RH systems

Manual

Duet Chilled Mirror Hygrometer

Warranty

RH Systems (RHS) warrants that its products are free from defects in materials and workmanship under normal use and operation within the specified design limits for 12 months from the shipment date. To obtain warranty service, the customer must return the system to the RHS facility for inspection and repair, with shipping prepaid. Upon receipt and examination by RHS or its duly authorized representatives, RHS will, at its discretion, repair or replace any component found to be defective during the warranty period. Improper or unauthorized maintenance, storage, repair, or alteration of any kind by personnel other than RHS or its duly authorized representatives may void all warranties. Warranty may also be voided due to misuse, neglect, accidents, corrosion, or improper installation. This warranty is exclusive and in lieu of any and all other warranties of merchantability, fitness for a particular purpose, or any other warranty, expressed or implied, and all other liabilities and obligations on the part of RHS. RHS will not be liable for any other claims or damages, either direct, indirect, or consequential, arising out of the use of its products.

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Revision History

Version	Revision Date	Summary of Changes	Author
A	4 Feb 2026	Initial Release	Brett
B	10 Mar 2026	Revised for Clarity, Formatting, and updated settings menus.	Brett
C	15 April 2026	Added mechanical drawings, pump bypass instructions and Rack Mount assembly instructions.	Brett
D	17 July 2026	Amended to comply with European Standards	Brett

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1 Key Features

Precise and Stable Humidity Measurement

The Duet Chilled Mirror Hygrometer is a high-performance instrument with an integral measuring head, pressure sensor, sample pump, flow meter, and external temperature sensor for continuous precision measurement of frost/dew point, temperature, pressure, and calculated humidity parameters across a wide range of applications. The Duet humidity measurement uses chilled-mirror technology, providing highly precise, stable, and repeatable results.

Frost Lock Function

At temperatures below 0 °C, water can condense as either frost or dew (supercooled water). This makes it difficult to determine whether the condensate layer on the mirror is liquid or solid. The Frost Lock function overcools the mirror to force the condensed layer into the solid phase. By rapidly cooling the mirror to a temperature below -40 °C, the formation of an ice layer is guaranteed. After reaching -40 °C, the system stabilizes the mirror at the frost point temperature. This eliminates the uncertainty of whether dew or frost point is measured. More information about Frost Lock and how it's configured is detailed in section 6.1.1 'Frost Lock' on page 17.

LCD Color Display with Touch Panel

The Duet has a full-color LCD touch panel for simple interface, readability, and customization. Data is displayed in large, easy-to-read fonts. Using the on-screen buttons and menus, you can easily configure each display line for a variety of humidity, temperature, and pressure parameters that may be viewed in a wide variety of units.

Accurate and Repeatable Temperature Measurement

Both the wire-wound mirror temperature PRT (platinum resistance thermometer) and the external temperature probe are compared ratiometrically to highly stable reference resistors. Adjustable current modes and full current reversal technology eliminate polarity and self-heating probe errors, while the external Smart Probe retains its calibration data, removing the chance of input error, no matter how many times you reconnect or swap a probe.

Dual Wire-Wound Mirror PRTs

Two PRTs are included: one for internal thermometry, and a second 4-wire, 100Ω PRT is available for connection on the back of the unit. This unit is also equipped with Smart Probe technology, which allows calibration data on the 2nd PRT to be stored with the unit and read automatically by a PT12 thermometer.

Ice Test Function

Users can check the Duet system's accuracy at any time using the built-in Ice Test function. This can be an automated self-test, or manually conducted with the mirror exposed for instant verification of system accuracy and integrity. See section 6.4 'Ice Test' on page 23.

ARIA (Standard Duet only)

ARIA (Accelerated Response Injection Algorithm) dramatically reduces the time to achieve an acceptable layer of frost on the mirror surface when the gas is drier than about -40 °C frost point. ARIA works by momentarily injecting a small amount of water vapor into the sample gas flow. This "seeds" a frost layer on the mirror surface and reduces hours of delay to just minutes. ARIA is typically used for measurements below -40 °C. The threshold for its operation can be set by the user. For further information, please see page 18.

Configurable Sampling Circuit (Duet-HT only)

The Duet-HT gas path can be configured by the user to suit different application scenarios. The measuring head, flow meter, and sample pump use separate internal tubing, connected via the Duet-HT back panel tubing links. The user can therefore bypass the flow meter and sample pump when needed. For example, this is useful when measuring at high dew points.

Measuring Head and Sample Tube Heating (Duet-HT only)

When measuring at high dew points, condensation will occur if any section of the sample path is below the dew point temperature. These conditions would result in measurement errors and flooding of the sample path. To avoid this and achieve precise measurements, the Duet-HT heats the sample path, the measuring head, and the external inlet sample tube. For further information, please see section 7 'Set Up and Operation', page 25.

2 Safety Instructions

Please read all Safety Instructions carefully. Important safety instructions will appear in red boxes as below throughout the Duet Manual:

Check all connections carefully before use

Disconnect power supply before opening the instrument housing

In the event of damage do not use the instrument

Important information throughout the manual will appear in blue boxes as shown below:

Depending on the operation, the following parts of the instrument may get very hot:

- Measuring head
- Gas Inlet/Outlet Manifold
- Connection for external heated hose

3 Quick Start

This section guides you through the setup and most important first steps when using the Duet. It is a summary and should only be used as a general overview. It is not a substitute for the remainder of the manual. To understand the instrument thoroughly, please read the entire manual carefully.

3.1 Unpacking

The Duet will be delivered to you in a custom, foam-lined, plastic, hardshell transport case. It is highly recommended to keep the case for future transport, calibration, or storage.

The following items are typically included:

- Duet Chilled Mirror Hygrometer
- Temperature probe (Pt-100) with cable
- External mirror PRT cable
- AC Power cable
- Gas connections, 6 mm or ¼" Swagelok
- Operation manual
- Calibration certificate
- DB9 cable for RS-232 communication
- USB A to USB B cable for serial communication
- USB Flash Drive with Manual and RHS Control
- Analog output connectors x2
- Pump Bypass Tube (only on some Standard Duets)
- Optional heated inlet sample hose (Duet-HT only)
- Optional steam trap (Duet-HT only)
- Optional Rack Mount Kit (see Appendix B)

Before you start operating the Duet, carefully remove all items from the case and visually check for any signs of damage. Check that all items on the packing list are included.

If you are missing any items or find that any are damaged, please contact your supplier immediately.

3.2 Cleaning the Mirror

The heart of the Duet is a highly sensitive and precise chilled mirror measuring head. To achieve the highest measurement accuracy, the mirror should be cleaned prior to each use. Maintaining the mirror in a clean condition is essential for the Duet's full measurement capability. The exact procedure is described in section 10.1 'Mirror Cleaning' on page 41.

3.3 Starting the Duet

The Duet requires an AC power source. 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 a grounded AC outlet.
2. The power switch is located next to the AC power connector. Turn the power switch ON.

The display should become visible within 20 seconds, and the rear fans should turn on immediately. If nothing happens, check the cable connections and the power switch.

After approximately 30 seconds, the Duet is ready for use, as evidenced by the appearance of the main screen.

Measurement does not start until ***Dew/Frost Control*** is activated by pressing the respective button on the bottom right of the screen.

3.4 Humidity Measurement

When you switch on the Duet, the default display shows 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 can be entered via the touchscreen. To test the Duet humidity measurement by measuring the dew point temperature of the room, follow these simple steps below:

For a Duet-HT, check that the back panel sample connections are in place as shown. This is the standard setup of the Duet back panel connections.

On the right is the Duet-HT Inlet and outlet ports. The Duet-HT requires back panel connections to make use of

the flow meter and pump. For below-ambient dew points, the tubing setup shown is appropriate.

Duet

Duet-HT

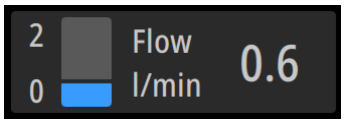
A standard Duet (left) only has a single input and output, and no extra back panel configuration is required

> WARNING: Do not run a Standard Duet above ambient dew points. Doing so will flood and may damage the Duet. To run a Duet-HT above ambient, carefully read Sections 6.2.1 'Heaters (Duet-HT Only)' and all of section 7 before measuring above ambient dew point.

The Duet always needs flow over its mirror to function properly. To obtain a representative sample of the room air, press the ***Pump*** button to generate a gas flow.

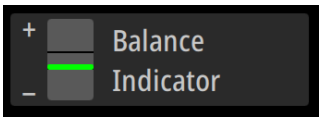
When on, the button will glow blue. Pump power can be adjusted with a long press of this button. See section 6.1.4 'Pump:' on page 20.

By default, with no external sample tube restrictions, the pump should be configured to pull about 0.5 to 1.2 l/min of gas across the mirror, which is the recommended flow rate for most measuring applications. You can verify this by checking the flow indicator at the bottom-right of the screen.



Start the measurement by pressing the Dew/Frost Control button, labeled ***D/F Control***. 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 layer.

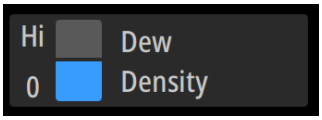
When Dew/Frost Control is enabled, the button will glow blue, and the dew or frost point temperature display will begin showing the mirror temperature as it cools to the condensation point. See section 7 'Set Up and Operation' on page 25 for further information.



The mirror will chirp when it stabilizes on a layer, and the line in the balance indicator changes from red to green. This indicates that the mirror now has a condensate layer and that the readings now accurately reflect the dew/frost point. This is referred to as a ***Stable*** indicator.

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 be unable to indicate a stable measurement result. However, as long as the Layer Density indicator (which indicates either Frost or Dew depending on conditions) is significantly above zero and appears relatively stable, the dew/frost point is very likely still correct.



See section 5 'System Configuration' page 13 for information on how to select the parameters you want to display.

3.5 Sample Gas Connections

The Duet is equipped with fittings for gas inlet and outlet connections. This allows the Duet to measure the humidity of generators, chambers, and other environments or equipment connected using a sample tube.

The inlet and outlet connections are located on the instrument's back panel and are clearly labeled as shown. Connections are either 6mm or ¼" 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 section 4.3 'Back Panel' page 7.

When connecting Swagelok fittings, it is best practice to tighten them ¼ turn past finger tight with a 9/16" (or 14mm) wrench.

4 Get to know the Duet

4.1 Front Panel

The front panel of the Duet features a color touch screen. 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 Duet is turned on, the display will activate within 20 seconds. A sample display configuration is shown below. The display configuration can be customized, so your display may look different. The use and the functions of the display are described in the following sections.

4.1.1 Data Lines

By default, the first three lines of the display show a numeric and graphic representation of the measured data. These are the Data Lines. The Data Lines can be set to show only numeric data, only graphic data, or both, and can be easily adjusted by sliding the white bar separating the two across the Data Line.

In all cases, both the graphic and numeric data on a line corresponds to the same single parameter. That parameter is always identified with corresponding units on the right-hand side of the Data Line, with the units under the parameter.

These Data Lines are highly customizable. Data can be displayed in different parameters, units, and colors either numerically or graphically. Please refer to section 5 ‘System Configuration’ on page 12 to learn how to configure them.

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

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

By dragging the white dividing line, you can display both the graph and numeric simultaneously.

4.1.2 Status Line

Near the bottom of the display is the Status Line. The Status Line displays the ***Balance***, ***Density***, and ***Flow*** indicators.

Balance Indicator

Balance is effectively the rate of change of the dew/frost thickness measurement. It indicates the rate of growth or reduction of the mirror's condensation layer on the mirror. While the dew or frost layer on the mirror surface is growing (condensing or depositing), the indicator will be above center (+). The faster the layer is growing, the higher the indication. Conversely, when the layer on the mirror surface is reducing (evaporating or sublimating), the indicator will be below the center (-). The faster the reduction, the more negative the indication.

When the indicator is in the center, the thickness of the dew or frost layer is neither growing nor reducing and is therefore in equilibrium with the water vapor within the sample gas. If the gas sample's humidity is homogeneous and sufficiently low in variability for the control system to sense a steady value, the Balance Indicator will switch to a green line, accompanied by an acoustic chirp. This indicates that the Duet has a stable reading. In all other instances, the indicator line will be red, including when it is in the center, because either there is no layer or the layer is near equilibrium but not yet sufficiently stable.

Density Indicator

The density indicator graphically depicts the approximate thickness of the dew or frost layer on the mirror surface. The Duet can automatically differentiate between dew and frost layers, and the indicator will display the current condensation state. The label on the density indicator will change from ***Layer Density*** (when the layer's state 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 section 6.1.1 'Why it is Important to distinguish between Dew and Frost' on page 17.

Flow Indicator

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

4.1.3 Fixed Function Keys

The bottom line of the display contains a row of fixed function keys. These keys are used to toggle the Heater on/off (Duet-HT only), start and stop the Pump, prepare for Mirror Cleaning, initiate a Mirror Check, and switch Dew/Frost Control on/off. On a Standard Duet model, the Heater button is greyed out and disabled. Generally, a long press on a fixed function key takes you to the relevant configuration menu.

4.1.4 Menu Keys and Navigation

On the right-hand side of the fixed function keys is the ***Menu Key***. Selecting it opens up the menu screen.

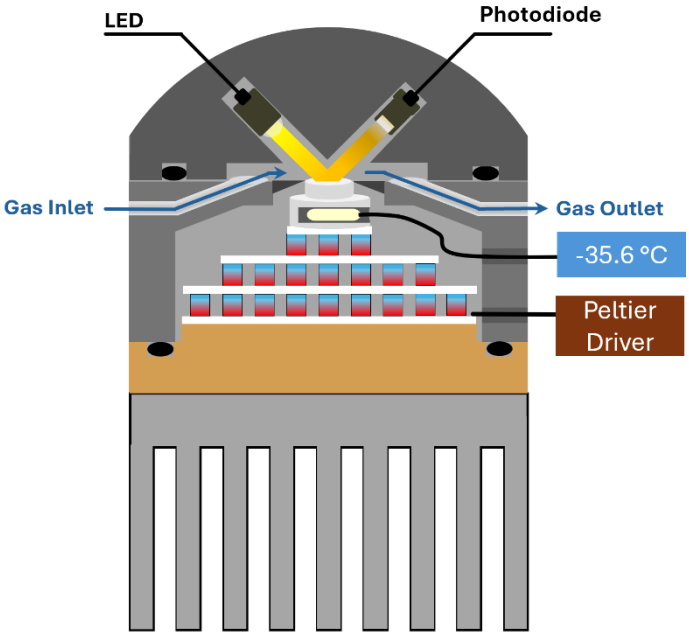
The menu is divided into 4 sections: ***Control***, which affects Duet operation; ***Components***, for heaters and accessories; ***Coefficients*** for the temperature, pressure, and flow sensors; and ***System Settings,*** which include setting global units along with system information. See section 6.1 for more menu details.

4.2 Measuring Head

The core of the Duet is the measuring head. It is designed to be highly sensitive, accurate, robust, and easily accessible for regular inspection and cleaning. You will want to familiarize yourself with the mirror's location and accessibility, as well as those of the other optical components.

> WARNING: Depending on the operating mode, the measuring head parts can get very hot. Check the measuring head temperature before handling, and allow it to cool if necessary.

The drawing below is a cross-sectional representation of the measuring head, including the optical module where the light source and detector are mounted. The mirror PRT is in the center of the copper core mirror, reading an accurate temperature of the mirror surface.



4.2.1 Mirror Assembly

The mirror assembly consists of a rhodium plated mirror, a mirror temperature sensor (PRT), and a Peltier thermoelectric element. These parts are carefully assembled during production and rarely require repair or replacement. Take care not to damage the mirror. The mirror PRT is fundamental to the accuracy, repeatability, and stability of the whole instrument. If the mirror or PRT is damaged by the user and needs to be replaced, the instrument's calibration history will be lost. Always clean the mirror according to the instructions in section 10.1, 'Mirror Cleaning' on page 41.

4.2.2 Optic Module

The Optic Module contains an LED light source, a photodiode light detector (the opto-electronic components), and a temperature sensor. This assembly is used to detect the formation and thickness of condensation on the mirror surface. In the event of damage or failure, the optic module can easily be repaired or replaced. Unlike the Mirror, repairing or replacing an optical module will not affect the instrument's calibration.

Removing the Optic Module

The Duet's measuring head is located on the right side of the front panel. To access the mirror or the optic module, the measuring head cover needs to be removed. The Duet uses a latching mechanism rather than a threaded one to retain the Optic Module. To access the mirror and optical module of the Duet, firmly grasp the cover and twist it counter-clockwise approximately 1/8th turn, then pull straight off. The optical module is the black part located under the measuring head cover.

