Humidification Done Right

Fundamentals and Applications

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Presenters

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- **Matt Nowak**

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Agenda

1. **Fundamentals of Humidity**
   - Key Terms and Definitions
   - Humidification Applications

2. **Humidification: Commercial and Industrial**
   - Steam Solutions
   - Liquid Water Solutions

3. **Humidification: In the Home**
   - Residential Applications
   - Technology Solutions

4. **Questions**

What is Humidity and How Do We Measure It?

Humidity

- The amount of water vapor in the air
- Measured in “Absolute” or “Relative” terms

Absolute Humidity

- Mass of water in particular volume of air
- Expressed as mass (grains/lb_{da} or g_w/kg_{da})

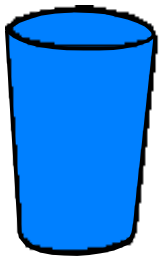
Relative Humidity

- Amount of water vapor in the air relative to how much it can hold at a given temperature (%)

How Much Water Can the Air Hold?

It depends on the temperature of air!

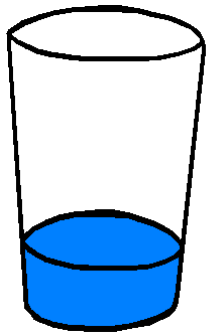
1 lb (kg) of Air
35°F (2°C)
30 gr (2g/kg)



100% RH

Sensible Heating

1 lb (kg) of Air
72°F (22°C)
30 gr (2g/kg)



25% RH

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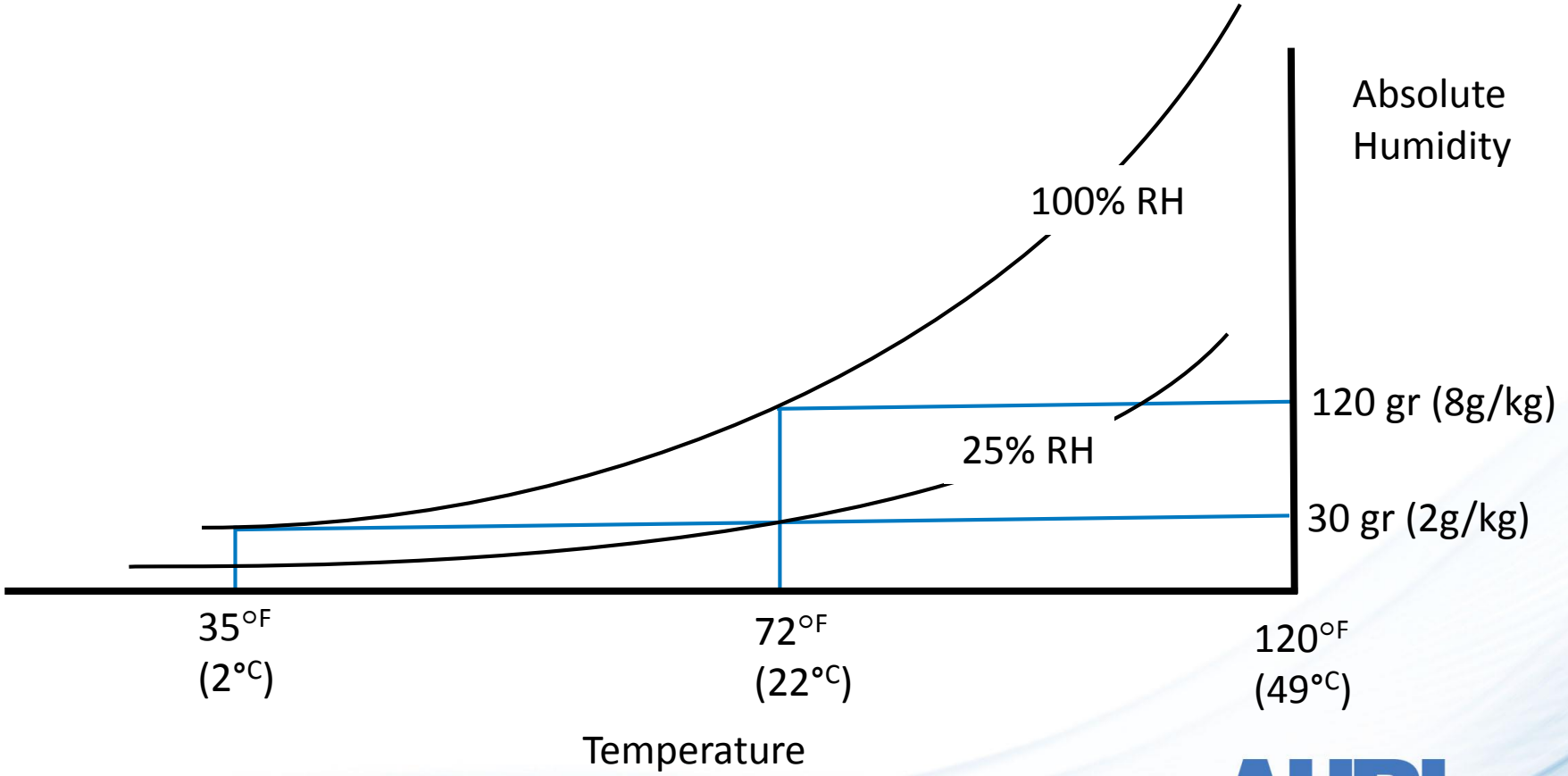
How Much Water Can the Air Hold?



