

Dew Point Measurement with Model 2781 DEWCEL Element

Electrical Temperature Measurement

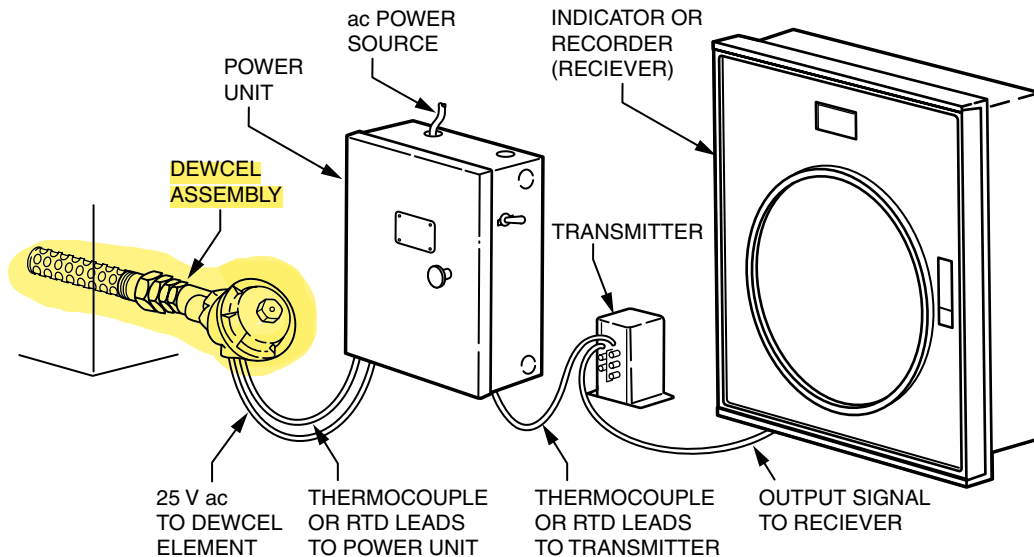


Figure 1. Typical DEWCEL System

Principle of Operation

The Foxboro dew point measuring system (see Figure 1) consists of a DEWCEL assembly, 25 V ac power source, transmitter, and an indicator or recorder.

DEWCEL assemblies are made up of two parts; a moisture sensitive element with heater and a temperature detector. The moisture element is a fabric (wick) covered tube on which two individual gold wires are wound in a double helix. The wires are spaced evenly, not allowed to touch, and connected to a 25 V ac power source. A temperature detector (either a thermocouple or a resistance temperature detector (RTD)) is inserted in the tube.

The fabric (wick) of the tube is initially saturated with a 5% lithium chloride solution. Dry lithium chloride is non-conductive, but in solution with water it becomes conductive. Lithium chloride is also hygroscopic. When the 25 V ac is turned on, current flows through the heater wires by way of the conductive lithium chloride solution warming the wick fabric.

This evaporates moisture and reduces conductivity and heating until an equilibrium condition exists. The rate at which the lithium chloride is absorbing moisture from the air is now exactly equalled by the rate of moisture evaporation from the wick to the air. The temperature of the wick, at which this occurs, is called the equilibrium temperature and is related to the quantity of water in the air.

The thermocouple or RTD output indicates this equilibrium temperature. By using the proper tables, the output signals or the equilibrium temperature can be converted to dew point, % water vapor, parts per million (ppm), and other units of absolute moisture.

In a Foxboro dew point system, this conversion is accomplished by the recorder chart or the indicator scale. Because the relationship between the equilibrium temperature and the dew point is nonlinear, the chart and scale graduations are not uniform.

Standard Specifications

Ambient Temperature Limits:	-45 and +105°C (-50 and +220°F)
Dew Point Limits:	-45 and +60°C (-50 and +140°F)
Relative Humidity Limits:	12 and 100%
Pressure Limits:	Full vacuum and 850 kPa (125 psi)

Air (Gas) Velocity Limit

With Perforated-Tube Element Shield:	0.3 m/s (1 ft/s)
With Open-End Element Shield:	5 m/s (16 ft/s)
With Draft Shield:	10 m/s (33 ft/s)

Power Supply:

Single DEWCEL Element:	100, 120, 220, 240 V ac; 50 or 60 Hz; as specified
Up to Six DEWCEL Elements:	120 V ac, 60 Hz

Power Consumption (Approximate)

Startup:	50 W
Running:	2 W (at equilibrium)

Application Limitations

The DEWCEL element can be used to measure dew points in atmospheres containing many common gases. These include air, CO, CO₂, N₂, H₂, O₂, etc. With H₂S, concentrations above 100 ppm require 24 karat gold windings (instead of the standard 18 karat).

The element is not recommended for atmospheres containing SO₂, SO₃, NH₄, diethylene glycol, or triethanilamine. For details about specific applications, consult Invensys Foxboro.

In general, the presence of dust, oil, or hydrocarbon vapors will not interfere with the operation of the element. For gas velocity and temperature limitations, refer to the previous section.

Installation

Types of Mounting

A variety of optional mounting equipment is available to provide element protection and proper functioning of the DEWCEL under many different operating conditions (see Figures 2, 3, 4, and 5).

