

# Add Precise Amounts of Water Vapor to Atmospheric and Vacuum Processes

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

## Applications

Applications for the RainMaker® Humidification System (RHS) include atomic layer deposition (ALD), rapid thermal processing (RTP), plasma stripping, water plasma, carbon nanotubes (CNT), immersion lithography, biomedical processing and formation and annealing of TCO layers for thin film solar cell manufacturing.

## Benefits

The RHS is the only system that can purify water vapor and control its delivery into a carrier gas stream at ppm levels of water in atmospheric or vacuum processes.

Benefits include:

- **Cost of Ownership**—increased yield through process stability, automatic water control, and continuous process purification without consumables leads to a very low cost of ownership. The turn key solution eliminates in-house engineering needed for alternative solutions. Integration of moisture sensor allows for 24/7 process control.
- **Complete System**—Integrated temperature, pressure, and water flow control as well as closed loop control through internal or external monitoring.
- **Purity**—Patented technology greatly reduces volatiles, ionic contaminants, dissolved gases and other impurities found in de-ionized water as well as water droplet entrainment.
- **Yield**—Metals, hydrocarbons, and particles are rejected by the non-porous membrane to deliver the purest water vapor possible. Because only molecular water can transfer across the membranes, water droplets cannot penetrate. Closed loop control eliminates the guesswork on water vapor in the process.
- **Throughput**—Continuous unattended 24/7 operation.
- **Versatility**— Can be configured to add water into a wide range of carrier gas flow rates as well as delivery into positive, ambient or vacuum pressure systems. The RHS humidifies inert gases

(e.g., nitrogen, clean air, and argon), oxidizing gases (e.g., oxygen and ozone), corrosive gases (e.g., HCl) and flammable gases (e.g., hydrogen).

- **Safety**—Humidification of flammable, corrosive or toxic gases. The heater does not directly contact the water or carrier gas.

## How It Works

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, volatile gases, and other opposite charged species from being transferred to the carrier gas and ensures only water vapor is added. The membrane is designed specifically to select only water vapor.

- Carrier Gas flows into the RHS.
- The water is heated to match the desired dewpoint temperature or humidification level.
- Water diffuses across the nonporous membrane to fully saturate the gas to be humidified.
- Temperature or dew point (optionally) of the humidified gas is measured and fed back to a process controller to adjust the humidification level.
- If the water loading (dewpoint) is below ambient temperature, a dilution leg is added. The gas flow is split between two lines, one of which is fully saturated and the other is kept dry. Based on an internal or external sensor the dilution leg is continuously adjusted to control the split ratio.
- Based on internal pressure requirements the system is configured for high, ambient, or vacuum pressure environments.

## 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** 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, can vaporize only limited quantities due to thermal transfer rates, and risks water droplet entrainment—leading to challenges in 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 in vacuum processes.

**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, which is problematic if the carrier gas is pyrophoric or toxic.



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**To configure your RainMaker RHS, determine:**

- Maximum carrier gas flow rate
- Maximum dewpoint or humidification level
- Minimum dewpoint or humidification level
- Carrier gas pressure and if process gas is to be delivered at ambient pressure, high pressure or vacuum
- If humidity will be controlled by RainMaker RHS or a remote dewpoint sensor
- Mains voltage

**Operating Mode**

For best operations, locate the RHS as close to the tool as possible. Enter the dewpoint from the front panel or remote connector to set the amount of water vapor to be added to the carrier gas. An optional temperature controller and heat tape may be needed downstream of the RHS to prevent water vapor from condensing out the humidified gas stream.

