Ashrae – Manitoba chapter

Presented by Nuno Silva, PhD

Acknowledgements and Biases

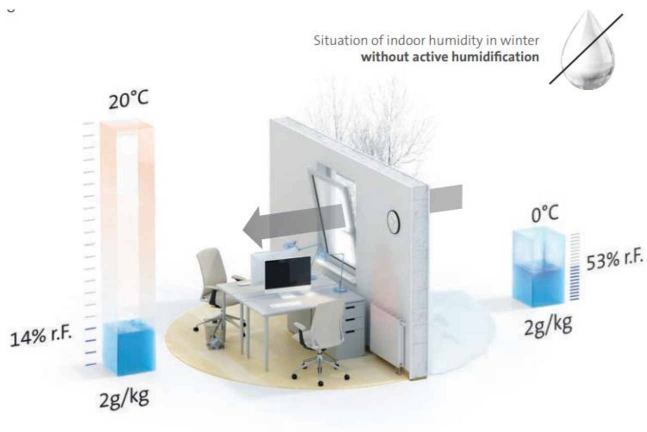
Special thanks to:

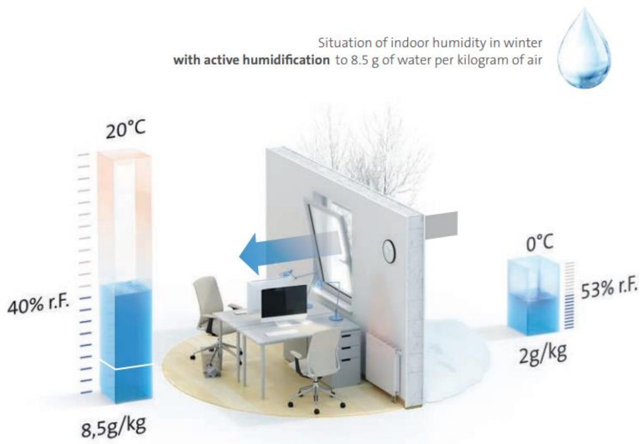
- ASHRAE TC 5.11 – Humidifiers
- ASHRAE TC 5.7 – Evaporative Cooling
- AHRI Humidifiers Educational Working Group

Potential Biases

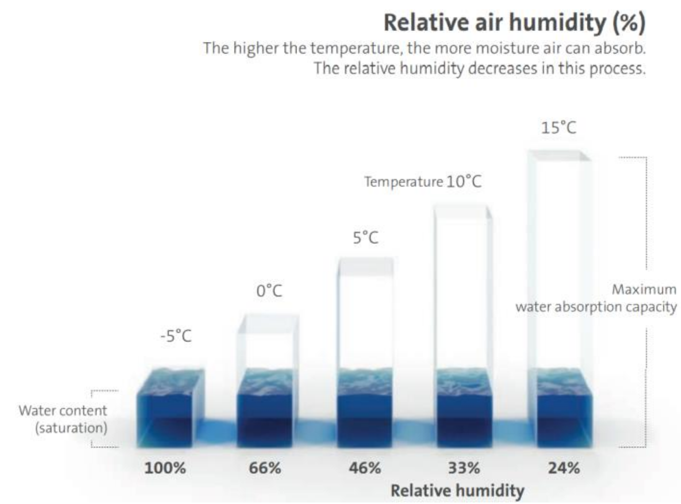
- I am currently employed by Condair Ltd, a manufacturer of humidity control equipment

Why the air gets dry?





20 °C = 68 °F
0 °C = 32 °F



Outdoor RH%	Indoor RH% *after heating ventilation air to 70°F*										
	-20	**-10**	**-5**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**
100	2	4	5	6	7	9	12	17	19	23	29
60	1	2	3	3	4	5	7	9	11	14	17
50	1	1	3	3	4	4	6	8	9	12	14
45	1	1	2	3	3	4	6	7	8	11	13
40	1	1	2	3	3	4	5	7	7	10	12
30	0	1	2	1	2	3	4	5	5	7	9
20	0	1	1	1	2	2	3	3	3	5	5

Outdoor Temperature (°F)

Effects of humidity below 40%

Human Comfort - There are a large number of worldwide studies dealing with the causes of loss of comfort, illness and reduced performance from low RH%.

Mucous membranes:

- dry, stuffy nose with bleeding tendency
- dry, mucilaginous neck
- cough, ear pressure, paranasal sinus problems

Voice:

- coughing, hoarse, toneless voice

Eyes:

- dry, itchy eyes, blurred vision, blinking

Skin:

- dry, itchy and prone to eczema skin with increased dandruff

Colds:

- frequent colds
- sore throats and ear infections
- bronchitis and flu

The Rh% debate

Protect the building

Protect the occupants

RH: 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %

<u>Buildings don't care about humidity</u>

Facility managers often incorrectly think:

- The drier the air the better
- Easier to dry the air than fix the envelope construction

<u>Occupants need RH between 40% and 60% for optimal health</u>

- Decreased infections
- Fewer allergies
- Improved hydration
- Improved wound healing
- Increased work performance

Humidity for prevention

A defined range of 40 to 60% relative humidity has been scientifically proven to provide ideal conditions for health, performance and well-being.

Humidity has a significant influence on the transmission rate of covid, influenza and SARS viruses.