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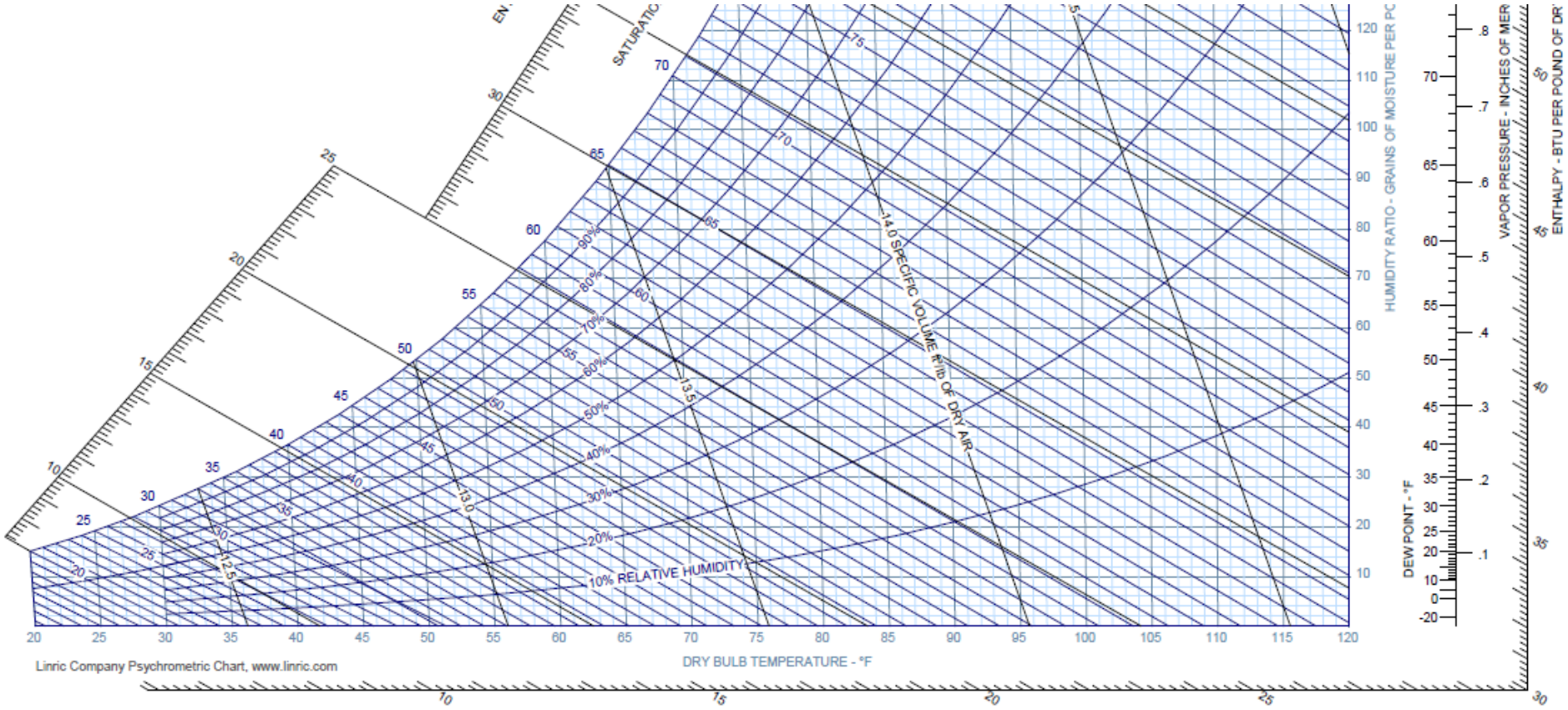
The Psychrometric Chart



