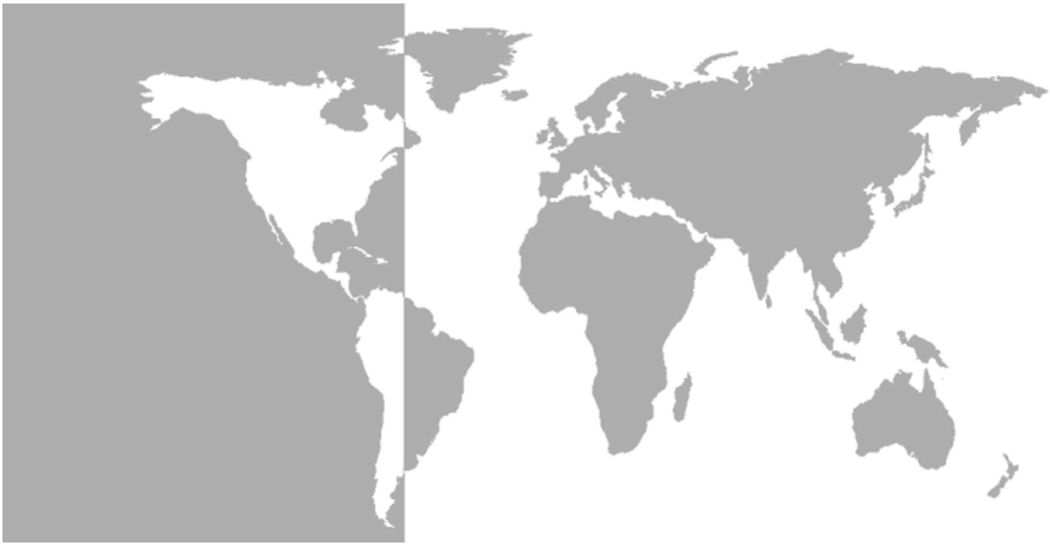
GE
Sensing



HYGRO M4/E4

General Eastern Dew Point Monitor

Operator's Manual

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HYGRO M4/E4 Dew Point Monitor is a General Eastern Instruments product. General Eastern Instruments has joined other GE high-technology sensing businesses under a new name—GE Sensing.

Warranty

Each instrument manufactured by GE Sensing is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of GE Sensing. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If GE Sensing determines that the equipment was defective, the warranty period is:

- one year for general electronic failures of the instrument
- one year for mechanical failures of the sensor

If GE Sensing determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified by GE Sensing, the repairs are not covered under this warranty.

The warranties set forth herein are exclusive and are in lieu of all other warranties whether statutory, express or implied (including warranties or merchantability and fitness for a particular purpose, and warranties arising from course of dealing or usage or trade).

Return Policy

If a GE Sensing instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify GE Sensing, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, GE Sensing will issue a RETURN AUTHORIZATION number (RA), and shipping instructions for the return of the instrument to a service center will be provided.
2. If GE Sensing instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.
3. Upon receipt, GE Sensing will evaluate the instrument to determine the cause of the malfunction.

Then, one of the following courses of action will then be taken:

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
- If GE Sensing determines that the damage is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs at standard rates will be provided. Upon receipt of the owner’s approval to proceed, the instrument will be repaired and returned.

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Chapter 1

Features and Capabilities

Introduction

The GE Sensing Hygro M4 and Hygro E4 are multi-purpose chilled-mirror hygrometers, suitable for use in a wide variety of applications. The units can be mated with any of the five GE Sensing chilled-mirror sensors to provide the following overall measurement ranges (depending on the sensor selected):

- dew/frost point from –80°C to +85°C (–112°F to +185°F)
- relative humidity from 0.002% to 100%
- moisture content from 500PPBv to over 1.3 x 10^6 PPMv

The Model M4 is a benchtop indicator, with rack- and panel-mount adapters available.

The Model E4 is functionally identical, but designed for wall or surface mounting. It is housed in a gasketed, NEMA-12 steel enclosure, suitable for industrial environments. The E4 can be ordered with either one or two displays.

Three sensing configurations of the unit are available: the **-DP**, the **-RH** and the **-PR**. For example, the Model M4-DP is a benchtop unit which displays dew point. Each configuration is described in the section *Hygro M4/E4 Configurations* on page 1-6 of this manual.

Available interfaces include the following:

- Analog outputs: 4–20mA and 0–5 VDC (single or dual, depending on the version)
- Alarm relay (Form C, 5 Amp)
- 4–20mA and Resistance Temperature Detector (RTD) inputs (Model M4-RH only)
- 4–20mA Pressure Sensor inputs (Model M4-PR only)
- RS-232C communications

Introduction (cont.)

The Hygro M4/E4 utilizes advanced microprocessor control, and all models include the GE Sensing patented *Programmable Automatic Contaminant Error Reduction* (PACER) system to insure accuracy.

Detailed specifications for the Hygro M4/E4 are given in Appendix A.

System Components

The complete system consists of the following items:

- The electronic monitor
- Dew point sensor
- Interconnecting sensor cable
- AC line cord
- Temperature sensor (optional: Model **-RH** only)
- Pressure sensor (optional: Model **-PR** only)
- Maintenance kit
- Operator’s manual
- Certification that the unit is traceable to the National Institute of Standards and Technology

Hygro M4

The Hygro M4 dimensions are shown in Figure 1-1 below.

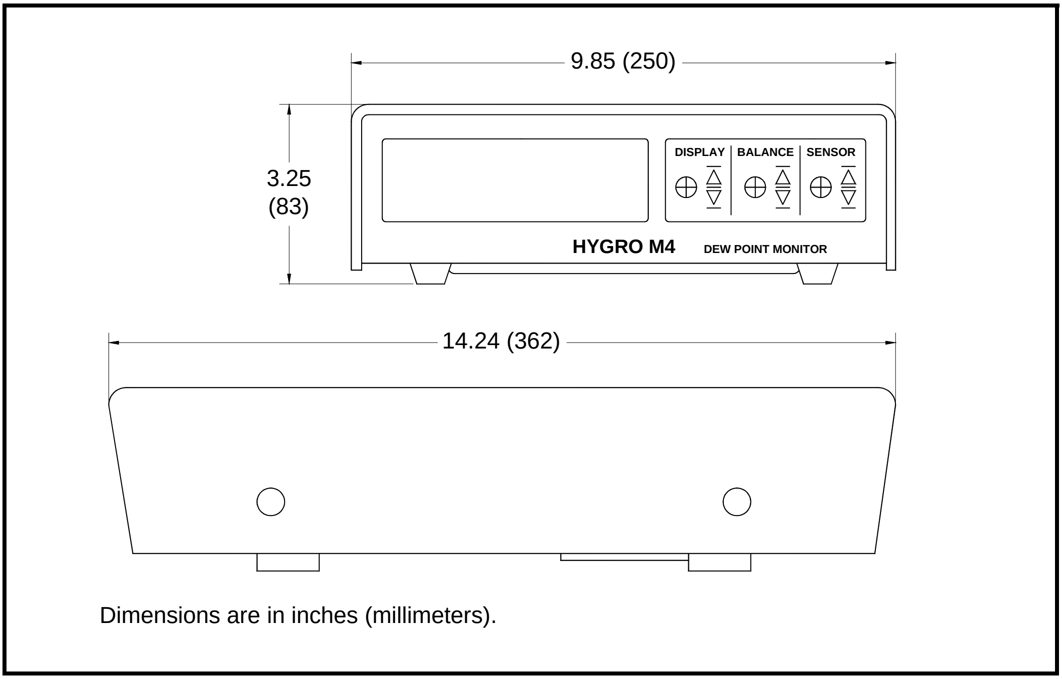


Figure 1-1: Hygro M4 Outline Dimensions

Hygro M4 (cont.)

The M4 front panel, shown in Figure 1-2 below, includes a **CONTROL** light, digital displays for **DEW POINT** and **STATUS**, and three switches: **DISPLAY** (controls display and alarm settings), **BALANCE** (controls manual or automatic balancing of the system) and **SENSOR** (overrides automatic temperature control of the sensor with manual heating or cooling).

Figure 1-3 below shows the rear panel of the Model M4 dew point monitor, illustrating its input and output connectors and the RS-232C connector.

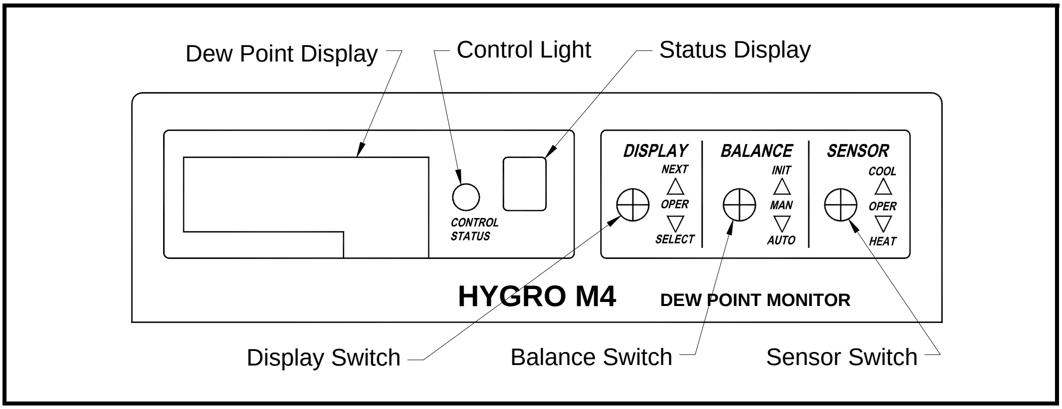


Figure 1-2: Hygro M4-DP Front Panel

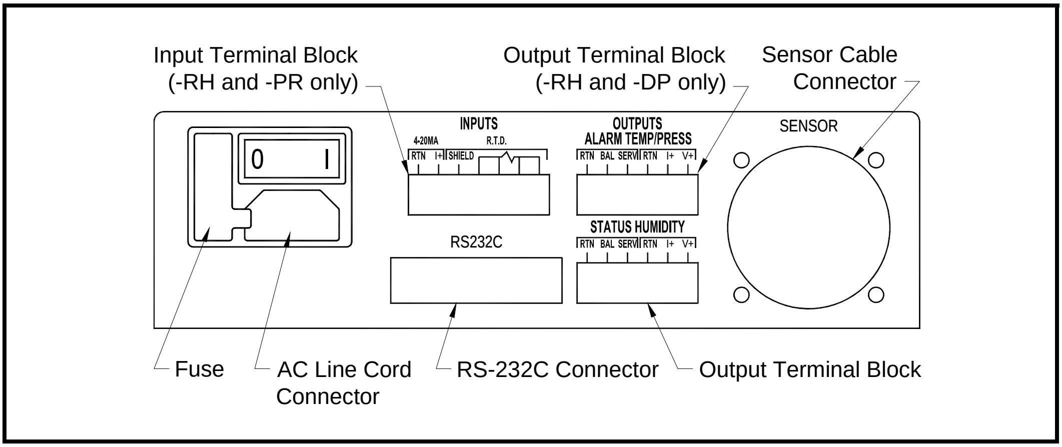


Figure 1-3: Hygro M4 Rear Panel

Hygro E4 The Hygro E4 dimensions are shown in Figure 1-4 below.

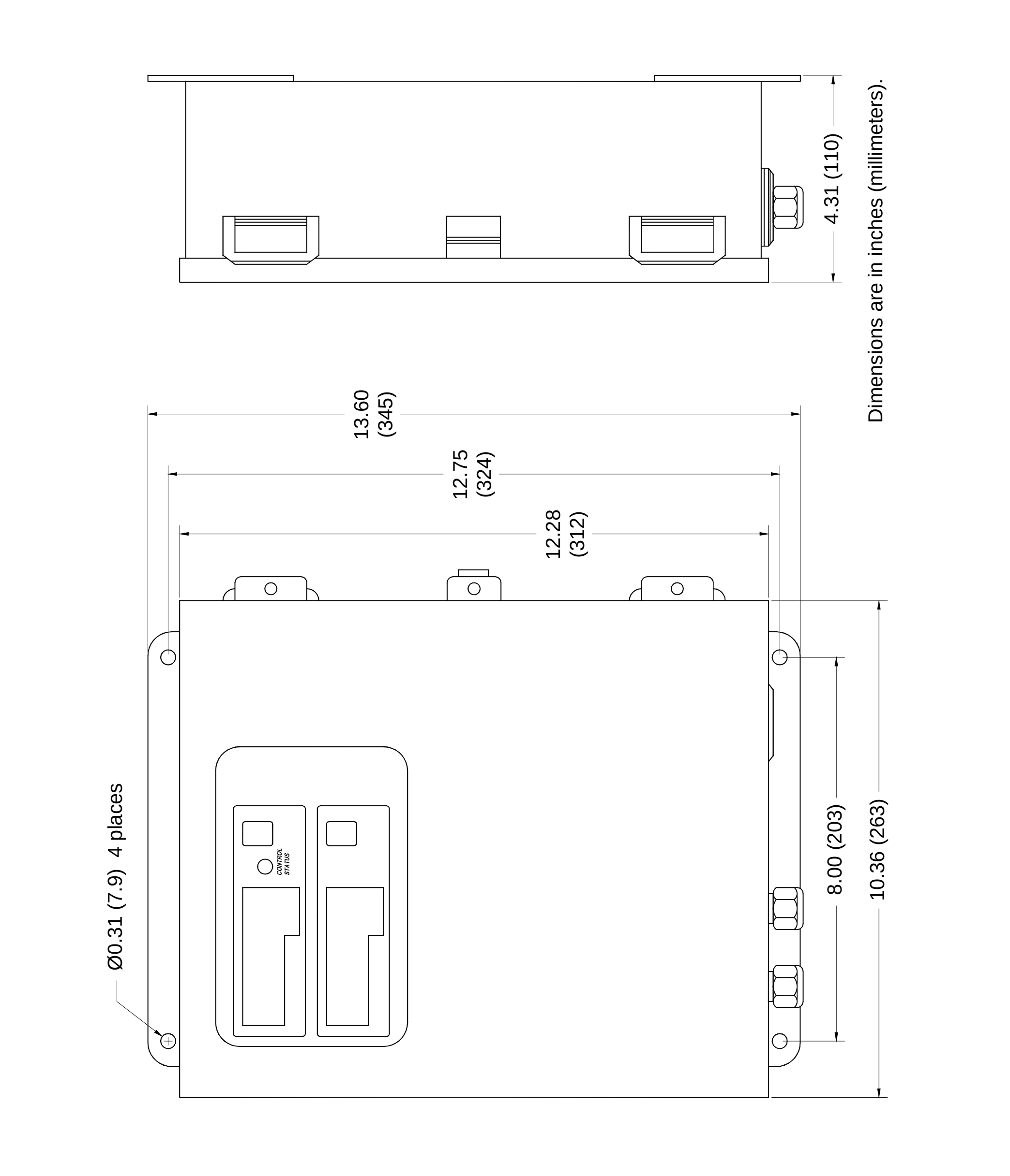


Figure 1-4: Hygro E4 Outline and Mounting Dimensions

Hygro M4/E4 Configurations

The M4 is a benchtop model hygrometer; the E4 is designed for surface mounting on a vertical wall or panel. Each model is available in three configurations:

- the **-DP** (displays dew point only)
- the **-RH** (displays dew point and relative humidity)
- the **-PR** (displays dew point and vapor concentration)

A configuration label identifying the version of the Model E4 is attached to the inside of the front door. Configurations of the M4 can be identified by examining the front panel as described below.

Model M4/E4-DP

The M4/E4-DP is the basic model. It measures and displays humidity as dew/frost point only. It accepts input from a GE Sensing chilled mirror sensor, and provides a single analog output (4–20mA and 0–5VDC) as well as an RS-232C communications port.

As shown in Figure 1-5 below, the Model -DP has no **ALARM** annunciator at the left of the main LED display, and no parameter annunciators at the bottom right of the main LED display.

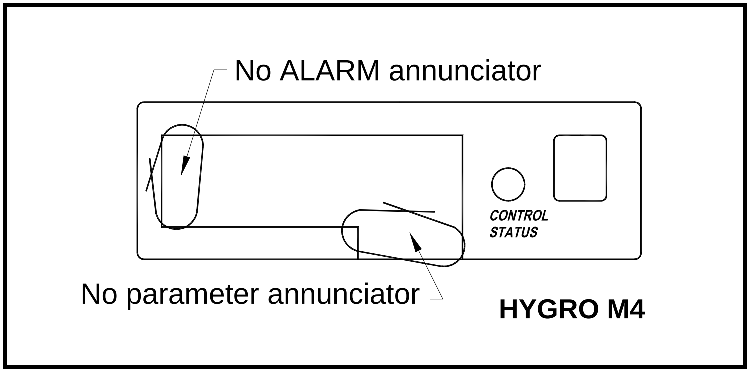


Figure 1-5: Identifying the M4-DP

Model M4/E4-RH

The M4/E4-RH measures and displays humidity as dew/frost point or as relative humidity. It also measures and displays temperature. It accepts input from a GE Sensing chilled mirror sensor, and from a temperature sensor. The temperature sensor may be a GE Sensing Model T-100E, or a user-supplied Resistance Temperature Device (RTD) or 4–20mA transmitter. The **-RH** provides dual analog outputs (4–20mA and 0–5VDC), an alarm relay, and RS-232C communications.

As shown in Figure 1-6 below, the Model **-RH** can be identified by its red **ALARM** annunciator at the left of the main LED display, and green **HUMIDITY** and **TEMPERATURE** annunciators at the bottom right of the main LED display.

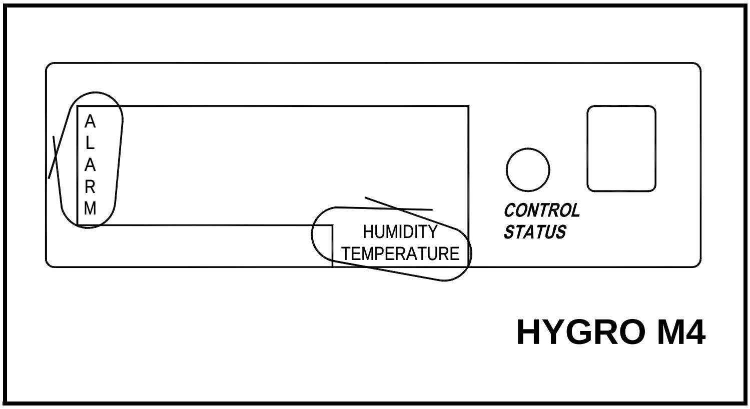


Figure 1-6: Identifying the M4-RH

The E4-RH and the M4-RH are functionally identical, except that the E4 is available with an optional second digital display. When configured with two displays, the E4-RH can show humidity (either RH or dew point) and temperature simultaneously.