Once the head cover is removed, the optical module is held in place magnetically. It can be easily removed by pulling it back gently from the Duet. The optical module contains an O-ring that seals the measuring head gas path and gold spring-loaded 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, or the gas path.

For more instructions on disassembly of the measuring head and mirror cleaning, see section 10.1, 'Mirror Cleaning' on page 41.

4.3 Back Panel

Duet-HT:

Power Switch

The main power switch is on the back panel above the power plug. Between the switch and the plug is an AC fuse that can be replaced if it is blown. The power supply also has built-in short and surge protection and will automatically switch off in case of overload. To restart power, the main power switch must be turned off and then back on.

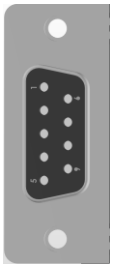
Power Plug

The supplied C13 power cord is connected to the C14 power socket on the instrument's back panel. The supported power supply voltage is 80 to 264 VAC at 47 to 63 Hz. Power requirements vary by model and are specified on the serial number label on the back of the instrument.

4.3.1 Data Ports

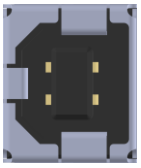
All digital ports, when connected to a computer, allow for serial communication. RHS Control, a software package included with every Duet, allows for easy control, monitoring, and data logging. It can log as many Duets, humidity generators, and other instruments as can be physically connected to the computer. For more information on RHS Control, or to interface manually with the Duet using serial commands, see section 9.3 ‘Command Syntax’ on page 36.

RS-232



The RS-232 port can be used to connect the Duet to a computer. The necessary 9-pin RS-232 (serial) extender cable (male to female 1:1 pinout) is provided with the instrument, and is a common accessory easily obtained online. This is one way of connecting the Duet to RHS Control.

USB B

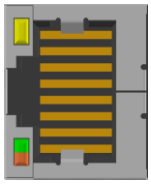


The USB B port can also be used to connect the Duet to a computer and does not require an adapter. The Duet ships with a USB A-to-B cable. Simply plug the B side of the provided USB cable into the Duet and the A side into your computer. The Duet will appear as a COM port on your computer. The USB A-to-B cable is USB 2.0 and can be easily obtained online. This is one way of connecting the Duet to RHS Control.

USB A

The USB A port is used primarily to update the Duet’s firmware.

Ethernet

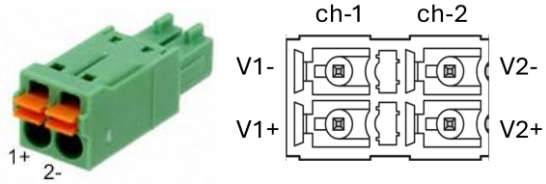


The Ethernet jack can be used to connect to RHS Control over a network, allowing datalogging and control from anywhere on that network. For full compliance with the European Union CE Directive, a fully shielded twisted pair ethernet cable must be used.

Analog Outputs

The Duet comes with two analog outputs, which are independently configurable. For each of the analog outputs, you can choose which parameter to transmit, scale its range, and select between current and voltage. Please refer to section 6.2.2 ‘Configuration of Analog Outputs’ on page 21 to learn how to configure the analog outputs.

Two 2-pin Phoenix Contact connectors (Part Number: *1952267*) are supplied with the instrument. These can be used to make up a custom cable for your installation.



With the orange push tabs facing up, pin one is on the left side, and pin 2 is on the right. In the connector, pin 1 is always the positive voltage and pin 2 is the negative voltage, regardless of which channel you plug into. Wires with appropriately sized ferrules (like the 24 AWG AW02506) are recommended for installation. With ferrules, the orange push tabs should only be needed for removing the wires. Pushing the ferrules in is usually sufficient for a strong connection.

Analog Channel 1 is on the left, and Analog Channel 2 is on the right. The connectors provided allow for connecting to one channel or the other, but not across two. V+ indicates the higher voltage in either voltage or current mode. V- indicates the lower voltage. In the voltage mode, V- is grounded internally.

The Duet allows both a voltage and a current output signal. Switching between 0... 20 mA, 4... 20 mA, or 0-5V is done either on the screen or with serial commands. Inside the instrument, the output signal from a DAC is split into a voltage and a current signal. The desired signal is switched to the connector at will. Therefore, you may use either a voltmeter or an ammeter to measure the analog signal. The configuration of the analog outputs is described in section 6.2.2 ‘Configuration of Analog Outputs’ on page 21

The maximum output voltage range is 0 to +5 V in voltage mode and 0 to 12V in current mode when open-circuited. Because of this difference, it is important to verify the channel is configured correctly before plugging into a voltage-sensitive instrument to avoid damage.

4.3.2 Gas Paths

Measuring Head Input/Output

Inlet sample gas is connected directly to the measuring head. Inside the Duet, Teflon tubing connects from the inlet fitting to the measuring head. After the measuring head, the gas passes through Teflon tubing to the pressure sensor, flow meter, and pump before reaching the Output port.

On Duet-HT units, the internal gas inlet and outlet tubes are heated, electro-polished stainless steel. The outlet from the measuring head returns to the back panel, where the sample gas can be directly vented or connected to the flow meter/pressure sensor, and/or the sample gas pump.

To prevent condensation when measuring at dew points above ambient temperature with the Duet-HT, excess water vapor must be condensed or trapped if the gas flow is connected to the flow meter or sample pump inlet connections, which are not heated. The optional steam trap is one such method of accomplishing this.

Inlet Sample Hose Heating (Duet-HT)

For measuring a dew point above ambient temperature, an externally heated sample hose must be used to prevent condensation in the sampling system.

The Duet-HT is equipped with a connection and internal control for one external heated hose. The electrical connector ***Heated Hose*** is directly to the left of the gas input fittings. The connector is compatible with legacy Heated Hoses sold by RH Systems, but only the 24V models. If you need additional or replacement Heated Hoses or need a different length, contact RH Systems. If you need to return the sampled gas in its original condition (closed loop applications), Heated Hoses with external temperature controllers are also available. For control of the external heated hose, see section 6.2.1 ‘Heaters (Duet-HT Only)’ on page 20.

Gas Pump Input/Output

The Duet is fitted as standard 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/flow rate can be changed on the touchscreen by long pressing the ***Pump*** button and adjusting the power output between 0 and 100%. See section 6.1.4 'Pump' on page 20 for details.

> For the Duet-HT, the internal connecting tubes for the sample pump and the sample pump itself are not heated. When measuring at dew points above ambient, the gas pump can be bypassed to avoid internal condensation or 'flooding'. By installing a steam trap between the measuring head outlet and the pump inlet, the internal sample pump can be used in these conditions. See 'Steam Trap' on page 25 for more details.

4.4 External Temperature Connections

The external temperature socket on the back panel is used to connect an external temperature probe. External temperature measurements are required for the Duet to calculate certain humidity parameters, such as relative humidity (%RH). External temperature measurements are not required for dew or frost point measurements.

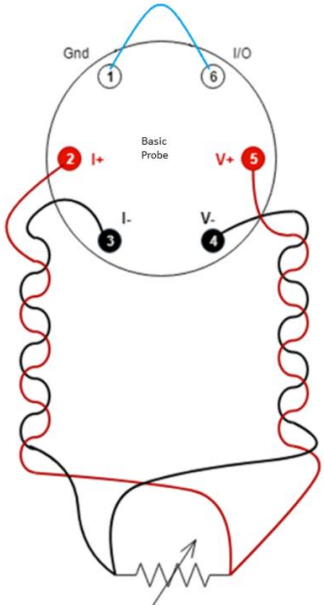
If you wish to connect your own Pt100 probe, the Duet requires a 6 pin LEMO connector (www.lemo.com), part number FGG.1B.306.CYCD42 (crimp) or FGG.1B.306.CLAD42 (solder).

The dot aligns between pins 1 and 6. 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:

Standard Probe Configuration:

Pin	Signal
1	Jumper
2	+I
3	-I
4	-V
5	+V
6	Jumper

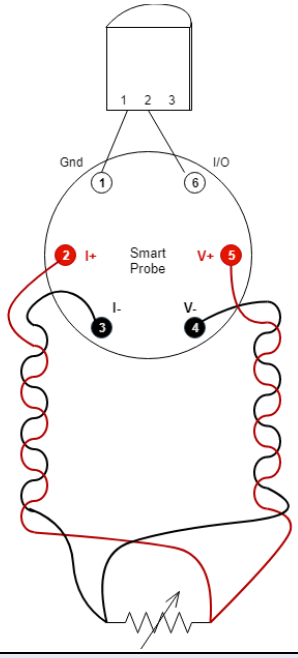
Key: G



When viewing the solder tubs (or pin holder) of a disassembled 6-pin LEMO connector, pin 1 is usually identified with a full or partial circle drawn around it. A line is then drawn towards the other pins in ascending order. 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).

In a standard probe configuration, the user must manually enter the probe coefficients into the Duet. Contact RH Systems for more information.

Smart Probe Configuration:

Pin	Signal	Position	Description
1	GND		Each smart probe's LEMO connector is embedded with a Maxim Integrated DS28EC20 20Kb 1-Wire EEPROM chip. This memory chip holds the probe's coefficients, serial number, and calibration date. When a smart probe is plugged in and programmed, the Duet automatically detects it and extracts configuration information from the chip. Manual entry of coefficients is not required as the configuration information travels with the probe regardless of which Duet it's plugged into. Connector assembly with the chip can be challenging. Contact RH Systems for detailed assembly instructions.
2	+I		
3	-I		
4	-V		
5	+V		
6	I/O		
Key: G			

When the 6-pin LEMO connector is properly assembled, the red dot of the housing is located between pins 1 and 6.

If a user's own PRT is utilized, the external temperature PRT coefficients in the Duet must be programmed on the Duet's touchscreen. If the jumper wire is used in probe construction, these coefficients will be saved to the Duet. However, if a Smart Probe is used, the coefficients will be saved to the chip instead. If a Standard probe is swapped for a Smart Probe, the coefficients stored on the probe will be used, and those saved to the Duet will not. If any other non-Smart Probe is connected after, it will revert to the Duet-saved coefficients. Contact RH Systems or your supplier for further advice.

4.5 Steam Trap Connector (Duet-HT only)

This connection enables automated control of a steam trap on the gas outlet from the measuring head. This means that water vapor with a dew point above the steam trap's temperature will condense into the trap. The electrical connection is for a solenoid that occasionally vents the condensed water from the steam trap to a container. If a project-specific connecting cable is required for a steam trap, a 2-pin LEMO connector, part number FGG.1B.302.CYCD42 (www.lemo.com) can be used. The dot is placed on pin1.

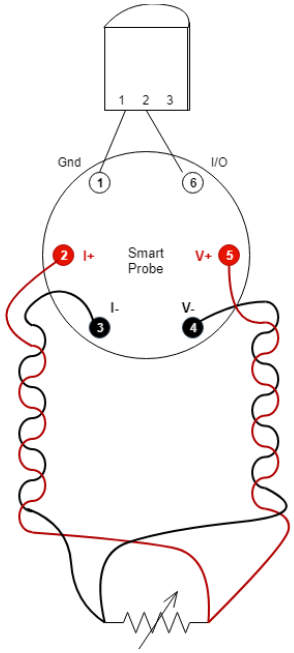
Pin	Signal	Position	Description
1	+24V (max. 15W)		When looking at the solder tubs or pin holder of a disassembled 2-pin LEMO connector, pin 1 is usually identifiable by a full or partial circle around it. Pin 2 should have no identification.
2	GND		

4.6 Second Mirror PRT Connector

The chilled mirror of the Duet contains two embedded wire-wound 100Ω Platinum Resistance Thermometers (PRTs). The first PRT is wired directly to the Duet's thermometer for onscreen indication. The second PRT is wired directly to the back panel. The wiring for this pin is identical to the external temperature probe, except that the Smart probe chip and the PRT are on the inside of the unit, while the thermometer will be the externally connected device. The keying is different for this connector (A instead of G). The connector part number is FGA.1B.306.CYCD42 or FGA.1B.306.CLAD42, and may be purchased through RH Systems or www.lemo.com

Pin	Signal
1	GND
2	+R
3	-R
4	-R
5	+R
6	I/O

Key: A



The EEPROM in this case is installed inside the Duet. This allows the mirror PRT coefficients to be saved on the Duet and read by a Smart Probe compatible device, like an RH Systems PT12 Thermometer. If your thermometer does not support Smart Probes, connect only to pins 2 through 5 and enter the coefficients manually.

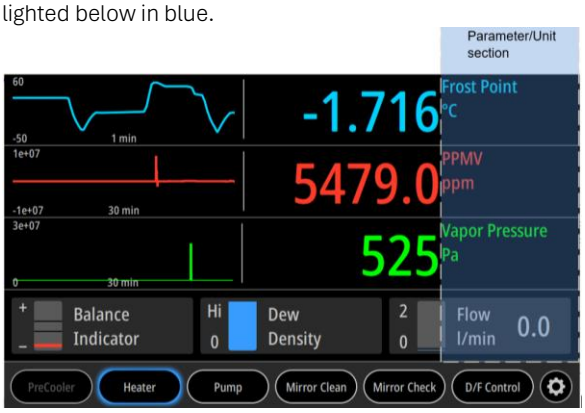
The Second Mirror PRT Connector is supplied with a cable that breaks out to flying leads for easy use with an external Thermometer. GND is Black, I/O is Blue, the two red wires are one side of the PRT, and the two white wires are the other side of the PRT.

5 System Configuration

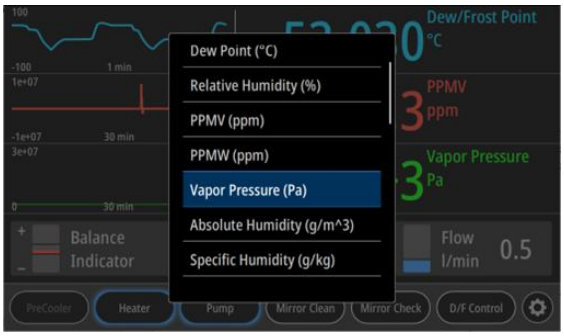
Many aspects of the Duet can be configured depending on your measuring needs and preferences. You can choose which humidity, temperature, and pressure values will be indicated on the screen, their order and units, and whether each will be shown as a number, graph, or both. In addition to the display options, you can define how the Duet performs its control functions, such as Dew/Frost determination. Configuration settings will remain until they are changed.

5.1 Selection of Indicated Parameters

On the main screen, you can easily select which parameters you would like displayed. On the Data Line you want to change, touch in the Parameter/Unit section of the screen to the right of the value or graph (not the number itself, this opens a different menu). This area is highlighted below in blue.



This brings up the parameter selection menu. Simply scroll through the list and select the desired parameter to display on that line:



When you select parameters for display on any of the Data Lines, those selections remain until you change them again, even after you turn the Duet off.

The Status Line, which by default displays the Balance Indicator, Dew Density, and Flow, is also a Data Line, and can be selected by taping the same right-hand segment of the line, as shown in the first picture. It can be changed to any other parameter, and any other Data Line can be selected as a Status Line (Bar Graphs) if desired.

List of Selectable Parameters:

Parameter	Description
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. Below 0°C, Dew Point is not the same as Frost Point, but both can be reported in harmony on the Duet.
Dew/Frost Point	Above 0°C, this value will be identical to **Dew Point**. Below 0°C, it indicates the temperature to which a gas must be cooled for water vapor to begin depositing as ice. Frost point is pressure-dependent and must be stated together with its associated pressure. While incorrect, it was previous industry practice to report frost point values below 0 °C as dew point. However, they are numerically different values. For further explanation on dew or frost point, refer to 'Why it is Important to distinguish between Dew and Frost' on page 17.
Relative Humidity	The ratio between the amount of water vapor in a sample and the maximum amount possible at that same temperature and pressure. If you choose this parameter, but have not connected the external temperature sensor, no reading will be displayed.

