# E4-1111H-GE
# DEW POINT MONITOR

## Operator's Manual

GENERAL EASTERN
*The Humidity Experts*
A SPIRENT Company



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**Safety:** This manual as well as safety labels posted on the instrument use the following safety alerts to draw your attention to special safety instructions that should be followed.

**CAUTION**

**CAUTION:** Hazards or unsafe practices could result in electrical shock, minor injury, or product damage.

**WARNING**

**WARNING:** Refer to accompanying document for additional information.

**ALERT**

**ALERT:** Earth ground connection; removal could result in electrical shock, minor injury, or product malfunction.

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# Chapter 1 — Introduction

## About General Eastern

General Eastern is devoted solely to the design and manufacturing of accurate, reliable and rugged humidity measuring equipment. We specialize in providing solutions for applications where humidity measurements are critical.

There are many ways to make humidity measurements, and no one humidity sensor meets all requirements for all applications. Our variety of sensor types — including chilled mirror, lithium chloride, resistance polymer, and wet bulb — can precisely determine dew point, parts per million by volume, percent relative humidity, and other parameters.

In keeping with General Eastern's philosophy of providing the best solutions to humidity measurement problems, we offer the following products and services:

- high quality state-of-the-art instrumentation to assure excellent performance
- a broad range of humidity instruments capable of covering virtually any humidity measurement application
- full applications assistance to help you choose the sensor that is best for your needs
- full and superior service, should it ever be needed

If you have questions about a particular measurement problem, we invite you to call and discuss your application with one of our engineers. Call 800-225-3208 (if you're calling from Massachusetts or outside the United States, call 781-938-7070). Our fax number is 781-938-1071.

## Overview of the E4-1111H-GE

The General Eastern E4-1111H is a multi-purpose chilled-mirror hygrometer, suitable for use in a variety of applications. The unit measures dew/frost point from –25°C to +65°C (–13°F to +149°F).

The E4-1111H is designed for wall or surface mounting. It is housed in a gasketed NEMA-4 aluminum enclosure, suitable for industrial environments.

A 4–20mA analog output is provided as well as an RS-232C communications port.

A red indicator light shows when **POWER** is applied and a green indicator light shows that the unit's **BALANCE** function is in operation (see *"The PACER Cycle"* beginning on page 21).

The monitor utilizes advanced microprocessor control and includes General Eastern's patented *Programmable Automatic Contaminant Error Reduction* (PACER) system to insure accuracy.

Detailed specifications are given in Appendix A, beginning on page 39.

## System Components

The complete system is packaged with the following items:

- The electronic monitor with integrated dew point sensor and filter
- Operator's manual
- Certification that the unit is traceable to the National Institute of Standards and Technology

## Physical description

The E4-1111H is designed for surface mounting on a vertical wall or panel. The unit's dimensions are shown in Figure 1 in inches (cm).

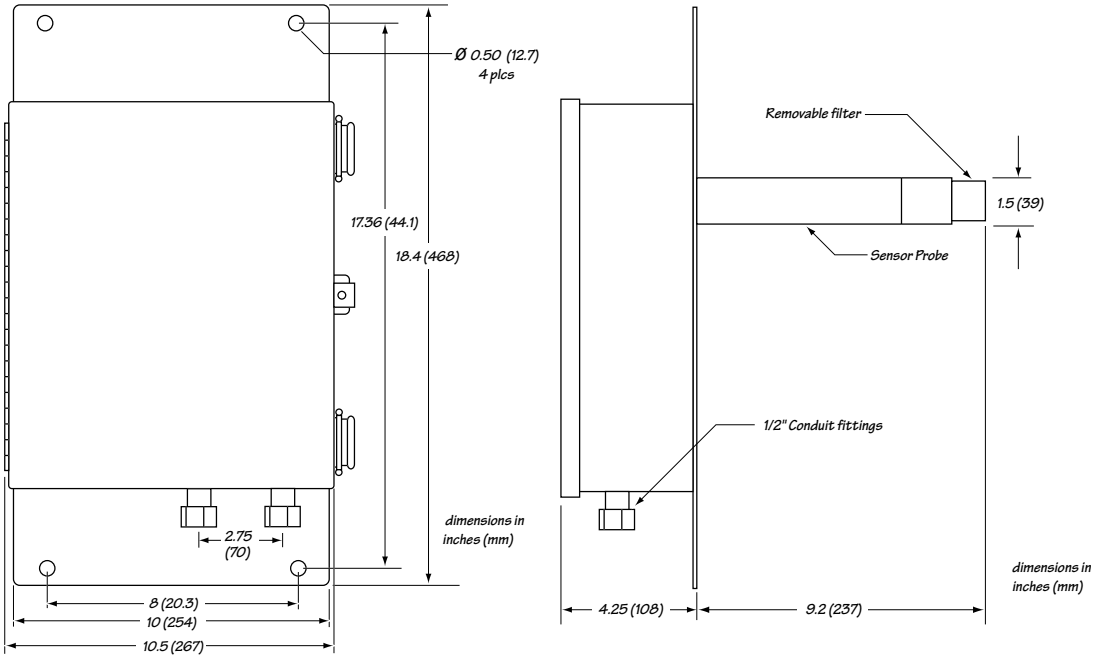


***Figure 1 — Dimensions***

# The humidity sensor

The monitor is configured with a General Eastern 1111H single-stage chilled-mirror dew point sensor. The sensor provides data to the electronics unit that calculates humidity.

# Theory of operation

## What is 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 do General Eastern hygrometers function?

Figure 2 illustrates how General Eastern hygrometers detect and measure dew point. The condensate mirror is illuminated with a high-intensity, solid state, light emitting diode (LED). A photodetector monitors the LED light reflected from the mirror. The photodetector is fully illuminated when the mirror is clear of dew, and it receives less light as dew forms. A separate LED and photodetector pair are used as a known reference to compensate for any thermally induced changes in the optical components. The photodetectors 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.