1. The element will operate satisfactorily indoors in any standard mounting provided the velocity of the gas does not exceed the maximum for the specific element shield installed (refer to section above).

If the velocity exceeds this value, use the draft shield mounting (see Figure 3) together with the perforated-tube shield.

2. If the temperature of the gas is outside the particular operating range of the element (refer to graph on page 11 or 12), mount the element in a sampling chamber so that the gas can be cooled to a temperature within the operating range (refer to page 8).
3. If the element is placed outdoors, mount it in a weatherhood to protect it from precipitation, wind, and sunlight (see Figure 4).

Mounting Dimensions

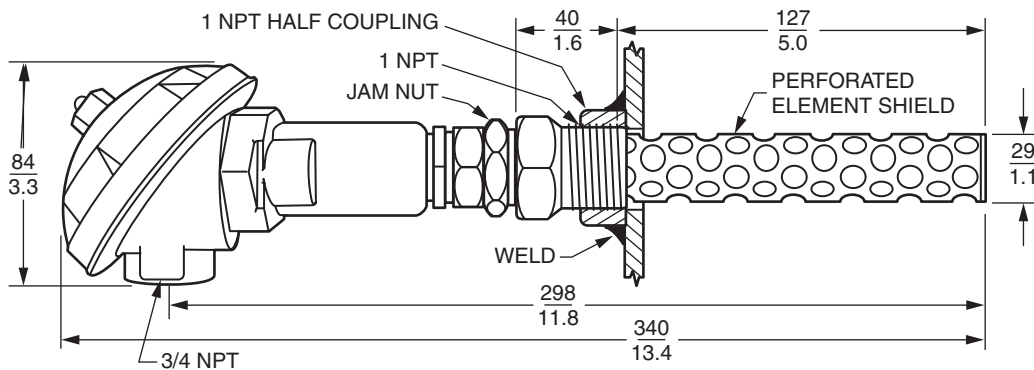


Figure 2. Element Shield

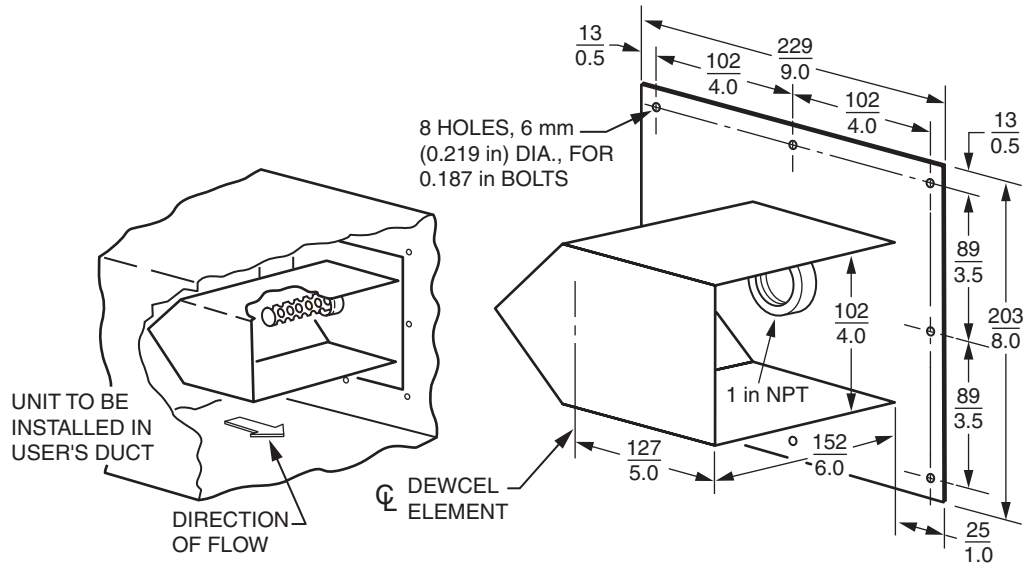


Figure 3. Draft Shield

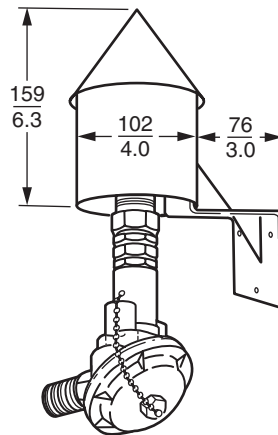


Figure 4. Weatherhood

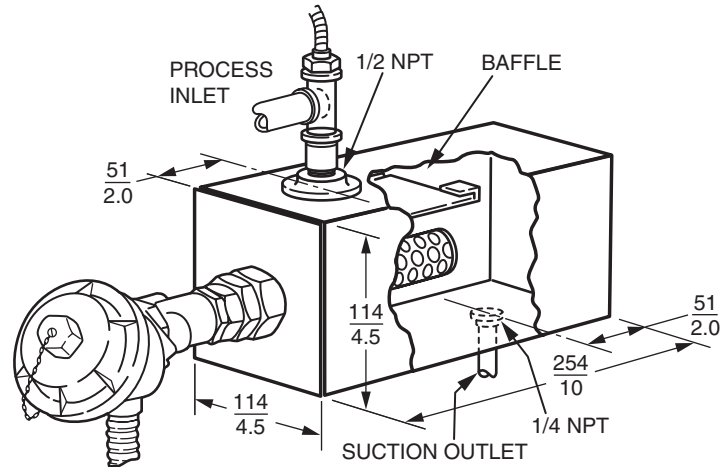


Figure 5. Sampling Chamber

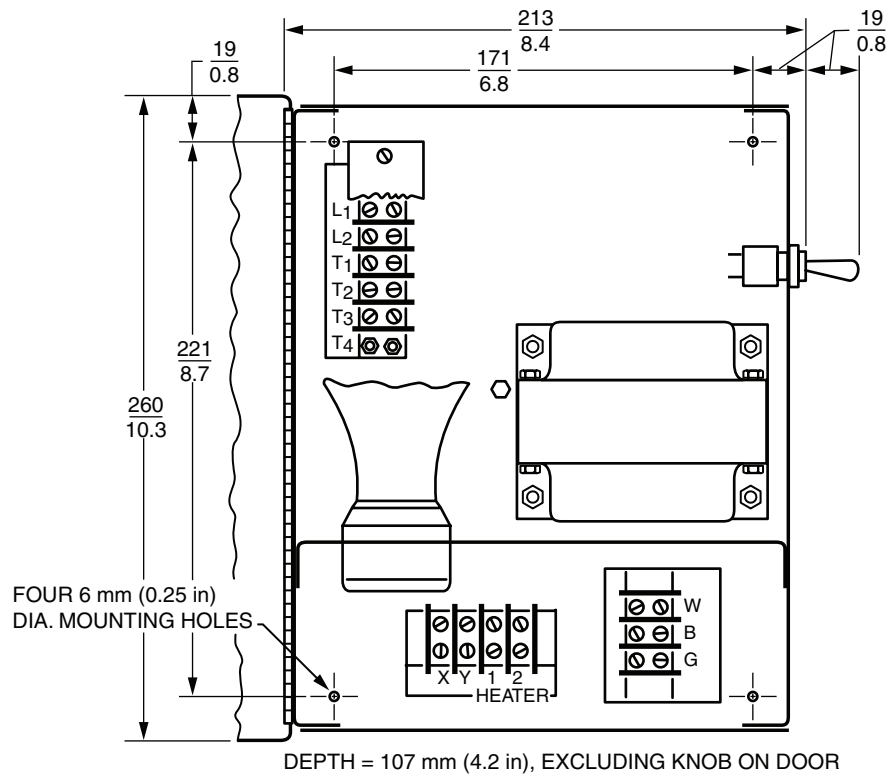


Figure 6. Power Unit (Single DEWCEL Element)

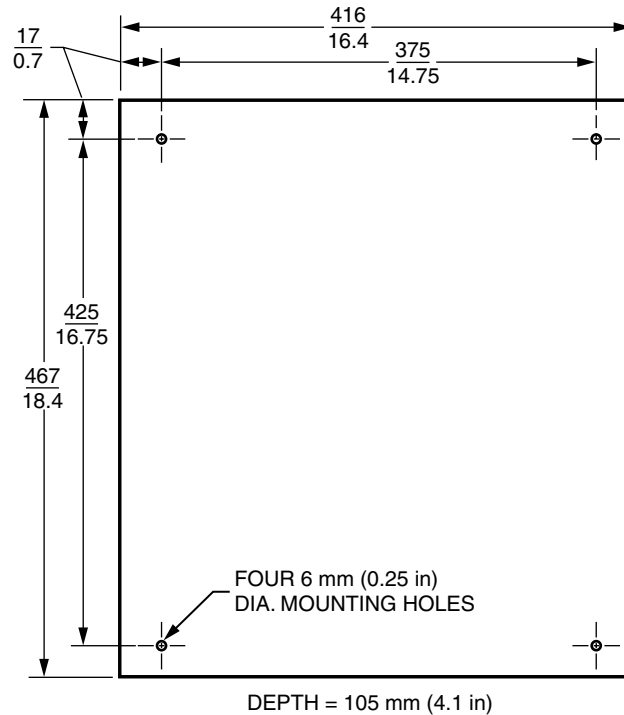


Figure 7. Power Unit (Two to Six DEWCEL Elements)

Wiring

DEWCEL Element

The thermocouple extension wire leads or RTD cable should be continuous one piece wires without intermediate connections from the DEWCEL element, through the power unit, to the transmitter. However, for convenience, intermediate connections can usually be made inside the power unit without causing element signal errors.

Thermocouple and RTD terminals are labeled W, G, and BK. Refer to connection and other wiring details.

1. Run heater and temperature-measurement leads in conduit. Provide drain at lowest point in conduit run for periodic removal of condensate.
2. For 25 V ac heater leads, use 1.0 mm² or 18 AWG, or larger wires.
3. With a thermocouple, use extension wire leads having same thermoelectric properties as thermocouple wires. Connect red lead to W(-) terminals, and other lead to BK(+) terminals. Note that G terminals are not used (see Figure 8).
4. With an RTD, use a 3-conductor, 1.0 mm² or 18 AWG, copper wire extension cable (Foxboro Part R0101LY, or equivalent). A 5-conductor cable for both heater and RTD leads is available (Foxboro Part R0101BA) (see Figure 8).
5. Complete wiring to remaining components in system (refer to Figure 1).

