MBW calibration

Dew Point Mirror 973

Operation and Maintenance Manual

V2.3

Warranty

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Original manuals are prepared in English and German. Translations in other languages are available, but in the event of any discrepancy, the German or English versions will be considered as the official version.

Subject to change without notice.

For the latest version of this manual please visit our website.

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Table of Contents

1 Safety Instructions

IMPORTANT, please read the Safety Instructions carefully:

- Check all connections carefully before use
- Disconnect power supply before opening the instrument housing
- In the event of damage do not use the instrument
- When working at increased pressures, wear eye protection

2 Key Features

Precise and Stable Humidity Measurement

The 973 Dew Point Mirror is a high-performance instrument with an integral measuring head, pressure sensor, flow meter and sample pump (when specified) for continuous precision measurement of frost/dew point, temperature, pressure, and calculated humidity parameters in a wide range of applications. The humidity measurement of the 973 is based on chilled mirror condensation technology which provides highly precise, stable and repeatable results.

ORIS (Optimal Response Injection System)

ORIS speeds up the measurement process in low humidity applications, typically when the gas is drier than about -40 °C frost point. ORIS works by a temporary injection of a small quantity of water vapor in to the sample gas flow. This accelerates the formation of a frost layer on the mirror surface and reduces hours of delay into just minutes. The threshold for its operation can be set by the user. For further information please see page 28.

Integrated Pre-Cooler (973L)

To enable reliable measurements of low humidity with dew/frost point values as low as -76 °C, some versions incorporate a Stirling cycle pre-cooler so that the mirror thermoelectric Peltier element can achieve the very low temperatures necessary to effectively control the ice layer.

Ice Test Function

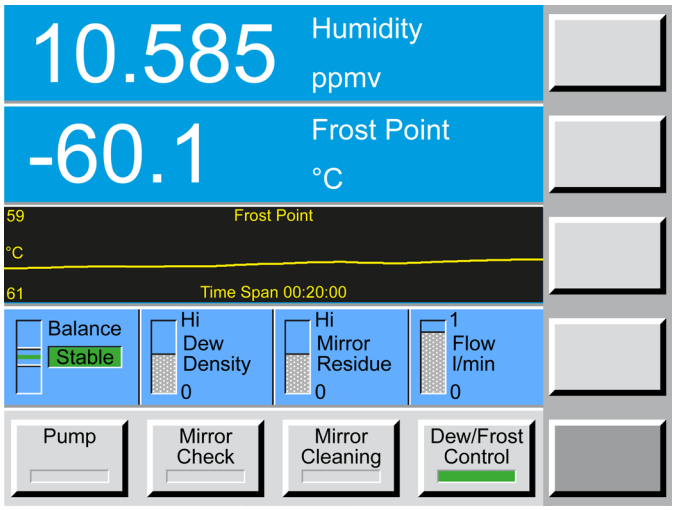
Using the fundamental melting point of ice as a reference value, users can perform a check of the 973 measurement system stability at any time using the integrated Ice Test function to provide an instant verification of system accuracy and integrity. See chapter “Ice Test” page 41.

ForceFrost™ Function

At temperatures below 0 °C water can condense either as frost or dew (supercooled water), this makes it difficult to determine whether the condensate layer on the mirror is solid or liquid. The Force Frost™ function over-cools the mirror to force the condensed layer to the solid phase. By rapid cooling of the mirror to a temperature below -40 °C the formation of an ice layer is assured, and the system then stabilizes the mirror at the frost point temperature. This eliminates the uncertainty of whether dew or frost point is measured. More information about Force Frost and how it’s configured are detailed in chapter 5.4.1 ‘Dew/Frost Control’ on page 27.

LCD Color Display with Touch Panel

The 973 has a full color LCD touch panel with 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.



3 Quick Start

This chapter guides you through the set-up and most important first steps when using the 973. It is a summary and should only be used as a general overview. Do not use it as a substitute for the remainder of the manual. To understand the instrument thoroughly, please read the other chapters carefully.

3.1 Unpacking

The 973 will be delivered to you in a custom transport case. It is recommended to keep the delivery packaging in case of future need for transportation or storage.

The following items are typically included:

- 973 Dew Point Mirror
- Power cable
- Gas connections 6 mm or ¼" Swagelok
- Operation manual
- Calibration certificate
- Temperature probe (Pt-100) with cable (depending on 973 version ordered)
- Mirror Cleaning swabs

Before you start using the 973, carefully remove all items from the case and visually check for any signs of damage. Check the packing list contents are all included, and **if you are missing any item or find something is damaged, please contact your supplier immediately.** Make sure that the power rating on the type label corresponds to your power supply specification.

3.2 Mirror Cleaning

The heart of the 973 is a highly sensitive and precise chilled mirror measuring head. To achieve high measurement accuracy, it should be cleaned prior to each measurement. Maintaining the mirror in a clean condition is fundamental to best measurement capability. The exact procedure is described in chapter 9.2 'Mirror Cleaning' on page 68.

3.3 Starting the 973

The 973 needs a source of AC power. It will work over a wide power range and will most likely operate at your local voltage and frequency. Check the back-panel label for the power requirements for your specific instrument.

1. Plug the supplied AC power cord into the back of the instrument, then into an AC outlet.
2. The power switch is located next to the AC power connector. Turn the power switch to ON.

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

After approximately 30 seconds the 973 is ready for measurement.

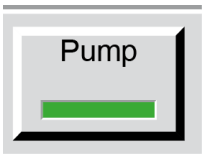
Measurement does not start until ***Dew/Frost Control*** is activated by pressing the respective button on the front panel. On the 973L, the Pre Cooling starts automatically when Dew/Frost Control is activated.

3.4 Humidity Measurement

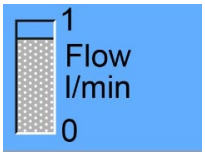
When you switch on the 973 the display will show the pressure in the measuring circuit. If a temperature probe is connected, an external temperature reading will also be displayed. Dew/frost point will also display the current mirror temperature, but not the actual dew/frost point. To measure humidity (dew point, frost point, RH, etc.), ***Dew/Frost Control*** must be started and gas should be flowing through the measuring head.

If relative humidity (RH) readings are required, an external temperature probe must be connected. Alternatively, a fixed external temperature value may be entered via the touch screen. Please follow the instructions in chapter 6.2.1 ‘Set Fixed External Temperature’ page 48.

For versions with a sample pump fitted, you can test the 973 humidity measurement by measuring the dew point temperature of the room, following these simple steps:



As the 973’s measuring head is internal, to obtain a representative sample, flow through the measuring head is required from the internal sample pump. Press the ***Pump*** button to generate gas flow. Pump power can be varied, see chapter 5.4.8 ‘Sample Pump’ on page 36.



Using the flow meter indication on the 973 status line, observe and set the flow rate in the range 0.5 to 2 LPM.

Start the measurement by pressing the ***Dew/Frost Control*** button. This button enables the system to cool the mirror to the dew or frost point temperature, monitor the thickness of the condensation layer on the mirror, and precisely adjust the mirror temperature to maintain a stable condensation layer. When Dew/Frost Control is enabled, the indicator on the key will turn green and the dew or frost point temperature display will begin to show the mirror temperature as it cools to the condensation point. See chapter 6 ‘Set Up and Operation’ page 45 for further information.

Please be aware that you may not receive a ***Stable*** indication when measuring ambient humidity. Humidity fluctuations in an open space are much greater than in a generator or climatic chamber. A fluctuation of ± 0.2 °C is normal for room conditions and therefore the instrument may not be able to achieve a stable measurement result.

See chapter 5.2 “Selection of Indicated Parameters” page 23 for information on how to select the parameters you want to display.

3.5 Sample Gas Connections

The 973 is equipped with fittings for gas inlet and outlet connections. This allows the 973 to measure the humidity of gases, generators, chambers and other equipment that can be connected using sample tubes.

The inlet and outlet connections are located on the back panel of the instrument and are clearly labeled ‘Inlet’ and ‘Outlet’. Connections are either 6mm or ¼ inch Swagelok (specified at the time of ordering).

The back panel layout is different depending on the instrument version. For more detailed information on sample gas connections, see chapter 4.4 ‘Back Panel’ page 14.

Measuring ranges

Each version of the 973 has a specific dew point measuring range, please refer to chapter 6.1 ‘Measurement Set Up’ page 45 for guidance.

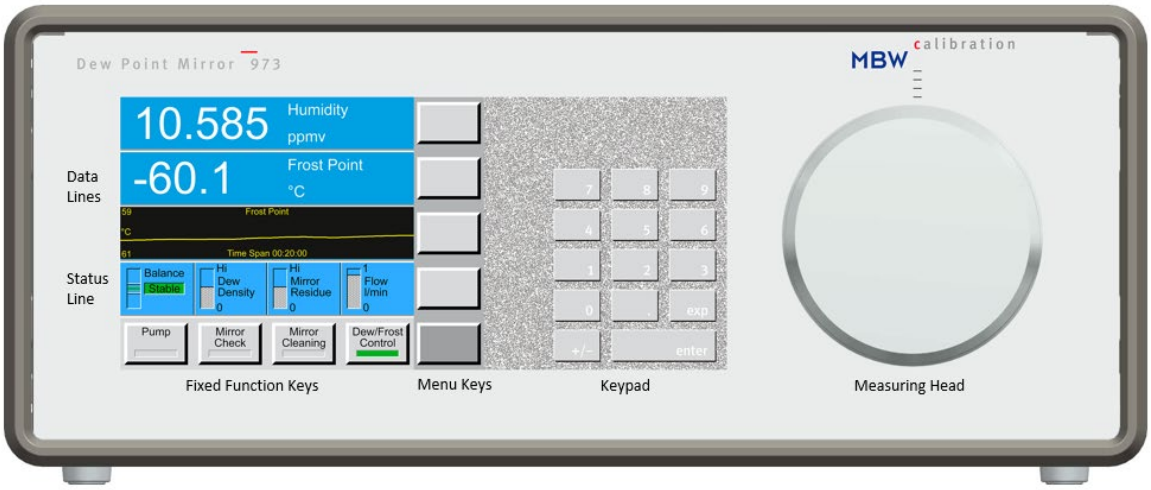
4 Get to know the 973

4.1 Front Panel

The front panel of the 973 is equipped with a full color touch screen and a keypad for data entry. To activate a menu option or toggle a function on or off, simply touch the desired key or object directly on the screen.

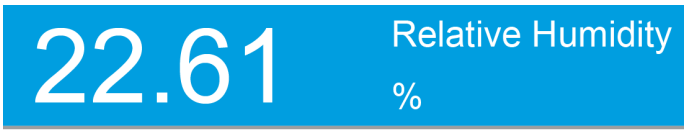
When the 973 is turned on, the display will activate within a few seconds. A sample display configuration is shown below. The display configuration can be customized, so your display may be different. The use and the functions of the display are described in the following chapters.

973 Front Panel

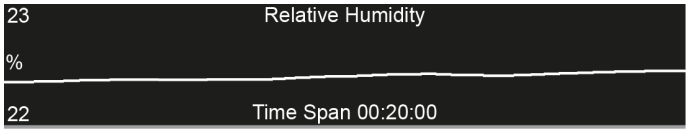


4.1.1 Data Lines

The first three lines of the display show a numeric or graphic representation of the measured data. We will refer to these first three lines as Data Lines.



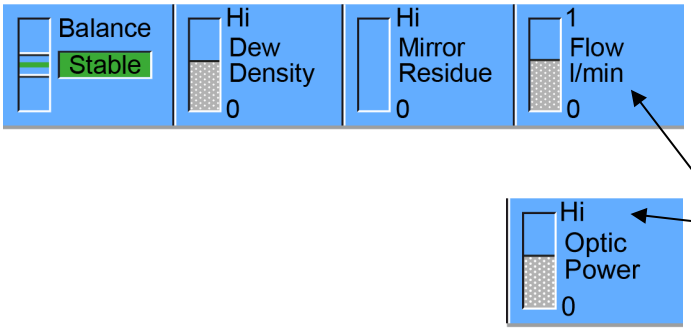
If numeric, a data line contains the value to the left, with the parameter description and unit to the right.



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

Data can be displayed in different parameters and units either numerically or graphically. Please refer to chapter 5 ‘System Configuration’ on page 21 to learn how to configure your preferences.

4.1.2 Status Line



Near the bottom of the display is the Status Line. The Status Line displays ***Balance***, ***Density***, ***Mirror Residue***, and ***Flow*** *or* ***Optic Power***.

The last field can be toggled between Flow and Optic Condition indicator. You can switch the displayed data by pressing directly on the indicator.

Balance

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 thickness of the condensed water layer. 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.

Density

The density indicator graphically depicts the approximate thickness of the dew or frost layer on the mirror surface. The 973 can differentiate between dew and frost layers and the indicator will display the current condensation state. The label in 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 being measured). For more information regarding dew/frost point determination see chapter 5.4.1 ‘Dew/Frost Control’ on page 27.

Mirror Residue

The mirror residue indicator shows the amount of mirror contamination that was detected during the last mirror check (see chapter 5.4.6 ‘Mirror Check’ on page 32). If the bar covers more than a quarter of the space, we recommend that you clean the mirror.

Flow

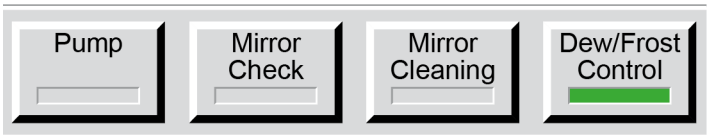
The flow indicator shows the current gas flow over the mirror in liters per minute or the unit of flow selected by the user.

Optic Power

The optic power indicates the aging of the LED. When the instrument is used at higher measuring head temperatures, the LED will age more quickly. When new, the optic condition bar graph will show as ‘full’. When the indication starts to decrease, it provides the user with advanced notification that the LED of the optical module may need service or replacement.

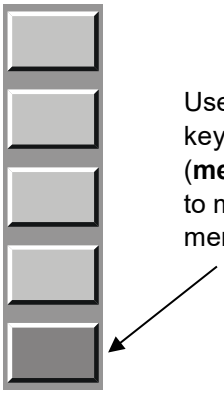
4.1.3 Fixed Function Keys

This configuration depends on the instrument version



The bottom line of the display contains a row of fixed function keys. These keys are used to start and stop the **Pre-Cooler**, sample ***Pump***, prepare for ***Mirror Cleaning*** and switch ***Dew/Frost Control*** on and off.

4.1.4 Menu Keys and Navigation



Use the dark grey key on the bottom (**menu selection key**) to move between menus.

On the right hand side of the display there is a column of menu keys. The bottom, dark grey key changes the current menu by cycling to the next menu. Each of the light grey keys change their label and function based on the menu that is currently selected.

The menu selection is circular. Once you go past the last menu, the first one will appear again and the selection repeats. You can use the **±** key on the keypad to move backward through the menus. Use the ***Enter*** key to exit the menu.

4.2 Touch Screen

The 973 dew point mirror is operated using the touch screen. To make a menu selection or switch functions on or off, touch the screen where appropriate with your finger or a stylus. Never use sharp objects, damage may occur.

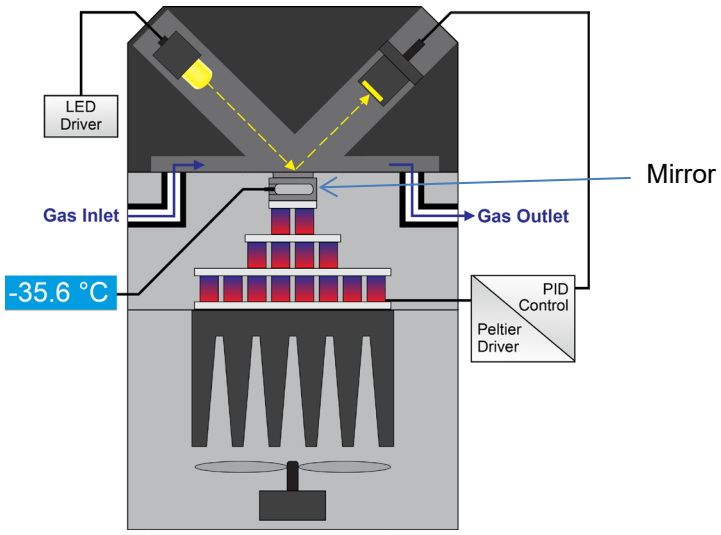
Before using the 973 for the first time or when several users operate this unit, the touch screen can be calibrated to suit the user. The procedure is described in chapter 9.1 ‘Calibrate the Touch Screen’ in section 9.1.

4.3 Measuring Head

The heart of the chilled mirror 973 is the measuring head. It is designed to be highly sensitive, accurate, robust and easily accessible for regular cleaning. Although cleaning the mirror is not necessary before the first use, you might want to familiarize yourself with the location and accessibility of the mirror and the other optical components.

Be sure to reduce the pressure in the instrument before removing the measuring head cover.

The schematic below is a cross section of the complete measuring head including the optical module where the light source and detector are mounted. The mirror PRT is identified in this case with the temperature -35.6 °C, and in normal circumstances this temperature can be anywhere within the operating range of the instrument.



4.3.1 Mirror Assembly

The mirror assembly consists of a 6 mm diameter rhodium plated mirror, the mirror temperature sensor (PRT) and a Peltier thermoelectric element. These parts are carefully assembled during production and rarely require repair or replacement. The mirror PRT is carefully characterized before being fitted and its stability is fundamental to the stability of the whole instrument. If the mirror or PRT are damaged by the user and need to be replaced, the calibration history of the instrument is lost.

