

473 Dew Point Mirror



Operation and Maintenance Manual

MBW Calibration Ltd.
Seminarstrasse 57
CH-5430 Wettingen / Switzerland
+41 56 426 21 33 phone
+41 56 427 14 00 fax
www.mbw.ch
info@mbw.ch



UK Distribution by IMA Ltd:
Parkwell House,
Otley Road,
Guiselley, West Yorkshire,
LS20 8BH, England
Phone: +44 (0)1943 878877
Email: info@ima.co.uk
Web: www.ima.co.uk

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Welcome

With the 473 Dew Point Mirror you will be able to perform precision dew point measurements as well as measurements of other parameters such as relative humidity. The 473 utilizes a full color active matrix liquid crystal display with an integral touch panel. It has a high contrast ratio and a wide viewing angle for easy readability. Data is displayed in large easy to read fonts. Using the on screen buttons and menus, you can easily configure each line of the display for a variety of humidity, temperature, and pressure parameters that may be viewed in either SI or non-SI units.

How to Use This Manual

If you have the time and inclination, you can read this manual from front to back. Since we realize your time is valuable and you may not wish to do that yet, we recommend the following approach to familiarize yourself with the 473 and start using it right away.

1. With the 473 at hand, go straight to the Getting Started section on page 3. From there, you can quickly learn to use the 473 to make a dew point measurement.
2. Next, read the System Configuration section beginning on page 9 to learn how to configure the system to meet your preferences.
3. Finally, read the Back Panel Connections section beginning on page 16. That section identifies all the electrical and gas connections available on the back panel and explains how and when to use them.

For More Information

For a more thorough understanding of the 473 and other humidity measurement information, please read the remaining sections of this manual.

The Installation section covers environmental and power requirements.

The Remote Communication section discusses the RS-232 interface both from a hardware and software perspective. It gives details relating to cabling to connect the 473 to a computer, and gives the syntax and examples of each of the commands that the 473 recognizes.

The Maintenance section covers topics such as Mirror Cleaning and general maintenance required to keep your 473 performance at its best.

If the information you seek is not in one of the manual's included sections, never hesitate to contact us with your questions. Relevant phone, fax, and email contact information is on the front page of this manual.

Operation

Getting Started

This section allows you to set up and start using the 473 right away. You'll turn the system on and quickly familiarize yourself with the layout and features of the display and touch screen. Next, you'll learn about the optical mirror assembly for later care and cleaning that may be required. Finally, you'll use the 473 to measure the dew point temperature. Set your 473 on the bench and let's get started!

Turning the 473 On and Off

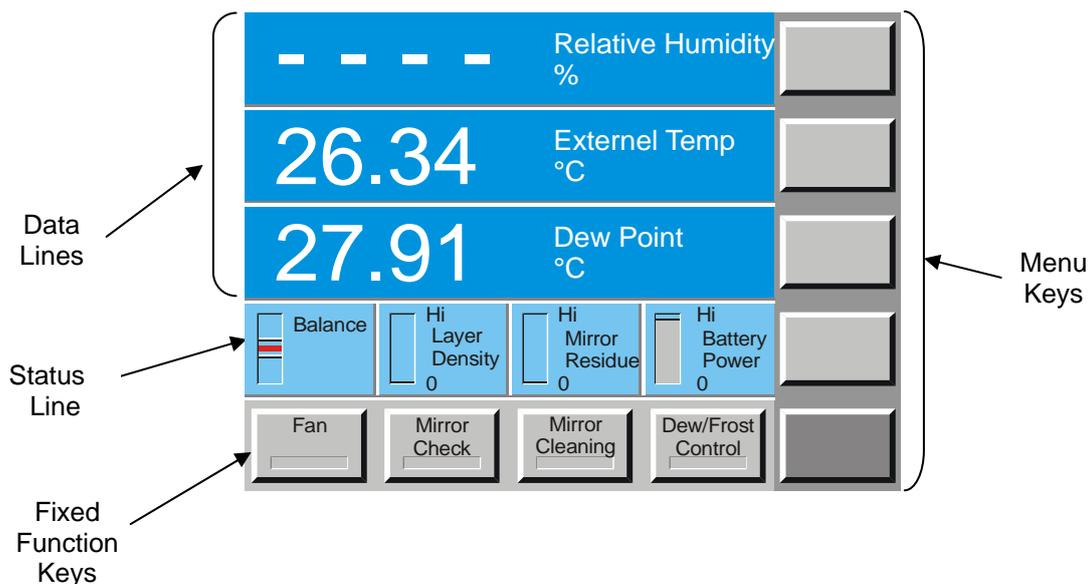
The 473 needs a source of normal AC power. The 473 has been designed to work over a wide power range and will most likely operate at your local voltage and frequency. Look at the back panel label for the power requirements of your specific system.

1. Using the supplied AC power cord, apply the proper voltage to the instrument by plugging the cord into the back of the instrument, then into an AC receptacle of the proper voltage.
2. The power switch is located on the back panel next to the power cord input. Turn it ON.

The display should become visible within a few seconds. If nothing seems to happen, check the power source.