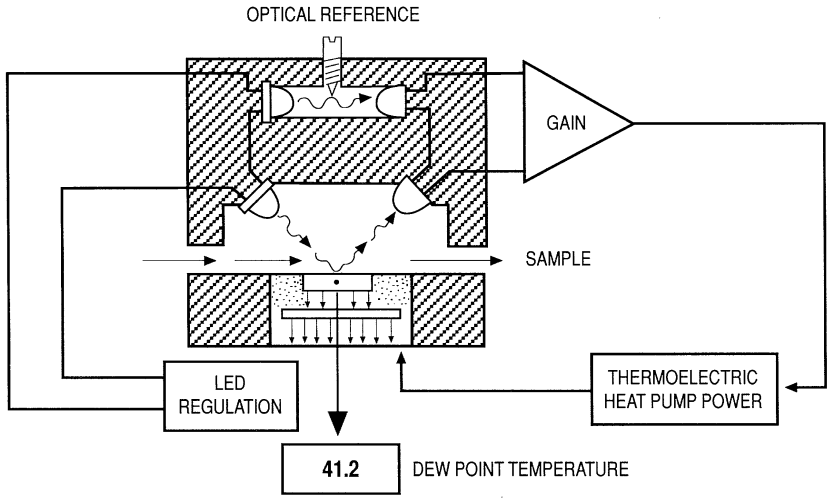


***Figure 2 — The chilled-mirror hygrometer***

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.

## Using General Eastern Hygrometers as a standard for calibration

An optical condensation hygrometer such as the E4-1111H 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.

# Chapter 2 — Installation

## Mounting

Mount the E4-1111H on a vertical surface using the four mounting holes at the corners of the unit. Provide adequate space below the unit for cabling, and to the left of the unit to allow the door to open fully. The sensor module protrudes from the rear of the unit into the measurement space. Mounting dimensions are shown in Figures 3, 4 and 5.

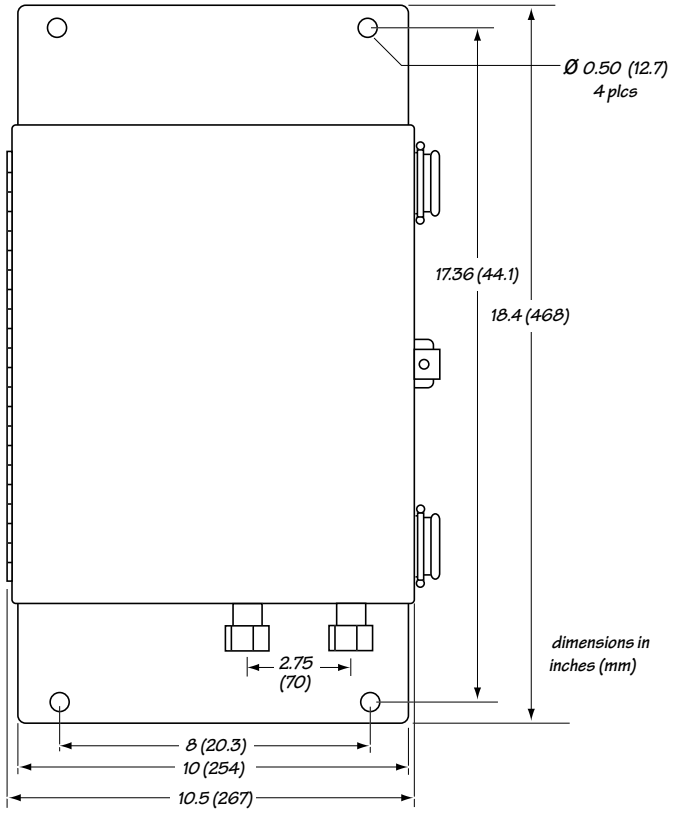


***Figure 3 — Front view***

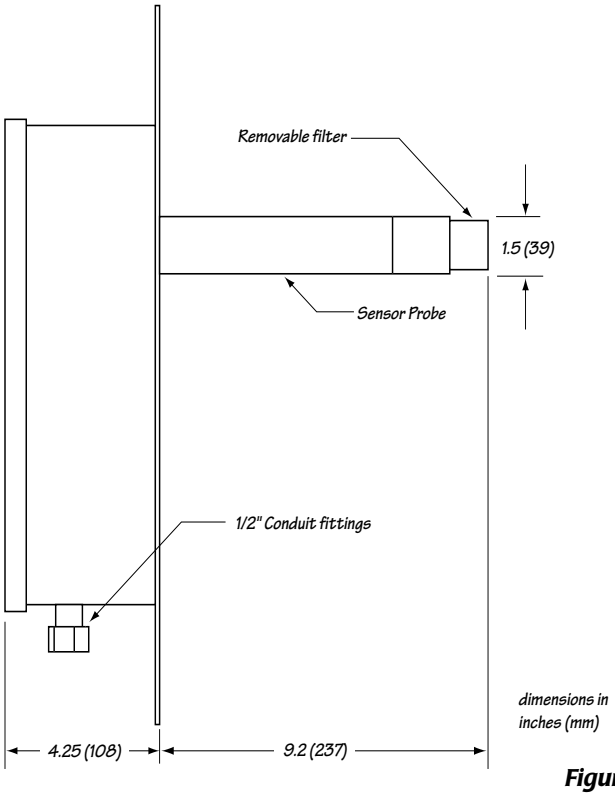


***Figure 4 — Side view***

# Input power

The E4-1111H is available in versions wired for 115, 230, and 100 VAC. The 230 VAC version is double-fused.