4.3.2 Optical Module

The Optical Module contains an LED light source and a photodiode light detector (opto-electronic components). This assembly is used to detect the formation and thickness of condensation on the mirror surface. In the event of damage or failure, the optical module can easily be repaired or replaced. This will have no effect on the calibration of the instrument.

Removing the Optical Module

The measuring head of the dew point 973 is located on the right side of the front panel. To access the mirror or the optical module, the measuring head cover needs to be removed.

To access the mirror and the optical module of the 973 the measuring head cover is removed by unscrewing counterclockwise approximately three turns. The optical module is the black part located under the measuring head cover.

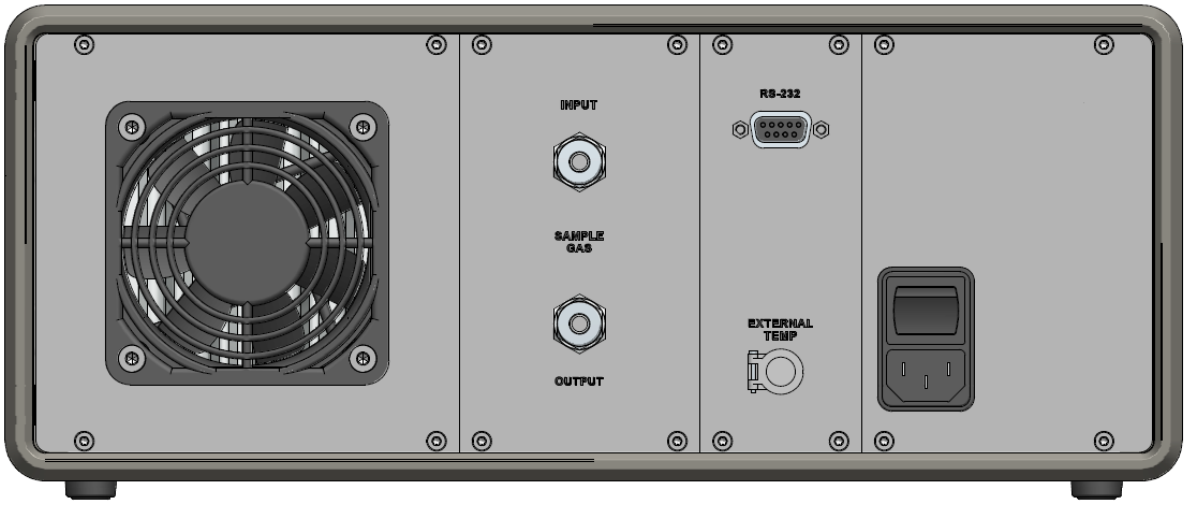
Once the head cover is removed, the optical module can easily be removed by pulling gently from the guide pin. The optical module contains an O-ring that seals the measuring head and gold electrical contacts.

Do not touch the inner surface of the optical module with your fingers to avoid contamination of the contacts, the O-ring, the optical components and the gas path.

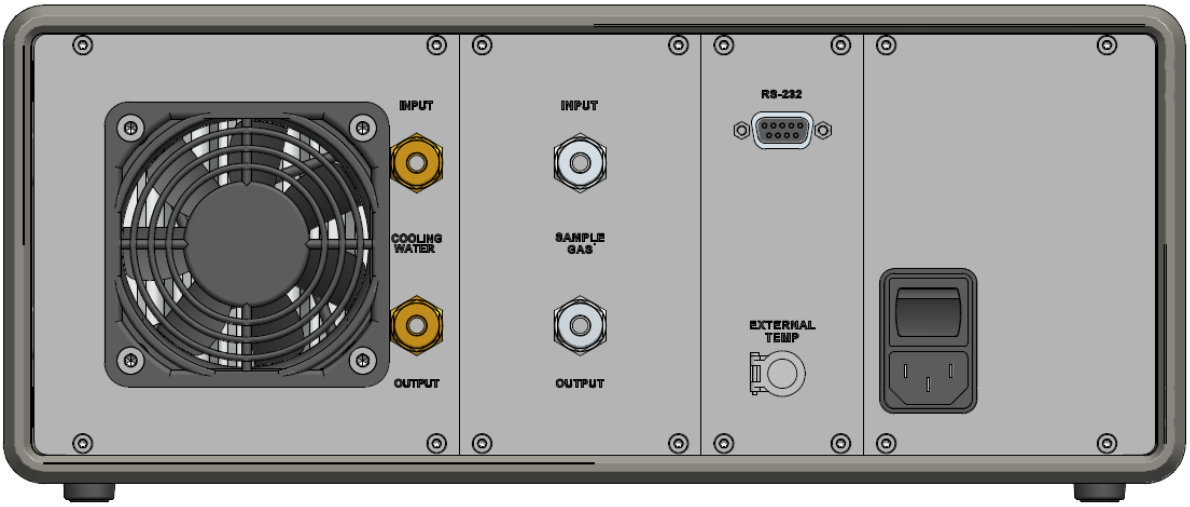
For more instructions on disassembly of the measuring head and mirror cleaning, see chapter 9.2 ‘Mirror Cleaning’ on page 68.

4.4 Back Panel

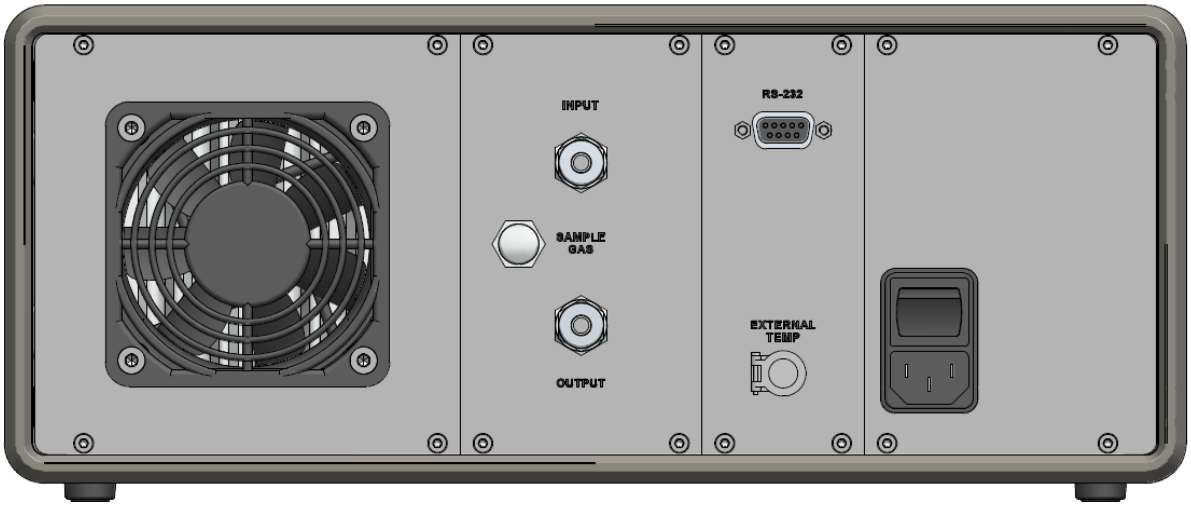
973S and 973E Back Panel



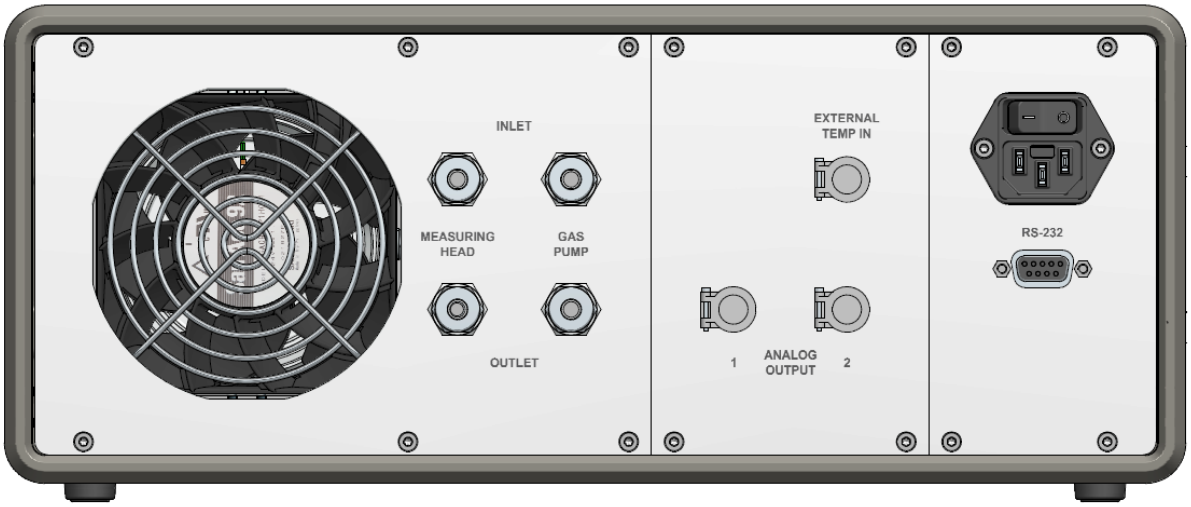
973S and 973E Back Panel (with optional water cooling)



973CA Back Panel



973L Back Panel (with optional analog outputs)



The back panel of the 973 includes various features, some of which are version dependent, here is an overview of the key points:

Power Switch

The main power switch is on the back panel above the power plug. The power supply has a built-in fuse and will automatically switch off in case of overload. To restart power, the main power switch must be switched off and on again.

Power Plug

The supplied power cord is connected to the power socket on the instrument back panel. The supported power supply voltage is 100-120 VAC / 200-240 VAC at 50 to 60Hz. The power requirements are specified on the serial number label on the back of the instrument.

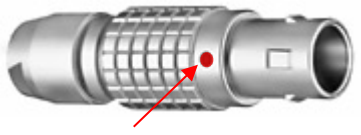
RS-232

The RS-232 port can be used to connect the 973 to a computer. The necessary 9-pin RS-232 (serial) extender cable (1:1 pinout) is a common accessory and can easily be obtained at any computer accessories retailer.

Optional Analog Outputs

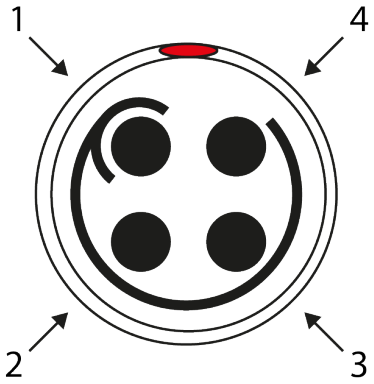
The 973 can be ordered with two optional analog outputs which are independently configurable. For each of the analog outputs, you can choose which parameter to transmit and scale its range. Please refer to chapter 5.7 ‘Configuration of Optional Analog Outputs’ on page 39 to learn how to configure the analog outputs.

If the instrument is ordered with the optional analog outputs, two 4-pin LEMO connectors (Part Number: FGG.1B.304.CLAD52 www.lemo.com) will be supplied with the instrument. These can be used to make up a custom cable for your installation.



The red dot is between pin 1 and 4

When the 4-pin LEMO connector is properly assembled, the red dot of the connector housing should be between pin 1 and 4.

Pin	Signal	Position	Description
1	+V		When viewing the solder points of a disassembled 4-pin LEMO connector, pin 1 is usually identified with a full or partial circle drawn around it. Pin 4 should have no identifier. When wiring the cable, note that the pin numbering of the socket in the back panel of the instrument starts at the top left (pin 1) and goes counterclockwise (as viewed from the rear of the unit).
2	-V		
3	+I		
4	-I		

The 973 allows both a voltage and a current output signal. As shown in the illustration above, pins 1 and 2 connect the voltage signal (V), and pins 3 and 4 the current signal (I). Inside the instrument, the output signal is connected from a DAC and then split into a voltage and a current signal. Therefore, you may use either a volt or current meter to measure the analog signal.

The maximum voltage output range is -10…+10 V. The following table identifies the corresponding current signal. Configuration of the analog outputs is described in chapter 5.7 ‘Configuration of Optional Analog Outputs’ on page 39.

Voltage [V]	Current [mA]
+10	20
2	4
0	0
-10	N/A

Measuring Head Inlet and Outlet

Inlet sample gas is connected directly to the measuring head with the shortest possible stainless steel connecting tube. The outlet from the measuring head returns to the back panel where the sample gas can be directly vented or returned to the origin of the sample.

973S, E and CA versions have a sample pump (if specified) fitted in the outlet sample tube. Sample gas pressure must be below 2 bar, or damage to the pump can occur.

Gas Pump Inlet and Outlet (973L)

The 973L can be specified with an internal sample pump that can be used to flow sample gas through the measuring head where the application is at ambient pressure (for example sampling room or chamber conditions). The pump rate can be varied using the touch panel and the flow rate adjusted using the 973 flow indication (see section 6.1.4). For the pump to function, the outlet from the measuring head must be connected to the inlet of the gas pump. A connection loop is provided for this purpose.

If the sample pump is within the gas circuit, the maximum pressure must be **below 2 bar**, or damage to the pump can occur.

Cooling Water Connection

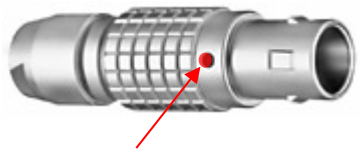
The 973S, E and CA can be optionally equipped with an additional water cooling connection. This allows a flow of water to cool the measuring head to increase the mirror depression capability beyond the normal working limits of the Peltier thermoelectric cooler that regulates the mirror temperature.

Water cooling can also be useful in applications where the ambient temperature is high and low frost/dew points are measured.

The temperature of the water circulated should always be regulated to a temperature **above** the ambient dew point temperature to avoid condensation formation.

External Temperature Probe

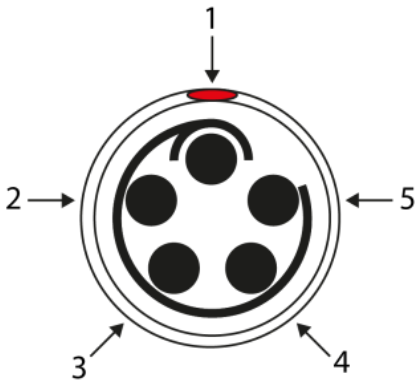
The external temperature socket on the back panel is used for the connection of an external temperature probe. External temperature measurements are required if certain humidity parameters, such as relative humidity (%rh) are calculated by the 973. External temperature measurements are not required for dew or frost point measurements.



Red dot aligns with pin 1

If you wish to connect your own Pt-100 probe, the 973 requires a 5 pin LEMO connector (www.lemo.ch), part number FGG.1B.305.CLAD52.

After identifying pin 1, follow the line counter-clockwise from pin 1 to all other pins in succession. Wire the cable according to the following scheme:

Pin	Signal	Position	Description
1	Shield		When viewing the solder tubs of a disassembled 5-pin LEMO connector, pin 1 is usually identified with a full or partial circle drawn around it. Pin 5 should have no identifier. When wiring the cable, note that the pin numbering of the socket in the back panel of the instrument starts at the top left (pin 1) and goes counter-clockwise (as viewed from the rear of the unit).
2	+I		
3	+V		
4	-I		
5	-V		

When the 5-pin LEMO connector is properly assembled, the red dot of the connector housing is located directly above pin 1.

If a user's own PRT is used, the external temperature PRT coefficients in the 973 will need to be changed and this will invalidate any calibration of the temperature measurement performed during production. Contact MBW or your supplier for further advice.

5 System Configuration

Many aspects of the 973 can be configured depending on your measuring needs and preferences. You can choose which humidity, temperature, and pressure values will be indicated on the screen, their order and units, and whether each will be shown as a number or as a graph. In addition to the display options, you can define how the 973 performs its control functions, such as Dew/Frost determination. Any changes in the configuration settings will remain active until the next time they are changed. Color settings will be restored to the standard settings after restarting the instrument.

5.1 The Menu Overview

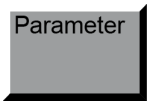
The 973 has several menus to configure the system to meet your requirements. Use the dark gray menu selection key to cycle through each of the menus. Each time you press the menu selection key, the respective label will indicate which menu is currently active. Use the **±** key on the keypad to move backward through the menus.

Use the ***Enter*** key on the numerical keypad to exit the menus. This is not necessary, however, as staying in a specific menu will not affect the measurement.

List of available menus:

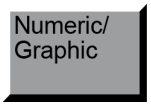
0 - Default Screen, Menu off

No menu is selected. All the keys are blank.



1 - Parameter

This menu is used to select the parameters displayed on the data lines.

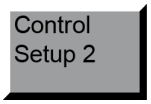


2 - Numeric/Graphic

This menu is used to toggle a data line between numerical and graphic display.

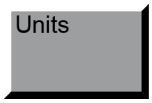
3 - Control Setup

This menu is used to configure the control functions like dew/frost control, mirror check, pump power, heating configuration etc.



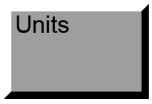
4 – Control Setup 2 (973L only)

This menu is used to configure the Pre Cooler.



4 - Units

This menu is used to select the units in which you would like the data to be displayed. Unit changes will be applied to all values displayed on the screen This menu configures the units for temperature, pressure and flow rate. For the 973S, CA and E this menu also encompasses the System Info. With the 973L the System Info is included in the Diagnostic Functions menu.