Aerosol transmission and RH%

Virus transmission occurs more readily in dry environments

Humidity has a significant influence on the viability and transmission of viral infections.

Between 40 and 60% rel. humidity:

- Prevents droplets from drying out and forming a salt casing
- in a highly-concentrated saline solution they become inactive within a few minutes

Humidity range	Ability to float	Length of stay	Risk of infection
60–100% RH	Large germ droplets sink and settle quickly	Short length of stay in the room air	Due to the low salt concentration in the water, the germs remain infectious
40–60% RH	Medium sized germ drop-lets with low ability to float	Short length of stay in the room air	High salt concentration kills the germs
0–40% RH	Small germ droplets remain capable of floating	Long length of stay in the room air	Salts crystallize out and preserve the germs

RH% recommendation

Application	°C	°F	%RH
Data Center	15-32	59-90	20-80
Homes	21	70	25-60
Office space	21	70	25-60
Hospitals	21-24	70-75	30-60
Gym	20-25	68-77	30-40
Clean Rooms	22-23	72-73	43-47
Pharmaceuticals	24	75	35-50
Printing	24-27	75-81	50
Museums	20-22	68-72	45-55
Plywood (Pressing)	32	90	60
Wine Storage	12-14	55-58	55-65
Textiles	24-27	75-81	70-85
Meat & Fish	0-1	32-34	88-92

To avoid damage to products, achieve proper process conditions and/or protect against illness and discomfort, it is critical to keep the indoor climate within certain temperature and humidity limits.

IEQ integration = money

The cost to humidify a building is easily offset by having occupants that are healthy, comfortable and productive.

Cost per sick day
Assume that the average salary plus benefits ranges between $45k to $70k USD per year. The average lost salary per sick day is between $172 and $267, plus the loss in productivity.

Cost for humidification
Humidification load per person:
15 CFM/person ventilation
0°F - 50% RH conditioned to 72°F - 35% RH
0.45 lbs/hr x 2000 hrs = 900 lbs/year

Humidification cost per person:
Average capacity: 3 lbs/kWh
Average cost of electrical: $0.10 / kWh
900 ÷ 3 lbs/kw x $0.10 = $30.00/person per year ($0.08 per day)

Absenteeism costs money and reduces productivity

Employee sick day cost
$172
to
$267

Humidification cost per day
$.08

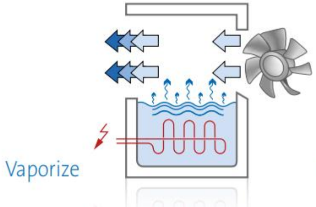
You can save money with humidified air

(Based on 120 – 150 sq. ft. of humidification per person)

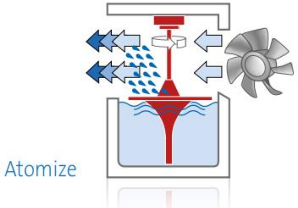
Humidification and Evaporative Cooling as we know them from nature

The principles at the base of our technologies

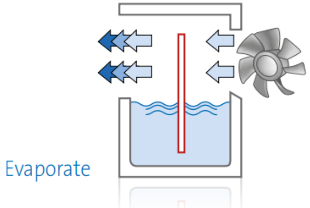
Steam (isothermal)



Atomization



Evaporation



Overview

Adiabatic Humidification/Cooling:

- Injects cold water directly into the air
- Heat from the surrounding air allows the water to evaporate
  - Air becomes more humid
  - Air becomes cooler “evaporative cooling”
- Can save energy and energy costs
  - If cooling is beneficial the cooling can reduce mechanical cooling needs
  - If cooling is not beneficial, preheating is required to offset cooling
  - Total energy balance is consistent with steam humidification
- Often requires water treatment
  - Removes minerals from water (avoid dust)
  - Reduce risk of biological contamination

How does Evaporative Cooling Work?

- Why does it work? - Evaporation of water!
- Water is spread over a wide area enabling quick evaporation in warm and dry air.

- The evaporation energy for water is – more or less – independent of temperature

Temperature	Energy Btu/lb	Energy kWh/lb
50 °F	1067	0.313
68°F	1054	0.309
86°C	1046	0.306
140°F	1015	0.297