Model M4/E4-PR

The M4/E4-PR can measure and display humidity as dew/frost point, as parts-per-million by volume (PPMv), as grains per pound, or as grams per kilogram. It also measures and displays gas pressure. It accepts input from a GE Sensing chilled mirror sensor, and also from a pressure sensor. The pressure sensor may be a GE Sensing PT-30A or PT-300A, or a user-supplied 4–20mA pressure sensor. If the pressure is known to be constant, a fixed pressure can be programmed, eliminating the need for a pressure sensor. The **-PR** provides dual analog outputs (4–20mA and 0–5VDC), an alarm relay, and RS-232C communications.

As shown in Figure 1-7 below, the Model **-PR** can be identified by its red **ALARM** annunciator at the left of the main LED display, and green **HUMIDITY** and **PRESSURE** annunciators at the bottom right of the main LED display.

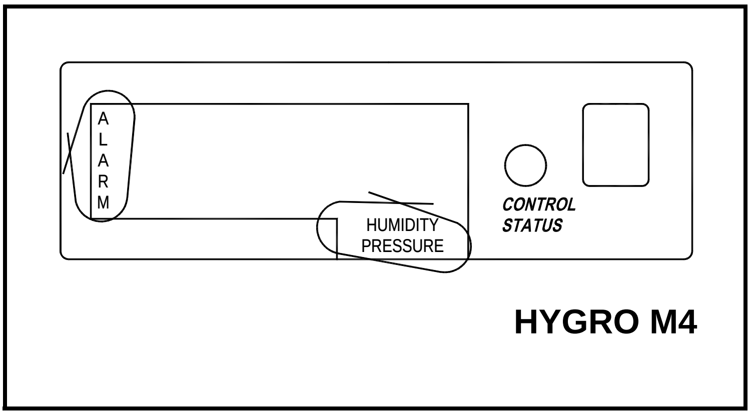


Figure 1-7: Identifying the M4-RH

The E4-PR and the M4-PR are functionally identical, except that the E4 is available with an optional second digital display. When configured with two displays, the E4-PR can show humidity and pressure simultaneously.

Sensors

The M4/E4 must be configured with a chilled-mirror dew point sensor. The sensor provides data to the electronics unit that calculates humidity. The specific sensor is chosen according to the expected dew point range and the environment in which dew point is to be determined. In addition, the models **-RH** and **-PR** are normally configured with a temperature or pressure sensor.

GE Sensing provides the following sensors for various applications:

Dew Point Sensors

- Model 1111H — Single-stage sensor
- Model D-2 — Two-stage sensor
- Model SIM-12H — Two-stage heated sensor
- Model 1311DR — Four-stage, liquid or air cooled sensor
- Model 1311XR — Five-stage, liquid cooled sensor

Temperature Sensor

- Model T-100E

Pressure Sensor

- Model PT-30A or PT-300A

Theory of Operation

Optical Condensation Hygrometry

Optical condensation hygrometry is a precise technique for determining the water vapor content in gases by directly measuring dew point or frost temperatures. Using this technique, a metallic mirror is cooled until it reaches a temperature at which a thin layer of condensation begins to form on it. The dew layer is detected optically, and the mirror is held at that temperature. The mirror temperature, measured with a platinum resistance thermometer, is an accurate indicator of the dew or frost point. Because these hygrometers are so accurate, they are widely used as a standard in many of the world's metrology laboratories.

How Hygrometers Function

Figure 1-8 below illustrates how GE Sensing hygrometers detect and measure dew point. The condensate mirror is illuminated with a high-intensity, solid state, light emitting diode (LED). A photo detector monitors the LED light reflected from the mirror. The photo detector is fully illuminated when the mirror is clear of dew, and it receives less light as dew forms. A separate LED and photo detector pair are used as a known reference to compensate for any thermally induced changes in the optical components. The photo detectors are arranged in an electrical bridge circuit, the output current of which is proportional to the light reflected from the mirror. The bridge output controls the electrical current to the thermoelectric cooler.

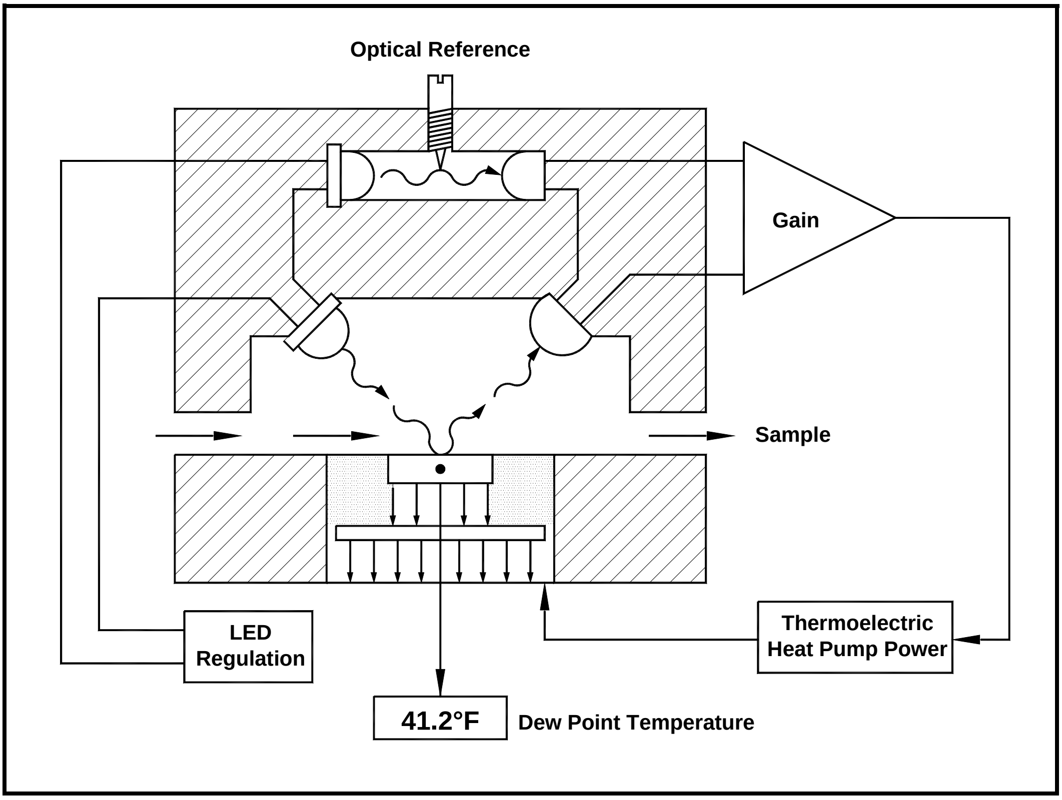


Figure 1-8: The Chilled-Mirror Hygrometer

How Hygrometers Function (cont.)

A large bridge current develops when the mirror is dry, causing the mirror to cool toward the dew point. As dew begins to form on the mirror, less light is reflected, and the bridge output decreases. This, in turn, causes a decrease in cooling current. A rate feedback loop within the amplifier ensures critical response, causing the mirror to stabilize quickly at a temperature that maintains a thin dew or frost layer on the mirror surface. A precision thermometer element embedded within the mirror directly monitors this dew point temperature.

Hygrometers as a Standard for Calibration

An optical condensation hygrometer such as the M4 or E4 can be sent to the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland for calibration against the NIST standard. A calibrated instrument can then be used as a transfer standard in local laboratories to calibrate lower echelon instruments. Hygrometers used as calibration standards must have the following characteristics:

- The mirror thermometer must have suitable long-term accuracy (such as that obtained with a platinum resistance thermometer).
- A means must be provided for viewing the dew or frost formation on the mirror.

Other Optical Condensation Hygrometer Applications

The majority of condensation hygrometers are used in routine industrial applications rather than metrology. The optical condensation hygrometer is a totally inert sensor, not readily damaged or contaminated by industrial process gases that can degrade other secondary measurement schemes such as salt systems or resistance grids. If the sensor or sampling components should become contaminated with oils, salts, etc., they can be readily cleaned without harm to the sensor or impairment to the system accuracy. The performance of the hygrometer can be checked at any time by heating the mirror above the dew point, causing the dew deposit to evaporate, then reclosing the servoloop and checking that the system cools and returns to the same dew point.

The GE Sensing optical condensation hygrometer has a wide range of applications limited only by the heat pumping capabilities of the thermoelectrically cooled mirror.

At high dew points (up to 212°F/100°C), the sensor is limited only by the thermal properties of the solid state optical components and the thermoelectric heat pump.

To measure low dew points, a two-stage thermoelectrically cooled mirror can typically reach a temperature 40°C lower than an ambient (heat sink) temperature of +77°F (+25°C). The thermoelectric cooler pumps heat from the mirror into the heat sink. By reducing the temperature of the heat sink with a coolant such as tap water, or by applying the sensor in a low-temperature condition such as monitoring of a test chamber, even lower dew points can be measured. In meteorological applications where the heat sink temperature is considerably lower, frost points down to –103°F (–75°C) can be monitored.

Four- and five-stage sensors are available for measuring the lowest dew/frost points.

Chapter 2

Installation

Installing the Model M4

The M4 benchtop unit can be mounted in an existing panel with the optional Model PB-M4 panel mounting brackets. Figure 2-1 below shows the dimensions required for the panel cutout when using these brackets.

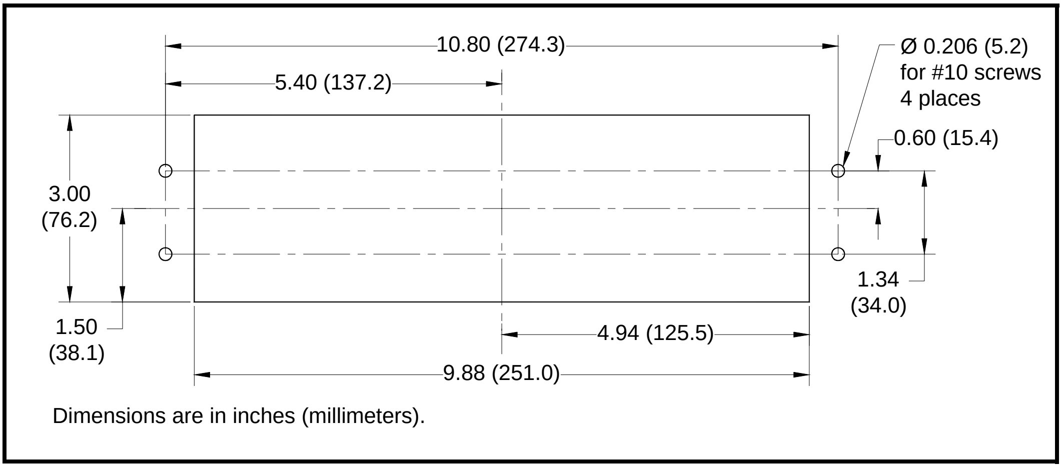


Figure 2-1: M4 Panel Cutout Dimensions

A standard 19-inch rack adapter (Model PM-M4) is also available for rack mounting as shown in Figure 2-2 below.

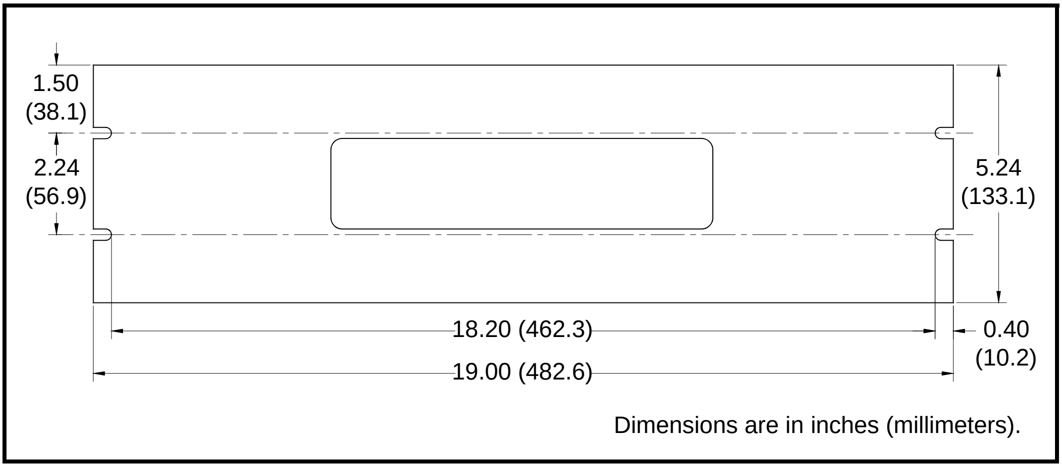


Figure 2-2: M4 Rack-Mount Adapter Dimensions

M4 Rear Panel Connections

The rear panel of Models M4-RH and M4-PR is shown in Figure 2-3 below. The rear panel of the M4-DP is identical except that the terminal blocks labelled **INPUTS** and **OUTPUTS** are omitted.

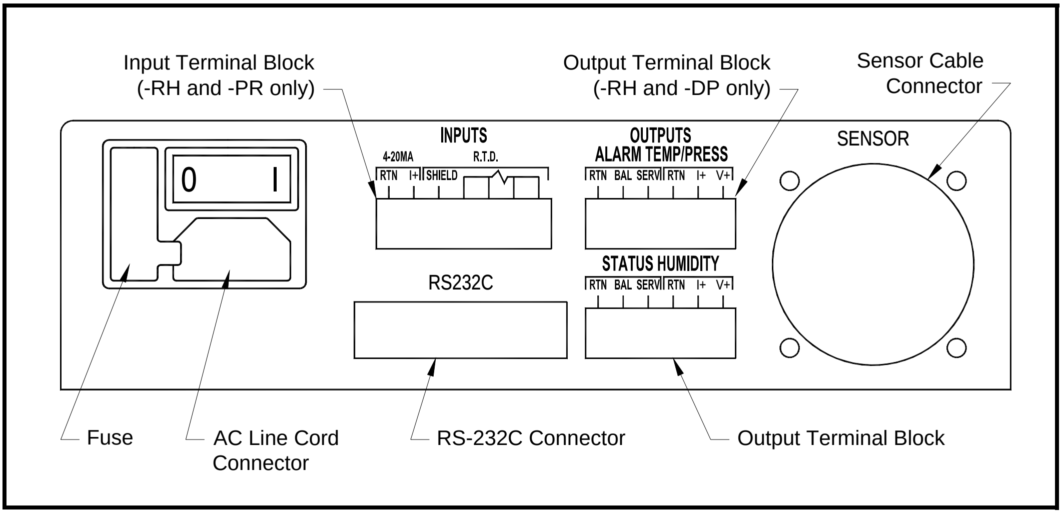


Figure 2-3: M4 Rear Panel

Input Power

The Hygro M4/E4 is available in versions wired for 115, 230, and 100 VAC. The 230 VAC version is double-fused.

Power Requirements: 100/115/220 VAC 48-66Hz 75VA Max

Fuse Type: 1 A/1 A/0.5 ASB 250V Type T

Sensor

Connect the sensor cable’s metallic connector to the chilled mirror sensor, and the plastic connector to the M4’s SENSOR connector.

Installing the Model E4

The E4 is designed to mount on a flat, vertical surface, such as a wall or panel. Installation is generally similar to that of the M4, described in the previous section.

E4 Connections

The control panel and connection terminals of the E4 are shown in Figure 2-4 on page 2-4. The Sensor Cable connector is located at the lower right of the unit. Power wiring, and any additional I/O cabling, are brought into the unit at the lower left and connected to the terminal blocks on the control panel as shown. All connections are clearly identified on the unit and are also shown on the next page. The E4's voltage and frequency rating and tolerances, as well as fusing data, are listed next to the AC power input terminal block at the lower left.

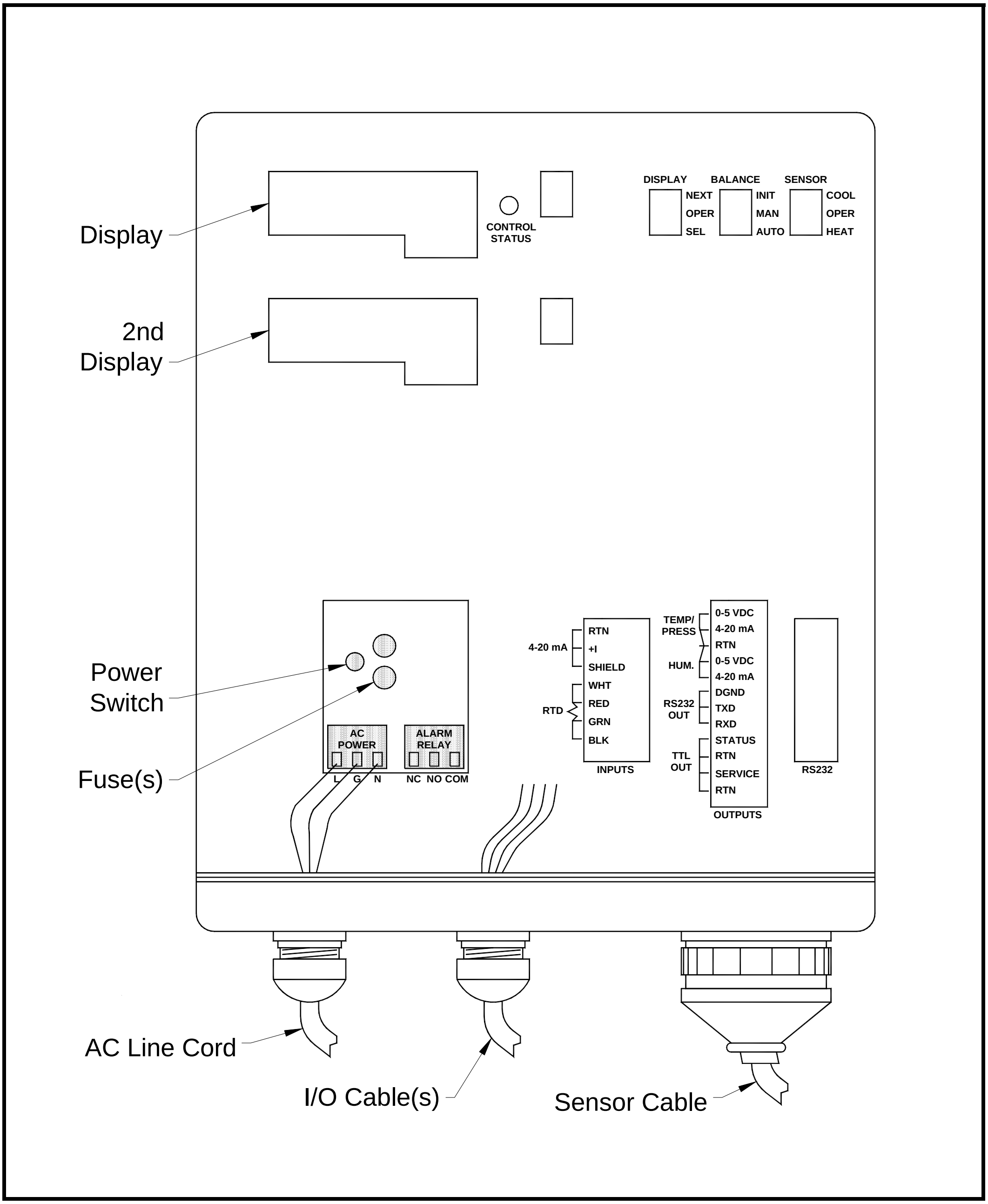


Figure 2-4: Model E4 Controls and Connectors

Installing a Sensor

GE Sensing produces a variety of sensors compatible with the M4, ranging from one to five stages of thermoelectric cooling. A comparison chart listing specifications of each sensor is given in Appendix E. The following sections provide information on installing the following dew point sensors:

- Model 1111H — Single-stage sensor
- Model D-2 — Two-stage sensor
- Model SIM-12H — Two-stage heated sensor
- Model 1311DR — Four-stage heated sensor
- Model 1311XR — Five-stage water-cooled sensor

Aspirated sensors with weatherproof housings are also available from GE Sensing. When ambient air measurement is required, these are appropriate for measuring humidity, either in a large indoor space (such as a manufacturing area, warehouse or airplane hangar), or outdoors on a roof or tower for meteorological applications.