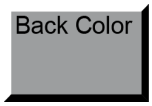


5 - Units

This menu is used to select the units in which you would like the data to be displayed. Unit changes will be applied to all values displayed on the screen. This menu configures the units for absolute humidity, specific humidity and vapor pressure parameter.

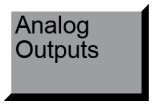
6 - Foreground Color

The menu ***Fore Color*** is used to temporarily change the color of the lines drawn on graphs and the color of text (numbers and letters). The foreground color of each data line can be changed individually. Unlike other settings, the color settings will be restored to the standard color settings when the 973 is restarted.



7 - Background Color

The menu ***Back Color*** is used to temporarily change the color of the background of the numeric or graphic data lines. The background color of each data line can be changed individually. Unlike the other settings, the color settings will be restored to the standard color settings when the 973 is restarted.



8 - Analog Outputs

If the analog output option is fitted to the 973, it can be configured in this menu. For the 973S, CA and E this menu also encompasses the System Info. With the 973L the System Info is included in the Diagnostic Functions menu.

9 - Diagnostic Functions (973L only)

Here you have access to the System Info, Ice Test, Peltier Cooling Test (PCT) and baud rate settings for the RS-232 port.

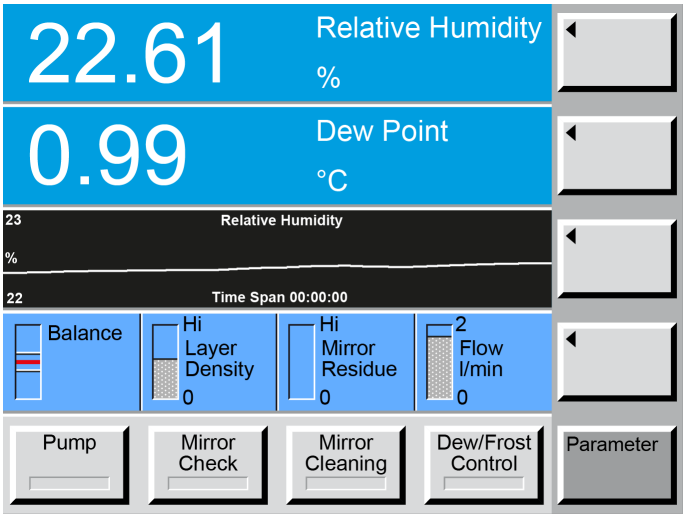
5.2 Selection of Indicated Parameters

In the ***Parameter*** menu you can choose which parameters you would like to have displayed 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 after you turn the 973 off. Below you will find the list of the available parameters.

Parameter	Explanation
Dew Point	The temperature to which a gas must be cooled to start condensing water vapor to liquid water. Dew point is pressure dependent and must be stated together with its associated pressure.
Frost Point	The temperature to which a gas must be cooled to start deposition of water vapor in the form of ice. Frost point is pressure dependent and must be stated together with its associated pressure. Frost point exists only below 0 °C. While not technically correct, it has been common industry practice to report values below 0 °C as dew point, although frost point is the correct term. For further explanation on dew or frost point refer to chapter 5.4.1 'Dew/Frost Control'.
%RH	The ratio between the amount of water vapor in a sample and the maximum amount possible at that same temperature and pressure.
%RH WMO	The ratio between the amount of water vapor in a sample and the maximum amount possible at that same temperature and pressure calculated using the World Meteorological Organization (WMO) formula.
Volume Ratio	The ratio between the water vapor volume and the total volume of the sample gas, generally expressed in parts per million by volume, ppm_v or its numerical equivalent µl/l. Once determined, ppm_v has no further pressure dependence. It is also independent of the gas type or mixture.
Weight Ratio	Weight ratio is the ratio between the mass of water vapor and the total mass of the sample gas, generally expressed in parts per million by weight, ppm_w or its numerical equivalent mg/kg. Once determined, ppm_w has no further pressure dependence, but depends on the gas type and mixture through the molecular weight of the constituents.
Absolute Humidity	The weight of water vapor per unit volume of humidified gas.
Specific Humidity	A ratio of the water vapor to the total weight of the humidified gas.
Vapor Pressure	The partial pressure exerted by vapor in thermodynamic equilibrium with its condensed phases (solid or liquid) at a given temperature. It is usually expressed in kPa.
Head Pressure	The pressure of the gas sample in the measuring head.
Flow Rate	The flow rate of gas.
External Temp	The temperature measured by the external temperature probe.
Head Temp	The temperature measured by the PRT in the measuring head.
Status Line	This Data Line Displays Data like Balance Indicator, Dew density
Mirror Temp	This parameter shows the mirror temperature.

Follow the steps below to choose the parameters you wish to have displayed on the four data lines:

1. Select the ***Parameter*** menu by pressing the dark gray menu selection key until ***Parameter*** appears. Small left pointing arrows will appear on the four upper menu keys.
2. Press the arrow key next to the data line you wish to change. Each time you press the arrow key, the parameter of the respective line will change. Continue pressing the arrow key until the parameter you wish to view is displayed.
3. Change the parameters on any of the other data lines the same way.



4. If you choose the parameter ***External Temp***, but have not connected the external temperature sensor, no reading will be displayed. Please make sure all the relevant equipment is connected for the instrument to be able to display the chosen parameters.

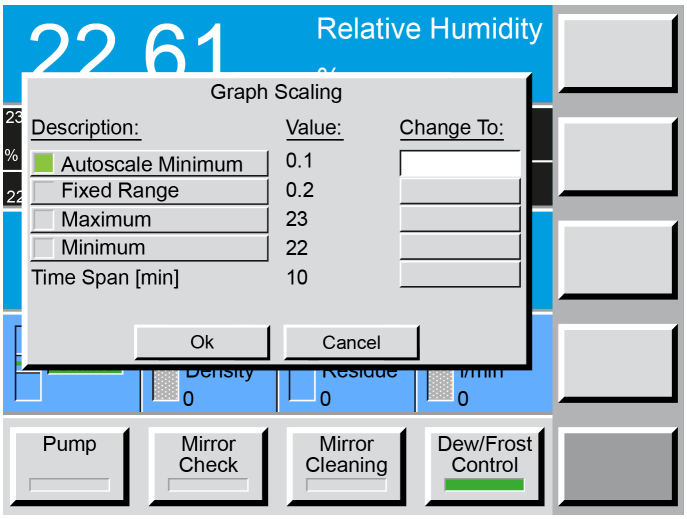
5.3 Selection of Numeric or Graphic Data Display

Any data line may be viewed either in a numeric or a graphic format. The 973 automatically keeps a short data history of every selectable parameter so that a graph appears instantly whenever a data line is switched from numerical to a graphic mode. Use the ***Numeric/Graphic*** key to toggle any data line between numerical or graphic mode.

1. Use the dark gray menu selection key to select the ***Numeric/Graphic*** menu. Small left-pointing arrows will appear on the four upper menu keys next to the data lines.
2. Press the arrow key next to the data line that you wish to change. The data line will toggle between numerical and graphic mode each time you press the key.

5.3.1 Graph Scaling

Each graph can have its own x and y-axis scaling and range settings. There are three different scaling modes to choose from; ***Autoscale Minimum*** (which is the default setting), ***Fixed Range*** or ***Minimum/Maximum***. Each of these is explained in more detail below. You can change the graph scaling and switch between the three scaling modes at any time.



1. On the screen, touch 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. This shows you the currently selected mode.
2. If you would like to change the scaling mode, touch the button of the mode you would like to select. Note that for the ***Minimum/Maximum*** option, only the ***Maximum*** button needs to be selected (the ***Minimum*** is then automatically selected by the system).
3. Touch the corresponding field in the ***Change To*** column, next to the range that you have selected.
4. Using the numerical keypad, enter the value needed. If you make a mistake while entering the value, touch the field you are editing on the screen. With each touch, the last digit in the field will be erased.
5. Once you have entered the correct value, press the ***Ok*** button (or the enter key on the numeric keypad) to confirm. Press the ***Cancel*** button if you wish to abort all changes made in the dialog box.

Any values you enter will only be accepted by the system if they correspond with the selected mode. If, for example, you enter a value into the bracket next to the ***Autoscale Minimum***, but ***Fixed Range*** is the selected mode, the ***Autoscale Minimum*** value will remain unchanged.

Autoscale Minimum

The Autoscale Minimum mode is the default setting for this instrument. This mode sets 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 will the range of the graph. In Autoscale Minimum mode, you can select the minimum range that you want the graph to scale to. For viewing temperature and dew or frost point graphs, setting the Autoscale Minimum to a value of 0.1 or greater is generally a good choice. It allows the graph range to close in on the data as it stabilizes at a single value without the range of the y-axis becoming too narrow.

For example, setting an Autoscale Minimum of 0.1 while the 973 is displaying a graph of a steady dew point measurement of 20.0 °C will set the minimum and maximum value limits of the graph to 19.95 °C and 20.05 °C, respectively. The graph will also zoom out as needed if a reading goes outside that range. You can experiment with this value to determine your personal preference.

Fixed Range

The Fixed Range mode allows you to select a fixed range for the graph's y-axis. It automatically centers on the most recent data point. As the most recent data varies, so will the center point of the graph, leaving the overall range fixed. The Fixed Range mode is mostly used to monitor data for stability. For example, if you set the fixed range for the external temperature graph to 0.2 and the current data is 23.00 °C all data between 22.80 °C and 23.20 °C is visible on the graph.

Minimum/Maximum

In the Minimum/Maximum mode you can specify the minimum and maximum values used for the graph's y-axis. Unlike the other modes, the visible range of the graph's y-axis will not automatically change if a data point is outside the set minimum/maximum range. If the data points are outside the specified range, you will not see them on the graph.

Time Span

Time Span determines the number of minutes of the data history that is visible on the graph. The 973 stores a fixed number of data points independent of the selected time span. Thus, changing the time span will change the time interval at which the data points are stored. The total number of stored data points will not change. With a time span of 15 (15 minutes), the graph data is sampled and stored every few seconds. With a time span of 120 (2 hours), the graph data is only sampled, stored, and updated about once a minute.

When you change the time span, the data that was sampled and stored at the old interval will be incrementally replaced by new data sampled at the new interval. The time span indicated on the graph will always reflect the actual time span of the data that is displayed on the graph, and will agree with the time span you selected once enough data points have been sampled. The selected time span is common to all graphs, so they will always have the same time relationship to one another.

The time span can be changed in the Numeric/Graphic menu:

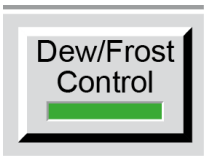
1. Touch the graph you wish to change on the screen. The Graph Scaling dialog box will appear.
2. Touch the ***Change To:*** field next to ***Time Span***. The field will turn white.
3. Use the numerical keypad to enter an *even* value between 2 and 1440. As you enter the value it will appear in the white ***Change To:*** field of the dialog box.
4. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.
5. Press the OK button in the dialog box or press Enter on the key board to confirm the new value. Press Cancel to leave it unchanged.
6. The result will take some time to show as the old data at the old time interval will be replaced by data at the new time interval gradually as determined by your selected time span.

If you prefer to see the same measurement as both numerical value and graph, you may select the same parameter on two data lines, and set one line to graph mode and the other to numeric mode. See pages 23 and 24 for instructions on selecting displayed parameters and changing their display modes.

5.4 Control Setup

The ***Control Setup*** menu enable you to control how the 973 operates.

5.4.1 Dew/Frost Control



To measure humidity (dew point, frost point, RH, etc.), ***Dew/Frost Control*** must be started and gas should be flowing through the measuring head. Activating Dew/Frost Control on the 973L also starts the pre-cooler.

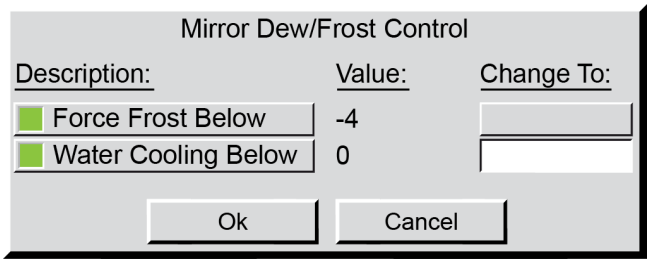
5.4.2 Force Frost Below

When measuring dew/frost points between 0 °C and -20 °C, condensation on the instrument's chilled mirror may be in the form of dew, frost, or a combination of both. If the state of the condensation is not known, it will introduce errors into all the humidity measurements reported by the instrument.

To eliminate this potential source of error, the Force Frost function is used to rapidly cool the mirror to below -20 °C, forcing all dew on the mirror into frost. The mirror will then re-stabilize at the frost point temperature. Once the condensate layer is in a state of frost, it will remain frost for all sub-zero mirror temperatures, allowing the instrument to measure the frost point accurately. The dew point and all other humidity measurements are then mathematically calculated from the frost point.

To change the ***Force Frost*** settings:

1. Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears.
2. Touch the ***Dew/Frost Control*** button. The ***Mirror Dew/Frost Control*** window will open.



3. The Force Frost function can be enabled or disabled by touching the ***Force Frost Below*** button. If the indicator on the left side of the button is green, Force Frost is enabled. If the indicator is grey, Force Frost is disabled.
4. To adjust the temperature below which Force Frost activates, touch the ***Change To:*** field to the right of the Force Frost Below button. The field will turn white.
5. Enter the temperature in degrees C below which Force Frost should activate.
6. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

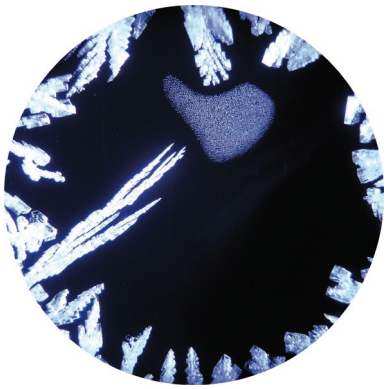
Press the *OK* button in the dialog box or press *Enter* on the keyboard to confirm the new value. Press *Cancel* to leave it unchanged.

Why it is Important to distinguish between Dew and Frost

For mirror temperatures above 0 °C, water vapor always condenses on the mirror in its liquid phase (dew). A condensation layer on a mirror above 0 °C is therefore always considered a dew point.

Although ice always melts at exactly 0 °C, water will not necessarily freeze at 0 °C. Water may stay in its liquid phase at temperatures far below 0 °C. This phenomenon is referred to as 'Super-Cooled Water'.

The fact that water at subzero temperatures can condense either as dew or as frost makes it somewhat difficult to determine whether the condensate layer on the mirror at temperatures below 0 °C is liquid or solid. Various factors such as contaminants, time, pressure etc. may cause the condensate layer to remain liquid at mirror temperatures of –20 °C and below.



It is important to understand that the difference in the temperature at which the liquid or the solid condensate layer stabilizes can be up to 3 ˚C. As shown on the picture to the right, it is also possible that dew and frost exist concurrently on the mirror which results in a non-stable value reading somewhere between the dew and frost point.

Therefore, the phase of the condensate must be known in order to avoid significant errors and to correctly calculate all humidity values, including vapor pressure, dew point, %RH, volume ratio, weight ratio, absolute humidity and specific humidity.

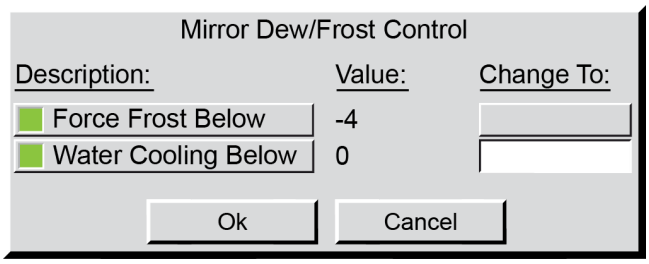
It would be desirable for manufacturers and users of humidity instruments to use the term *frost point* for temperatures below zero and *dew point* for temperatures above zero. While not technically correct, it has been common practice to use *dew point* for temperatures below 0 °C, although *frost point* would be the correct term. As discussed above, *dew point* can exist below 0 °C in the form of super-cooled water and is different in value from the equivalent *frost point* temperature. For the same vapor pressure, the *frost point* is approximately 10% of reading *above* the corresponding *dew point* value (when expressed in °C). For example, a vapor pressure of 38 Pa corresponds to a *frost point* of −30 °C and a *dew point* of −33 °C. From a measuring perspective it seems obvious that a clear and consistent distinction between dew and frost point is important.

5.4.3 Water Cooling

973S, E and CA instruments can be optionally equipped with a water cooling feature. This allows the connection and control of water flow through the measuring head so that mirror cooling capability can be increased, and lower dew/frost points can be measured.

To change the ***Water Cooling*** settings:

1. Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears.
2. Touch the ***Dew/Frost Control*** button. The ***Mirror Dew/Frost Control*** window will open.



3. The Water Cooling function can be enabled or disabled by touching the ***Water Cooling Below*** button. If the indicator on the left side of the button is green, Water Cooling is enabled. If the indicator is grey, Water Cooling is disabled.
4. To adjust the mirror temperature below which the Water Cooling valve should open, touch the gray ***Change To:*** field to the right of the ***Water Cooling Below*** button. The field will turn white.
5. Enter the temperature in degrees C below which the Water Cooling should activate.
6. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

Press the *Ok* button in the dialog box or press *Enter* on the keyboard to confirm the new value. Press *Cancel* to leave it unchanged.

Take care that the temperature of the cooling water is not below the ambient dew point temperature or condensation may occur on the connecting tubes.

