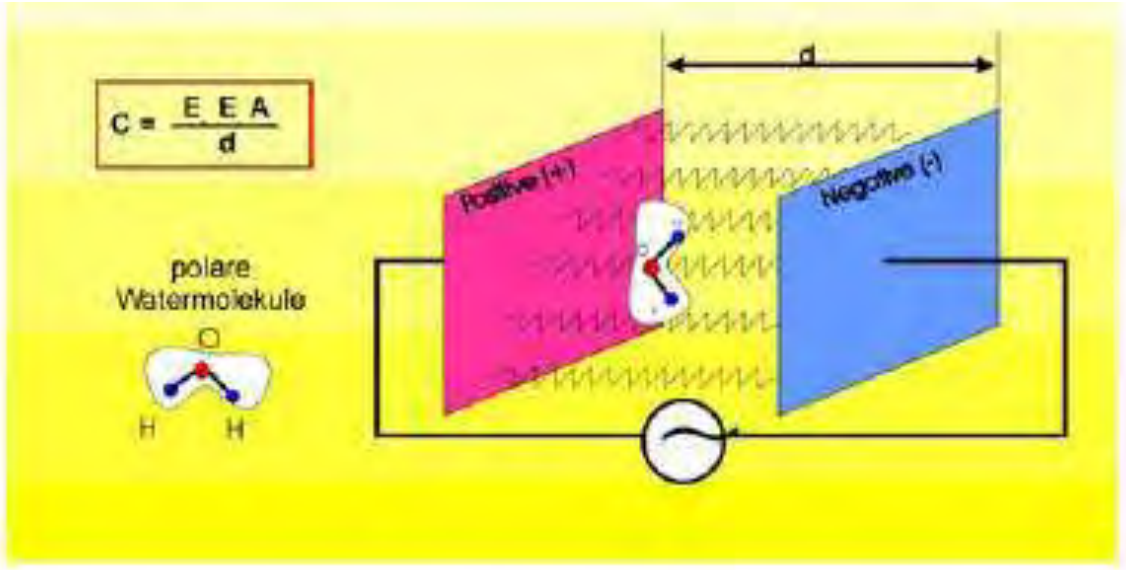
Aluminum Oxide Sensors for Trace Moisture Measurement

imagination at work

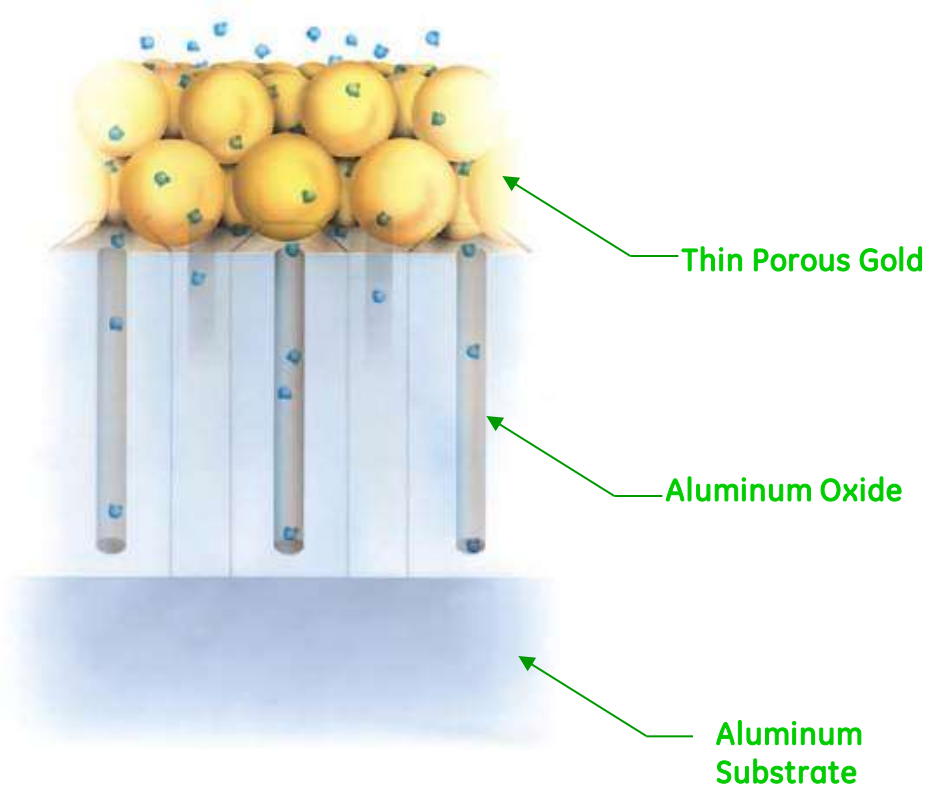
Aluminum Oxide Trace Moisture Sensor

Dew/Frost Pt	-110°C	-80°C	-70°C	- 60°C	-40 °C	-20 °C	-10°C	0°C	+20°C
Volume Ratio At 1 Bar	1.61ppbv	541ppbv	1.6 ppmv	10.7ppm	127ppmv	1020ppmv	2572ppmv	6068ppmv	23621ppmv





Aluminum Oxide – Trace Moisture Sensors



The oxide layer is porous and under dry conditions the pores are filled with gas or organic liquids.

Water has a dielectric constant of ≈ 80

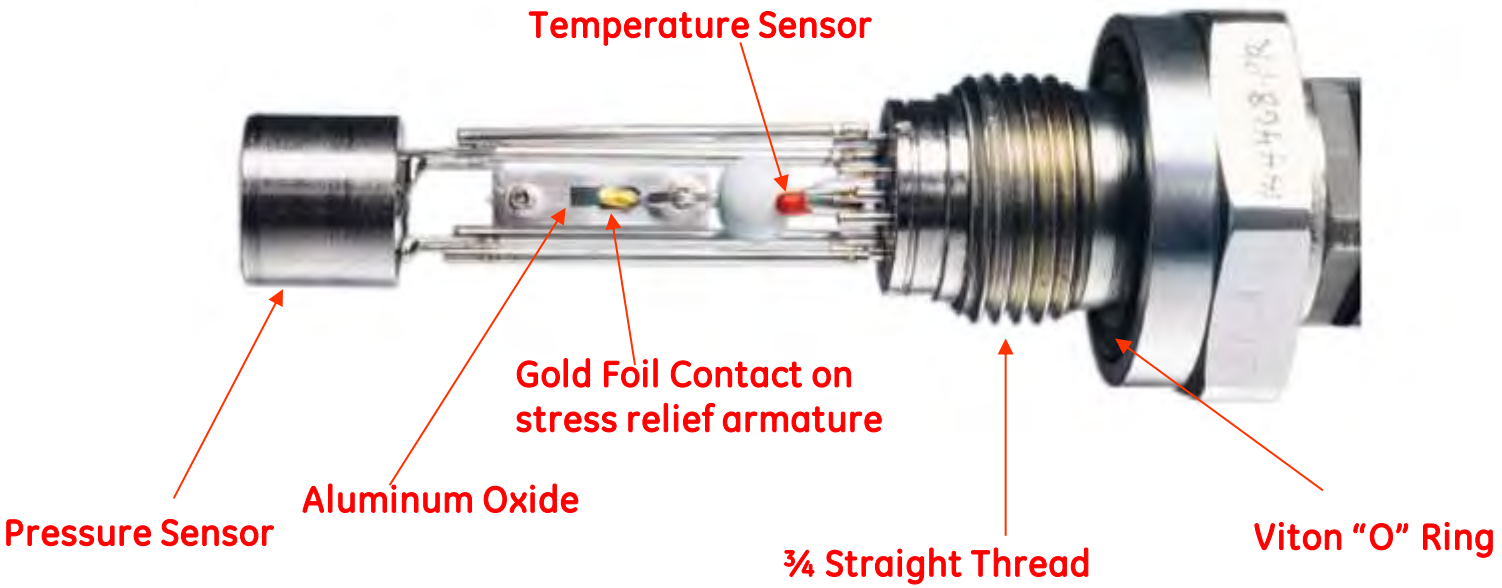
Air & non-polar organic liquids have low dielelectic constants. Air ≈ 1

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

The porous structure of aluminum oxide sensors form parallel capacitors between the aluminum substrate and gold electrode. Capacitors in parallel are added. You can think of the sensor as a "water molecule counter"

$C_t = C_1 + C_2 + C_3 \ldots .$

Panametrics Al_2O_3 Sensor – To 2012



GE Sensor Present

- Used on all Probes & Transmitters (Panametrics & GEI)
- Wafer technology – produces very repeatable sensors
- Improved long-term stability
- Improved bonding and mechanical strength

Aluminum Oxide Probe Styles

M-Series: Analog Moisture Sensors
Moisture with thermistor option

TF: Analog Three function; moisture, temperature and pressure

MIS: Moisture Image Series: Digital "Smart Probe" TF probe with electronics module (smart probes – stores calibration data)

Accuracy:

±2°C Td –65°C to +20°C

±3°C Td –80°C to –66°C

Temperature: ±0.5°C

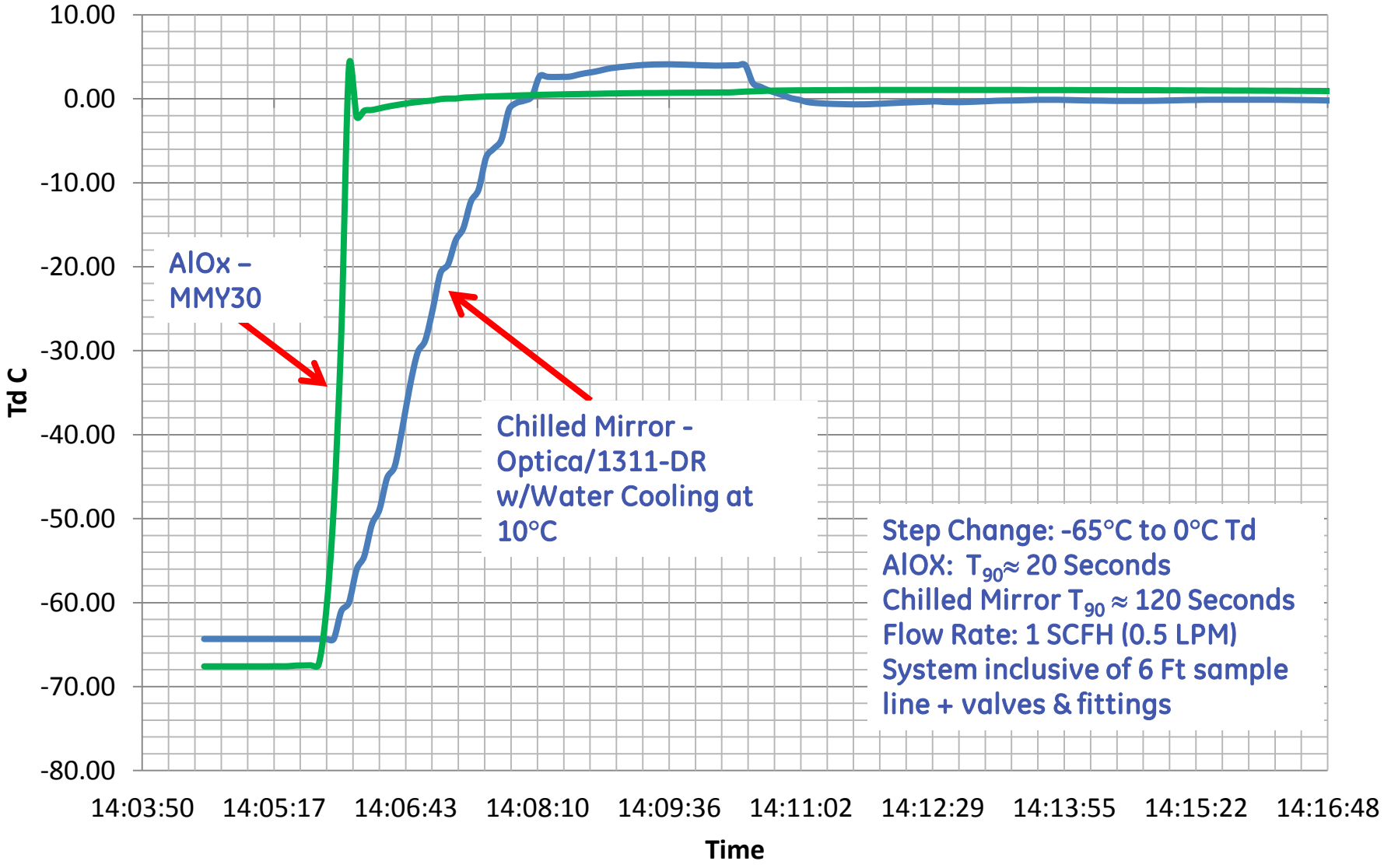
Pressure: ±0.5% of scale

Sensor Shields

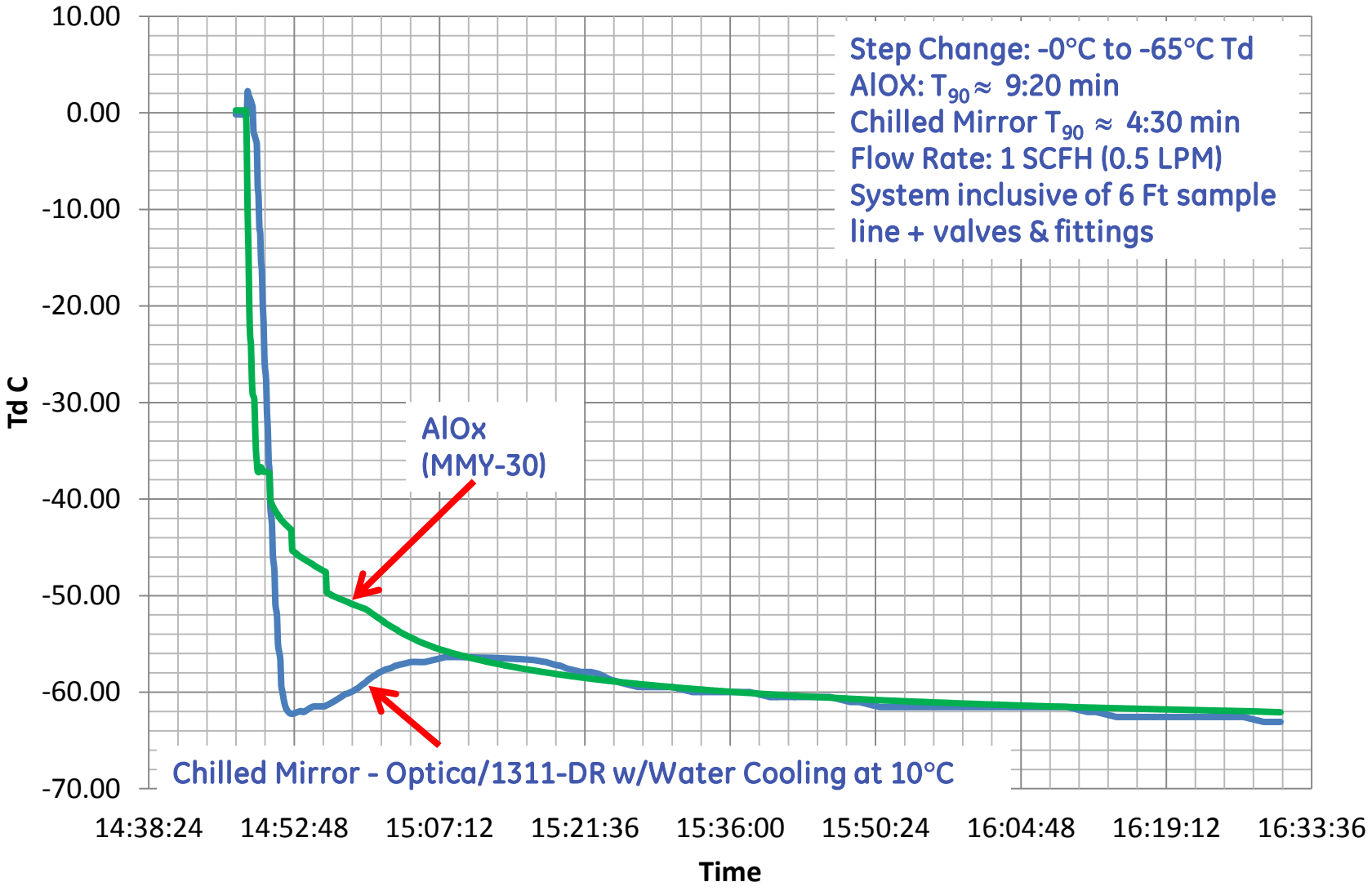
"R" Shield for gases – sintered steel

"W" Shield for liquids

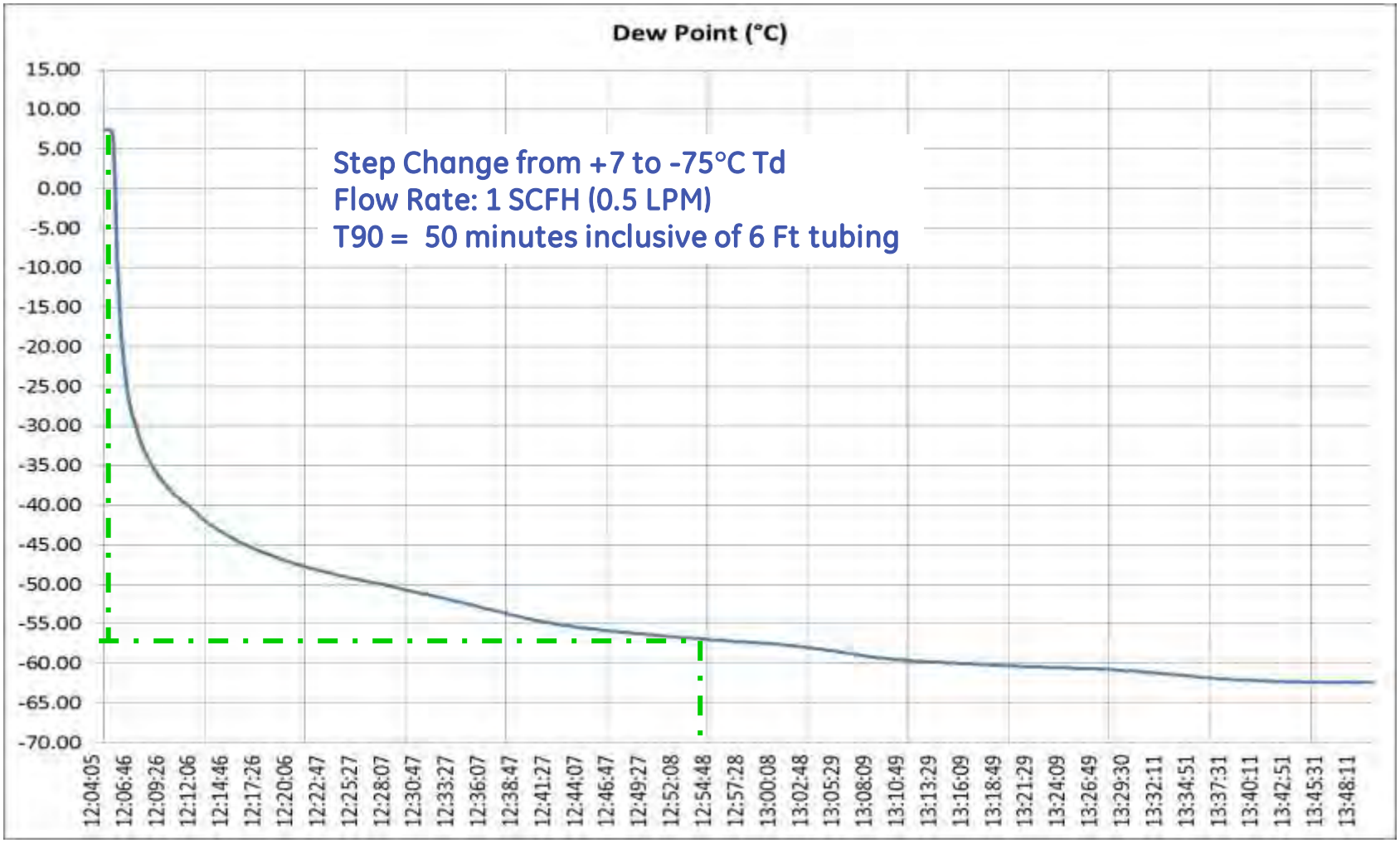
System Wet Up Response Compared to Chilled Mirror



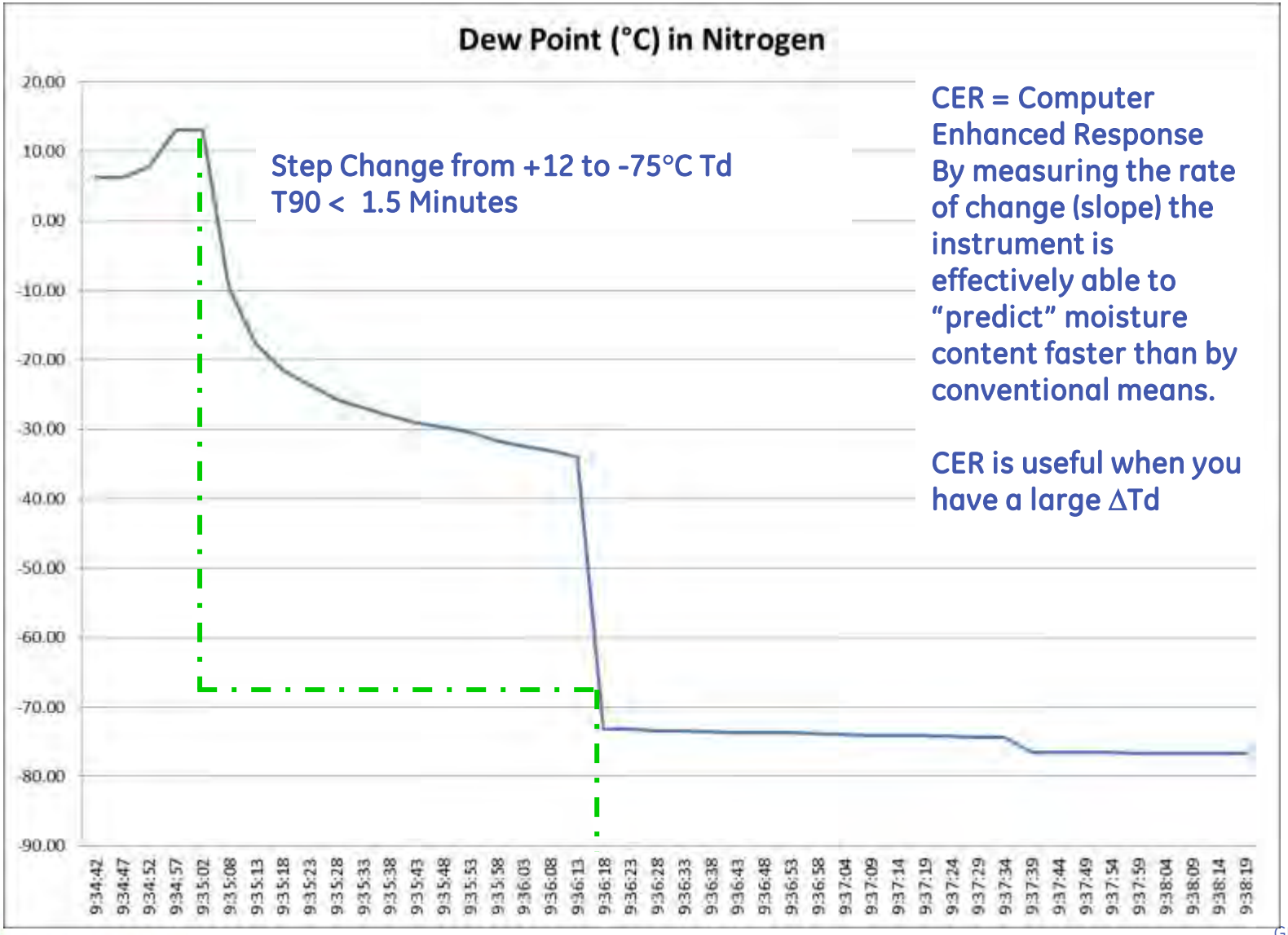
System Dry Down Response Compared to Chilled Mirror