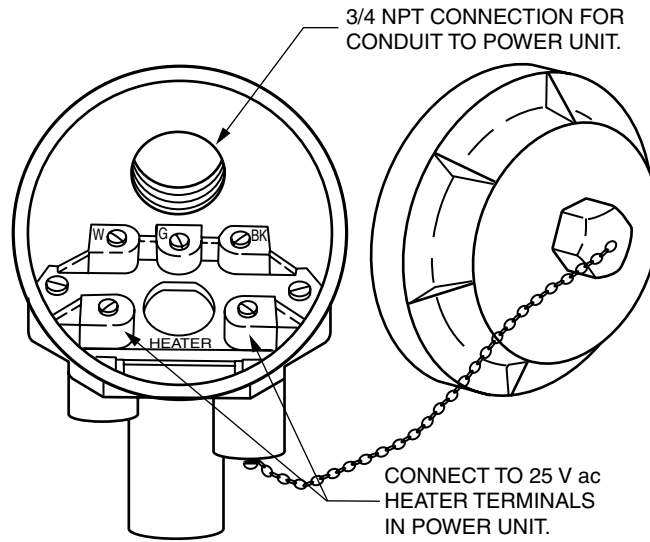
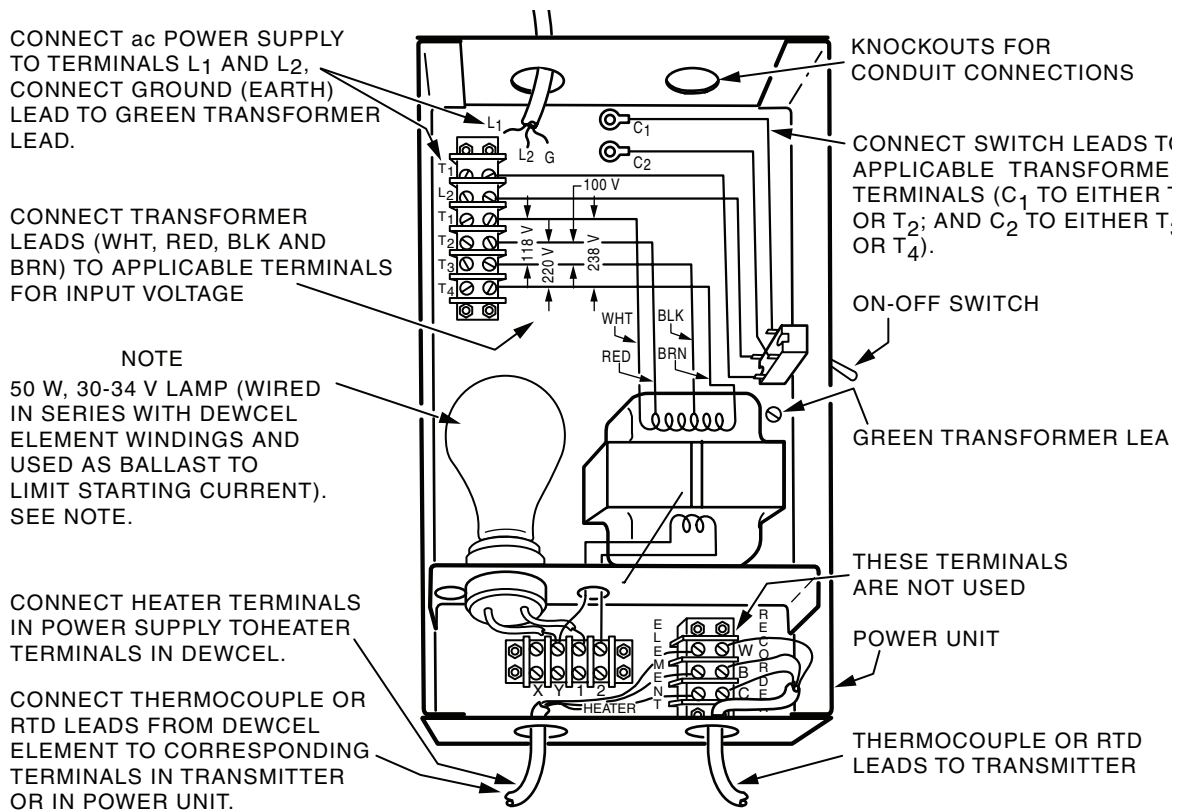


Figure 8. Terminal Head Connections



NOTE: IN 2004, LIGHT BULB WAS REPLACED WITH A 9 OHM, 95 WATT BALLAST RESISTOR.

Figure 9. Power Unit Connections

Using Sampling Chamber

If the temperature of the gas being measured is outside the particular operating range of the DEWCEL element (if the temperature is above the element characteristic line for the particular dew point condition), the sample gas must be cooled to a temperature within the operating range before it is passed over the element (see Figures 12 and 13).

When using the sample gas, the temperature of the cooling medium must not be lower than the dew point being measured. (If the temperature were lower, condensation would occur and an incorrect dew point would be measured.)