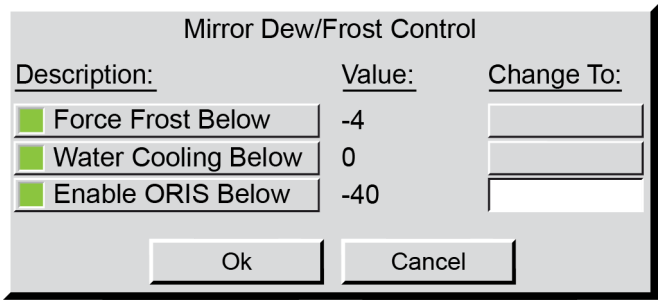
5.4.4 ORIS

At low frost point conditions, the time to stabilize a condensate layer can be significant, sometimes as long as two hours for full equilibrium. The ORIS (Optimal Response Injection System) speeds up the measurement of low humidity, typically when the gas is drier than about -40 °C frost point. ORIS reduces the stabilization time using a carefully programmed vapor injection procedure that accelerates the formation of a frost layer and then interfaces with the mirror control system to maintain stability. This accelerates the formation of a frost layer on the mirror surface, so that measurement takes minutes rather than hours.

If the threshold temperature entered by the user is reached as the mirror cools down and no condensate is detected, the ORIS valve will open and carefully inject vapor until a layer starts to form. The 973 will then close the ORIS valve and automatically control the layer thickness until stable.

To change the ***ORIS*** settings:

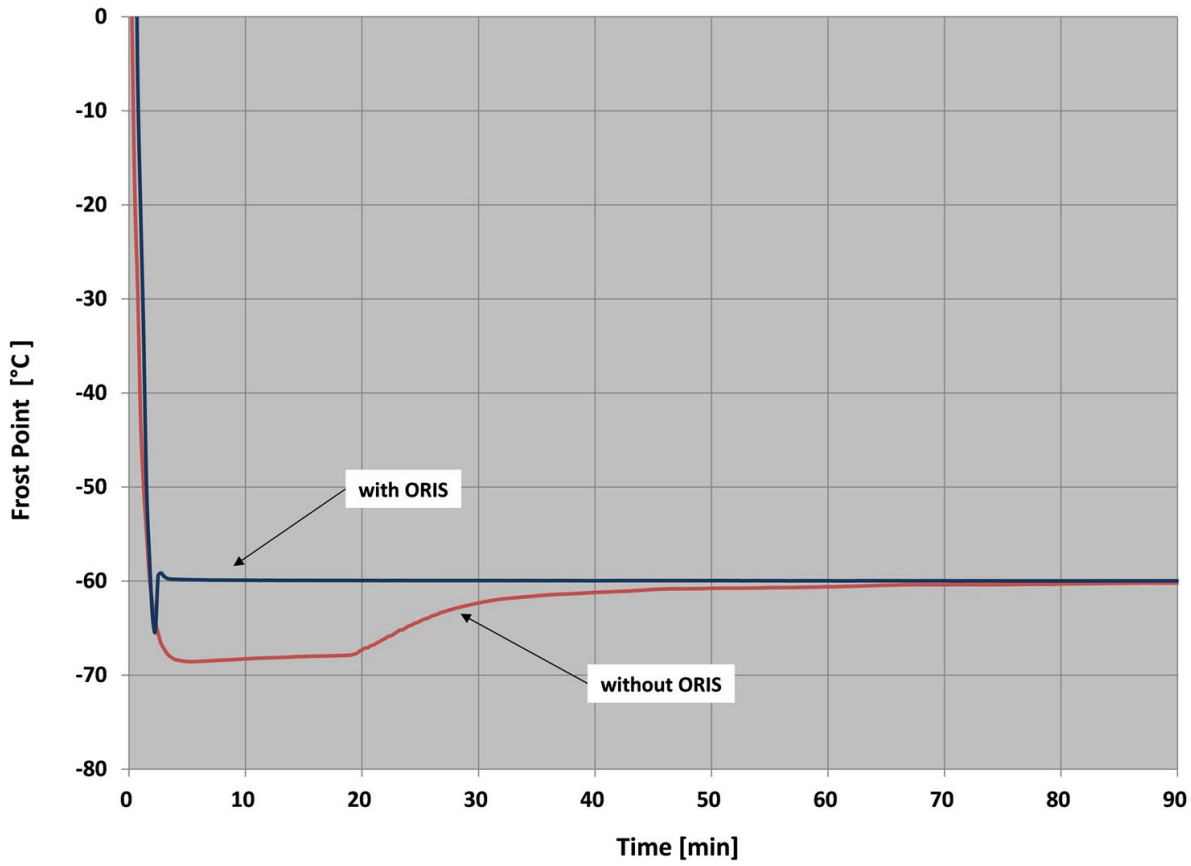
1. Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears.
2. Touch the ***Dew/Frost Control*** button. The ***Mirror Dew/Frost Control*** window will open.



3. The ORIS function can be enabled or disabled by touching the ***Enable ORIS Below*** button. If the indicator on the left side of the button is green, ORIS is enabled. If the indicator is grey, ORIS is disabled.
4. To adjust frost point temperature below which the ORIS should be activated, touch the gray ***Change To:*** field to the right of the ***Enable ORIS Below*** button. The field will turn white.
5. Enter the frost point temperature in degrees C below which the ORIS should activate.
6. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

Press the *Ok* button in the dialog box or press *Enter* on the keyboard to confirm the new value. Press *Cancel* to leave it unchanged.

The following graph shows how ORIS helps decrease the time needed for the system to stabilze when measuring low humidity:

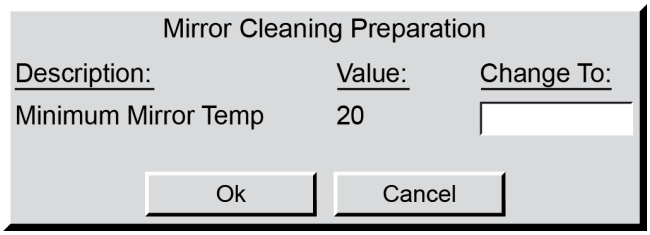


5.4.5 Mirror Cleaning

Activating the Mirror Cleaning function with the respective key at the bottom of the screen will heat the mirror to a pre-specified temperature, preparing the measuring head ready for the removal of the cover and the optical module. If the mirror and other internal measuring head components are disassembled while they are cold and become exposed to normal atmospheric air, the possibility of undesired condensation exists. Warming the mirror and other internal components to a safe head removal temperature, greater than or equal to the current ambient temperature, will prevent the formation of dew on the mirror assembly during servicing.

To set the Minimum Mirror Temperature when activating the Mirror Cleaning mode:

1. Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears.
2. Touch the ***Mirror Cleaning*** menu button.
3. Touch the ***Change To:*** field to the right of the ***Minimum Mirror Temp*** label.



4. Enter the temperature in degrees C which the mirror must warm to during the Mirror Cleaning mode. It is recommended that you enter your current ambient temperature or higher.
5. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

Press the *Ok* button in the dialog box or press *Enter* on the keyboard to confirm the new value. Press *Cancel* to leave it unchanged.

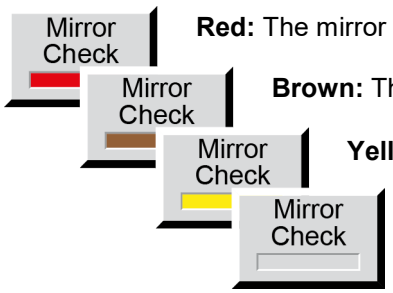
5.4.6 Mirror Check

Mirror Check is the process of warming the mirror to evaporate all condensation, looking for the presence of contamination, compensating for it if necessary and then initiating a new dew or frost point measurement. Mirror Check may be started manually with the fixed ***Mirror Check*** key, or if enabled, it will start automatically at pre-specified time intervals.

Mirror Check is a useful tool for evaluating any possible effect of mirror contamination on measurements. By observing the dew/frost point measurement before and after Mirror Check, one can determine the effect of the contamination. For example, if the dew/frost point is lower after Mirror Check, it is likely that the difference is attributable to condensed contaminants of the mirror. Equally, if the dew/frost point value is the same before and after Mirror Check, this is a confirmation that the Mirror surface is clear of contamination that could affect the measurement precision.

Mirror Check Sequence

During a mirror check, whether triggered automatically or manually, the indicator on the fixed ***Mirror Check*** key has the following meanings:



Red: The mirror is heating.

Brown: The mirror is holding at the programmed Mirror Check Temperature.

Yellow: The mirror is cooling to re-form the dew or frost layer.

Gray: The mirror check function is not currently active.

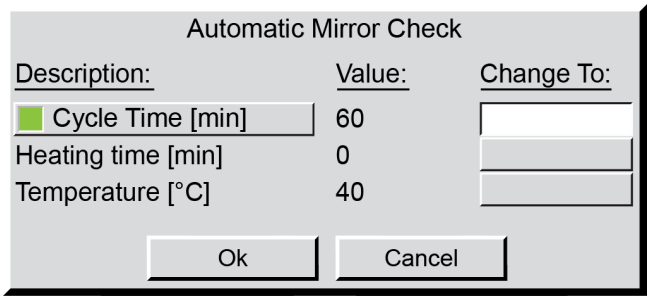
Once the system has re-established a dew or frost layer and become stable, the mirror check function is completed and the color indicator turns gray.

After the Mirror Check is completed the bar of the Mirror Residue Indicator shows the amount of contamination remaining on the mirror. If the bar covers more than a quarter of the space, we recommend that you clean the mirror. For instructions on mirror cleaning, please refer to chapter 9.2 ’Mirror Cleaning’ on page 68.

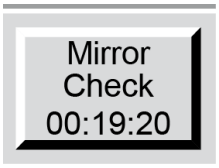
Automatic Mirror Check

To view or edit the Mirror Check parameters, press the ***Mirror Check*** key of the ***Control Setup 1*** menu.

If automatic mirror checks are desired, select it by pressing the ***Cycle Time*** button. The green indicator on the left side of the button shows that automatic mirror check is enabled.



When the automatic mirror check is enabled, the ***Mirror Check*** key at the bottom of the screen shows a countdown timer indicating the time before the next automatic mirror check is performed. In the automatic mode, the mirror check may still be initiated manually by pressing the ***Mirror Check*** button.



Cycle Time

The ***Cycle Time*** is the number of minutes between automatic mirror check operations. Use the numerical keypad to enter the desired cycle time in minutes.

Heating Time

The Heating Time determines how long the mirror check temperature will be held before allowing the next dew or frost point measurement. A heating time of 0 means that the instrument will resume dew or frost point measurement immediately after reaching the mirror check temperature. If a heating time greater than 0 is entered, the mirror will heat and remain at that temperature for the chosen duration. Heating time is effective regardless of whether mirror check is triggered automatically or manually.

Temperature

Edit the ***Temperature*** field to change the temperature, in degrees C, that the mirror will be heated to, and optionally held at during Mirror Check.

If you have entered a wrong value into a field and want to erase it, press the entry field to backspace.

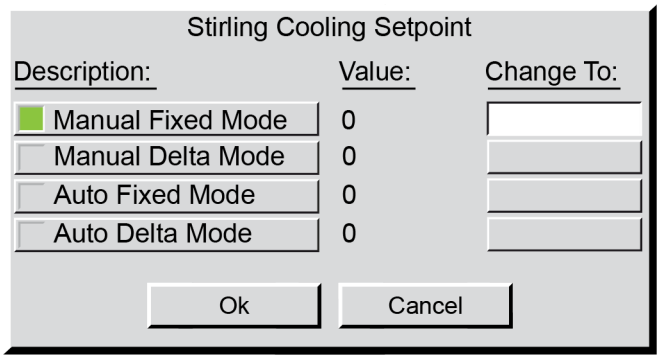
5.4.7 Pre-Cooler Control (973L)

For the purpose of measuring low dew/frost points, the 973L incorporates additional cooling capability that pre-cools to temperatures in the range of -76 to 0 °C. This enables the Peltier Thermoelectric element in the measuring head to control the mirror temperature to much lower values so that frost points as low as -76 °C can be reached. The precooler consist of a Stirling cooler and heater elements which combines a large cooling capacity and a dynamic response to stabilize the precooler temperature. In normal operation the precooler temperature will slightly overshoot the target and then stabilize (see the graphic describing delta and fixed mode).

The Pre-Cooler is the heat sink for the Peltier Mirror Thermoelectric element. If the Pre-Cooler is not active, heat from the Peltier cannot dissipate, so low mirror temperatures will not be achieved, and over temperature limits reached.

Pre-Cooler Set Up

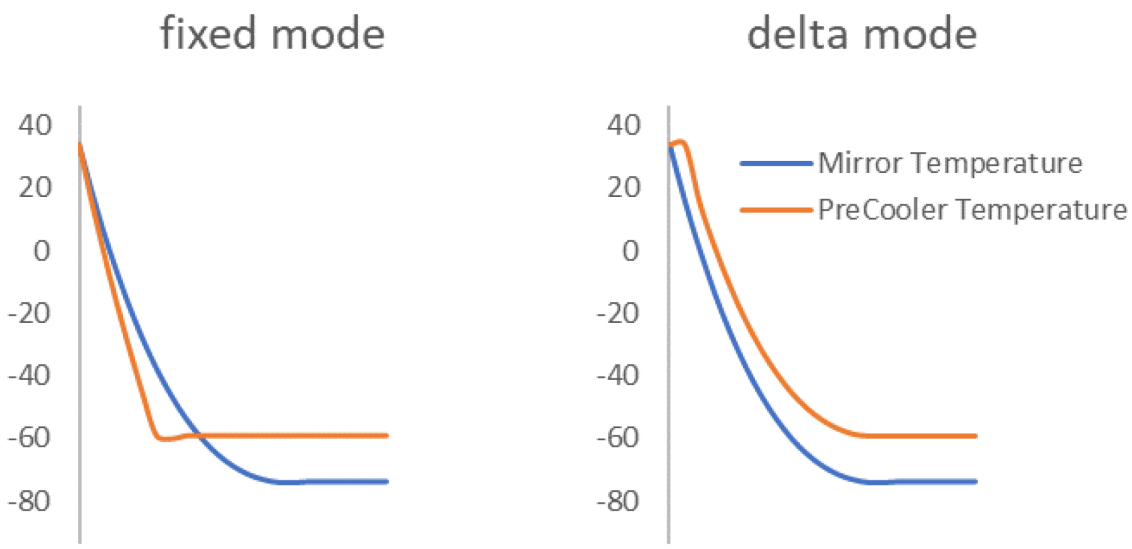
Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears. Touch the Pre-Cooler Config button. The Stirling Cooling Set Point window will open. As can be seen from the precooler Control submenu, there are 4 setpoint control modes selectable. In the manual modes the precooler starts as soon as the device is turned-on and ready, in auto mode the precooler is started and stopped with Dew/Frost Control.



Per factory default the unit will start up in auto-delta mode with a target of 0 and revert to this setting after a restart. This can be changed by an advanced user configuration, see subsection 8.4.5 Precooler initial Control Parameters.

Choosing between fixed mode and delta

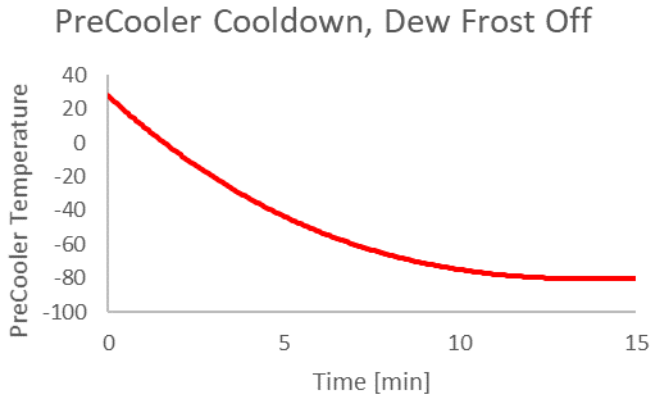
The precooler temperature setpoint can be set as a fixed temperature, or as a temperature delta to the mirror temperature. The graphic below illustrates the two modes for a fixed point target of -65 °C and a delta value of 15 °C.



The delta mode is suitable in general, a delta of 10 °C is a good starting value most of the time. Fixed mode shall be used when fluctuations of the sample gas humidity lead to noisy precooler setpoint in delta mode or when a specific sample gas humidity should be checked.

Choosing between manual und auto

For normal operation auto mode is suitable, if however, the 973L is to measure very low humidity sample gas, manual mode is the faster way to go. The precooler cools down faster when the device is not measuring (Dew/Frost Control off) because there is no heat dissipation from the peltier element. The Pre-Cooler cooldown curve with disabled measurement at 30 °C ambient is shown below:



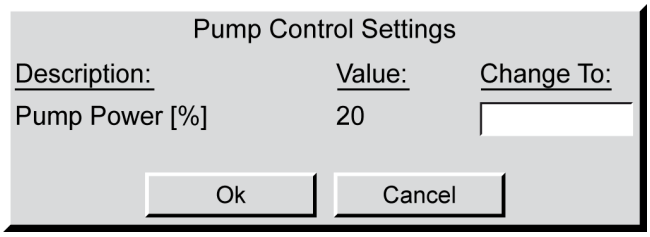
5.4.8 Sample Pump Settings

Where included in the 973 an internal sample pump allows the instrument to extract a sample from an application for measurement. The pump has variable power so that the user can change the flow rate using the pump. Before setting pump power, fully open any valves in the gas sample circuit.

