GE Infrastructure
Sensing

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A COMPARISON OF CHILLED MIRROR HYGROMETERS, CAPACITIVE OR RESISTIVE SENSORS AND WET/DRY BULB PSYCHROMETERS

	CHILLED MIRROR	SENSORS	WET/DRY BULB
Principle of Humidity Measurement	Primary temperature measurement of mirrored surface at equilibrium between dew or frost formation and evaporation. Mirror temperature control based on optical feedback.	Secondary: resistance or capacitance change with respect to water vapor concentration and temperature.	Secondary: Comparison of thermometer covered with wet wick against a dry thermometer. Rate of evaporative cooling based on the surrounding humidity, temperature & pressure.
Direct NIST Traceability	Yes – Primary Standard. . may also be validated at other Metrology labs within the uncertainty of their humidity standards	No – Secondary Measurement	No – Secondary Measurement
Calibration	Temperature measurement is calibrated against NIST temperature standards. Hygrometers are calibrated against master chilled mirrors (transfer standards) certified by NIST to primary national standard.	Resistance or Capacitance values are calibrated against a reference chilled mirror or two-pressure reference humidity generator. Multipoint %RH calibration at various temperatures is required to produce good accuracy across the operating range.	Thermometers or electronic temperature sensors (RTDs, ICs or Thermocouples) are calibrated against reference thermometers
Parameter Measured	Dew Point Temperature	Resistance (Impedance) or Capacitance	Wet bulb & dry bulb temperatures compared to published reference data.
Range	% RH: 0.05 to 99% Dew Point: -80 to +80°C	%RH Sensors %RH: 5-95% Dew Point: -20 to 80°C Al203 or other metal oxides: -90 to 0°C Dew Point.	Limited to Dew Points above 0°C and below 60°C for practical measurements
Minimum Humidity Measurement Range	-80°C frost point. -100°C by extrapolation.	%RH Sensors: 2% RH at 25°C Dry Bulb. Al2O3 & Metal Oxides: -80°C frost point. -100°C by extrapolation.	1°C for practical purposes.
Accuracy Based on 50% RH at 25°C	Dew Point: ±0.2°C %RH: ±.0.6% RH	%RH Sensors Dew Point: ±0.6-1°C %RH: ±2-5% RH	Dew Point: ±.0.5°C %RH: ±2.5% RH with 0.5°C accurate thermometers
Accuracy Based on 50% RH at 40°C	Dew Point: ±0.2°C %RH: ±0.6% RH	%RH Sensors Dew Point: ±1°C %RH: ±3-7% RH	Dew Point: ±1°C %RH: ±3.5% RH
Accuracy Based on 50% RH at 5°C	Dew Point: ±0.2°C %RH: ±0.9% RH	Dew Point: ±0.7°C %RH: ±3-7% RH	Dew Point: ±1.5°C %RH: ±8.5% RH
Dew Point Accuracy & Drift	±0.2°C – Negligible long-	Al2O3 & Metal Oxides:	N/A

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based on -40°C Dew Point	term Drift	±2°C with 2-10°C drift per year	
Dew Point Accuracy & Drift based on -80°C Dew Point	±0.2°C - Negligible long-term Drift	±2°C with 2-10°C drift per year	N/A
Effect of Barometric Pressure	No Effect. Measures Dew Point in situ.	No Effect. Measures % RH in situ. Enhancement factors should be applied to compensate for the deviation from an ideal gas at elevated pressures.	Published data is typically based on 1 Atmosphere. Readings must be adjusted for prevailing pressure.
Response Time	5-30 Seconds for 1 Time Constant (approximately 63% step change). Limited by cooling rate is 1°C/sec	5-120 Seconds for 1 Time Constant (approximately 63% step change).	5-120 Seconds for 1 Time Constant (approximately 63% step change).
Temperature Compensation of Humidity	None required. Measures Dew Point Fundamentally	Required for accurate readings. Humidity sensors use temperature coefficients (or linear approximations). Actual coefficients are not linear with respect to temperature and water vapor concentration.	None required, based on published data.
Temperature Operating Range	-40 to +80°C	-40 to 150°C	0-60°C for practical purposes. Measurements below 0°C is difficult.
Long Term Drift	<0.05°C Dew Point over Five Years	1-7% RH per year for %RH sensors 2-10°C Td for Oxide Sensors used for trace dew point	<0.2°C per year if RTDs are used. 1-5°C with Thermocouples.
Recommended Calibration Interval in Laboratory Setting	Yearly validation recommended. No offsets or adjustments are typically required.	Calibrate every 3 months for the first year then at least every year thereafter. More frequently in industrial applications where the sensor is subject to contaminants and environmental stress (such as outdoors). Oxide probes should be calibrated on a 6 month – 1 year frequency	Yearly calibration recommended for RTDs. More frequent calibration for Thermocouples, Thermometers and other types of temperature sensors.
Maintenance	Cleaning of mirror. Use of filters and utilizing the self-cleaning cycle (PACER) will minimize the requirement for manual cleaning.	No special maintenance required other than calibration. Certain sensors may be cleaned with specific solutions but may require calibration. Replacement of filters etc.	Replacement of wick when dirty and calibration.
Air Flow	Requires regulated airflow across sensor (0.5-5	May be installed directly in the process. Humidity	Requires controlled airflow across sensors and the