What You See

When power is applied to the 473, the display will activate within a few seconds. A typical display configuration is depicted below. If you or someone else previously configured your system, it may look slightly different. But don't worry, we'll show you how to set it up the way you like.



Data Lines

The first four lines of the display are for numeric or graphic representation of the measured data. We refer to those first four lines as *data lines*.



If numeric, a data line contains the value to the left, with the parameter description and units to the right.



If graphic, a data line shows a simple graph of the data over time.

The choice of which parameter is shown on which data line, as well as whether a data line is viewed as numeric or graphic, is easily selectable. You'll see how to make these selections shortly.

Status Line



Near the bottom of the display is the *status line*. The status line contains balance, density, contamination, and the optional battery power indicators. The position of the status line can be changed like the data lines.

Fixed Function Keys

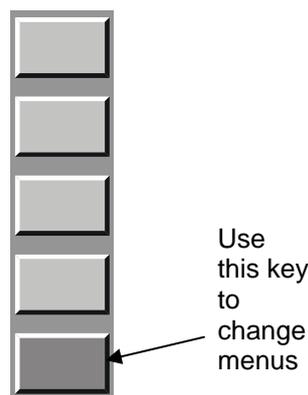


The bottom line of the display contains a row of fixed function keys. You'll use these keys to start and stop the optional fan, enable and disable measurement of dew point, and other things. The function of each of these keys never changes, and they are always available for use.

Menu Keys

To the right side of the display is a column of menu keys. Each of these keys changes function as needed.

Notice that the bottom key in this column is different from the rest. The bottom key is used to cycle the upper keys through the various menu options. The text on the bottom key changes to indicate the currently selected menu option. The text of the upper keys change based on the functions available in the menu.



The Touch Screen

The 473 utilizes a touch screen for user interaction. To activate a menu option or toggle a function on or off, simply touch the screen directly over the key or object desired.

Calibrate the Touch Screen

Before using the instrument for the first time, you may need to calibrate the touch screen to your finger positioning preference. Here's how -



Press and hold the *enter* key on the numeric keypad for 3 or 4 seconds. If you've done it correctly, you'll hear two short beeps and a key in the upper right corner will turn yellow. If not, release the *enter* key and try again.



With the tip of your finger, press the center of the yellow key in the upper right corner of the touch screen. It is labeled 'Touch This Key'. Once you touch it, the yellow color goes away and another key turns yellow.



Now, touch the yellow key that's in the lower left corner of the touch screen. Once you touch it, the yellow color goes away and you have successfully calibrated the touch screen.

Test your new touch screen calibration by pressing each of the four blank menu keys on the right side of the touch screen several times. If they seem not to work well, just repeat the calibration steps again from the beginning.

You may recalibrate the touch screen as often as needed, however, it is rarely required

Navigating the Menus

The various menus of the right column of keys are navigated by using the key in the lower right corner of the touch screen. Each time you press the lower right key, a new menu appears on the keys directly above it. The menu is circular, meaning that once you go past the last menu, the first one appears again and the process starts over. You can use the +/- key on the keypad to move backward through the menus. Use the *enter* key to clear the menu.

Selecting Parameters to Display

Selecting which parameters to display on the four data lines is easy. It is done with the Parameter menu.

1. Use the lower right menu key to select the Parameter menu. 'Parameter' appears on the key, and the keys above get left pointing arrows. Notice that each key corresponds to the data line it points toward.
2. Press the arrow key corresponding to the data line you wish to change. Notice that each time you press the arrow key, the parameter of the data line changes. The parameter selection is circular, meaning that once you reach beyond the last available parameter the first one is again displayed and the cycle starts over.
3. Change the parameters on any of the other three data lines with the same method.
4. If you like, you may clear the menu keys when finished by cycling through all the menus using the lower right key on the touch screen, or by pressing the *enter* key once. Note that this is not required and nothing is wrong with leaving the Parameter menu (or any other menu) on the screen.

Selecting Graph vs. Numeric Data

Any data line may be viewed either as numeric or as a graph. The Numeric/Graphic menu is used to toggle any data line between numeric and graph mode.

1. Use the lower right menu key to select the Numeric/Graphic menu. 'Numeric/Graphic' appears on the key, and the keys above contain left pointing arrows. Notice that each key corresponds to the data line it points toward.
2. Press the arrow key corresponding to the data line you wish to change. Notice that the data line toggles between numeric or graph mode each time you press the key.
3. Select numeric or graph mode on any of the other data lines with the same method.
4. If you like, you may clear the menu keys when finished by cycling through all the menus using the lower right key on the touch screen, or by pressing the *enter* key once. Note that this is not required and nothing is wrong with leaving the Numeric/Graphic menu (or any other menu) on the screen.

Selecting Units

The data may be viewed in any of the many available units. There are two Units menus used to change the units of displayed data.