Duet Chilled Mirror Hygrometer

Parameter	Description
%RH WMO	The ratio between the amount of water vapor in a sample and the maximum amount possible at that same temperature and pressure is calculated using the World Meteorological Organization (WMO) formula, where the value is computed from the vapor pressure over *water*, even when the dew point is below 0°C. If you choose this parameter, but have not connected the external temperature sensor, no reading will be displayed.
Volume Ratio	The ratio of the water vapor volume to the volume of the remaining sample gas constituents, generally expressed in parts per million by volume (ppmv) or its numerical equivalent µl/l. Once determined, ppmv has no further dependence on pressure nor gas type or mixture.
Weight Ratio	Weight ratio is the ratio of the mass of water vapor to the total mass of the sample gas, generally expressed in parts per million by weight (ppmw) or its numerical equivalent mg/kg. Once determined, ppmw has no further pressure dependence but depends on the gas type and mixture through the molecular weights of the constituents.
Absolute Humidity	The mass of water vapor per unit volume of humidified gas.
Specific Humidity	A ratio of the mass of water vapor per unit mass 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.
Head Pressure	The pressure of the gas sample nearest the measuring head.
Flow	The flow rate of the sampled gas.
External Temp	The temperature measured by the external temperature probe. If you choose this parameter, but have not connected the external temperature sensor, no reading will be displayed.
Head Temp	The temperature of the Optic Module. Unlike the Duet-HT only components, the optic module isn't actively heated, and can therefore be a few degrees below the others while the heater is on.
Bar Graphs	A display of the Balance, Layer Density, and Flow Rate indicators.
Mirror Temp	The current mirror temperature, as measured by the mirror's embedded PRT.
Mirror Resistance	The measured resistance of the mirror's embedded PRT.
Ext Resistance	The measured resistance of the external temperature probe.

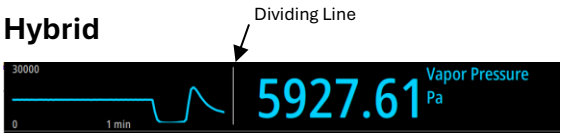
The following Parameters are only available on the Duet-HT:

Parameter	Description
Input Tube Temp	The temperature of the tube running from the back panel to the measuring head.
Output Tube Temp	The temperature of the tube running from the measuring head to the back panel.
Bulkhead Temp	The temperature of the gas input/output fittings on the back panel.
Heat Sink Temp	The temperature of the heat sink and measuring head surrounding the mirror.
Elbow Temp	The temperature of a small adaptor between the internal tubes and the measuring head.
Heated Hose Temp	The temperature of the input Heated Hose. If disconnected, no reading will be displayed.

5.2 Selection of Numeric or Graphic Data Display

Any data line may be viewed in numeric, graphic, or a hybrid format. The Duet automatically maintains a data history of every selectable parameter, so a graph of all data for that parameter since power-on can be viewed as desired. To dynamically adjust the graphs and numbers, slide the vertical white ***Dividing Line*** on the data line to the right or left. Below are examples of the same parameter in each mode.

Hybrid



Full Numeric

Full Graphic

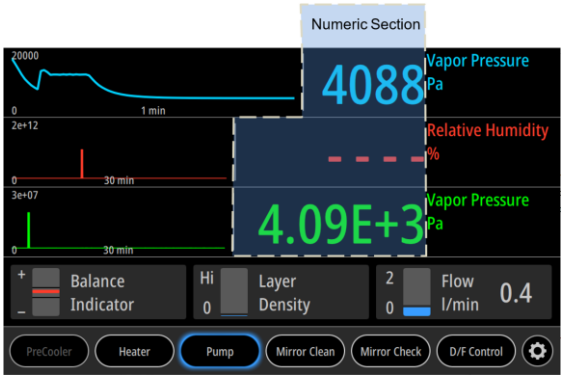
Hybrid pushed more to the right

In Hybrid configuration, the numeric value will lose significant figures after the decimal place as needed to fit both the graphic and the numeric while adhering to the dividing line. Moving the line to the left will restore the number of significant figures as defined in the ***Numeric Format Menu***.

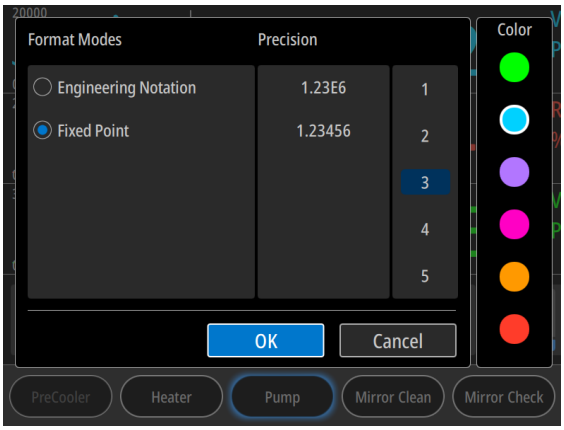
Double-tapping on the white dividing line moves the dividing line to the hybrid location where the maximum graph area is displayed, while the full numeric value (based on the chosen Numeric format and significant digits) is shown. Long pressing on the line aligns ***ALL*** Dividing Lines, making the sizes of all graphs consistent. In this case, the ***Dividing Lines*** align at the location just to the left of the longest number, so that all numeric values are displayed in full selected format.

5.2.1 Numeric Configuration

The ***Numeric Format Menu*** can be accessed by touching the numeric value on the desired Data Line. If the Data Line is in ***Full Graphic*** mode, you will need to first slide the white dividing line over to the left to expose the number.



In the ***Numeric Format Menu***, you can select between Engineering and Fixed-Point notation on the left, and on the right the number of significant figures after the decimal place to be shown. You can swipe up on this section to get to higher numbers. The middle area gives an example of a number in the selected format.

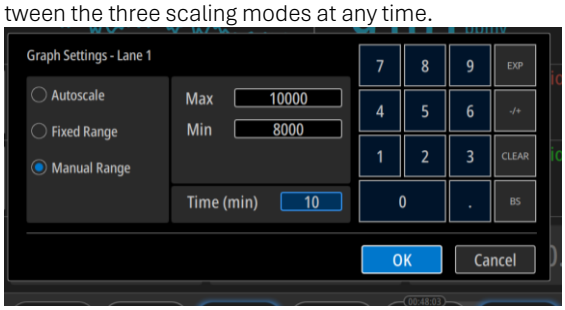


You can also select between 6 different colors. All Data Lines can be the same color if desired, but the background is always black. On the next page is a demonstration of some different options for the numeric display of the same Parameter:

On Data Line 1, the settings are Fixed Point, 0 precision; line 2 is Fixed Point, 2 precision; line 3 is Engineering Notation, 3 precision.

5.2.2 Graph Configuration

Each graph can have its own X and Y-axis scaling and range settings. There are three scaling modes to choose from: ***Autoscale*** (the default setting), ***Fixed Range,*** or ***Manual Range***. 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, tap on the graph you wish to change. A Graph Settings dialog box will appear. One of the buttons in the left-hand column will have a blue fill. This shows you the currently selected mode.
2. If you would like to change the scaling mode, tap the button of the mode you would like to select.
3. Tap the corresponding number in the middle column, next to the range that you have selected. It will go blank and be shaded blue.
4. Using the keypad, enter the desired value.
5. Once you have entered the correct value, press the next box whose value you wish to change. Once you are happy with the values, press the OK button to confirm. Press the Cancel button to abort all changes made in the dialog box. Both OK and Cancel close the menu.

Time Span

The Y-axis adjustments are always in the top box. The X-axis, ***Time***, is always on the bottom. The ***Time*** axis always spans from the current time on the right to the number of minutes in the past set in the ***Time*** box on the left. If the time since power-on is less than the set time, the graph will re-scale the graph dynamically to show only the data that currently exists. The graph will "zoom-out" as more data gets recorded.

Autoscale

The Autoscale mode is the default setting for this instrument. This mode automatically sets the scaling so that data is visible on the graph at the best possible resolution. As the data range changes, the graph's Y-axis scaling will change accordingly. In Autoscale mode, you can select the minimum range that you want the graph to scale to with the ***Min*** variable. For viewing temperature and dew or frost point graphs, setting ***Min*** to 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 Y-axis range becoming too narrow.

For example, setting ***Min*** to 0.1 while the Duet displays a steady dew point of 20.0 °C will set the graph's minimum and maximum values to 19.95 °C and 20.05 °C, a 0.1 °C span. 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 ***Range*** for the external temperature graph to 0.2 and the most recent measurement is 23.00 °C, all data between 22.80 °C and 23.20 °C is visible on the graph.

Manual Range

In the Manual Range 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 fall outside the specified range, they will not appear on the graph.

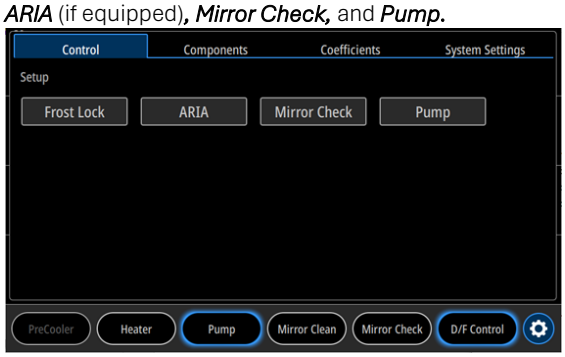
6 Settings

The Duet has several settings menus to configure the system to meet your requirements. There are 4 main menu tabs at the top of the screen: ***Control***, ***Components***, ***Coefficients,*** and ***System Settings.*** Each time you press a tab, the respective menu screen will display. When in a specific sub-menu, click the tab to return to the main menu.

While in the menus, the Duet will continue to operate in its existing mode, respond to serial commands, and record data in graphs. This includes ***Dew/Frost Control***, ***Pump,*** and ***Heaters.*** Which ones are enabled is evident from the highlighted fixed function buttons, which are always visible on the display.

6.1 Control Settings

The ***Control*** menus enable you to control how the Duet operates. It has the following sub-menus: ***Frost Lock, ARIA*** (if equipped)***, Mirror Check,*** and ***Pump.***



6.1.1 Frost Lock

When measuring dew/frost points between 0 °C and -40 °C, condensation on the instrument's chilled mirror may be dew, frost, or a combination of both. If the condensation state is unknown, it will introduce errors into all humidity measurements reported by the instrument.

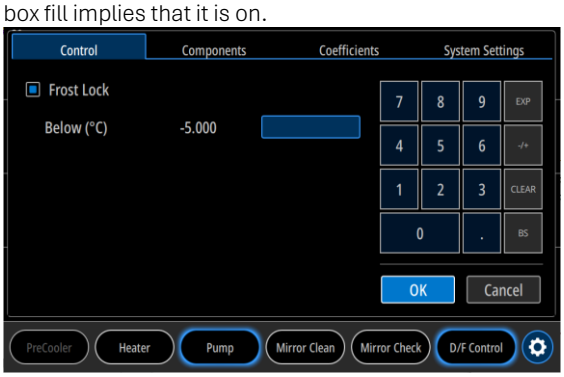
To eliminate this potential source of error, the Frost Lock function rapidly cools the mirror to below -40 °C, forcing all dew on the mirror to freeze. The mirror will then re-stabilize at the frost point temperature. Once the condensate layer is in a frost state, it will remain frost at all sub-zero 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.

layer to remain liquid at mirror temperatures of –20 °C and below.

Importantly, the difference in temperature between the dew and frost point can be up to 3 ˚C. Confusing matters further, it is also possible for dew and frost to coexist on the mirror, resulting in a non-stable value somewhere between the dew and frost point temperatures.

Therefore, the phase of the condensate must be known

Frost Lock can be toggled on and off by clicking on the square to the left of the words in the sub-menu. The blue box fill implies that it is on.



The ***Below (°C)*** value sets the temperature at which the Frost Lock Function activates. The default is -5°C. Valid Frost Lock ***Below (°C)*** values should be between -5 and -40.

During Frost Lock cooling, the mirror condenses a thick layer that must be "burned off" or decreased in thickness to return to an operational frost layer. This burn off is achieved by driving the mirror temperature to a value between the dewpoint (at the specified ***Below (°C)*** value) and °0C. If Frost Lock triggered at or near 0°C, the burn off temperature would have to be above freezing, and the mirror layer's frozen state could not be guaranteed. For this reason, it is important not to set ***Below (°C)*** too close to 0°C.

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.

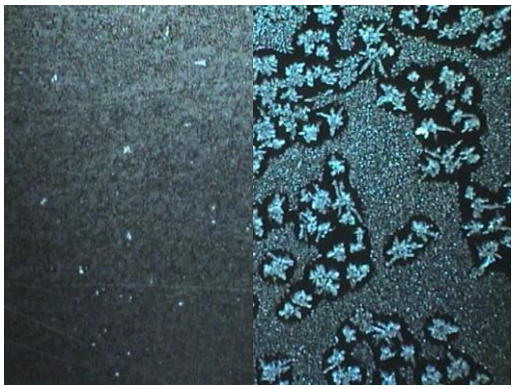
Although ice always melts at exactly 0 °C, water will not necessarily freeze at 0 °C. Water may stay a liquid at temperatures far below 0 °C. This phenomenon is referred to as 'Super-Cooled Water'.

The fact that water at subzero temperatures can condense as either dew or frost makes it 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 allow the condensate

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, was often previous

practice to use dew point for temperatures below 0 °C when actually referring to the frost point. As discussed above, dew point can exist below 0 °C as supercooled water and differs from the equivalent frost point temperature. For the same vapor pressure, the frost point is approximately 10% of reading warmer than the corresponding dew point value (when expressed in °C). For example, a vapor pressure of 103 Pa corresponds to a frost point of −20 °C and a dew point of −22 °C. From a measurement perspective, it is imperative that a clear and consistent distinction be made between dew point and frost point.



On the left, Super-cooled Dew at -22°C, on the right, Frost at -20°C. Both layers formed under the same sample gas water vapor pressure.

6.1.2 ARIA (Standard Duet only)

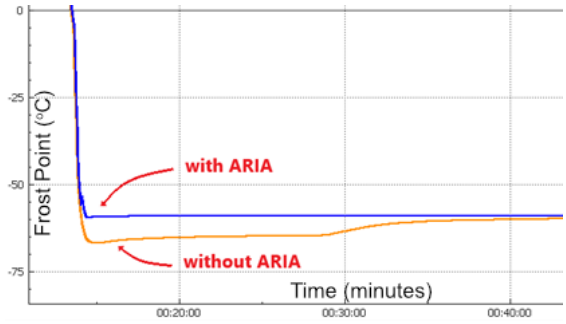
At low frost point conditions, the time to stabilize a condensate layer can be significant, sometimes several hours to reach equilibrium. ARIA (Accelerated Response Injection Algorithm) speeds up the measurement of low humidity, typically when the gas is drier than about -40 °C frost point. ARIA reduces stabilization time through a carefully programmed vapor injection procedure that accelerates frost layer formation, then interfaces with the mirror control system to maintain stability. This speeds the formation of a frost layer on the mirror surface, so that an accurate measurement takes minutes rather than hours.

If the user-entered threshold temperature is reached as the mirror cools and no condensate is detected, the ARIA valve will open and carefully inject vapor until a layer begins to form. The Duet will then close the ARIA valve and automatically control the layer thickness until stable.

ARIA can be toggled on and off by clicking on the square to the left of the words in the sub-menu. The blue box fill implies that it is on.

The ***Below (°C)*** value sets the temperature at which ARIA activates. The default is -40°C.

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

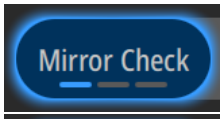


6.1.3 Mirror Check

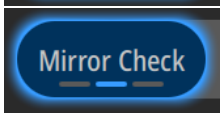
Mirror Check is the process of warming the mirror to evaporate all condensation, then initiating a new dew or frost point measurement. Mirror Check can be started manually with the fixed ***Mirror Check*** key or, if enabled, automatically at pre-specified time intervals.

Mirror Check aids in the determination of repeatability and can also be used to clear the mirror of condensable contaminants through evaporation.

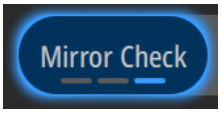
During a mirror check, whether triggered automatically or manually, the indicator on the fixed ***Mirror Check*** key has the following meanings:



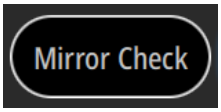
A Mirror Check is Initializing.



The Mirror is Heating.



The mirror is holding at the programmed Mirror Check Temperature.



The mirror check function is not currently active.

When Dew/Frost Control is active, a light gray line connects the two fixed function keys together. This indicates that Dew/Frost Control will resume after the mirror check.

If Dew/Frost Control was not running before, the end of the Mirror Check will not enable Dew/Frost Control, and there will be no light gray line connecting the two buttons.

Once the mirror check function is completed, the ***Mirror Check*** button stops glowing blue. If Dew Frost Control was enabled before the Mirror Check, the ***D/F Control*** button will glow blue again, signifying Dew Frost Control is cooling the mirror to re-acquire a layer and resume measurement.

A mirror check is a good first step when troubleshooting a potential measurement error, as it burns off contaminants and resets the measurement by forming an entirely new layer. If a Mirror Check does not resolve measurement errors, please refer to section 10.1 ' Mirror Cleaning' on page 41.

The settings for mirror check can be found in the ***Control*** menu or, alternatively, by long pressing the ***Mirror Check*** fixed function key.