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	SCFH utilizing 1/4" OD tubing). Some sensors may be installed directly in the process. Sampling systems may be used as dew point is not changed unless condensation occurs or outside air leaks in.	sensor should be at the same temperature as temperature sensors. May be used in non-moving air/gas however airflow across the sensor facilitates a faster response and recovery from condensation.	use of distilled water for wet bulb. 30-60Ft sec.
Position Sensitivity	Negligible however for extremely dry conditions (less than –60°C) horizontal position provides faster response for accumulating frost layer	Negligible – Some sensors are only coated with polymer on one side. Sensor should face air flow	Position sensitive. Sensor must be perpendicular to air flow. The wick must remain in good contact with the sensor.
Over Range/Under Range Indication	GEI Chilled Mirrors indicate when the reading is stabilized	No indication	No indication
Environmental Contaminants	GEI Chilled Mirrors have automatic cleaning (PACER) and balancing which negates the effect of contaminants. "Mirror dirty" indication alerts user when manual cleaning is required. Mirrors are field replaceable without the need for calibration.	Physical contaminants generally slow down these sensors. Oil mist can coat the surface resulting in a vapor barrier, which slows down the response. Some sensors are field replaceable within a specified tolerance.	Contaminants on wick alter evaporative cooling which induces error. Wicks are field replaceable.
Chemical Contaminants	Chilled Mirrors cannot discriminate between water and other condensable such as hydrocarbons or alcohol. Generally can be used with chemicals that do not attack stainless steel, and various types of sealants and rubber or synthetic O-rings. (refer to GEI for a report on various chemical species)	Conductive salts interfere with resistive humidity sensors while polar compounds such as alcohol interfere with capacitive sensors. Reactive compounds can break down thin films and metallic coatings.	Contaminants on wick alter evaporative cooling which induces error. Only distilled water should be used for wet bulb.
Ability to recover from condensing environments	Fully recovers. Moving air facilitates faster recovery Sample lines, filters etc can be heated to avoid condensation.	Some sensors recover over time. Long-term exposure to condensation causes drift. Moving air facilitates faster recovery	Fully recovers. Moving air facilitates faster recovery
Ability to measure uniformity in a test chamber	Dew point measurement is based solely on water vapor pressure, which is uniform in a closed system. Multiple temperature sensors may be used to profile the %RH	Sensors based on %RH measurement vary in reading in a closed system due to thermal variance. Multiple %RH sensors are recommended to profile the system.	Wet/Dry Bulb Psychrometers vary in a closed system due to thermal variance. Several sensors may be required to profile the systems.

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	of the system		
Intrinsic Safety or Explosion Proof.	GEI's CM sensors are not FM approved for hazardous environments however the wetted parts are inert and do carry or store electrical energy.	Certain sensors are available in intrinsically safe & explosion proof configurations	Many Thermometers, RTD elements, thermocouples and thermistors are considered "simple devices". Intrinsic safety barriers may be required.
Cost	$1.2-$24K	$150-$6,000	$50-$4,000