

Add Precise Amounts of Water Vapor to Atmospheric Processes

RHS purifies and controls moisture addition for a wide range of flow rates

Applications

Applications for the RainMaker Humidification System (RHS) include thermal oxidation such as vertical-cavity surface emitting laser (VCSEL), rapid thermal processing (RTP), plasma stripping, water plasma, carbon nanotubes (CNT), biomedical processing, formation and annealing of TCO layers for thin film solar cell manufacturing and decarburization.

The RHS can also be configured for atomic layer deposition (ALD) applications. Contact RASIRC for further details.

Benefits

The RHS purifies and precisely controls water vapor delivery, reducing costs, increasing yield, and improving throughput. Delivery of water vapor can be controlled from low ppm levels to high concentrations.

Benefits include:

- **Cost of Ownership**—The RHS is a turnkey solution that provides continuous operation and monitors real-time process parameters with remote operation. The system reduces engineering costs by allowing user recipes to be automated with rapid startup time and improved stability compared to competitive systems.
- **Yield**—Patented membrane technology greatly reduces volatiles, ionic contaminants, dissolved gases, and other impurities found in de-ionized water. Metals, hydrocarbons, and particles are rejected by the nonporous membrane to deliver the purest water vapor possible. Because only molecular water can transfer across the membranes, water droplets cannot penetrate, eliminating entrained droplets from entering the carrier gas. Utilizing proprietary closed loop control of pressure, temperature, and energy sensors, the RHS increases production yield through accurate and stable water vapor delivery.
- **Throughput**—Continuous unattended 24/7 operation. Process parameters

can be controlled through automated process recipes and monitored in real time—there is no need to replace consumables. This allows processes to run without interruption.

- **Versatility**— Can be configured to add water into a wide range of carrier gas flow rates. The RHS can humidify a wide range of gases such as clean air, oxygen, nitrogen, hydrogen, and other inert gases.



How It Works

The RHS is an integrated water vapor delivery system featuring adaptive closed loop control. Process parameters are set through automated process recipes or the controller touchscreen. Internal pressure, flow and temperature sensors provide feedback to the control system, which automatically adjusts operations to maintain required temperature and concentration stability.

The RHS adds a controlled amount of water vapor to a carrier gas. The RHS consists of a non-porous membrane that excludes particles, micro-droplets, and volatile gases from being transferred to the carrier gas and ensures only water vapor is added. The membrane is water selective.

- Carrier Gas flows into the RHS.
- Power is added to meet a desired dewpoint or mass flow rate.
- Water diffuses across the nonporous membrane to fully saturate the gas to be humidified.

Competitive Comparison

Until now, the delivery of water to a process has been difficult and choices have been both limited and unsatisfactory.

Direct Liquid Injection (DLI) does not purify the liquid being vaporized. It has limited

control accuracy at low flow rates and at high flow rates is susceptible to bubbles in the liquid that generate erratic values. DLI needs a metallic vaporizer or additional metal hot plate to convert liquid to gas and can vaporize only limited quantities due to thermal transfer rates. DLI also leads to water droplet entrainment, which reduces uniformity and repeatability.

Bubblers are inaccurate due to the temperature of the gas and liquid, operating pressure, liquid level, and thermal droop. They cannot prevent entrainment of dissolved gases, volatile molecular contaminants, and micro-droplets. Bubblers have very limited gas flow rates and risk bacterial growth with continuous use. With over-limit flow rates, water droplets are entrained, leading to contamination, particles, flow instability, warpage, and uncontrolled flow.

Membrane Contactors are made with hollow fiber membranes that are porous, allowing simultaneous transfer of the gas into the liquid and the liquid into the gas, so the carrier gas can permeate the liquid source.