The following settings can be adjusted for Mirror Checks:

Warm To Temp (°C):

Sets the temperature, in degrees C, that the mirror will be heated to, and temporarily held at, during ***Mirror Check***.

Hold Time (min):

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

Auto Enable:

If automatic ***Mirror Checks*** are desired, (for instance to deal with contamination as described in section 7.1.6 'Sample Gas Contamination' on page 26, simply select the ***Auto Enable*** button. The blue glow around the button shows that ***Auto Enable*** is active.

When ***Auto Enable*** and ***Dew/Frost Control*** are on, the ***Mirror Check*** key at the bottom of the screen displays a countdown timer indicating the time until the next automatic mirror check. In the automatic mode, a mirror check may still be initiated manually by pressing the ***Mirror Check*** button.

Auto Interval (min):

The ***Auto Interval*** is the number of minutes between automatic mirror check operations. Use the numerical keypad to enter the desired cycle time in minutes. For example, since there are 1440 minutes in a day, entering 1440 results in daily automatic mirror checks.

6.1.4 Pump:

Pump Power, which directly influences the flow through the Duet, can be adjusted from 0 to 100%. The Pump Settings can be accessed through the Control menu, or by long-pressing the ***Pump*** fixed function key. Setting the percentage too low may cause the pump to not run at all. Percentages above about 25% are recommended.

6.2 Component Settings

Component settings include submenus for the Analog Outputs (***Analog Out Ch1*** and ***Analog Out Ch2),*** as well as ***Heaters*** and ***Steam Trap*** on the Duet-HT.

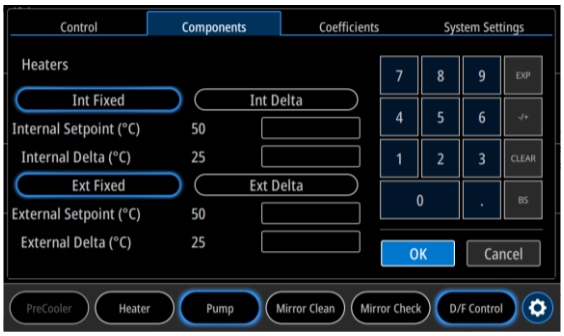
6.2.1 Heaters (Duet-HT Only)

For the purpose of measuring dew points above ambient temperature, the Duet-HT is equipped with heated components to prevent condensation in its gas path. Additionally, a heated sample hose can be connected to the Duet to prevent condensation in the path from the sample area to the Duet-HT

The measuring head and all internal heated sample tubes are controlled at a common set point. A separate control set point is available for the external heated sample hose. Both variables may be defined as either ***fixed*** set points (i.e. 85°C), or a ***delta*** temperature above the current mirror temperature (i.e. dew point + 15°C). Both variables may be enabled/disabled independently.

It is also possible to run one heater group in a fixed set point mode, with the other running in delta mode. Since the measuring head (and internal components) heating is completely independent from the heating of the external heated hose, any combination of control is acceptable. Keep in mind that all components, including external fittings and interconnects, must also remain above the dew point of the gas being measured to prevent condensation with the gas path.

The following settings can be adjusted for the Heaters:



For the Internal Heaters, select ***Int Fixed*** to maintain a fixed setpoint of the value of ***Internal Setpoint (°C)***, which you can set by clicking on the box to the right and entering the desired temperature with the keypad. Alternatively, select ***Int Delta*** to set the heaters to a number of degrees above the current measured dewpoint equal to the value of ***Internal Delta (°C)***

Note that the highest possible internal temperature in either mode is 85°C.

The Settings for the External Heated Hose are identical. Select ***Ext Fixed*** to maintain a fixed setpoint of the value of ***External Setpoint (°C)***. Alternatively, select ***Ext Delta*** to set the heaters to a number of degrees above the current measured dewpoint equal to the value of ***External Delta (°C)***.

Note that the highest possible external temperature in either mode is 105°C.

Press the *OK* button in the dialog box to confirm new values. Press *Cancel* to leave it unchanged. Pressing either button closes the menu.

Once configured at the desired fixed or delta set points, turn the heaters ON or OFF using the fixed function ***Heater*** button.

> WARNING: When using the heater functions above 50 °C, surfaces of the measuring head and the gas inlet and outlet connectors on the Duet-HT can be very hot and can cause burns if touched. Take care and wear protective gloves if handling hot components.

Steam Trap (Duet-HT only)

The Steam trap controls consist of a single solenoid that is toggled on and off to drain the condensed fluid. There are three settings for the Steam Trap: Turning the steam trap control on and off, setting the Cycle Time, and Setting the Drain Time.

To turn the steam trap control on and off, tap the square to the left of ***Steam Trap***. A square filled with blue indicates that control is enabled.

Cycle Time (min) sets the amount of time between drain events.

Drain Time (sec) sets the amount of time the Drain is open for.

In this example, every 45 minutes, the Solenoid energizes and the Steam Trap drains for 10 seconds. After the solenoid closes, the 45-minute timer restarts.

Draining the Steam trap causes a momentary drop in flow across the mirror, because a break is created between the pump and the mirror. Therefore, you may observe a momentary change in the Dew Point reading during a drain event. Adjusting the ***Cycle Time*** and ***Drain Time*** can minimize these disruptions while preventing the Steam Trap from becoming flooded.

6.2.2 Configuration of Analog Outputs

The Duet comes with two analog outputs which are independently configurable. For each of the analog outputs, you can choose which parameter to transmit, scale its range, and select between current and voltage. These selections are configured per output through the ***Analog Out CH1*** and ***Analog Out Ch2*** menus.

Access the Analog Outputs menus through the ***Components*** menu.

The setup for the analog outputs is simple. Select the parameter you would like to track with the drop-down box in the ***Linked Sensor*** line. Most parameters available for display on the main menu are available here.

Then select between ***Off, 0-5V, and 0-20mA.*** Off leaves the voltage of the positive pin at the same voltage as the negative pin. ***0-5V*** puts the output in voltage mode, and ***0-20mA*** sets the output mode to current. The limits of each range are identified in their buttons. The selected mode button will glow blue.

For each mode, a linear slope between two points: (***Sensor Min, Output Min***) and (***Sensor Max, Output Max***), is defined by the user. ***Sensor Min*** and ***Sensor Max*** define the upper and lower limits of the measured parameter to map to ***Output Min*** and ***Output Max*** respectively. For example, assume you entered the following values:

Linked Sensor: Dew Point

Sensor Min: -60

Sensor Max: 20

0-5V

Output Min: 0

Output Max: 5

In this case a dew point of -60°C would have an output of 0V, a dewpoint of 20°C would have an output of 5V. The relationship is a linear y=mx+b equation, alternatively written in a single equation as:

$$P = S_{min} + \left(\frac{S_{max} - S_{min}}{V_{max} - V_{min}} * (V - V_{min})\right)$$

Where P is the selected parameter (in this case Dew Point), S_{min} and S_{max} are the sensor min and max respectively, V_{min} and V_{max} are the output min and max respectively, and V is the output voltage.

In this example, a voltage of 4.59V would correspond to a Dew Point of 13.44°C. In current mode, *Voltage* becomes *Current* in the equation above, and V, V_{min} and V_{max} are the output current.

Both ***Output Min*** and ***Output Max*** can be set between 0 and 5V (or 0 and 20mA), but cannot exceed either value. For example, it is common in current mode to measure a range of 4 to 20 mA instead of 0 to 20 mA. This would be accomplished by selecting the ***0-20mA*** button, then setting ***Output Min*** to 4, and ***Output Max*** to 20.

If your application is measuring a %RH range of 5 to 15%, you can get more resolution by shrinking the measuring range down so that that 5%RH is 0V and 15%RH is 5V.

Values below or above this range stay locked at the minimum or maximum output. For example, if ***Output Max*** is 3V and ***Sensor Max*** is 10°C Dew Point, a dew point of

20°C would still have an analog output of 3V.

6.2.3 Coefficient Settings

These values are in password protected menus. To adjust the coefficients of the mirror or the external temperature probe, contact RH Systems.

6.2.4 System Settings

System settings display System information and allows for the setting of system-wide units for Temperature, pressure, and flow rate.

ID indicates the type of mirror, in this case a standard Duet.

SN indicates the Serial Number of the unit. This should match the Serial Number on the back panel of the unit, and the Serial Number on RHS Control or when queried with serial commands.

Access Code allows for calibration and diagnostic control. If you believe you need this functionality, please contact RH Systems.

Pressure, *Temperature*, *Vapor Pressure, Specific/Absolute Humidity,* and *Flow* set the global units for the Duet. To select a different unit, select the box to the right of the parameter and select the desired unit. The Duet includes a broad selection of units for each parameter. The full list of units can be found in in the next section.

6.3 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, meaning that all values of that parameter type across the system will be converted to the chosen units. For example, changing the temperature units to °C will display all temperature data in °C.

> Data retrieved via serial communication will always be in SI units regardless of the units chosen for display. Also note that settings in dialog boxes used to change system parameters are entered and displayed in SI units. Units only affect the four Data Lines.

Available units:

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

6.4 Ice Test

Measurement accuracy can be easily checked with an Ice Test. This simple built-in 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.

Ice Test utilizes the fact that ice melts at 0°C to verify system functionality. A layer of frost is first formed, and then it is slowly warmed until it melts. The temperature the Duet reports can then be compared to 0°C, and any offsets can be evaluated.

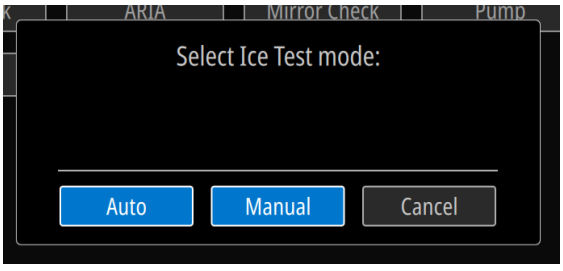
There are two Ice Test modes, ***Manual*** and ***Auto***. An ***Auto*** ice test will use the built in optics to detect the ice layer melting on the mirror and report the value, while a ***Manual*** test is conducted with the optic module off, allowing you to use your eyes to identify when the ice melts. This allows for first-hand human verification of measurement integrity. If a ***Manual*** Ice Test is successful but not an ***Auto*** Ice Test, this can isolate the Optical Module as the faulty component, rather than the mirror PRT.

> Ice Test will override dew/frost control functionality, and therefore any measurement in progress. If you start an Ice Test while dew/frost control is running, Dew/Frost Control will be disabled.

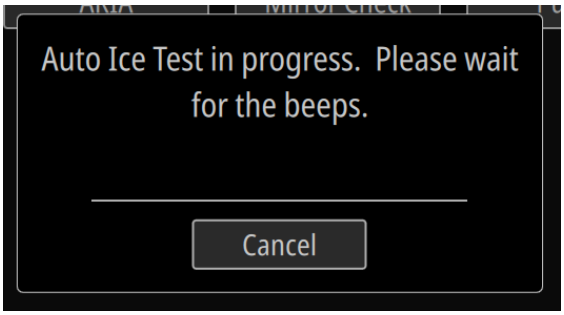
6.4.1 Auto Ice Test

From the ***Control*** menu, select Ice Test. Then Select ***Auto***. It is at this point that Dew/Frost Control will be automatically halted. However, pressing ***Cancel*** closes the Ice Test Dialog box, and will not halt Dew/Frost Control.

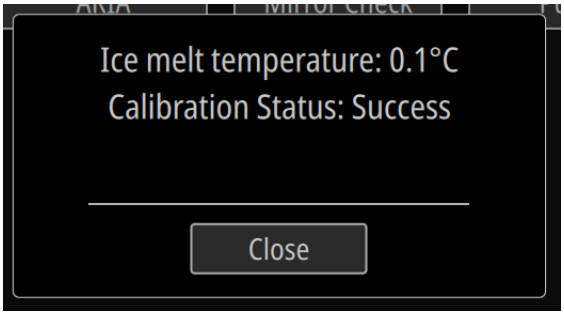
Be sure to leave the Optical Module and Cover connected to the Duet for an ***Auto*** Ice Test



The dialog box will change to display *"Auto Ice Test in progress. Please wait for the beeps."* The mirror will then proceed to cool to -40°C, before returning to 0°C, slowing as it reaches the melting point.



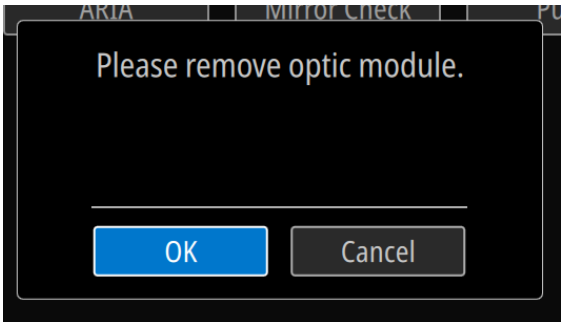
When complete, the mirror will chirp, indicate the determined ice melt temperature, and the margin of error. This datapoint is displayed but not saved. Pressing ***Close*** will close the pop-up window, an ending the Ice Test function.



6.4.2 Manual Ice Test

As in an ***Auto*** Ice test, from the ***Control*** menu, select Ice Test. Then Select ***Manual***. It is at this point that Dew/Frost Control will be halted. However, pressing ***Cancel*** closes the Ice Test Dialog box, and will not halt Dew/Frost Control.

At this point you will be presented with the following dialog box, telling you to remove the optical module.



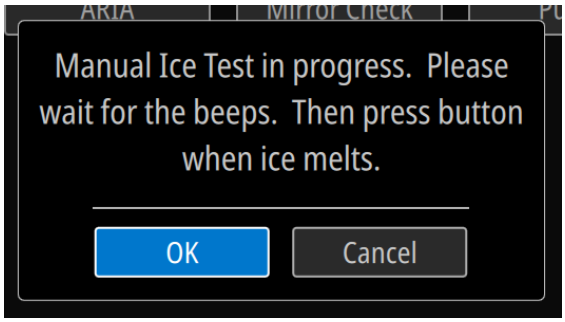
Remove the Snap Cover and Optical Module. The Duet Mirror should now be exposed as in the following picture. For more details on removing the optical module, section 10.1 'Mirror Cleaning' on page 41.

When you are ready to continue, and are in a comfortable position to observe the mirror for a few minutes, press ***OK***.

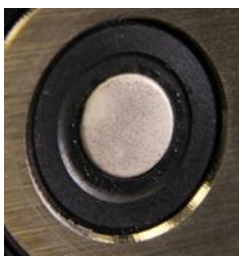
Note: it is often easier to observe the difference between dew and frost with a light source, like a small flashlight or penlight, directed onto the mirror.

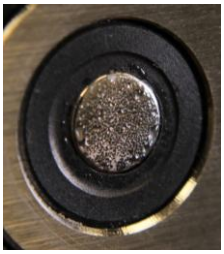
The mirror will then proceed to cool to -40°C, to build an ice layer, before returning to 0°C, slowing as it reaches the melting point. As it gets closer to the melting point, the Duet will begin to chirp, or beep, with increasing frequency to alert you to its immanence.

At the moment the mirror fully transitions from frost to dew, press the ***OK*** button. The moment you do this, a mirror temperature measurement is taken and presented on the next screen

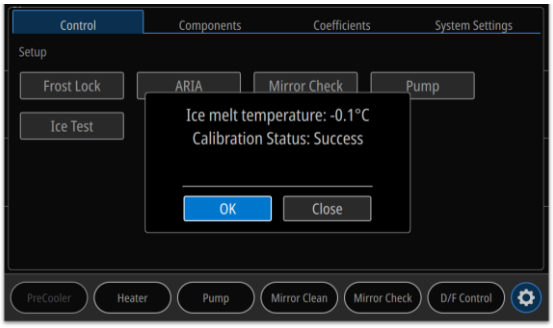


Below is an example of the melting from frost to liquid water:





After ***OK*** has been pressed, the mirror will indicate the determined ice melt temperature, and if it is within the margin of error of a correctly calibrated Duet. This datapoint is displayed but not saved. Pressing ***Close*** will close the pop-up window, ending the Ice Test function.



Clean and reassemble the measuring head as described in 'Mirror Cleaning' on page 41. At this point the mirror is ready for operation.

> It is best to avoid multiple mirror checks in quick succession, as it can cause a temporary buildup of moisture under the mirror. This can cause inaccurate mirror checks and can slow the speed of acquiring a new dew point.

7 Set Up and Operation

7.1 Measurement Set Up

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

7.1.1 Determination of the measurement range

Each Duet has a maximum operating range and a calibrated range in which the accuracy specification of of frost/dew point is achieved. Please refer to section 11 ‘Specifications’ on page 44 for full details.