Setting the pump power to its lowest setting extends its operational life, but with low settings, the pulsing of the diaphragm within the pump may create small pulses of the gas pressure that may be shown by the flow meter indicator. It is recommended that the pump power is set within the range 20…100%.

To adjust the pump settings:

1. Select the ***Control Setup*** menu by pressing the dark gray menu selection key until ***Control Setup*** appears.
2. Touch the ***Pump*** menu button.
3. Touch the ***Change To:*** field to the right of ***Pump Power [%]***.



4. Enter the percentage value at which you would like the pump to operate.

   If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

Press the *Ok* button in the dialog box or press *Enter* on the keyboard to confirm the new value. Press *Cancel* to leave it unchanged.

5.5 Selection of Units

You can display system data in any of a wide variety of units. When you change units, your selection will remain until you change it again. Unit selections are global, which means that all values of that parameter type across the whole system will change to the chosen units. For example, changing the temperature units to °C will display *all* temperature data in °C.

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 entered and displayed in SI units. Units only affect the four data lines.

Available units are:

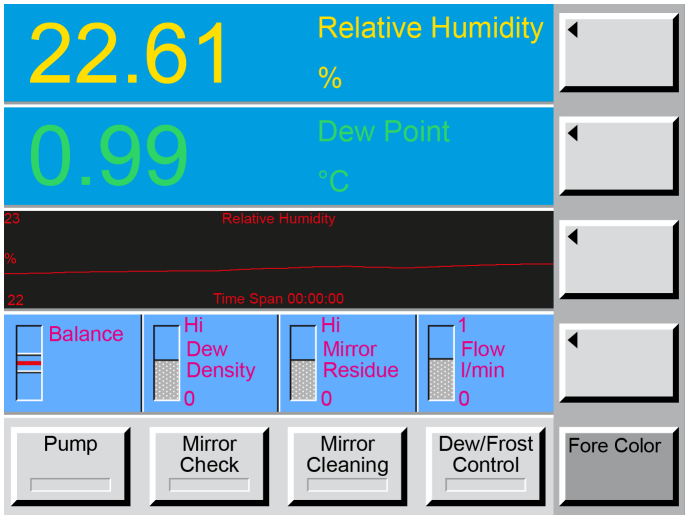
Temperature Units	°C, °F or K
Pressure Units	Pa, hPa, kPa, MPa, atm, bar, mb, inHg, mmHg, cmHg, inH_2O, mmH_2O, cmH_2O, Torr or psia
Flow Rate Units	l/min, ml/min, l/h, cfm, or cfh
Absolute Humidity Units	g/l, g/m^3, mg/m^3 or lb/ft^3
Specific Humidity Units	g/g, g/kg, or lb/lb
Vapor Pressure Units	Pa, hPa, kPa, MPa, atm, bar, mb, inHg, mmHg, cmHg, inH_2O, mmH_2O, cmH_2O, Torr, or psia

5.6 Selection of Color

The foreground and/or background color of any data line can be changed in the ***Fore Color*** and ***Back Color*** menus. Access the ***Fore Color*** and ***Back Color*** menus with the menu selection key. To revert to the default color scheme, press and hold key number 9 on the keypad for a few seconds until the instrument beeps.

Foreground Color

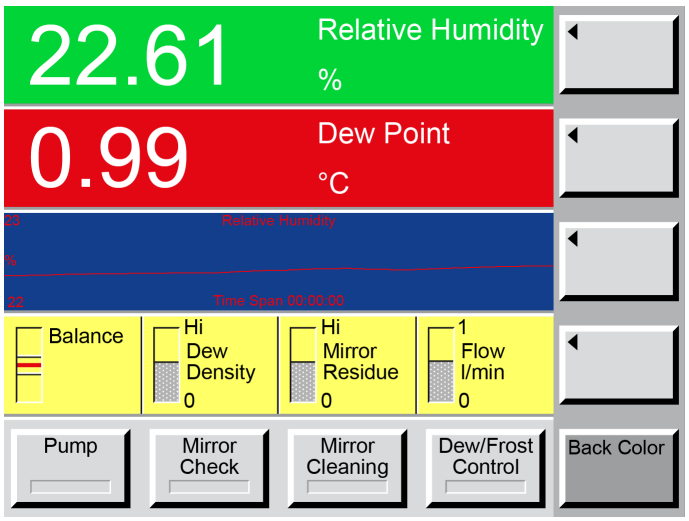
The foreground color is the color of the numbers and letters. To change a data line's foreground color:



1. Access the ***Fore Color*** menu. ***Fore Color*** will appear on the dark gray menu key, and the keys above will show left-pointing arrows. Note that each of the upper keys correspond to the data lines they point to.
2. Press the arrow key of the data line you wish to change. Note that the foreground color of the data line will change with each touch of the key.
3. Change the foreground color on any of the other data lines the same way.

Background Color

To change a data line's back color:

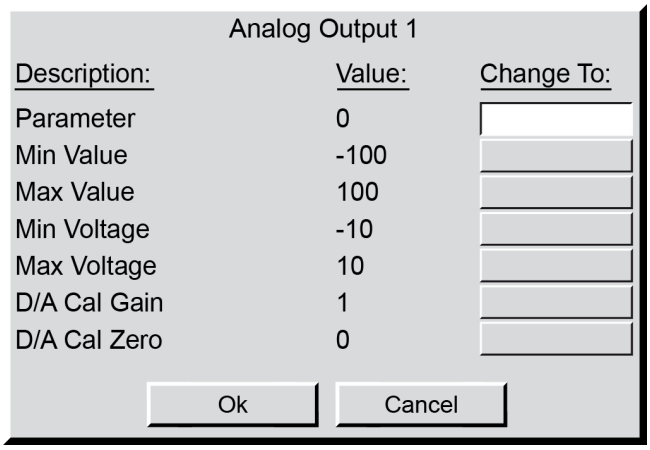


1. Access the ***Back Color*** menu. ***Back Color*** will appear on the dark gray menu key, and the keys above will show left-pointing arrows. Note that each of the upper keys correspond to the data lines they point to.
2. Press the arrow key of the data line you wish to change. Note that the background color of the data line will change with each touch of the key.
3. Change the background color on any of the other data lines in the same way.

5.7 Configuration of Optional Analog Outputs

For each analog output, you can select the measured parameter and configure the range. These selections are made via the ***Analog Outputs*** menu.

1. Access the ***Analog Outputs*** menu with the menu selection key.
2. To make the selections for the first analog output, press the ***Analog Output 1*** key.
3. Use the numerical keypad to enter the desired values. For details on each option, read the three following subsections.
4. Follow the same procedure for the second or any subsequent analog outputs as needed.



Selection of Parameter to Track

In the analog configuration window, enter the number which corresponds to the parameter you wish to track. Use the following table to identify which number to enter into the ***Parameter*** field. For example if you wish to track the Volume ratio, enter number 4 into the entry field next to ***Parameter***.

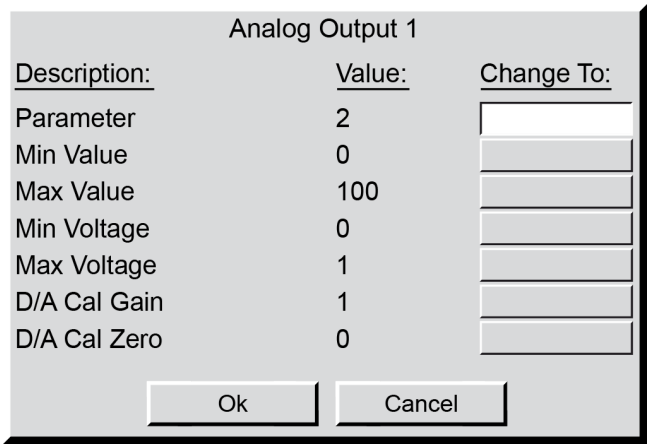
Parameter	Units	Enter this #
Dew Point	[°C]	0
Frost Point	[°C]	1
RH	[%]	2
RH WMO	[%]	3
Volume Ratio	[Ppmv]	4
Weight Ratio	[PPMw]	5
Absolute Humidity	[g/m^3]	6
Specific Humidity	[g/kg]	7
Vapor Pressure	[Pa]	8
Head Pressure	[Pa abs]	9
Flow Rate	[l/min]	10
External Temperature	[°C]	11
Head Temperature	[°C]	12

Scaling the Output Signal

Use ***Min Value*** and ***Max Value*** to set the range of the Parameter and use ***Min Voltag***e and ***Max Voltage*** to set the range of the analog output signal.

Example 1

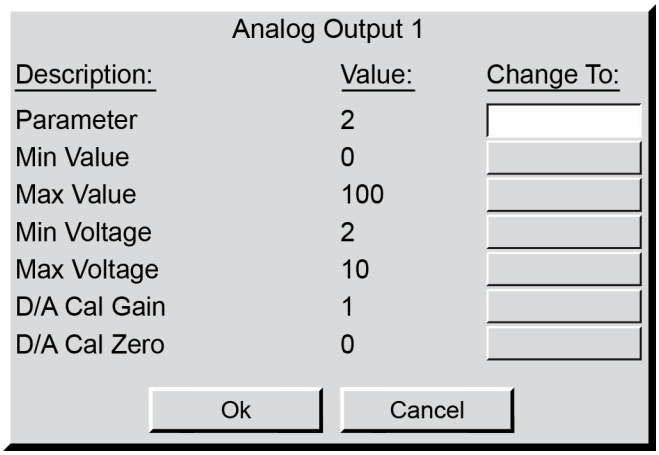
1. You want to track the parameter ***RH*** as an analog voltage output. The previous table on page 39 shows that the parameter ***RH*** has been allocated number ***2***. Enter number ***2*** into the field next to ***Parameter***.
2. The next step is to define the RH range which will be covered with the analog output signal. If you want to have the full 0…100 %rh range. Enter ***0*** into the field next to ***Min Value*** and ***100*** into the field next to ***Max Value***.



3. Then, set the scaling of the analog output signal. You want to have 0…1 VDC on the analog output to represent the 0…100 %rh. Enter ***0*** into the field next to the ***Min Voltage*** and ***1*** into the field next to ***Max Voltage***.

Example 2

To keep things simple, we will take the same ***Parameter, Min Value and Max Value*** settings as in the first example. However, this time you want the analog output range to be scaled to mA instead of volts. Your selected range is 4…20 mA for the parameter range of 0…100 %RH. In order to enter this into the system, please refer to the table on page 16 to find the voltage which corresponds to your desired mA output range. You will find that 2…10 V corresponds to 4…20 mA. Thus, enter ***2*** into the field next to ***Min Voltage*** and ***10*** into the field next to ***Max Voltage***.



Calibration Adjustment

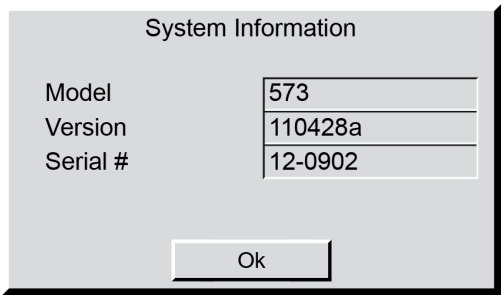
DAC Cal Gain and ***DAC Cal Zero*** are used to adjust the analog output signal accuracy. This adjustment is made at the factory and will rarely need to be changed by the user.

5.8 Diagnostic Functions

The Diagnostic Functions menu as described below is only present in the 973L menu. However, the System Information as well as the Ice Test are also available in the menus of the other models. There the System Information can be found in the menu “Analog Outputs” and the Ice Test can be found in the menu “Units”.

5.8.1 System Information

When you press the ***System Info*** button in the ***Diagnostic Functions*** Menu a window appears which gives you information about the model of the instrument, the version of the software and the serial number of the instrument.

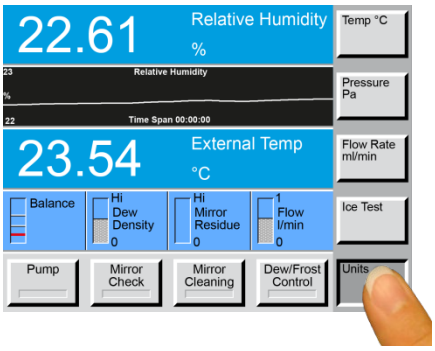


5.8.2 Ice Test

The measurement accuracy can be checked with a simple, built-in test. The test may be performed at any time, and is recommended whenever the results of your normal measurements do not correspond to expectations, and you suspect that there may be an error with the instrument.

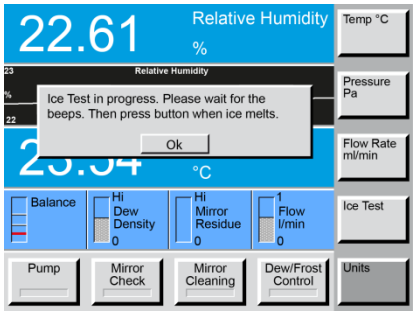
The mirror must be visible to perform the Ice Test. Therefore remove the measuring head cover prior to the Ice Test as described in section 9.2 “Mirror Cleaning” on page 68.

Ice Test cannot be started as long as a dew/frost point measurement is in progress. Make sure that the bar on the ***Dew/Frost Control*** key is grey.

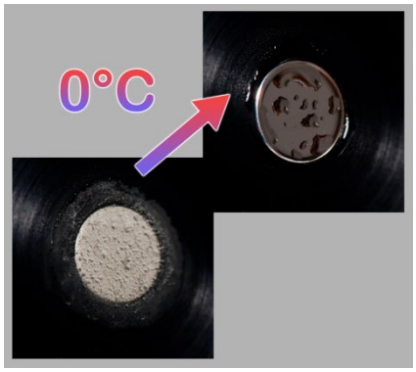


Press the menu selection key on the lower right to select the ***Diagnostic Functions*** menu. Then press the ***Ice Test*** button.

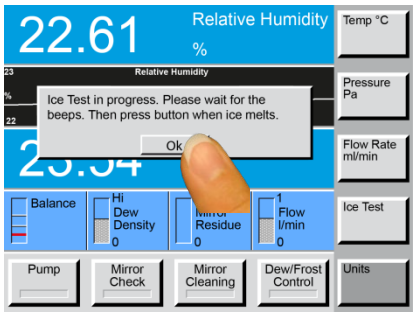
Please note that the Ice Test will start immediately after the ***Ice Test*** button has been pressed.



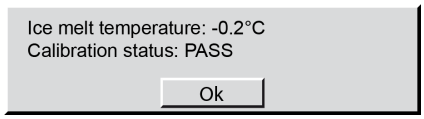
During Ice Test, the mirror rapidly cools to approximately -30 °C. Because the measuring head is open, humidity from the ambient air starts to condense on the mirror. This forms a frost layer on the mirror which can be increased if necessary by breathing on it. After reaching the low temperature and forming ice on its surface, the mirror begins to heat. As the temperature approaches 0 °C, the instrument will beep increasingly rapidly as the mirror gets closer to the ice-melt temperature.



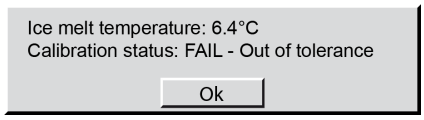
Watch the mirror closely. As soon as the mirror temperature reaches 0 °C, the ice will melt into liquid water drops (phase transition).



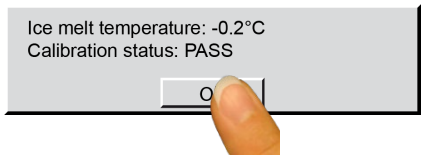
When you observe the phase transition on the mirror, press the ***Ok*** button. The mirror temperature is measured at that moment and a dialog box appears with the test results.



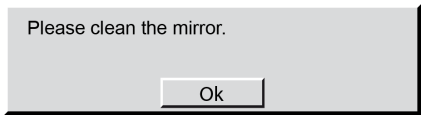
If the measured ice-melt temperature was in the range of ± 0.2 °C, the check is successful and will be indicated with the calibration status ***PASS***.



If the measured ice-melt temperature was outside the range of ± 0.2 °C, the check was not successful and indicated with the calibration status ***FAIL***. In this case, clean the mirror and repeat the ice test. If it continues to fail, the instrument should be sent to the manufacturer or an authorized agent for evaluation and/or repair.



Press the ***Ok*** button on the ***PASS/FAIL*** status window.



The next window requests that you clean the mirror.

Clean and reassemble the measuring head as described in section 9.2 “Mirror Cleaning” on page 68.

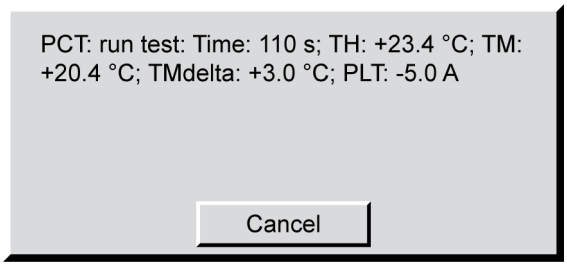
5.8.3 Peltier Cooling Test

The Peltier module used for mirror cooling and heating can age over time. It can also lose capability when used at its limits. If you think the measuring head is not cooling down fast enough during measurement, you can check this with the Peltier Cooling Test (PCT) function.

This function will perform a stress test of the Peltier module. It cools the Peltier module down for two minutes with the highest allowed current (5 Amps). During this test, the measuring head will heat up a little as power from the Peltier module is dissipated.