1. Use the lower right menu key to select the Units menu. 'Units' appears on the key, and the keys above contain current units indications such as 'Temp °C'. Notice that each of the keys contains different types of units. In this case, the keys do not correspond to the adjacent data lines, but rather to different units types.
2. To change temperature units, press the key labeled 'Temp'. Notice that the corresponding units change each time the key is pressed. Also notice that any data line that is currently indicating temperature data also changes to reflect the newly selected units.
3. Change other units (such as pressure, flow rate, etc.) with the same method.
4. Note that there are two Units menus since there are so many types of units that may be changed. The second Units menu is obtained by pressing the lower right menu key again.

5. If you like, you may clear the Units keys when finished by cycling through all the menus using the lower right key on the touch screen, or by pressing the *enter* key once. Note that this is not required and nothing is wrong with leaving the Units menu (or any other menu) on the screen.

The Measuring Head Assembly



The heart of the 473 Dew Point Mirror Instrument is the measuring head assembly. It is designed to be highly sensitive and accurate, yet easily accessible for periodic mirror cleaning. Although not required prior to initial operation, you may wish to familiarize yourself with the location and accessibility of the mirror and the other optical components within this assembly.

For further discussion of the measuring head, and the mirror cleaning procedure, refer to Mirror Cleaning on page 25.

Dew Point Measurement

When you power the 473 on, it begins in an idle state. In this state, it measures and displays temperature and pressure transducers (if so equipped), but does not yet provide any meaningful humidity related data. In order to provide humidity data (dew point, frost point, %RH, etc.), the Dew/Frost Control mode must be enabled and gas must be flowing across the mirror. If %RH is desired, note also that an external temperature probe must be connected. For external temperature probe use, see External Temperature on page 16.

Fan



Measuring heads which are equipped with the optional fan use the Fan key on the bottom row of the touch screen to toggle the fan on/off.

Measuring the Room Ambient Dew Point Temperature

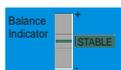


Let's use the 473 to measure the dew point temperature of the room by enabling the portion of the system responsible for cooling and maintaining the mirror at the dew or frost point temperature. Do so by pressing the Dew/Frost Control key. When enabled, a green bar on the key illuminates and any dew or frost point temperature indication begins to drop as the mirror cools toward the Point, see Selecting Parameters to Display on page 6 to select one of those parameters for display.

The Status Line

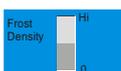
When the Dew/Frost Control is enabled, have a look at the Status Line. The Status Line is near the bottom of the display and has visual bar graphs that represent Balance, Density, Mirror Residue, and Flow Rate.

The Balance Indicator



Although it is directly obtained from the intensity of the mirror's reflected light signal, the Balance Indicator is effectively the first derivative of the dew thickness. In other words, it indicates the rate of growth or decay of the condensed layer on the mirror. While the dew or frost layer is growing in thickness due to an increase in condensation on the mirror surface, the indicator is above center. The faster the layer grows the higher the indication. Conversely, if the layer is evaporating from the mirror surface thereby becoming thinner, the indicator is below center. The faster it decays the lower the indication. When the indicator is in the center, it indicates that the thickness of the dew or frost layer is neither growing nor decaying and that the layer on the mirror surface is in equilibrium with the gas. In this center-balanced indication, there is no net exchange of water vapor between the gas and the mirror surface. If the humidity of the gas sample is homogeneous and of low enough variability for the control system to sense a steady value, the Balance Indicator will illuminate a green 'Stable' message, and the system will emit a few short audible beeps.

The Density Indicator



The Density Indicator graphically depicts the approximate relative thickness of the dew or frost layer currently on the mirror surface. Since the 473 has the ability to differentiate between dew and frost layers, it will also indicate which state the mirror's layer is in. The label within the density indicator will change from Layer Density (when the state of the layer is uncertain) to either Dew Density or Frost Density (when either dew or frost is assumed). For more information regarding Dew/Frost point determination see Dew / Frost Control on page 12.



To disable the control system, press the Dew/Frost Control key again. The green bar on the key disappears indicating that the control is no longer enabled. Any dew or frost point temperature indications will begin to rise toward the temperature of the measuring head, often within several degrees of the ambient room temperature. Also, the density indication drops off and the balance indication moves downward but eventually returns toward center.

System Configuration

You may configure many aspects of the 473 based on your preferences at the time. For instance, you may easily select which humidity, temperature, and pressure values to indicate on the screen, the order in which they should appear, their units, and whether each will be shown as a number or as a graph. In addition to display configuration, you can also change how the 473 performs its control functions such as Dew/Frost determination. Most configuration settings that you change remain valid until the next time you change them, even if you shut the 473 off.

Menu Options

The 473 has several menus available which are used to configure the system to your requirements. To activate each of the menus, press the lower right menu key. Notice that it is a slightly different color than all the other keys on the touch screen.

Each time you press this menu key, the 473 advances to the next menu and the key's label changes to indicate which menu is currently active. Once you've reached the last menu item, and press the menu key again, the menu options just start over again at the beginning.

Pressing +/- on the keypad steps backward through the menus. Pressing *enter* on the keypad clears all menus from the screen. Note however, that there is no requirement to clear the menus from the screen for any reason other than cosmetic, or for fear of accidentally changing a configured option.

Simplified descriptions of each menu follow.