In each case, the instrument’s minimum frost point will be limited by the measuring head temperature. For example, a frost point of -50 °C will not be possible when the measuring head heating is set to +80 °C.

Duet (-60 °C Frost Point to +20 °C Dew Point)

The Duet mirror’s cooling capacity and the materials of the measuring head limit its lowest frost-point performance. The ambient temperature (20 °C) sets the upper limit of the measurement range. If you attempt to measure dew points above ambient temperature, condensation will occur within the sample path and the measuring head, and damage to the instrument may result. With the inclusion of ARIA, the Duet is best suited to measure dry frost points.

Duet-HT (-40 °C Frost Point to +70 °C Dew Point)

The Duet-HT is equipped with heated components that enable an extended upper range of use. To avoid condensation, the Duet-HT controls the temperature of the measuring head, internal sample tubes to and from the measuring head (including the fittings on the back of the unit), and an external inlet sample hose. This variant trades maximum cooling performance for heating, and without ARIA, equilibrium times will take longer in the lower part of the measurement range than the standard Duet.

7.1.2 Sample Tubes

Sample tubes connect the Duet to the application. Careful selection and assembly will minimize the risk of leaks and, therefore, 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 (Fluorinated Ethylene Propylene) or Teflon may also be used.

The main adverse effect from sample tubing is adsorption/desorption, especially at low frost points. If a measurement changes from high to low dew points, trace amounts of water previously absorbed in the tubing can cause measurement errors as the water very slowly desorbs.

When measuring dew points above ambient temperature, a heated inlet sample hose is required. These are available from RH Systems in various lengths to suit your application. A rear panel connector is provided power and temperature control the heated hose.

7.1.3 Steam Trap (optional for Duet-HT)

When measuring dew points at temperatures close to or above ambient temperature, precautions must be taken to prevent condensation in the unheated flow meter, pressure sensor, and flow pump. Failure to do so can result in measurement errors, flooding, and possible damage to the instrument.

To address these issues, a steam trap is available as an option for the Duet-HT. It is connected to the measuring head outlet to condense water vapor, and includes an electrical connection to the Duet so that the condensed water can be drained as required. See Section 6.2 ‘Component Settings’ for more information on setting drain frequency.

When the sample gas with a high dew point passes through the steam trap, excess water vapor condenses and is collected. The remaining gas can then pass through the Duet flow meter and sample pump without flooding. Users can also implement their own steam trap within existing installations or sampling systems. See chapter 4.5 ‘Steam Trap Connector (Duet-HT only)’ on page 11 for the electrical connection of the steam trap.

However the steam trap is implemented, it is the user's responsibility to ensure that the equipment is correctly installed and set up.

IMPORTANT: Protect the Steam Trap from direct sunlight and warm areas. It should remain at or below room temperature if possible.

Installation notes:

The steam trap must be installed below the Duet to prevent water from flowing back into the measuring head.

If attached directly to the back of the Duet-HT, make sure it is free floating and not pushed by or set on any other surface or instrument. Failure to ensure this could result in damage to the steam trap or Duet.

7.1.4 Pressure

Frost/dew point is pressure dependent. It is therefore important that the measuring head pressure and the application pressure are the same, or that the effects of pressure are accounted for. The Duet has an integrated pressure sensor positioned in the gas path just after the measuring head. The Duet-HT features a pressure sensor located just before the flow sensor, outside the heated gas path. The pressure sensor is factory-calibrated and can be selected as one of the parameters to display or output. See section 11 'Specifications' on page 44 for pressure sensor specifications.

7.1.5 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; in contaminated applications mirror cleaning may be required more frequently.
2. At high dew point conditions, high flow means more water vapor, so condensation issues can be exacerbated.
3. At low frost points, a high flow rate can help purge the sampling system, minimizing desorption effects (which appear as a delay in reaching the correct value).
4. At low frost points, insufficient flow may increase stabilization time.

The optimal flow rate through the measuring head is typically 0.5...1.2 l/min.

To adjust the flow rate with the sample pump, long press on the ***Pump*** fixed function button, then adjust the % pump power until the flow matches the desired result.

7.1.6 Sample Gas Contamination

Contaminants in a sample gas can affect the measurement results obtained by any hygrometer. The Specially plated mirrors used in RH Systems hygrometers are extremely robust and will withstand most application gases.

Contaminants build up on the mirror surface and can cause measurement errors. During a manual or automated mirror check routine (see Section 6.1.3 'Mirror Check), the mirror can compensate for surface changes, though depending on conditions and contaminants, this may not be effective or may only be effective for a limited time. To reduce this effect, an inlet filter can be used.

Gases other than water within the sample flow may also condense on the mirror surface. The user should consider the gas makeup and check that gas condensation temperatuers are not above the likely water dew-point to be measured. Otherwise, the dew point of this other gas may be measured instead.

Sometimes, if a gas has a higher dew point than water but is at a much lower concentration, the mirror will track the water dew point for a period of time, until the other gas builds up enough of a layer to become dominant on the mirror. Then the Duet will change-over to track the dew point of the other gas instead. This can appear in the data as a sudden change in, or a gradual and steady increase of, the dew point. A mirror check usually

addresses this issue by attempting to evaporate the contaminant.

An automatic mirror check can also be utilized to perform this contaminant evaporation on a timed, periodic basis. The use of the Hold Time may also help to allow a longer evaporation time at the mirror check temperature.

7.1.7 Bypassing the Pump

Some Duet models are fitted with a pump to draw air across the mirror. If gas flow is provided externally (as when measuring the output from a dew point generator) it may be necessary for the gas flow to bypass the pump. This is because the pump can create a restriction that will at best create backpressure within the measuring head, and at worst will completely block the gas path.

Newer units have addressed this issue by replacing the pump with a high-power blower, which when off has adds no restriction to the gas path. Duet-HTs avoid this issue entirely by allowing you to choose whether to include the pump in the gas path by how you connect the ports on the back panel.

If your Duet has a pump, a bypass tube is included with your accessories.

To Bypass the pump, you will need to remove the top two screws on the back panel, remove the top panel, and then disconnect the flow meter from the pump, the pump from the back panel, and then route the bypass tube between the flow meter and the output. For detailed instructions on how make this change, see Appendix A

7.2 External Temperature

If a measurement application requires relative humidity (%RH), careful consideration of temperature measurement is critical to achieving accurate %RH results.

The Duet is supplied complete with a Pt-100 temperature probe (PRT). The probe must be placed in a position that accurately reflects the application's temperature condition (for example, in the middle of a sampled humidity chamber), or significant errors can result. Avoiding temperature instability is equally important, as there is a delay between the probe's instantaneous temperature reading and the time it takes for the sample gas to reach the mirror.

You can use the graphical data display mode to show stability over time.

Placing the temperature probe as close as possible to a %RH device under test (DUT) minimizes %RH errors from thermal gradients.

The PRT-specific coefficients are stored in the internal memory of the included Smart Probe. In a standard probe construction, the coefficients must instead be entered manually in the Duet. See section 4.4 'External Temperature Connections' on page 10 for more details. In the event that the probe is lost, damaged, or replaced, new coefficients must be entered to obtain a correct temperature measurement. Please contact RH Systems or your supplier for further advice.

7.3 Operational Considerations

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

7.3.1 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 Duet can be programmed to do this automatically. How often this is performed depends on the application, and this should be determined experimentally. Once per day is a good starting point, but initial supervision of mirror performance is advised.

Programming of the automatic mirror check system is described in section 6.1.3 'Mirror Check' on page 18. For instructions on cleaning the mirror please see section 10.1 'Mirror Cleaning' on page 41.

7.3.2 Inlet Filters

Inlet sample filters can be used to minimize the effects of particulate contamination and reduce the required frequency of mirror cleans. The correct filter type depends on the contaminants. The filter element should be non-hygroscopic, and filter pore sizing should be matched to the application. 0.5 to 50µ filters are typical, with a coarse then fine filter 'cascade' being ideal.

If installed, filters must be routinely maintained within operational procedures. An overly restrictive or blocked filter will reduce flow and could affect pressure at the measuring head, especially if the internal sample pump is used. In some circumstances, the use of a heated filter may be needed to prevent condensation within the sampling system, please contact RH Systems or your supplier for further guidance if needed.

8 Installation

8.1 Facility Requirements

8.1.1 Environmental

The Duet is a precise, laboratory quality instrument. While it does not require any special environmental controls, it works best when the temperature is stable and free of rapid fluctuations. It is best to keep the operating conditions within the following parameters if possible:

Operating Temperature: 10 to 30 °C

Operating Humidity: 5 to 95% RH non-condensing

Keep the Duet away from direct air flow output of room HVAC equipment

8.1.2 Power

Duet systems are equipped with universal power supplies capable of operation from 80 to 264 VAC at 47 to 63 Hz. Check that the power supply in your facility meets this requirement before connection and first use.

8.1.3 Instrument Cooling

All versions of the Duet use forced air cooled (fans) mounted on the back panel with ventilation slots on the base. Air is pulled into the instrument from the base and forced out through the back panel. Fan control is automatic and requires no user input. Air cooling is sufficient for dew/frost points from -60 to +70 °C in a typical ambient temperature range.

The rear exhaust fans must have at least 15 mm of clearance to provide sufficient air flow. For air input at the bottom of the unit, 15 mm of clearance from the bottom panel must also be provided. The Duet feet are the appropriate height to create the needed clearance when the Duet is set on a hard, flat surface. Do not operate the Duet on top of foam, fabric, or other soft surfaces where the feet can't create adequate clearance for the bottom intake vents. Failure to provide sufficient ventilation to ambient conditions may cause overheating. And failure to achieve proper dew point temperatures.

8.1.4 Heating of the Sampling System (Duet-HT only)

The Duet-HT is equipped with heated measuring heads, internal sample tubes, and external inlet sample tube control. Control settings are described in section 6.2.1 'Heaters (Duet-HT Only)' on page 20.

The Duet-HT includes overheating protection. Each heat sensitive component has a specific upper temperature limit. In the event of overheating, power to the heaters will be removed, and the Peltier driver will be disabled.

Measuring Head Heating

When measuring at high dew points, the measuring head can be set to a fixed temperature or a delta mode.

In delta mode, the head temperature is controlled to a fixed difference from the actual mirror temperature, so that even if the dew point changes, condensation in the measuring head is avoided.

In fixed mode, a stable fixed temperature is maintained independent of the measured dew point temperature. This provides the most stable condition, but lacks the ability to track changes in dew point and could result in unwanted condensation, or lack of adequate mirror cooling.

Internal Gas Path Heating

The measuring head inlet and outlet sample tubes can be controlled to a fixed temperature or to a temperature difference relative to the current mirror temperature (Delta mode). The control mode and temperatures are set via the touch screen menu. The main reason for heating the control path is to prevent condensation in the sample path.

It is important to note that the sample tubes to and from the flow meter, pressure sensor, and the internal sample pump are not heated. When measuring at dew points above ambient temperature, a steam trap must be fitted between the measuring head outlet and the flow meter and/or sample pump inlet to prevent condensate from damaging these parts of the system.

If the heating control is switched on while in delta mode and dew frost control is not active, the system will still heat to the target value. This means that the measuring head and sample tubes will be at a higher temperature, and there will be a limit to the minimum dew point temperature that can be reached while dew/frost control is activated.

External Heated Hose

The Duet-HT is equipped with a control port for an external Heated Hose. This feature allows the gas being drawn from the measured environment to reach the Duet without condensing. Heated tubes are available in various lengths with either 6 mm or ¼" Swagelok fittings. The Heated Hose includes a connection cable to plug into the Duet. Heated hose temperature is set within, and maintained by, the Duet.

8.2 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 of successful measurement. If, after carefully reviewing the manual, you still have questions about using the Duet in your application, contact your supplier or RH Systems.

8.2.1 Benchtop Use

All Duets are suitable for benchtop or other flat surface installation. An area of at least 0.6 x 0.6 m (24" x 24") is recommended. Make sure there is sufficient clearance around the instrument to allow air movement. See section 8.1.3 'Instrument Cooling' on the previous page for further guidance.

8.2.2 Rack Mounting (optional)

The Duet may be optionally equipped with a 4U 19" rack configured enclosure. The 8 front panel mounts are sufficient to hold the Duet in the rack without further support. It is recommended that the instrument is fixed to the rack before connection of the external power, sample tubes, heated hoses, and steam trap.

8.2.3 Sample Tube Connection

Correct specification and connection of sample tubes is critical for full measurement accuracy. Connect tubes with the shortest possible length and avoid unnecessary connections and possible pressure drops or restrictions. Use stainless steel for measurements below -50 °C frost point. FEP or Teflon is suitable for the remainder of the measurement range.

Make sure that the 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 manufacturer's instructions.

When connecting Swagelok fittings, it is best practice to tighten them ¼ turn past finger tight with a 9/16" (14 mm) wrench.

8.3 Preparation for Transportation

All shipping and transportation should be in suitable padded containers. A heavy-duty case with at least 50 to 100 mm (2 to 4 inches) of foam padding on all sides is recommended. All Duets ship with such a case, which should be retained for future transportation and storage.

Before transporting your Duet:

- 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 heated sample hoses are included, always ensure that the minimum bend radius of 4" is not exceeded.
- Ensure the optical head assembly and cover screw are firmly attached.
- Ensure accessories are stored in separate compartments inside the case to avoid damaging collisions in transit.
- Do not load a Duet-HT into its case directly after using the heaters. Wait at least 15 minutes after powering down to allow the unit to cool down to a safe storage temperature.
- Depending on case/foam configuration, the rack mounting kit may need to be removed prior to storage within the transport case.

9 Remote Communication

The Duet is equipped with bidirectional communication interfaces, including RS-232, USB 2.0, and Ethernet, allowing a broad range of digital communication options. This section provides the necessary information for using these interfaces, including hardware connections, communication settings, and command syntax.

9.1 Hardware Connection

9.1.1 RS-232

Connect to the Duet over RS-232 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. The 9-pin RS-232 extender cable is readily available from multiple vendors online.

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

* Denotes a required connection.

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

Communication Settings

To communicate with the Duet over RS-232, set your computer to the following configuration:

Baud Rate:	115200
Data Bits:	8
Stop Bits:	1
Handshaking:	None

9.1.2 USB to Serial Port

The USB Type B host port is used for connecting the Duet to a PC without the need for an external RS-232 to USB converter. The device will show up on a PC as a serial port and will need to be configured with the same serial settings as the RS-232 connection (above).

9.1.3 Ethernet

The duet can be accessed via raw TCP/IP over port 21. It has DHCP enabled by default, and the commands are syntactically identical to the RS-232 commands. Contact RH Systems for other options regarding the use of this port to interface with RHS Control over a Local Area Network (LAN).

9.2 RHS Control

RHS Control is provided with the purchase of a Duet and allows for easy and robust control, monitoring, and data logging for as many Duets, humidity generators, and other instruments as you can connect to one computer.

When you launch RHS Control, the main program loads and automatically presents the software splash screen followed by the Connection window. The splash screen indicates the software version number.