Difference: 2.2 %

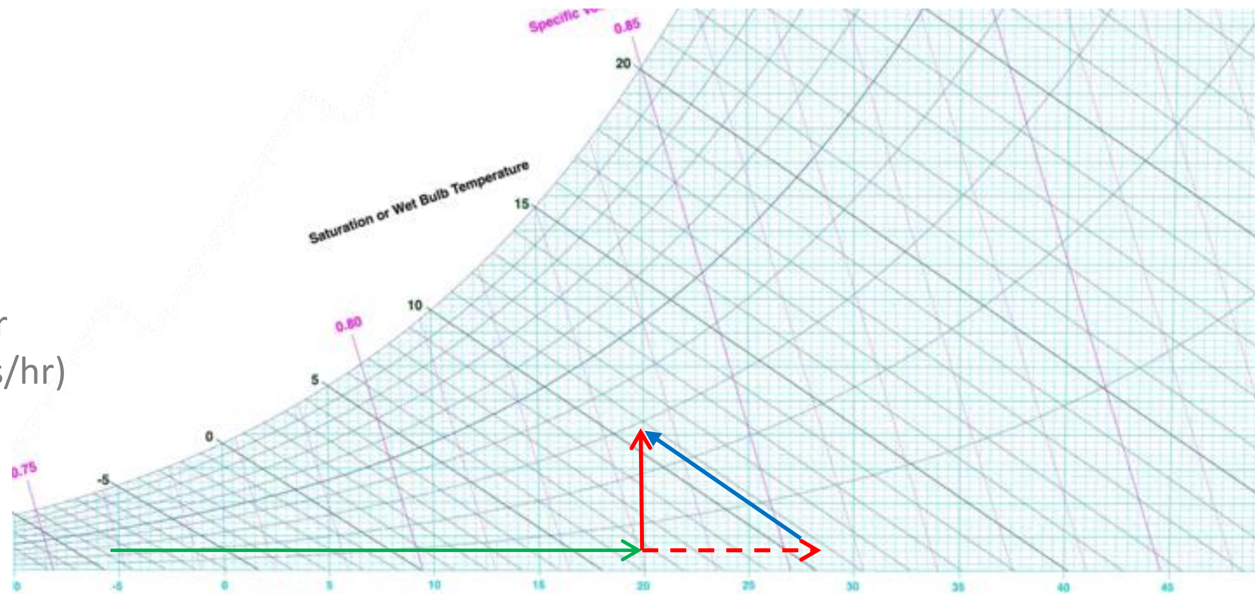
Isothermal vs Adiabatic

- Vapor pressure differential governs evaporation rate
- Evaporation slows as it approaches saturation
- Constant Enthalpy process

- Arid = Rapid Evaporation
- Damp = Slow Evaporation

Benefits of Adiabatic Systems

- Energy efficient
- Free cooling
- Typical larger capacities for single units (up to 2800 lbs/hr)
- Minimal maintenance



Approaches for Evaporative Cooling

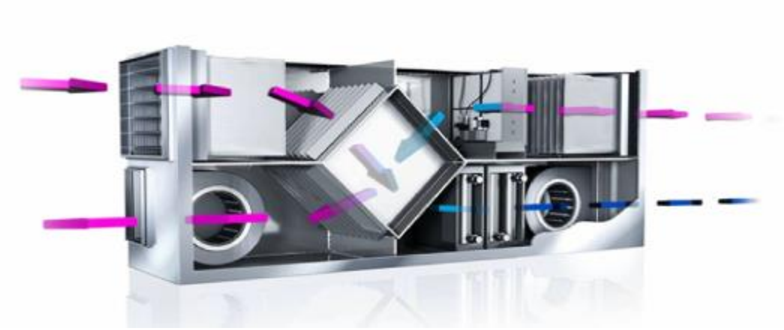
Direct Evaporative Cooling
- Conditions supply air for space
- Increases moisture content in air

HVAC

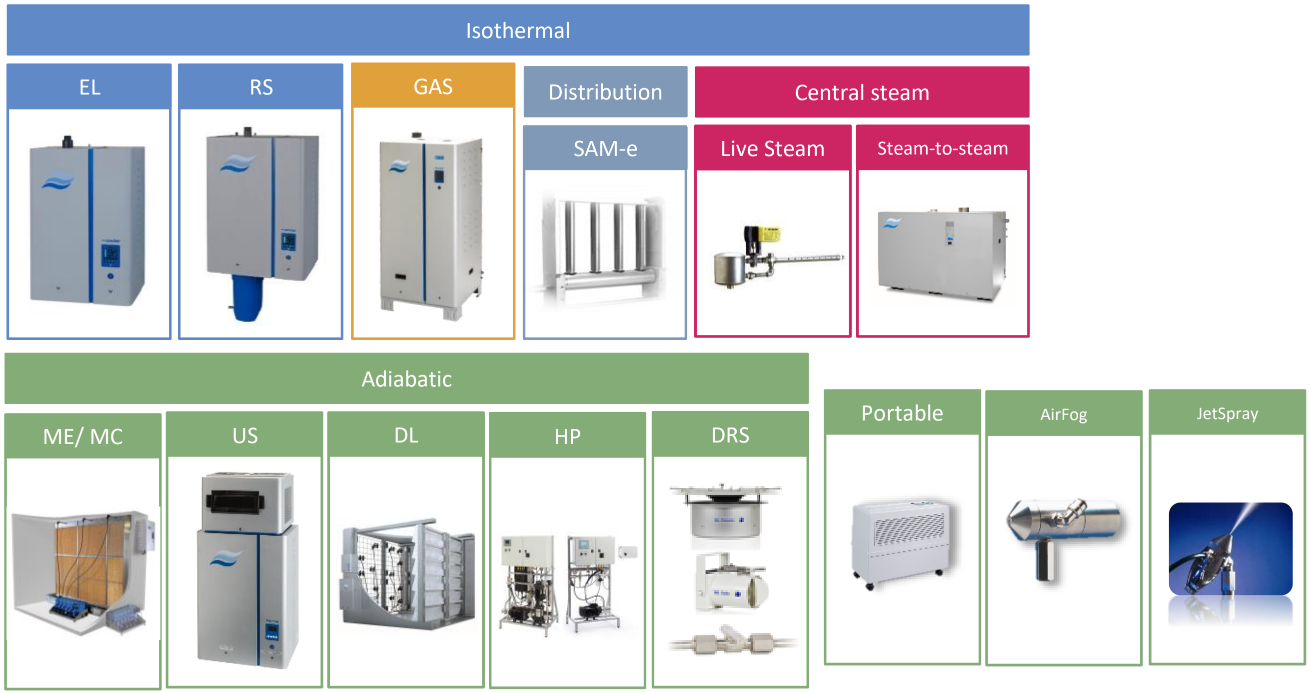
Direct Space

Indirect Evaporative Cooling
- Conditions exhaust air before HX
- Does not increase moisture content