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Effect of Outdoor Conditions

Heating Climates

- High outdoor RH does not translate indoors!

RH %	Indoor RH% When Heated to 70°F													
100	2	4	5	6	7	9	12	17	19	23	29	36	42	53
60	1	2	3	3	4	5	7	9	11	14	17	21	26	31
50	1	1	3	**3**	4	4	6	8	9	12	14	18	22	26
45	1	1	2	3	3	4	6	7	8	11	13	16	20	24
40	1	1	2	3	3	4	5	7	7	10	12	14	18	21
35	1	1	2	2	2	4	5	6	6	7	10	12	15	18
30	0	1	2	1	2	3	4	5	5	7	9	11	13	15
25	0	1	1	1	2	3	4	4	4	5	7	9	11	13
20	0	1	1	1	2	2	3	3	3	5	5	7	9	10
	-20	**-10**	**-5**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Outdoor Temperature (°F)														

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How Much Humidity is Enough?

Humidity Control Is Needed Everywhere

- Warm Climates: Dehumidification to remove excess moisture
- Cool Climates: Humidification to prevent excessive dryness

Humidification for People

- Important for health and well being of occupants
- Applications at work and home

Humidification for Industry and Process

- Moisture sensitive materials
- Product Quality / Process Reliability

Humidification for People

Human Body Response

- Human body is ~60% water
- Body doesn't sense moisture well

Humidity and Respiratory Infections

- Evidence of link between moisture and cold / flu transmission
- Clinical trials between 1963 and 1985 showed significant reduction of respiratory infects when mid-range humidity was maintained [1-5]
- 2013 NIOSH/CDC Research showed reduced infectivity of flu virus aerosols with mid-range air humidity levels [6]

Photo Credit: iStock 000018649460

1. Ritzel G, Sozialmedizinische Erhebung zur Pathogenese und Prophylaxe von Erkältungskrankheiten, sog. «Kindergartenstudie» Zeitschrift für Präventivmedizin 1966, 11. 9-16
2. Sale C, Humidification to Reduce Respiratory Illnesses in Nursery School Children, Southern Medical Journal, July 1972, Vol 65
3. Green G H, Winter humidity and related absenteeism in Canadian hospitals, Digest of the 3rd. CMBES
4. Green G H, The effect of indoor relative humidity on absenteeism and colds in schools, ASHRAE Trans., Vol. 80, Part II
5. Gelperin A, Humidification and upper respiratory infection incidence, Heating, Piping and Air Conditioning, 45:3, 1973
6. Noti JD et. al, High Humidity Leads to Loss of Infections Influenza Virus from Simulated Coughs, PLoS ONE 8(2): e57485, 2013

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Humidification for People

Humidity and Productivity

- Study in Germany found possible influence of air humidity on eye irritations, dryness of mucous membranes, and vocal stress.
- Survey responses showed that insufficient air humidity have negatively impact well-being, motivation, and performance. [1]

Photo Credit: DRAABE Industrietechnik GmbH

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ASHRAE Standard 55

"There are no established lower level humidity limits for thermal comfort, consequently, this standard does not specify a minimum humidity level.