Connection Window

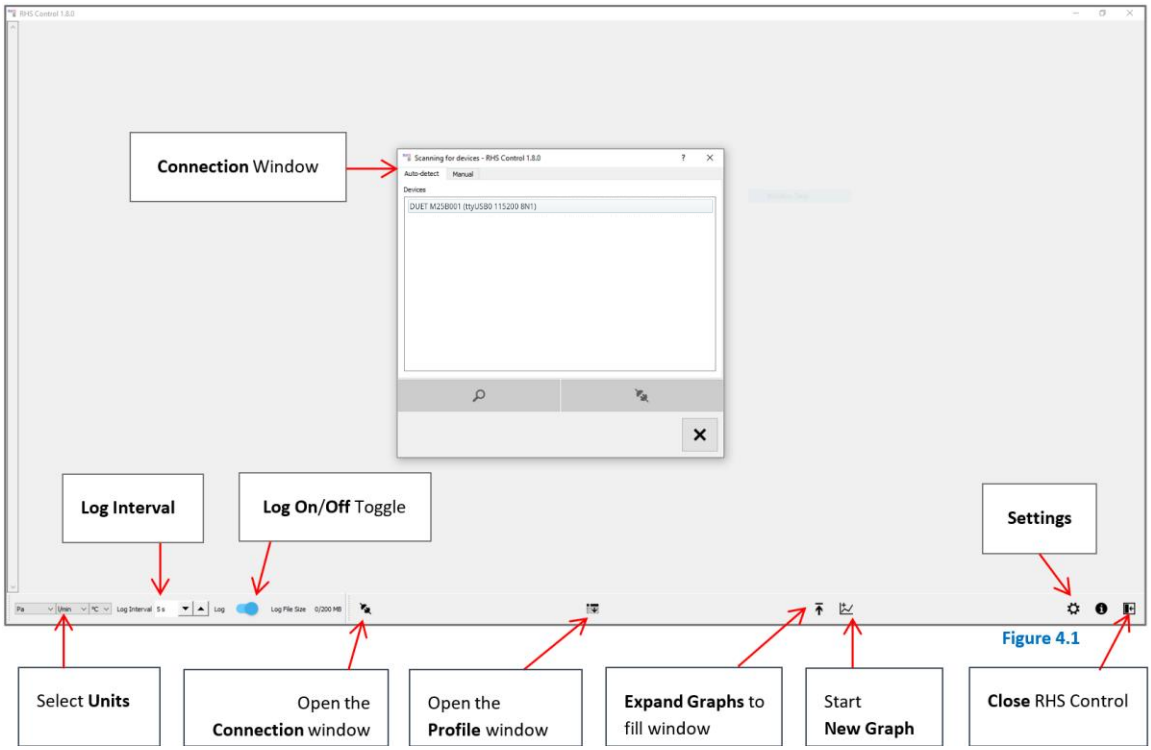
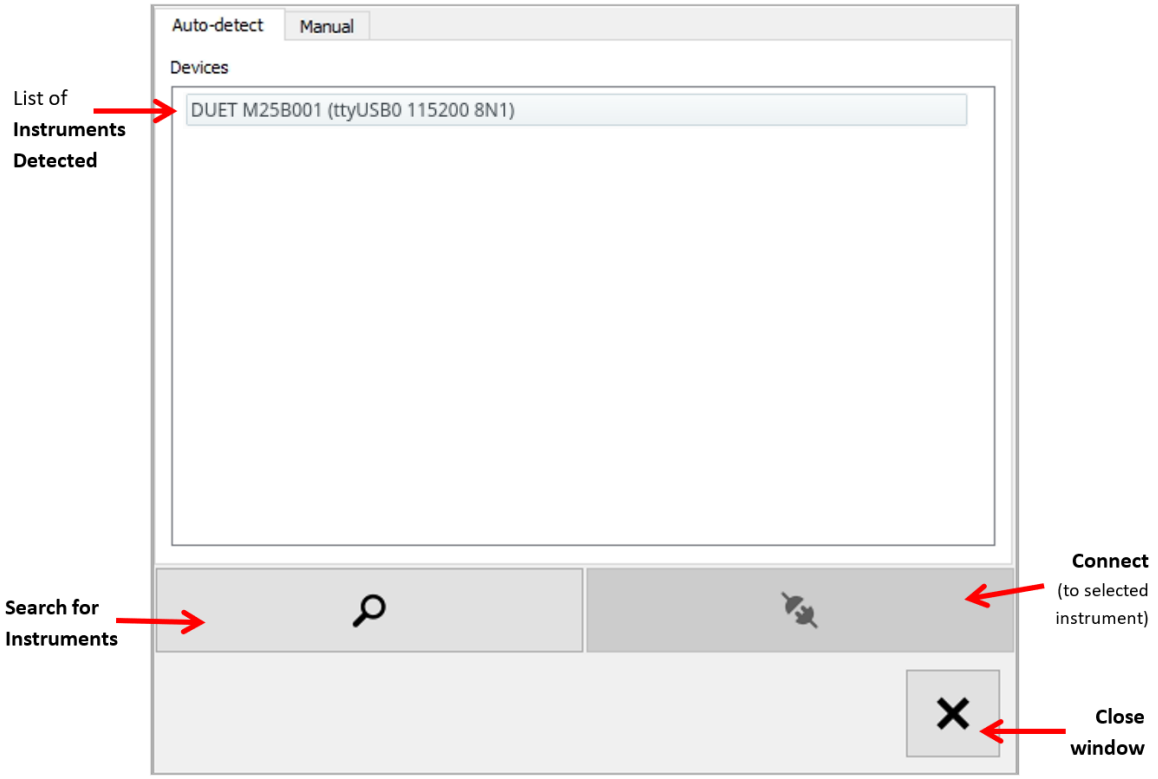


Figure 4.1

All instrument connections are initiated via the Connection window. When the program is first launched, this window appears automatically. However, it may be opened for use at any time simply by pressing the Connection button on the main RHS Control screen:



When the Connection window opens, it automatically searches for attached instruments.

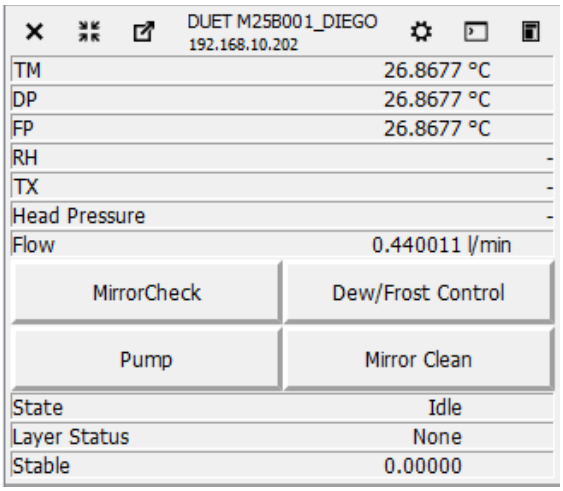
To connect:

1. If the instrument you want to connect with is not listed, ensure it is plugged into a USB port (via a USB/232 converter as needed), then press the **Search** button.
2. Click on any instrument(s) listed. The selected line(s) will highlight.
3. Click the **Connect** button. If there are no further instruments listed, the window closes automatically. If other instruments are still listed, the window remains open.
4. To close the window, press the **Close** button.

9.2.1 Duet Specific Controls

Once connected to a Duet, a unique control window will appear in the left-hand column of RHS control. If there are devices connected already, the newest connected device is always the furthest down. You may have to scroll down the column if this is the case

The following window is typical for a Duet:



Here you can see at a glance the main readings of the Duet, including TM (Mirror Temperature), DP, FP (Dew and Frost Points) RH, TX (External Temperature), Head Pressure and Flow. The values are abreviated to allow for more readable log files.

From left to right, the icons across the top banner have the following functions:

Close instrument connection

Minimize window

Undock this window away from main screen

Open **Secondary Data / Coefficients** menu

Open a **Mini Terminal** to send commands

Show **Serial Comm** data stream, which shows a live view of all sent and received data

In the middle of the window are 4 command buttons: ***MirrorCheck***, ***Dew/Frost Control***, ***Pump***, and ***Mirror Clean***. These function identically to the fixed function buttons on the bottom of the Duet screen. When the button is highlighted yellow, it is an indication that a command has been sent but RHS Control has not yet received confirmation of the changed state yet.

Pressing the **Secondary Data / Coefficients** menu brings up the following menus, which can be selected from the drop down just below the main window:

Other Measurements: includes most other measurements for water vapor listed in section 5.1 ‘Selection of Indicated Parameters’ on page 13. It also includes Head Temp and Head pressure. If an external temperature probe is not connected, certain values that require a temperature will display a dash, as this value cannot be calculated.

Mirror Temp: includes the averaged and un-averaged or “Raw” value for temperature as well as the mirror PRT’s measured resistance. It also includes values for adjusting the exponential moving average filter. AVGBAND sets the step size that resets the filter, while AVGCOUNT effectively sets the number of previous readings to average with the current reading. AVGCOUNT= 0 results in no averaging.

External Temp: is exactly the same as the Mirror Temp menu, but for the external PRT

Heat Control: only functional for the Duet-HT, this allows you to control the gas path heaters exactly as described in section 6.2.1 ‘Heaters (Duet-HT Only)’ on page 20

Heaters: displays the measurements involving the gas path heaters described in section 5.1 ‘Selection of Indicated Parameters’ on page 13

Peltier: Shows the Voltage and Current applied to the thermoelectric element controlling the mirror temperature. This is mostly for diagnostic purposes

ARIA: indicates if ARIA is currently active, allow for enabling/disabling ARIA, and setting the ARIA Below value as described in section 6.1.2 'ARIA (Standard Duet only)' on page 18

Mirror Check CFG: allows for configuration of Mirror Check as described in section 6.1.3 'Mirror Check' on page 18

Frost Lock: allows for the configuration of Frost Lock as described in section 6.1.1 'Frost Lock' on page 17

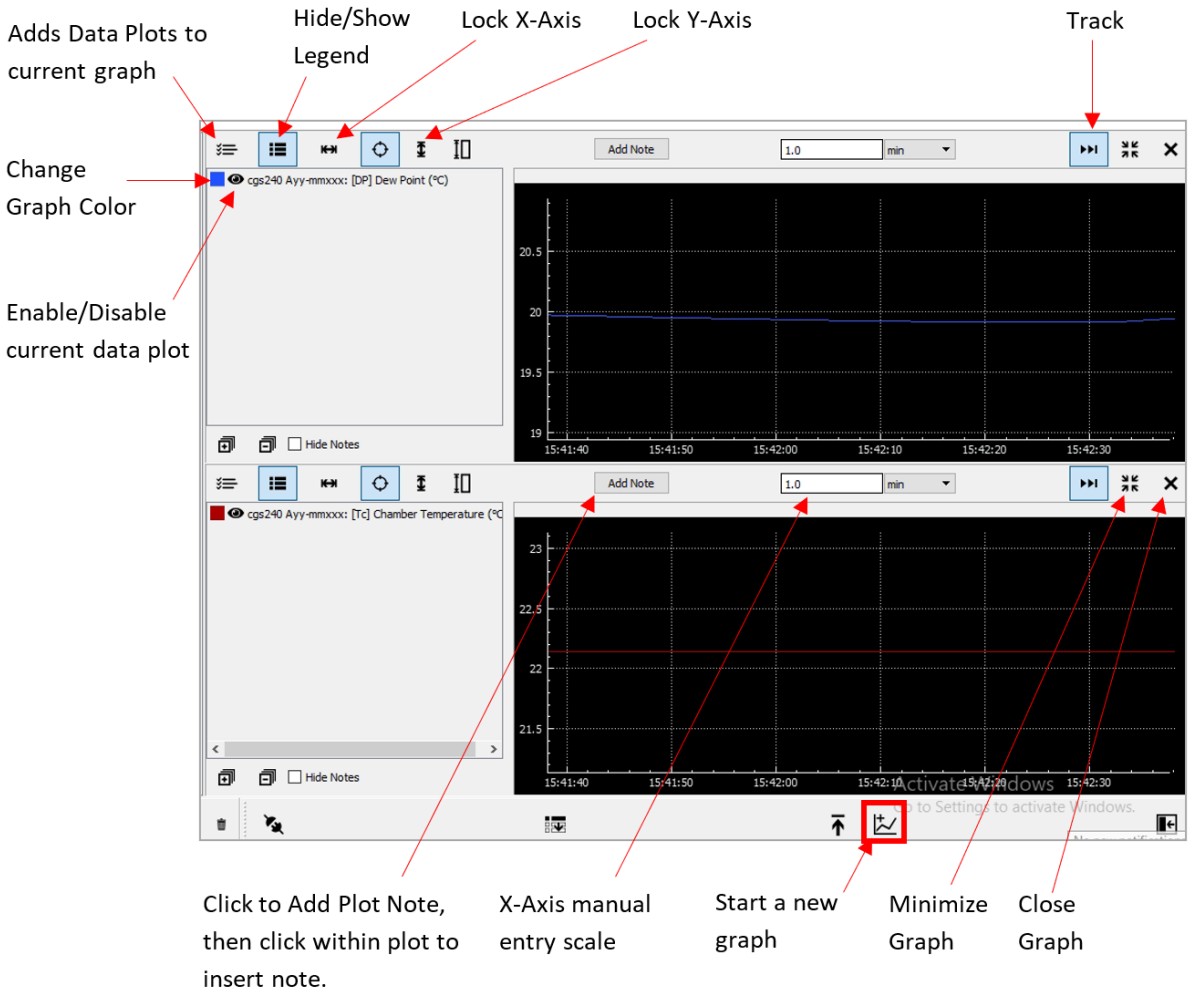
System Info: Displays ID, Serial Number, and allows for the setting of Pump Power to a value between 0 and 100%

9.2.2 Viewing Data Numerically and Graphically

Data may be viewed numerically or graphically. You may display several graphs at once, each with independent variables, axes, and timing. All graphs can display fixed data or running strip-chart-style data, which is always up to date with current information.

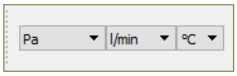
Graphs may display data from any connected instruments. Each parameter may be graphed in a different color and quickly shown or hidden during analysis.

Graphs respond to normal pinch-and-zoom or multi-touch gestures on the touch screen. They also work with a mouse to move/zoom/scale as desired.



9.2.3 Change Units

Changing the units can be done at any time using the Units bar in the lower-left corner of RHS Control. The units will change globally (numerically and graphically). This will affect the displayed units for each and every instrument connected to RHS Control. This does not affect the units logged during data collection. For consistency,



data is always logged in units of Pa, L/min, and °C, regardless of the units displayed.

9.2.4 Connection of Other Instruments and Generators

A variety of other instruments may also be connected to RHS Control. If the instrument has a serial port, is connected to the computer via a serial or USB port, and has a properly written description file (.json), the Connection window should be able to find and connect to it. The system already includes several .json files for connecting to most RH Systems brand instruments. The .json files may also be written to communicate with other brands of instruments.

The .json files are stored in `RHS Control\configs\`.

Further information, including how to write your own .json file, may be obtained by contacting RH Systems.

Add instrument connections at any time using the **Connect** button:

The Connection window appears and automatically searches for physically present instruments that are not currently connected to RHS Control.

When an RH Systems Humidity generator is connected to RHS control, a variety of function buttons and automated calibration functions are available. For more information on these, see the RHS Control sections of those manuals. In general, items with control buttons that you interact with more should be connected first, as they will appear at the top of the list.

9.2.5 Data Logging

All instrument data is stored in log files. Logging is enabled by default at startup of RHS Control. Each connected instrument has a separate log file with common timestamps for easy post-run analysis in Excel or other programs of your choice. Data files are stored in CSV (comma-separated value) format for easy import.

The data is logged at a time interval defined by the 'Log Interval' spinbox located at the lower left corner of RHS Control.

Located to the immediate right of the Log Interval spinbox is the Log toggle switch. The Toggle switch will be blue when logging is enabled and red when logging is disabled. A yellow color indicates that the size is approaching its maximum. Toggling this off will close the file and stop data collection for all instrumentation connected to RHS Control. Toggling it back to on will start a new log file.

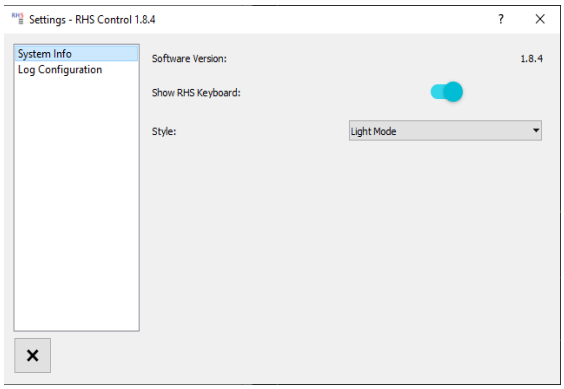
Log files are stored in: `RHS Control\logs\`

File names are identifiable by instrument name, serial number, and time stamp. The current log file size is indicated. If the file reaches the maximum size limit, the file closes and a new file is automatically started. Maximum log file size is user-selectable by accessing the System Settings window.

9.2.6 System Settings

The **Settings** button provides access to the Settings Window.

System Info allows for selection/deselection of the on-screen keyboard. It also allows for a light and dark mode theme (light mode is shown throughout this manual).



9.3 Command Syntax

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

9.3.1 General Use

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

PUMPEN?

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

All commands that set variables in the Duet use **=**, the equal sign character. For example, the following turns the pump on:

PUMPEN=1

The Duet will reply with the current pump status.

9.3.2 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 Duet 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 for Dew Point:

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

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

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

Abcdef?$^{\mathbf{C}}_{\mathbf{R}}$ (invalid command)

(no response from the Duet)

9.3.3 Case Sensitivity

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

9.3.4 Numerical Values

All numerical data received from the Duet 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 numerical values in question, the Duet may display them in either standard or scientific notation.

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

The following table lists the units of the numerical data returned by the Duet, regardless of the units selected on the touch screen display or set via RS-232. When you change units, 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
Temperature	°C
Pressure	Pa
Flow	l/m
Volume Ratio	PPMv
Weight Ratio	PPMw

9.4 Command Reference

Below is a list of all available commands, grouped by function. All commands are considered read-only values.