Parameter	The Parameter menu is used to select which parameter to display on each of the four data lines. Each menu item key contains an arrow and directly corresponds with its adjacent data line.
Numeric / Graphic	The Numeric/Graphic menu is used to toggle a data line between displaying the data as numbers or as a graph. Each menu item key contains an arrow and directly corresponds with its adjacent data line.
Control Setup	The Control Setup menu is used to configure such things as dew/frost control, pump control, internal and external heater control, cooling water control, etc.
Units	The Units menu is used to change units used for displaying data. Unit changes are system global, meaning that if the temperature units are changed, then all temperature values displayed (including dew and frost point temperatures) will appear in the new units. Since there are so many units that may be configured, there are two units menus.
Fore Color	The Fore Color menu is used to temporarily change the color of the lines drawn on graphs and the color of text (number and letters). Each data line may be changed individually. Unlike other selections, changing colors is only temporary and cycling the power causes the 473 to return to standard color settings.
Back Color	The Back Color menu is used to temporarily change the color of the background drawn on graphs and numeric data lines. Each data line may be changed individually. Unlike other selections, changing colors is only temporary and cycling the power causes the 473 to return to standard color settings.

Display Parameters

Use the Parameters menu to select which parameters to display on the data lines. When you select parameters for display on any of the four data lines, those selections remain valid until you change them again, even if you turn the 473 off. See *Selecting Parameters to Display* on page 6 to select which values to display. A list of the available parameters follows. Note that not all parameters are available on all systems since some systems may not contain the associated hardware components.

Dew Point
Frost Point
%RH
%RH WMO
Volume Ratio
Weight Ratio
Absolute Humidity
Specific Humidity
Vapor Pressure
Head Pressure
External Temperature
Head Temperature

Graphing Data

Any value that you can view numerically can also be viewed as a graph at any time. The 473 automatically maintains a short history of each and every selectable parameter so that a graph may be seen instantly whenever a data line is toggled from a numeric mode to a graph mode.

Selecting Between Numeric Data and Graph

Selecting between numeric and graph modes is done with the Numeric / Graphic menu. See *Selecting Graph vs. Numeric Data* on page 6.

Changing Graph Attributes

You can change the overall time span (or x-axis) and the scaling (or y-axis) attributes of graphs.

Time Span

Changing the time span allows you to see a longer or shorter history period for the data. The 473 stores a fixed number of data points independent of the selected time span. Changing the time span changes the interval used for data storage. With a 15 minute time span, the graph data is sampled and stored every few seconds. However, with a 2 hour time span, the graph data is only sampled, stored, and updated about once a minute.

When you change the time span, the old data previously sampled and stored at the old interval will be incrementally replaced by new data sampled at the new interval. The Time Span as indicated on the graph will always reflect the actual time span of the currently stored data, and will eventually agree with the time span you select. The selected time span is common to all graphs so that they all have the same time relationship to one another.

The time span is changed with the Numeric/Graphic menu.

1. Using the touch screen, press directly on the graph you wish to change. The Graph Scaling dialog box will appear.
2. Press the Time Span key. A dialog box appears for entry of the desired time span.
3. Use the numeric keypad to enter a new value. As you press each numeric key, the numbers appear in the white Change To field of the dialog box.
4. If you make an entry error, press the touch screen over the field that holds the number you wish to change. Each time you press the touch screen there, the number backspaces one digit. Use this technique to erase any unwanted digits, then continue with the keypad use.
5. Press the dialog box's Ok button to accept the new value, or press Cancel to leave it unchanged. Note that pressing *enter* on the keypad does the same as pressing the Ok button.

The result will not be instant. It will take some time for the old data at the old time interval to be replaced by data at the new time interval as determined by your selected time span.

Scaling

Each graph can have its own scaling (or y-axis) values. There are three distinctly different scaling modes to choose from.

- *Autoscale*

Autoscale mode determines the scaling automatically so that all of the stored data will be visible on the graph at the best possible resolution. As the range of the data changes, so does the range of the graph. In autoscale mode, you can select a minimum that you want the graph to scale to. This is very useful for data that is very stable with little variation. This prevents the 473 from setting the scaling to such a small range that even the highly stable data appears visibly as wildly variable. For viewing dew or frost point graphs, setting this Autoscale Minimum to a value of at least 0.2 or more is generally preferable. This allows the graph range to close in on the data as it stabilizes at a point without becoming too narrow. You can experiment with this value to determine your personal preferences with different parameters. Autoscale mode is the power up default.

- *Fixed Range*

Fixed Range scaling allows you to select a fixed graph range, but automatically centered on the current data point. In other words, as the current data varies so does the graph center point, but the overall range remains fixed. This fixed range auto centering is mostly used to monitor data for stability.

- *MinMax*

You can specify the minimum and maximum values used for the graph. This is completely fixed scaling. If the data falls outside the minimum and maximum values you specify, you will not see them on the graph. If you wish to see the data that is outside the values you specified, you'll need to specify minimum and maximum values with a larger spread.

You can change the graph scaling at any time, and freely switch between the three scaling modes as well. Try it.