Response Time of PM880-M2LR



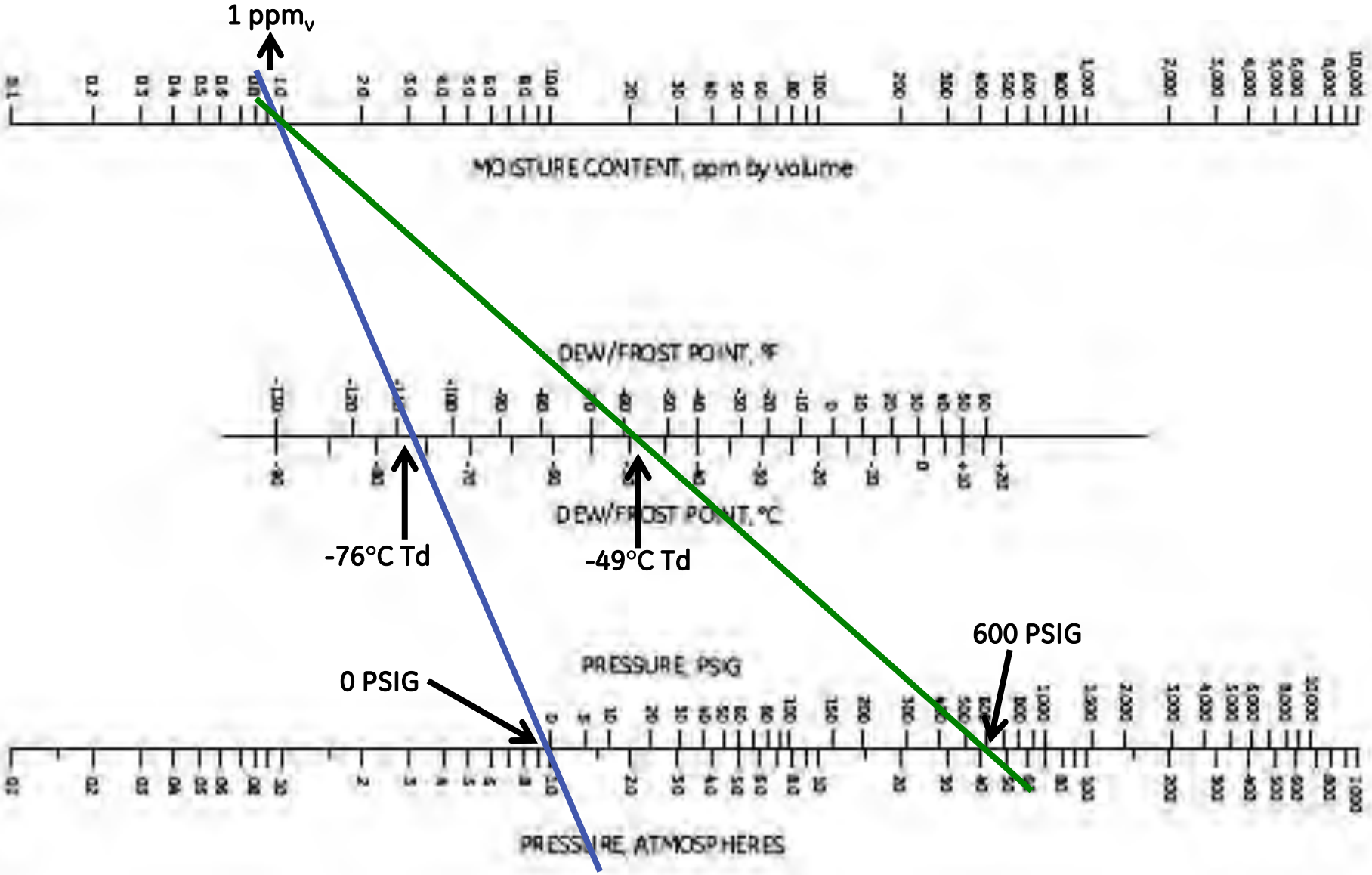
Response Time of PM880-M2LR with CER



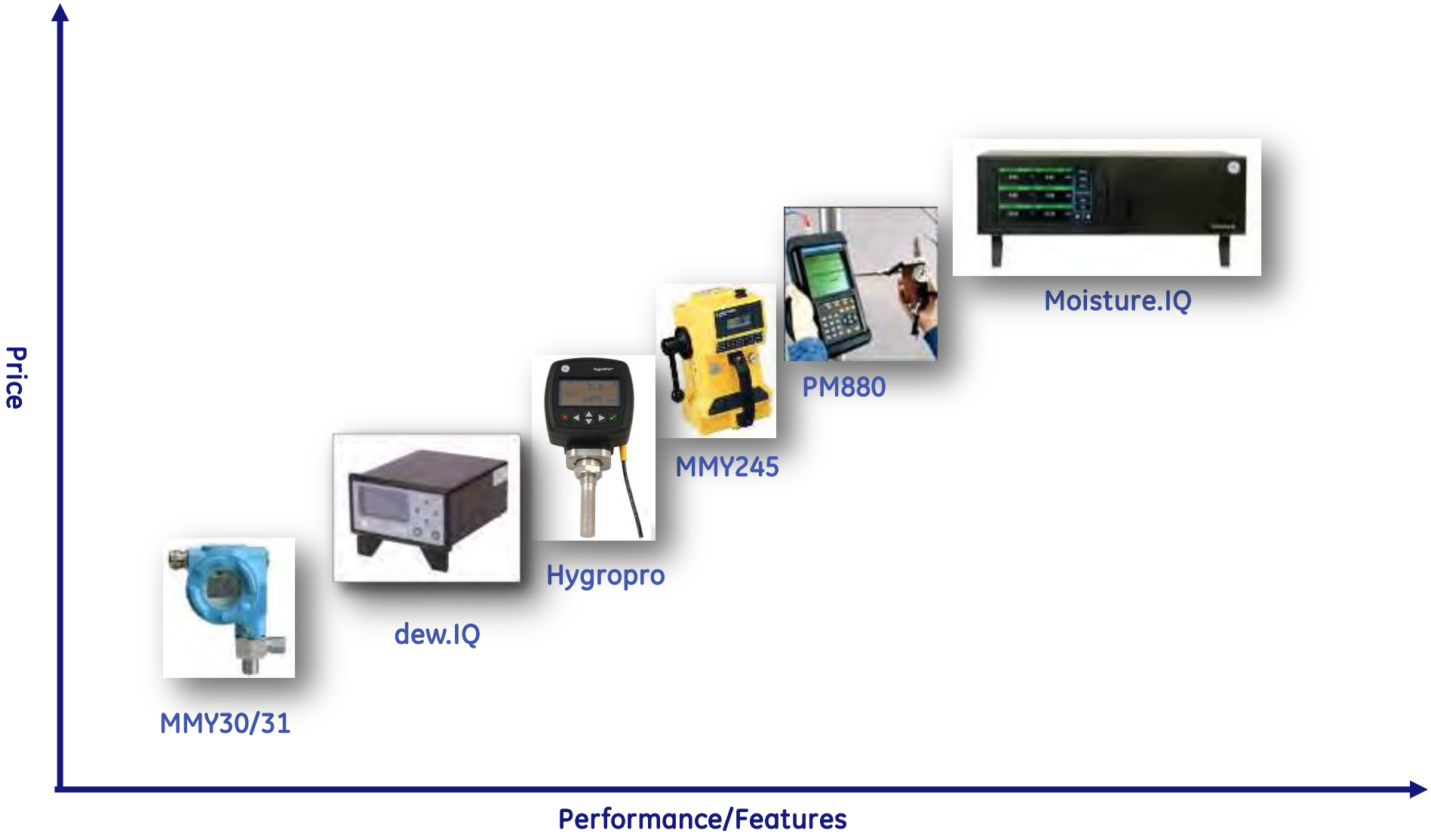
CER = Computer Enhanced Response
By measuring the rate of change (slope) the instrument is effectively able to "predict" moisture content faster than by conventional means.

CER is useful when you have a large ΔTd

Installing Probes at Pressure - Improves Response



Aluminum Oxide Sensors & Instruments



DewPro MMY Trace Moisture Transmitters

Common Features

Loop Powered 4-20mA Signal (8-32 VDC, 24 VDC Nominal)

Dew Point Range: -90 to +10°C Td (-130 to +50°F)

Display & Transmission for: Dew Point (°C or °F) or ppm_v (based on pressure constant)

Accuracy: ±2°C Td

Hazardous location use:

- FM IS Cl. I, II, III; Div. 1, Groups A-G
- FM XP Cl. I; Div.1, Groups A-D
- FM Cl. I, Div. 2, Groups A-D; Cl. II, III; Div. 2, Groups E-G
- IP-67 (Type 4X) ingress rating

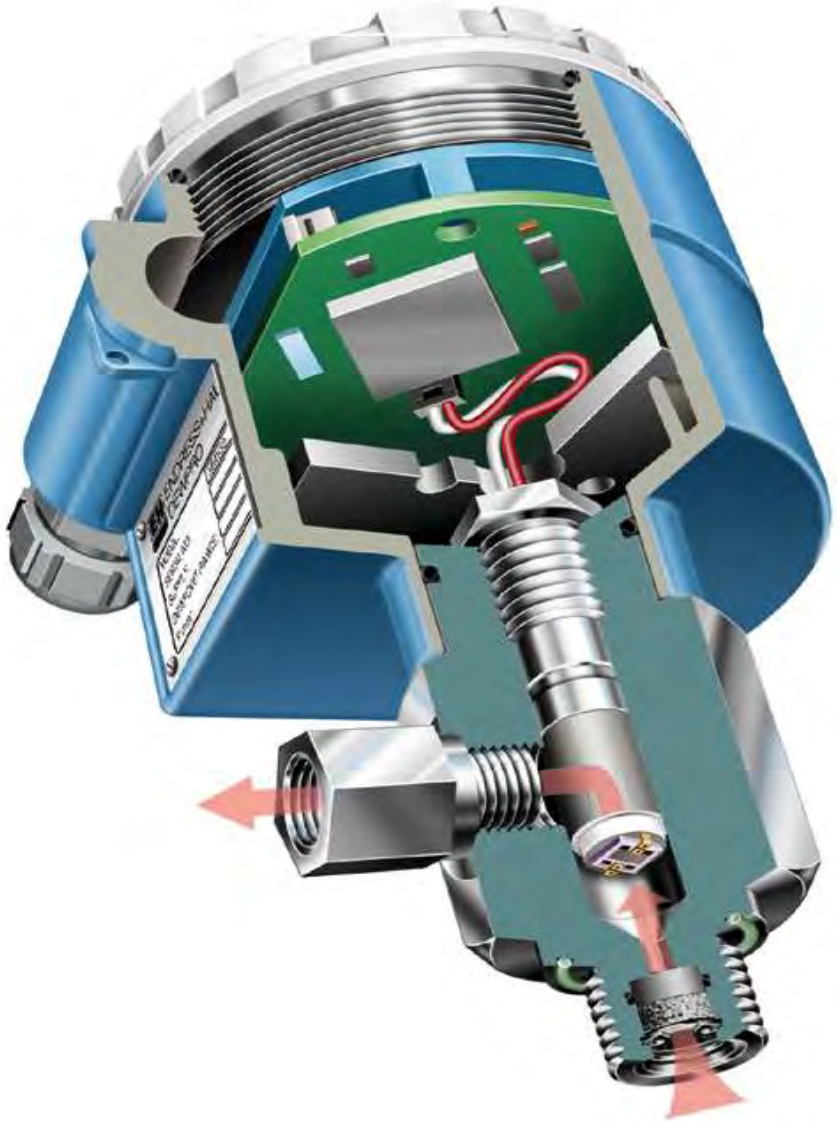
MMY31: Insertion probe (Glove Boxes & thru Ball Valve). 1/2" OD 316 SS tube.

MMY30: Integrated 316 stainless steel flow cell with inlet sintered steel filter.

For compressed air and orifice in installed to maintain 1 SCFH (0.5 LPM) at 100 PSIG (8 Bar).

imagination at work

A Cutaway of the MMY30



The MMY30 has a built in sintered steel filter, flow cell and orifice for flow control. It simplifies the sample system design.

The orifice is sized to provide a flow rate of 1.5 SCFH at inlet pressure of 100 PSIG (8 Bar) nominal

HygroPro

Loop Powered (12-30 VDC) with 4-20 mA signal

User programmable units and scaling

Multiple moisture parameters including dew point temperature, ppm_v, ppm_w, absolute humidity (m/v) & lbs/MMSCF (natural gas).

Backlit LCD display – up to 3 parameters

Three-Function probe: dew point, temperature and pressure

Programmable "solubility data" for moisture in organic liquids

Operation to 5000 PSIG

IP-67, 4X Type Enclosure

Intrinsically safe – Zener barrier in safe zone

Range: -110 to +20°C Td

The HygroPro is a "mini-moisture analyzer. It has many of the features only found in much larger analyzers

HygroPro – Field Replaceable Digital Probe

- The HygroPro is designed with a field replaceable probe (RTE)
- Calibration data is stored in the probe (smart probe)
- The probe is “plug & play” and only takes a few minutes to replace
- Eliminates the possibility of entering the wrong calibration data or mixing up probes

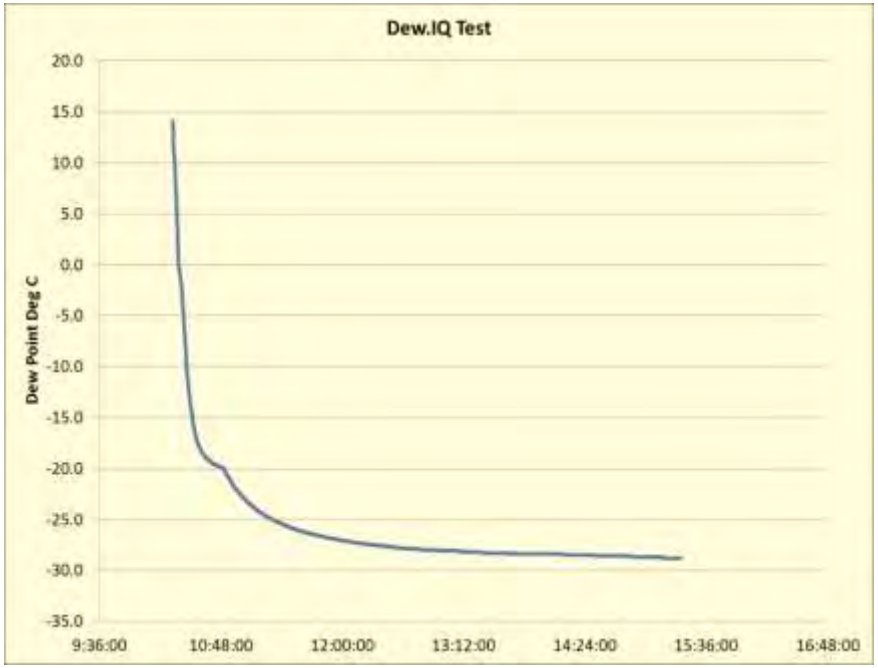
dew.IQ

- 1/8 DIN Panel Mounted Analyzer
- Available in bench top and wall mounted configurations
- 100-240 VAC or 24 VDC Power
- Connects to “M” series probes or IQ probe
- IQ.probe is “plug & play” - no need to enter calibration data
- Displays Dew Point, ppm_v and mg/m^3
- Programmable pressure constant
- Programmable analog output (switch selectable for 0-20mA, 4-20mA & 0-2VDC.
- (2) Alarm Relays (Dry Contact SPDT)
- Fault Relay
- Equipped with 2 GB data logger - enables months of data to be recorded on micro SD card

dew.IQ

dew.IQ Data Logger

Date	Time	DP C	PPMv
11/3/2012	10:18:28	-17.7	1248
11/3/2012	10:18:38	-17.8	1240
11/3/2012	10:18:48	-17.9	1232
11/3/2012	10:18:58	-17.9	1225
11/3/2012	10:19:08	-18.0	1217
11/3/2012	10:19:18	-18.1	1212
11/3/2012	10:19:28	-2.3	4929
11/3/2012	10:19:38	14.1	15939
11/3/2012	10:19:48	12.9	14654
11/3/2012	10:19:58	11.5	13357
11/3/2012	10:20:08	10.9	12901
11/3/2012	10:20:18	10.8	12735
11/3/2012	10:20:28	10.4	12459
11/3/2012	10:20:38	10.0	12090
11/3/2012	10:20:48	9.5	11682
11/3/2012	10:20:58	9.0	11341
11/3/2012	10:21:08	8.5	10896
11/3/2012	10:21:18	7.8	10445
11/3/2012	10:21:28	7.2	10007
11/3/2012	10:21:38	6.5	9550
11/3/2012	10:21:48	5.8	9064
11/3/2012	10:21:58	5.0	8573
11/3/2012	10:22:08	4.2	8078
11/3/2012	10:22:18	3.3	7610
11/3/2012	10:22:28	2.4	7135
11/3/2012	10:22:38	1.4	6612
11/3/2012	10:22:48	0.3	6125



The dew.IQ is equipped with a SD card slot which enables months of data to be saved. The SD micro card pops out and may be directly read on a PC (via a SD card slot) or USB adapter.

MMY245 Portable Trace Moisture Analyzer

- Portable battery operated (4 Standard "D" cells)
- Range: -100 to +20°C Td with ±2°C accuracy
- Al_2O_3 sensor is stored around desiccant when not in use – this keeps the sensor dry (-60°C typ). This results is fast response
- Programmable display: Td, %RH, absolute humidity, volumetric mixing ratio and mass mixing ratio
- Analog output: 0-5 VDC
- IP-66 NEMA-4X case

PM880 Portable Moisture Analyzer

- A great instrument to “walk up” and check trace moisture process – with compact sampling system
- Probes can also be permanently installed in the process

- Use with M, TF or MISP-2 probes
- Graphical Display
- Display up to 4 parameters
- Trend graph display
- Meets IP67 rating
- Internal Data Logger
- IrDATM wireless transfer
- Stores 60 data files (data logger, configuration or probe calibration)
- Stores solubility data for organic liquids
- Rechargeable battery
- Intrinsically safe
- Computerized Fast Response (M or TF probes)

Moisture.IQ Analyzer

- Color Touch Screen Display
- Modular Design - Two Bays
- Each Bay accepts either a 1 channel or 3 Channel Module (1, 2, 3, 4 or 6 channels)
- Each channel supports a moisture probe, Oxygen sensor & (2) 4-20mA inputs
- Up to (6) moisture probes, (6) Delta-F O2 cells & (12) 4-20mA process inputs
- Supports M series & MISP2 Series probes
- Process inputs programmed for display in engineering units & retransmission (4-20mA)
- Numerical or trend graph display
- Programmable 4-20mA outputs & Alarm Relays
- Built in IS Barriers
- USB, RS-232 & Ethernet with Modbus
- Data logging
- VNC Viewer enables emulation of touch screen via ethernet/internet