The unit's voltage and frequency rating and tolerances, as well as fusing data, are listed inside the unit.

Input power wiring enters through the bottom edge of the unit and connects to the right-hand terminal block as shown in Figure 7.

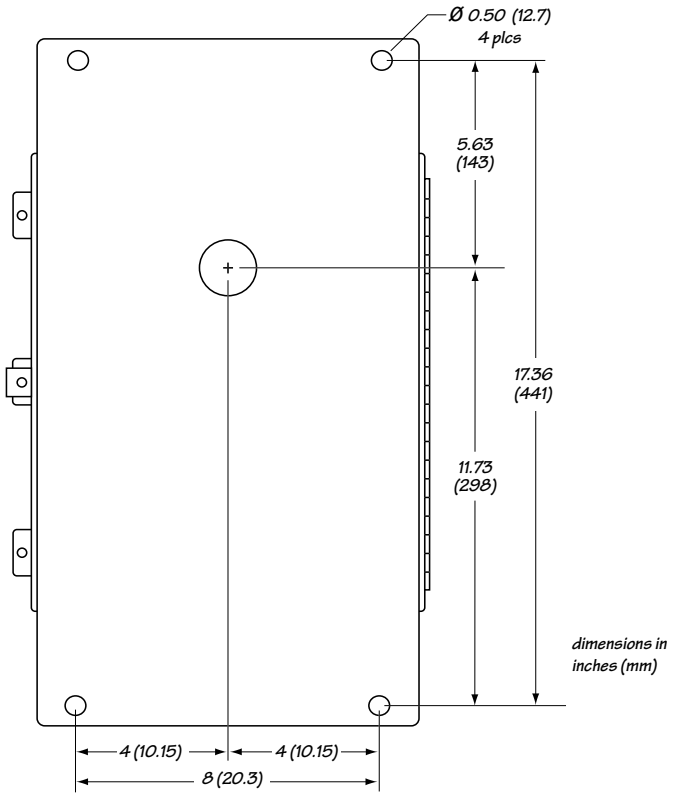


***Figure 5 — Rear view***

# Wiring the outputs

The E4-1111H's output terminals are located inside the unit's front door. Cabling is brought in through the bottom edge of the unit and connected to terminal blocks as shown in Figure 7.

## Analog humidity output

The humidity output provides a 4–20mA analog signal (500 Ohms maximum load). Connect to the terminals labelled **I+** and **RTN** on the left-hand terminal block.

The humidity units and scaling may be set using the RS-232C port. See *"Chapter 4 — Programming"* beginning on page 23 for details.

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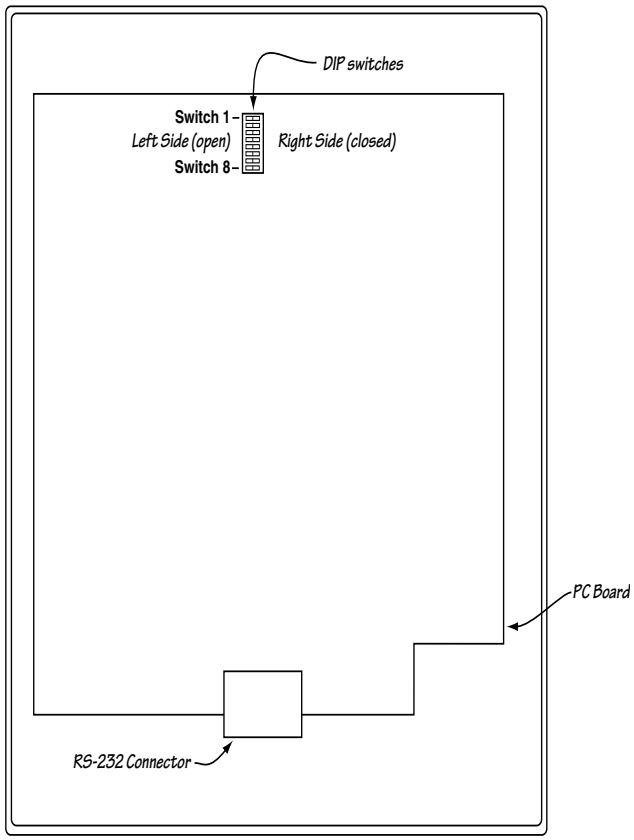



***Figure 6 — PC Board***

## Service output

The **SRVC** output provides a TTL-compatible signal that indicates that the mirror needs cleaning (see page 31).

Connect to the terminals labelled **SRVC** and **RTN** as shown in Figure 7.

## RS-232C connector

The RS-232C connector is located at the bottom edge of the PC board (see Figure 6). It provides RS-232C digital communications between the unit and an RS-232C terminal or a PC running in terminal emulation mode.