1. Using the touch screen, press directly on the graph you wish to change. A graph scaling dialog box will appear. One of the buttons in the Description column will have a green indicator. That shows you the currently selected mode. Note that there are three buttons – one for each mode.
2. Press the button of the mode you'd like to change to. Note that for the MinMax option, only the Maximum button need be pressed (as Minimum is then automatically assumed).
3. Press the corresponding button in the Change To column for the range you selected.
4. Using the numeric keypad, enter the value needed. If the number shown in the Value column is already correct, no entry is needed here. If you make a mistake while entering the value, use the touch screen and press on the number in error. Each time you press the touch screen there, the number will backspace one, erasing the flawed digits.
5. Once the value is shown as what you want press the OK button (or the enter key) to accept the new value, or press the Cancel button to abort all changes made to the mode and to any values.

The only values that get accepted by the system are those that correspond with the selected mode. In other words, if you change the value of the Autoscale Minimum, but Fixed Range is the selected mode, the Autoscale Minimum value remains unchanged.

Viewing Data both as Numeric and as a Graph

Since all displayable data may be viewed either numerically or as a graph, it does not matter which parameters are selected on which lines of the display. Often times you may even want to select the same parameter on two different data lines. That way you can have one of them set for numeric mode and the other one showing you a graph of that same data.

Control Setup

With the Control Setup, you can control the manner in which the 473 operates. The control setup capabilities are accessible through the Control Setup menu. See Navigating the Menus on page 6.

Dew / Frost Control

The 473 can control on either dew point or frost point, and has the ability to distinguish the difference through a function known as Force Frost. The Dew / Frost Control setup menu is used to control the Force Frost function

Force Frost Below

For mirror temperatures above 0°C, water vapor condenses on the mirror as liquid water (dew). A condensation layer resulting from a mirror temperature above 0°C is considered a dew point.

For mirror temperatures far below 0°C (generally mirror temperatures below –20°C), water vapor condenses on the mirror as solid ice (frost). A condensation layer resulting from a mirror far below 0°C is considered a frost point.

However, for mirror temperatures between 0 and approximately –20°C, the state of the condensed layer is generally indeterminate since dew can, and does, exist on the mirror in a meta-stable state at temperatures well below 0°C. In reality, the condensed layer on the mirror could be dew, frost, or some combination of the two. Significant errors can result if wrongful assumptions are made and can be in excess of 2°C.

To eliminate this problem, the 473 can automatically force all sub-zero condensation to a known state of frost using the Force Frost function. Force Frost works by rapidly cooling the mirror below –20°C forcing the condensate to solidify to a layer of ice or frost. The mirror will then re-stabilize at the frost point temperature. Once the condensed layer is in a state of frost, it will remain frost for all sub-zero mirror temperatures.

You can enable or disable the Force Frost function, and also decide at which temperature it begins to work. From the Control Setup menu, press Dew/Frost Control (the top menu key). Change the value of the *Force Frost Below* field. Mirror temperatures below this value will be forced to frost.

Now enable or disable the Force Frost function by pressing the *Force Frost Below* button. A green indicator light on the button means that the function is enabled. If the light is not illuminated, then the Force Function is disabled, and no Force Frost will be performed. Complete your preference by pressing *Ok* or the keypad's *enter* key.

Mirror Cleaning Control

When the fixed Mirror Cleaning key at the bottom of the screen is pressed, the mirror immediately warms to a pre-specified temperature, readying the measuring head for removal of the cover and optical assembly. If the mirror and other internal measuring head components become exposed to normal atmospheric air while cold, the possibility of undesired condensation exists. By warming the mirror and other internal components to a safe head removal temperature prior to accessing the mirror, this adverse condensation is avoided.

The safe temperature to which the mirror and internal components will be warmed during a Mirror Cleaning procedure is selectable from the *Mirror Cleaning* key of the *Control Setup* menu. Enter a value between 20°C and 50°C for the *Min Head Removal Temp*.

Mirror Check Control

Mirror Check is the process of warming the mirror to evaporate all condensation, look for the presence of contamination and account for it if necessary, then re-initiating a new dew or frost point measurement. Mirror Check may be initiated manually with the fixed Mirror Check key, or if enabled to do so, it may trigger automatically at pre-specified time intervals. During a mirror check function, whether triggered automatically or manually, the fixed mirror check key indicates

red while heating, brown while holding at the high temperature, then yellow while allowing the mirror to cool to reform the dew or frost layer again. Once the system has again established a dew or frost layer, and become stable at that value, the mirror check function is complete and the color indications are removed. To view or edit the Mirror Check parameters, press the *Mirror Check* key of the *Control Setup* menu.

Cycle Time

If Automatic Mirror Check is desired, enable it by pressing the Cycle Time button. A green light on the Cycle Time button indicates that automatic mirror check is enabled. Even if automatic mirror check is not enabled, manual mirror check may be initiated at any time simply by pressing the fixed Mirror Check key at the bottom of the screen. When automatic mirror check is enabled, the fixed Mirror Check key also displays a countdown timer indicating the time until the next automatic mirror check function.

Changing the Cycle Time changes the time interval between automatic mirror check operations.