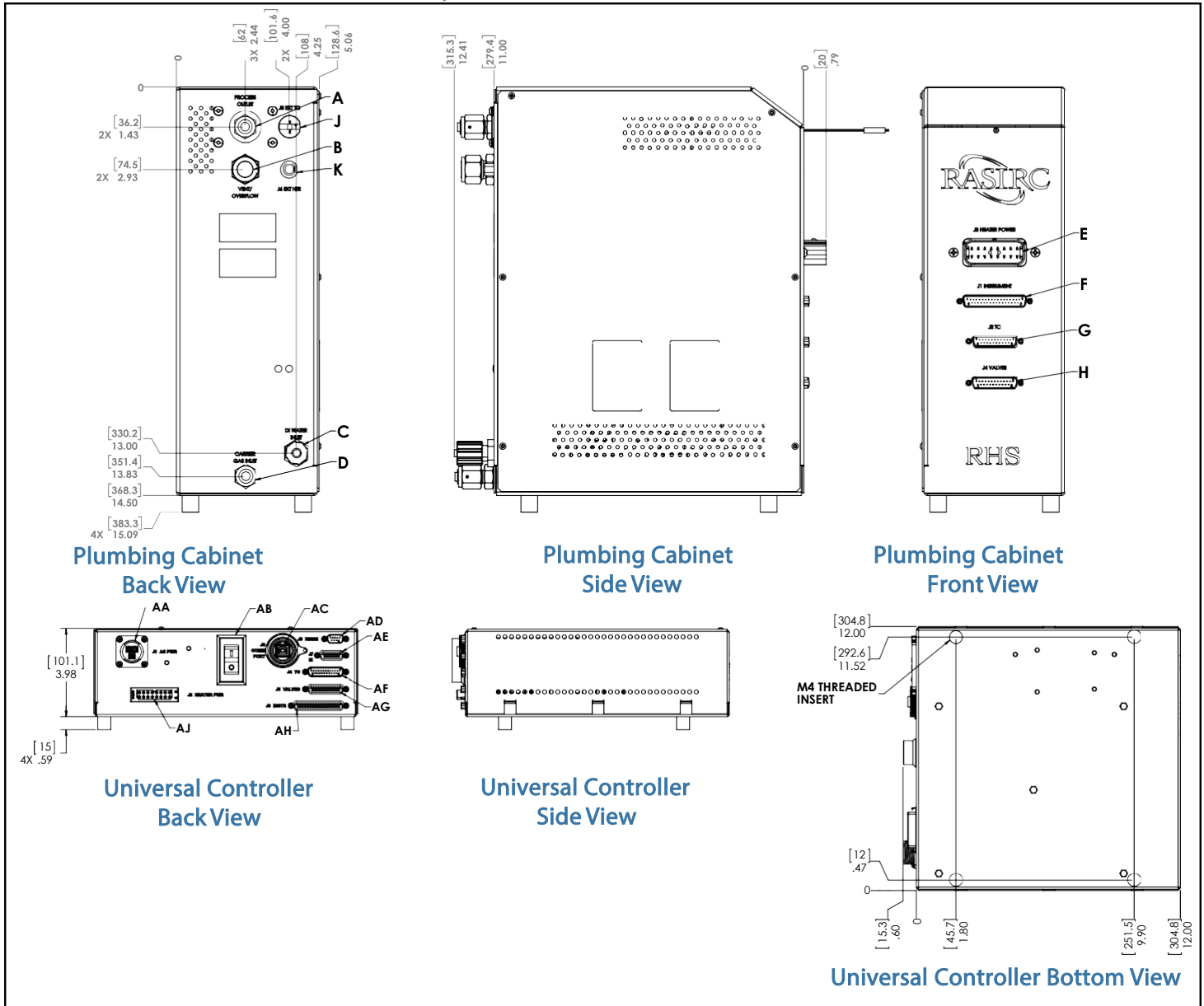


Figure 1: RHS Cabinet and Universal Controller Line Diagrams

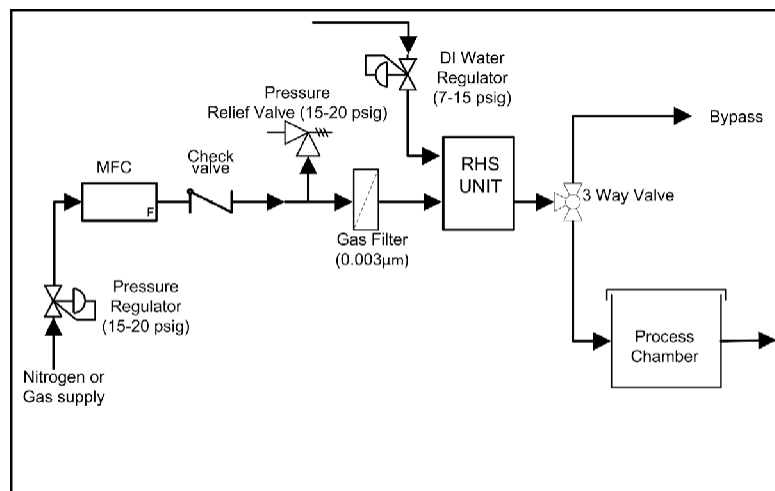


Figure 2: RHS Recommended Installation P&ID

Table 1: Facility Connects and Supply Requirements				
	Description	Size/Type	Tools and parts needed	Supply Requirements
A	Process Gas Outlet	¼" SS316 male face seal (VCR)	<ul style="list-style-type: none"> ¼" SS VCR gasket SS316 Tubing Heater and controller 	Heated (heater not included, user controlled)
B	Vent/Overflow	½" SS316 Swagelok male compression fitting	<ul style="list-style-type: none"> ½" Swagelok compression nut and ferrule set ½" PFA Tubing 	Open to atmospheric pressure. Line must not be submerged in water or sealed off.
C	DI Water Inlet	¼" PFA Compression fitting	<ul style="list-style-type: none"> ¼" PFA tubing User supplied shut-off valve Particle filter 	<ul style="list-style-type: none"> Pressure Regulated to 7-15 psig Filtered to 0.1 µm Resistivity of 17-18 megaohm 17-24 °C
D	Carrier Gas Inlet	¼" SS316 male face seal (VCR)	<ul style="list-style-type: none"> ¼" Stainless Steel VCR gasket (No nickel or Silver) ¼" Stainless Steel Tubing User must control with mass flow controller in the specified range. Particle filter 	<ul style="list-style-type: none"> N2, O2, Air or Inert gas only, purity of 6N Regulated to 15-19 psig Filtered to 0.003 µm
J	J5 External Thermocouple	Flat Female	<ul style="list-style-type: none"> None 	Not for customer use
K	J6 External Heater	2X20GA	<ul style="list-style-type: none"> None 	Not for customer use

Table 2: Interconnect Connections on RHS Cabinet				
	Description	Size/Type	Supply Requirements and Notes	