9.4.1 Measurement Data

Syntax	Function
DP?	Dew Point, °C
FP?	Frost Point, °C
RH?	Relative Humidity, %
RHWMO?	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
F?	Flow, l/min

9.4.2 System Identification

Syntax	Function
ID? **IDN?**	Either command returns a string containing instrument identification, i.e. Duet or Duet-HT
SN?	Serial Number

9.4.3 Indicators

Syntax	Function
LAYER?	State of Mirror Layer
0	No Layer
1	Dew
2	Frost
3	Unknown
STABLE?	1 = system is stable, 0 = not stable

9.4.4 Global Control Parameters

Syntax	Function
PUMP.EN[=i][?]	Pump On(1) /Off(0)
HEAT[=i][?]	Heaters On(1) /Off(0)
STATE[=i][?]	Current Mirror Operating condition:
0	Idle
1	Dew/Frost Control
2	Mirror Check
3	Mirror Temperature Control
4	Mirror Clean
5	Ice Test

9.4.5 Advanced Features

Frost Lock Settings	
`FROSTLOCK.EN[=i][?]`	1 enables Frost Lock (FL), 0 disables FL
`FROSTLOCK.BELOW[=n][?]`	Temperature, under which FL activates, °C
`FROSTLOCK.COOLTO[=n][?]`	Temperature, to which FL cools, °C
`FROSTLOCK.HOLDBELOW[=n][?]`	Temperature, below which FL holds, °C
ARIA Settings (Standard Duet only)	
`ARIA.EN[=i][?]`	1 Enables ARIA, 0 disables ARIA
`ARIA.BELOW[=n][?]`	Frost/dew point temperature, under which ARIA activates, °C
`ARIA.TRIGGERED[?]`	ARIA Active
Steam Trap Settings (Duet-HT only)	
`STEAMTRAP.EN [=i][?]`	1 activates a manual steam trap drain
`STEAMTRAP.TRIGGER [=i][?]`	1 activates automated steam trap drain cycles 0 disables steam trap drain cycles
`STEAMTRAP.CYCLE_TIME_SEC[=i][?]`	Steam trap cycle time in *seconds*
`STEAMTRAP.DRAIN_TIME_SEC[=i][?]`	Time how long steam trap is open, seconds
Mirror Check Configuration	
`MIRRORCHECK.TIMEOUT [=n][?]`	Mirror Check Timeout, minutes
`MIRRORCHECK.HOLDTIME[=n][?]`	Mirror Check Hold Time, minutes
`MIRRORCHECK.DELTAT[=n][?]`	Heat Temperature Delta
Automatic Mirror Check (AMC)	
`AMC.EN[=i][?]`	1 activates AMC, 0 disables AMC
`AMC.INTERVAL [=n][?]`	AMC cycle time in minutes
`AMC.REMAINING_SEC[?]`	Time, in seconds, before the next AMC
`AMC.temp[=n][?]`	Target temperature during AMC, °C
`AMC.dispHold[=i][?]`	=1 enables frost/dew point output hold during AMC
Pump Control Parameters	
`PUMP.EN[=i][?]`	1→ Pump ON, 0→ Pump OFF
`PUMP.DUTYCYCLE[=n][?]`	Pump duty cycle in %, 0...100 MIA
Measuring Head and Internal Sample Tube Temperature Control	
`INTHTR.MODE[=i][?]`	Internal Heater Off(0) / Fixed(1) / Delta (2)
`INTHTR.FIXEDSP[=n][?]`	Internal fixed control mode Setpoint, °C
`INTHTR.DELTASP [=n][?]`	Internal Setpoint for delta control mode, °C
`TI [=n][?]`	Input Tube Temp, °C
`TO [=n][?]`	Output Tube Temp, °C
`TB [=n][?]`	Bulkhead Heat Temp, °C
`TE [=n][?]`	Elbow Heat Temp, °C
`TH [=n][?]`	Head Temp, °C

Setting internal temperatures on a per-component setting is not advised. Use Internal Heat Setpoint to set a temperature and then monitor individual temperatures with the listed commands.

External Heated Hoses	
EXTHTR.MODE[=i][?]	Heated Hose Off(0) / Fixed(1) / Delta (2)
EXTHTR.FIXEDSP[=n]	Heated Hose Setpoint, °C
EXTHTR.DELTASP[=n][?]	Setpoint for fixed control mode, °C
EXTHTR.EN[=i][?]	Heated Hose Enable Off(0) / On(1)
TXH [?]	Input Heated Hose Temperature
Analog Outputs	
ANA1.PARAM[=i][?]	Parameter configuration for analogue output 1
0	Disabled
5	External Temperature Probe
6	Dew Point
8	Frost Point
11	%RH
14	Pressure
17	Mirror Temperature
21	Photodiode
26	Flow
42	Head Temp
ANA1.PARAMMIN[=n][?]	Min. Value
ANA1.PARAMMAX[=n][?]	Max. Value
ANA1.OUTMODE[=i][?]	Output Mode of channel 1: 0 = disabled, 1 = Voltage (0...5V), 2= Current (0...20mA)
ANA1.CURRENT_RANGE[=i][?]	Current range: 0 = 4...20mA, 1 = 0...20mA
ANA1.OUTMIN[=n][?]	Min. Voltage
ANA1.OUTMAX[=n][?]	Max. Voltage
ANA2.PARAM[=i][?]	Parameter configuration for analogue output 2. See Analogue output 1 for list of selectable parameters
ANA2.PARAMMIN [=n][?]	Min. Value
ANA2.PARAMMAX [=n][?]	Max. Value
ANA2.OUTMODE[=i][?]	Output Mode of channel 1: 0 = disabled, 1 = Voltage (0...5V), 2= Current (0...20mA)
ANA2.CURRENT_RANGE[=i][?]	Current range: 0 = 4...20mA, 1 = 0...20mA
ANA2.OUTMIN [=n][?]	Min. Voltage
ANA2.OUTMAX [=n][?]	Max. Voltage
Miscellaneous	
SYS.BAUD [=i][?]	Serial Baud Rate (WARNING! will end communications if changed)
SYS.TCP_PORT [=i][?]	TCP Port
SYS.AUTOSTART [=i][?]	Autostart Dew/Frost
SYS.PUMP_AUTOSTART [=i][?]	Autostart Pump

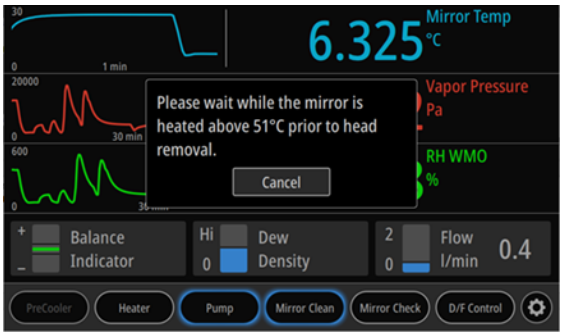
10 Maintenance

10.1 Mirror Cleaning

The Mirror is the most critical component of the Duet. Its temperature is used to report the dew or frost point, and it is controlled to achieve a specific light level by condensing more or less water on the mirror. If contaminants, such as oils, dust, hydrocarbons, or salts, end up on the mirror, the light level can change, and thus the reported dew point can be inaccurate. The ways in which different contaminants affect measurements vary widely, and the Duet is resilient to many contaminants at low levels. In any case, cleaning the mirror is a good practice whenever starting a new measurement, and periodically, depending on the level of contamination in the sample gas.

Removing the mirror cap while Dew/Frost Control is active can cause sudden, unwanted, and potentially damaging levels of condensation in the Duet, especially when measuring at low frost points where the mirror is very cold. To avoid this in an expedient fashion, the Duet is equipped with a function that quickly brings the mirror and related components above the dew point of both the room and the sample gas. This function and instructions for cleaning the mirror itself are described below.

Preparation for Mirror Cleaning



The first step of any mirror cleaning operation is to press the Press the ***Mirror Clean*** fixed function button. When pressed, the ***Mirror Clean*** button will glow blue. If enabled, ***Dew/Frost Control*** will be disabled, the top data line will temporarily be changed to Mirror Temp, and the following notification box will appear:

The mirror will then heat up to either the mirror check

NOTE: Cover and optical module may be hot!

Warm To Temp (°C) parameter (25°C by default) or 5°C above the Head Temperature, whichever is warmer. This value will appear in the notification box. You can monitor the mirror temperature on the top data line. Pressing cancel will stop the mirror heating, but will not resume Dew/Frost Control. When the mirror reaches the desired temperature, the notation box will change to read:

At this point, the mirror is safe to be opened. Dew/Frost Control will not automatically resume after a mirror clean. If you remove the optical module while Dew/Frost Control is active, a Mirror Clean will be triggered automatically to try to protect the Duet from damage. However, intentionally performing a mirror clean in this manner is not advised.

Removing the Measuring Head Cover

The measuring head is located on the right side of the Duet front panel. To access the mirror and optical module, you must first remove the cover by twisting it counter-clockwise 1/8th of a turn. It should audibly snap open. At this point, you can simply pull the cover straight back to remove it and set it aside.

Once the cover has been removed, the black, curved optical module, retained by magnets, can be pulled straight toward you. This piece contains the light emitting and light sensing opto-electronic components.

There is a triangle-shaped O-ring on the optical module's face that seals it to the measuring head. There are also spring-loaded gold contacts on the face. Avoid touching the optical assembly face with your fingers to prevent contamination of the contacts and the gas channel.

Inspecting and Cleaning the Mirror

After removing the cover and optical module, the Duet mirror is ready for cleaning. Inspect the mirror with the naked eye or with a magnifying glass. If signs of contamination (particles, tint, or a lack of reflectivity) are present or suspected, use the following procedure to clean the mirror.

1. Apply alcohol to the mirror with a clean cotton swab. Methanol is recommended in most cases, but isopropyl or other alcohols may be better at cleaning a specific contaminant.
2. After the alcohol, follow up with a cotton swab wetted with distilled water.
3. Finally, use a dry sterile cotton swab to dry off the mirror.

Never attempt to polish the mirror. The custom plating can wear off, exposing a less resilient lower layer, which can lead to mirror surface degradation. Buffing or polishing can also result in unstable dew/frost control

At this point, inspect the mirror surface. It should be completely reflective, with no contaminants visible on the surface.

Inspect the condition of the O-ring in the optical module and replace it in the event of damage.

Reassemble the Mirror Components

Reassemble the mirror components in the reverse order of disassembly.

1. Install the optical module. For convenience, the module is magnetically and mechanically keyed and should snap into place if put into the approximate correct position. You can refer to the gold contacts or the protruding screw for alignment.
2. Replace the cover or clamp. Slide into place, then rotate clockwise 1/8th turn until you hear a snap. Exit the mirror clean dialog box only after you have reconnected the optical module. This allows for a light level rebalance to occur. The Duet is now ready for operation.

10.2 Exterior Cleaning

Front Panel

The Duet front panel is glass and can be easily cleaned with liquid glass cleaner or other mild cleaning chemicals applied to a cloth. Clean the front panel periodically as needed. It is recommended to turn the instrument off beforehand to avoid unplanned touch inputs.

Fan Grills

The rear and bottom-facing fan grills may require periodic cleaning 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.

10.3 Calibration

A factory Calibration Certificate is supplied with all new instruments. For a small additional cost, this can be upgraded to an ISO17025 NVLAP accredited calibration

during production.

Once in use, a carefully maintained Duet should need adjustment only very rarely to maintain its stated accuracy. The value of successive calibration at an accredited laboratory is to provide you with measurement traceability and evidence of the instrument's long-term stability.

All Pt-100 elements used in the Duet are pre-calibrated to determine their specific coefficients, and these coefficients can be tracked across multiple calibrations to better understand the instrument's drift. Repairing or replacing the mirror or other parts of the measuring head, or the external temperature PRT, may require changing the Pt-100 element, which would result in a loss of calibration history.

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.

10.4 Periodic Maintenance Checks

Apart from periodic mirror cleaning, the Duet 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 external cables and connectors, especially those left unconnected. Connectors included with covers should be used while disconnected.
- Check the condition of sample tubes and connections before connecting new tubes.
- Where used, check or replace sample gas inlet filters.
-

11 Specifications

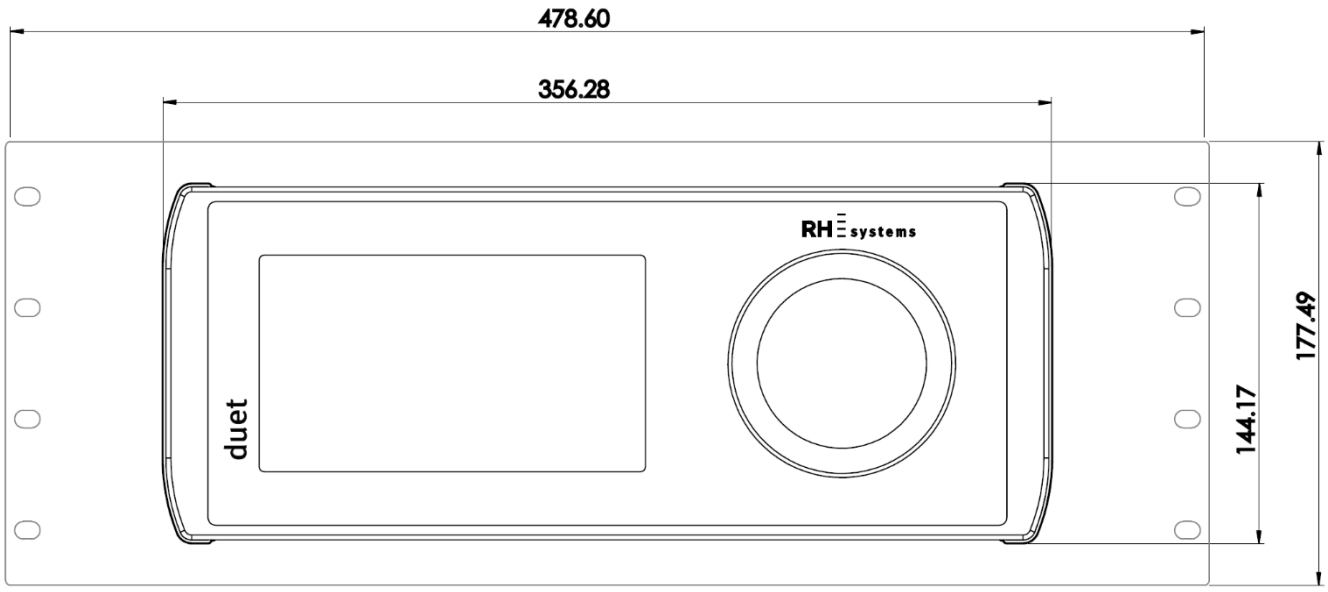
Model:	Duet	Duet-HT
Measuring range		
Frost/Dew Point	-60 °C FP to 20 °C DP	-40 °C FP to 70 °C DP
Relative Humidity	0.1 %RH to 100 %RH	
Temperature	-100 °C to 100 °C*	
Accuracy		
Frost/Dew point	± 0.1 °C	
Temperature	± 0.07 °C	
Reproducibility		
Frost/Dew Point	± 0.05 °C	
Temperature	± 0.05 °C	
Inputs/Outputs		
Digital Communication	RS-232, USB-B, TCP/IP	
Analog Outputs	2 Channel, 0-5 V or 0-20 mA, user configurable	
Second Mirror PRT	Pt100, 4-wire connection	
Miscellaneous		
Mirror cooling	3-stage Thermoelectric	
Measuring head cooling	Air	
Display	Color Touch Screen	
Gas couplings	¼" or 6mm Swagelok (specify)	
Sample gas flow rate	0.2 l/min to 2 l/min	
Sample gas circuit	PFA	Heated Stainless Steel
Sample gas max pressure	2 bar	
Environmental		
Operation temperature	10 °C to 30 °C	
Storage temperature	-20 °C to 60 °C	
Ambient humidity	90 %RH max., non condensing	
Power Requirements		
Voltage	100 - 240 VAC, 50/60 Hz	
Power consumption	200 W	300 W
Physical		
Height	155 mm	
Width	440 mm	
Depth	410 mm	
Weight	12 kg	

* Calibrated range -20 °C to 70 °C,
We reserve the right to change design or technical data without notice.