When selecting a location for installing a sensor, consider the following criteria:

Locate the sensor as close as practical to the source of the gas to be measured, to keep the sampling lines as short as possible. This minimizes the system response time and reduces the error rate at low frost points due to line outgassing.

Choose a sensor location that provides access to the dew point chamber cover, to facilitate periodic mirror cleaning.

Caution!
Never place the sensor in a location where temperatures rise above the maximum rated temperature for the device. See Appendix E for complete sensor specifications.

Sampling Lines

Keep the length of sample tubing between the source and the sensor short, for quick response and highest accuracy.

Any sampling line compression fittings provided with the sensor are for ¼-inch diameter tubing, unless otherwise specified at the time of order.

Allow for easy access to the sensor cover to facilitate periodic mirror cleaning.

The material used for the inlet lines can have an important effect on the validity of the readings. Do not use rubber hose or plastic tubing such as PVC or Tygon, because of their hygroscopic nature.

When measuring frost points below –30°C, sample gas leaving the sensor outlet should be vented through an additional line 3 to 6 feet long, since backflow of ambient moisture into the sensor can take place even under positive pressure, altering the measured frost point. Use stainless steel tubing and fittings, and ensure that all plumbing is completely free from leaks.

At dew/frost points above –20°C, tubing material is not as critical. Copper, Teflon, polypropylene, aluminum or brass tubing and fittings may be used.

The sampling system should allow for periodic cleaning. It may be helpful to install a tee and closing valve on the inlet side, to permit the sensor to be shut off while the sampling lines are flushed. At very low humidities, even a trace amount of contamination can alter measured frost point, so cleanliness is particularly important.

Ensuring Heat Transfer

Be sure the sensor has an adequate heat sink when operating in hot environments. The sensor must never be allowed to reach a temperature above its rated limit. It is not sufficient merely to ensure that the sensor is in an environment whose temperature is below the rated limit; a means must be supplied to remove the heat pumped from the dew point mirror.

When the Model 1111H or D-2 sensors are to be used at ambient temperatures of 24° to 20°C, full rated depression can be achieved by mounting the sensor on a smooth, thermally conductive surface (such as metal), which tends to remain at the ambient temperature. The GE Sensing maintenance kit supplied with each new instrument includes a capsule of heat-conducting compound.

If possible, do not operate the sensor continuously at or near full depression. Doing so may decrease the anticipated life of the thermoelectric heat pump.

High Dew Point Measurements

Using Heated Sensors

When measuring dew points at or above the ambient temperature, the sensor must be heated to a temperature at least 5 to 10°C above the highest anticipated dew point (but not higher than the sensor temperature rating). Some sensors can be mounted on a liquid heat exchanger or a temperature-controlled electric hot plate, or installed in a heated enclosure. The factory recommends actively controlling the elevated sensor body temperature.

The sensor base should be coated with zinc oxide-filled silicone thermal grease and securely anchored to the heat sink with suitable fasteners. Allow ½ hour for the sensor to reach thermal equilibrium after adjusting the temperature of the heat sink.

Using Heated Sensors (cont.)

The GE Sensing SIM-12H high temperature sensor is designed for high-temperature applications. It measures dew points above ambient temperature without condensation problems. When used with the M4/E4, the
SIM-12H should be used to measure dew point temperatures up to 50°C. In some applications, measurements of higher dew points may result in oscillations or instability.

Sample Lines for High Dew Point Measurements

Sampling lines carrying gas to the sensor must be heated and insulated when the dew point of the gas is above the sample line's ambient temperature. The simplest way to achieve this is to use heater tape (either thermostatically controlled, or operating continuously and sized to provide the required temperature rise). At high temperatures, use stainless steel tubing with adequate insulation to avoid hot and cold sections in the line and to avoid water absorption/desorption cycling when the heater is thermostatically controlled. Heated sampling lines are available from the factory.

Filter Requirements

If the gas to be monitored is free from particulates and hydrocarbon liquids or vapor, filtering is not necessary. However, most sample gas streams contain some particulates, and using a filter reduces the need for frequent mirror cleaning. On the other hand, filtering tends to slow the system's response, particularly at low frost points.

The series 912 filters manufactured by Balston Company (or equivalent) are effective for most applications. They are efficient, economical, and convenient, and their fittings are compatible with ¼-inch tubing. For particulates and liquid hydrocarbons, use a Balston type DX filter element. To filter out very fine particles, the type DX can be followed by a type BX filter. A type CI filter can be used to remove hydrocarbon vapors.

If the sample gas is heavily and routinely contaminated, we recommend using a quick-change filter element. Avoid using glass wool, cellulose, and other hygroscopic materials as a filter medium.

Flow Rate

It is important to have adequate flow through the sensor. Too little flow can slow the response (particularly at very low frost points). Too much flow can cause instability of the control system at high dew points and can reduce the depression capability of the cooling pump at very low dew points. Too much flow also accelerates the rate of system contamination.

A flow rate of 2 to 2.5 ft^3/h (a little over 1 liter/min) is ideal for most applications. In many cases, flow rates between 0.2 and 5 ft^3/h (0.1 and 2.5 liter/min) may be used.

Details for Various Models

This section provides details for installation of several GE Sensing humidity sensors.

Models 1111H and D-2

For maximum thermal conductivity, the base of the Model 0111D pressure boss or the Model D-2 sensor should be coated with heat-conducting grease. When so installed on a surface suitable for dissipating heat, the sensor will achieve its maximum rated depression. See the *Chilled Mirror Sensor Comparison Chart* in Appendix E.

Model 1311DR

Mount the 1311DR sensor so that the air inlet and exhaust openings are free from obstruction. If the sensor is liquid cooled, vertical wall mounting is recommended, observing the **UP** arrow on the case. This ensures that condensation forming on cold portions of the 1311DR will drain from the enclosure.

Liquid cooling is required for measuring frost points below –65°C (at 25°C ambient), and may be used to cause faster response at higher temperatures. If a recirculating chiller is used, it should have a capacity of at least 300 watts at the coolant temperature.

Switch the internal fan ON if air cooling is used; leave it OFF for liquid cooling.

Install the gas sampling lines according to the instructions listed in *Sampling Lines* on page 2-6.

Model 1311XR

Electrical Connections

All the electrical connectors on the Model 1311XR dew/frost point sensor are unique. The cables supplied with the sensor can only interconnect the system in one way. Connect the cables as follows:

1. Plug the instrument into a 115 VAC power outlet.
2. Connect the 37-pin round black connector on the back of the instrument to the 19-pin military-style connector on the back of the 1311XR sensor.
3. Connect the 17-pin military style connector on the back of the 1311XR sensor to the 24-pin round connector on the back of the heat pump controller module.
4. Connect the 9-pin route connector on the back of the heat pump controller module to the 8-pin rectangular connector on the back of the fourth stage heat pump power supply.
5. Plug the heat pump power supply into a 115 VAC outlet.

Note: *To operate the 1311XR on a voltage other than 115 VAC, order a special unit from the factory.*

Coolant

Connect the two 3/8-inch brass compression fittings on the back of the 1311XR sensor to the coolant lines. Do not run the instrument without sufficient coolant flow.

Suitable coolants include water, glycol and other noncorrosive liquids. The coolant can be recirculated liquid or tap water that is cooled or chilled. If a recirculating chiller is used, it should have a capacity of at least 600 watts at the coolant temperature.

Sample Gas Fittings

The 1311XR sensor has ¼-inch stainless steel compression fittings for sample gas inlet and outlet at the back of the sensor chassis.

Purging the Sensor

Caution!
The 1311XR must be purged after each use, either with the sample gas after measuring it, or with another dry gas source. Otherwise, condensation inside the sensor housing may cause corrosion and eventual failure of the thermoelectric coolers.

For extremely dry gas measurements, the 1311XR sensor must be purged with a gas having a frost point lower than –20°C. For intermediate temperatures, any gas having a frost point at least as low as the sample gas can be used.

The sample gas outflow from the sensor can be used for this purpose. Introduce the purge gas via the purge fitting on the rear of the sensor. The simplest method for purging is to run the sample gas outflow through the U-tube supplied with the sensor.

Wiring the Inputs

The **INPUTS** terminal block (which is found only on the Models **-RH** and **-PR**) allows connection of a second input sensor, for either temperature (Model **-RH**) or pressure (Model **-PR**). It is located at the top center of the rear panel of the M4, and at the lower center of the E4.

Temperature Input (Model -RH)

To connect a GE Sensing T-100E temperature sensor to the Model **-RH**, attach the colored sensor wires to the RTD inputs of the terminal block as shown in Figure 2-5 on page 2-12. A customer-supplied 1/3 Class A DIN 43760 PRT (100 Ohm at 0°C) may be connected in the same way.

Temperature Input (Model -RH) (cont.)

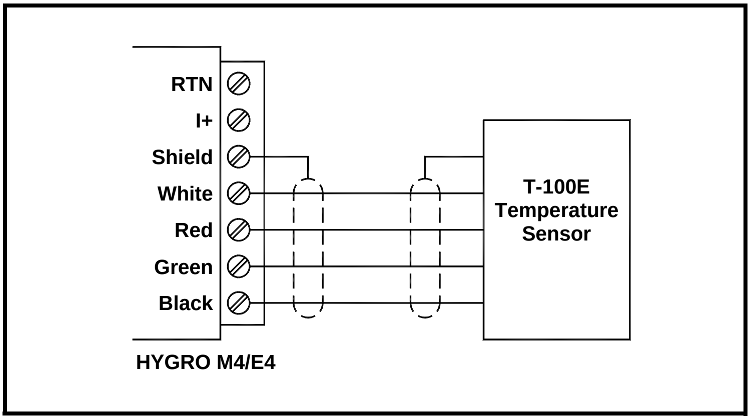


Figure 2-5: RTD Temperature Sensor Connections

To connect a customer-supplied 4–20mA temperature transmitter, attach the sensor wires to the terminals marked **I+**, **RTN**, and **SHIELD** as shown in Figure 2-6 below.

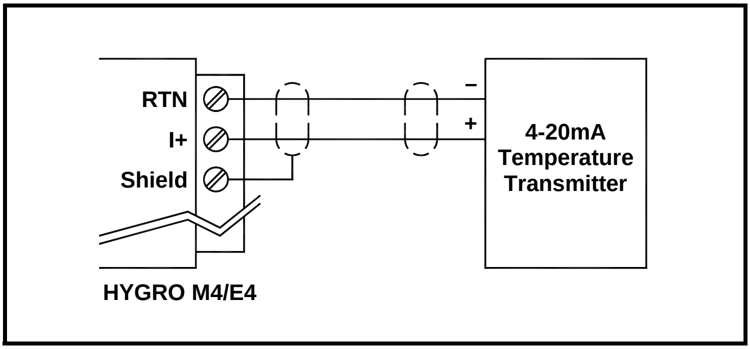


Figure 2-6: 4-20mA Temperature Transmitter Connections

Note: *The unit is shipped configured to accept an RTD input, unless it was specifically ordered with a 4–20mA interface. To change this configuration to allow use of a 4–20mA device, use Function 9 on the RS-232C port. See* Function 9: Set Input2 Param. *on page 4-27. Scaling information for your 4–20mA temperature transmitter must be provided to the unit's microprocessor when using the RS-232C port.*

Pressure Input (Model -PR)

To connect a GE Sensing PT-30A or PT-300A pressure transmitter to the **-PR**, attach the sensor wires to the **INPUTS** terminal block as shown in Figure 2-7 below. To connect a customer-supplied 4–20mA pressure transmitter, connect it in the same way. The Model **-PR** provides 15-volt excitation for a loop-powered pressure transmitter having a load resistance of 50 ohms or more.

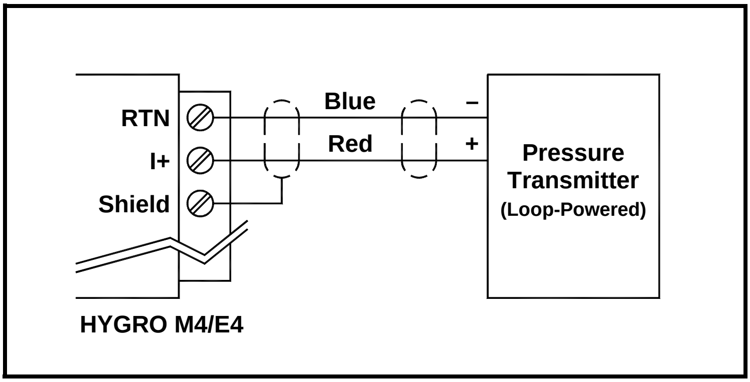


Figure 2-7: Loop-Powered Pressure Transmitter Conn.

A non-loop-powered 4–20mA transmitter can also be used provided it has a common ground. The voltage applied to the unit's **RTN** pin should be positive with respect to the **SHIELD** pin. Connect as shown in Figure 2-8 below.

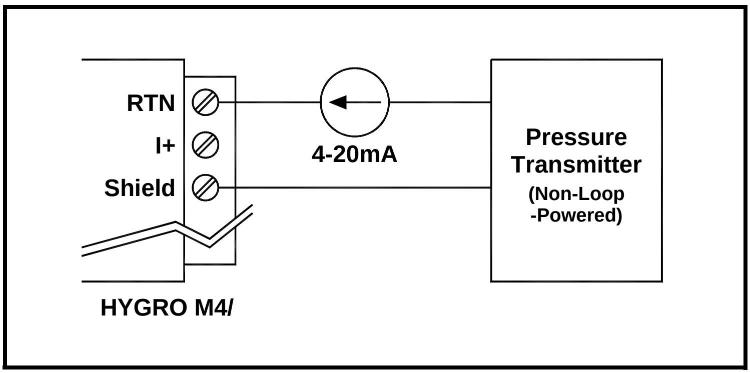


Figure 2-8: Non-Loop-Powered Pressure Trans. Conn.

Pressure Input (Model -PR) (cont.)

Scaling information for a customer-supplied pressure transmitter must be supplied to the M4 using the RS-232C port. For more information, refer to the programming instructions *Function 9: Set Input2 Param.*on page 4-27.

Wiring the Outputs

The M4 outputs are located on terminal blocks on the rear panel as shown in Figure 1-3 on page 1-4.

The E4 outputs are located inside the front door. Cabling is brought in through the bottom edge of the unit and connected to terminal blocks as shown in Figure 2-4 on page 2-4.

Analog Humidity Output

The humidity outputs provide 4–20mA and 0–5 VDC analog signals for the designated humidity parameter. This group of connections is clearly labelled **HUMIDITY**.

- For 4–20mA output (500Ω maximum load), connect to the humidity terminals labelled **I+** or **4–20MA** (+) and **RTN** (–)
- For 0–5 VDC output (5mA maximum load), connect to the humidity terminals labelled **V+** or **0–5VDC** (+) and **RTN** (–).

The humidity units and scaling may be set using the RS-232C port or the front panel **DISPLAY** switch. The unit is shipped with the analog output parameter and scaling *viewable* but not *changeable* using the **DISPLAY** switch. In order to allow changing of the analog outputs, the behavior of the **DISPLAY** switch must be modified using the RS-232C Port. See *RS-232C Data Outputs* on page 3-12 for details.

Analog Humidity Output (cont.)

The available humidity units are as follows (the abbreviations shown in parentheses are used when programming the outputs with the RS-232C port):

M4/E4-DP:	Dew Point °C (DP C)
	Dew Point °F (DP F)
M4/E4-RH:	Dew Point °C (DP C)
	Dew Point °F (DP F)
	Relative Humidity (RH)
M4/E4-PR:	Dew Point °C (DP C)
	Dew Point °F (DP F)
	Grains/Lb (G)
	PPMv (P)
	Grams/Kg (g)

Status Output

The **STATUS** outputs provide TTL-compatible signals for **SERVICE** status and for **BALANCE** status. On the M4, this group of connections is labelled **STATUS**. On the E4, they are labelled **TTL OUT**. The service signal indicates that the mirror needs cleaning. The balance signal indicates the system is performing a PACER balancing function.

- For **SERVICE** status, connect to **SERVICE** (+) and **RTN** (–).
- For **BALANCE** status, connect to **BAL** or **STATUS** (+) and **RTN** (–).

Temperature and Pressure

M4 Connections

The three right most terminals of the **STATUS/HUMIDITY** terminal block supply analog output signals for temperature (Model **-RH**) or pressure (Model **-PR**).

E4 Connections

The three terminals at the top of the **OUTPUTS** terminal block supply analog output signals for temperature (Model **-RH**) or pressure (Model **-PR**).

Make connections as shown below:

- For 4–20mA output (500Ω maximum load), connect to the **TEMP/PRESS** terminals labelled **I+** or **4–20MA** (+) and **RTN** (–).
- For 0-5 VDC output (5mA maximum load), connect to the **TEMP/PRESS** terminals labelled **V+** or **0–5VDC** (+) and **RTN** (–).

The available temperature and pressure units are listed below.

M4/E4-RH:	Temperature: °C (TMP C)
	Temperature: °F (TMP F)
M4/E4-PR:	Pressure: Psia (P)
	Pressure: Bar (b)

The temperature or pressure output units and output scaling may be set using either the RS-232C port or the front panel **DISPLAY** switch. Note that the unit is shipped with the analog output parameter and scaling only viewable and not changeable using the **DISPLAY** switch. In order to allow changing of the analog outputs, the behavior of the **DISPLAY** switch must be modified using the RS-232C Port. See *RS-232C Data Outputs* on page 3-12 for details.

Alarm Outputs

M4 Connections

The three leftmost terminals of the **OUTPUTS** terminal block supply alarm outputs from the **-RH** and **-PR**. These outputs connect to a 5 Amp, Form C (SPDT) alarm relay.

E4 Connections

The alarm relay connections are located at the lower left of the unit, near the AC power connections.