HVAC



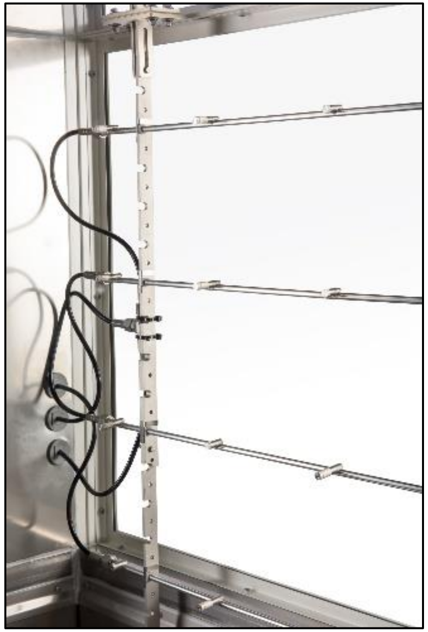
Typical Product Technology Offering in the Industry



High Pressure Fogging

- Applications
  - Broadly applicable, many applications
  - Direct room or ducted models
- Advantages
  - Scalable performance for large loads
  - High-reliability, low maintenance
  - Instant output / shutoff
  - Higher accuracy than wetted media
- Considerations
  - Usually customized for application
  - Treated water required
  - Pump, Valves, Nozzles
  - Staged control

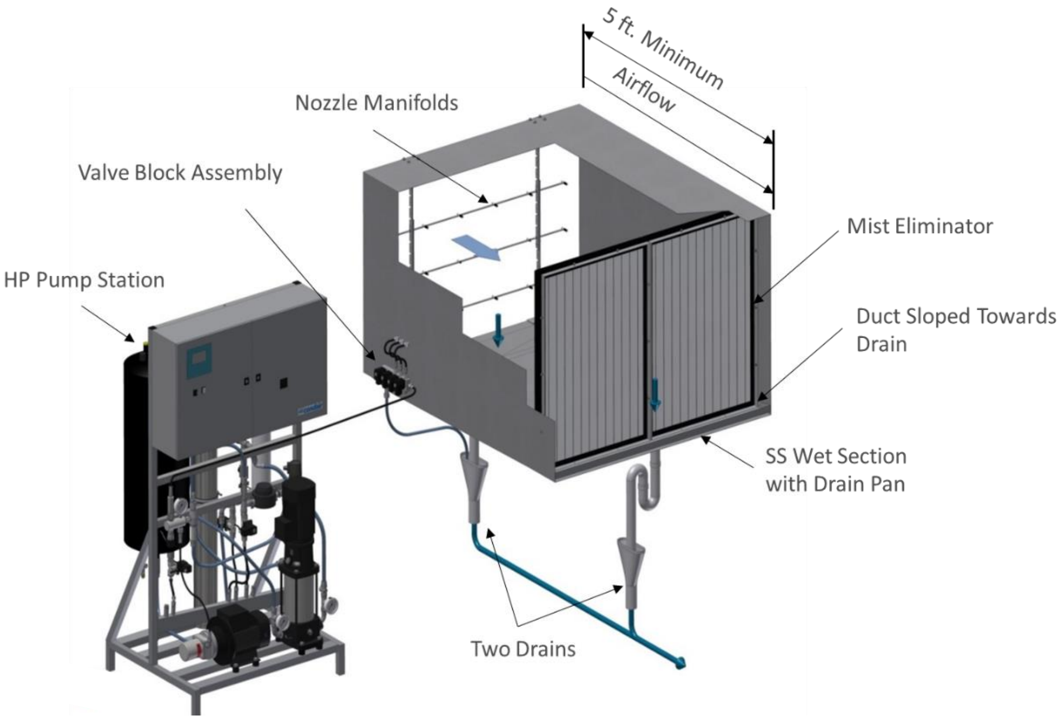
Pressurized water (~1000 psi) is sprayed through small orifice nozzles to create a very fine mist