The cooling medium can be ambient air, water, or other material. The sampling chamber illustrated on page 5 uses ambient air to cool the sample gas. The gas can be circulated by a pump or aspirator; however, the gas velocity limitations (refer to page 2) must be observed.

RTD Operational Checks

1. Disconnect RTD leads at DEWCEL element. Turn off 25 V ac power source, and allow RTD to stabilize at ambient temperature. Note temperature.
2. Measure resistance between terminals W and BK (see Figure 10). Resistance should be about value specified for this temperature in Measurement-Temperature Table listed on page 14. If resistance is not correct, replace RTD.
3. Measure resistance between each RTD terminal and terminal housing. If any resistance is less than 10 M Ω , replace RTD.
4. Measure resistance between leads in cable, and between each lead and conduit. If any resistance is not infinite, replace cable.
5. Measure resistance between terminals G and BK. Resistance should be 218 Ω with a nickel RTD, and 0 Ω with a platinum RTD. If resistance is not correct, replace RTD.
6. Reconnect RTD cable leads at element.

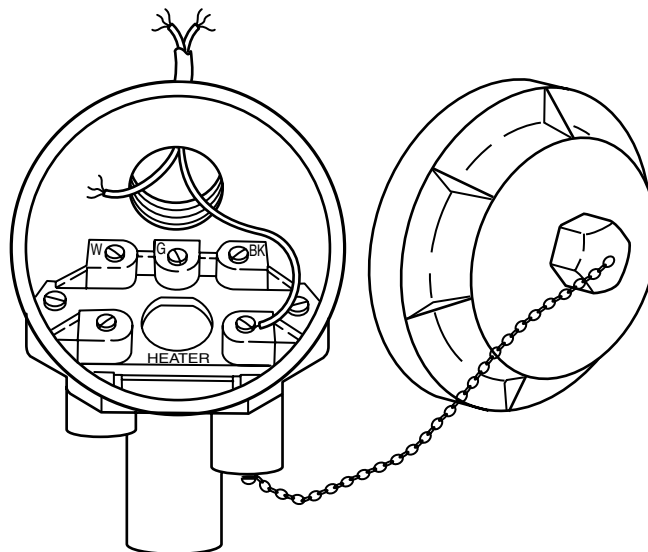


Figure 10. Connection Head

Operation

Preparing DEWCEL for Operation

Included with the DEWCEL element is a 1 oz (30 mL) bottle of 5% lithium chloride solution. The fabric under the element windings must be saturated with the solution before the system can be operated. About 10 to 15 mL (1/3 to 1/2 oz) of solution is required for the saturation.

1. Unscrew element shield and carefully remove shield from element. Do not allow shield to touch element windings.
2. Gently squeeze lithium chloride bottle and direct stream onto windings (see Figure 11) along length of element. Repeat around circumference of windings until fabric is completely saturated.
Saturation is indicated when droplets of solution form on windings. Shake off excess solution.
3. Carefully wipe solution from plastic surfaces at both ends of windings.
4. Carefully reinstall shield and insert element into atmosphere being measured.
5. Allow atmospheric stabilization (permit excess moisture to evaporate) prior to applying electrical power.
If temperature of atmosphere is such that there is a possibility of moisture condensing on cool element and washing off salt solution, apply heat to warm surface to hasten stabilization. Do this prior to inserting element in atmosphere.
6. Torque jam nut to shield by no more than 27 N·m (20 lb·ft).

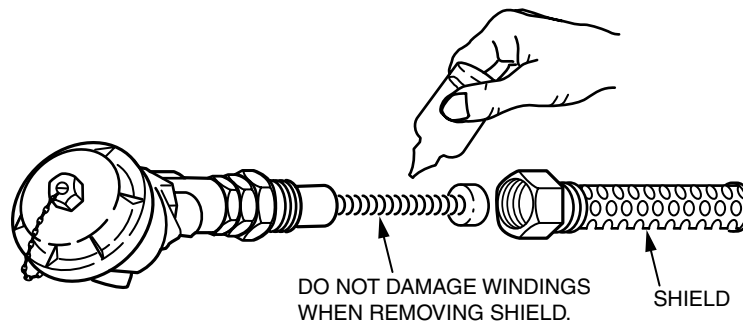


Figure 11. DEWCEL Element

Putting into Operation

After the saturated DEWCEL element is installed in the atmosphere being measured and the 25 V power supply is turned on, the time for the instrument to be in operation is approximately six minutes.

— **NOTE** —

For Dewcel elements that were shipped prior to 2004.

After the saturated DEWCEL element is installed in the atmosphere being measured and the 25 V power supply is turned on, the ballast lamp in the power unit will glow and gradually darken as equilibrium is reached. If the glow persists, check for free water in the sampling chamber, for solid material short-circuiting the element windings, or for excessive gas flow.

After equilibrium is reached, the element receiver will indicate the dew point. Check the operation of the system by determining the dew point using a sling psychrometer and suitable tables. If the two dew points are in approximate agreement, the system is operating properly. If there is a marked discrepancy, check the thermocouple leads or check the RTD. If the equipment is satisfactory, calibrate the system (refer to page 14).