Heating Time

The Heating Time determines how long to hold at the mirror check temperature before allowing another dew or frost point measurement. A heating time of 0 results in no hold, meaning that once the mirror check temperature has been reached, the function ends and dew/frost control resumes immediately. If a heating time greater than 0 is entered, then the mirror will heat and remain at that temperature for the duration of the heating time value. Heating time is effective regardless of whether mirror check was triggered automatically or manually.

Heat To

Edit the 'Heat To' field to change the temperature that the mirror will be heated to, and optionally held at, during Mirror Check.

Changing Units

You can display system data in any of a wide variety of units. When you make a new units selection, that selection remains until you change it again. To change units, follow the instructions given in the Selecting Units section on page 6. Units selections are global across the system, meaning that all values of that parameter type change to reflect the chosen units. For instance, changing the temperature units to °C forces *all* temperature data to appear in °C.

Note:

Data retrieved via RS-232 will *always* be in SI units regardless of the units chosen for display. Also note that settings within dialog boxes used for changing system parameters are also entered and displayed in SI units. Units only affect the four data lines of the normal display window.

Temperature Units

Temperature values may be displayed in units of °C, °F, or K. When changing temperature units, all temperature values, whether displayed as numeric or in a graph, change to reflect the new units selection. Notice that the chosen units will appear on the screen both on the units selection key and next to any temperature related values currently displayed.

Pressure Units

Pressure values may be displayed in units of Pa, hPa, kPa, MPa, atm, bar, mb, inHg, mmHg, cmHg, inH₂O, mmH₂O, cmH₂O, Torr, and psia. . When changing pressure units, pressure values (not including vapor pressure), whether displayed as numeric or in a graph, change to reflect the new units selection. Notice that the chosen units will appear on the screen both on the units selection key and next to any pressure related values currently displayed.

Flow Rate Units

The gas flow rate may be displayed in units of l/min, ml/min, l/h, cfm, and cfh. When changing flow units, any indicated flow rate will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to the flow rate when displayed.

Volume Ratio Units

Humidity expressed as a volume ratio may be displayed in units of PPM_v (Parts Per Million by Volume) or PPB_v (Parts Per Billion by Volume). When changing these units, volume ratio will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to the volume ratio when displayed.

Weight Ratio Units

Humidity expressed as a weight ratio may be displayed in units of PPM_w (Parts Per Million by Weight) or PPB_w (Parts Per Billion by Weight). When changing these units, weight ratio will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to the weight ratio when displayed.

Absolute Humidity Units

Absolute humidity may be displayed in units of g/l, g/m³, and lb/ft³. When changing these units, absolute humidity will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to absolute humidity when displayed.

Specific Humidity Units

Specific humidity may be displayed in units of g/g, g/kg, and lb/lb. When changing these units, specific humidity will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to specific humidity when displayed.

Vapor Pressure Units

Vapor pressure may be displayed in units of Pa, hPa, kPa, MPa, atm, bar, mb, inHg, mmHg, cmHg, inH₂O, mmH₂O, cmH₂O, Torr, and psia. . When changing vapor pressure units, vapor pressure will change to reflect the new units selection, whether displayed numerically or as a graph. Notice that the chosen units will appear on the screen both on the units selection key and next to vapor pressure when displayed.

Changing Color

You are free to change the foreground and/or background color of any data line with the Fore Color and Back Color menus. Access the Fore Color and Back Color menus with the menu selection key discussed in the Menu Keys section on page 4. Like other system settings, these color changes are retained. To revert to the standard system default color scheme, press and hold the 9 key for a few seconds while in the Fore Color or Back Color menu.

Fore Color

Fore color affects the color of number and letters, and the plotting color of graphs. If you change the fore color of a data line that is displayed numerically, the graph attributes of that line are not affected. Likewise, if you change the fore color of a line displayed as a graph, the numeric display attributes of that line are unaffected. Which aspect of the data line that is affected is determined by whether that line is currently displayed as a number or as a graph when changing the fore color.

To change a data line's fore color:

1. Access the Fore Color menu as described in the Menu Keys section on page 4. 'Fore Color' appears on the key, and the keys above contain left pointing arrows. Notice that each key corresponds to the data line it points toward.
2. Press the arrow key corresponding to the data line you wish to change. Notice that the fore color of the data line changes with each press of the key.
3. Change the fore color on any of the other data lines with the same method.

Back Color

Back color affects the background color of number and letters, and the background color of graphs. If you change the back color of a data line that is displayed numerically, the graph attributes of that line are not affected. Likewise, if you change the back color of a line displayed as a graph, the numeric display attributes of that line are unaffected. Which aspect of the data line that is affected is determined by whether that line is currently displayed as a number or as a graph when changing the back color.

To change a data line's back color:

1. Access the Back Color menu as described in the Menu Keys section on page 4. 'Back Color' appears on the key, and the keys above contain left pointing arrows. Notice that each key corresponds to the data line it points toward.
2. Press the arrow key corresponding to the data line you wish to change. Notice that the back color of the data line changes with each press of the key.
3. Change the back color on any of the other data lines with the same method.

Back Panel Connections

Power Plug

The power requirements are identified on the serial number label on the back of the instrument.