**Product Features and Specifications**

- Humidity from 50 ppm to 100% RH of carrier gas depending upon configuration.
- Automatic water level / fill control.
- Vacuum to ambient pressure delivery 0.1 to 760 Torr (.002 psia to 14.7 psia).
- High pressure models available on request.
- Local and remote setpoint control.
- Microcontroller driven.
- Patented flow control of water addition.
- Dimensions: 168mm x 381mm x 402mm (6.61”w x 15”d x 15.82”h)

**Installation**

The RHS requires the following environmental conditions:

- 5°-30° Celsius
- 0% to 90% humidity, non-condensing
- De-ionized water regulated to 10+/-5 psig ( 0.6+/-0.3 barg) and filtered to 0.1 micron
- Carrier Gas Pressure ( must be specified at time of order)

**How to Order**

To place an order for the **RainMaker Humidification System**, construct the model number from the options below. The model number should follow this pattern:

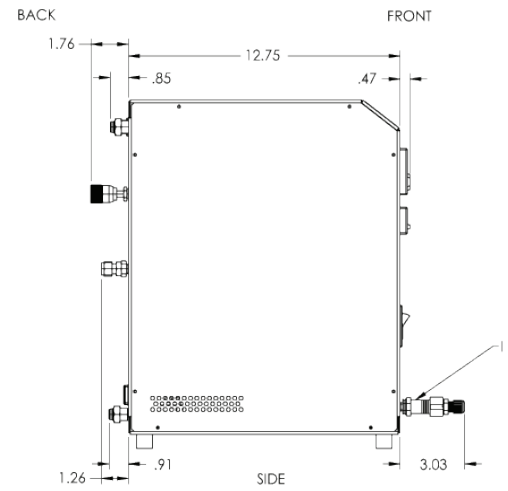
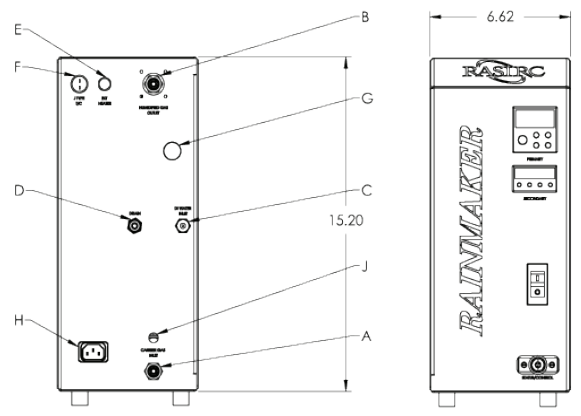
RHS-Probe-Delivery Pressure -GasFlowRate, Humidity Requirement and Power (e.g., RHS-XP-V-3-SH-A)

Item	Designation	Notes
Probe	T	Internal Thermal Control based on 100% saturation for dewpoint above ambient
	IP	Internal with dewpoint sensor
	XP	External with dewpoint
Delivery Pressure	A	Ambient
	V	Vacuum
	H	High Pressure
Carrier Gas Flow Rate	2	Represents 100 sccm
	3	Represents 1000 sccm
	4	Represents 10,000 sccm
Humidity Requirement	SP	Below Ambient Temp (<15C) - Requires IP or XP option
	HT	Above Ambient Temp (>25C) - Use IP, XP or T control signal
	SH	Below to Above Ambient - Requires IP or XP option
Power	A	110-120v (7A)
	B	200-240v (3.5A)

**Additional Optional Components**

- Additional temperature controller and heater tape to prevent condensation of humidified gas.
- 1/4” FNPT or 3/8” male flare 3-way PFA pneumatic valves to control delivery between process tool and vent.

Orders can be placed through authorized dealers or directly with the factory.



**Connections**

A	Carrier gas inlet 1/4” Male VCR Stainless Steel
B	Humidified gas outlet to 1/4” Male VCR Stainless Steel
C	DI Water inlet is 1/4” Swagelok fitting Stainless Steel
D	Drain for Water 1/4” fitting Stainless Steel
E	External Heater Connector, Bulkhead, Mini, AWG, 2-pin Female (optional)
F	Thermocouple receptacle, bulkhead, round, flat pin J type, panel mount (optional)
G	Metering Valve (for H configuration)
H	IEC 320 AC Power connection
I	Remote control DB 15 Female Adapter (not provided)
J	Metering Valve (for SP and SH configuration)



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