**D-ZERO
INSTRUMENT AIR SYSTEM
HUMIDITY TRANSMITTER EVALUATION**

T.J. SERGES

7-15-88

D-ZERO ENGINEERING NOTE 3740.515-EN-169

APPROVED: _____

A handwritten signature in black ink, appearing to read 'T.J. Serges', is written over a horizontal line that follows the 'APPROVED:' label.

INTRODUCTION:

This report shows the findings that resulted in the purchase of the optimum dew point hygrometer for use in the D-Zero instrument air system (see diagram 2 on page 9). The hygrometer will monitor the air system to insure that the dew point level does not go above the normal operating output of the driers (this precise value will be determined during initial system start-up). The following criteria was used in the evaluation:

1. Long term durability
2. Minimum calibration
3. Indicate a dew point level down to -40°C accurately
4. Designed to work in a low humidity region
5. Minimum maintenance
6. Fast response time
7. Lowest cost provided all other criteria is met

COMPANIES CONSIDERED:

The following companies carrying hygrometers were considered:

1. EG & G Environmental Equipment
2. General Eastern Instruments
3. Vaisala Sensor Systems
4. Sahara Air Dryers
5. SHAW Moisture Meters
6. Rosemont Analytical Division- Beckman Industrial
7. Panametrics

HUMIDITY SENSOR TYPES CONSIDERED:

This is a list of the possible types of sensors that could be used before applying any criteria.

1. Wet bulb/ dry bulb (Psychrometer)
2. Saturated salt-type dew point sensor
3. Aluminum oxide sensor
4. The electrolytic hygrometer (Phosphorous pentoxide)
5. Optical condensation hygrometer
6. Infrared humidity/moisture detector

An infrared humidity/moisture detector generally costs well above any of the other instruments considered. For detection of water vapor in gaseous atmospheres, IR devices have found only limited applications. They are primarily for use as moisture detectors in solid materials.

The hygrometer will be used in a low humidity area which makes the wet bulb/dry bulb psychrometer and the saturated salt-type dew point sensor impractical considerations. The electronic wet bulb/dry bulb psychrometer is economical, but accuracy is seriously impaired below a relative humidity of 20%. Also, a wet bulb psychrometer is a source of moisture. The saturated salt-type dew point sensor cannot be used to measure dew points below a relative humidity of 11%, and have a relatively slow response time due to the bobbin control process. For applications requiring great accuracy, and for humidities lower than 11% relative humidity, condensation-type, electrolytic, or aluminum oxide hygrometers should be considered.

The aluminum oxide sensor is economical and suitable for very low dew point levels without the need for sensor cooling (as in condensation-type sensors). Typically, dew points down to -100° F can be measured without great difficulty. The sensor device must be periodically calibrated to accomodate aging

device must be periodically calibrated to accomodate aging effects, hysteresis, and contamination. It has lower accuracy than other measurement sensor types and can provide reliable data only if kept in calibration and if damage due to incompatible contaminants is avoided.

The electrolytic hygrometer gives reliable performance for prolonged periods in the low PPM region, if the gas is clean. An electrolytic hygrometer must be set up using a sampling system. A sampling system is used to carry a gas sample from the main flow to a remote sensor, which means additional stainless steel tubing, fittings, related gages and pressure reducers. Adding all this up, the sampling component costs often exceed those of the hygrometer. The sampling system also means a slower response time than direct line sensors. If contaminants damaging to phosphorous pentoxide (P_2O_5) get in, the entire electrolytic cell must be replaced.

None of the above devices measure the dew point directly. They either measure the relative humidity or PPM from which a monitor must be used to calculate the dew point based on the pressure. This makes these hygrometers secondary measuring devices for dew point. The only primary measuring device for dew point is the optical condensation type dew point hygrometer. This type of hygrometer has become one of the most accurate and reliable humidity instruments offering a broad measuring range and excellent repeatability. These features are achieved at the expense of increased complexity and initial cost. In the optical dew point hygrometer, a mirror is cooled by a thermoelectric or Peltier cooler until dew or frost begins to condense on its surface. The condensate surface is maintained electronically in vapor pressure equilibrium with the surrounding gas and surface condensation is detected by optical, or in some cases, electrical techniques. The condensation surface, when maintained at the temperature at which the rate of condensate exactly equals the evaporation, is

at the dew point temperature by definition. Problems may be experienced with this instrument when soluble salts of condensable vapors other than water (such as hydrocarbons) are present in the gas stream. The reason for this is that the instrument tends to control on the highest vapor component present in stream, which may not be the water vapor constituent. On the other hand, the inert construction of the device gives a long life expectancy and makes it easy to maintain. Most instruments employ condensation chambers which can be quickly opened allowing the mirror to be cleaned with a suitable swab.