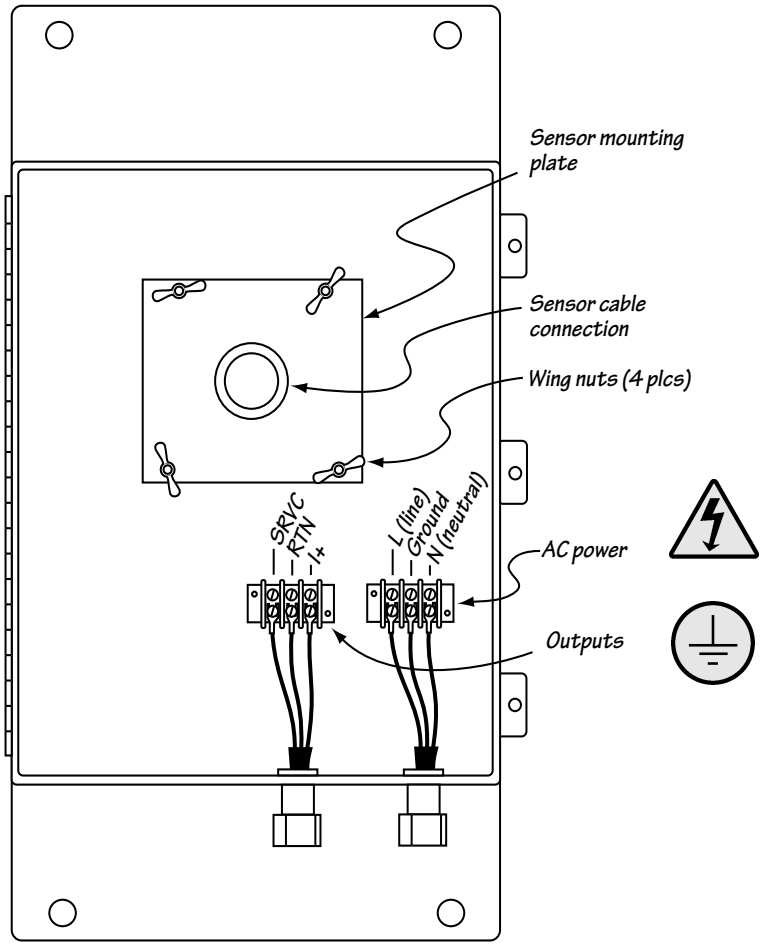



***Figure 7 — Wiring and sensor replacement***

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

| E4-1111H | 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 28 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.

# Sensor information

### Filter Requirements

The E4-1111H is equipped with a submicron Teflon filter to avoid particulate contamination and to protect the sensor from the presence of liquid water. In many applications, the filter requires periodic inspection and replacement. Typical applications might require replacement twice a year.

### 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.

## Sensor replacement

If it necessary to remove the sensor module, follow the steps below:

1. Disconnect the line power from the unit.
2. Open the front door.
3. Unplug the sensor cable from the end of the sensor probe as shown in Figure 7.
4. Unscrew the four wing nuts shown in Figure 7.
5. Carefully remove the sensor module.

# Chapter 3 — Operation

## General information

Operating instructions fall into three categories:

- normal operation
- setup and programming
- system maintenance

**Normal operation** of the unit's 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 customer's requirements (see Appendix A). Complete programming instructions are given in Chapter 4, beginning on page 23.

**Maintenance** involves manually testing the unit's 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.

An RS-232C-compatible device, such as a laptop computer, can be connected to the unit to perform programming and configuration functions. The RS-232C port can also be used to send data measured by the unit to an external computer or other device.

## Control switches

Control switches are located at the top edge of the PC board, within the red switch module containing eight DIP switches. Switches are number from 1 to 8, with Switch 1 at the top and Switch 8 at the bottom as shown in Figure 8.

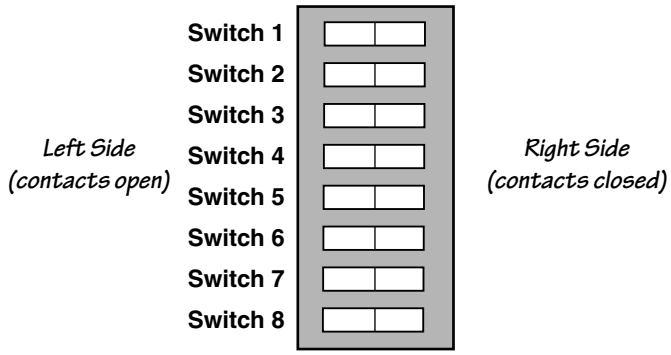



***Figure 8 — DIP Switches***

All switches are normally set to the open position, with the left-hand side depressed. Press the right hand side to activate a function as described below. (Switches 5–8 are not used).

| Switch | Function | Left side pressed | Right side pressed |
|---|---|---|---|
| 1 | Mirror cooling | Normal | Cool the mirror. |
| 2 | Mirror heating | Normal | Heat the mirror. |
| 3 | Initiate PACER cycle | Normal | Initiate one PACER cycle. |
| 4 | Automatic PACER cycles | Normal | Periodic PACER cycles. |

The PACER cycle for automatically cleaning the sensor mirror is described in *"The PACER Cycle"* beginning on page 21.

To initiate a single PACER cycle, press Switch 3 to the right and then return it to the normal position.

To cause automatic PACER cycles at a programmable periodic rate, set Switch 4 to the right. See *"Setting the balance interval."* beginning on page 26 for programming the rate.

# RS-232C data outputs

See *"RS-232C connector"* on page 11 for details on hardware, cabling and protocols for establishing RS-232 communications with the monitor. 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. The data available for this model is as follows:

DP C=xxxx
DP F=xxxx

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 23.)
- 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 28.)

Programming is described in *"Chapter 4 — Programming"* beginning on page 23.

# 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. Once the system is stable valid readings may be taken.

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 measured dew point, therefore, drifts upward above the true dew point. Because the measurement error increases gradually, it often goes undetected.

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 31. 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 DIP Switch 2 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 monitor 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 General Eastern's Humidity Handbook for additional detailed information.

# The PACER Cycle

General Eastern 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 General Eastern products.