NOTE: Non-thermal comfort factors such as shin drying, irritation of mucus membranes, dryness of the eyes, and static electricity generation may place limits of the acceptability of very low humidity environments."

1. Rief S and Juric M, Air Humidity in the Office Workplace, Fraunhofer IAO, 2014

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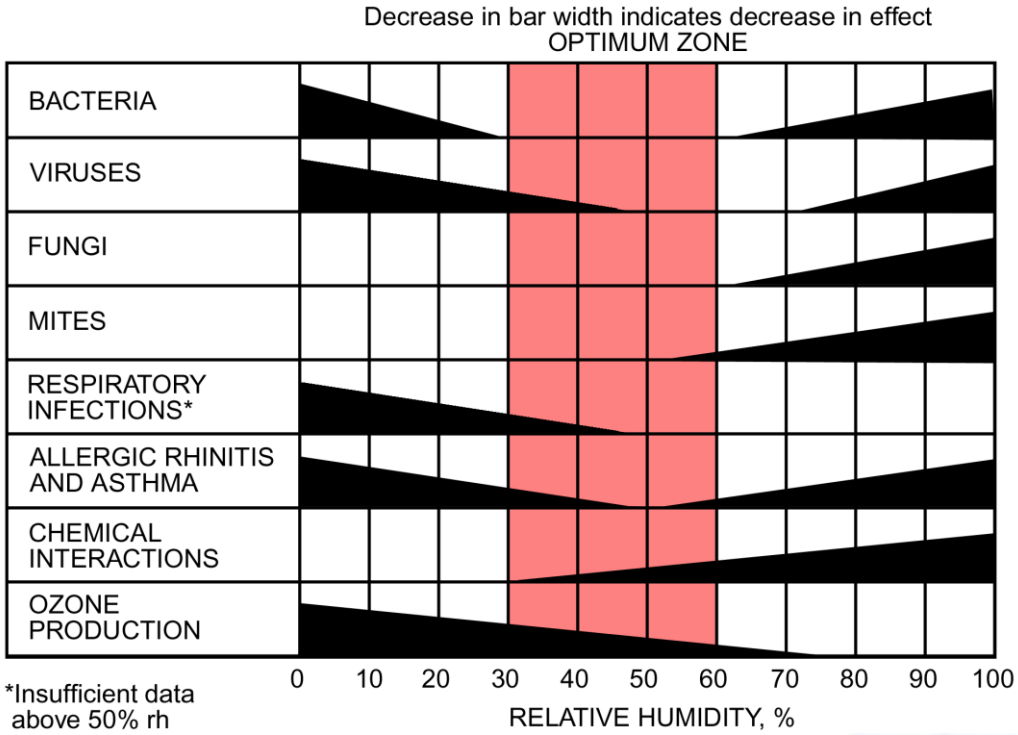
Humidification for People

The Sterling Chart

- Common design reference
- Suggests mid-range 30 - 60% is optimal
- ASHRAE RP-1630 is working to update chart with latest research