Power Switch

The main power switch is mounted on the back panel near the power plug. Use the power switch to turn the system ON and OFF.

RS-232

The RS-232 connector is used when connecting the 473 to an external computer. Use a standard 9 pin cable to connect between the 473 and a desktop or laptop computer. The cable is wired straight through with pins 1 through 9 of the male end wired to pins 1 through 9 respectively of the female end. The RS-232 extender cable is a common accessory item easily obtained at most any computer accessory dealer.

See Remote Communication on page 21 for complete discussion of the RS-232 command reference and hardware connections.

Measuring Head Connection



The measuring head is connected to the 473 with the 19 pin measuring head cable.

External Temperature

External temperature measurements are required if certain humidity parameters are to be computed, such as %RH. External temperature measurements are not required for dew or frost point measurements.



The External Temperature probe is usually directly connected to the 473 measuring head.



Use the optional 5 pin temperature probe cable to connect the external temperature probe directly to the 473 back panel.

Pressure Sensor

Some units are optionally equipped with an ambient pressure sensor. The 473 ambient pressure sensor is built into the 473 case. If properly equipped with the back panel pressure connector option, the pressure sensor may also be used as a remote sensor.



To remove the pressure sensor, remove the top cover of the 473. Disconnect the 5 pin connector and open the two C-style clamps.



Use the 5 pin cable to connect the pressure sensor to the 473 back panel.

Installation

Facility Requirements

Environmental

Your 473 is a precise laboratory quality instrument. While it does not require any special environmental control, it works best when the temperature is stable and free of rapid transitions. For operation, it is best to keep the operating conditions within the following parameters if possible.

Operating Temperature	-10°C to 40°C
Operating Humidity	90%RH max., non-condensing

Power

The 473 is equipped with a universal power supply capable of operation from 100 to 250 VAC at 50 to 60 Hz.

Preparation for Use

Benchtop Use

All 473 models are ready for benchtop use. Bench space of no more than 24" x 24" (0.6 x 0.6 m) is recommended.

Field Use

The handle swivels to allow a multitude of viewing angles when the unit is on its side.

Preparation for Shipping or Transportation

All shipping and transportation should be done in suitable padded containers. A heavy duty container with at least 2 to 4 inches of clearance for foam padding is recommended.

Due to the design of the 473 system, any shipping carton used should be constructed to provide support only on the top and bottom of the side panels and on the front and rear frame of the unit. Try not to have any load bearing neither directly on the face, nor on the top or bottom center of the front or rear frame. Reusable shipping containers are available. Please contact the factory for pricing and availability.

Remote Communication

Introduction

The 473 is equipped with a bidirectional RS-232 communications interface that allows it to be connected to a remote computer. This section is intended to provide necessary information for programming personnel regarding the use of the interface, including the hardware connections, communications settings, and the command syntax.

Hardware Connection & Cabling

Connect a computer to the 473 using a standard *RS-232 9-pin extender cable*. The extender cable has a male connector on one end and a female connector on the other end. It is wired straight through with pins 1 through 9 on one end wired to pins 1 through 9 on the other end. If your computer has a 25-pin serial port connector rather than a 9-pin connector, you'll also need a *25-pin to 9-pin port adapter*. Both the 9-pin RS-232 extender cable and the 25-pin to 9-pin port adapter are commonly available from most computer hardware dealers.

The 473 ignores the DSR and CTS handshaking signals. While there is no harm in connecting all 9 pins, the 473 only requires connection of three of the pins (pins 2=TxD, 3=RxD and 5=GND). For your reference, the complete connector pin-out is listed in the following table. Note that those signals identified by * are required, while the others are completely optional.

Signal	473 (9 pin)	Direction	Computer (9 pin)	Computer (25 pin)
	1		1	8
*TxD	2	→	2	3
*RxD	3	←	3	2
DSR	4	←	4	20
*GND	5	← →	5	7
DTR	6	→	6	6
CTS	7	←	7	4
RTS	8	→	8	5
	9		9	22

* Denotes a required connection. All others are optional.

Communications Settings

To communicate with the 473, set your computer to the following configuration:

Baud Rate: 9600
Data Bits: 8
Stop Bits: 1
Handshaking: None

Command Syntax

This section details the general syntax guidelines regarding termination, leading and trailing spaces, case sensitivity, and numeric values. Throughout this section, characters originating from the computer will be shown for illustrative purposes in **this font**. Characters originating from the 473 will be shown in *this font*.

General Usage

All commands require a question mark to indicate you are requesting data. When requesting data from the 473, follow the command with `?`, the question mark character. For example, the following requests the current pump status.

Pump.on?

The 473 replies with the current pump status (1 = on, 0 = off).

Termination Characters

All commands must be terminated with either a carriage return C_R or a carriage return linefeed combination $C_R L_F$.