Make connections as shown below:

- For normally open (inactive state) contacts, connect to **NO** (+) and **COM** (–).
- For normally closed (inactive state) contacts, connect to **NC** (+) and **COM** (–).

Any available parameters can be assigned to the alarm output:

M4/E4-RH:	Dew Point °C (DP C)
	Dew Point °F (DP F)
	Relative Humidity (RH)
	Temperature °C (TMP C)
	Temperature °F (TMP F)
M4/E4-PR:	Dew Point °C (DP C)
	Dew Point °F (DP F)
	Grains/Lb (G)
	PPMv (P)
	Grams/Kg (g)
	Psia (P)
	bar (b)

E4 Connections (cont.)

The alarm parameter and its ON/OFF threshold values can be set using the RS-232C port (see *Function 8: Set Alarm* on page 4-25) or the front panel **DISPLAY** switch (see *Programming from the Front Panel* on page 4-1). The unit is shipped with alarm parameter and threshold values only *viewable* and not *changeable* using the **DISPLAY** switch. In order to allow changing of the alarm controls, the behavior of the **DISPLAY** switch must be modified using the RS-232C Port. (See *Function 4: Display Options* on page 4-19 for details.)

RS-232C Connector

The RS-232C connector, which is present on all models, is located at the lower center of the rear panel of the M4, and the lower right of the E4. It provides RS-232C digital communications between the unit and an RS-232C terminal or a PC running in terminal emulation mode.

The connector is a standard 25-pin D connector. To connect to another RS-232C device, the cable must be wired as shown below. Pin connections are given for both 25-pin and 9-pin devices.

Table 2-1: RS-232C Connections

M4 Connector	25-Pin Device	9-Pin Device
2	3	2
3	2	3
7	7	5

The baud rate of the data is 1200. The format of the data is 8 data bits, 1 stop bit, and no parity.

The unit can communicate with a handheld RS-232C terminal or a personal computer running in terminal emulation mode. See Appendix D for a BASIC computer program that can be used for simple RS-232C communications between the unit and your PC.

Handshaking

The default handshaking protocol for the unit is set to **NO HANDSHAKE**.

In order to enable handshaking, the RS-232C menu must be accessed through the RS-232C port. See *Handshake Control* on page 4-19 for details. To implement handshake control using Clear-To-Send and Ready-To-Send, use pins 4 and 5. Applying 8 volts (±3) to Pin 5 of the RS-232C connector allows the unit to transmit.

Chapter 3

Operation

General Information

Operating instructions fall into three categories:

- normal operation
- setup and programming
- system maintenance

Normal operation of the controls is described in the next section.

Setup and programming involves customizing the unit for specialized applications, and is not required for many conventional applications. The unit is shipped properly programmed to meet the majority of requirements. The factory default settings are listed on page 3-4. Complete programming instructions are given in Chapter 4.

Maintenance involves manually testing the cooling capacity, clearing the mirror, and other operations that might be required on a regular basis, or when a problem is suspected, depending on the application.

The front panel controls allow for selection of displayed information and maintenance functions. In addition, an RS-232C-compatible device, such as a laptop computer, can be connected to the unit to perform additional programming and configuration functions.

The RS-232C port can also be used to send data measured by the M4/E4 to an external computer or other device.

Operating the Controls

The **DEW POINT DISPLAY** shows the dew or frost point in degrees Celsius or Fahrenheit.

The green **CONTROL** light illuminates when the system detects both a stable dew or frost layer and a stable dew/frost point temperature, and a valid reading may be taken.

The green seven-segment **STATUS** display shows system status as described on page 3-3.

The **DISPLAY** switch is a three-position switch that selects:

NEXT A momentary position used when viewing or changing displayed units, output units and scaling, or alarm units and limits.

OPER Normal operating position.

SELECT A momentary position used when viewing or changing displayed units, output units and scaling, or alarm units and limits.

The **SENSOR** switch is a three-position switch that selects:

HEAT Allows the mirror to be cleared of condensation in order to check for proper control loop operation.

OPER Normal operating position.

COOL A momentary position that forces maximum cooling in order to check depression capability.

The **BALANCE** switch is a three-position switch that selects:

AUTO The PACER balancing cycle will occur at a preselected interval. Details on setting this interval are given in the section *Function 2: Set Balance Type* on page 4-16.

MANUAL No PACER cycle occurs unless manually initiated.

INIT Momentary position that initiates a PACER cycle.

Displays

Main Dew Point Display

The main dew point display consists of a 3½-digit red LED readout that shows numerical data, and a green LED that shows the data units of measure. The display can show dew point in °C or °F. Models **-RH** or **-PR** can also display other humidity parameters, and temperature or pressure data.

The front panel **DISPLAY** switch, or the RS-232C port, can be used to determine which parameter is displayed. See Chapter 4 *Programming*. The factory default displays dew point in °C.

The Model E4 can be ordered with either one or two displays.

Status Display

The **STATUS** display is a green seven-segment LED that can display a single character indicating system status and programming status. Although normally not illuminated, it can display the following status information:

P	Programmable Automatic Contaminant Error Reduction (PACER) mode is in operation.
S	Service is needed. The system optics require service, cleaning or adjustment.
U	The M4/E4 is in **UNITS SELECT** mode (available when using the **DISPLAY** switch).
O	The M4/E4 is in **OUTPUT SELECT** mode (available when using the **DISPLAY** switch).
A	The M4/E4 is in **ALARM SELECT** mode (available when using the **DISPLAY** switch).
H	The M4/E4 is in **HIGH** scaling value entry mode (available when using the **DISPLAY** switch).
L	The M4/E4 is in **LOW** scaling value entry mode (available when using the **DISPLAY** switch).
(bars)	Used during calibration to determine the proper setting for the sensor’s balance adjustment screw.

Alarm Annunciator (Models -RH and -PR only)

A red LED **ALARM** annunciator is located at the left of the main display on models **-RH** and **-PR**. The alarm can be programmed to alert to any range of values for any measured parameter. See *Function 8: Set Alarm* on page 4-25. When an alarm condition occurs, this annunciator displays the word **ALARM** and the alarm relay energizes, to actuate an external device.

On the dual display version of the E4-RH and E4-PR, an alarm annunciator is located to the left of each display. However, the unit contains a single alarm detector and output relay that can be assigned to monitor any displayable parameter. In an alarm condition, the word ALARM will appear next to the parameter to which the alarm relay has been assigned.

Humidity/ Temperature Annunciator (Model-RH only)

A green LED annunciator, located at the bottom right of the main display, indicates whether humidity or temperature is displayed. A Model E4-RH configured with two displays will show only humidity on the upper readout and temperature on the lower.

Humidity/Pressure Annunciator (Model-PR only)

A green LED annunciator, located at the bottom right of the main display, indicates whether humidity or pressure is displayed. A Model E4-PR configured with two displays will show only humidity on the upper readout and pressure on the lower.

Factory Default Settings

As shipped from the factory, the unit is programmed so that the user can perform the following operations:

*Model **-DP***

View and change all display units (DP C, DP F).
View, but not change, output units and scaling:
(Output1 set to DP C; Low = –40°C; High = +60°C).

*Model **-RH***

View and change all display units:
(DP C, DP F, RH, TMP C, TMP F)

View, but not change, output units and scaling:
(Output1 set to DP C; Low = –40°C; High = +60°C)
(Output2 set to TMP C; Low = –40°C; High = +60°C)

View, but not change, alarm parameter and limits:
(Alarm set to DP C; Off = 100°C; On = 100°C)

*Model **-PR***

View and change all display units:
(DP C, DP F, G, P (PPMv), g, P (Psia), b (bar))

View, but not change, output units and scaling:
(Output1 set to DP C; Low = –40°C; High = +60°C)
(Output2 set to P (Psia); Low = 0; High = 30 or 300, depending on sensor)

View, but not change, alarm parameter and limits:
(Alarm set to DP C; Off = 100°C; On = 100°C)

The operation of the **DISPLAY** switch can be modified using the RS-232C port to allow the above outputs and alarm to be changed from the front panel. See *Function 4: Display Options* on page 4-19. Some possible changes are summarized below:

Units:	Show all parameters (default) Customize the parameters displayed
Output(s):	View only View and change Hide from view
Alarm:	View only (default) View and change Hide from view
Display:	Fix (display a single selected parameter) Alternate (display a list of parameters)

In all models, the handshake mode is set at the factory to **NO HANDSHAKE**.

Operating the Sensors

The following sections provide descriptions and instructions for using various sensors manufactured by GE Sensing. See Chapter 2 for information on installing sensors.

Model 1111H Sensor

The Model 1111H is an open-type sensor. It can be threaded into standard pipe fittings or mounted in a type 0111D pressure boss, which encloses it and adapts it for ¼-inch compression fittings. When installing the sensor in the pressure boss, remove the black aluminum sensor cover.

Figure 3-1: Model 1111H Sensor

Model D-2 Sensor

The Model D-2 is a general purpose, two-stage sensor with 65°C (117°F) of depression capability. It features wetted parts of stainless steel and glass, for durability in demanding industrial applications. The Model D-2 can be used as a benchtop sensor, mounted to a heat sink, or mounted to a cooling fan for maximum operating range. Advanced features include field-replaceable optics and cooler assemblies, and auxiliary visible light optics with a viewing window for inspecting the mirror during operation.

Figure 3-2: Model D-2 Sensor

Model SIM-12H Heated Sensor and Components

The SIM-12H heated sensor module is suitable for measuring dew/frost points between –10°C and +85°C. It contains precision heating, as well as cooling, capability. Three separate heaters are located in the sensor walls, 120 degrees apart. Three temperature sensors measure the body temperature at those points, and three control circuits precisely adjust the temperature of each heater. Any detected temperature gradient across the sensor cavity is immediately eliminated, resulting in very even control. All three heaters are controlled by the temperature set by the front panel selector knob. The sensor is a two-stage unit, providing 65°C of depression capability, and 60°C actual measurement range.

Figure 3-3: Model SIM-12H Sensor

Type SIM-HFT Heated Filter Module

The SIM-HFT heated filter module allows the sample gas to be purged of particulate contaminants prior to entering the sensor. The incoming gas is first passed through a 90-micron prefilter, then a 15-micron final filter. All parts in contact with the sample are heated to a constant 105°C, eliminating any possibility of condensation. The sintered filters are easily removed for cleaning or replacing if required.

Type SIM-HFM Heated Flow Meter

The SIM-HFM heated flow meter module allows the sample gas flow rate to be both measured and controlled at a rate that is optimum for the sensor. A metering valve mounted on the front panel allows control over a range of 0 to 2 ft^3/h. All parts in contact with the sample gas are heated to a constant 105°C, so that no condensation occurs. The flow meter is normally mounted downstream from the heated sensor.

Type SIM-HSL Heated Sampling Line

The SIM-HSL heated sampling line is self-regulated at a temperature high enough to ensure that no condensation occurs. It is stocked in standard 15-foot lengths, and longer lengths are available on special order. The line is made of ¼-inch outside diameter Teflon, with stainless steel fittings.

Type SIM-MPL Mounting Plate

The SIM-MPL mounting plate is designed to accept one, two or three heated modules: the heated sensor, the heated filter, and the heated flow meter. The mounting plate provides a convenient method of wall-mounting the entire heated sampling system. When ordered with one or more modules, the factory performs all mounting, plumbing and wiring work, thus providing a complete system ready for installation.

Model 1311DR Sensor

The 1311DR is a stainless steel, liquid cooled, four-stage sensor suitable for measuring dew points between –75°C and +35°C.

Figure 3-4: Model 1311DR Sensor

At room temperatures (25°C) with air cooling, dew points from –65°C to +25°C can be measured. When operating it without liquid cooling, switch on the built-in fan. For lower frost point measurements, ordinary tap water can be used for cooling. Make sure the fan switch is **OFF** when using liquid cooling.

Sample flow rates from 0.5 to 5 standard cubic feet per hour (0.25 to 2.5 liters per minute) should be used. Do not exceed 5 ft^3/h.

Caution!
If it can be avoided, do not operate the sensor continuously at or near full depression. Doing so may decrease the life of the thermoelectric heat pump.

Model 1311XR Sensor

The 1311XR is a stainless steel, water cooled, five-stage sensor that can measure frost points as low as –80°C. The system is made operational simply by making all connections and turning on the instrument. The sample gas flow rate should be between 1 and 5 ft^3/h. The maximum permissible coolant temperature is +50°C; the minimum is –10°C. A minimum coolant flow rate of 0.1 gallons per minute must be maintained for most dew point measurements. If the fourth stage power supply control is set below –65°C, the minimum coolant flow rate is 0.25 gal/min. The coolant temperature affects the maximum dew/frost point depression. For frost points of –80°C, coolant temperature should be below 20°C.

Figure 3-5: Model 1311XR Sensor

Setting the Model 1311XR Heat Pump Controller

The 1311XR heat pump controller module has the following settings:

AUTO	When set to **AUTO**, the system operates fully automatically, controlling the heat pump in response to any dew/frost point within its operating range. In **AUTO** mode, the controller senses the current supplied to the top two stages of the thermoelectric coolers by the M4. The controller switches on the fourth stage power supply as required to maintain the mirror temperature at the dew/frost point. The **AUTO** setting is recommended for most applications.
Below –55°C	If the frost point is known to be below –55°C, the switch can be set to this position to provide slightly faster response than the **AUTO** setting. However, depression is limited at this setting. If frost points approaching –80°C are to be measured, use the **AUTO** setting.
–65°C to –10°C	If the dew/frost point is known to be between –65°C and –10°C, the switch can be set to this position to reduce overshoot and settling time.
Above –25°C	If the dew/frost point is known to be above –25°C, the switch can be set to this position to reduce overshoot and settling time.

Note: *The third-stage power indicator may blink in any setting. This is normal.*

Fourth-Stage Power Supply Control Knob

The control knob on the 1311XR fourth-stage power supply sets the power consumption limit and the coolant requirement when measuring dew/frost points using the **AUTO** or **BELOW –55°C** settings. Set this knob to the lowest anticipated dew/frost point.

If the control is set lower than necessary, the system dissipates excess power and requires additional cooling to remove the extra heat generated. If the setting is too high, the system may not be able to reach the true dew/frost point.

To allow the 1311XR sensor to act as a turnkey system (whereby it will cover its entire range automatically), set the switch to **AUTO** and the power supply control knob to the **–80°C** position.

1311XR Heat Pump Controller Error Indicators

The heat pump controller module has two overheat indicators connected to thermal shutdown switches. One indicator monitors the third stage and the other the fourth stage. If either indicator comes on, check for and correct any problems before continuing operation. If the third stage overheat indicator is on, check the cable connections and the coolant flow and temperature. If the fourth stage overheat indicator is on, check the coolant flow and temperature.

RS-232C Data Outputs

See *RS-232C Connector* on page 2-18 for details on hardware, cabling and protocols for establishing RS-232 communications with the Hygro M4/E4. RS-232 communications can be divided into two sections: *Operate Mode* and *Programming Mode*.

Operate Mode

While the unit is in Operate Mode, the RS-232C port can provide any data that is available for display on the front panel. The data available for each model is as follows:

Model M4/E4-DP	DP C=xxxx DP F=xxxx
Model M4/E4-RH	DP C=xxxx DP F=xxxx RH=xxxx TMP C=xxxx TMP F=xxxx
Model M4/E4-PR	DP C=xxxx DP F=xxxx GR/LB=xxxx PPMV=xxxx G/KG=xxxx PSIA=xxxx BAR=xxxx

Operate Mode (cont.)

The data output by the unit can be modified in two ways:

- the user can customize the data output to a subset of the above (see *RS-232C Programming* on page 4-12).
- the user can enter commands via the RS-232C port to obtain immediate output of a single parameter (see *Outputting Data "On Command"* on page 4-18).

In addition to the output data, the unit outputs the following status flags when appropriate:

ALARM	The alarm relay is activated. Disabling the alarm relay will also disable this status flag.
CONTROL	The unit is actively controlling the mirror temperature at a stable dew point.
BALANCE	The unit is in PACER balance mode.
SERVICE	The system optics require service, cleaning or adjustment.
COOL	The sensor is in maximum cooling mode.
HEAT	The sensor is in maximum cooling mode.
SHUTDOWN	The unit has shut down because of excessive temperature.

Any appropriate alarm flags are displayed following the output data. They will appear with each output for as long as they are active. Each alarm flag is followed by a carriage return.

Helpful Hints for Operating the Unit

Time Response

At dew points above 0°C, the system stabilizes within a few seconds at a consistent dew or frost layer. The green **CONTROL** light illuminates when the system is stable and valid readings may be taken.

Time Response (cont.)

When the system is operating at very low frost points (below –40°C), extra care may be required when interpreting readings because of the slower response of the system. Time response depends on a number of factors including dew/frost point, slew rate, upstream filtering, and flow rate.

- As the dew/frost point becomes lower, water molecules in the air sample become scarcer, and it takes longer to condense a frost layer on the mirror sufficiently thick to establish an equilibrium condition.
- Temperature slew rate is dependent on dew point and depression (the temperature difference between the mirror and the sensor body); at higher dew points and moderate depressions, it is typically 1.5°C/second. At lower dew points and/or larger depressions, slew rate becomes progressively slower.
- Flow rate affects response by determining the rate at which water vapor is supplied or carried off.

There is, of course, a trade-off between response time, control system stability, and sensitivity to contamination.

Supercooled Dew Points

Slightly below the freezing point, water can exist in a supercooled liquid state for extended periods of time. Extra care may be needed when making measurements in the frost point region of 0° to –20°C, because the mirror temperature may temporarily stabilize at the supercooled dew point, 0.5° to 1°C below the actual frost point.

To assure that the unit is operating in the ice phase within this temperature range, allow the instrument to operate continuously. Before manually clearing a frost layer, take a reading, and afterwards allow sufficient time to reform a stable frost layer before taking further readings.

Contamination

Mirror Cleanliness

Proper operation of a condensation hygrometer depends on the condition of the mirror surface. In general, accuracy is reduced when contaminants accumulate on the mirror.

However, the mirror does not have to be microscopically clean. In fact, the mirror performs best a few hours after cleaning, when nucleation sites have formed. On an unscratched, freshly cleaned mirror, there are relatively few nucleation sites on which dew or frost deposits can form, and more time is required to collect a condensation layer at low frost points. Also, overshoot may occur, which can cause oscillations as the temperature stabilizes.

Particulate Contaminants:
Particulate matter that is insoluble in water may accumulate on the mirror surface, but does not affect the instrument accuracy until the mirror reflectance is reduced substantially. In many cases, particulates improve instrument response by providing condensation sites.

Water-Soluble Contaminants:
Contaminants which readily dissolve in water, such as naturally occurring salts, are detrimental to accurate vapor concentration measurement by any condensation method. These materials readily go into solution with the water condensate on the mirror surface, and then reduce the vapor pressure in accordance with Raoult’s Law. As the concentration increases with time, the saturation vapor pressure of the liquid solution decreases.