The optical condensation hygrometer exceeds the performance of the aluminum oxide and electrolytic hygrometers for this particular application. The optical condensation hygrometer needs no calibration, no sampling system, is easy to clean and maintain, and will work continuously for long periods of time.

The companies that produced optical condensation hygrometers meeting the criterias previously stated were the following:

1. EG & G Environmental Equipment
2. General Eastern Instruments

EG & G Environmental produces the Model 200 Dewtrak™ Humidity Transmitter. General Eastern Instruments produces the M1(auto)/1211H Dew point Hygrometer with monitor. The following page shows the general specifications for each product.

GENERAL SPECIFICATIONS

		COMMENTS	
COMPANY:	EG & G Environmental Equipment	General Eastern Instrument	<i>both reputable companies</i>
MODEL:	Dewtrak Series 200 transmitter extended range	M1/1211H Monitor with sensor	<i>Dewtrak sensor works alone M1/1211H needs a monitor</i>
DEW POINT RANGE:	-40° C to 60° C	-35° C to 93° C (requires optional water cooling jacket for -40° C	<i>need -40° C capability so the M1/1211H needs liquid cooling</i>
ACCURACY:	± 0.6° C, Nominal	± 0.2° C, Typical	<i>below ± 1° C is excellent</i>
OPERATING TEMPERATURE:	-40° C to 72° C	-15° C to 93° C	<i>will operate at room temperature</i>
OPERATING PRESSURE:	100 psi max	0 to 300 psi range	<i>need 100psi capability can go up to 120 psi Dewtrak has safety factor of 2 can handle 120</i>
EQUIVALENT RH RANGE:	1% to 99%	1% to 100%	<i>low relative humidity expected</i>
BODY CONSTRUCTION:	Aluminum	Aluminum	
POWER:	24 VDC, 24 VAC, 115/220 VAC	115/230 VAC from monitor	
COST OF SENSOR:	\$1875	\$1775	<i>comparable price for sensor alone</i>
NECESSARY OPTIONS:	200 RK Remote mounting kit \$275 200 PF Pipe mount \$55	CJ-12 water cooling jacket \$100 M1(auto) monitor \$1295 1123HK Cables \$225	<i>For the M1/1211H water lines are necessary along with a monitor. The Dewtrak needs a mount</i>
TOTAL COST:	<u>\$2205</u>	<u>\$3395</u>	<u>Dewtrak is big savings</u>

Our application for the hygrometer is only for measuring dew point. Particularly, it will help to determine when the dew point of the compressed air from the dryers in the air system exceeds an acceptable value. The monitor with the M1(auto)/1211H gives unnecessary information which is still part of the cost. The M1(auto)/1211H cannot operate without its specific monitor. The Model 200 Dewtrak can operate on its own and hook up to the microcomputer used in the system. This makes the Dewtrak \$1190 lower in total cost. The Dewtrak also avoids the need for water cooling lines to monitor a dew point level at -40° C. Although the Dewtrak does not come with a monitor the instrument incorporates self-diagnostic circuitry which indicates to the user, logically via an LED light source, and remotely via a logic level TTL signal, when and if maintenance is required. The Dewtrak also, features a unique sensing scheme which discriminates between dew and contaminations, and continuously compensates for any variations in humidity measurements due to mirror contamination or component variations. **These benefits along with the low cost makes the EG & G Environmental Equipment Model 200 Dewtrak™ Humidity Transmitter the best choice.**

The Model 200 Dewtrak™ Humidity Transmitter will need a pipe mount to attach the sensor into the piping system. The sensor tip is 1-1/4" diameter while the air system piping is 1" in diameter and expands to 2" diameter. A special tee fitting will be used to allow the sensor to be in the flow. The entire sensor does not have to be in the flow, only about 1/4" of the tip which is enough for flow to go through four holes to the mirror. A remote mounting kit using a six foot cable will also

DIAGRAM 1. SPECIAL TEE FITTING FOR SENSOR

be used to mount the transmitter against the wall or on a panel, out of the way. The transmitter provides a standard 4-20 mADC output for the range of dew point temperatures. Under normal operating conditions, the output current ("I") will track the Dew Point Temperature (in DEGREES CENTIGRADE) of the gas stream, according to the following output transfer function

$$\text{DEW POINT TEMP (}^{\circ}\text{C)} = [I(\text{mADC}) - 10.4] \times 6.25$$

Example: a 4 mADC output current corresponds to -40°C , i.e.: $(4 - 10.4) \times 6.25 = -6.4 \times 6.25 = -40^{\circ}\text{C}$. The output current transfer function, expressed in DEGREES FARENHEIT is:

$$\text{DEW POINT TEMP (}^{\circ}\text{F)} = [I(\text{mADC}) - 7.555] \times 11.25$$

This model will use the optional 115 VAC supply voltage.