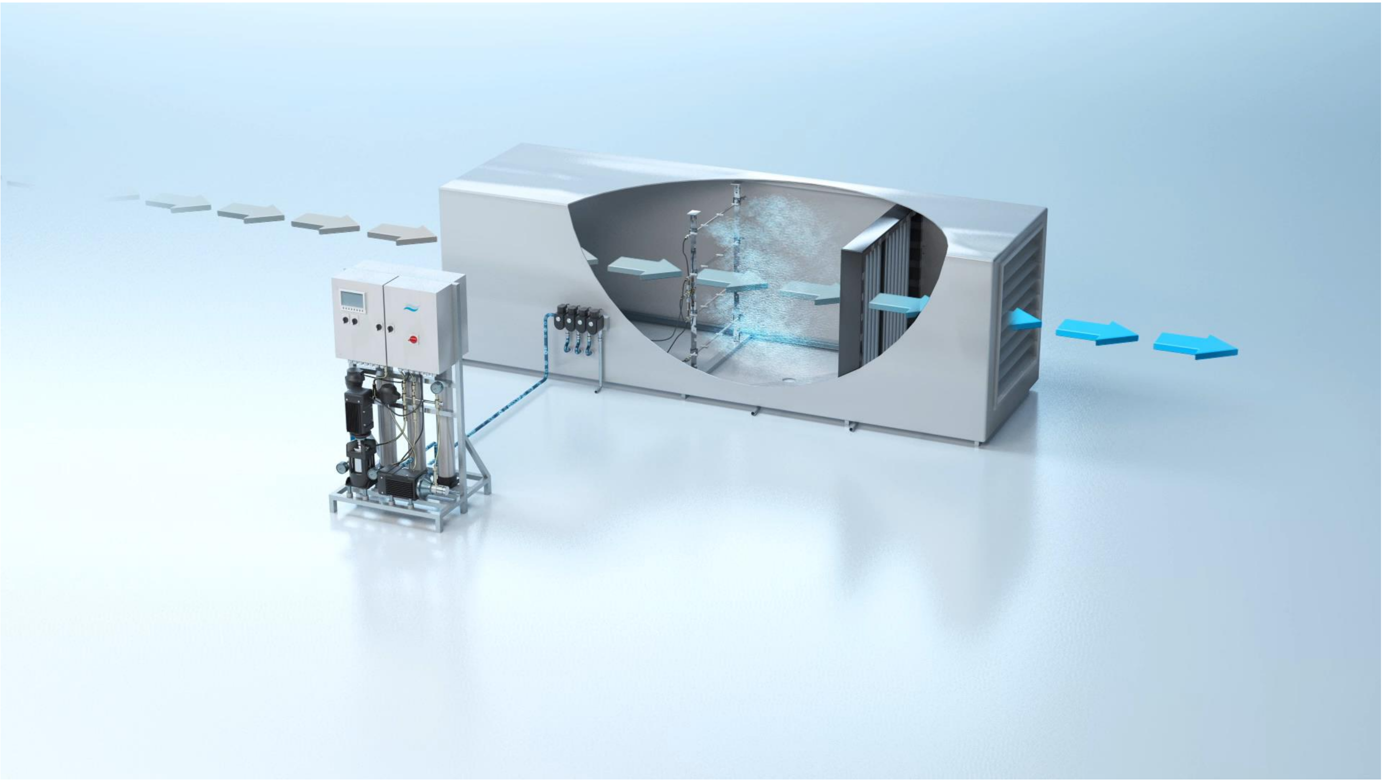
High-Pressure Atomizing:

- Humidification and Cooling
- Individual pump skid can typically deliver up to 3000 L/hr
- Feed multiple AHUs from one pump skid
- Hygienic features like UV sterilization and automatic line flushing
- Control accuracies of +/- 2%

Typical High Pressure Atomizing (In Duct)



High Pressure Atomizing (In Duct)

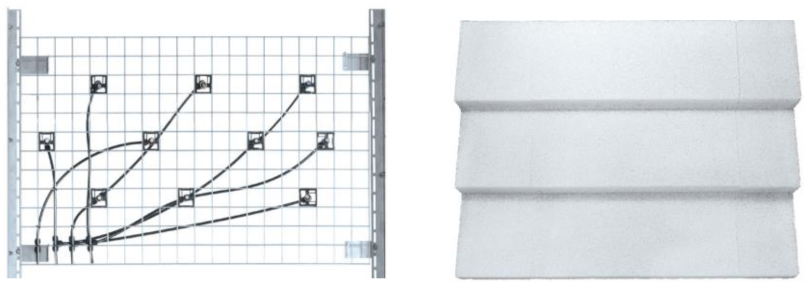


Hybrid fogging Humidifiers

Dual Technologies

Combine the advantages of both atomization and evaporation, minimizing the problems associated with each individual technology