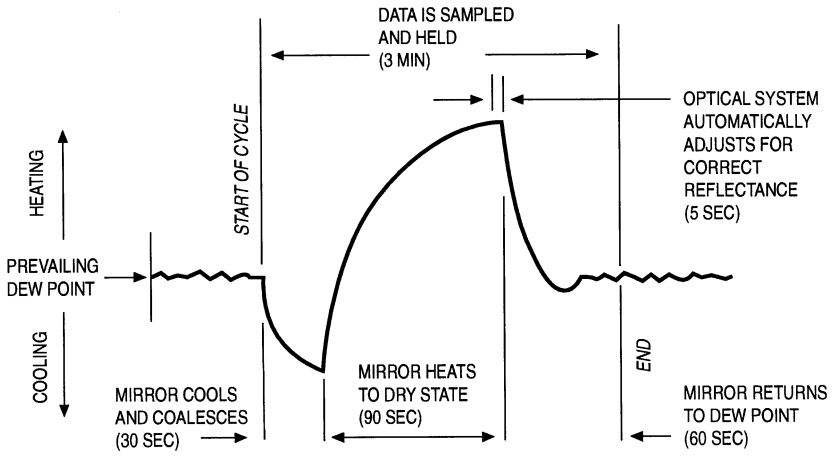



***Figure 9 — The PACER cycle***

The PACER cycle, diagrammed in Figure 9, 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 10, with more clean mirror surface available for dew formation.

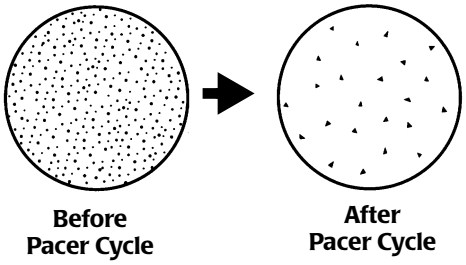



***Figure 10 — Results of the PACER cycle***

# Chapter 4 — Programming

## General information

The E4-1111H-GE 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 two major items:

- the analog outputs
- the digital (RS-232C) outputs

Programming is most easily accomplished using a computer or data terminal connected to the RS-232C data 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.*

## RS-232C programming

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. (Switch 3 in closed position)

When programming menus are active, the sensor cooling is deactivated and the sensor mirror is allowed to rise to ambient temperature.

## 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
                    E) Exit
```

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 = 75          LOW = -45


1) OUTPUT1                          E) EXIT
```

**Scaling Output1.** Press 1 to access the Output1 menu, which controls the Humidity output. The text OUTPUT1: is displayed, followed by the menu listed below:

```
OUTPUT1:

0) DPC   1) DPF    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 (20mA), and press **RETURN**.

```
LOW =
```

Enter the value that should cause 4mA 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 11.

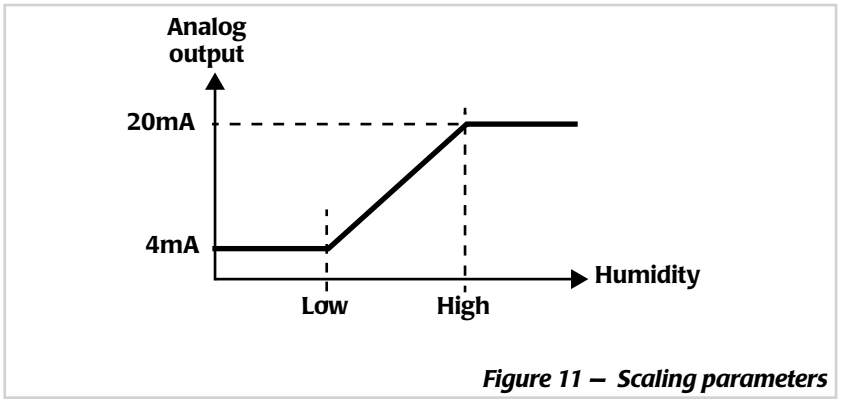



***Figure 11 — Scaling parameters***

## Function 2: Set balance type

From the main menu, press 2 to change the type of balance used, 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
1) Pacer Bal          2) Auto Bal     3) Set Interval
4) Initiate Balance   E) Exit
```

**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 E4-1111H, 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 21.*

**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.

**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` 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 (Toggle)     3) Exit
```

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

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

Press `1` to select the parameters to be displayed. The following menu is displayed:

```
1) DPC    2) DPF   3) None   E) Exit
```

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'.** A feature of the E4-1111H 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.

To output dew point in °C, enter the prompt "**D1**".

**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 5: Set Averaging

From the main menu, press 5 to set the data averaging parameter. This number determines how many dew point readings are averaged to determine the reading that is 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 number of points to be averaged. 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 Access Code:
```

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+** and **RTN** terminals. 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.

# Chapter 5 — Service

## Minor maintenance of sensor optics

Periodically inspect and maintain the sensor optics as described in the following paragraphs.

### 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 18. When necessary, clean the sensor mirror, following the procedure below.

1. Deactivate the sensor cooler, by placing DIP Switch 2 to **HEAT** (press the right-hand side).
2. Open the sensor by removing the sensor filter.
3. Moisten a cotton swab with a cleaning solution suitable for mirrors, such as the blue cleaning solution in the General Eastern maintenance kit, or dilute methanol or alcohol. Clean the mirror with a few light wipes. If the sensor has been exposed to significant contamination, clean the other optical surfaces in the sensor and the sensor cavity itself.
4. Replace the sensor filter.
5. Return switches to normal.
6. Initiate a PACER cycle by closing Switch 3 and then returning it to the open position

### Balancing the sensor optics

If the service "**SRVC**" TTL output 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. Always clean the mirror as described above before performing an optical balance.

1. Clean the mirror as described in *"Cleaning the sensor mirror"* on page 31, if you have not already done so.
2. Set DIP Switch 2 to **HEAT** (right-hand position) and wait one minute for any condensation to evaporate.

   *Be sure to cover the optical cavity with your hand to prevent ambient light from affecting the sensor balance.*
3. Observe the green **BALANCE** LED at the bottom of the unit. If the LED is illuminated, the sensor is properly balanced. If not, balance the sensor using the following steps.
4. Turn the balance screw on the sensor **COUNTERCLOCKWISE** until the **BALANCE** light goes out. The location of the balance adjustment screw is shown in Figure 12.
5. Slowly turn the balance screw **CLOCKWISE** until the **BALANCE** light just comes on.
6. Replace the sensor filter and verify that the **BALANCE** LED remains illuminated.
7. Return DIP Switch 2 to the normal (left) position to stop heating the mirror.
8. Initiate a PACER cycle by switching DIP Switch 3 to the right, and then returning it to the left.