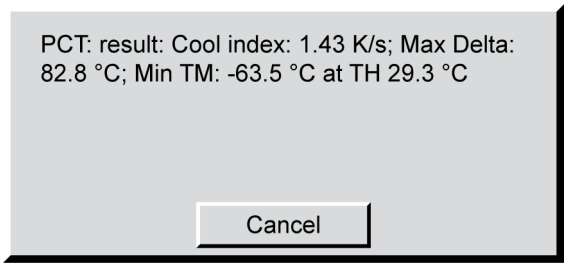
You will find the button ***Peltier Cooling Test*** on the ***Diagnostic Functions*** menu. Before you start, please let the device cool down or heat up to near ambient temperature. If you press the ***Peltier Cooling Test*** the test will start immediately.

During this test the following is displayed:



- ***Time*****:** Countdown in seconds until the test ends. The duration of the test is two minutes.
- ***TH:*** Temperature of the measuring head
- ***TM:*** Actual temperature of the mirror
- ***TMdelta:*** Delta between head temperature and mirror temperature
- ***PLT:*** Peltier current. A negative value means that the mirror is being cooled. → Check and note that value

After this test, the instrument displays the following results:



- ***Cool index:*** Calculates a speed index for the first 40 °C of cooling (kelvin per second)
- ***Max Delta:*** Maximum delta between head and mirror temperature during test
- ***Min TM:*** Lowest mirror temperature reached during test
- ***TH:*** Head temperature at the end of the test

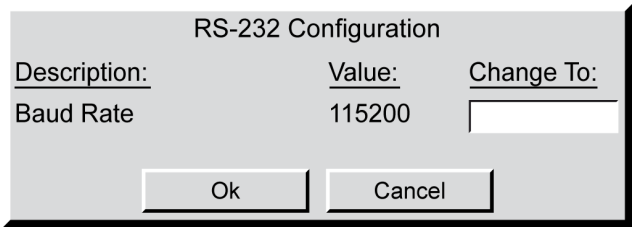
Following results indicate a successful test:

- ***Cool index:*** Should be higher than 1 °K/s
- ***Max Delta:*** The reached Delta should be higher than 80 °C, at laboratory conditions of about 23 °C ambient temperature.
- ***PLT:*** Peltier current during test should be around 5 Amps

5.8.4 RS-232 Configuration

The RS-232 Configuration window allows you to change the baud rate on the serial port. Default setting is 9600 Baud.

To change the ***RS-232 Configuration***:



1. Select the ***Diagnostic Functions*** menu by pressing the dark gray menu selection key until ***Diagnostics Functions*** appears.
2. Touch the ***RS-232*** button. The ***RS-232 Configuration*** window will open.
3. To change the baud rate value touch the gray ***Change To:*** field. The field will turn white.
4. Enter the desired baud rate. (1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 are possible values)
5. If you make an entry error, touch the field that holds the number you wish to change. Each time you touch the field, the last digit entered will be deleted.

6 Set Up and Operation

6.1 Measurement Set Up

Since each version of the 973 is suitable for a specific dew/frost point range, it is important to have a basic knowledge of the value to be measured to ensure that the correct instrument is being used. In addition to the correct instrument selection, measurement success depends on other factors such as the selection and connection of sample tubing, cooling and heating requirements, sample gas pressure, and flow rate. These topics are described below, and they must be considered when developing best measurement capability within any application.

6.1.1 Determination of the measurement range

The 973 has a maximum range of use, and a calibrated range in which the accuracy specification of ± 0.1 °C frost/dew point is achieved. Please refer to chapter 11 ‘Specifications’ on page 75 for full details.

In each case, the minimum frost point will be limited by the instrument temperature, so, for example, a frost point of -50 °C will not be possible when the ambient temperature is 40 °C.

The maximum frost point is also limited by the instrument temperature. MBW specifications are based on a room temperature of 20 °C, so the specified maximum dew point is 20 °C. If the instrument temperature is higher, then the maximum dew point can also be higher, the instrument will measure, but it may be outside of its calibrated range.

In any situation, condensation within instruments should be avoided to prevent possible damage to internal sensors. Wetted internal surfaces will lead to longer equilibrium times when measuring at low humidity.

973S/E/CA (-60 ... +20 °C)

These three 973 versions feature three stage Peltier and air cooling. At 20 °C, they typically have 85 °C cooling capability. Their typical range of use is -60 to + 20 °C, and the calibrated range is -50 to +20 °C. The standard ORIS feature helps the 973 to achieve rapid measurement stability at low dew/frost points, making this instrument well suited to spot check applications.

973L (-76 ... +20 °C)

The 973L features three stage Peltier and Stirling Cycle cooling system that pre-cools the measuring head to temperatures between -76 and 0°C. In combination with the ORIS system, this makes the 973L particularly well suited to very low dew/frost points.

6.1.2 Sample Tubes

Sample tubes connect the 973 to the application or condition to be measured. Careful selection and assembly will minimize the risk of leaks and measurement errors. Stainless steel should always be used below -50 °C frost point, and ideally the whole measurement range. At higher frost/dew points FEP can also be used.

The main effect from sample tubing is adsorption/desorption, especially when measuring at low dew/frost points. After a period of use at high dew point, the internal surfaces of sample tubes will adsorb water, so when changing to a lower humidity condition, additional time is needed to dry the sample tubes and reach equilibrium with the sample gas.

6.1.3 Pressure

Frost/dew point is pressure dependent. It is important therefore that measuring head pressure and the application pressure are the same, or the effects of pressure are taken into consideration. The 973 has an integral measuring head pressure measurement that can be selected as one of the parameters to display or output.

When regulating pressure to a lower value, it is a common issue that materials used in regulators cause measurement errors due to (for example) leaks or desorption.

6.1.4 Sample Gas Flow

Frost/dew point measurement is not directly flow dependent, but there are some flow related effects:

1. The higher the flow rate, the more gas passes the mirror, so in contaminated applications; mirror cleaning would be more frequent.
2. At low frost points, a high flow rate can help purge the sampling system to minimize desorption effects.
3. At low frost points, insufficient flow may increase stabilization time.
4. At high dew point conditions, high flow means more water vapor, so condensation issues can be exacerbated.

See also chapter 6.4.3 ‘Sample Gas Flow’ on page 51 regarding flow control.

6.1.5 Sample Gas Contamination

Contaminants in a sample gas can have an influence on the measurement results obtained from any hygrometer. The Rhodium mirrors used in MBW mirrors are extremely robust and will withstand most application gases.

Contaminants build up on the mirror surface and can cause measurement errors. During manual or automated mirror check routine (see chapter 5.4.6 on page 32), the mirror can compensate for surface changes, and the mirror residue display informs the user of possible need to a mirror clean. To reduce

this effect, an inlet filter can be used. The filter element should be non-hygroscopic and filter pore sizing should be matched to the application, 5…50µ filters are typical.

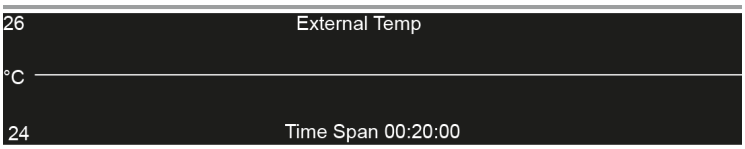
Gases other than water within the sample flow may also condense on the mirror surface. The user should consider the gas make up and check that condensation points are not above the likely dew-point to be measured.

6.2 External Temperature

As frost/dew point is not temperature dependent, the 973 maintains its best measurement capability across the full working range. If the application requires relative humidity (RH) measurement, then careful consideration of temperature measurement is critical to achieve accurate RH values.

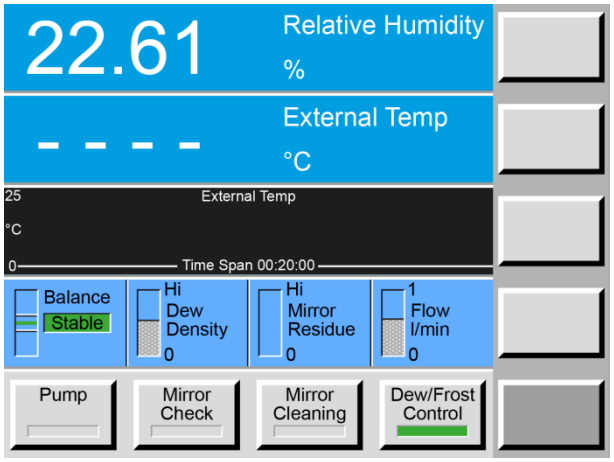
The optional 973 external temperature probe must be in a position that correctly represents the application condition or significant errors can result. Non-stability of temperature is equally important.

Use the graphical data display mode to show stability over time.

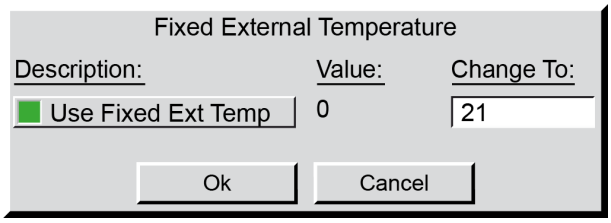


6.2.1 Set Fixed External Temperature

If you do not use an external temperature sensor, you have the possibility to enter a fixed external temperature so that RH can be determined. Set the parameter so that ***External Temp*** shows on one data line (see section 5.2). If no temperature sensor is installed, the data line will not show any reading. Touch the ***External Temp*** data line on the screen. A window (see picture below) will appear where you can enter the desired temperature.

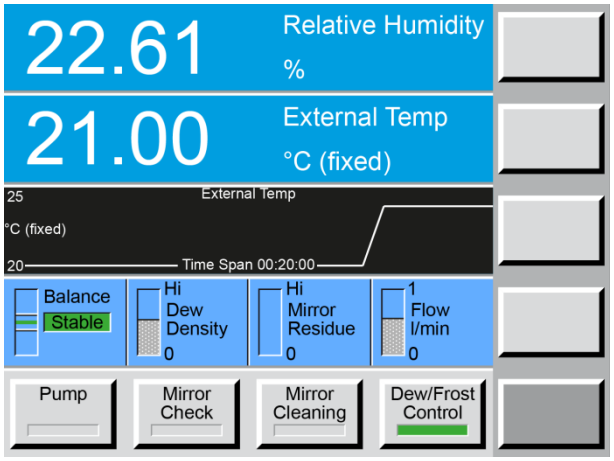


Enter the desired temperature in degrees Celsius (21 °C in this example) and activate the ***Use Fixed Ext Temp*** option by touching the button. When the indicator square turns green, the fixed external temperature is active.



The External Temp data line (and the graph, if shown) will now say "***(fixed)***". As shown in the image on the right, the external temperature will immediately change to the temperature that was entered, and will remain there until it is changed again.

If you want to start using an external temperature probe, go to ***the Fixed External Temperature*** window and press the ***Use Fixed Ext Temp*** to disable the fixed external temperature function. The green square will turn grey.



6.3 Application Integration

The following are examples of typical 973 applications and some issues to consider. For further advice on any given application, please contact MBW or your supplier.

6.3.1 Compressed air systems

Compressed air systems are commonplace in industry and commerce. In many situations, the quality of the compressed air is critical to processes or may be required to be validated within Quality Systems. The 973 can be used to directly measure the humidity in compressed air, either at ambient or operational pressure.

6.3.2 Checking breathing gas quality

Cylinders of breathing gas can be measured to ensure that they meet the required standard. A suitable regulator will be required, and any sample tubes must of a non-adsorbent and leak tight material (rubber is not suitable).

6.3.3 On-site calibration of dew point sensors

Dew point sensors are widely used throughout industry. They are cost effective and convenient, but can have significant calibration and stability issues, so must be periodically calibrated to ensure performance meets the requirement of the application. The 973 is suitable for use as a transfer standard in the calibration process.

6.3.4 Battery Manufacturing

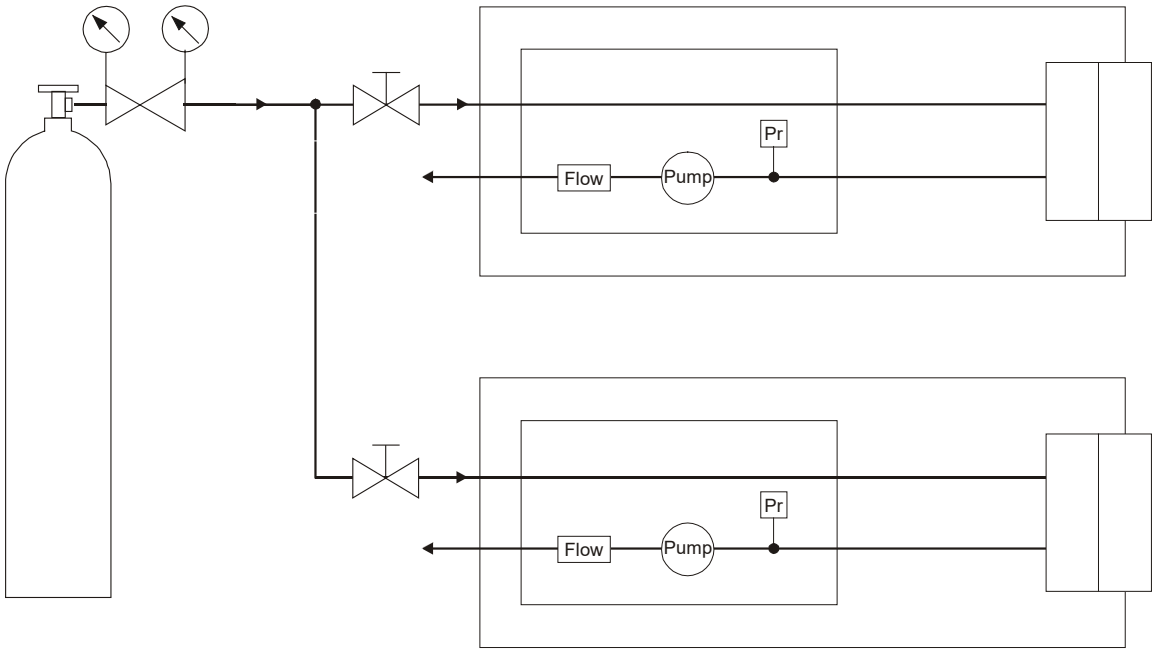
To optimize product quality, production conditions in battery manufacturing are maintained as dry as possible. Measurements systems are typically based around multiple dew point sensors installed at various points. Sensors have issues with stability in this application, so dew point mirrors are applied in critical points and are used for calibration checks on installed sensors

6.3.5 Dryer performance tests

The outlet from compressor/dryer systems is a common application for dew point mirrors. Measurement of dry gases requires careful consideration of sampling components. Ideally the sample tube should be as short as possible and constructed from stainless steel. For spot measurements, the effect of moisture desorption from sample tubes and stabilization must be carefully considered.

6.3.6 Dew Point Calibration

When using the 973 to compare with another instrument, the units must be connected in parallel as shown below. This prevents any masking effects of the first instrument in a series configuration.



6.3.7 Climatic Chamber Validation

With the optional built-in sample pump and external temperature probe, the 973 can be used to calibrate or validate RH conditions where the dew point is not above ambient temperature. Care should be taken that the sample tubes are correctly sealed, and the temperature probe is homogenous with the environment to be calibrated.

The 973's integral sample pump can be used to create the required sample flow. The use of both inlet and outlet sample tubes means the 973 can re-circulate within closed loop systems. See chapter 6.4 'Operational Considerations' on page 51 for further information.

6.3.8 Contaminated Applications

Dust or chemical contamination will lead to instrument damage and incorrect measurements. With careful filtration, even the worst environments can be measured. Discuss with project engineers what types of process contamination may be present and specify appropriate filtration. Make consideration of any sample gas constitutes that may condense within the likely water dew/frost point range.

6.4 Operational Considerations

In many cases, dew point mirrors are used continuously. Correct maintenance procedures will optimize measurement accuracy, stability and reduce downtime. The following operational considerations are provided to help the user achieve best measurement capability and maximize the investment in the chilled mirror instrument.

6.4.1 Mirror Check Interval

To measure correctly, the mirror must be clean. Routine mirror checks, and if necessary mirror cleans, must be performed. The user can manage this manually, or the 973 can be programmed to automatically check and correct. How often this is performed depends on the application, and this should be determined experimentally. Once per day would be a good starting point, but initial supervision of the mirror residue indication is advised.

Programming of the automatic mirror check system is described in chapter 5.4.6 ‘Mirror Check ’ on page 32. For instructions on cleaning the mirror please see chapter 9.2 ‘Mirror Cleaning’ on page 68.

6.4.2 Inlet Filters

Inlet sample filters can be used to minimize the effects of contamination and to reduce the number of mirror cleans. The correct type of filter can be determined by reference to process engineers who will be aware of any possible contaminants. The filter element should be non-hygroscopic and filter pore sizing should be matched to the application 0.5…50µ filters are typical, with a course then fine filter ‘cascade’ ideal.

If installed, filters must be routinely maintained within operational procedures. A blocked filter will reduce flow and could affect pressure. In some circumstances, the use of a heated filter may be needed to prevent condensation within the sampling system, please contact MBW or your supplier for further guidance if needed.

6.4.3 Sample Gas Flow

The flow rate through the measuring head should be in the range 0.5…2 LPM. See also chapter 6.1.4 ‘Sample Gas Flow’ on page 46 for further description.

The 973L includes an internal flow sensor that provides indication on the front panel of the flow rate. The flow measurement is adjusted during production, but is not calibrated, so should be considered ‘for indication only’.