The unit responds to this lower vapor pressure by elevating the mirror temperature in order to maintain a vapor pressure that is in equilibrium with the partial pressure of atmospheric water vapor. The displayed dew point, therefore, drifts upward above the true dew point. Because the measurement error increases gradually, it often goes undetected.

Water-Soluble Contaminants (cont.):
To determine whether dissolved contaminants are affecting dew point measurement, perform the following steps:

1. Note the indicated dew point.
2. Clean the mirror.
3. Balance the detector by initiating a PACER cycle.
4. Measure the dew point again.

If the new reading is lower than the first reading, it is likely that soluble material was present in sufficient quantity to cause a measurement error.

Gaseous Contaminants:
When a gaseous material that has a higher condensation temperature than that of water is present (even in very low concentrations), the unit will eventually control on that material, rather than on water. The system then displays the condensation temperature of the contaminant, not of water. Such material accumulates on the mirror only when chilled. In the normal atmosphere, gaseous contaminants do not have a detectable effect.

Minimizing the Effects of Contaminants:

1. Use the PACER feature to reduce the effect of contaminants on the unit's performance.
2. Reduce the gas flow rate to reduce the rate of accumulation of contaminants on the mirror.
3. Clean the mirror according to the recommended optics cleaning procedure. See *Cleaning the Sensor Mirror* on page 5-1. To determine the proper cleaning interval for a given set of conditions, take a dew point reading before and after the cleaning. Any appreciable shift indicates that under these conditions, the mirror should be cleaned more often.

Mirror Flooding

If there is an abrupt transition from dry to moist conditions (particularly when accompanied by a transition from cold to warm temperatures), the mirror may accumulate an overload of moisture. It then may take several minutes before the sensor dries out and valid readings can be obtained. The drying process can be accelerated by setting the **SENSOR** switch to **HEAT**, to temporarily heat the sensor.

Sample Line Maintenance

Contaminated sample lines slow the unit's response time and can cause erroneous readings, usually on the high side. Clean the sample lines as often as necessary. To determine the required cleaning frequency, take dew point readings before and after cleaning the lines, sensor cavity, and mirror. If the two readings differ appreciably, the sampling lines should be cleaned more often. To reduce the rate of contamination, reduce flow and/or install a filter upstream.

Pressure Effects

If the pressure of the gas is increased or reduced from atmospheric pressure, but the mixing ratio (moisture content) stays constant, the dew point is correspondingly increased or decreased. The M4 displays the dew/frost point at the pressure to which the sensor chamber is exposed. The sensor location and hookup arrangement can influence the pressure. The dew point change due to pressure change can be calculated by using Dalton's Law and the Smithsonian Tables or a proper nomograph. Appendix C contains basic data for these calculations. Request a copy of the GE Sensing *Humidity Handbook* for additional detailed information.

The PACER Cycle

GE Sensing has developed and patented a compensation technique called PACER (Programmable Automatic Contaminant Error Reduction) that is very effective in reducing the Raoult Effect error associated with soluble contaminants, particularly for near-ambient dew points. The PACER cycle replaces the AUTO balance cycle available on earlier GE Sensing products.

The PACER Cycle (cont.)

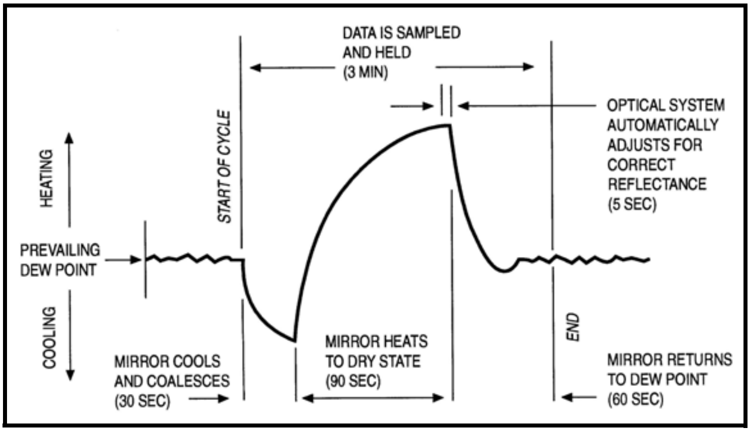


Figure 3-6: The PACER Cycle

The PACER cycle, diagrammed in Figure 3-6 above, begins with a coalescence period, during which the mirror is cooled well below the dew point of the sample gas, condensing out a large amount of water. This excess water easily dissolves any water-soluble contaminants. The mirror is then heated. During the heating phase, the large puddles of water gradually evaporate, carrying increasingly heavy concentrations of salt as the puddles become smaller. Finally, when all the puddles have evaporated, dry “islands” of crystallized salt are left on the mirror. The area between the islands (80-85% of the mirror surface) is now clean and shiny, whereas before the PACER cycle it may have been completely covered. The total amount of contamination has not been reduced, but instead redistributed as shown in Figure 3-7 below, with more clean mirror surface available for dew formation.

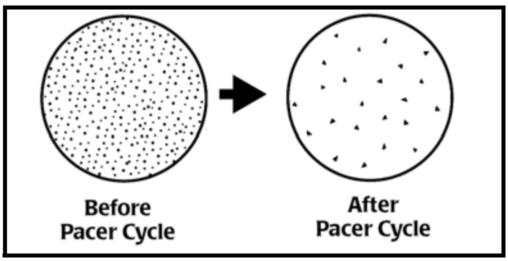


Figure 3-7: Results of the PACER Cycle

Chapter 4

Programming

General Information

The hygro M4/E4 is programmed at the factory to display and output the data required for most applications. In many cases, no further programming is required.

Programming allows control of four major items:

- the front panel display
- the analog outputs
- the digital (RS-232C) outputs
- the built-in alarm (models **-RH** and **-PR** only)

Programming is most easily accomplished using a computer or data terminal connected to the RS-232C data port. It can also be accomplished using the front panel display switch, provided this function has been enabled by a command issued through the RS-232C port.

Note that commands issued to the unit through the RS-232C port would usually come from a manually operated computer or terminal as described below. For specialized automated operation, commands could also be issued autonomously by a properly programmed computer.

Programming from the Front Panel

The DISPLAY Switch

The front-panel **DISPLAY** switch allows the user to control the following aspects of displaying and outputting data:

- The units of data displayed on the front panel can be viewed or changed.
- The parameters and scaling of data on the analog outputs can be viewed (but not changed).
- Data used to control the unit's alarm outputs can be viewed (but not changed).

The Display Switch (cont.)

In addition, the analog outputs and alarm can be changed by the **DISPLAY** switch if the switch's functionality has been modified using the RS-232C port.

The **DISPLAY** switch has a central rest position (**OPER**), and two momentary positions (**NEXT** and **SELECT**). It is used in conjunction with the three green LEDs:

- the units portion of the main display
- the parameter annunciator
- the **CONTROL STATUS** display).

Note: *You may need to keep the **DISPLAY** switch pressed for 1 or 2 seconds until the display changes to indicate that the action has taken effect.*

Note: *The unit's microprocessor checks the state of the **DISPLAY** switch once per second, and the switch must be depressed during this instant for the action to take effect.*

Note: *When stepping through a sequence of options, it is often easier to hold the switch in the **NEXT** position until the desired option is displayed, than to press it several times.*

Note: *While the unit is in programming mode, it will not display or output measurement data.*

General Procedure

In general, pressing **NEXT** enters programming mode, and then scrolls through the programming functions, and scrolls through digits and characters to display new values. Pressing **SELECT** chooses which area of programming will be accessed, and enters values and characters.

As a brief introduction to using the **DISPLAY** switch, try the following. This exercise won't change the unit's operation, but it will give you some familiarity with the **DISPLAY** switch. Locate your model in the table below, and follow along as the unit steps through the available functions.

- To enter programming mode, press the **DISPLAY** switch to **NEXT** (you may need to keep this switch pressed for 1 or 2 seconds).
- The unit will leave **OPERATE** mode and enter **PROGRAM** mode. The **STATUS** display illuminates, displaying the first programming function (controlling the display).
- Press **NEXT** to display the next programming function (controlling the lower display, if any, or controlling the analog outputs).
- Hold the switch in the **NEXT** position to scroll through any remaining functions. After all functions have been displayed, the unit will return to **OPERATE** mode. (The **STATUS** display goes out.)

Each time the **NEXT** switch is pressed, the **STATUS** display advances to the next programming function as shown below. After displaying the last programming function, the unit returns to **OPERATE** mode.

General Procedure (cont.)

Table 4-1: DISPLAY Switch Functions

Model	Display Switch	Status Indicator	Parameter Annunciator
Model **-DP**	start first press next press next press	(operate) **U** (units) **O** (output) (operate)	
Model **-RH**	start first press next press* next press next press* next press next press* next press	(operate) **U** (units) **U** (units - second display) **O** (analog output 1) **O** (analog output 2) **A** (alarm) **A** (alarm - second display) (operate)	**HUMIDITY** **TEMPERATURE**
Model **-PR**	start first press next press* next press next press* next press next press* next press	(operate) **U** (units) **U** (units - second display) **O** (output 1) **O** (output 2) **A** (alarm) **A** (alarm - second display) (operate)	**HUMIDITY** **PRESSURE**

* This line only applies to a Model E4 with two displays.

Note: *The alarm functions are not shown if the alarm has been disabled using the RS-232C commands.*

General Procedure (cont.)

Symbol functions shown by the **STATUS** indicator are shown below:

- **U** shows all units available for display on the front panel
- **O_1** shows the humidity parameter currently chosen for Output1, and its scaling (High and Low limits)
- **O_2** shows the temperature or pressure parameter currently chosen for Output2, and its scaling (High and Low limits)
- **A** shows the parameter currently chosen for controlling the alarm, along with the on/off values

While any of the above programming functions is accessed (with the **STATUS** display showing **U**, **O** or **A**), pressing **SELECT** displays the parameter currently chosen for output, and the scaling of the analog outputs, if applicable.

All of the programming steps below must be carried out in sequence. In the remainder of this section, steps shown in shaded boxes apply only to units that have had their **DISPLAY** switch functions modified to allow changing output data. Skip over these steps if the **DISPLAY** switch functionality has not been modified.

Programming the Display Units

From **OPERATE** mode, press **NEXT** until "**U**" is displayed in the **STATUS** display.

If you wish to view and select the display units, perform the following steps:

1. Press **SELECT**. The currently selected unit flashes.
2. Press **NEXT** to scroll through the available units.
3. Press **SELECT** to designate the units to be displayed.

The state of the **DISPLAY** switch is determined only once per second, at the instant that the green units LED flashes on. Either hold the switch depressed for more than a second at a time, or develop a rhythm of pressing the switch so that it is depressed while the green LED is turning on.

The units of data available for each model are shown below.

Table 4-2: Available Units of Data

Model	Units Display	Parameter	Explanation
Model **-DP**	**°C** **°F**	Humidity Humidity	Dew Point, °C Dew Point, °F
Model **-RH**	**°C** **°F** **H** **°C** **°F**	Humidity Humidity Humidity Temperature Temperature	Dew Point, °C Dew Point, °F Relative Humidity, % Temperature, °C Temperature, °F
Model **-PR**	**°C** **°F** **G** **p** **g** **P** **b**	Humidity Humidity Humidity Humidity Humidity Pressure Pressure	Dew Point, °C Dew Point, °F Grains/lb PPMv Grams/kg Psia Bar

When finished with the display units, press **NEXT** to move to the next step.

Programming the Humidity Analog Output

The **STATUS** indicator displays "**O**," and, on a model **-RH** or **-PR**, the **HUMIDITY** annunciator illuminates.

If you wish to view the humidity output settings, press **SELECT**. (Otherwise, press **NEXT** to move to the next step.)

If **SELECT** was pressed, the humidity units selected for output, and the humidity scaling parameters, are displayed. The scaling parameters set the high and low values of the analog output. The **STATUS** display shows "**H**," and the current high value is shown on the main display. The high value is the humidity level that will cause full-scale analog output.

If the behavior of the **DISPLAY** switch has been appropriately modified, you can change the humidity output settings. If you wish to change the humidity output parameter, perform the following steps:

1. Press SELECT. The **STATUS** indicator displays "**O**" and the units character blinks.
2. Press and hold **NEXT** to scroll through the available units. Stop when the desired units are displayed.
3. Press **SELECT** to designate the parameter to be output.

Programming the Humidity Analog Output (cont.)

.

If you wish to change the high value, press **SELECT**. (Otherwise, press **NEXT** and skip to the next step, the low value). Enter the new high value, one digit at a time, starting with the right-most digit, as follows (the digit currently being changed blinks.):

1. Press and hold **NEXT** to scroll through the digits until the desired digit is displayed.
2. Press **SELECT** to select this digit.
3. The next digit now blinks. Set it to the correct value in the same way.

The left-most digit displays only the values 1, –1, –, or blank. Use it to set the sign of the value as appropriate.

The left-most digit can be difficult to set to "blank," because no character blinks to indicate the timing of pressing the switch, and, in addition, the display does not change immediately to indicate the switch change has been successfully recognized. Have patience, and proceed slowly and deliberately!

The **STATUS** display shows "**L**," and the current low value is shown on the display. The low value is the humidity level that will cause minimum analog output.

If you wish to change the low value, press **SELECT**. Enter the new low value as described in the previous step.

When finished with humidity output units, press **NEXT** to move to the next step. For the Model **-DP**, the next step is a return to **OPERATE** mode.

Programming the Temperature/ Pressure Analog Output (-RH & -PR only)

The **STATUS** indicator displays "**O**."

- On the Model **-RH**, the **TEMPERATURE** annunciator illuminates, and temperature settings can be accessed.
- On the Model **-PR**, the **PRESSURE** annunciator illuminates, and pressure settings can be accessed.

If you wish to view the temperature or pressure output settings, press **SELECT**. (Otherwise, press **NEXT** to move to the next step.)

Next, the temperature or humidity units currently selected for output, and the output scaling parameters, are displayed. The scaling parameters set the high and low values of the analog output. The **STATUS** display shows "**H**," and the current high value is shown on the main display. The high value is the temperature or pressure level that will cause full-scale analog output.

> If the behavior of the **DISPLAY** switch has been appropriately modified, you can change the temperature or pressure output settings. If you wish to change the these output settings, perform the following steps:
>
> 1. Press **NEXT** to scroll through the available units. Stop when the desired units are displayed.
> 2. Press **SELECT** to designate the units to be output.

Programming the Temperature/ Pressure Analog Output (-RH & -PR only) (cont.)

If you wish to change the high value, press **SELECT**. (Otherwise, press **NEXT** and skip to the next step). Enter the new high value, one digit at a time, starting with the right-most digit, as follows (the digit currently being changed blinks.):

1. Press **NEXT** to scroll through the digits until the desired digit is displayed.
2. Press **SELECT** to select this digit.
3. The next digit now blinks. Set it to the correct value in the same way.

The left-most digit displays only the values 1, –1, –, or blank. Use it to set the sign of the value as appropriate.

The left-most digit can be difficult to set to “blank,” because no character blinks to indicate the timing of pressing the switch, and, in addition, the display does not change immediately to indicate the switch change has been successfully recognized. Have patience, and proceed slowly and deliberately!

The **STATUS** display shows “**L**,” and the current low value is shown on the display.

If you wish to change the low value, press **SELECT**. Enter the new low value as described in the previous step.

When finished with temperature/pressure output units, press **NEXT** to move to the next step.

Prog. the Alarm Parameter & Limits (-RH & -PR only)

The **STATUS** indicator displays “**A**.” This step will be skipped if the alarm functions have been disabled using the RS-232C commands.

If you wish to view the alarm output settings, press **SELECT**. (Otherwise, press **NEXT** to return to **OPERATE** mode.)

> If the behavior of the **DISPLAY** switch has been appropriately modified, you can change the alarm settings. If you wish to change the alarm units, perform the following steps:
>
> 1. Press **NEXT** to scroll through the units available to be monitored by the alarm. Stop when the desired parameter is displayed.
> 2. Press **SELECT** to designate the alarm parameter.

Next, the alarm threshold levels are displayed. Threshold levels control the points where the alarm is energized. The **CONTROL STATUS** display shows “**H**,” and the current alarm **ON** value is shown on the main display.

> If you wish to change the **ON** value, press **SELECT** and enter the value. (Otherwise, press **NEXT** and skip to the next step.)
>
> 1. Press **NEXT** to scroll through the digits until the desired digit is displayed.
> 2. Press **SELECT** to select this digit.
> 3. The next digit now blinks. Set it to the correct value in the same way.
>
> The left-most digit displays only the values 1, –1, –, or blank. Use it to set the sign of the value as appropriate.

Prog. the Alarm Parameter & Limits (-RH & -PR only) (cont.)

The **STATUS** display shows “**L**,” and the current low value is shown on the display.

> If you wish to change the **OFF** value, press **SELECT**. Enter the new value as described above. Note that for a Model **-RH** or **-PR** with two displays, alarm values may be entered on either the upper or lower display. There is only a single alarm relay, and it is the most-recently entered values on either display that will control the alarm relay.

When finished with the settings, press **NEXT** to return to **OPERATE** mode. The **STATUS** goes blank, and after a few seconds, data will be displayed.

The alarm may be disabled by issuing a command through the RS-232C communications port. See *Function 8: Set Alarm* on page 4-25. If disabled, the alarm function is not accessible from the **DISPLAY** switch.

RS-232C Programming

Programming Mode

Programming of the unit using the RS-232C channel is accomplished by a series of menus described in this section. The menus can be accessed by a computer or data terminal connected to the unit’s RS-232C data port. The Data Terminal Emulator included in Windows software provides a very convenient means of controlling the unit.

The programming menus are not available while **BALANCE** mode is active. When programming menus are active, the sensor cooling is deactivated and the sensor mirror is allowed to rise to ambient temperature. In addition, the front panel display is blank.

Main Menu (Software Version 2.0)

The main menu is the starting point for all programming functions. To access the main menu from normal operating mode, press **ESC** (hex 1B) twice on your terminal. To return to the main menu from any sub-menu, press **E** on your terminal one or more times until the main menu is displayed. The main menu will contain some or all of the following choices, depending on the model:

```
1) Scale Outputs        2) Set Balance Type 3) Set RS-232 Units
4) Display Option       5) Set Averaging    6) Calibrate Output1
7) Calibrate Output2    8) Set Alarm        9) Set Input2 Param
A) Molecular Weight     E) Exit
```

Note: *Menu choices* **7** *and* **8** *appear only on Model* **-RH** *and Model* **-PR***.*

Note: *Menu choice* **9** *appears only on a Model* **-RH** *configured with a 4–20mA input.*

Note: *Menu choice* **A** *appears only on Model* **-PR***.*

Press the digit or letter corresponding to the item you wish to program.

When finished, press **E** from the main menu to return to **OPERATE** mode. Note that several seconds may be required for the system to respond and provide data on the RS-232 terminal or the main display.

Each menu item is described in detail in the sections following.