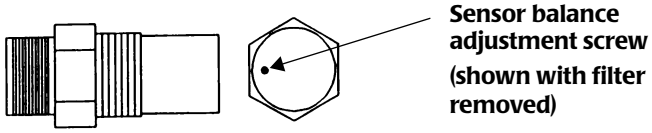



***Figure 12 — Balance adjustment screw locations***

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 21.

# Field replacement of sensor mirror

One advantage of the General Eastern 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, but of course you can return it for factory service, if 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. General Eastern's 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 filter.
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.

> ***CAUTIONS:***
> *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 General Eastern cleaning solution supplied with the maintenance kit. Distilled alcohol or diluted alcohol is also acceptable.
6. Replace the filter 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 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 E4-1111H. 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, General Eastern 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 monitor:

- Startup and power supply voltage
- Normal sensor operation
- Digital and analog outputs
- No heating or cooling

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 and has been checked out 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 measured readings. The 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 29.

# Troubleshooting

### Red POWER indicator doesn't light when powered up

1. Check the AC line supply. Make sure both ends are connected and that the unit is connected to a proper source of AC voltage.
2. Check the fuse. Make sure the proper fuse size is installed. Make sure the fuse is not open.

### Incorrect dew point measured

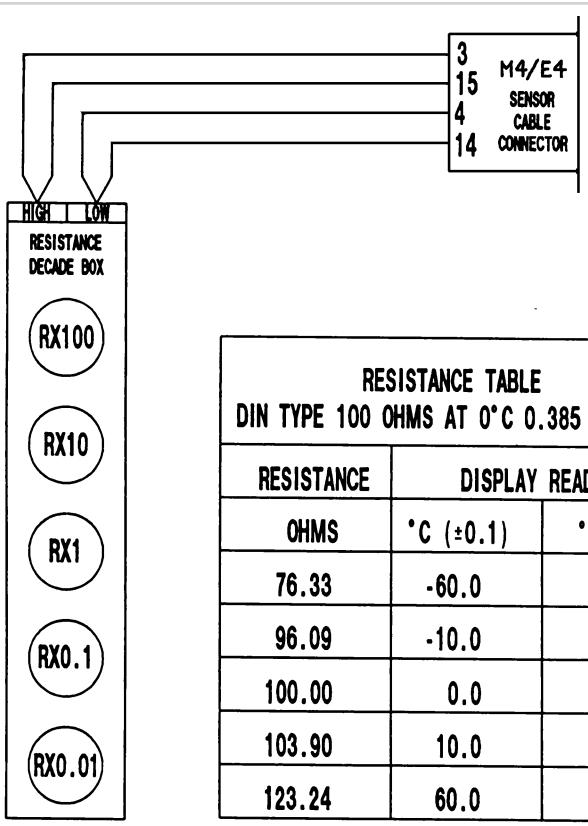
If the dew/frost point reads incorrectly, first check the standard preventive maintenance items:

1. Clean the mirror. See *"Cleaning the sensor mirror"* on page 31.
2. Balance the sensor optics. See *"Balancing the sensor optics"* on page 31.

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 unit. After J9 has been disconnected, and after the sensor mirror has stabilized at ambient temperature, the measured dew point should equal 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 General Eastern for factory 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 13, and verify that the resistance settings shown in the table produce the temperatures shown.




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 13 — Using a Resistance Decade Box***

## No analog output

If there is no analog output, check the analog output scaling. See *"Function 1: Scale outputs"* on page 24.

## No digital RS-232C output

Check the output scaling for the RS-232C port. See *"Function 1: Scale outputs"* on page 24.

## No cooling and/ or heating

The RS-232 or analog output can be used to indicate whether or not cooling and heating are operating correctly. If DIP Switch 2 is set to **HEAT**, the displayed temperature should increase. If Switch 1 is 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 DIP Switch 1 to **COOL** (press the right-hand side). The voltage should read approximately 0.22 (±0.02) VDC. Return the switch to its normal position.
5. Set DIP Switch 2 to **HEAT** (press the right-hand side). The voltage should read 0.06 (±0.01) VDC with the opposite sign from the previous reading. Return the switch to its normal position.

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 General Eastern for factory service.

# Appendix A — Specifications

## PERFORMANCE

**Accuracy:** Dew/Frost point: ± 0.2°C (± 0.36°F)
[complete system at 25°C (77°F)]

**Sensitivity:** > 0.05°C (0.09°F)

**Repeatability:** ± 0.05°C (±0.09°F)

**Hysteresis:** None

**Measurement range:**

Measurement capability: (at 25°C ambient air temp.) –25°C to +65°C (–13°F to +149°F) dew/frost point

Full-Scale analog output range: –45°C to +75°C (–49°F to +167°F) dew/frost point

**Response time:**

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

**Update time:** 2 sec

## FUNCTIONAL

**Analog output:** 4–20mA DC, 500 Ohm maximum load

**Standard Analog Scaling (field or factory programmable):**

–45 to +75°C (–49 to +167°F)

**Digital output:** RS-232C

**Alarms:** Service alarm: TTL compatible. Service flag also available on RS-232C output.

**Balance status:** Green indicator light. Balance (PACER) flag also available on RS-232C output.

**Power:** 110, 115 or 230 VAC (+/– 10%), 50-60 Hz, 35 Watts maximum, 250V 3AG 2A SB double fuses

**Operating ranges:**

Dew point sensor

Ambient temperature: –20°C to +80°C (–4°F to + 176°F)

pressure: –14.7 to 300 psig (0 to 22 bar)