Note that the dew point determined by a sling psychrometer is not accurate enough to use as a standard. It is used only as a check. A discrepancy of more than a few degrees between dew points may indicate that the element requires washing (refer to page 15), or that the ambient temperature is outside the operating range for the particular conditions (see Figures 12 and 13).

To Determine Dew Point

If the element temperature measurement is transmitted to a calibrated recorder or indicator, the dew point can be read directly. If the receiver is not a recorder or indicator, the dew point can be determined by noting the output signal (mV or Ω) and using either the applicable table listed on page 13 or applicable graph (see Figures 12 and 13). Other tables listed on page 14 contain element temperatures and corresponding values of other psychrometric variables.

DEWCCEL Element Graphs, °F Units

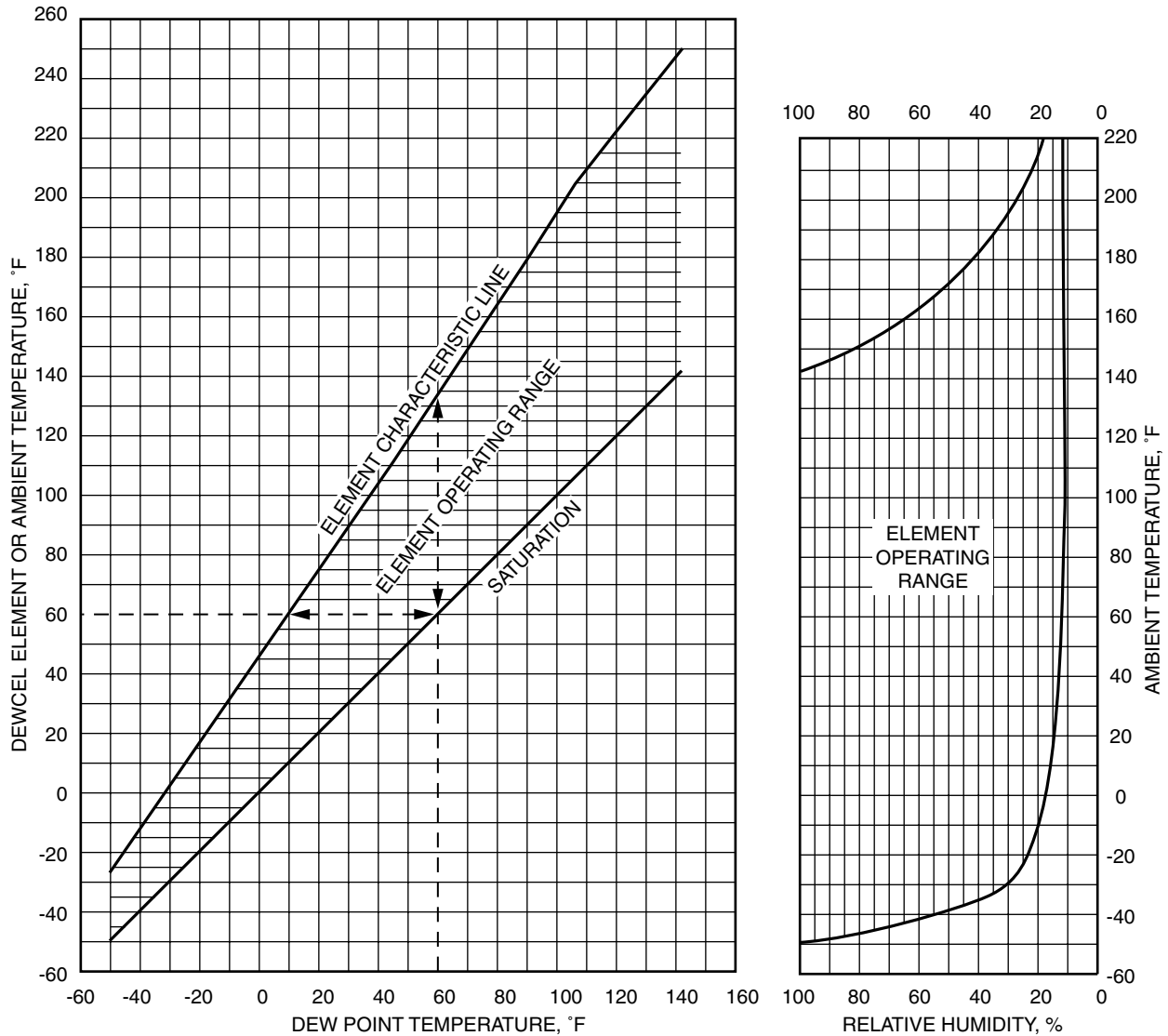


Figure 12.

To Determine Dew Point Data

The Y-axis can be either the element temperature or the ambient temperature.

If the Y-axis is the element temperature:

Dew point is corresponding X-axis reading at intersection of element characteristic line.

If the Y-axis is the ambient temperature:

1. Horizontal line in element operating range at a specific ambient temperature defines limits of dew point that can be measured.
2. Vertical line in element operating range at a specific dew point defines limits of ambient temperatures in which this dew point can be measured.

To Determine Limits of Element Measurement in Terms of Relative Humidity

For a given ambient temperature, the element can operate over a relative humidity range defined by the maximum and minimum humidity lines. See examples on page 12.