Function 1: Scale Outputs

From the main menu, press **`1`** to assign and scale the analog outputs. The current output selection(s) and scaling are displayed, followed by the **`Scale Outputs`** menu:

```
OUTPUT1:
DP C:
HIGH = 60          LOW = -40

OUTPUT2:
TMP C:
HIGH = 60          LOW = -40

1)  OUTPUT1        2) OUTPUT2       E)  EXIT
```

Information on Output2 and menu item 2 appear only on a Model **-RH** or **-PR**.

Scaling Output1

Press **`1`** to access the **`Output1`** menu, which controls the Humidity output. The text **`OUTPUT1:`** is displayed, followed by one of the three menus listed below, depending on the particular model:

```
               OUTPUT1:


Model  -DP:    0) DPC  1) DPF E)  EXIT
       -RH:    0) DPC  1) DPF 2)  RH      E)  EXIT
       -PR:    0) DPC  1) DPF 2)  GR/LB   3)  PPMV  4) G/Kg  E)  EXIT
```

Select a humidity parameter to be output, or press **`E`** to exit and return to the previous menu. If you select a parameter, the unit will also ask for the analog output scaling values (full-scale high and low values for the analog outputs).

```
HIGH =
```

Enter the value that should cause full-scale output, and press **RETURN**.

```
LOW =
```

Scaling Output1 (cont.)

Enter the minimum value to be output, and press **RETURN**. The unit will again display the newly entered values and the **`Scale Outputs`** menu. Check the values, and press **`E`** to exit back to the main menu. When the unit returns to operating mode, the analog output voltage will vary with the measured humidity as shown in Figure 4-1 below.

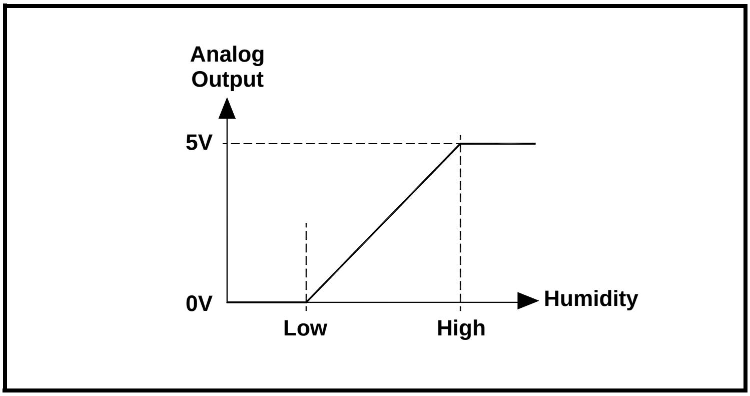


Figure 4-1: Scaling Parameters

Scaling Output2

For a Model **-RH** or **-PR**, Output2 may also be selected, and the following parameters will be displayed for selection:

	OUTPUT2		
Model -RH:	**0) TMPC**	**1) TMPF**	**E) EXIT**
-PR:	**0) PSIA**	**2) BAR**	**E) EXIT**

Select the desired parameters and enter the scaling values, just as for Output1.

Function 2: Set Balance Type

From the main menu, press **2** to change the type of balance used by the Hygro M4/E4, to adjust the balance interval, or to remotely initiate a balance cycle. The current balance state is displayed, followed by the **Balance Type** menu.

```
BALANCE TYPE =
Pacer
DAY = 0
HOUR = 12              2)  Auto Bal   3)  Set Interval
1)  Pacer Bal          E)  Exit
4)  Initiate
Balance
```

Selecting the Balance Type

Press **1** to set the type of balance to PACER (the default) or **2** to set the type of balance to AUTO.

Note: *In the Model M4/E4, only the PACER cycle type is available, even though the older AUTO cycle can be selected. Do not use the AUTO setting. See The PACER Cycle on page 3-17.*

Setting the Balance Interval

To set the balance interval, press 3. The balance interval is specified in days and hours, and the interval will be the sum of the days and the hours entered. The following will appear:

```
DAY =
```

Type a value for the number of complete days between balance cycles and press **RETURN**. The following will appear:

```
HOUR =
```

Type a value from 1 to 24 for the number of hours between balance cycles, and press **RETURN**.

The new interval will be displayed, and the unit will return to the **Balance Type** menu.

Setting the Balance Interval (cont.)

Examples:

```
Day = 0               Balance every 12 hours
Hour = 12

Day = 1               Balance every 24 hours
Hour = 0

Day = 5               Balance every 5½ days
Hour = 12
```

Initiating a Single Balance Cycle

Press **4** if you wish to manually initiate a balance cycle. The unit will return to normal operating mode at the completion of the cycle.

Press **E** to return to the main menu.

Function 3: Set RS-232 Units

From the main menu, press **3** to customize the RS-232C data output. This menu selects the units to be output and the handshaking status. The currently selected units and handshaking status are displayed, followed by the **Set RS-232 Units** menu.

```
Selected Units = 1,2
Handshake = Disabled
1) Data           2) Handshake        3) Exit
(Toggle)
```

Selecting Output Data

Press **1** to configure the RS-232C data output units. The following menu is displayed:

```
Select Units     2) User Prompt       E) Exit
```

Press **1** to select the parameters to be displayed. One of the following menus will be displayed:

```
-DP: 1) DPC 2) DPF 3) None       E) Exit
-RH: 1) DPC 2) DPF 3) RH         4) TMPC 5) TMPF 6) None  E) Exit
-PR: 1) DPC 2) DPF 3) Grains/lb. 4) PPMV 5) G/Kg 6) PSIA  7) Bar 8) None E) Exit
```

Selecting Output Data (cont.)

Press numbers individually to add the designated parameter to the RS-232C data output. Press the digit for “None” to turn off all data outputs, or to clear the list before adding parameters.

Outputting Data ‘On Command’

The Hygro M4/E4 contains a feature which allows the unit to output data only when commanded or “prompted” by the user or by an external device. When a command code is received by the unit while operating in this mode, the data associated with that code will be output.

To configure the unit to output data on command, press **2** from the above menu to select User Prompt. The current user-prompt status is displayed, and a sub-menu allows the status to be changed.

```
Status = Disabled
ALLOW USER TO PROMPT FOR DATA
1) Enable     2) Disable      E) Exit
```

Press **1** to enable the user prompt for data. Press **E** twice to return to **OPERATE** Mode. To return to normal operation, access the above menu and press **2** to disable this function.

While the unit is set to output data ‘on command,’ data will be output only when requested by the user prompt. The codes for requesting data are listed in the following table. Note that any of the eight parameters may be requested from every M4/E4 model, but only those indicated in the table below by an “X” will output valid data.

Outputting Data 'On Command' (cont.)

Table 4-3: Codes for Requesting Data

CODE	PARAMETER	–DP	–RH	–PR
D1	DPC	X	X	X
D2	RH		X	
D3	TMPC		X	
D4	Grains/lb			X
D5	PPMV			X
D6	GRAMS/KG			X
D7	PSIA			X
D8	BAR			X

Handshake Control

From the Set RS-232C units menu, press **2** to change the handshake protocol. The default is "no handshake." The unit will ask for a password before allowing the handshaking protocol to be changed.

```
Enter Access Code:
```

Type the code word "**ACCESS**". The status will be changed and the new status will be displayed. Press **E** to return to the main menu.

Function 4: Display Options

To change the behavior of the front panel **DISPLAY** switch, press **4** from the main menu. Under the default behavior:

- all units are available
- the output(s) are viewable but not changeable
- the alarm (if present) is viewable but not changeable.

Function 4: Display Options (cont.)

One of the following Display Options menus will appear:

```
       Model  -DP: 1) Display Units    2) Outputs  E) Exit
Models -RH and -PR: 1) Display Units    2) Outputs  3) Alarm  E) Exit
```

Setting Front Panel Display Units

Press **1** to select the output units available to be displayed on the front panel. The **Display Units** menu is displayed:

```
Selected units =
1) Select   2) Fix/Alternate Display   E) EXIT
```

Press **1** to select the units to be displayed. One of the following sub-menus will appear:

```
-DP: 1) DPC 2) DPF 3) None         E) Exit
-RH: 1) DPC 2) DPF 3) RH           4) TMPC 5) TMPF 6) None  E) Exit
-PR: 1) DPC 2) DPF 3) Grains/lb.   4) PPMV 5) G/Kg 6) PSIA  7) Bar 8) None E) Exit
```

Press numbers individually to add the designated parameter to the sequence available to the **DISPLAY** switch. Press the digit for “None” to turn off all data outputs, or to clear the list before adding parameters.

Display Sequencing

Press **2** from the **Display Units** menu to “fix” or “alternate” the display. The following sub-menu will appear:

```
1) Fix     2) Alternate
```

When “Fix” is selected, only the selected unit will be displayed during normal operation. When “Alternate” is selected, the display will sequence through the available units at a 2-second interval. The default mode is “Fix.”

Allowing the DISPLAY Switch to Control Outputs

Press **2** from the **Display Options** menu to display and/or change how the **DISPLAY** switch can control output units and scaling information. The current status is displayed, followed by a menu.

```
Status = View Only
ENABEL/DISABLE SWITCH FUNCTIONS
1) View only   2) View & Change   3) Hide   E) Exit
```

Press **1** to make the output units and scaling viewable but not changeable (the default status). Press **2** to make the units and scaling changeable from the front panel. Press **3** to hide the units and scaling on the front panel. When hidden, the units and scaling previously selected are still in effect, but they cannot be accessed using the **DISPLAY** switch. Press **E** to exit.

Allowing the DISPLAY Switch to Control the Alarm

Press 3 from the **Display Options** menu (Models **-RH** and **-PR** only) to change how the **DISPLAY** switch can control the alarm units and scaling. The following menu will appear:

```
Status = View Only
ENABEL/DISABLE SWITCH FUNCTIONS
1) View only   2) View & Change   3) Hide   E) Exit
```

Press **1** to make the alarm settings viewable but not changeable (the default status). Press **2** to make the alarm settings changeable from the front panel. Press **3** to hide the alarm settings on the front panel. When hidden, the alarm settings previously selected are still in effect, but they cannot be accessed using the **DISPLAY** switch. Press **E** to exit.

Function 5: Set Averaging

From the main menu, press **5** to set the data averaging parameter. This number determines how many of the most recent dew point readings are averaged to determine the reading displayed and output. The number may range between 1 and 20. The factory default is 20. The current value is displayed, followed by a menu:

```
Number of Points = 20
1) Set Average   E) Exit
```

Press **1** to change the value. The current averaging value is displayed:

```
VALUE =
```

Type a value between 1 and 20 and press **RETURN**. The new value is displayed. Press **E** to Exit.

Function 6: Calibrate Output1

To calibrate the unit's Output1 (humidity), the following equipment is required:

- 4½-digit voltmeter
- 0.01%, 100-Ohm precision resistor

Caution!
Please consult the factory before attempting to calibrate the outputs of the unit. All analog outputs are factory calibrated and normally do not require calibration or field adjustment.

From the main menu, press **6** to calibrate the **HUMIDITY** output. The analog outputs are calibrated at the factory and normally never require recalibration. To protect against inadvertent calibration, this function is protected by a password. The following is displayed, allowing the password to be entered:

```
Enter Acces Code:
```

Function 6: Calibrate Output1 (cont.)

Type the code “**ACCESS**”. The **Calibrate Output1** menu is displayed:

```
1) Calib Output    2) Check Output    E) Exit
```

Calibrating the Current Output

Disconnect all devices from the unit’s humidity output. Connect the 100-Ohm precision resistor across **I+** (or **4-20MA**) and **RTN** of the **HUMIDITY** output. Connect the voltmeter across the resistor leads. Set the voltmeter to 4 volts full scale.

From the above menu, press **1** to calibrate the humidity current output. The unit passes a current through the resistor, generating a voltage measured by the voltmeter. Multiply this voltage by 10 to convert it to milliamps of current in the resistor, and enter the result:

```
VALUE =
```

For example, if the voltmeter reads 1.6421 volts, type 16.421 and press **RETURN**.

The unit passes a new current through the resistor, and asks for a new reading to be entered. Type the new voltage (times 10) and press **RETURN**. The unit recalibrates its **HUMIDITY** output and returns to the **Calibrate Output1** menu.

Checking and Adjusting the Voltage Output

The output voltage calibration can be checked and adjusted. Connect the voltmeter to **V+** (or **0-5VDC**) and **RTN** for the **HUMIDITY** output and press **2** from the **Calibrate Output1** menu. The following menu is displayed:

```
1) Set output current      E) Exit
```

Press **1** to calibrate voltage humidity output. The following is displayed:

```
Desired output current (mA) =
```

Checking and Adjusting the Voltage Output (cont.)

Note: *On this screen,* **`Press E to Exit`** *is displayed. Do not press* **`E`** *until the entire procedure is complete and all values are correct.*

To set the 4mA (0.0 Volt) point, type **`4`** and press **RETURN**. Adjust R33 on the main circuit board so that the voltmeter reads 0.000 Volts, ±0.005. Press **RETURN** when this is done.

The menu is displayed again:

```
1) Set output current      E) Exit
```

Press **`1`** to set the second calibration point. The following is displayed:

```
Desired output current (mA) =
```

To set the 20mA (5 Volt) point, type 20 and press **RETURN**. Adjust R32 on the main circuit board so that the voltmeter reads 5.000 Volts, ±0.005. Press **RETURN** when this is done.

Repeat the above steps with values of 4 and 20 mA until no further adjustment is required. Finally, enter a value of 12 and check that the voltmeter reads 2.5 Volts. Other values, such as 5, 10, 15 can also be checked. When all readings are correct, type **`E`** at the **`PRESS E TO EXIT`** message to return to the **`Calibrate Output1`** menu, and **`E`** again to return to the main menu.

Function 7: Calibrate Output2

This main menu option appears only on the Models **-RH** and **-PR**. Follow the procedure above for calibrating Output1, except making connections to the **TEMP/PRESSURE** output instead of the **HUMIDITY** output. In addition, adjust R78 to obtain a zero-volt reading, and R77 to obtain a 5-volt reading.

Table 4-4: Adjustments to Change Voltage Readings

Current Setting	Voltage Reading	Output 1 Adjustment	Output 2 Adjustment
4 mA	0	R33	R78
20 mA	5	R32	
12 mA	2.5	(no adjustment)	

Function 8: Set Alarm

This main menu option appears only on the Models **-RH** and **-PR**.

From the main menu, press **8** to assign and scale the alarm output. The current state of the alarm is displayed, followed by the **Set Alarm** menu:

```
Alarm:
DPC:
On = 30        Off = -20
1) Set Alarm  2) Enable Alarm  3) Disable Alarm  E) Exit
ALARM STATUS = ENABLED
```

Alarm Settings

Press **1** to access the alarm settings. One of the following menus will appear:

```
-RH: 0) DPC  1) DPF  2) RH          3) TMPC  4) TMPF  E) Exit
-PR: 0) DPC  1) DPF  2) Grains/lb.  3) PPMV  4) G/Kg  5) PSIA   6) Bar  E) Exit
```

Select a parameter to be monitored by the alarm, or press **E** to exit. If you select a parameter, the following is displayed:

```
ON =
```

Alarm Settings (cont.)

Enter the value at which the alarm should turn on, and press **RETURN**. The following is displayed:

```
OFF =
```

Enter the value at which the alarm should turn off and press **RETURN**. The new values will be displayed, along with the `Set Alarm` menu.

Figure 4-2 illustrates the results of four different alarm relay configurations on the same dew point temperature curve. In the upper left chart, the relay is wired normally closed and the **ON** value is set higher than the **OFF** value. The 10° deadband creates better control stability. The upper right chart shows how the opposite control action can be achieved with the relay wired normally open. The lower charts show how the alarm will activate if the **OFF** value is set higher than the **ON** value.

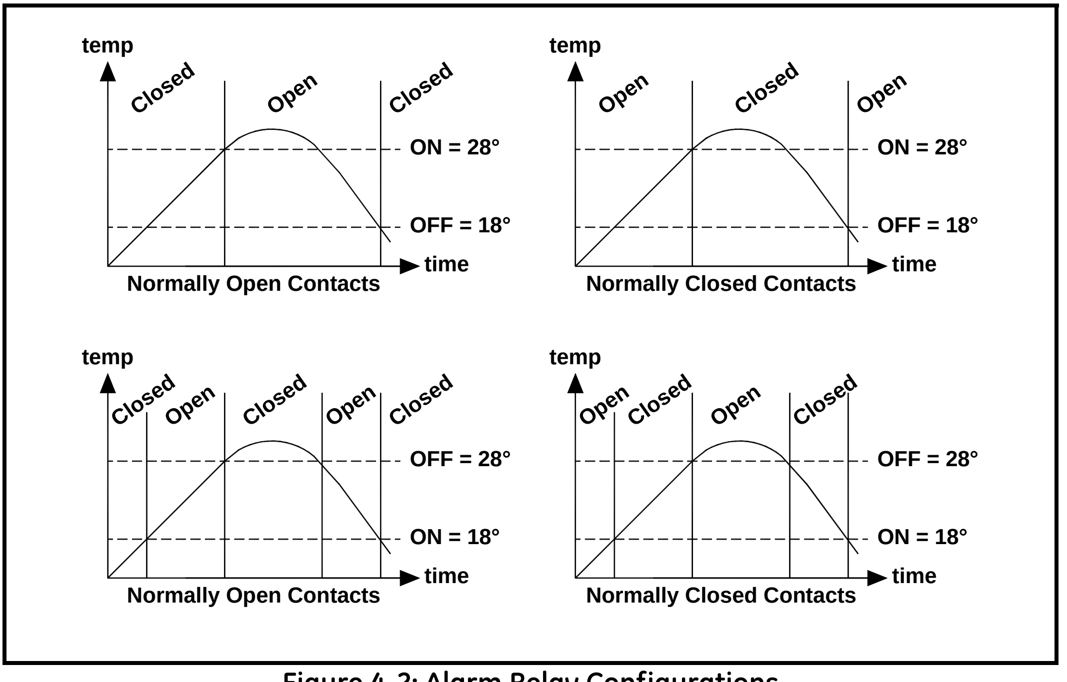


Figure 4-2: Alarm Relay Configurations

Enabling and Disabling the Alarm

From the **Set Alarm** menu, press **2** to enable the alarm relay. Press **3** to disable the alarm relay. The relay is enabled when shipped from the factory.

Function 9: Set Input2 Param.

This main menu option appears only on the Models **-RH** (with 4–20mA input) and the **-PR**.

From the main menu, press 9 to scale the 4–20mA temperature or pressure input.

Model -RH

On the Model **-RH**, this function switches the input from an RTD interface to a 4–20mA temperature sensor interface, and allows the maximum and minimum input values to be entered. The following menu is displayed:

```
1) Set Scale       2) Exit
```

Press **1** to scale the 4–20mA temperature input. The **Sensor Characteristics** menu is displayed.

```
SENSOR CHARACTERISTICS
MAX INPUT (20mA) = 30
MIN INPUT ( 4mA) = 0
INPUT PARAMETER
1) MAX INPUT (20mA)     2) MIN INPUT (4mA)   E) EXIT
3) SET DEFAULT          4) SELECT STANDARD
```

Press **1** to set the 20mA value. The following is displayed:

```
MAX INPUT (20mA) =
```

Enter the temperature in degrees C that corresponds to 20mA, and press **RETURN**.