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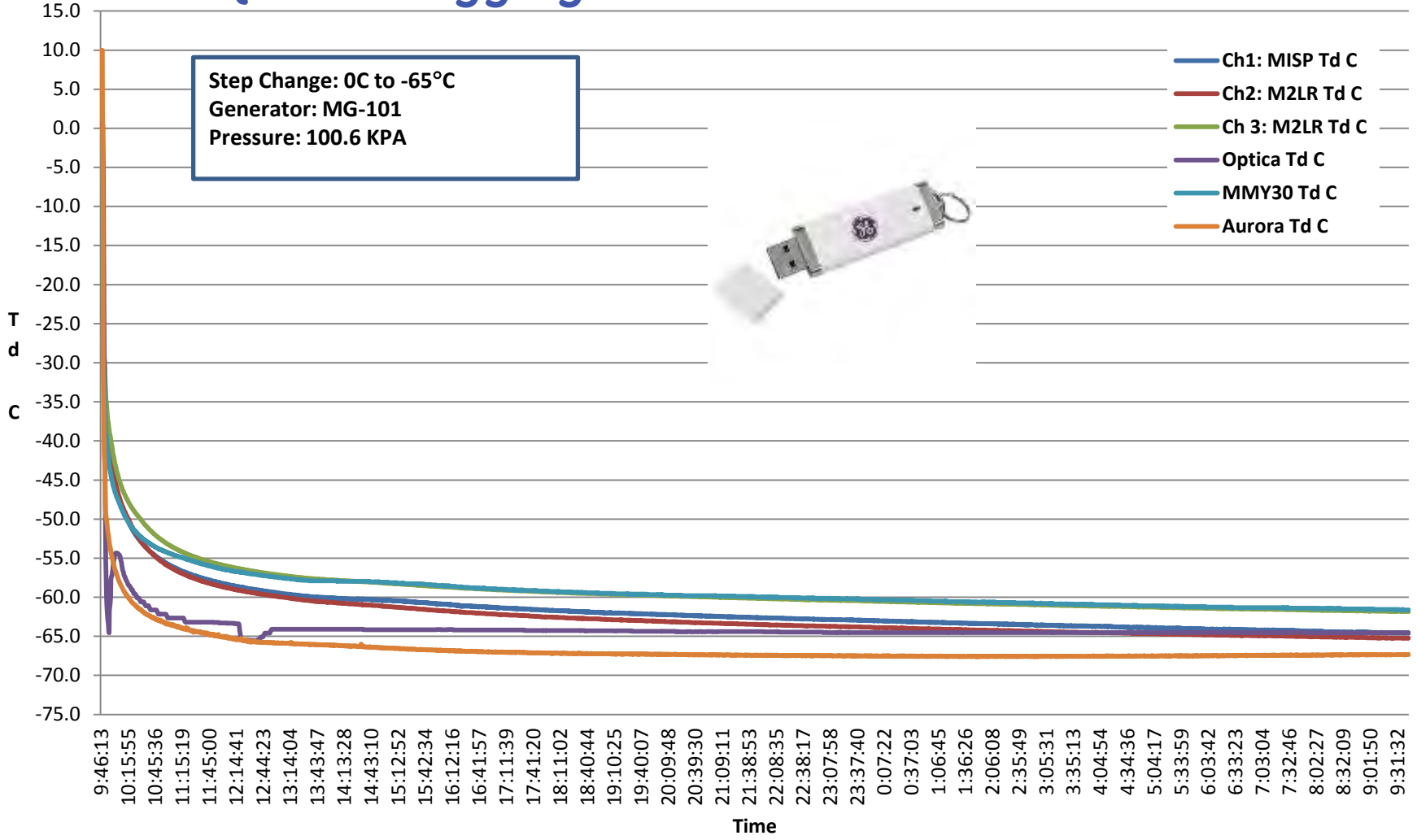
Moisture.IQ Wall Mounted Versions

NEMA-4X/IP66 Weather Proof

Explosion Proof

Moisture.IQ Data Logging



The Moisture.IQ is equipped with a USB port. Saved data is easily transferred to a USB memory stick (flash drive) or across a network (LAN or Internet) via Ethernet. The data can be exported to excel for graphing or further analysis.

Panametrics Aluminum Oxide Sensor Calibration System

5-Stage Chilled Mirror Hygrometer

Saturator Bath

T & P Sensors

Enclosure for Mass Flow Control Valves

Test Chamber

64 Ports per Manifold

Six Manifolds per system

PC based Labview Control & Data Acquisition System

System equipped with UPS resume on loss of power

Calibration of GE Panametrics Al_2O_3 Sensors

- Dry Nitrogen is saturated with distilled water at a precisely controlled temperature. The saturated N_2 is warmed and diluted with dry N_2 to produced the desired moisture concentration
- Precise mixing ratios are controlled with mass flow controllers arranged in a cascade system for multiple dilutions
- Stainless steel manifolds house the sensors under test
- Impedance data (MH or FH) is recorded for each probe at (10) points
- The reference dew/frost points is measured with a chilled mirror (redundant standard)
- The calibration data is either programmed into the transmitter or provided on a calibration data sheet for entry into the analyzer
- The calibration process is automated

CALIBRATION DATA SHEET

GE Sensing

Probe Serial Number: 251350-PR
Last Calibration Date: 21-March-2015
Probe Part Number: M2LRT

ND Number	Dew Point (Deg C)	MH Reading	Dew Point (Deg F)
0	-110	0.1979	-166
1	-100	0.2027	-148
2	-90	0.2076	-130
3	-80	0.2126	-112
4	-70	0.2177	-94
5	-60	0.2255	-76
6	-50	0.2348	-58
7	-40	0.2466	-40
8	-30	0.2642	-22
9	-20	0.2966	-4
10	-10	0.3502	14
11	0	0.4581	32
12	10	0.6695	50
13	20	0.9786	68

Analog Probes

- M
- TF

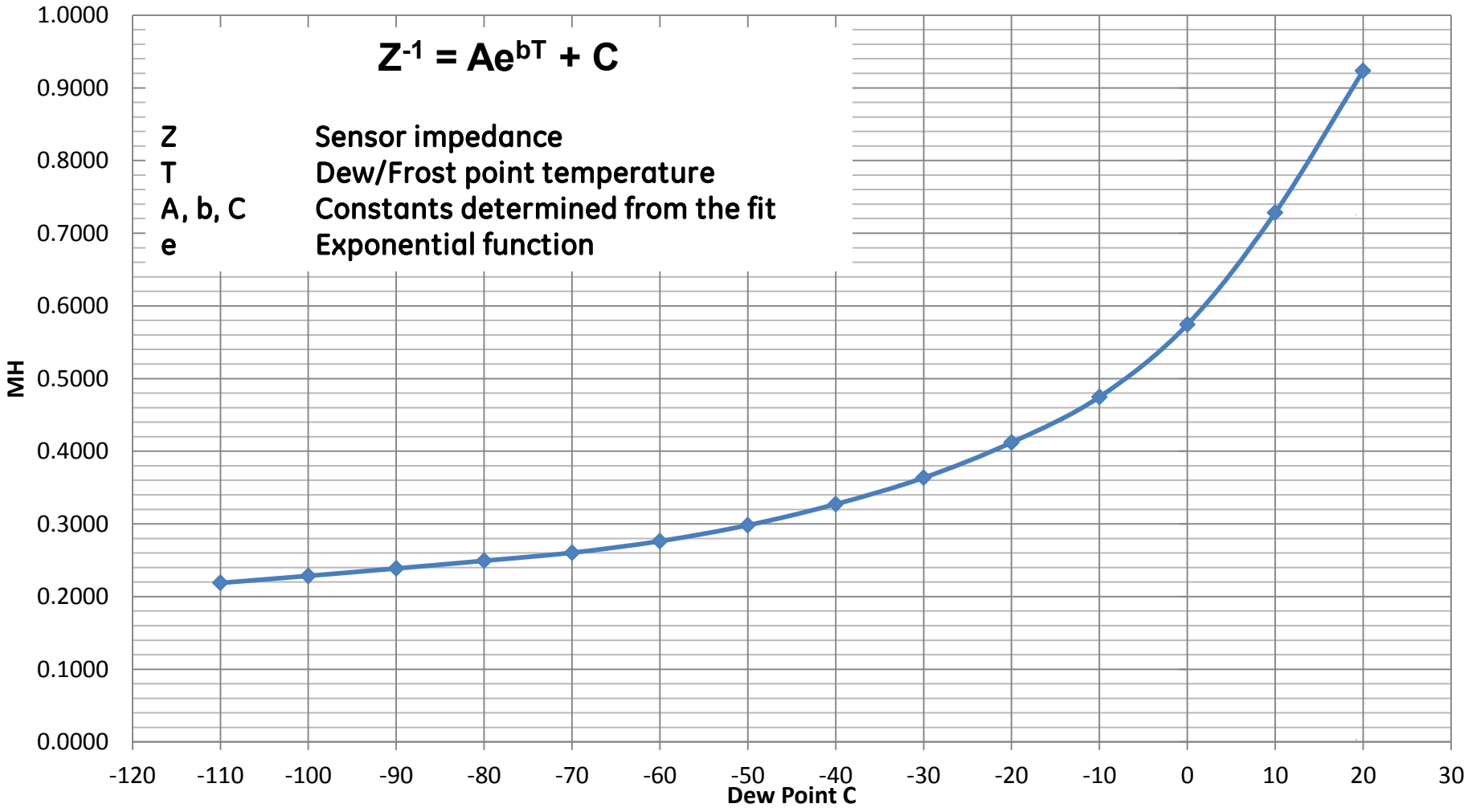
The calibration data must be entered into the analyzer

Digital Probes

- MISP-2
- HYGRO-RTE
- DEW.IQ

The calibration data automatically uploads to analyzer

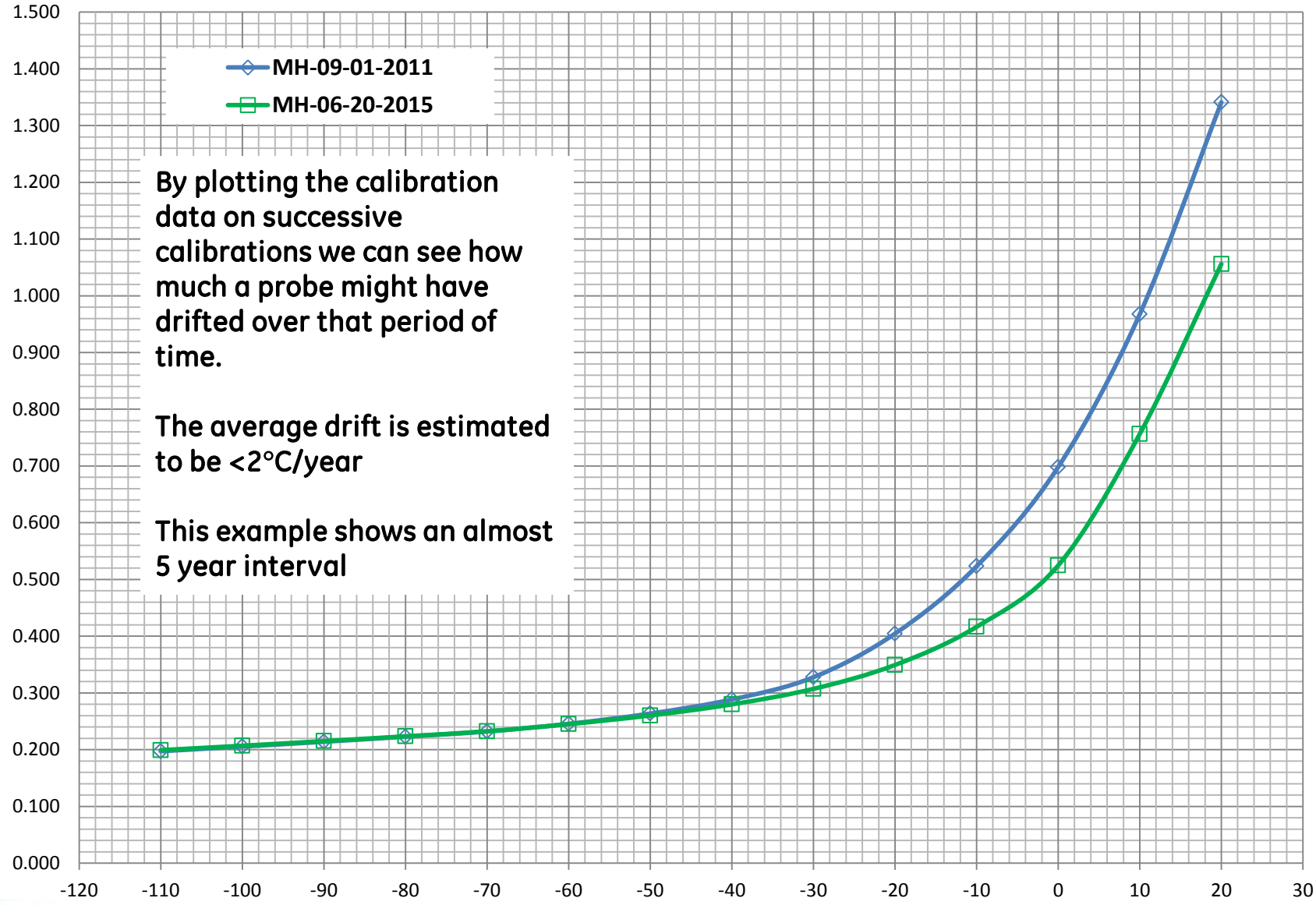
Calibration Curve for Panametrics AlOx Sensors



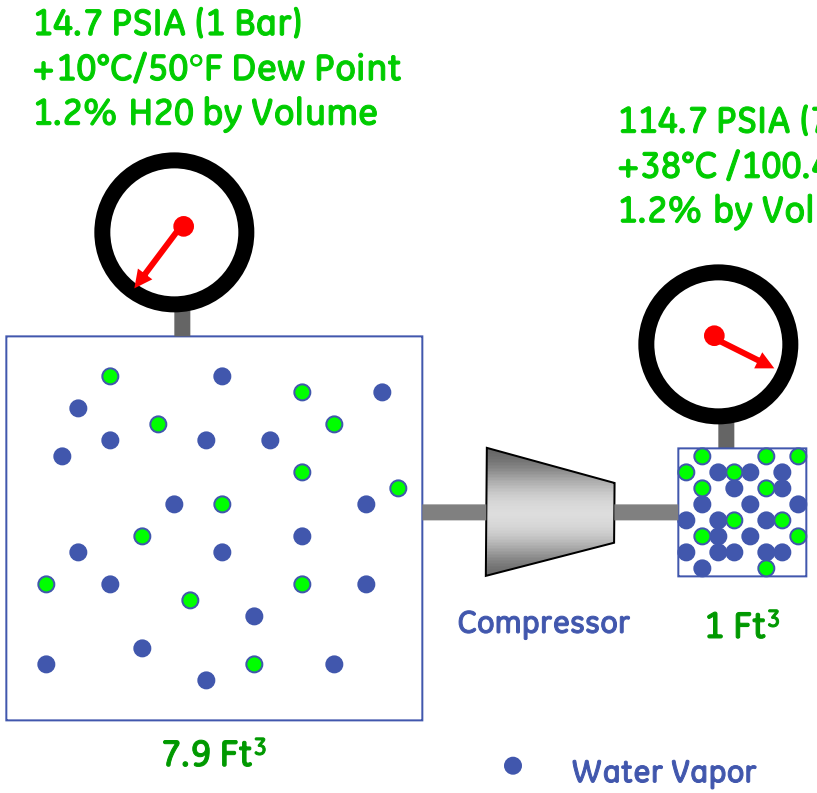
"MH" is a function of the sensor's "impedance" at a specific excitation voltage & frequency

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

AlOx Sensor Drift Over Time



Compressed Air



$$P_1V_1 = P_2V_2$$

- Water Vapor
- Contaminants (Oils, Particulates etc.)