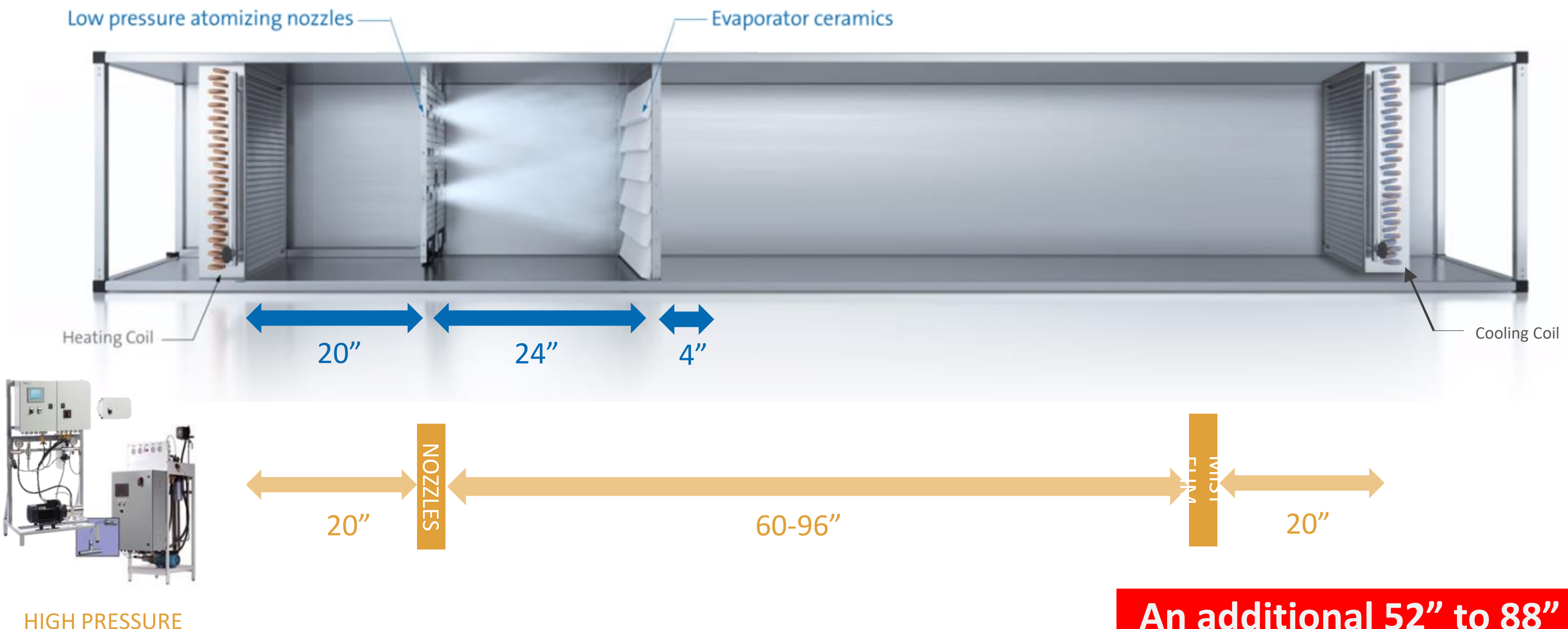
Sustainable humidification system in terms of hygiene, energy efficiency and long term cost-effectiveness.



Dual Hybrid systems:

- Humidification and Cooling
- Humidification load up to 2200 lbs/hr per unit
- No carry-over and low pressure drop
- Fast Start-Up and Tight Control Accuracy (±2%)
- Hygienic Operation
- Efficient Water Consumption – Patented Ceramics
- Small AHU Footprint – Minimum 2 feet
- Minimal Maintenance

Install Length – Adiabatic fogging Solutions

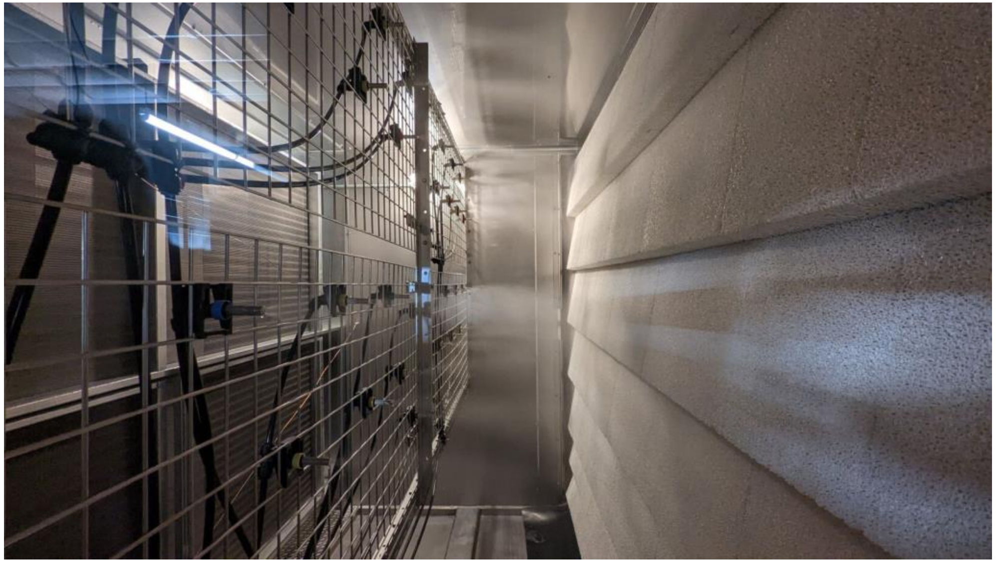


An additional 52” to 88”

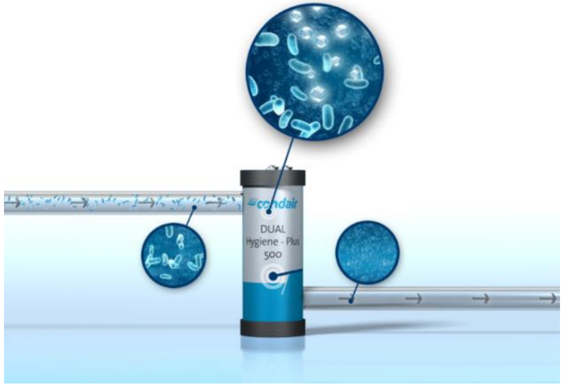
Hybrid humidifiers

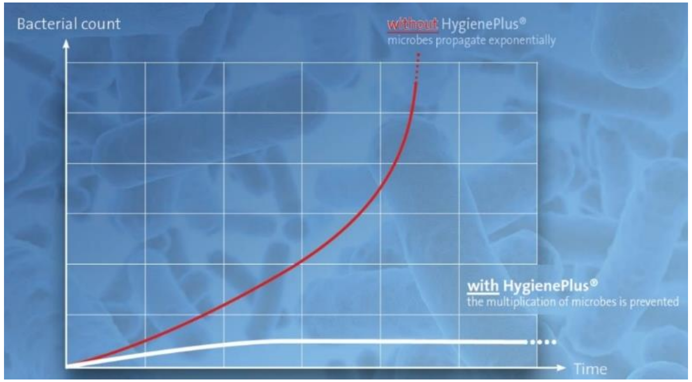
Installation Pictures

Normal operation



Active silver dosing





- Demonstrable bacteria, fungi and algae neutralization in water, hoses, nozzles and the ceramic plates by silver ions
- Demand control - Exact dosing of Silver according to the humidity demand