E	J12 Heater Cable	16 pin Male	<p>Cables are supplied by RASIRC. Order appropriate cable kit from the How to Order section.</p>	
F	J11 Instrument Cable	<ul style="list-style-type: none"> 37 Pin D Sub Female Receptacle Connects to Universal Control Box 		
G	J13 TC	<ul style="list-style-type: none"> 25 Pin D Sub Male Receptacle Connects to Universal Control Box 		
H	J10 Valves	<ul style="list-style-type: none"> 25 Pin D Sub Female Receptacle Connects to Universal Control Box 		

Table 3: Universal Control Box				
	Description	Size/Type	Supply Requirements and Notes	
AA	J1 AC Power	CPC Type XIII, Male	Dependent on part number ordered: <ul style="list-style-type: none"> 100-120 VAC, 10 amp 200-240 VAC, 5 amp 	
AB	Power Switch	Toggle switch	None	
AC	J3 USB COM Port	USB Type B Female port	Optional: Used for collecting data	
AD	J8 RS232 COM Port	9 Pin D Sub Female Receptacle		
AE	J7 Analog Remote Interface	15 Pin D Sub Female Receptacle	Optional: Used for remote control of setpoints	
AF	J4 TC	25 pin D-sub Male Receptacle	<p>Cables are supplied by RASIRC. Order appropriate cable kit from the How to Order section.</p>	
AG	J5	25 pin D-sub Female Receptacle		
AH	J6 Instrument Cable	37 Pin D Sub Receptacle		
AJ	J2 Heater Cable	6 Pin Mate-N-Lok Receptacle		

Operation Overview

For best operation locate the RHS as close to the tool as possible and heat all downstream lines above 100°C to prevent condensation. From the universal control box or the remote interface cable enter the dewpoint or mass flow rate of water, along with the carrier gas flow rate. Once the RHS has heated up to setpoint it will indicate that it has reached 'Ready' mode.