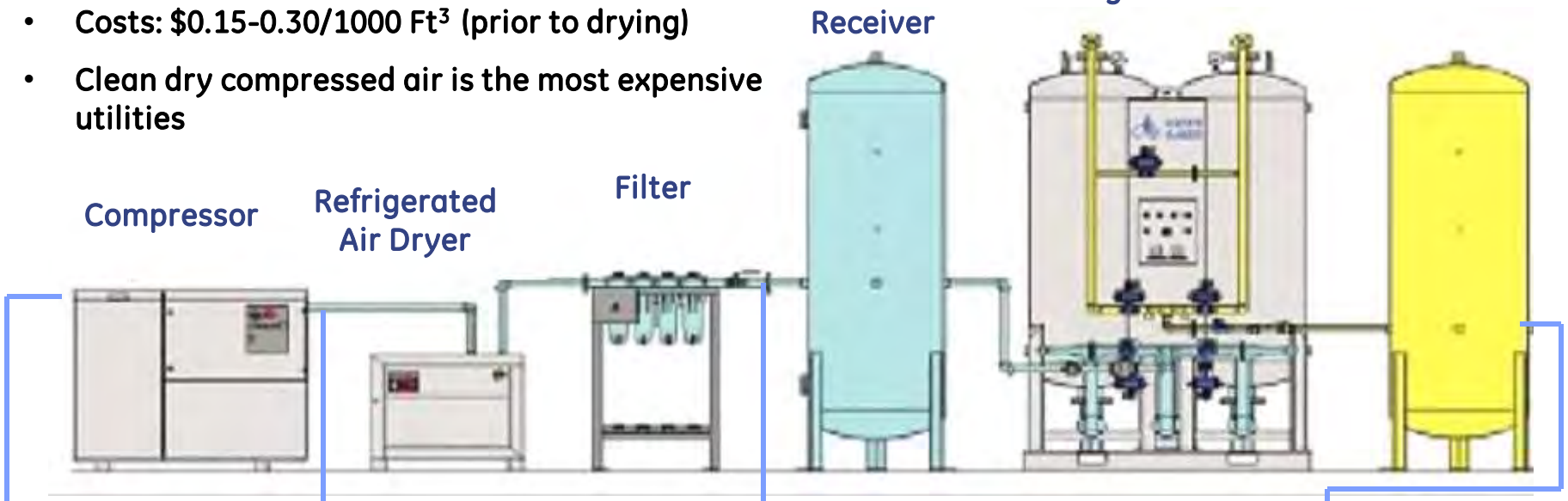
When air is compressed the moisture and other contaminants are concentrated. The partial pressure of the water vapor will increase and therefore the dew point increases.

The volume ratio (% by volume or ppm_v) remains the same

The compressed air must be cleaned and the moisture removed

Plant Air Drying System

- Compressed air is the 5th utility. 7% of the total energy consumption in the USA is used to produce compressed air
- Costs: $0.15-0.30/1000 Ft^3 (prior to drying)
- Clean dry compressed air is the most expensive utilities



Plant Air: 0 PSIG, 100°F & 50% RH = 78°F T_d

Compressed Air:

100 PSIG, 100-150°F T_d at 180°F & T_a

100 PSIG, 35-50°F Td at 100°F T_a

100 PSIG, -40 to -140°F T_d at 78°F T_a

T_d = Dew Point

T_a = Temperature

ISO-8573 Classifications for Compressed Air

Class	Solid Particulate per M3			Water Vapor Dew Point °C	Oil mg/m3
	0.1-0.5 uM	0.5-1 uM	1-5 uM		
1	100	1	0	-70	0.01
2	100000	1000	10	-40	0.1
3	-	10000	500	-20	1
4	-	-	1000	3	5
5	-	-	20000	7	-
6	-	-	-	10	-

ISO 8573 is the group of international standards relating to compressed air – Part 1 specifies the quality of compressed air & Part 2 defines the testing methodologies

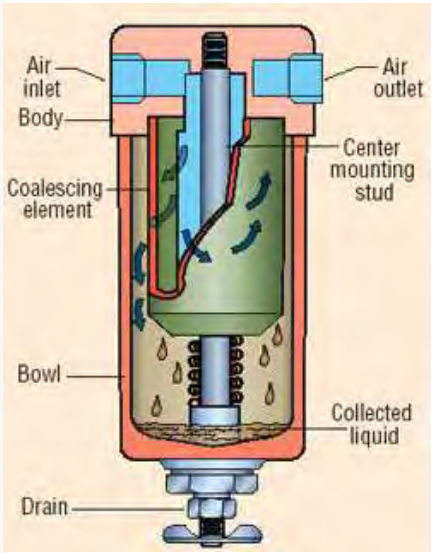
A maximum level can be specified for each class (Solid Particulate, Water Vapor & Oil).

Example: "ISO 8573: Class 1.2.1"

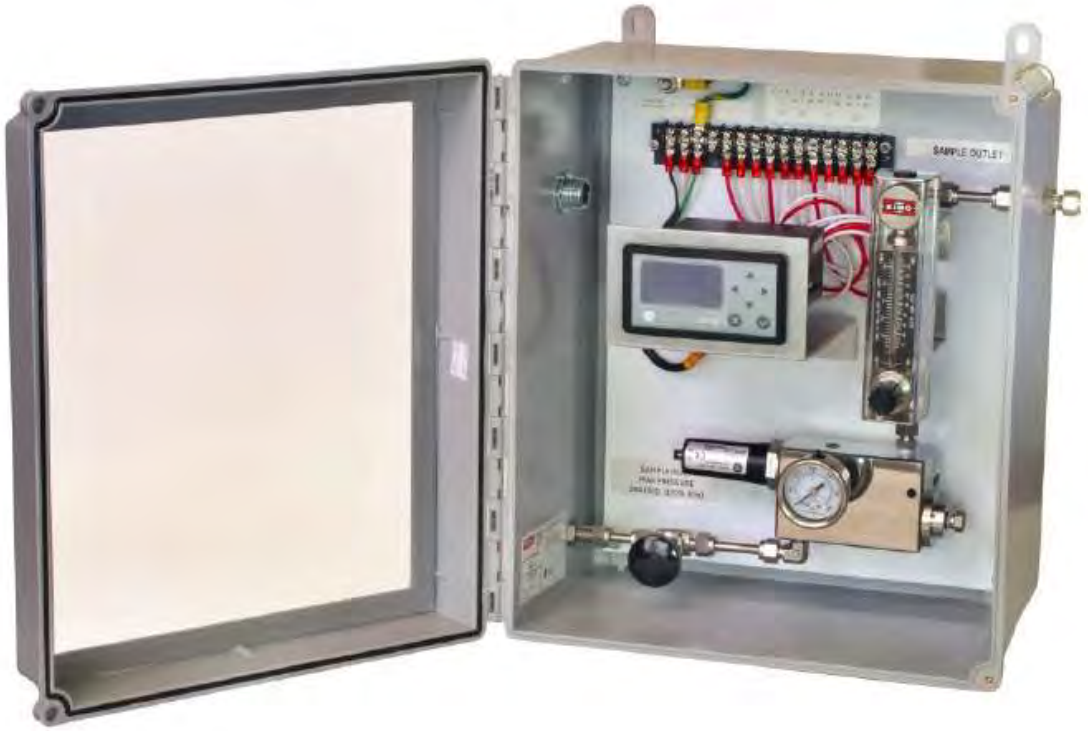
- Not greater than 100 Solid Particles 0.1-0.5 uM
- Not greater than 1 Solid Particles 0.5-1 uM
- No Solid Particles >1 uM
- Dew Point < -40°C
- Oil (including oil mist) < 0.01 mg/m3

Sampling System for Compressed Air

For compressed air systems where oil is present, a coalescing filter should be used upstream of the sensor.



air.IQ – Moisture Analyzer Packaged Solution



- Turnkey Moisture Analyzer and probe with sample conditioning system assembled in high impact ABS (NEMA-4X) enclosure with dew.IQ meter and IQ.probe.
- Simplified wiring – Terminal for Power, Alarms, & analog output
- Sample cell with built in filter
- Inlet needle valve, rotameter with valve, and pressure gauge to control and indicate flow and back pressure
- Built in data logger
- Special pricing

air.IQ simplifies the selection and installation of your moisture analyzer. Install the moisture probe, wire your power and outputs to the terminal strip, and connect your gas to the inlet fitting.

Regenerative Desiccant Dryers

Regenerative desiccant dryers remove water from compressed air by adsorption onto microscopically porous desiccant. Desiccant materials include, salts, silica gel, activated alumina, or molecular sieve.

These dryers cycle between an "online" column and an "offline" (regeneration) column.

The dryer uses a fraction of expanded dried air to purge the adsorbed water from the desiccant in the "offline" column

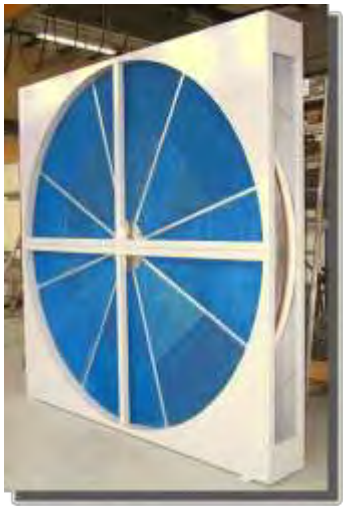
To produce -40°C frost point at 100 PSIG (7.8 Bar) a pressure swing dryer consumes ~15% of the compressed air for regeneration. Lower frost points require more purge air.

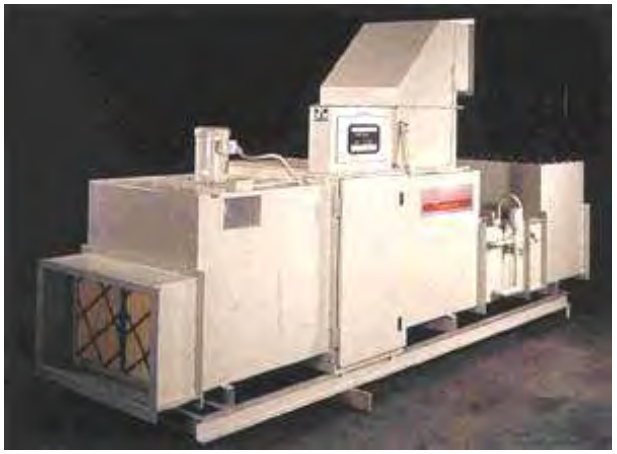
Heaters can be employed to reduce the of purge gas usage. A heated dryer uses about ~5% of the compressed air for regeneration to produce -40 °C frost point at 100 PSIG (7.8 Bar)

Typical frost points obtained with these dryers are –40°C to –75°C.

Desiccant column switching can be programmed with a "timer" control or switching could be based on dew point measurement. Dew point switching can often save energy costs.

Desiccant Wheel Process Air Dryers





Desiccant wheel dryers produce large volumes of air at low pressure for environmental control and materials processing.

Desiccant wheels are used to lower the refrigeration or air conditioning loads and used as heat-recovery units in commercial and industrial buildings

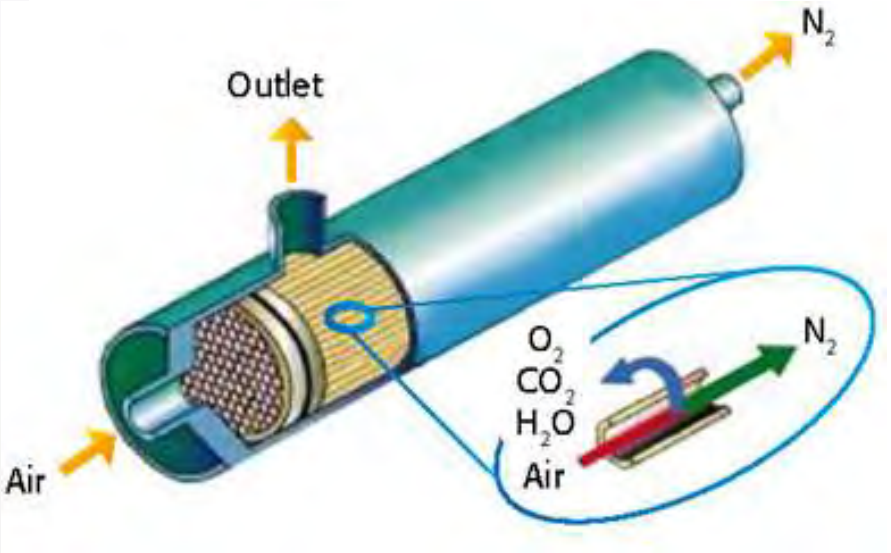
A wheel of desiccant (silica gel) rotates slowly as process air flows through it

A section of the wheel is back-purged with heated air to regenerate the desiccant

Desiccant wheels produce air between –40 to -70°C Td.

As desiccants adsorb water heat energy is released. The heat energy can be used to prewarm incoming air to a building

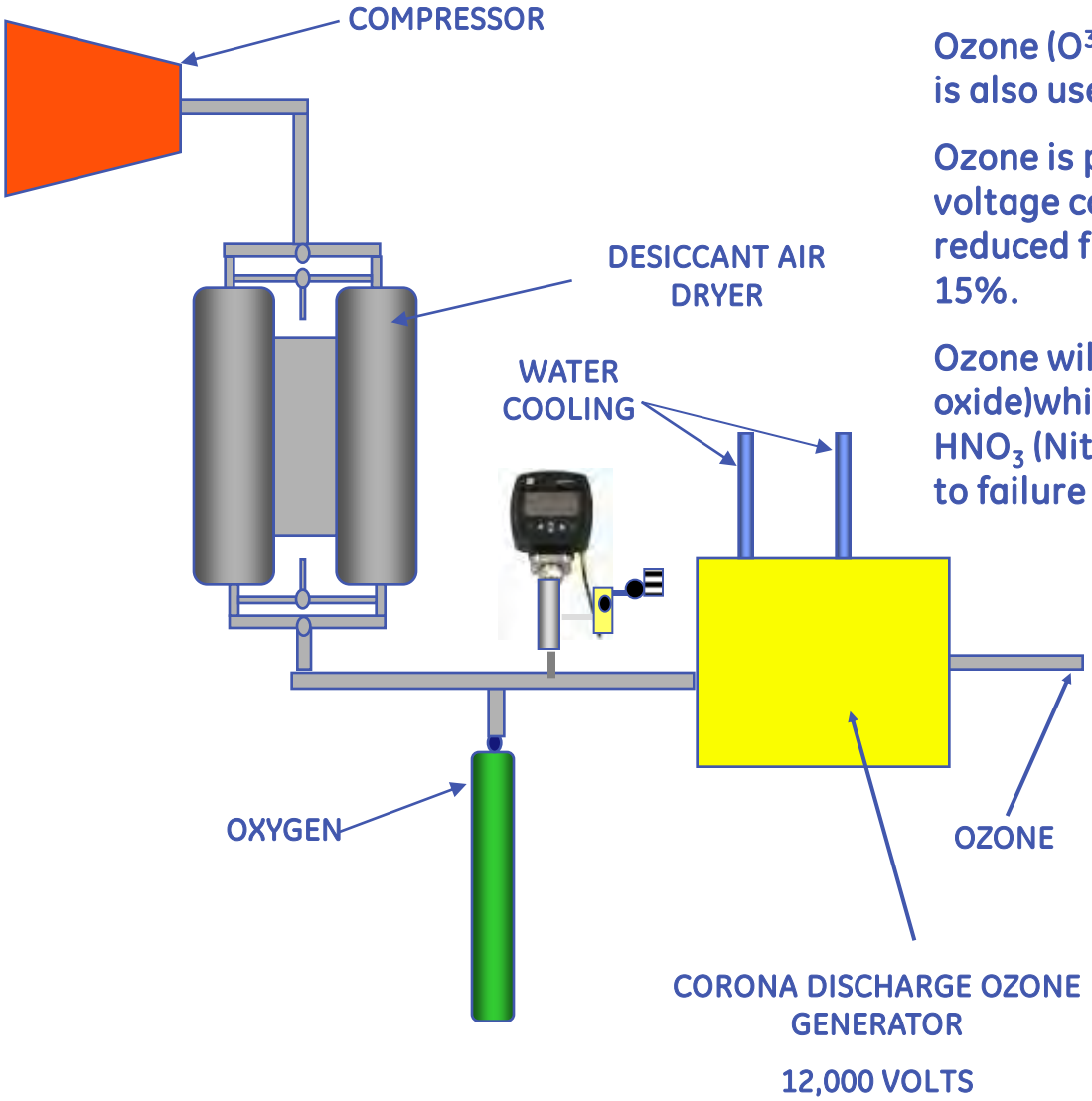
Membrane Dryers



Water vapor permeates through micro membrane gas separation filters when there is a water vapor pressure gradient. The separated water vapor is then swept away by decompressed "purge" air.