Electronics:

Ambient temperature: –20°C to +75°C (–4°F to +167°F)

relative humidity 85% maximum

## PHYSICAL

**Dimensions:** 10.5"W x 18.4"H x 4.25"D (267 x 468 x 108 mm) not including sensor

**Weight:** 12 lbs (5 kg)

**Shipping Weight:** 14 lbs (5.5 kg)

**Environmental:** Surface-mount, industrial environment (NEMA-4)

# Appendix B — Warranty and return procedure

## Warranty

General Eastern (the Seller) warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment. Liability of the Seller under this warranty is limited, at Seller's option, to:

- Repair or replacement of defective parts at no charge
- Credit adjustment, not to exceed original sales price

This warranty is subject to the following conditions:

- Prompt notification to Seller upon discovery of defects or missing items
- Obtaining a Return Authorization Number from Seller to return defective items to plant as directed
- Return of equipment with freight charges prepaid, or as otherwise agreed

Defects caused by negligence, misuse, improper installation, accident or unauthorized repair or alteration by buyer or user, or any modification, such as changing range resistors, may void this warranty.

This warranty does not include mechanical parts failing from normal usage, nor does it cover limited-life electrical components which deteriorate with age.

This warranty is in lieu of all other warranties, expressed or implied, including the implied warranty of fitness for a particular purpose to the original Purchaser or to any other person. Seller shall not be liable for consequential damages of any kind.

## Damaged Shipments

In case of shipping damage, it is the Buyer's responsibility to file a claim. The Buyer should inspect the shipping container upon receipt and note any evidence of damage on the freight waybill. If concealed damage is found after opening the container, the

customer should file a claim with the carrier at once. The customer must retain the shipping container and all materials during the lifetime of the warranty.

## Repaired Equipment

All repairs are warranted for 90 days. Only the repairs and components replaced as part of these repairs are covered by this warranty. Other repairs or defective parts are covered by the original warranty, if applicable.

The aforementioned provisions do not extend the original warranty of any article which has been either repaired or replaced by the Seller.

## Instrument Return Procedure

All General Eastern instruments are fully tested and calibrated prior to shipment. Should a problem with the operation of the equipment arise, follow the procedure below:

1. Contact the factory to discuss the problem. In countries other than the U.S., the local agent can also be contacted. Sometimes a problem can be resolved by a change in operating procedure or an adjustment to the equipment.
2. If the equipment must be returned to the factory, obtain a return authorization number from General Eastern, and reference the number on the return shipping papers. A written description of the problem should also be included with the instrument.
3. If equipment is not covered by General Eastern's Warranty Policy, a purchase order should be submitted with the equipment returned. The order should cover one of the following:
    a. **Open order**, authorizing repair of equipment to meet published specs. Repair costs will be billed on an actual basis, but will not exceed 50% of the replacement cost without prior customer approval.
    b. **Order that is not to exceed $500.00 or 30% of the replacement cost**, whichever is higher. If repair costs exceed this amount, the customer will be quoted costs before the work is done.
    c. **Order to cover cost of test and evaluation only.** Amount based on type of equipment returned. General Eastern will

evaluate but not repair the unit. General Eastern will call the customer to discuss the evaluation and quote the cost of repair or replacement.

To expedite repairs and reduce costs, General Eastern recommends options (a) or (b).

4. After receiving a Return Authorization Number, the equipment must be returned **freight prepaid**.
5. General Eastern reserves the right to apply a minimum service charge in cases where an instrument is returned for repairs or recalibration, but does not require service.

Returning equipment without a Return Authorization number and Purchase Order significantly delays turnaround time and incurs additional costs. To expedite repairs and reduce costs, please follow the above instructions.

Note: General Eastern guarantees NIST traceability and operation within stated specifications. However, claims regarding accuracy or traceability will be covered under warranty only when verified at General Eastern, or by a fully independent testing laboratory. Examples of independent labs are: National Institute of Standards and Technology in the U.S., and the National Physical Laboratory (NPL) in the U.K.

# Appendix C — Humidity equations and conversion chart

The following symbols appear in the equations below:

$\boldsymbol{e}$ = Vapor Pressure, millibars

$\boldsymbol{e}_{\mathrm{i}}$ = Vapor Pressure with respect to ice, millibars

$\boldsymbol{e}_{\mathrm{w}}$ = Vapor Pressure with respect to water, millibars

$\boldsymbol{e}_{\mathrm{is}}$ = Saturation vapor pressure, ice, millibars

$\boldsymbol{e}_{\mathrm{ws}}$ = Saturation vapor pressure, water, millibars

$\boldsymbol{P}$ = Total Pressure, millibars

$\boldsymbol{T}$ = Temperature, °C

$\boldsymbol{T}_{\mathrm{a}}$ = Ambient temperature, °C

$\boldsymbol{T}_{\mathrm{d}}$ = Dew point temperature, °C

$\boldsymbol{T}_{\mathrm{f}}$ = 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:

$$e_{ws} = 6.1121 \exp\left[\frac{17.502T}{240.97 + T}\right] \quad (1)$$

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

$$e_{is} = 6.1115 \exp\left[\frac{22.452T}{272.55 + T}\right] \quad (2)$$

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):