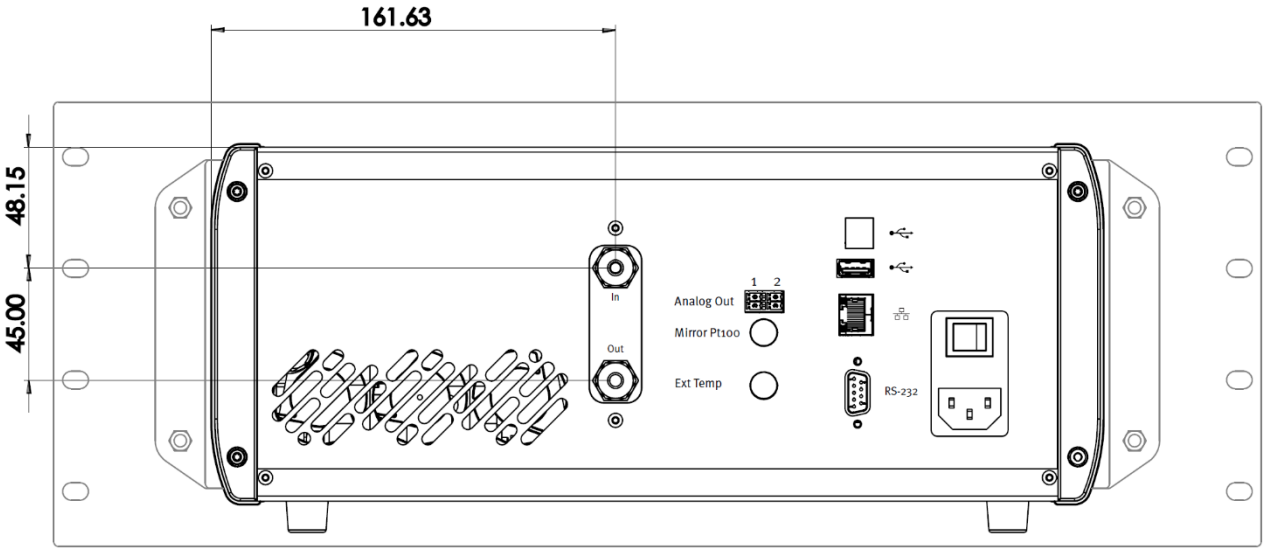
12 Dimensions

Optional rack mount attachment shown in light grey in all drawings. All dimensions in mm.

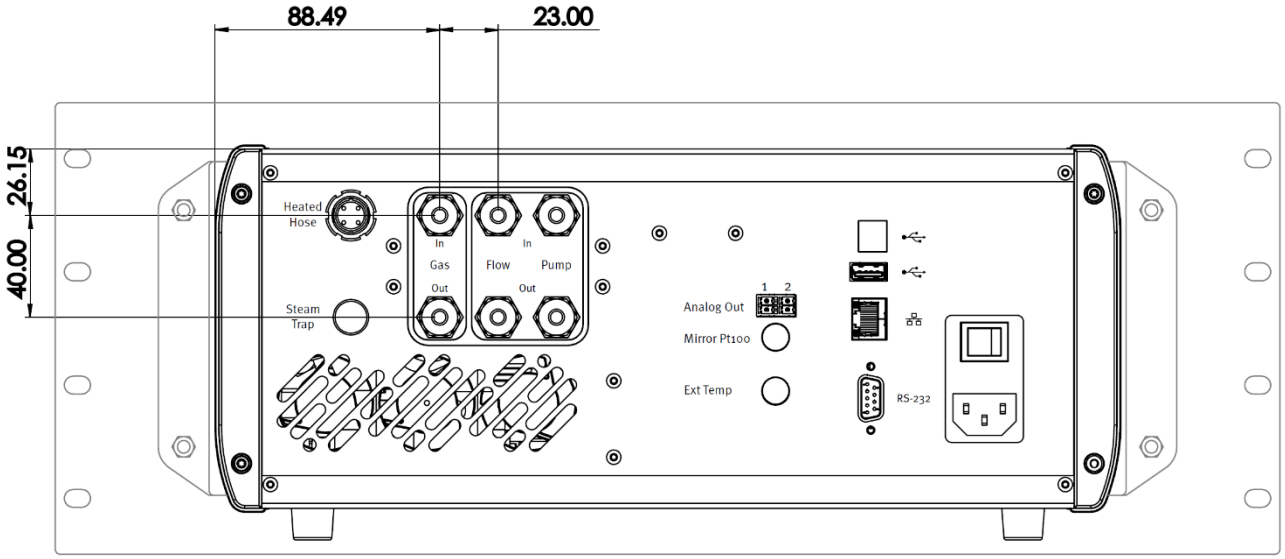
12.1 Front Pannel:



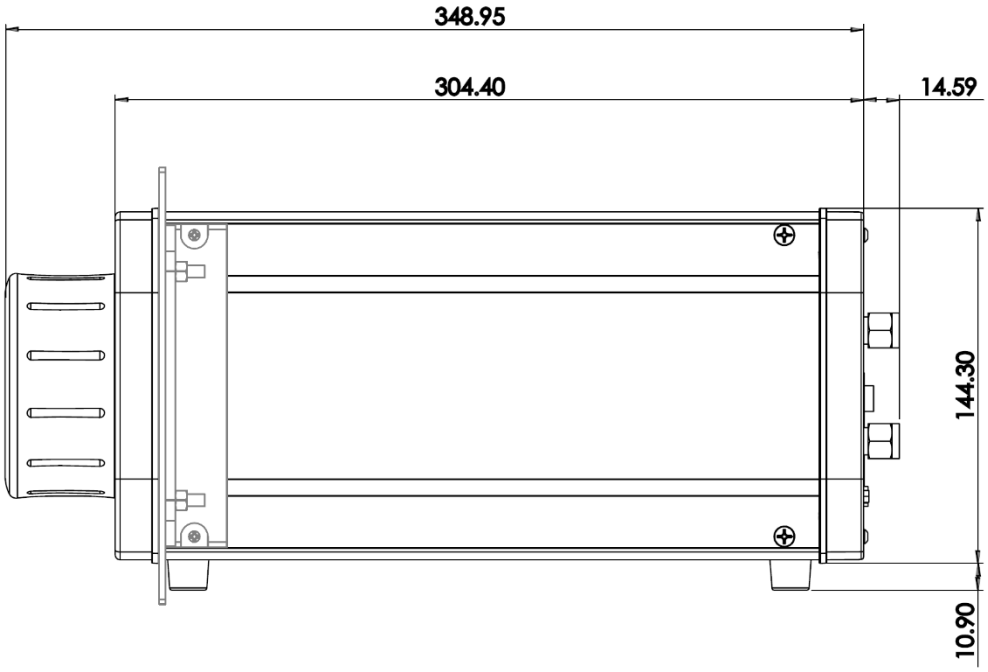
12.2 Duet Back Pannel



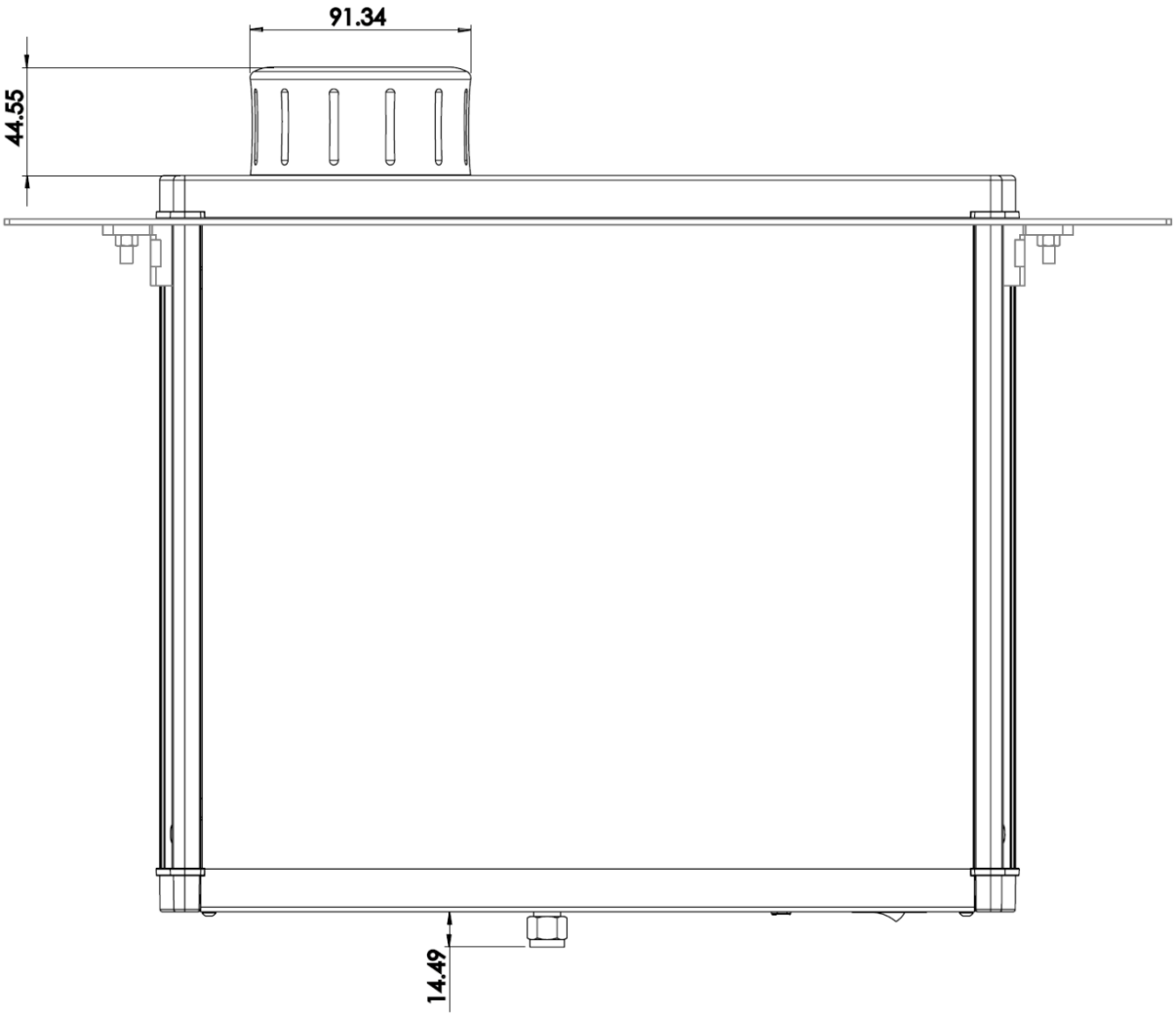
12.3 Duet-HT Back Pannel



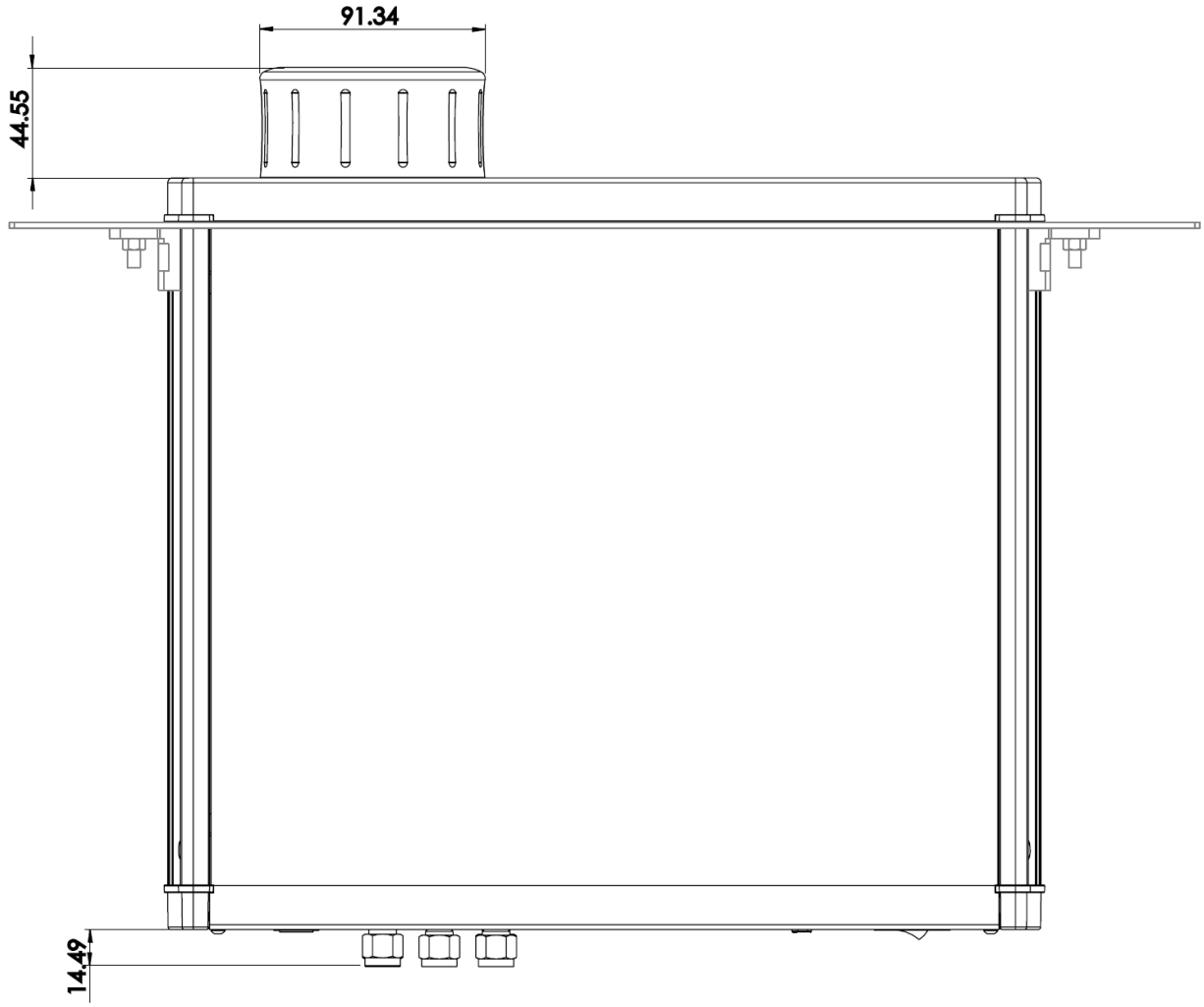
12.4 Side Profile



12.5 Duet Top Pannel



12.6 Duet-HT Top Pannel



13 FAQ's

Problem:	The Duet 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 Duet by running dry gas (or N_2) through the unit, and set heating control (if equipped) to 50 °C. Do not enable Dew/Frost control.* *Alternatively, open the measuring head and remove the optical module. Once removed, blow compressed air through the gas path inlet from the back panel. Dry with a cotton cloth any visible water that comes out of the gas path near the mirror.*
Problem:	Dew/Frost Control does not engage when I press the button.
Solution:	*Check to see if the optical module is correctly connected. Remove and reinstall the optical module. Check the "Head Temp" parameter, which, if not connected properly, will either display dashes or a static value. Increase the precision of the data line to better determine if the head temp value is static. If this does not fix the problem, the optical components may be damaged. Consult RH Systems or your local supplier for advice.*
Problem:	The readings are oscillating more than expected, or the readings are significantly offset from the expected value.
Solution:	*Conduct a Mirror Clean (see Section 9), verify heated components are above the measured DP, and check the gas path to the Duet for leaks, untightened fittings, or a sampling location without consistent airflow (like the corner of a chamber).*
Problem:	The readings are erratic, plunging and climbing seemingly at random.
Solution:	*Check that there is adequate flow across the mirror (0.5…1.2 LPM). Check that the pump and flow meter in the Duet-HT are connected to the mirror's output. If the readings are impossible (200°C momentary spikes or 0 bar abs) the issue may be electrical or related to a broken component. Contact RH Systems or your local supplier for troubleshooting help.*
Problem:	The mirror conducts a Frost Lock, and then a burn off, repeating indefinitely. (This looks like a Frost point dive to -40 °C, followed by readings around 0…-5°C, and then finally drifting above 0°C before spiking to above ambient temperatures, before starting over again.)
Solution:	*The measured value is too close to 0°C for Frost Lock to burn off the excess frost without reverting the layer to dew. Lower the* ***Frost Lock Below*** *value in the Frost Lock settings. -5°C is usually safe. This prevents determination between Frost and Dew, but the differences around 0°C between Dew and Frost point are relatively small.*

Appendix A: Installing the Pump Bypass Tube

If a Duet is equipped with a traditional pump, a bypass tube is provided to allow for a low restriction gas path when flow is provided externally. Follow the instructions below to install the pump bypass tube. Remember that while in this configuration, the pump, while powered, cannot flow gas across the measuring head. This modification is never needed on a Duet-HT, as the pump can be bypassed from the back panel. Newer Duet models have fan instead of a pump that does not restrict the flow when off, and therefore does not need to be bypassed.