DEWCEL Element Graphs, °C

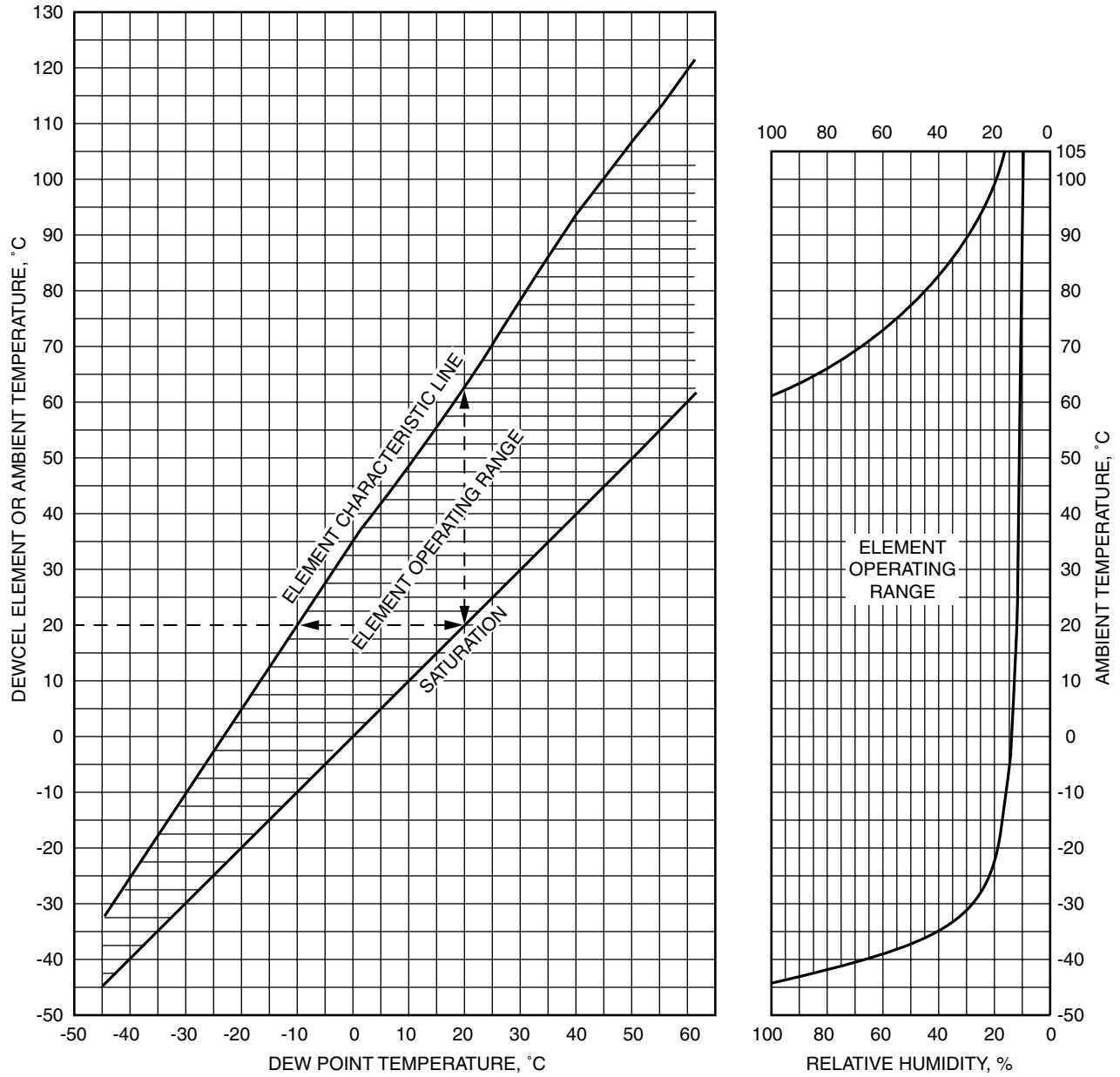


Figure 13.

EXAMPLE

At an element temperature of 20°C:

Dew point is -10°C.

At an ambient temperature of 20°C:

1. Dew points between -10 and +20°C can be measured.
2. A dew point of 20°C can be measured at ambient temperatures between 20 and 63°C.

EXAMPLE

At an ambient temperature of 70°C, dew points can be measured between relative humidities of 11 and 67%. See explanations on page 11.

Reference Literature

Listed below are various Instructions (MIs) and Technical Information (TI) references that can be used with the element. This literature is available from Foxboro.

Thermocouple and RTD Details

For details on the installation, operation, and servicing of thermocouples and RTDs, refer to the applicable MI below.

Thermocouple	MI 016-128
RTD, Nickel	MI 016-132
RTD, Platinum	MI 016-131

Dew Point Table

The TIs listed in the table below contain basic element data (element temperatures and corresponding dew points). In addition, some contain equivalent values of other psychrometric variables, as indicated.