These dryers consumes a fraction (~20%) of the dried air and produce –40 to -60°C frost point. There are no moving parts and they are generally used as "point of use dryers"

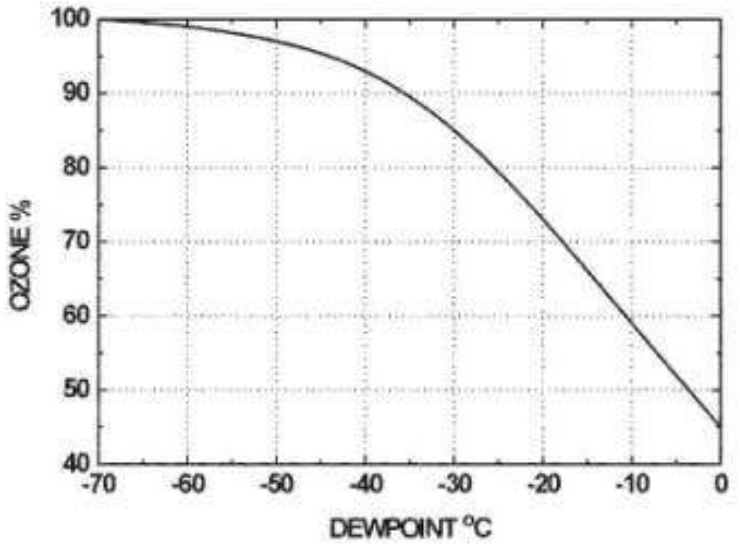
Ozone Generators



Ozone (O^3) is a powerful oxidizer and disinfectant. It is also used as a bleaching agent.

Ozone is produced by exposing dry oxygen to a high voltage corona. It is found that if the dew point is reduced from –40 to -60°C the yield increases by 15%.

Ozone will also oxidize N_2 to NO_2 (nitrous oxide)which will combine with water to produce HNO_3 (Nitric Acid); a very corrosive acid which leads to failure of the corona discharge electrodes.



Desiccant Dryers for Plastics Processing

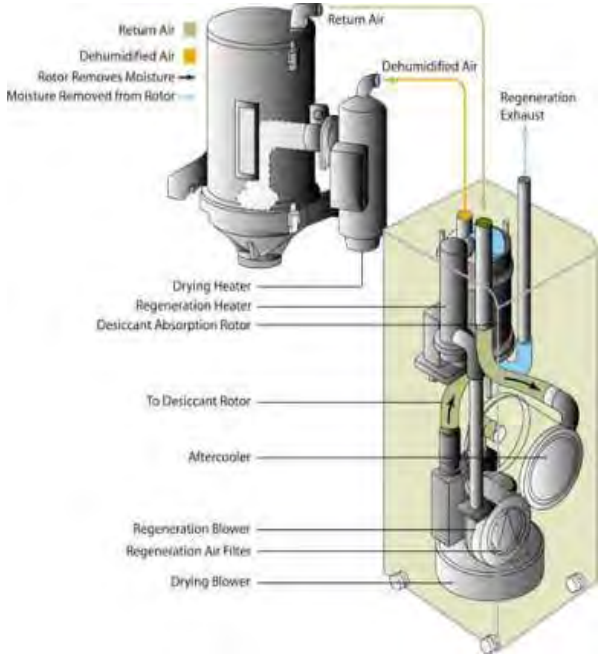
Desiccant dryers are used for drying plastic resins prior to processing (injection and blow molding)

The dryers also serve to pre-heat the resins prior to molding

These dryers are heat-regenerative and produce air at low pressure and high volume

Column switching (heat regenerative) and rotary desiccant wheel technologies are used.

In addition plastics may be dried by refrigerated dryers, batch ovens, vacuum and expansion and heating of compressed air



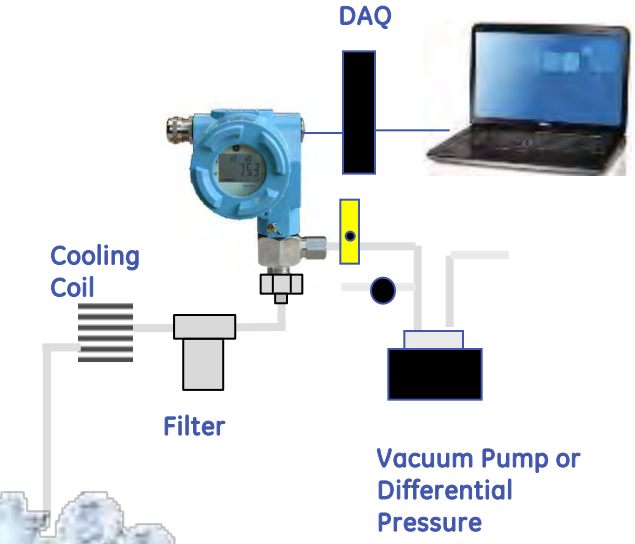
Plastics Resin Drying

In this example polycarbonate is dried for injection molding CD Roms

Polycarbonate resin is dried & preheated prior to being molded under pressure

If sufficient water is not removed from the resin bubbles & surface imperfections form in the finished CD ROM

The dew point sensor optimizes the drying process – insuring the material is dry but not over drying which waste energy



Case Study: Portable Hygrometer for Submarine Pneumatic Control Systems

Location: Rhode Island – USA

Application: Portable dew point meter for measurement of the moisture content of pneumatic systems used on board submarines. (Example: The periscope is pneumatically operated). The Dew point must be less than -40°C Td

Need for reliable and fast response meter. Subs go out to sea for many months at a time

Also wanted ability to verify & calibrate the units at Navy metrology labs

Product Solution: MMY-245

Amount: 13 units + Optica/1311-XR/MG-101 = $110K

Value Propositions:

- Fast response due to pre pre-drying chamber
- MMY-245 utilizes standard "D" cell batteries
- Unit demonstrated to decision makers
- GE could provide a calibration system + onsite training

Case Study: Bleaching Kaolin with Ozone

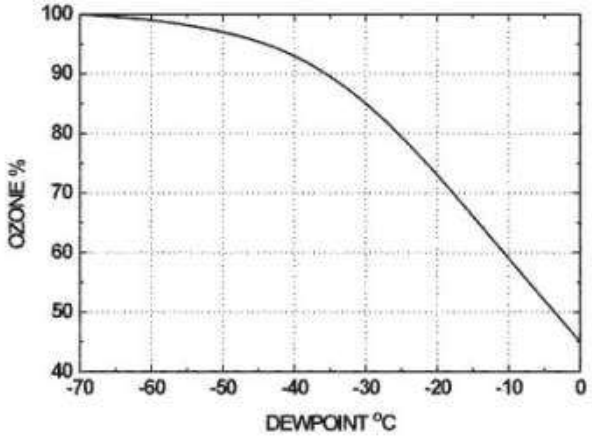
Location: Georgia, USA

Application: Kaolin is a mineral which is bleached by exposure to ozone. Ozone (O_3) is produced from oxygen enriched air by passing it through a "corona discharge". For efficient O_3 production the feed gas must be below -60°C Td. Customer was looking for transmitters to connect to data acquisition system

Product: MMY-30

Value Propositions:

- Compact transmitter with built in sampling cell & display
- Loop powered 4-20mA for direct connection to DCS (Digital Control System)
- Ordered units with exit orifice however pressure was too low – sales/service call corrected this by replacing the orifice with a needle valve and rotameter.



Kaolin is one of several types of clay, and is commonly referred to as China Clay or Paper Clay. It is a hydrated silica of alumina with a composition of approximately 46% SiO_2; 40% Al_2O_3, and 14% H_2O.

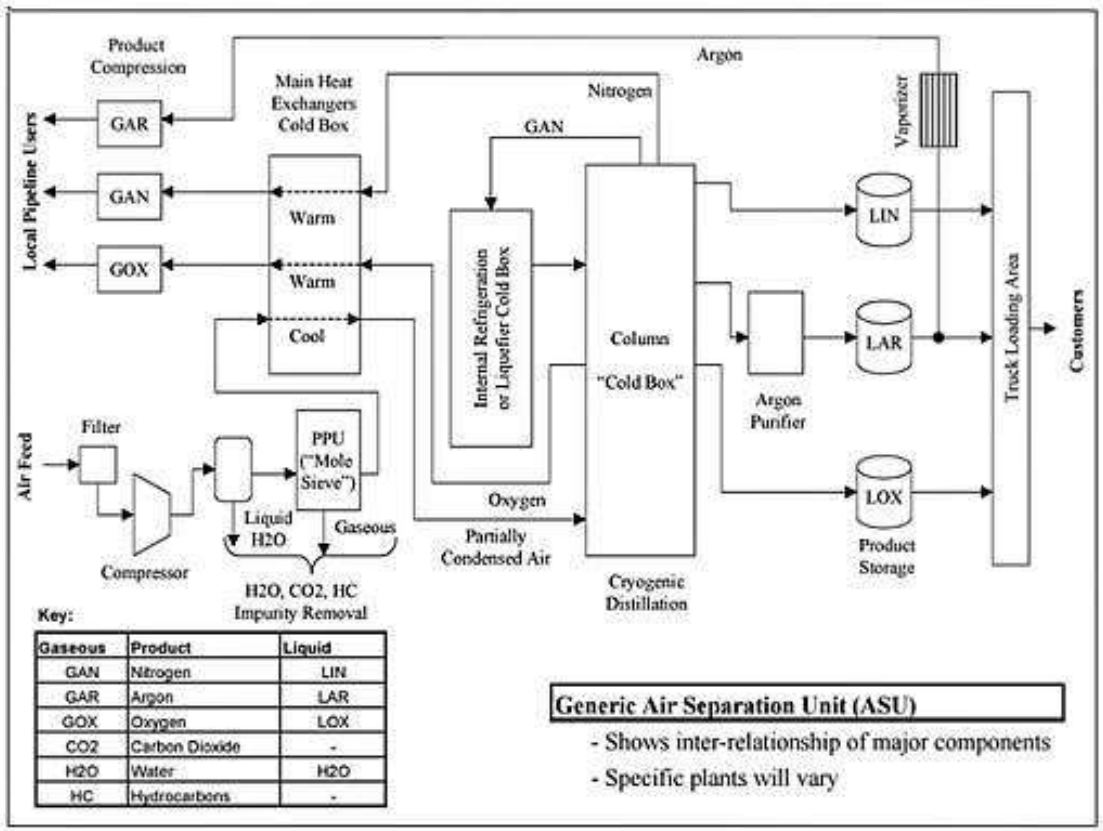
1.5 million tons of kaolin produced annually in the United States, approximately 56% is used in the paper industry. In paper-making, Kaolin is utilized as a pulp filler as well as for coating. Some newspapers have a kaolin content of about 2%, while magazines with a relatively high gloss contain on the average of 30%.

Other uses: Rubber products consume about 16% of the kaolin, with a major portion of the remainder going into such products as linoleum, paints, inks, leather, refractories, pottery, insecticide, fertilizers, and plastics.

Air Separation

Air separation plants use compression and cooling to liquefy air and boil off the various components to separate them.

Moisture is a contaminant in pure gases and is monitored



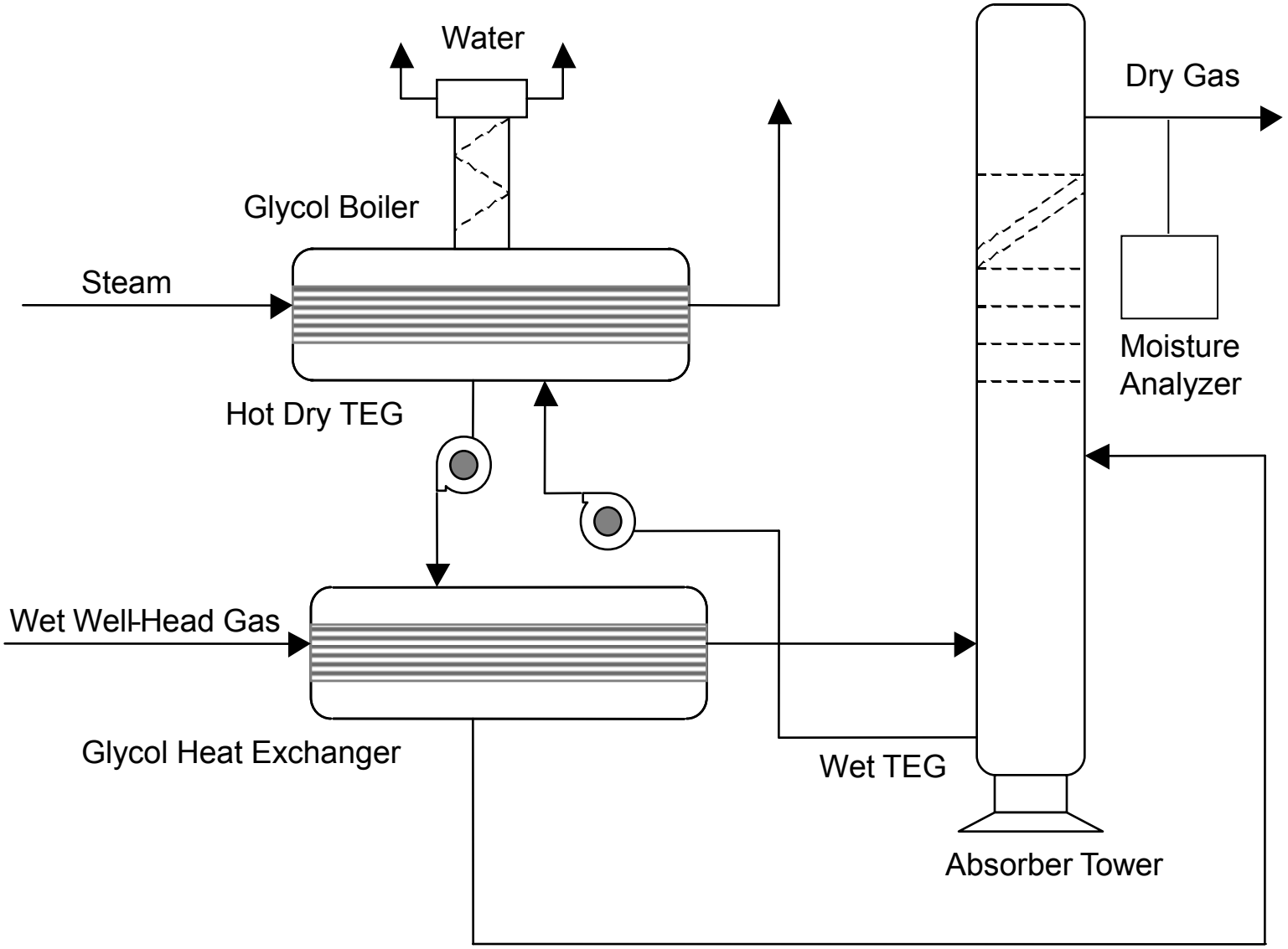
Gaseous	Product	Liquid
GAN	Nitrogen	LIN
GAR	Argon	LAR
GOX	Oxygen	LOX
CO2	Carbon Dioxide	-
H2O	Water	H2O
HC	Hydrocarbons	-