The local distributor for this model is

RAECO INC.
550 Armory Drive
S. Holland, IL 60473
312-331-6001

D0 Instrument Air System

DIAGRAM 2

GTM 5/27/88

Serving the humidity and moisture market for over 20 years.

DewTrak™ Humidity Transmitter*

the DewTrak™ series....

A New Generation of Advanced State-of-The-Art Optical Chilled Mirror Dew Point Hygrometers

FEATURES

- ☞ Primary Measurement Technique.
- ☞ High Accuracy and Reliability. Certificate of Traceability to NBS Provided.
- ☞ NEW Sensing Scheme* Discriminates between Dew and Contamination. Virtually No Maintenance Required.
- ☞ No Drift, No Hysteresis.
- ☞ Fast Response.
- ☞ No Calibration Required.
- ☞ Self-Diagnostics and Continuous Unattended Operation. No Balancing or Other Adjustments Required.
- ☞ Low Cost.

APPLICATIONS

The DewTrak™ Humidity Transmitter, Model 200, is designed for continuous monitoring of air and other gases where a cost-effective, high reliability measurement of humidity will contribute to significant energy cost savings, or improve product or process quality. Applications include:

- HVAC/Energy Management
- Manufacturing and Process Areas
- Storage Areas
- Clean Rooms
- Process Control

DESCRIPTION

The DewTrak™ Humidity Transmitter, Model 200, is a low power, blind transmitter which consists of a sensor probe and an electronic control unit. The control unit is housed in a plastic or aluminum enclosure. The aluminum enclosure enhances the depression capability of the system due to an improvement in the heat transfer from the system to ambient. This instrument combines the inherent accuracy, reliability, and long-term stability of optical chilled mirror technology with a new electro-optical sensing scheme, to provide continuous, repeatable, and low-cost humidity measurements.

The DewTrak™ Humidity Transmitter features, for the first time, a new, unique sensing scheme which discriminates between dew and contaminations, and continuously and on-line compensates for any variations in humidity measurement due to mirror contamination or component variations. **THERE IS NO NEED TO HEAT THE MIRROR AND BALANCE THE INSTRUMENT TO COMPENSATE FOR CONTAMINANTS ON THE MIRROR!! THERE IS NO NEED TO CLEAN THE MIRROR!!** The instrument incorporates self-diagnostic circuitry which indicates to the user, locally via an LED light source, and remotely via a logic level TTL signal, when and if maintenance is required.

PRINCIPLE OF OPERATION

Dew point temperature measurement is made using a direct-measuring sensor utilizing a Peltier-cooled, NEBS™ mirror, automatically held at the dew point temperature by a photosensing, condensate-detecting, optical system incorporating a LED light source and photodetector. As condensate

forms on the mirror, the optical sensing bridge detects the change in light level that occurs when dew or frost forms on the mirror and develops a proportional control signal that modulates the thermoelectric cooler current. This control scheme permits the mirror to continuously track the dew point. **THIS TECHNIQUE IS A PRIMARY MEASUREMENT OF THE WATER VAPOR CONTENT OF THE GAS.** The mirror temperature represents the true dew point temperature and is measured by an imbedded precision platinum resistance thermometer. For dew points below 0°C, the system tracks the frost point.

OPTIONS

- Model 200-S2 Extended Range Dew Point Sensor
- Model 200-AT Ambient Temperature Kit.
- Model 200-AR Aspirator (for no flow conditions, Self-Powered, Slide-On Unit).
- Model 200-RH Humidity Computer, % RH or other Psychrometric Variables.
- Mounting Configurations
  - Model 200-FM Flange Mount (for duct mounting).
  - Model 200-PF Pipe Mount (compression fitting, 1¼-inch npt).
  - Model 200-RK Remote Mounting Kit, 6 feet standard (extra lengths available).
- Model 200-SV Supply Voltage, 115/230V AC, 50/60 Hz.