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

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

$$\frac{g}{m^3} = \frac{216.7e(T_d)}{T + 273.16} \quad (4)$$

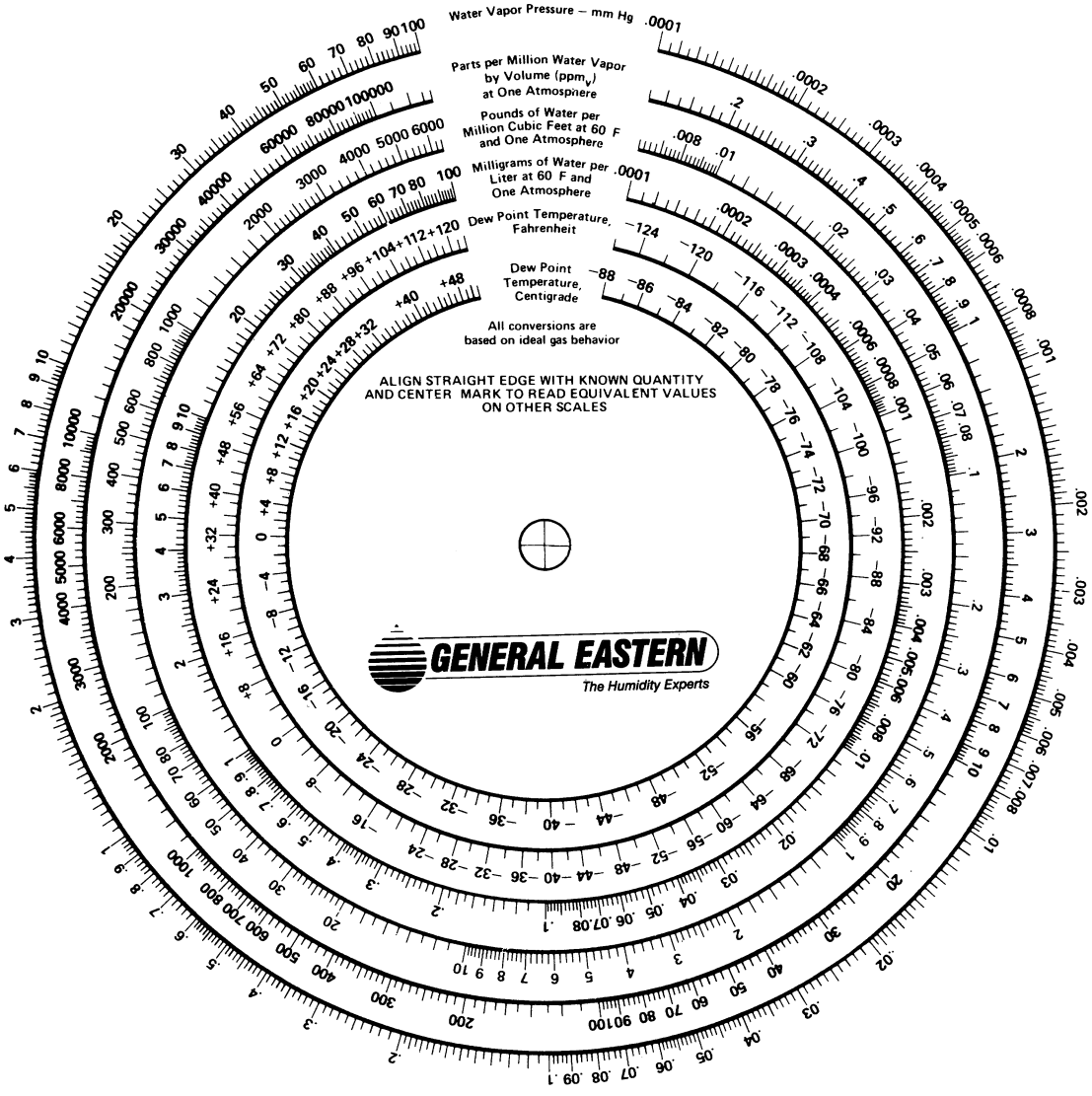
Water vapor content expressed as parts per million by volume is given by the following:

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

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:

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

A graphical humidity conversion chart is given below.




WATER VAPOR CONVERSIONS

# Appendix D — Configuring the RS-232 interface

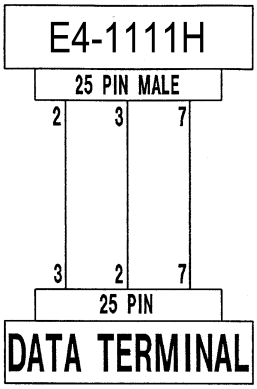
The E4-1111H is configured as Data Terminal Equipment (DTE). The following pins are used on the RS-232 interface:

2 - Transmitted data (**TXD**)

3 - Received data (**RXD**)

7 - Signal ground (**GND**)

To send the output of the monitor to a terminal or a terminal emulator, use the cable arrangement shown below.




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

4 - Request to send (**RTS**)

5 - Clear to send (**CTS**)

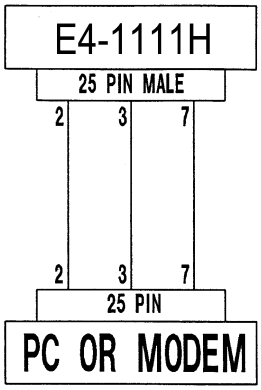
6 - Data set ready (**DSR**)

20 - Data terminal ready (**DTR**)

The unit, as shipped from the factory, has pins 4 and 5 connected and pins 6 and 20 connected via 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.

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




In order to communicate with the unit, 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 monitor
- A 25-pin female D connector connecting to the computer

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

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 unit. 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, CHR$(27)
150 LINE INPUT #1, A$                            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 E4-1111H 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 E — Glossary

**depression capability** — The temperature difference by which the chilled mirror can be lowered from the ambient temperature.

**PACER** — General Eastern's patented *Programmable Automatic Contaminant Error Reduction* system, which consolidates soluble contaminants to reduce their effect on system accuracy. See *"The PACER Cycle"* on page 21.

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

**scaling** — The process of selecting the maximum and minimum output values of a chosen parameter.