TI Reference	Calibration Curve	Calibrated Data
5-41b	DI-3	Dew point to DEWCEL element temperatures in °C. DEWCEL element to dew point temperatures in °C.
5-41a	DI-2	Dew point to DEWCEL element temperatures in °F. DEWCEL element to dew point temperatures in °F. Dew point temperatures below 32°F are based on the pressure of saturated vapor in contact with ice.
5-44a	DW-10	Dew point to DEWCEL element temperatures in °F. Dew point temperatures below 32°F are based on the pressure of saturated vapor over supercooled water.
5-42a	DI-4	Percent by volume water vapor and parts per million to DEWCEL element and dew point temperatures in °F. DEWCEL element temperature to percent by volume water vapor and to dew point temperature. Temperatures in °F.
5-43a	DI-6	Grains moisture per standard cubic foot dry air to DEWCEL element and dew point temperatures in °F.
5-43b	DI-8	Grains moisture per cubic foot saturated mixture on DEWCEL element and dew point temperatures in °F.
5-43c	DI-12	Grains moisture per pound dry air to DEWCEL element and dew point temperatures in °F.
5-46a	DI-18	Pounds moisture per million standard cubic foot air to DEWCEL element and dew point temperatures in °F.
5-46b	DI-30	Pounds moisture per pound dry air to DEWCEL element and dew point temperatures in °F.

Measurement-Temperature Table

The TIs referenced in the table below list thermocouple or RTD outputs (mv or Ω) and corresponding temperatures.

Measurement			Reference Curve	TI Reference
Thermocouple	ISA Type T	°F	S232-32/68	5-11c
		°C	S233-0/68	
	ISA Type J	°F	S98J-32/68	5-12f
		°C	S99J-0/68	
	ISA Type K	°F	K222-32/68	5-13c
		°C	K233-0/68	
RTD	Nickel	°F	NR-226	5-24a
		°C	NR-227	
	Platinum	°F	PR-278	5-27a
		°C	PR-279	

System Calibration

1. Turn off power unit. Disconnect both cables from DEWCEL element; note identification of wires for correct reconnection. Remove element from process.
2. Carefully remove shield from element. Do not allow shield to touch windings.
3. Immerse element (see Figure 14) up to top of windings in a well-stirred water bath at approximate operating temperature. Measure bath temperature with a test thermometer.
4. Determine dew point corresponding to bath temperature by using applicable table listed on page 13, or applicable graph on page 11 or 10.
5. Adjust zero screw on recorder or indicator so that dew point reading is correct.
6. Wash element (refer to section below). Then resaturate with lithium chloride solution (refer to page 9).

— NOTE —

To simplify calibration, remove element from process and allow it to reach equilibrium in air. Compare temperature reading with that of a test thermometer. If satisfactory, complete Steps 4 and 6.

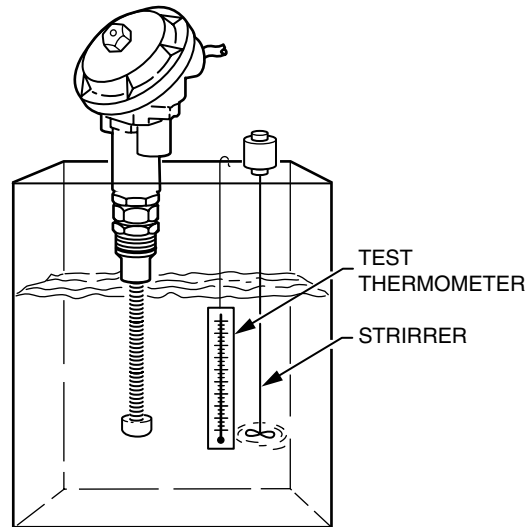


Figure 14. Calibration Setup

To Wash DEWCEL Element (Prior to Resaturation)

When the DEWCEL element system indicates an incorrect reading, the element requires washing in water and then resaturating with a 5% lithium chloride solution. (An incorrect reading can be detected by comparing the indicated dew point with one determined with a sling psychrometer. Note that a discrepancy of 1 or 2 degrees is not significant.) Under average plant conditions, this washing and resaturating is required about every 3 to 6 months.

Do not add lithium chloride solution to element without first washing element.

When resaturating element, use only a 5% lithium chloride solution.

The 5% lithium chloride solution is available from Foxboro in 1 pint (0.5 L) bottles (Part No. H0103AY) and in 1 oz (30 mL) bottles (Part No. 0048192).

1. Turn off power unit. Disconnect both leads from element; note identification of wires for correct reconnection. Remove element from process.
2. Carefully remove shield from element. Do not allow shield to touch windings.
3. Hold winding portion of element under a stream of water, or immerse element in a beaker of water and stir vigorously. Continue until dust and salt are removed. Avoid unnecessary wetting of portion above windings.
4. Rinse by repeating Step 3. If tap water has high mineral content, use distilled water.
5. Dry element and check for completeness of washing as follows:
 - a. Connect leads to element and turn on power unit. Current will flow between windings and thus heat element, and ballast lamp will glow.
 - b. As element dries, current flow will decrease, and lamp will become dark. Temperature will follow current flow; increase and then decrease. When temperature is stabilized, turn off power unit.
 - c. If washing is complete, temperature will remain constant. If it is not, temperature will continue to fall. In this case, repeat washing procedure.
6. Saturate element with lithium chloride solution (refer to page 9).

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