imagination at work

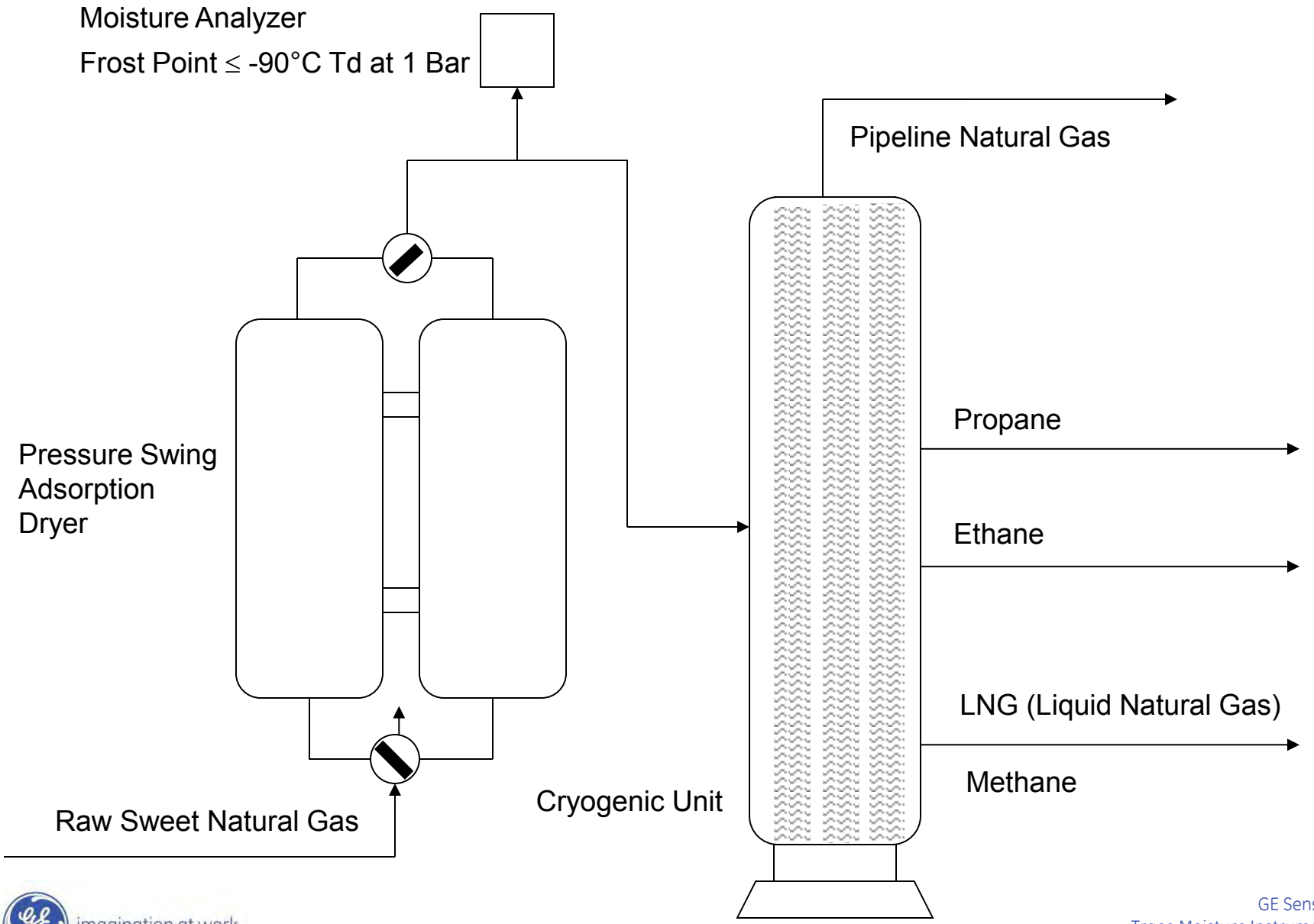
Trace Moisture in Natural Gas

- Water increases transportation cost
- In colder climates water freezes causing valves and pipes to be damaged or even blocked.
- Under pressure water combines with methane to form hydrates (an ice-like solid)
- Freezing can occur when high pressure gas is expanded (Joule-Thompson cooling – approximately 7 °F/100 PSID
- Water causes corrosion. It also combines with H_2S & CO_2 to form corrosive acids
- The maximum moisture content for US interstate commerce is 7 lbs/MMCF; Equal to approximately: -38.7°C/-36.4°F Frost Point at atmospheric pressure, 152 PPMv or 112mg/m^3
- Water lowers calorific content (heating value)
- Suppliers can be "locked in" if their moisture content is too high – cost the supplier lots of revenue!

Natural Gas TEG Drying System



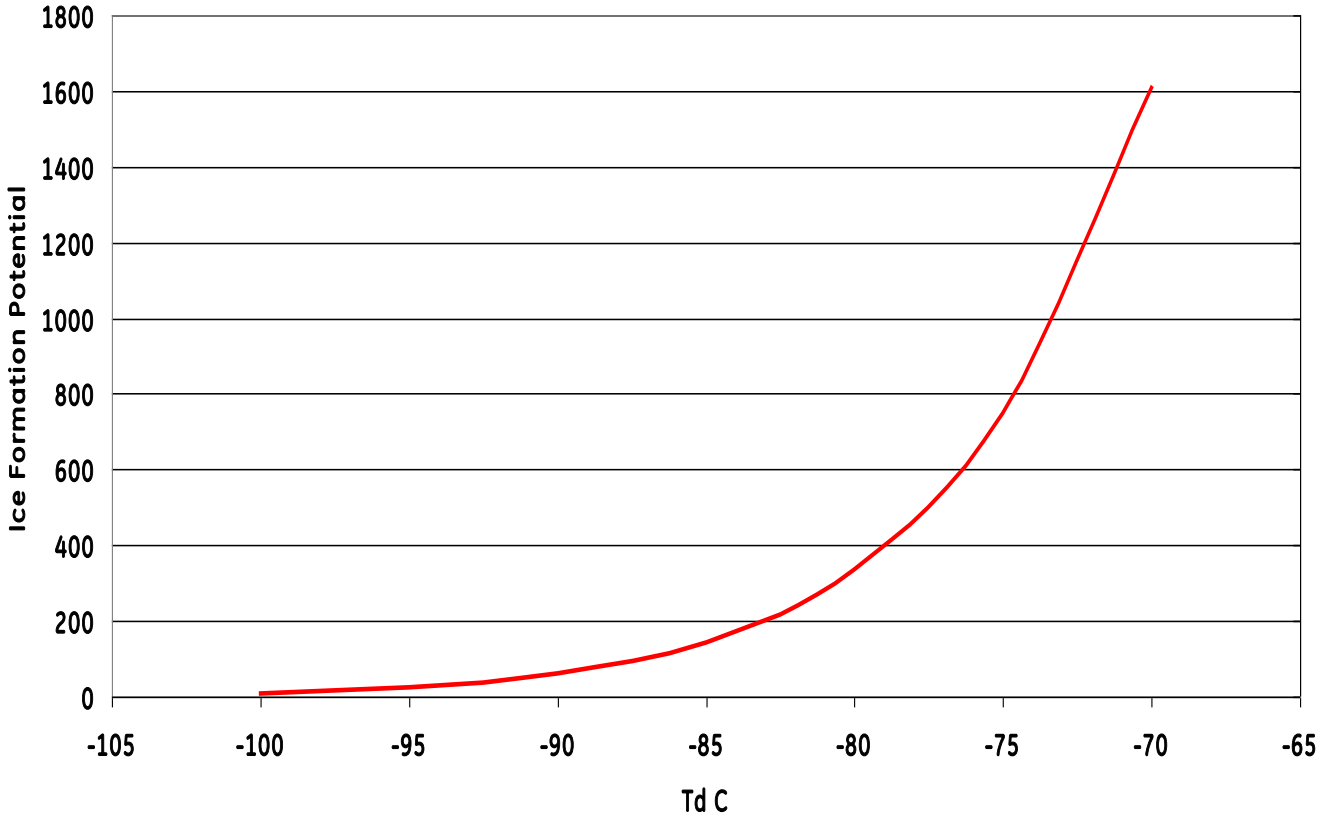
Liquid Natural Gas (LNG) and NGL (Natural Gas Liquids



Liquid Natural Gas (LNG) Processing
Ice Formation in the Cryogenic Unit

At frost points below -80°C ice crystals formed in the cryro are small and pass through the "screens".

As the frost point increases the formation of ice increases exponentially. Ice formation causes a loss of cooling efficiency (the ice is an insulator). Eventually the ice can block the flow.



Hydrogen Cooled Electric Power Generators

Due to high heat capacity Hydrogen is utilized to remove heat from the high power generators in this application. Hydrogen also has a very low viscosity (or windage), thus allowing higher capacity operation of the generators while maintaining efficient cooling.

The hydrogen must be kept free from moisture, for several reasons.

- Humidity increases the viscosity of the hydrogen (known as windage... windage is the resistance against the turbine blades)
- Humidity decreases the ability to carry away excess heat.
- Moisture deteriorates the seals on the rotating shaft causing leakage of the explosive hydrogen.
- Leaking seals necessitate costly generator rebuilds and operational downtime.
- Humidity increases the danger of arcing the high voltage (up to 12,000 V or more) and high current generators (arcing can lead to explosions)

SF_6 Filled Switchgear

Sulfur Hexafluoride a non-polar insulating gas used in switchgear. GE Sensing offers both continuous monitors and portable analyzers to insure that SF6 is dry. The portable analyzers predry the sensor resulting in minimal waste of expensive SF6. Typical dew points SF_6 are -60°C/ –76°F or dryer.

SF_6 has unique properties which render it a nearly ideal media for arc interruption and dielectric strength. The dielectric strength is greater than any other known media at the same density. The reason lies in the relatively large physical size and mass of the molecule. The size and mass help reduce the propagation of free electrons.

During arcing the SF_6 breaks down and is reformed. If moisture is present the Fluorine combines with water to make corrosive HF acids

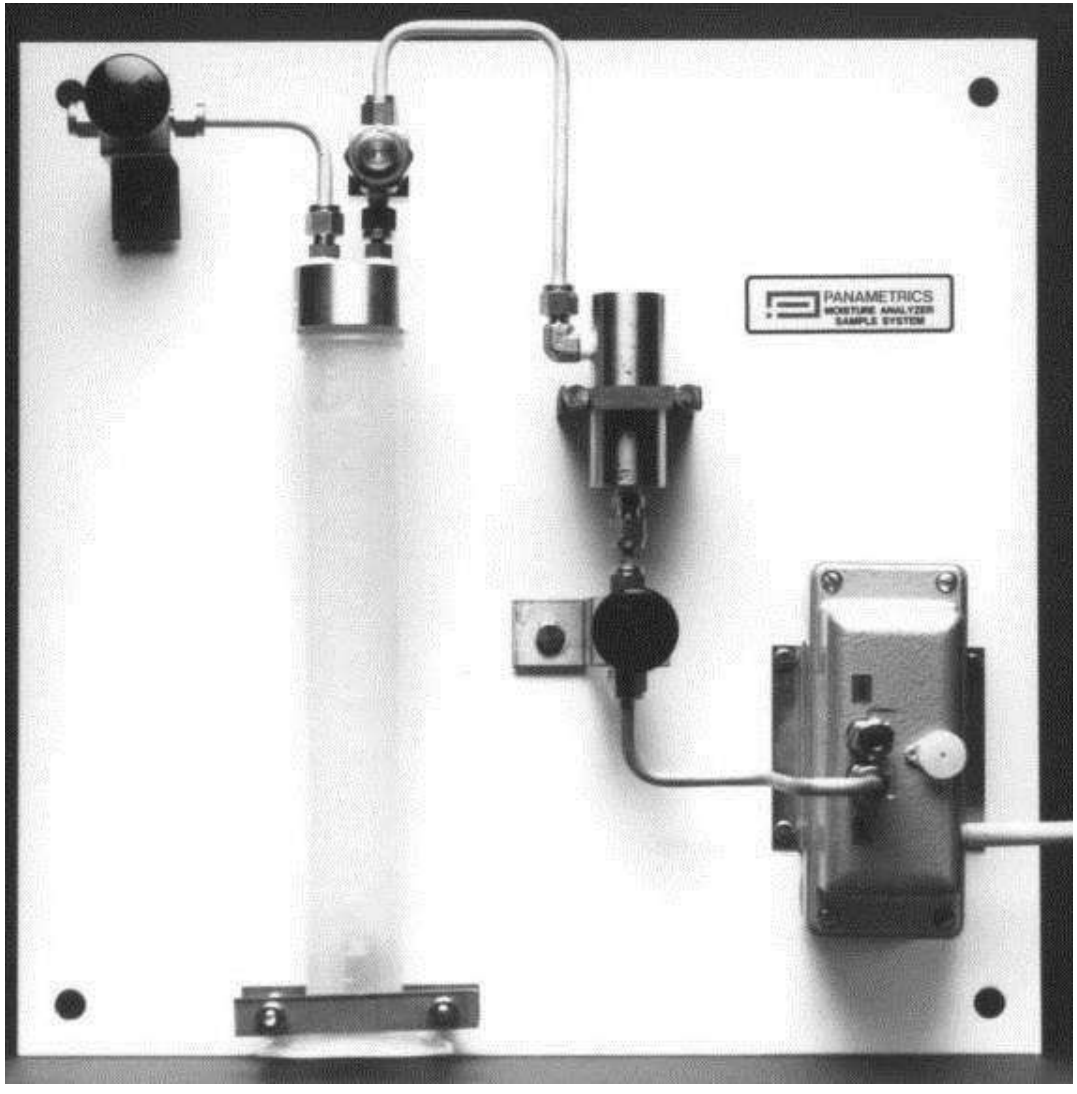
The PM-880 can be used with permanently installed sensors or the MMY-245 can be used to spot check and minimize wasted SF_6

GE Sensing – Moisture & Gas Measurement Instruments & Sampling Systems for Metal Heat Treating

Feed Gases

Furnace Atmosphere Monitoring

Oil Bath Sampling System for Heat Treating Furnaces



In this system oil is used to remove entrained particulate, oils and soot from the furnace.