SPECIFICATIONS

Dew Point Range:	–40°F (–40°C) to Near Ambient Temperature (see below)
Dew Point Depression:	80°F (45°C) with Standard Range Sensor, Nominal 108°F (60°C) with Extended Range Sensor, Nominal*
Ambient Temperature Range:	–40°F to +140°F (–40°C to +60°C)
Equivalent RH Range:	5% to Near Saturation with Standard Range Sensor Approximately 1% to Near Saturation with Extended Range Sensor*
Pressure:	100 psig, Maximum. (With Aspirator Option, Atmospheric Pressure Only)
Flow:	Static to 3000 Linear Feet/Minute. (Aspirator Option Available for Faster Response Under No Flow Conditions.)
Operating Temperature:	Sensor: –40°F to +160°F (–40°C to +72°C). Higher Temperatures Available, Consult Factory. With Aspirator Option, –4°F to +122°F (–20°C to +50°C). Control Unit: +32°F to +122°F (0°C to +50°C).
Accuracy:	±1°F (±0.56°C), Nominal
Temperature Sensor(s):	Platinum Resistance Thermometer, 100 ohms Nominal at 0°C
Output(s):	Dew Point: 4 to 20mA DC over span of –40°F to +140°F (–40°C to +60°C) (Standard). Ambient Temperature: 4 to 20mA DC over span of –40°F to +140°F (–40°C to +60°C) (Optional) % RH: 4 to 20mA DC over Span of 0% to 100% RH Clean Mirror Signal: TTL Compatible (Standard). Relay Contact Closure (Optional).
Supply Voltages:	24V DC, +25%, –50%, or 24V AC, +10%, –15%, 50/60 Hz (Standard-Field Programmable)
(Maximum Supply Current at 24V DC, 850mA)	115/230V AC, +10%, –15%, 50/60 Hz (Optional)
Weight:	3.5 lbs, plastic; 4.75 lbs, aluminum
Sensor Materials:	Inert NEBS™ Mirror, Glass, Epoxy, Anodized Aluminum
Enclosures:	ABS Plastic (Dust-Tight and Watertight), or Aluminum (Ventilated)* Input/Output Ports: Strain Relief Watertight Cable Glands (Plastic). ½-inch Conduit Access, Optional.

*ALUMINUM ENCLOSURE REQUIRED FOR EXTENDED RANGE SENSOR AND/OR % RH OPTIONS.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

EG&G ENVIRONMENTAL EQUIPMENT

217 MIDDLESEX TURNPIKE, BURLINGTON, MA 01803
TEL: (617) 270-9100 • TELEX: 6817440 EGG • FAX: (617) 270-9724

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- reputable

DewTrak™ Series

Chilled Mirror Dew Point Hygrometers Transmitter and Portable

THE MODEL 200 DewTrak™ HUMIDITY TRANSMITTER

The DewTrak™ Humidity Transmitter is a low power, blind transmitter designed for continuous monitoring of relatively clean air or other gases in applications such as HVAC/Energy Management; Manufacturing and Process Areas; Storage Areas; and Clean Rooms.

BASIC EQUIPMENT

Model 200 Transmitter

Consists of a dew point sensor probe with cover and filter; and an electronics box suitable for wall mounting. Power: 24V DC or 24V AC (field programmable); output 4-20mA DC over range of -40°F to +160°F, or -40°C to +60°C.

⇒ Standard Range (45°C depression) \$1,575.00
Extended Range (60°C depression) \$1,875.00

OPTIONS

Model 200-AT Ambient Temperature

\$ 395.00

Consists of 100-ohm platinum resistance thermometer mounted on dew point sensor probe, and signal conditioning circuitry. Output 4-20mA DC over range of -40°F to +160°F, or -40°C to +60°C (specify).

FACTORY INSTALLATION REQUIRED

Model 200-RH Humidity Computer

\$ 595.00

Consists of microprocessor-based PCB which permits computation of either %RH or other psychrometric data (specify). Output 4-20mA DC.

Note: Model 200-AT Ambient Temperature Kit required.

Model 200-SV AC Supply Voltage

\$ 95.00

Consists of transformer and related circuitry for 115/230V AC, +10%, -15%, 50/60 Hz operation (field programmable).

FACTORY INSTALLATION REQUIRED

Model 200-AR Aspirator

\$ 295.00

Consists of DC motor and fan mounted into an anodized aluminum housing. This assembly slides on to the dew point sensor probe, replacing the standard sensor cover.

⇒ Model 200-RK Remote Mounting Kit

\$ 275.00

Consists of 6-foot cable assembly with strain reliefs and mounting hardware.

Model 200-FM Flange Mount

\$ 75.00

Consists of mounting plate and neoprene gasket.

Model 200-PF Pipe Mount

\$ 55.00

Consists of brass slip-on compression fitting, 1¼-inch NPT.