Similarly, press menu item **2** to set the 4mA temperature, enter the value, and press **RETURN**. Press **E** to exit.

Model -PR

On the Model **-PR**, the following menu is displayed:

```
SENSOR CHARACTERISTICS
MAX INPUT (20mA) = 30
MIN INPUT ( 4mA) = 0
INPUT PARAMETER
1) MAX INPUT (20mA)     2) MIN INPUT (4mA)  E) EXIT
3) SET DEFAULT          4) SELECT STANDARD
```

Press **1** to set the 20mA value. The following is displayed:

```
MAX INPUT (20mA) =
```

Enter the pressure value that corresponds to 20mA and press **RETURN**.

Similarly, press **2** to set the 4mA value, enter the value and press **RETURN**. Press **E** to exit.

To return the settings to the standard values as shipped from the factory, press **4**.

If the gas entering the sensor is at a constant, known pressure, this pressure may be programmed into the system in place of using a pressure sensor. To enter a fixed pressure value, press **3** in the **Sensor Characteristics** menu to set this known, default pressure. Enter the constant pressure value, and press **RETURN**.

Press **E** to exit when finished.

Calibrate Input Pressure

The unit's input pressure measurement can be calibrated as described below.

Caution!
Please consult the factory before attempting to calibrate the analog input of the unit. The analog input is factory-calibrated and normally does not require recalibration or field adjustment.

From the **`Sensor Characteristics`** menu described above, type the access code **`POPT`**.

Connect the humidity output (pin **I+** or **4-20MA**) to the **RTN** terminal of the input connector.

Press any key when this is connected. The system will now automatically calibrate the input circuitry, and indicate when this is complete.

Press **`E`** to return to normal unit operation.

Reconnect the pressure sensor as described on page 2-13.

Function A: Set an Input Gas other than Air

Press **`A`** from the main menu of the Model -PR.

The unit displays the factory default molecular weight of air:

```
Molecular weight = 28.96
Molecular weight =
```

Enter the molecular weight of the gas being used, and press **RETURN**. Press **`E`** to return to normal operation.

Chapter 5

Service

Minor Maintenance of Sensor Optics

Periodically inspect and maintain the sensor optics as described in the following paragraphs. These procedures can be performed at any time but are only necessary when the letter "**S**" appears on the status display, indicating that service is required.

Cleaning the Sensor Mirror

Under normal conditions, the system is self-checking and self-balancing. However, there are occasions when particulate matter and water-soluble contaminants reduce sensor mirror reflectance and system accuracy (see *Contamination* on page 3-15). When necessary, use the procedure below to clean the sensor mirror.

1. Deactivate the sensor cooler, using one of the following actions:
   - Turn the sensor power off, or
   - Place the sensor switch to **HEAT**, or
   - Disconnect the sensor cable
2. Turn off the sample gas. Make sure the sensor cavity is depressurized before continuing with the next step.
3. Open the sensor by removing the sensor cover.
4. Moisten a cotton swab with a cleaning solution suitable for mirrors, such as the cleaning solution in the GE Sensing maintenance kit, or dilute methanol or alcohol.
5. Clean the mirror with a few light wipes.

Note: *If the sensor has been exposed to significant contamination, clean the other optical surfaces in the sensor and the sensor cavity itself.*

6. Replace the sensor cover.
7. Return the switches to normal, initiate a PACER cycle, and continue operation.

Balancing the Sensor Optics

If the service “**S**” indicator reappears after a PACER cycle (even after performing the mirror cleaning procedure above), check the sensor balance adjustment. Improper adjustment of the optical balance is the most common cause of instrument malfunction. In addition, new systems may require an optical balance adjustment after one or two months of operation.

IMPORTANT: *Always clean the mirror as described above before performing an optical balance.*

Set the **SENSOR** switch to **HEAT**, wait one minute, then observe the green bar segment display. If only the lowest bar is illuminated, the sensor is properly balanced. If not, balance the sensor according the procedure below. The location of the balance adjustment screw for various sensors is shown in Figure 5-1 on page 5-3.

1. Clean the mirror as described in *Cleaning the Sensor Mirror* on page 5-1, if you have not already done so. Make sure the sensor cover is replaced before checking the balance.
2. Set the **SENSOR** switch to **HEAT** and wait one minute for any condensation to evaporate.
3. If no bars are lit, turn the balance screw on the sensor **COUNTERCLOCKWISE** until only the lowest bar is lit. If more than one bar is lit, turn the balance screw **CLOCKWISE** until only the lowest bar is lit.

Note: *Be sure the mirror cavity is covered while adjusting the balance screw, since ambient light can cause an error. The 1111H sensor should be installed in the optional pressure boss, otherwise have the cover installed. The D-2 cover should be latched. On the 1311DR and XR sensors, place your thumb over the hole (or use a coin, if the sensor is horizontal).*

Note: *The sensor is balanced when one bar is lit.*

Balancing the Sensor Optics (cont.)

4. Replace the sensor cover, if necessary, and verify that one bar is still lit. If not, repeat Step 2, being sure that no light enters the cavity. Return the **SENSOR CONTROL** switch to **OPERATE** to stop heating the mirror.

5. Initiate a PACER cycle by switching the **BALANCE** switch to **INIT**.

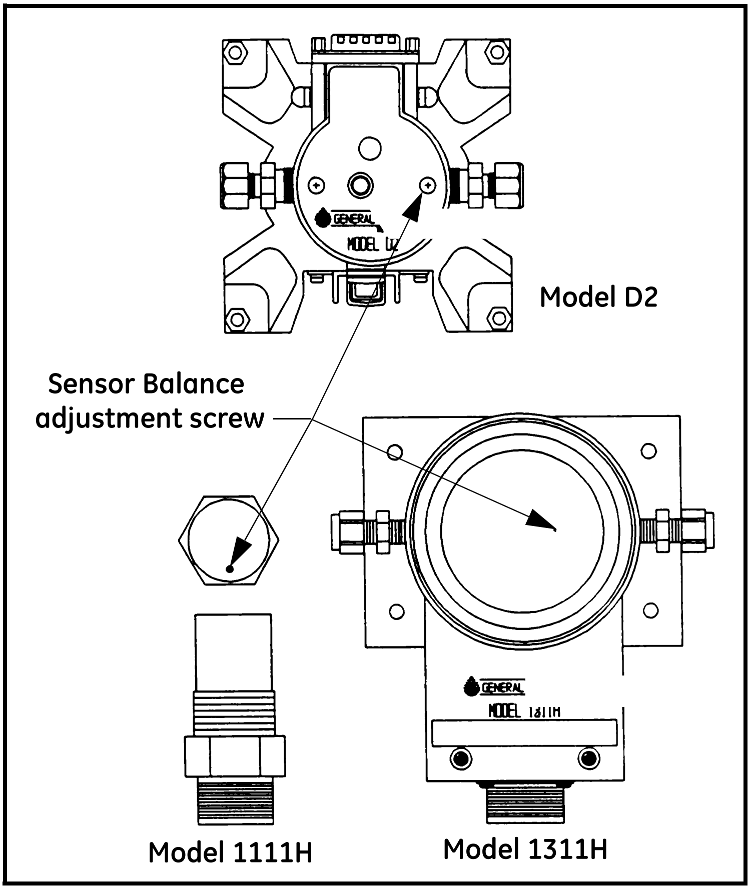


Figure 5-1: Balance Adjustment Screw Locations

Balancing the Sensor Optics (cont.)

At the completion of the PACER cycle, the system is properly balanced. For more information on the PACER cycle, see *The PACER Cycle* on page 3-17.

The sensor optics can be more precisely balanced with the adjustment screw by using a voltmeter in place of the green bar display. Follow the steps below:

1. Open the M4 and connect the **NEGATIVE** lead of a digital voltmeter to **TEST POINT 5** and the **POSITIVE** lead to **TEST POINT 3** on the main printed circuit board. The voltage should read between 2.00 and 2.08 volts while in **HEAT** mode.
2. Adjust the optical balance screw to set the proper voltage. Turn the screw **CLOCKWISE** to increase the voltage; turn the screw **COUNTERCLOCKWISE** to decrease the voltage.
3. Finally, initiate a PACER cycle as described above. At the end of this cycle, the “**S**” should not appear and the dew point reading should be correct.

Field Replacement of Sensor Mirrors

One advantage of using a GE Sensing chilled mirror dew point sensor is that the mirror is user-replaceable. The sensor does not have to be returned to the factory for replacement of the reflective surface, unless that is desired.

A mirror may require replacement for any of the following reasons:

- The mirror is constructed of silver/rhodium plated copper. Copper provides excellent thermal conductivity to the platinum thermometer. However, some gas constituents, such as sulfur dioxide (SO_2) may react with the copper and eventually pit the surface or form a copper sulfate coating.
- The reflective surface may be gradually abraded by sharp dirt particles in the gas being measured.
- The mirror surface may be accidentally scratched or gouged during use or cleaning.

If the sensor mirror has reacted with a corrosive material in the gas sample, such as an acid or sulfur compound, it should be replaced with a solid platinum mirror to remove any possibility of copper corrosion.

In extreme cases, a solid platinum mirror can make possible a successful application of chilled mirror technology. For example, measurements in tobacco factories and malting houses have drastically improved after this change, since both locations have sample gas constituents that attack copper.

In addition, fine scratches can be buffed out of a solid platinum surface, restoring the mirror to new condition, since it is of solid construction.

Replacing the Sensor Mirror

Required equipment: torque driver, set to 20-30 inch-ounces of torque. GE Sensing type TW-1 is recommended.

The kit supplied by the factory contains the replacement mirror, a container of white thermal compound for proper heat transfer, and (in some models) a mylar washer that is to be placed under the mirror.

1. Open the sensor by removing the sensor cover.
2. Unscrew and discard the old mirror, using a 3/16-inch (0.187) hex socket.
3. Use a toothpick or similar tool to place a small amount of thermal compound in the hole supporting the mirror.

Caution!
Do not apply thermal compound to the mirror stem.
Do not use an amount large enough to leak out when the mirror is tightened.
Do not allow any compound to get on the mirror surface, as it is very difficult to remove completely.

---

4. Carefully screw in the new mirror and tighten to the proper torque as specified for the particular sensor.
5. Carefully clean the mirror surface, using a cotton swab and the GE Sensing cleaning solution supplied with the maintenance kit. Distilled alcohol or diluted alcohol is also acceptable.
6. Replace the cover and return the sensor to normal operation. Under some circumstances, a new mirror may operate in a somewhat unstable manner for the first hour or two.

Modification for a Platinum Mirror

If you choose to upgrade from the standard plated copper mirror to the solid platinum mirror in the field, a circuit board change must also be made within the M4. Capacitor C4 must be increased from 33 microfarads to approximately 68 microfarads to avoid instability in the control loop. This change can be accomplished either by replacing C4 with a larger capacitor, or by adding a 33 microfarad capacitor in parallel with C4 using the designated pads on the circuit board.

If you received a system that had a platinum mirror installed at the factory, an additional 33 microfarad capacitor has already been added in parallel with C4.

If you purchase a platinum mirror to replace a standard mirror, you can return the unit to the factory for a no-charge circuit board modification. If you prefer to install the modification, GE Sensing will supply a field modification kit at no charge. A trained electronic technician with soldering skills is required for proper circuit board modification.

Test and Calibration

The procedures in this section effectively test and/or calibrate the following aspects of the Hygro M4/E4:

- Startup and power supply voltage
- Normal sensor operation
- Front panel display
- Digital and analog outputs.

The unit has been completely tested and calibrated at the factory, and is ready to plug in and operate. As shipped, it meets all of our published specifications.

When ordered as a complete hygrometer system with a chilled mirror sensor and cable, it is verified at a number of points against a dew point system that has been certified by the U.S. National Institute of Standards and Technology (NIST). A Certificate of Compliance is supplied with the unit to indicate traceability.

There are no calibration adjustments in the instrument that affect the digital display. The displayed reading is determined directly from the mirror temperature measured by the platinum Resistance Temperature Detector (RTD), which is controlled automatically at the dew point.

The analog outputs provided for recording or controlling are produced by a digital-to-analog converter. This converter can be adjusted as specified in the analog output calibration procedures (see *Function 6: Calibrate Output1* on page 4-22).

Troubleshooting

The Display Doesn't Light Up

1. Check the **POWER** switch on the rear panel. Make sure it's **ON**.
2. Check the line cord. Make sure both ends are plugged in and that it is plugged into a proper source of AC voltage.
3. Check the power supply. Make sure it is connected and has the proper output voltage.
4. Check the fuse. Make sure the proper size fuse is installed. Make sure the fuse is not open.

"S" Appears on the STATUS Display

The character "**S**" displayed on the **STATUS** line means service is required. The most frequent problem requiring service is that the mirror surface is contaminated and should be cleaned.

Clean the sensor mirror (refer to *Cleaning the Sensor Mirror* on page 5-1). Next, run the instrument through a PACER cycle. If, at the end of the cycle, the "**S**" appears again, balance the sensor optics (see *Balancing the Sensor Optics* on page 5-2).

Incorrect Dew Point Display

If the dew/frost point reads incorrectly, first check the standard preventive maintenance items:

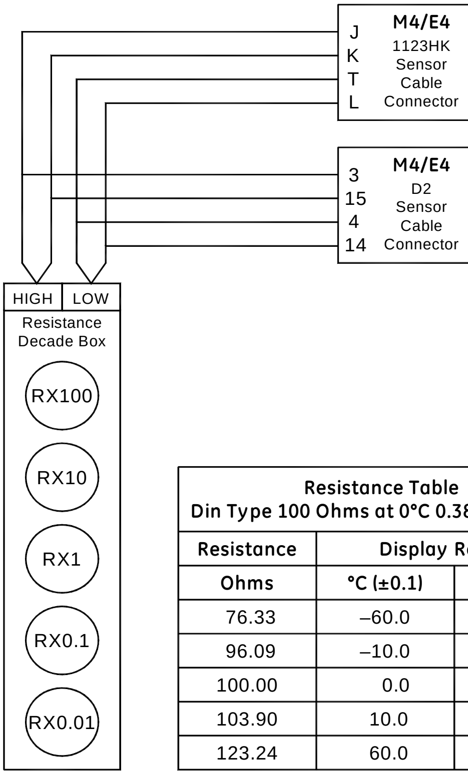
1. Clean the mirror (see *Cleaning the Sensor Mirror* on page 5-1).
2. Balance the sensor optics (see *Balancing the Sensor Optics* on page 5-2).

If the above procedures do not correct the problem, verify that the platinum resistance thermometer in the sensor is reading correctly with the following steps:

1. Disconnect the 6-pin J9 connector from the main circuit board in the M4. After J9 has been disconnected, and after the sensor mirror has stabilized at ambient temperature, the front panel dew point display should read the ambient temperature.
2. Check this temperature reading against another reliable thermometer placed near the dew point sensor.
3. If the platinum resistance thermometer is faulty, return the sensor to the factory for service.

An alternative method for checking the accuracy of the unit's electronics is to use a precision resistance decade box in place of the platinum thermometer. Wire the decade box to the unit's sensor connector as shown in Figure 5-2 on page 5-11, and verify that the resistance settings shown in the table produce the temperatures shown.

Incorrect Dew Point Display (cont.)



Resistance Table Din Type 100 Ohms at 0°C 0.385 Ohms/°C		
Resistance	**Display Reading**	
Ohms	**°C (±0.1)**	**°F (±0.2)**
76.33	–60.0	–76.0
96.09	–10.0	14.0
100.00	0.0	32.0
103.90	10.0	50.0
123.24	60.0	140.0

Figure 5-2: Using a Resistance Decade Box

"P" Remains Illuminated on the Front Panel

When the letter "**P**" remains illuminated on the front panel, the instrument has not recovered from a PACER cycle.

Check to see that the sensor and sensor cable are connected. If necessary, connect them, and the unit will complete the PACER cycle after a short time.

The sensor optical bridge may be out of balance (see *Balancing the Sensor Optics* on page 5-2).

No Analog Output

If there is no analog output, but the digital display indicates correctly, check the analog output scaling (see *Function 1: Scale Outputs* on page 4-14.

No Digital RS-232C Output

Check the output scaling for the RS-232C port (see *Function 1: Scale Outputs* on page 4-14.

No Cooling and/or Heating

The front panel dew point display can be used to indicate whether or not cooling and heating are operating correctly. If the **SENSOR** switch is set to **HEAT**, the displayed temperature should increase. If set to **COOL**, the temperature should decrease.

The following procedure can be used to determine whether or not the sensor thermoelectric cooler has failed.

1. Disconnect the sensor from the sensor cable.
2. Using a jumper wire, connect pins A and B of the 1123HK cable or 1 and 9 of the D-2K cable at the sensor end of the cable connector.
3. Connect a digital voltmeter across resistor R28 on the main circuit board.
4. Set the **SENSOR** switch to **COOL**. The voltage should read approximately 0.22 (±0.02) VDC.
5. Set the **SENSOR** switch to **HEAT**. The voltage should read 0.06 (±0.01) VDC with the opposite sign from the previous reading.

If the above voltages read correctly, the instrument is operating correctly and the sensor thermoelectric cooler is likely to have failed. Return the system to the factory for service.

Appendix A

Specifications

Performance

Accuracy	[complete system at 25°C (77°F)]
Dew/Frost Point:	± 0.2°C (± 0.36°F)
Temperature (optional):	± 0.2°C (± 0.36°F)
Pressure (optional):	± 0.5% of full scale
Relative Humidity (optional):	± 0.5% at 40% RH; ±1.25% at 95%RH (nom)
Other Humidity Param. (optional):	Consult factory
Sensitivity:	> 0.05°C (0.09°F)
Repeatability:	± 0.05°C (±0.09°F)
Hysteresis:	None
Measurement Ranges	
Chilled Mirror Sensors:	1111H, D-2, SIM-12H, 1311DR, 1311XR
Range:	–80°C to +50°C (–112°F to +122°F) dew/frost point, depending on sensor used
Temperature Sensor (optional):	T-100E: –80°C to +100°C (–112°F to +212°F) User-supplied RTD User-supplied 4–20mA signal
Pressure Sensors (optional):	PT-30A: 0–30 psia (0 to 2 bar) PT-300A: 0 to 300 psia (0 to 21 bar) User supplied 4-20mA or 0-5 volt signal
Required Sample Flow:	0.5 to 5.0 scfh (0.25 to 2.5 L/min)

Response Time

Dew/frost point cooling rate: 1.5°C (2.7°F)/sec [typical, above 0°C (32°F)]

Temperature response (optional): < 7 sec for step change within +25°C to +70°C (+77°F to +158°F)

Pressure response (optional): 1 sec to 90% of steady state (10% to 90% change)

Display Resolution: 0.1 (dew/frost point, temperature), 0.1% RH

Update time: 2 sec

Functional

Outputs:
Model -DP: One
Model -RH, -PR: Two
4–20mA DC, 500 Ohm maximum load
0–5 VDC, 5mA maximum

Std Analog Scaling: (field or factory programmable):

Sensor	Dew/Frost Point Range	
1111H, D-2	–40° to +60°C	–40° to +140°F
SIM-12H	–25° to +100°C	–13° to +212°F
1311DR, 1311XR	–80° to +20°C	–112° to +68°F

Digital Output: RS-232C

Alarms

Relay (optional) Form C (SPDT) 5A, 250 VAC (resistive load)

Service Alarm TTL compatible. Service flag also available on RS-232C output.