Hygiene Certificate for adiabatic humidifiers (example)

Fresenius Hygiene Certificate

Certificate Limits

- Humidifier Water < 100 CFU/ml
- Humidified Air < 255 CFU/m3
- Mold, CFU < 100 CFU/m3
- Silver concentration in air <0.01mg/m3
- Significantly stricter requirements than VDI6022 (European Hygiene Standard)

CERTIFICATE

TEST CONDITIONS

We subjected the Condair Dual 2 hybrid humidifier (developed and manufactured by: Walter Meier Climate International Ltd., Pfäffikon, Switzerland) to microbiological testing under practical conditions in an installed clean air technology unit from the 6th July 2005 until the 3rd February 2006. Tests will continue in two-month cycles.

TEST REQUIREMENTS

Humidifier water, colony forming units	< 100 CFU/ml
Humidified air, colony forming units	< 250 CFU/m³
Mould, colony forming units	< 100 CFU/m³
Silver concentration in air	< 0,01 mg/m³

These values were therefore considerably lower than the level of 100 CFU/ml recommended by bodies in the sector (VDI 6022, BG Druck und Papier - Print and Paper Trade Association).

TEST RESULT

The Condair Dual 2 hybrid humidifier tested by us meets the set requirements in every respect. Results of the tests were below the recommended reference values. We therefore have no hesitation in issuing the SGS INSTITUT FRESENIUS Hygiene Certificate and confirm that the Condair Dual 2 hybrid humidifier tested operates hygienically. The test certificate awarded is based on the following operating conditions:

- Operation of intrinsic system silver ionisation
- Operation with fully de-mineralised water with a colony forming unit level of max. 100 CFU/ml
- Adherence to prescribed operating regulations and maintenance/service

SGS INSTITUT FRESENIUS GmbH
Pestalozzistraße
D-78333 Stockach
www.institut-fresenius.de

Stockach, 16th February 2011

SGS INSTITUT FRESENIUS GmbH

INSTITUT FRESENIUS

SGS

Risk Management for Legionellosis

- A water management program is key to reducing the risk of a Legionella outbreak and should include:
  - Identifying areas in a building or water system where Legionella could grow and spread
  - Implement control measures and monitor the water system to stay within control limits
  - Establish procedures for corrective action if control limits are exceeded

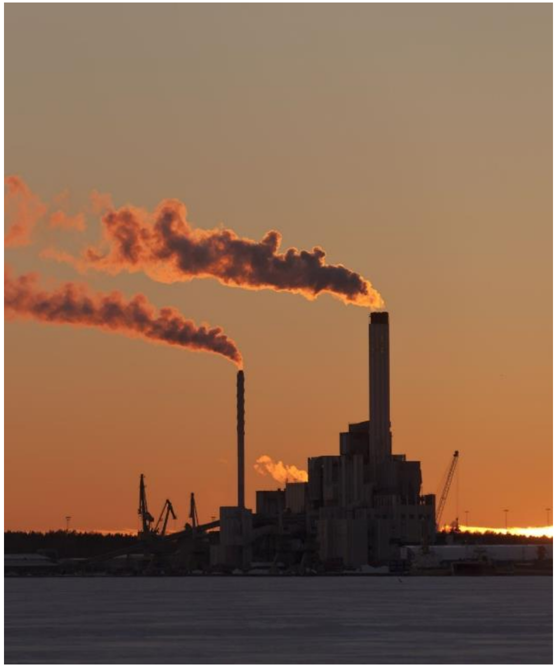
- Key considerations for aerosol-generating misters, atomizers, air washers, and humidifiers (non-steam):
  - Water temperature should be kept below 77°F (25°C)
  - Prevent water stagnation and pooling for more than 24 hours
    - Including water in the supply lines and storage tanks
  - Operate and equipment as per manufacturers recommendations.
  - Inlet purge to flush supply lines
  - 24 hour inactivity drain and periodic nozzle flushing
  - Water temperature monitoring
  - Additional hygiene/bacteria control device (UV lights, Silver dosing, water treatment, and dosing systems (H_2O_2))

Decarbonization

- **Decarbonization:** *Reduction of direct and indirect emissions from energy & water use, embodied carbon, and refrigerants*

- Industry Drivers:
    - Incentive Programs
    - Regulations: "Buy Clean" Acts, New York City Law 77, etc
    - ESG – Sustainable investing (e.g Blackrock)
    - Economics – Savings

- Top Trends in HVAC
    - Energy efficiency
    - Energy recovery - reuse waste
    - Electrification
    - Heat Pumps (leading electrification strategy)
    - Energy Storage / demand shifting
    - Low GWP refrigerants
    - Advanced Controls - Sequencing, self-learning, real-time grid response