A vacuum pump pulls a sample from the furnace

A cooling coil must be used upstream to reduce the sample temperature to the operating range of the sensor

Custom Mutliparameter Instrument Systems for Furnaces

GE M&C provides instrument cabinets for monitoring furnace atmospheres.

Measurements include:

- Moisture (Dew Point, ppmv…)
- Hydrogen (Purity or % composition)
- Oxygen (Trace levels)
- Combustibles

Saves the customer's time and money by having one source

- Prewired
- Control Valves for calibration gases
- Vacuum Pump or Eductor
- Pressure Regulation
- Filtration (must not alter moisture, H2 or O2 concentration)
- Control Drawing, Documentation
- Factory Acceptance Testing
- Combustibles Alarms
- Start up and comissioning service

Moisture, Oxygen and Hydrogen Analysis in Steel Production

Location: Burns Harbor, Indiana

Customer: ArcelorMittal Steel

Major Products: Full line of high quality flat rolled steels, including (AHSS) Advanced High Strength Steels and (UHSS) Ultra High Strength Steels

Application

- System upgrades for process control at the hot dip galvanizing line and continuous annealing line.
- In both applications, furnace atmosphere is critical to the quality of the steel strip product
- Atmosphere is 96% nitrogen, 4% hydrogen, with trace amounts of oxygen
- Trace (PPM) and percent oxygen measurements in H2/N2 gases
- Trace moisture measurement in H_2/N_2 gases
- Percent hydrogen in nitrogen measurement

Sheet Steel Galvanizing & Aluminizing

Location: Granite City, IL

Application: Purge air for furnace zones for cold rolled steel. Excess moisture creates scrap, wasted energy & materials.

Experiencing problems with water side heat exchangers leaking

3 zones per furnace

Sampling system with "oil bath" filter & vacuum pumps

Data sent to PC based control system – provides early warning before catastrophic problem occurs

Amount: $65K (3 furnaces x 3 zones = 9 points + spares)

Trace Moisture and Oxygen Measurement for Beverage Grade Carbon Dioxide

Carbon Dioxide (CO_2) is the gas that gives soda pop and beer it's "fizz". It is also used in a number of food processing applications including commercial bakeries and fruit distribution. CO_2 retards dough from rising and slows ripening of fruit. Specifications for "food grade" CO_2 have been set by the International Society of Beverage Technologists (ISBT). The specifications are listed at the right.

Parameter	Specification
CO_2 Purity	99.9 % v/v min
Moisture	20 ppm_v max
Oxygen	30 ppm_v max
Carbon Monoxide (CO)	10 ppm_v max
Ammonia (NH_3)	2.5 ppm_v
Nitric Oxide (NO)/Nitrogen Dioxide (NO_2)	2.5 ppm_v max
Non-volatile Residue	10 ppm_w max
Non-volatile Organic Residue	5 ppm_w max
Phosphine (PH3)	0.3 ppm_v max
Total Volatile Hydrocarbons (as Methane and including 20 ppm_v max of total non-Methane hydrocarbons)	50 ppm_v max
Acetaldehyde (CH_3CHO)	0.2 ppm_v max
Aromatic Hydrocarbon Content	20 ppb_v max
Total Sulfur Content (excluding Sulfur Dioxide)	0.1 ppm_v max
Sulfur Dioxide	1 ppm_v max

Beer Making & Bottling

Carbon Dioxide (CO2) produces the bubbles in beer (carbonation).

For "macro" breweries such as Anheuser- Bush in order to bottle beer at high speed the CO2 is removed. The CO2 is saturated and must be dried

After the "flat beer" is put into the bottles, dry CO2 is injected back in.

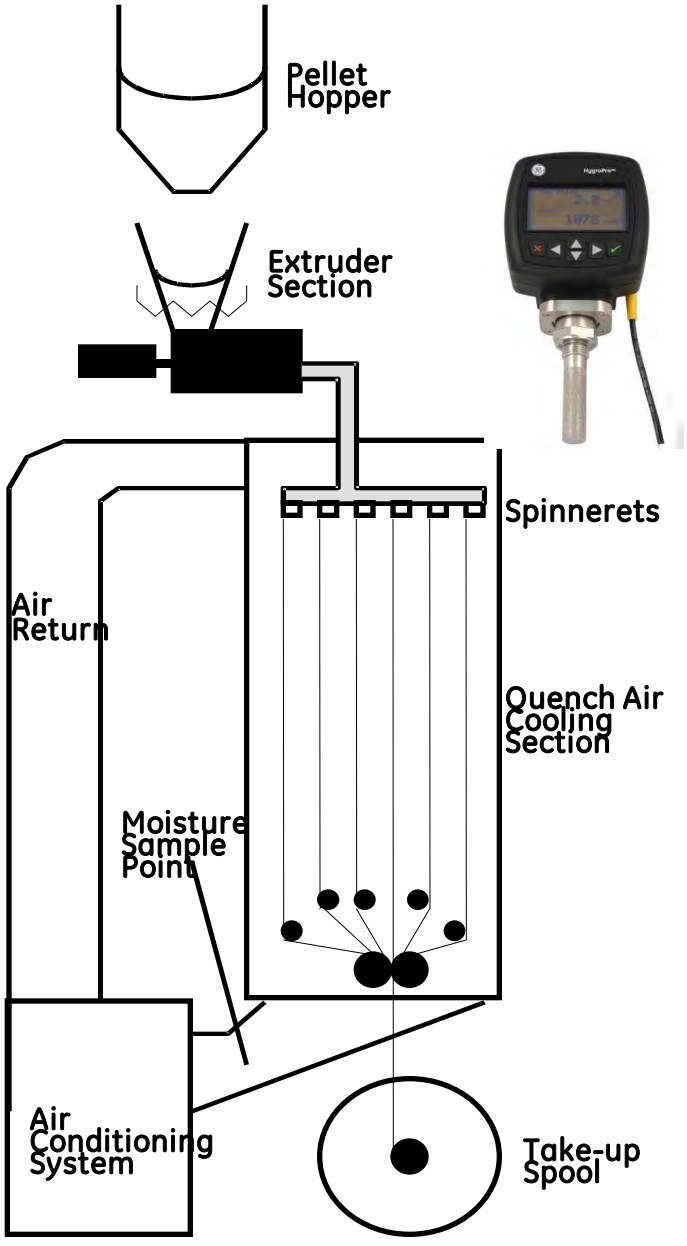
The CO2 is dried by "pressure swing" desiccant dryers.

GE's MMY30 is specified for their global operations

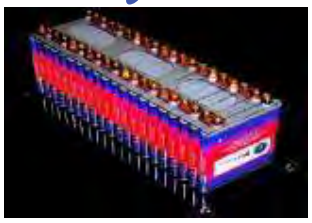
Synthetic Fiber Production

Synthetic fibers are produced by extruding polymer resins (Nylon, Polyester, Kelvar etc) with spinnerets. The fibers are drawn from molten resin and twisted. "Quench Air" is used to solidify the fibers.

For certain fibers the quench air must be dry while for other fibers the quench air must contain a specified amount of humidity



Lithium Battery Manufacturing



Electric, Gas Fired or Waste Heat with Blower

Reactivation Air

Reactivation Air

Exhaust Air

Dry is is typically delivered at –40 to –70°C Td

Dry Air

Process Air

Silica or Alumina Desiccant Imbedded in Honeycomb Structure

Process air is usually refrigerated to 5°C then reheated .

Lithium has become a generic term representing a variety of battery systems in which lithium metal is used as the active anode (negative) material. Variations in the cathode (positive) material and the cell's electrolyte result in hundreds of possible combinations of lithium batteries

Lithium batteries are processed under dry conditions as Li reacts violently with water to Lithium Oxide or Hydroxide + Heat!

Lithium is transported under dry Argon blanket

Process requirements are <-34°C Td and typically -60°C

Dry air is typically produced by rotary honeycomb heat reactivated desiccant dryers

Telecommunications, Radar, Antennas & Waveguides

Radio, radar and microwave transmission antennas and waveguides are purged with dry air to prevent, condensation, ice formation and for enhancement of signal transmittance.

As an EMF wave is propagated there is signal loss due the absorption by water

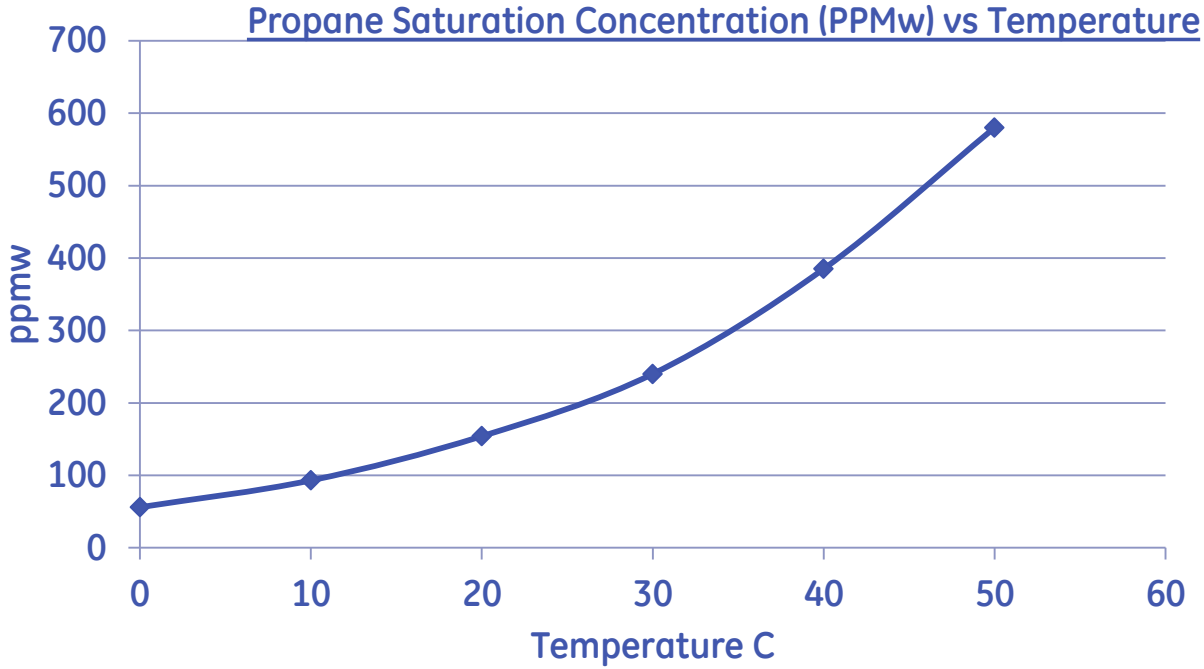
Telephone cables are also pressurized with dry air or Nitrogen

Glove Boxes

- Powder Handling
- Pharmaceutical Compounding
- Chemical Dispensing
- Instrument/Detector Containment
- Lithium Battery Manufacturing
- Hermetic Sealing and Welding
- Thin Film Production
- Electronic Component Manufacturing
- Nuclear Fuel

Moisture in Organic Liquids

Propane	C3H8
MW = 44	
T °C	PPMws
0	56
10	93
20	154
30	240
40	385
50	580



$$ppm_w = K \times P_w$$

$$K = \frac{ppm_{ws}}{P_{ws}}$$

$$ppm_w = \frac{ppm_{ws} \times P_w}{P_{ws}}$$

Another way of measuring moisture in liquids is the "Karl Fisher" . This requires a "grab sample" to be taken back to the lab.

Other methods include vaporizing the liquid but Joule Thompson Cooling and moisture ingress pose additional issues

K = Henry's Law constant
ppm_w = parts per million by weight
ppm_{ws} = parts per million by weight at saturation
P_w = Partial Pressure of water in the liquid
P_{ws} = Partial Pressure of water in the liquid at saturation

Our Website is the best place to get up to date additional information on our moisture and gas sensors and instruments

- Data sheets
- Application notes
- Product Manuals

www.ge-mcs.com

Thank you for your attendance.

Questions?

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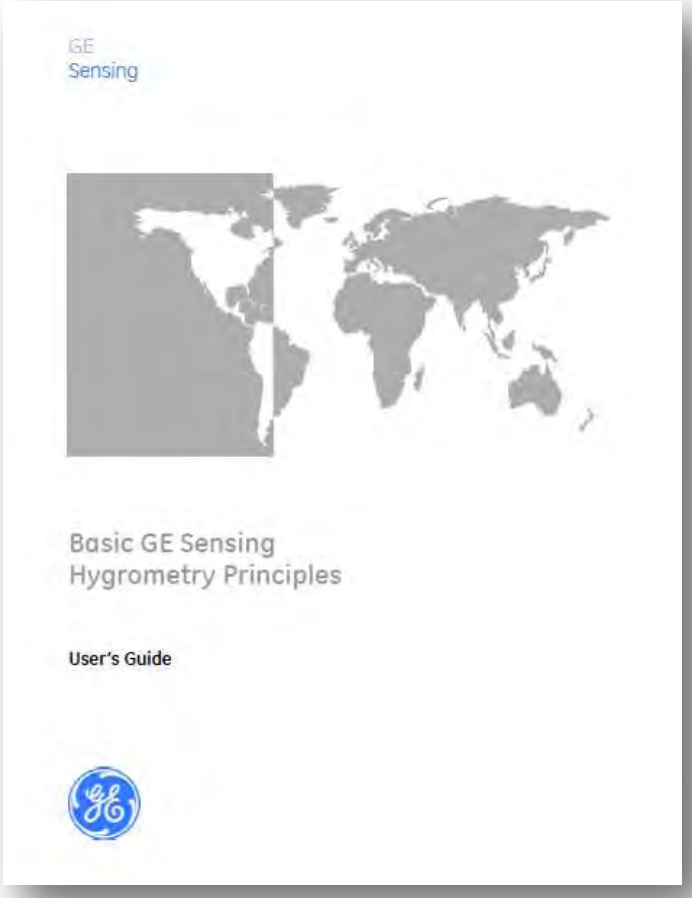

Thank You for Attending Today's Webinar

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