Carrier Gas (SLM)	Max Water Mass Flow Rate (mg/min)	Max Dew Point (°C) @ 760 torr	Min Water Mass Flow Rate (mg/min)	Min Dew Point (°C) @ 760 torr
5	4500	83	235	35.0
10	5000	75.2	471	
15	5250	69.7	707	
20	5400	65.4	943	

* Accuracy/Stability 2% F.S.

Carrier Gas (SLM)	Max Water Mass Flow Rate (mg/min)	Max Dew Point (°C) @ 760 torr	Min Water Mass Flow Rate (mg/min)	Min Dew Point (°C) @ 760 torr
0.1	180	90.0	10	35.0
1	1600	89.0	47.1	
2	2800	87.7	94.3	
3	3650	86.4	141	
4	4200	84.8	188	
5	4500	83	235	

* Accuracy/Stability 2% F.S.

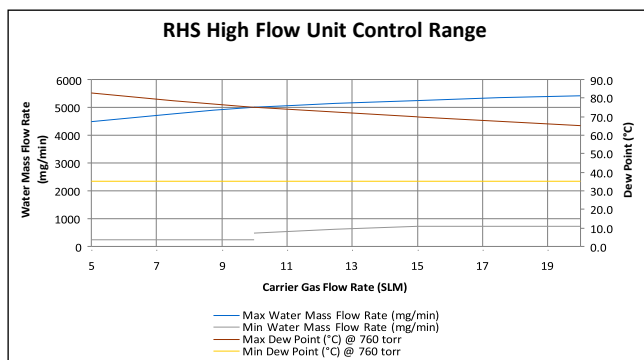


Figure 3: RHS High Flow Unit Control Range

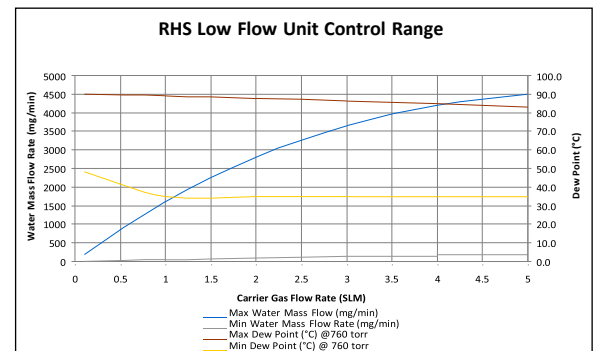


Figure 4: RHS Low Flow Unit Control Range

How to Order

To place an order for a RHS, select the part number for the corresponding operating carrier gas range and voltage, and the required cable kit.

Part Number	Description	Carrier Gas Range (SLM)	Power (VAC)
100801	RHS-HF-120: RHS High Flow 120V	5 to 20	100-120
100826	RHS-HF-240 RHS High Flow 208V	5 to 20	200-240
100803	RHS-LF-120 RHS Low Flow 120V	0.1 to 5	100-120
100816	RHS-LF-240 RHS Low Flow 208V	0.1 to 5	200-240

Required Cable Kit: Includes AC Power connector and four interconnect cables connecting the RHS plumbing cabinet to the universal controller.

Part Number	Length (ft)
100798	6
100799	10
100800	25

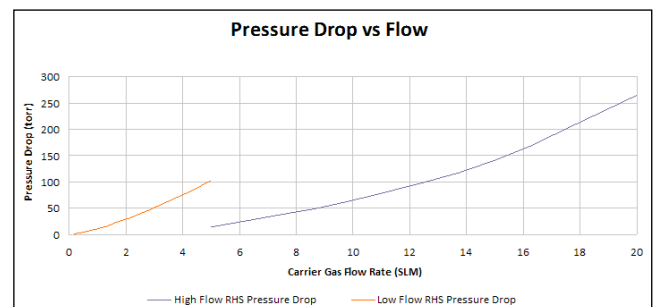


Figure 5: Water Vapor Pressure Drop vs Flow

About RASIRC

RASIRC develops products that purify and deliver ultra-pure liquids and gases. RASIRC humidifiers and vaporizers are of critical importance for many applications in the semiconductor, microelectronics, solar, and related manufacturing.