Case Study – Hospital in Toronto (retrofit)

Condair Energy Analysis Tool

Opportunity Name	Toronto Hospital
Customer Name	Company A
Agent Name	Company B
Agent Phone Number	
Currency	CAD
Units of Measure	Metric (SI units)

Project Location

Country	Canada
State/Province	ON
City	Toronto Lester B. Pearson Int

Opportunity Setup

Building Basic

Project Location WMO	716280	
Climate Zone	6	
Building Type	Hospital	
Total Building Floor Area	148144	m2
Building height	54	m
Number of Floors	9	
Ceiling Height	3	m
Window to Wall Ratio	25	%
Envelope Performance	ASHRAE 90.1-2019	
Infiltration	Airtight building	

Building Density

	Peak	Off-Peak	
Lighting	11.3	5.65	W/m2
Sensible Equipment	5.1	2.8	W/m2
Latent Equipment	5.41	1.78	W/m2
Average Occupancy	21	212	m2/person

Operational Schedule - Peak Hours

	SUNDAY	*MONDAY*	*TUESDAY*	*WEDNESDAY*	*THURSDAY*
Peak Begins	6:00:00 AM	6:00:00 AM	6:00:00 AM	6:00:00 AM	6:00:00 AM
Peak Ends	7:00:00 PM	7:00:00 PM	7:00:00 PM	7:00:00 PM	7:00:00 PM

Air System

HVAC Air Side Type	CV	
HVAC Cooling Type	Water-cooled chiller	
HVAC Heating Type	Gas Boiler	
Total Air Volume	1,764,904	m3/h
Outside Air %	70	%
Fan Efficiency	75	%
Preheat Energy Source	Natural Gas	
Preheat System COP	1	
Include Free Cooling?	TRUE	
Cooling System COP	3.3	

Building Setpoints

	Setpoint	Setback	
Cooling	22.22	27	C
Heating	22.22	18	C
Humidification	35	30	%
Dehumification	60	90	%

Case Study – Product selection

Product Selection

Selection Type	Humidification		
	Product 1	*Product 2*	*Product 3*
System Type	In-Duct	In-Duct	In-Duct
Technology	DL-A	GS-NX	RS
Bypass Dampers	NO	NO	NO
Water Type	Reverse Osmosis	Potable	Potable
Water Efficiency	95	85	85
Initial Purchase			
Installation Cost			
One Time Cost			
Recurring Costs			
RO System	MLRO		
RO System Efficiency	70		
RO System Purchase			

Utility Rates

Electricity Rate	0.13	$/kWh
Electricity Demand Charge	5	$/kWh/month
Natural Gas Rate	0.034	$/kWh
Propane Rate	0.04	$/kWh
Central Steam Rate	0.017	$/kg
District Heating Rate	0.08	$/kWh
Water Rate	0.002	$/L
Sewer Rate	0.0018	$/L

Case Study – Annual Costs

Section 3: Energy Analysis Results

Energy Cost Analysis Summary			
Model	Hybrid	Gas	Resistive
Water Type	Reverse Osmosis	Potable	Potable
Equipment	$ -	$ -	$ -
Water Treatment	$ -	$ -	$ -
Installation Cost	$ -	$ -	$ -
First Cost	**$ -**	**$ -**	**$ -**
Recurring Costs	**$ -**	**$ -**	**$ -**
Total Electricity (kWH)	226025	35677	14751231
Fan Energy due to ΔP (kWH)	183182	18318	18318
Preheat Energy (kWH)		0	0
Electricity Cost ($)	**$ 30,611.71**	**$ 5,000.25**	**$ 1,991,052.47**
Beneficial cooling energy (KWH)	60260		
Cooling Energy Savings ($)	**$ 2374**		
Gas Usage (kWH)	150300	15902879	0
Gas Preheat Energy (kWh)	150300		
Natural Gas Cost ($)	**$ 5,110.21**	**$ 540,697.88**	**$ -**
Potable Water Usage (gal)	0	5192006	5192006
Treated Water Usage (gal)	6636399	0	0
Potable Water to Drain (gal)	0	778801	778801
Treated Water to Drain (gal)	2223194	0	0
Water Cost ($)	**$ 67,996.51**	**$ 52,470.16**	**$ 52,470.16**
Total Utility Cost	**$ 101,348.72**	**$ 598,168.29**	**$ 2,043,522.63**
Max. Humidification Load (lbs/hr)		8374	
Annual Humidification Hours (h)		4822	

Cost Differences	vs. Gas	vs. Resistive
First Cost	$ -	$ -
Recuring Costs	$ -	$ -
Utility Costs	-$ 494,449.86	-$ 1,939,804.20
Estimated EOL Replacement	$ -	$ -

Summary

1. **Humidity control** is needed in many buildings, especially during the winter months
2. In Canada, **many technologies are viable** for decarbonization through electrification options
3. Adiabatic / Evaporative cooling takes decarbonization a step further by **reducing cooling loads**
    - Direct Evaporative systems can be applied directly in the space or an HVAC system
    - Indirect systems work with HVAC system and heat exchanger
4. There are **many evaporative technologies** available
5. New **hybrid technologies** combine the benefits of evaporative and fogging

Consider an evaporative / adiabatic system for your next project.

Thank You

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