Gas Flow can be generated by an overpressure in the application with the flow regulated using a needle valve on the outlet of the 973. For carrier gases other than air, corrections to the flow indication are necessary; please contact MBW or your supplier.

In some circumstances the internal sample gas pump is used to flow sample gas from the application into the measuring head. Set the pump speed using the menu option found in the ***Control Setup*** menu.

With the pump power setting at 20%, check the flow indication and adjust the pump power to obtain the correct value. If necessary, adjust the pump power until the desired flow is achieved.

When measuring gas with low water content, higher flow rates are desirable to minimize desorption effects.

6.4.4 Temperature Measurement

The 973 is supplied complete with a Pt-100 temperature probe (PRT). The probe must be positioned at a point that correctly represents the application to ensure that calculations of RH are correct.

The coefficients specific to the PRT are stored within the internal memory of the 973. In the event that the probe is lost, damaged or replaced, new coefficients may be entered to obtain correct temperature measurement. Please contact MBW or your supplier for further advice.

7 Installation

7.1 Facility Requirements

7.1.1 Environmental

The 973 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	15 to 35 °C
Operating Humidity	5 to 95 %rh non-condensing

7.1.2 Power

973 systems are equipped with universal power supplies capable of operation from 100 to 250 VAC at 50 to 60 Hz. Check the power supply in your facility meets this requirement before connection and first use.

7.1.3 Instrument Cooling

Cooling Air

All versions of the 973 are air cooled using a fan or fans mounted on the back panel and ventilation slots on the base. Air is circulated through the instrument and forced out through the base. Fan control is automatic and requires no user input.

The fan intakes and slots must have at least 15mm of clearance to provide sufficient air flow. When installed in racks or other enclosures, sufficient ventilation to ambient conditions must be provided to avoid overheating.

The 973 has overheating protection on critical components. Each heat sensitive component has a specific upper temperature limit. In the event of over temperatures, a warning message is displayed on the front panel and all heating included the mirror Peltier driver are disabled.

Measuring Head Water Cooling

The 973S, E and CA can be optionally equipped with cooling water connections. Cooling water is rarely needed unless you intend to perform dew or frost point measurement below approximately –50 °C or when the ambient or application temperature is higher than normal (> 30 °C). A recirculating water chiller or standard tap water flow at a temperature between approximately 10 and 20 °C may be used. The water cooling connections are either ¼" or 6 mm Swagelok fittings (specified on the order and by default the same as the sample gas input/output connection.

It is important to consider that the temperature of the water cooling is not below the ambient dew point, or condensation may occur on the water cooling tubes.

7.2 Preparation for Use

Prior to first use, the instrument must be safely bench or rack mounted before installing external connections such as power, sample and signals. Careful planning and implementation will increase the likelihood or successful measurement and minimize risk of problems. If after careful review of this entire manual there are any doubts or questions, always refer to MBW or your supplier for guidance.

7.2.1 Benchtop Use

All 973 models are suitable for bench top or other flat surface installation. An area of at least 0.6 x 0.6 m (24" x 24") is recommended. Make sure that there is enough clearance around the instrument to allow air movement.

7.2.2 Rack Mounting

The 973 is not suitable for direct rack mounting but can be installed on a rack shelf within a 5U space.

7.2.3 Sample Tube Connection

Correct specification and connection of sample tubes is very important for best measurement capability. Connect tubes with the minimum length and avoid unnecessary connections where possible. Use stainless steel for measurements below -30 °C frost point, FEP is suitable for the remainder of the measurement range.

Make sure that fittings used are of a high standard and of the same type. A common error is mixing ¼" and 6 mm fittings, and while the effect is small in most of the measurement range, errors can occur. Always follow the fitting manufacturer's instructions.

7.3 Preparation for Transportation

All 973 versions are supplied in a robust transport case that are suitable for transportation by road and air. For additional protection, the transport case can be mounted on to a mini pallet and wrapped in plastic or cardboard to protect the condition of the transport case.

In the event that your transport case is lost please note:

All shipping and transportation should be in suitable padded containers. A heavy duty container with at least 50…100 mm (2…4 inches) of foam padding is recommended.

Due to the design of the 973 systems, any shipping container 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 directly on the front panel, nor on the top or bottom center of the front or rear frame.

Key points to note before transportation:

- Prior to shipping, always cap the gas inlet and outlet fittings to prevent excess moisture and/or contamination from entering the gas path, and to prevent damage to the fittings. If applicable, drain the system of any cooling water, or cap the cooling water fittings.
- Ensure the optical head assembly and cover screw are firmly attached.

8 Remote Communication

The 973 is equipped with a bidirectional RS-232 communications interface which allows connection to a computer. This chapter provides the necessary information for the use of the interface, including the hardware connections, communications settings, and the command syntax.

8.1 Hardware Connection and Cabling

Connect a computer to the 973 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. If your computer has a 25-pin serial port connector rather than a 9-pin connector, you will 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 at most computer hardware dealers.

The 973 ignores the DSR and CTS handshaking signals. While there is no harm in connecting all 9 pins, the 973 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 the signals identified by * are required, while the others are optional.

Signal	973 (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.

8.2 Communication Settings

To communicate with the 973, set your computer to the following configuration:

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

8.3 Command Syntax

This chapter details the general syntax guidelines regarding termination, leading and trailing spaces, case sensitivity, and numeric values. Throughout this chapter, characters originating from the computer will be shown for illustrative purposes in **`this font`**. Characters originating from the 973 will be shown in `this font`.

8.3.1 General Use

All commands require a question mark to indicate you are requesting data. When requesting data from the 973, follow the command with **`?`**, the question mark character. For example, the following requests the current pump status.

`Pump.on?`

The 973 will reply with the current pump status (1 = on, 0 = off).

8.3.2 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 973 will reply with a carriage return linefeed $^{\mathbf{C}}_{\mathbf{R}}{}^{\mathbf{L}}_{\mathbf{F}}$ at the end of the response, provided the command is recognized as valid. Here is an example:

`DP?`$^{\mathbf{C}}_{\mathbf{R}}$ (sent by the computer to the 973)

`-10.015`$^{C}_{R}{}^{L}_{F}$ (sent by the 973 back to the computer)

If the command is unrecognized, the 973 does not respond. See example below.

`Abcdef?`$^{\mathbf{C}}_{\mathbf{R}}$ (invalid command sent from the computer)

(no response from the 973)

8.3.3 Leading and Trailing Spaces

The 973 ignores leading and trailing spaces. It also ignores spaces before and after equal signs and question marks. For example, both the following commands are perfectly valid.

```
Dp?CR
 Dp ? CR
```

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

```
D p?CR
```

8.3.4 Case Sensitivity

All commands are insensitive to case. For example, the commands **DP?**, **Dp?**, **dP?**, and **dp?** will trigger identical responses from the 973. They will return the measured dew point value.

8.3.5 Numerical Values

All numerical data received from the 973 is either in standard or in 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 numerical responses the 973 sends out, it may send the numbers in either standard or scientific notation.

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

The following table lists the units of the numerical data that the 973 returns, regardless of the units selected on the touch screen display or set via the RS-232. When you change units (even if you change them via RS-232), you affect only what is seen on the display. All numerical 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

8.4 Command Reference

Below you will find a list with all available commands grouped by function. All commands are considered read-only values.

8.4.1 Measurement Data

Syntax	Function
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

8.4.2 System Identification

Syntax	Function
ID?	Returns a string containing instrument identification, i.e. DPM 973
IDN?	Returns only numeric portion of identifier, i.e. 973

8.4.3 Stability Indicators

Syntax	Function
Stable?	1 = system is stable, 0 = not stable

8.4.4 Global Control Parameters

Syntax	Function
Pump[=i][?]	Pump on / off
Heater[=i][?]	Heater on / off
MirrorCheck[=i][?]	Execute mirrorcheck, manual
Control[=n][?]	D/F Mode on / off

8.4.5 Advanced Features

Force Frost Settings

Syntax	Function
ForceFrost.on[=i][?]	1 activates Force Frost (FF), 0 deactivates FF
ForceFrost.below[=n][?]	Temperature, under which FF activates, °C
ForceFrost.coolTo[=n][?]	Temperature, to which FF cools, °C
ForceFrost.holdBelow[=n][?]	Temperature, below which FF holds, °C
ForceFrost.dispHold[=i][?]	Freezes frost/dew point display/output during FF
SaveCfg=973	Saves all configurations to 973

Cooling Water Valve Settings (not on 973L)

Syntax	Funkction
WaterValve.armed?	1→ Cooling water valve control enabled 0→ Valve control disabled
WaterValve.on?	1→ Valve open, 0→ Valve closed
WaterValve.below[=n][?]	Meas. head Temp, under which valve is active, °C
WaterValve.hyst[=n][?]	Hysteresewert der Ventilschaltung, °C
SaveCfg=973	Saves all configurations to 973

ORIS Settings (973S only)

Syntax	Function
UseOris.on[=i][?]	1 activates ORIS, 0 disables ORIS
UseOris.below[=n][?]	Frost/dew point temperature, under which ORIS activates, °C
SaveCfg=973	Saves all configurations to 973

Preparation for Mirror Cleaning

Syntax	Function
MinHeadRemovalTemp[=n][?]	Head and internal cooling are heated above this temp when cleaning mirror button is pressed prior to removal of the head, °C
SaveCfg=973	Saves all configurations to 973

Automatic Mirror Control

Syntax	Function
AMC.on[=i][?]	1 activates AMC, 0 disables AMC
AMC.cycleTime[=n][?]	AMC cycle time in minutes
AMC.heatTime[=n][?]	AMC heating, hold time in minutes
AMC.temp[=n][?]	Target temperature during AMC, °C
AMC.dispHold[=i][?]	=1 enables frost/dew point output hold during AMC
SaveCfg=973	Saves all configurations to 973

Pump Control Parameters

Syntax	Function
Pump.on[=i][?]	1→ Pump ON, 0→ Pump OFF
Pump.dutyCycle[=n][?]	Pump duty cycle in %, 20...100
SaveCfg=973	Saves all configurations to 973

Precooler initial Control Parameters (973L only)

Syntax	Function
Precooler.initmode [=i][?]	Precooler Control Mode after device start: 0 → remember last setting 1 → delta auto, 2 → fixed auto 3 → delta manual, 4 → fixed manual
Precooler.initsetpt [=n][?]	Override precooler Setpoint in absolute temperature or delta after device start
SaveCfg=973	Saves all configurations to 973

Precooler Control Parameters (973L only)

Syntax	Function
Precooler [?]	1→ Precooler ON, 0→ OFF
Precooler.fixedOn [=n][?]	1→ manual fixed control mode enabled, 0→ disabled, on set 0 switch to auto delta control mode
Precooler.deltaOn [=n][?]	1→ manual delta control mode enabled, 0→ disabled, on set 0 switch to auto fixed control mode
PrecoolerPid.fixedOn [=n][?]	1→ auto fixed control mode enabled, 0→ disabled, on set 0 switch to auto delta control mode
PrecoolerPid.deltaOn [=n][?]	1→ auto delta control mode enabled, 0→ disabled, on set 0 switch to auto fixed control mode
Precooler.fixedSetPt [=n][?]	Setpoint for fixed control mode, °C, n is limited Do not heat above ambient Temperature.
Precooler.deltaSetPt [=n][?]	Setpoint for delta control mode, °C, n is limited Do not heat above ambient Temperature.
SavePID=973	Saves all PID configurations to 973

Additional data indication

Syntax	Function
PeltI [?]	Peltier current, A
Flow [?]	Actual Flow rate, l/m this sensor is not available in every unit

Additional data indication (973L only)

Syntax	Function
TP [?]	Precooler temperature, °C
TPB [?]	Powerbox temperature indicator, °C
TDB [°C]	Stirling driver box temperature indicator, °C this sensor is not available in every unit
FAN [?]	Stirling cooling fan setpoint, 0..100% The used fan has an offset control range and will never stop
THS [?]	Stirling Heatsink temperature, °C
CP [?]	Stirling cooling setpoint, 0..100% To prevent damages on stirling cooler the cooling power is limited when the precooler temperature > - 20°C
HP [?]	Preheater setpoint, 0..100%

Measuring Head and Internal Sample Tube Temperature Control (optionally)

Syntax	Function
HeadHtrPID.on[?]	1→Measuring head heating ON, 0→ OFF
HeadHtrPID.setPt?	Head temperature set point, °C
HeadHtrPID.fixedSetPt[=n][?]	Setpoint for fixed control mode, °C
HeadHtrPID.deltaSetPt[=n][?]	Setpoint for delta control mode, °C
HeadHtrPID.fixedOn[=i][?]	1→ fixed control mode enabled, 0→ disabled
HeadHtrPID.deltaOn[=i][?]	1→ delta control mode activated, 0→ disabled
SavePID=973	Saves all PID configurations to 973

The internal heated sample tubes are set and controlled to the same settings as the measuring head.

On 973L the Head Heater is used for condensation protection of the Head cover. It will heat the cover automatically to HeadHtrPID.fixedSetPt. The HeadHtrPID.on must stay deactivated for that functionality. Do not change the HeadHtrPID setup on 973L. This condensation protection is not build in into all 973L units.

Control of the External heated Sample Tubes (optionally)

Syntax	Function
ExtHtrPID.on[?]	1→ external sample tube heating ON, 0→ OFF
ExtHtrPID.setPt?	External sample tube set point temperature, °C
ExtHtrPID.fixedSetPt[=n][?]	Set point for fixed tube temp control mode, °C
ExtHtrPID.deltaSetPt[=n][?]	Set point for delta tube temp control mode, °C
ExtHtrPID.fixedOn[=i][?]	1→ fixed tube control mode enabled, 0→ disabled
ExtHtrPID.deltaOn[=i][?]	1→ delta tube control mode enabled, 0→ disabled
SavePID=973	Saves all PID configurations to 973

Control of the External heated Sample Tubes (optionally)

Syntax	Function
Ana1.param[=i][?]	Parameter configuration for analogue output 1
Ana1.paramMin[=n][?]	Min. Value
Ana1.paramMax[=n][?]	Max. Value
Ana1.OutMin[=n][?]	Min. Voltage
Ana1.OutMax[=n][?]	Max. Voltage
Ana1.calGain[=n][?]	Gain scaling factor for DAC
Ana1.calZero[=n][?]	Zero scaling factor for DAC
Ana1.output=n	Requires to set the analog output when the DAC converter is calibrated. Automatically sets to Ana1.hold = 1 If calibration done, Ana1.hold must be sent = 0.
Ana1.hold[=i][?]	1 calibration mode. Analog output is set with the command Ana1.output = n 0 normal mode. Analog output the parameters monitored set with Ana1.param = i
SaveCfg=973	Saves all configurations to 973
Ana2.param[=i][?]	Parameter configuration for analogue output 2
Ana2.paramMin[=n][?]	Min. Value
Ana2.paramMax[=n][?]	Max. Value
Ana2.OutMin[=n][?]	Min. Voltage
Ana2.OutMax[=n][?]	Max. Voltage
Ana2.calGain[=n][?]	Gain scaling factor for DAC
Ana2.calZero[=n][?]	Zero scaling factor for DAC
Ana2.output=n	Requires to set the analog output when the DAC converter is calibrated. Automatically sets to Ana1.hold = 1 If calibration done, Ana1.hold must be sent = 0.
Ana2.hold[=i][?]	1 calibration mode. Analog output is set with the command Ana1.output = n 0 normal mode. Analog output the parameters monitored set with Ana1.param = i
SaveCfg=973	Saves all configurations to 973

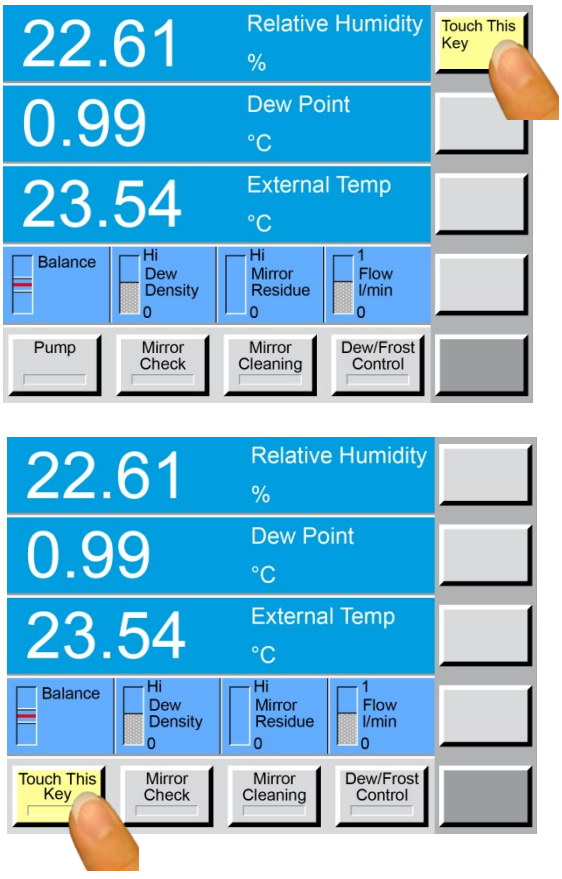
9 Maintenance

9.1 Calibrate the Touch Screen

Before using the instrument for the first time, or when the instrument is used by different operators, you may wish to calibrate the touch screen to your finger positioning preference. Left and right handed people, for example, may have different points of pressure when using the touch screen.

To calibrate the touch screen:

Press and hold the ***Enter*** key on the numerical keypad for 3 to 4 seconds. You will hear two short beeps and the key in the upper right corner will turn yellow.