Balance Status: TTL compatible. Balance (PACER) flag also available on RS-232C output.

Displays:	1 display, 3½ digit LED (Model M4) 2nd display optional on Model E4
Power:	110, 115 or 230 VAC (+/– 10%), 50-60 Hz, 35 Watts maximum
Operating Ranges	
Dew Point Sensors	Ambient Temperature: –15°C to +95°C (+5°F to + 203°F), depending on sensor Pressure: –14.7 to 300 psig (0 to 22 bar), depending on sensor)
Electronics:	Ambient temperature: 0°C to +50°C (+32°F to +122°F) Relative Humidity: 85% maximum
Physical (Model M4)	Dimensions: 9.8"W x 3.25"H x 14.24"D (250 x 83 x 362 mm)
Weight:	8 lbs (3.6 kg)
Shipping Weight:	10 lbs (4.5 kg)
Environmental:	General purpose bench-, panel-, or rack-mount
Physical (Model E4)	
Dimensions:	10.36"W x 13.6"H x 4.31"D (263 x 345 x 110 mm)
Weight:	11 lbs (5 kg)
Shipping Weight:	12 lbs (5.5 kg)
Environmental:	Surface-mount, industrial environment (NEMA-12)
Optional Accessories	
PB-M4	Panel mounting adapter for M4
PM-M4	19" rack mount adapter with dust cover for M4
T-100E	Temperature sensor
PT-30A	Pressure transducer (0 – 30 psia)
PT-300A	Pressure transducer (0 – 300 psia)

Appendix B

Humidity Equations and Conversion Chart

Introduction

The following symbols appear in the equations which follow:

e = Vapor Pressure, millibars

e_i = Vapor Pressure with respect to ice, millibars

e_w = Vapor Pressure with respect to water, millibars

e_{is} = Saturation vapor pressure, ice, millibars

e_{ws} = Saturation vapor pressure, water, millibars

P = Total Pressure, millibars

T = Temperature, °C

T_a = Ambient temperature, °C

T_d = Dew point temperature, °C

T_f = Frost point temperature, °C

Vapor Pressure

Saturation vapor pressure with respect to water is a function of temperature only and is given by the following:

$$e_{ws} = 6.1121 \exp\left[\frac{17.502T}{240.97 + T}\right] \tag{B-1}$$

Saturation vapor pressure with respect to ice requires a minor adjustment of the constants as given by the following:

$$e_{is} = 6.1115 \exp\left[\frac{22.452T}{272.55 + T}\right] \tag{B-2}$$

In addition to yielding saturation vapor pressure as a function of ambient temperature, the above equations also yield ambient vapor pressure as a function of dew/frost point.

The total pressure of a gas mixture is equal to the sum of the partial pressure each gas would exert, were it to occupy the same total volume, according to Dalton’s law.

Humidity

Relative Humidity is defined as the ratio of the water vapor pressure (e) to the saturation vapor pressure (e_S) at the prevailing ambient or dry bulb temperature (Ta):

$$\%RH = 100\left(\frac{e}{e_s}\right) = 100\left[\frac{e_w(T_d)}{e_{ws}(T_a)}\right] \qquad \text{(B-3)}$$

Absolute humidity is expressed as water vapor density: water vapor mass per unit volume of dry air, according to the following:

$$\frac{g}{m^3} = \frac{216.7e(T_d)}{T + 273.16} \qquad \text{(B-4)}$$

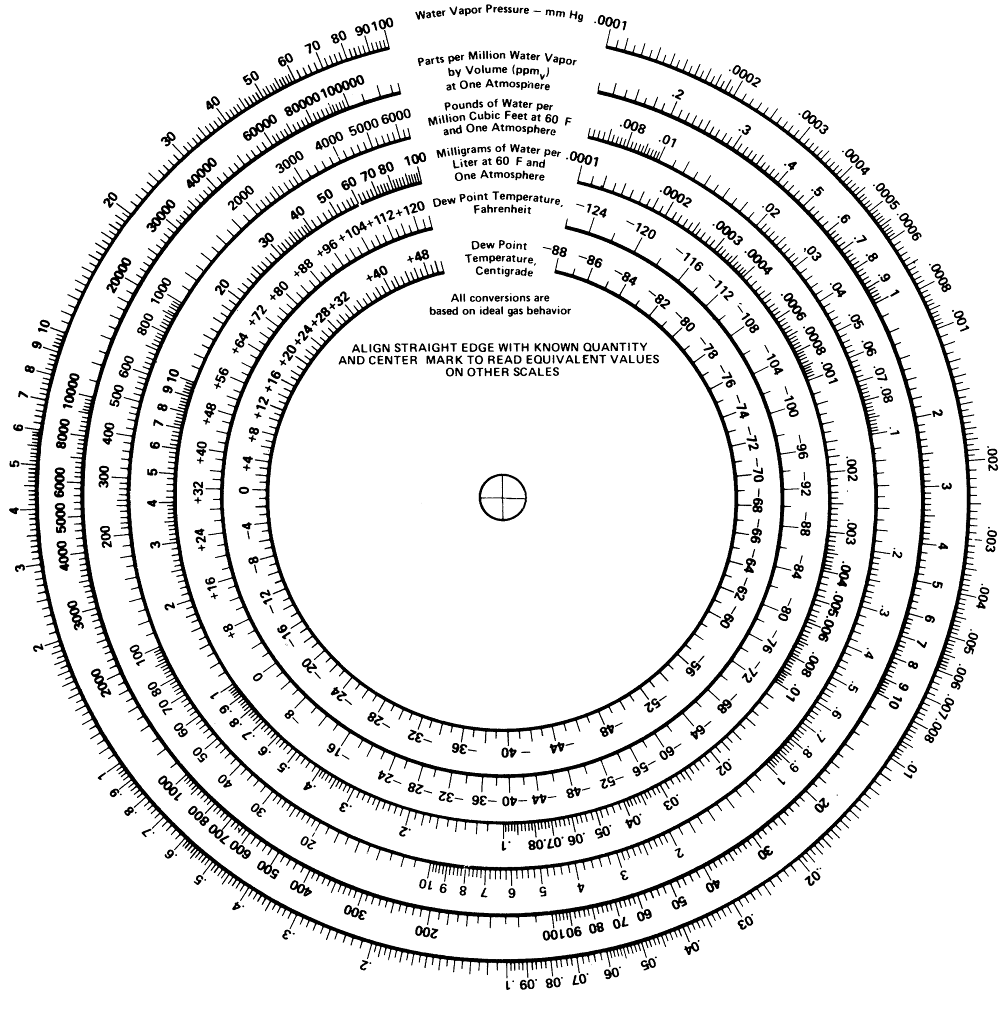
Water vapor content expressed as parts per million by volume is given by the following:

$$PPM_V = 10^6\frac{e(T_d)}{P - e(T_d)} \qquad \text{(B-5)}$$

Expressing water vapor content as parts per million by weight (or mixing ratio) requires multiplication of the above by the ratio of the molecular weight of water to that of air as given by the following:

$$PPM_W = (0.622 \times 10^6)\frac{e}{P - e} \qquad \text{(B-6)}$$

See Figure B-1 on page B-4 for a graphical humidity conversion chart.



WATER VAPOR CONVERSIONS

Figure B-1: Graphical Humidity Conversion Chart

Appendix C

Configuring the RS-232 Interface

Wiring to a Terminal or Terminal Emulator

The Hygro M4/E4 is configured as Data Terminal Equipment (DTE). The following pins are used on the RS-232 interface:

- 2 - Transmitted data (**TXD**)
- 3 - Received data (**RXD**)
- 7 - Signal ground (**GND**)

To send the output of the M4/E4 to a terminal or a terminal emulator, use the cable arrangement shown in Figure C-1 below.

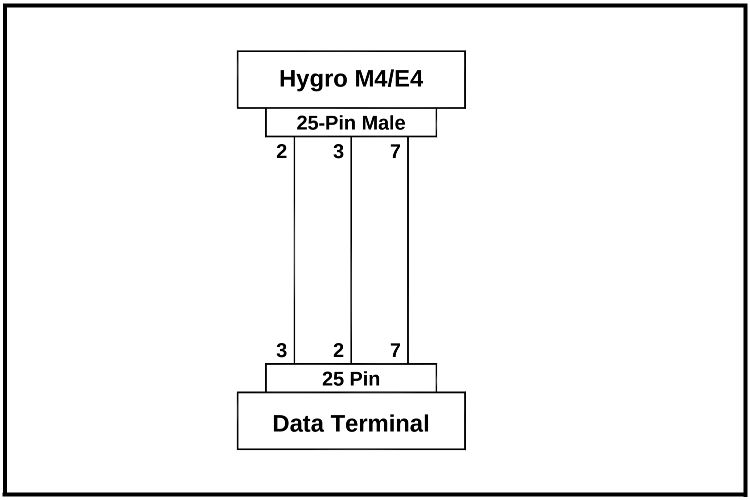


Figure C-1: Wiring Diagram - M4/E4 to Data Terminal

Some communications protocols require that the following pins also be used:

- 4 - Request to send (**RTS**)
- 5 - Clear to send (**CTS**)
- 6 - Data set ready (**DSR**)
- 20 - Data terminal ready (**DTR**)

Wiring to a Terminal or Terminal Emulator (cont.)

The unit, as shipped from the factory, has pins 4 and 5 connected and pins 6 and 20 connected using jumpers JPR4 and JPR5, generating the appropriate control signals for devices requiring these lines. If you want independent control over these signals, JPR4 and JPR5 can be removed. These jumpers are located on the printed circuit board and are clearly marked.

Wiring to a Personal Computer or Modem

If you wish to interface the M4 to Data Communications Equipment (DCE), use the cable configuration shown in below.

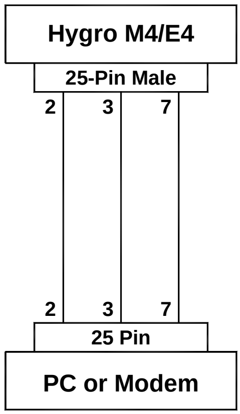


Figure C-2: Wiring Diagram - M4/E4 to PC or Modem

In order to communicate with the M4, you need a standard serial interface card installed in your computer. If your computer has one serial card, it is addressed as COM1. If there is a second serial card, it is addressed as COM2. You must also have a cable with the following connectors:

- A 25-pin male D connector connecting to the M4
- A 25-pin female D connector connecting to the computer

Only pins 2, 3, and 7 are used by the M4. They are connected straight through: 2 to 2, 3 to 3, and 7 to 7.

Communicating with the M4

After you have installed the serial card and connected the cable, you can use the Terminal program in Windows 3.1 to easily communicate with the M4. If Windows is not available, you can use the following BASIC program to interface to the instrument:

```
 10 ON ERROR GOTO 90
 20 OPEN "COM1: 1200,n,8,1,CS,DS,CD" AS #1
 30 OPEN "SCRN:" FOR OUTPUT AS #2
 40 B$ = INKEY$: IF B$ <> "" THEN GOTO 100                   'CHECK KEYBOARD
 50 IF EOF(1) THEN 40                              'CHECK END OF TRANSMISSION
 60 A$ = INPUT$(LOC(1), #1)                                 'GET DATA FROM PORT
 70 PRINT #2,a$;                                  DISPLAY DATA FROM SERIAL PORT
 80 GOTO 40                                                        'REPEAT LOOP
 90 CLOSE: GOTO 20                                      'ERROR, CLOSE AND REPEAT
100 IF B$<>CHR$(27) THEN PRINT $1,B$;: GOTO 50                'CHECK FOR ESCAPE
110 FOR I=1 TO 5                  'SEND BURST OF ESCAPE CHAR UNTIL RECOGNIZED
130 PRINT #1, A$
150 LINE INUT #1, A$                                                'GET STRING
160 IF INSTR(A$, "VERSION") THEN 210
170 IF INSTR(A$, "SCALE") THEN 210
180 IF INSTR(A$, "CALIBRATE") THE 210
190 NEXT I
210 GOTO 70
```

Notes:

Line 20: Serial input = **COM1**, baud rate = **1200**, parity = **NONE**, no. of data bits = **8**, no. of stop bits = **1**, timeout = **10 SECONDS**, set to file **#1**.

Line 30: File #2 set as the video display terminal.

Line 40: Input from keyboard. If there is no input then continue. If there is input, send it to M4 and to video display terminal.

To send data to your printer, insert the following line in the program:

```
75 LPRINT A$
```

For further information on interfacing, refer to the factory or to the Electronic Industries Association (EIA) standard for interfacing.

Appendix D

Chilled Mirror Sensors

Introduction

GE Sensing offers a choice of five, fully interchangeable, chilled mirror sensors which differ primarily in their depression (cooling) capability. Depression capacity determines the minimum dew point that can be measured. All of the sensors feature low-noise, infrared optics, a field-replaceable mirror, and can be located up to 300 ft (91 m) from the electronics. Other advanced features—depending on the sensor selected—include heating capability, four- or five-stage thermoelectric cooling, air and water cooling for additional depression, and modular, field-replaceable optics and cooling assemblies.

Note: *Many of these features were pioneered by GE General Eastern, and are available only on GE Sensing products.*

A chilled mirror sensor is generally selected so that its depression capability will allow it to measure the lowest dew/frost point anticipated for the application.

Depression

A Peltier device is a solid-state heat pump. It has one surface thermally bonded to the body (base) of a dew point sensor and the other surface bonded to the mirror block. When current is supplied to the Peltier device, heat is “pumped” from the mirror block to the sensor body where it is dissipated. With full cooling current, the mirror block will eventually cool to its minimum temperature. The difference between the temperatures of the mirror block and the sensor body when the mirror block is at this minimum temperature is defined as the depression capability of the sensor.

Depression capability is a function of how many “stages” the Peltier device has stacked in series. Thus, a two-stage sensor typically has 60°C to 65°C (108°F to 117°F) of depression capability, and can measure lower dew/frost points than a one-stage sensor which has 45°C (81°F) of depression capability. Depression is normally specified at 25°C (77°F) ambient temperature. For liquid-cooled sensors, it is specified at the coolant temperature. As ambient temperature (and therefore, sensor body temperature) is decreased, depression capability also decreases, due to the drop-off in efficiency of the thermoelectric cooler.

Therefore, there are limitations to using liquid-cooled sensors to increase low-end measurement range. At nominal dew/frost points, approximately one third of the additional cooling is lost due to cooler inefficiency, and does not result in additional measurement range. At low dew/frost points, as much as one half may be lost. As ambient temperature is increased, depression capability increases, resulting in a wider measurement range.

Measurement Range

The measurement range of a chilled mirror sensor is defined as the temperature range over which a stable dew or frost layer can be maintained on the mirror. Note that in order to acquire a dew or frost layer on the mirror, the depression capability of a sensor must extend below its measurement range. The minimum required differential between depression range and measurement range is 5°C (9°F) at nominal dew/frost points, and increases to 10°C to 12°C (18°F to 22°F) at very low frost points.

Measurement range is normally specified at 25°C (77°F) ambient temperature in air at atmospheric pressure. For sensor body temperatures other than 25°C (77°F), measurement range can be estimated by first estimating depression capability, and then decreasing this range according to the minimum required differential. For most gases other than air, the effect on measurement range is negligible. However, gases such as hydrogen or helium, which are more thermally conductive than air, will result in a decrease of several degrees in the measurement range. Measurement range will decrease as gas pressure is increased, because the increased density (and, therefore, increased thermal conductivity) of the gas results in an increased heat load. For air or nitrogen, each 50 psi (3 bar) increase above atmospheric pressure will result in a loss of approximately 2°C (4°F) of depression capability. Conversely, operating under vacuum may result in a small increase.

Other factors influencing sensor selection include temperature and pressure ratings, and whether anticipated dew points will be higher than ambient temperature.

Comparing Optica Models

Table D-1: Chilled Mirror Sensor Comparison Chart

Category	Model 111H	Model D-2	Model SIM-12H	Model 1311DR	Model 1311XR
System Performance					
Standard Accuracy*	0.2°C	0.2°C	0.2°C	0.2°C	0.15°C
Optical Accuracy*	0.15°C	0.15°C	0.15°C	0.15°C	
Cooling Stages	1	2	2	4	5
Depression (at 25°C (77°F), 1 atm, in air)	45°C	65°C	65°C	95°C, air 105°C, liquid	112°C
Typical Measurement Range (at given ambient, 1 atm)	at 25°C ambient	at 25°C ambient	at 85°C ambient	at 25°C ambient	at 25°C ambient
Dew/Frost Point	−15° to +25°C	−35° to +25°C	−10° to +85°C	−60° to +25°C, air −70°C to +25°C, liquid	−80° to +25°C
RH (equivalent)	6% to 100%	1.5% to 100%	1% to 100%	0.03% to 100%, air 0.007% to 100%, liq.	0.0003% to 100%
Functional Characteristics:					
Power	From Optica	From Optica	115/230VAC 75 watts	115/230VAC 300 watts	115/230VAC 700 watts
Ambient Temperature Range	−15° to +80°C	−25° to +85°C	−15° to +50°C	0° to +35°C	0° to +35°C
Pressure Range (psig)	−3 to +200	−14.7 to +150	−3 to +50	0 to +300	0 to +100
Auxiliary Cooling	No	No	No	Standard: air or liquid	Standard: liquid
Sensor Cavity Material	Epoxy-coat Aluminum	Stainless Steel	Anodized Aluminum	Stainless Steel	Stainless Steel

*Complete system at 25°C (77°F)

Appendix E

Glossary

Depression Capability The temperature difference by which the chilled mirror can be lowered from the ambient temperature.

PACER GE Sensing patented *Programmable Automatic Contaminant Error Reduction* system, which consolidates soluble contaminants to reduce their effect on system accuracy (see *The PACER Cycle* on page 3-17).

Parameter A measured quantity available for display by the unit, such as Dew Point in °C, Humidity in Grams/Kilograms, or Pressure in Bar.

Scaling The process of selecting the maximum and minimum output values of a chosen parameter.

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The GE Panametrics, GE Thermometrics, GE NovaSensor, GE Druck, GE Kaye, GE General Eastern and GE Ruska businesses have joined together under a new name - GE Sensing.