Regardless of the command sent, the 473 will reply with a carriage return linefeed $C_R L_F$ at the end of the response, provided the command is recognized as valid. Here is an example:

DP? C_R (sent by the computer to the 473)
-10.015 $C_R L_F$ (sent by the 473 back to the computer)

If the command is unrecognized, the 473 does not respond. See the example.

abcdef? C_R (invalid command sent from the computer)
(no response from the 473)

Leading and Trailing Spaces

The 473 ignores leading and trailing spaces. It also ignores spaces before and after equal signs and question marks. For example, each of the following commands is perfectly valid.

Dp? C_R
Dp ? C_R

However, the following command is invalid since spaces are embedded within the keywords.

D p? C_R

Case Sensitivity

All commands are insensitive to case. In other words, it does not matter if the command is sent in upper case letters, lower case letters, or as some combination of the two. For example, the commands `DP?`, `Dp?`, `dP?`, and `dp?` are identical to the 473 and will return the measured dew point value.

Numeric Values

All numeric data received from the 473 is done so in either standard or scientific notation.

Receiving a number as `12.34` is the same as receiving it as `1234e-2` or as `1.234e1`.

Depending on the value of numeric responses the 473 sends out, it may send the numbers in either standard or scientific notation.

Numeric data is never appended with text of any kind. In other words, if requesting a temperature related value, only the numeric portion of the value is sent. The units are assumed but never sent.

The following table lists the units that numeric data adheres to, regardless of the units selection on the touch screen display or set via the RS-232. In other words, when you change units (even if you changed them via RS-232), you affect only what is seen on the display. All numeric values retrieved from the RS-232 will always be in the following units.

Parameter	Units via RS-232
Temperature	°C
Pressure	Pa
Flow	l/m
Volume Ratio	PPMv
Weight Ratio	PPMw

Command Reference

The available commands listed here are grouped by function. All commands are considered as read only values.

Commands Listed By Functional Group

Measurement Data

<u>Syntax</u>	<u>Function</u>
DP?	Dew Point, °C
FP?	Frost Point, °C
RH?	Relative Humidity, %
RHw?	Relative Humidity (WMO), %
PPMv?	Volume Ratio, PPMv
PPMw?	Weight Ratio, PPMw
AH?	Absolute Humidity, g/m ³
SH?	Specific Humidity, g/kg
VP?	Vapor Pressure, Pa
P?	Head Pressure, Pa
Tx?	External Temperature, °C
Tm?	Mirror Temperature, °C
Th?	Head Temperature, °C
Om?	Mirror PRT Resistance, Ohms
Ox?	External PRT Resistance, Ohms

System Identification

<u>Syntax</u>	<u>Function</u>
ID?	Returns a string containing instrument identification, i.e. DPM 473
IDN?	Returns only numeric portion of identifier, i.e. 473

Maintenance

Mirror Cleaning

The heart of the 473 Dew Point Measuring Instrument is the measuring head assembly. It is designed to be highly sensitive and accurate, yet easily accessible for periodic mirror cleaning.

Removing the Head



To gain access to the mirror and opto-electronic components, you must remove the optical assembly from the measuring head. The two red dots indicate where the measuring head and optical assembly will separate.

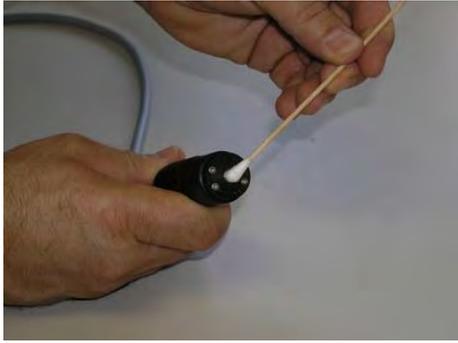
Removing the Optical Assembly



To remove the optical assembly, pull the two halves of the measuring head apart with your fingers. The loose half is the optical assembly and contains the light emitting and light sensing opto-electronic elements. There are also some gold pins on the inside. The other half contains the mirror, temperature sensor, and some mating gold contacts. Avoid touching the mirror and gold contacts with your fingers to prevent contamination.

Inspecting / Cleaning the Mirror

The mirror requires occasional periodic cleaning to maintain high accuracy measurements. The flush mounted mirror is easily accessible by separating the two halves of the probe assembly as shown above. Look at the mirror with the naked eye or with a magnifying glass. If signs of contamination are present, or suspected of being present, use the following procedure to clean the mirror.



1. Clean the mirror with a clean cotton swab or lint free tissue dampened with distilled water.
2. Dry the mirror with a cotton swab or tissue.

Although a clean mirror is important to accurate measurements and sound measurement practices, please take the following comments into consideration.

- Never attempt to polish the mirror. It is slightly roughened at the factory to allow for better nucleation sites and thus better dew formation.
- If needed, the mirror may also be cleaned with methanol or alcohol. Always follow the use of these cleaning chemicals with water to ensure they are completely rinsed from the mirror surface.

Reassemble the Mirror Components

Reassemble the mirror components in the reverse order of disassembly.



Install the optical assembly, taking note of the red dots. Ensure that the red dots are inline before you plug in the optical assembly.

Exterior Cleaning

Front Panel

The 473 front panel is completely sealed and easily cleaned with liquid glass cleaner or other mild cleaning chemicals moistened on a cloth. Clean the front panel periodically as needed.