With the tip of your finger, press the center of the yellow highlighted key. After a successfully detection you will hear a click and the yellow Key switches position.

It will ask you in that way three positions.

When all keys are back to grey, you have successfully calibrated the touch screen.

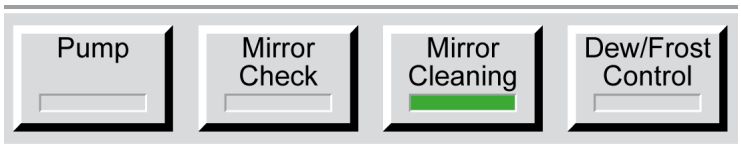
Test your new touch screen calibration by pressing the bottom right menu selection key several times. If it does not work to your satisfaction, repeat the calibration procedure.

9.2 Mirror Cleaning

At the heart of the 973 is the measuring head assembly. It is highly sensitive and accurate, yet easily accessible for periodic mirror cleaning. To ensure high accuracy, the mirror should be cleaned before starting a measurement. Inspect the mirror carefully. Use a magnifying glass if necessary. If there are signs of contamination or if you suspect that contamination is present, use the following procedures to clean the mirror.

Before opening the measuring head and starting the mirror cleaning, you need to prepare the measuring head.

973 Preparation for Mirror Cleaning



Press the ***Mirror Cleaning*** button. ***Dew/Frost Control*** will disable and the green bar on the button will turn gray. The mirror will then heat up until no condensation remains on its surface and the message ***'Mirror ready for cleaning'*** will display. Remove the measuring head cover, remove the optical module and clean the mirror. Replace the optical module and cover, press ***OK*** and the instrument will reactivate dew/frost control and start to measure. If you manually disable dew/frost control by touching the ***Dew/Frost Control*** button before initiating the mirror cleaning, the 973 will not automatically restart after the mirror cleaning until you manually reactivate dew/frost control.

9.2.1 Removing the Measuring Head Cover

The measuring head is located on the right side of the 973 front panel. To gain access to the mirror and opto-electronic components, you must first remove the cover screw by twisting it counter clockwise. It requires approximately three full turns to completely unscrew, allowing you to remove it.

Once the cover screw has been removed, the black optical module is now removed by pulling it straight toward you. This piece contains the light emitting and light sensing opto-electronic components. There is an oval shaped O-ring on the face of the optical assembly that is used to seal it to the measuring head. There are also some gold contacts on the face. Avoid touching the face of the optical assembly with your fingers to prevent contamination of the contacts, the O-ring, the optical area, and the gas channel.

9.2.2 Inspecting and Cleaning the Mirror

The mirror requires occasional periodic cleaning to maintain high accuracy measurements. The flush mounted mirror is easily accessible by removing the cover screw and optical mirror assembly as described above. Inspect 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, wet cotton bud. Always use sterile, pure water
2. If stubborn contamination such as oils or other hydrocarbons may be present, use a cotton bud wetted with alcohol such as IPA, Ethanol or Methanol.
3. Always finish with a wet cotton bud, removing as much excess water as possible. Use a dry sterile cotton bud if necessary.

Never attempt to polish the mirror. It is slightly roughened at the factory to allow for better nucleation sites and thus better dew formation.

Inspect the condition of ‘O’ rings in the mirror assembly and replace in the event of damage.

9.2.3 Reassemble the Mirror Components

Reassemble the mirror components in the reverse order of disassembly.

1. Install the optical assembly, taking note of guide pin (s) and alignment indication
2. Replace the cover screw or clamp. Hand tighten until snug. Do not over tighten.

9.3 Exterior Cleaning

Front Panel

The 973 front panel is completely sealed and can easily be cleaned with liquid glass cleaner or other mild cleaning chemical applied to a cloth. Clean the front panel periodically as needed when the instrument is switched off.

Rear Fan Grills

The rear fan grills may require cleaning periodically to ensure adequate airflow within the system. Use a vacuum or compressed air to clear dirt and dust from the grill and from inside the system.

9.4 Calibration

A Factory Calibration Certificate is supplied with all new instruments. For a small additional cost, this can be upgraded to ISO17025 SCS accredited calibration during production.

The 973 is carefully calibrated during manufacture. All Pt-100 elements used in the instruments are pre-calibrated to determine their specific coefficients, and these values are integrated within the sub-systems of the 973. Changing the measuring head or external temperature PRT will require the Pt-100 specific coefficients to be changed, and any calibration history lost.

Once in use, a carefully maintained 973 should never need to be adjusted to maintain optimal performance. Successive calibration at an accredited laboratory will provide you with measurement traceability and evidence of the long-term stability of the instrument.

Interim calibration checks are recommended as part of any good measurement practice routine. The Ice Test function and/or cross checks with other calibrated instruments helps maintain measurement confidence.

9.5 Peltier Cooling Test

The Peltier module used for mirror cooling and heating can age over time. It can also lose capability when used at its limits. If you think the measuring head is not cooling down fast enough during measurement, you can check this with the Peltier Cooling Test (PCT) function.

Please follow the instructions in chapter 5.8.3 ‘Peltier Cooling Test’ on page 43.

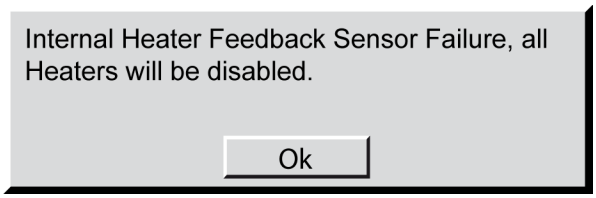
9.6 Periodic Maintenance Checks

Apart from periodic mirror cleaning, the 973 requires very little maintenance, but the following checks are recommended to maintain the optimal instrument performance:

- Check and clean the rear cooling fan grill
- Check the condition of power, RS-232 and other external cables and connectors
- Check the condition of sample tubes and connections
- Where used, check or replace sample inlet filters

10 Error Messages

10.1 Heater Feedback Sensor Failure



Each heated component has its own temperature sensor, in the event of this message appearing, please contact MBW or your local supplier.

11 Specifications

Specifications	973S	973E	973CA	973L
Measuring Ranges				
Frost/Dew point:				
Working range	-60…+20 °C	-60…+20 °C	-60…+20 °C	-76…+20 °C
Calibrated range	-50…+20 °C	-50…+20 °C	-50…+20 °C	-70…+20°C
Temperature	-50…+100 °C			
Relative humidity	0.1…100 %rh			
Mixing ratio	100…20'000 ppm_v		1…20'000 ppm_v	
Sample pressure	0... 2.5 bar	0…10 bar	0…20 bar	0…20 bar
Accuracy				
Frost/Dew point (over calibrated range)	≤ ± 0.1 °C			
Temperature	≤ ± 0.07 °C			
%rh	≤ ± 0.05 %rh			
Pressure	≤ ± 0.1 range			
Reproducibility				
Frost/Dew point	≤ ± 0.05 °C			
Temperature	≤ ± 0.04 °C			
Standard Features				
Digital I/O	RS-232			
Display	5.7" LCD with color touch screen			
External temperature probe	PRT (Pt-100), Ø2 x 100 mm on 3 m cable			
Mirror temperature sensor	PRT (Pt-100)			
Mirror cooling	3-stage Peltier thermoelectric			
Pre cooling	Stirling CryoCooler on 973L			
Internal gas tubes	Stainless Steel 316L (inlet and outlet) FEP outlet with sample pump			
Gas inlet connections	6 mm or ¼" Swagelok fittings			
Internal sample pump*	Standard on 973S optional on 973E, 973CA, 973L			
ORIS	Optimum Response Injection System			
Transport case	Robust custom fit, foam lined, hard-shell case			
Power cable	2.5 m			
Operating instructions	English			
Calibration certificate	Factory calibration: 5 points FP/DP, 3 points temperature			
Optional				
Calibration upgrade	Upgrade to SCS accredited ISO 17025 calibration			
High pressure	10 or 20 bar internal pressure sensor			
Analog outputs	Two analog outputs, user programmable, -10…+10 V and 4…20 mA			
Additional water cooling	Extends frost/dew point range to -70 °C (water temp. 5 °C, ambient 20 °C)			
Transport case	Custom fit foam lined Pelicase			
Additional Information				
Supply voltage	100-120 VAC / 200-240 VAC, 50/60 Hz (auto switching)			
Power consumption	200 Watt			
Cooling	Air, additional water cooling optional. Stirling Cryocooler on 973L			
Operational conditions	10 °C…+40 °C, Maximum 98 %rh, non-condensing			
Storage temperature	-20 °C…+50 °C			

Weight & Dimensions	Instrument	In Transport Case
Dimensions (W x H x D)	420 x 155 x 390 mm	627 x 303 x 497 mm
Weight	10kg / 14 kg (973L)	21kg / 26 kg (973L)

We reserve the right to change design or technical data without notice.

Ordering Information

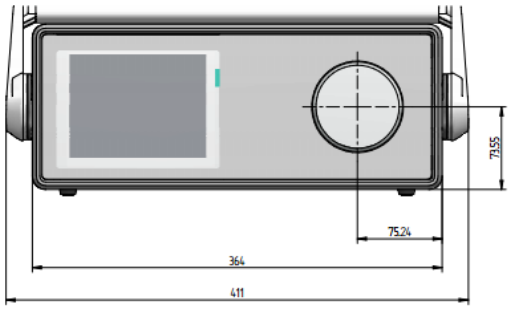
			Order Code
973S	-60…20 °C FP/DP	(incl. Ø2 x 100 mm PRT on 3 m cable and internal sample pump)	100055
973E	-60…20 °C FP/DP	(low cost version, 10bar maximum)	105082
973CA	-60…20 °C FP/DP	(compressed air version, 20bar maximum)	105083
973L	-76…20 °C FP/DP	(integrated Stirling Cryocooler)	141568

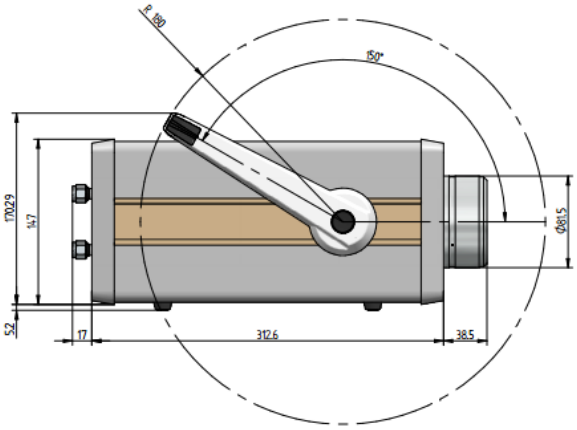
Options	
973-Upgrade to SCS accredited calibration (ISO17025)	103847
10 bar pressure upgrade (no sample pump)	103635
20 bar pressure upgrade (no sample pump)	104021
Two analog outputs, user programmable, -10...+10 V and 4...20 mA	102662
Internal sample pump (for 973E, 973CA, 973L)	105087
Additional water cooling 973	103362
Additional 1 year warranty upgrade (max. 3 years)	103632

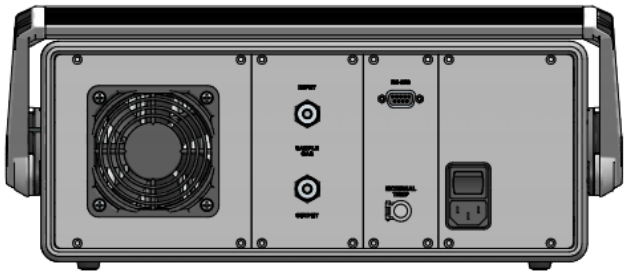
For the complete range of options and accessories, please contact us and request a pricelist.

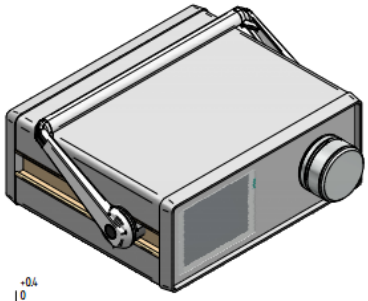
12 Drawings

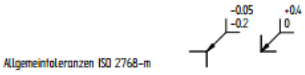
12.1 973 S, E, CA





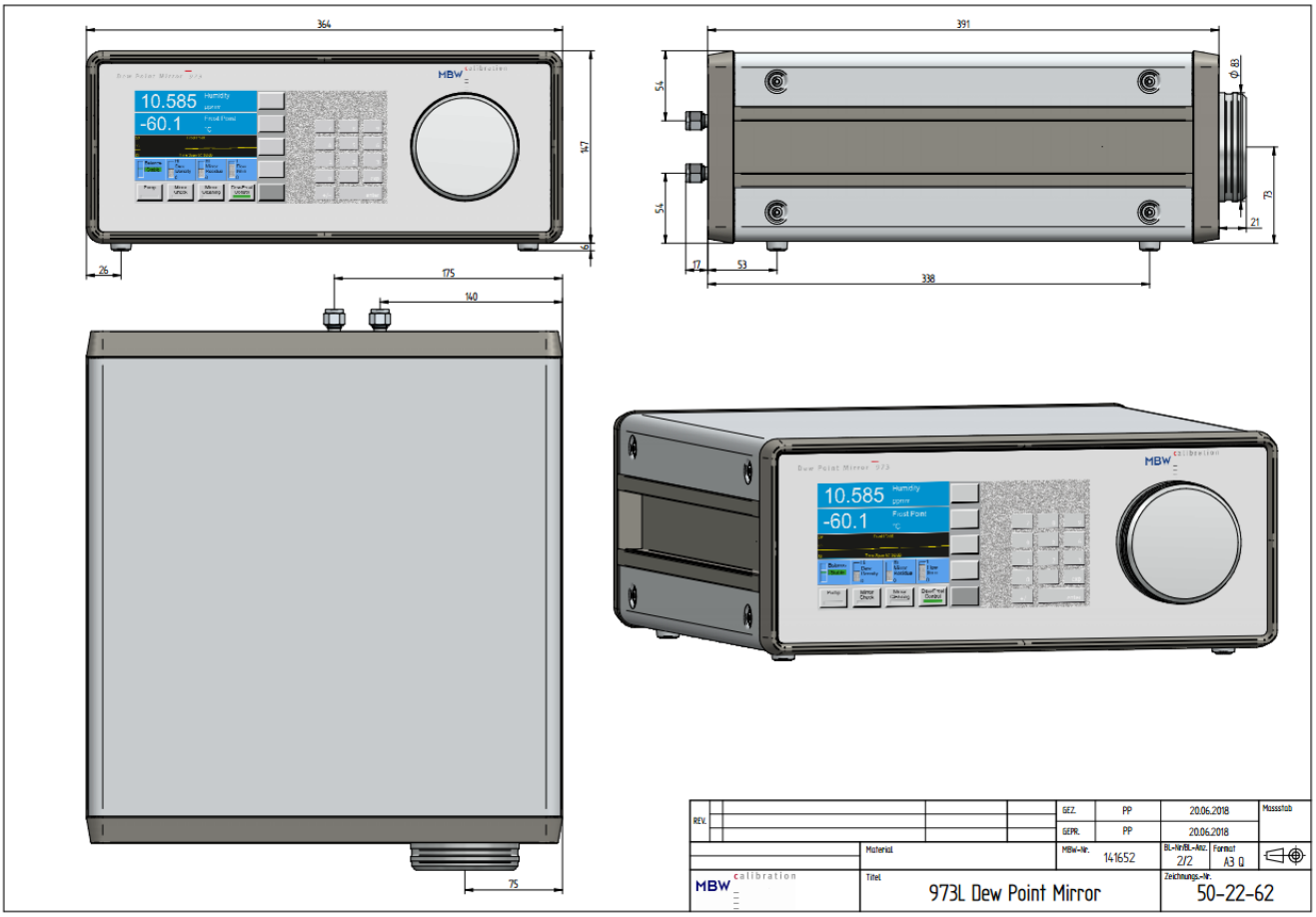






Allgemeintoleranzen ISO 2768-m

12.2 973 L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Ø 83
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26
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140
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53
338
75
10.585
-60.1
MBW
REV.
GEZ.
PP
20.06.2018
Massstab
GEPR.
PP
20.06.2018
Material
MBW-Nr.
141652
BL.-Nr/BL.-Anz.
2/2
Format
A3 Q
MBW calibration
Titel
973L Dew Point Mirror
Zeichnungs.-Nr.
50-22-62

13 FAQ's

Problem: The touch screen is not responsive or detects inputs in the wrong position.

Solution: *Try a touch screen calibration, as described in chapter 9.1 'Calibrate the Touch Screen' on page 67.*

Problem: I have setup my device with an unknown baud rate or badly configured display. What is the fastest way to go back to a default setup?

Solution: *Press and hold key number 9 on the key board for 3-4 seconds. Confirm the message by pressing Ok.*

Problem: I have configured my display incorrectly and would like to go back to factory default.

Solution: *Press and hold key number 7 or 8 on the key board for 3-4 seconds. This enables you to restore the factory default display setup.*

Problem: The 973 has been flooded with water due to sampling very high humidity without measuring head or sample tube heating. What should I do?

Solution: *Purge the 973 with a source of dry gas and Dew/Frost control disabled.*

Problem: Pressing Dew/Frost Control does not activate mirror cooling

Solution A: *Check the optical module is correctly fitted*

Solution B: *Check the optical condition by observing the optic power indicator in the status line. If the optical components have a fault, dew/frost control will not start. Please contact MBW or your local supplier for advice.*