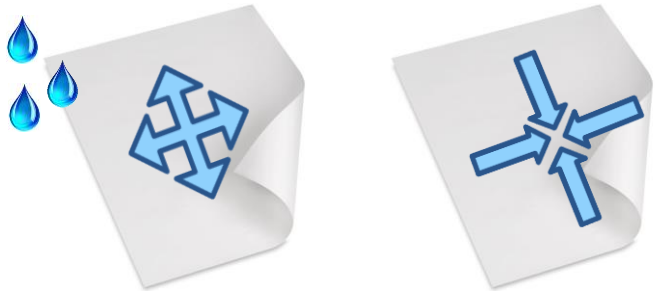


Adapted from Sterling et al. 1985

Humidity and Process

Humidity Affects Materials

- Swell and shrink effects
- Paper, wood, textiles, concrete

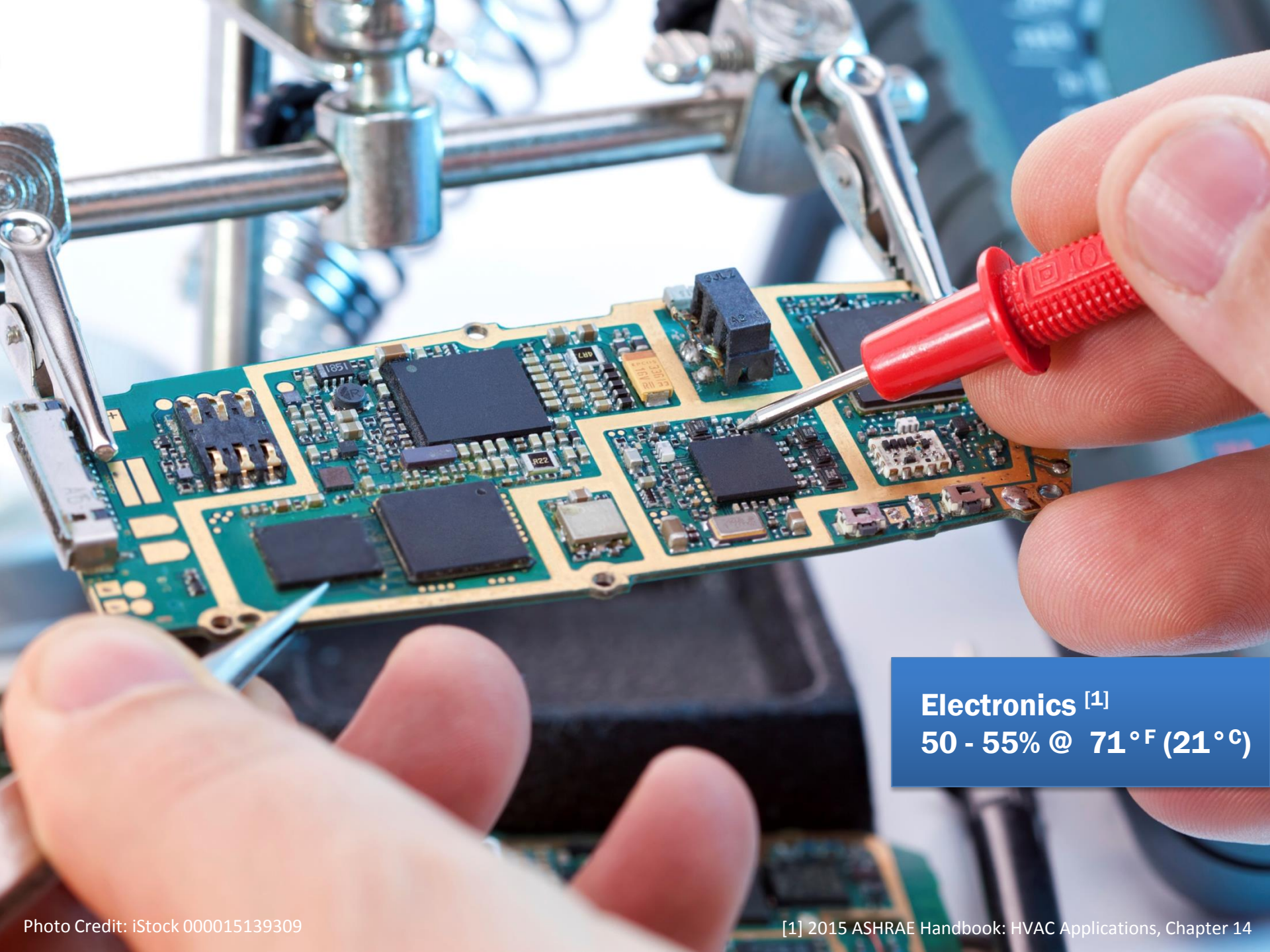


Humidity Affects Static Charge Accumulation

- Dry air resists charge dissipation
- High charge voltages result in spark discharge

Humidity Affects Production Processes and Product Storage

- Painting, concrete curing, leather processing all rely on moisture balance
- Food storage and processing; fruit, vegetables, cheese



Electronics [1]
50 - 55% @ 71°F (21°C)

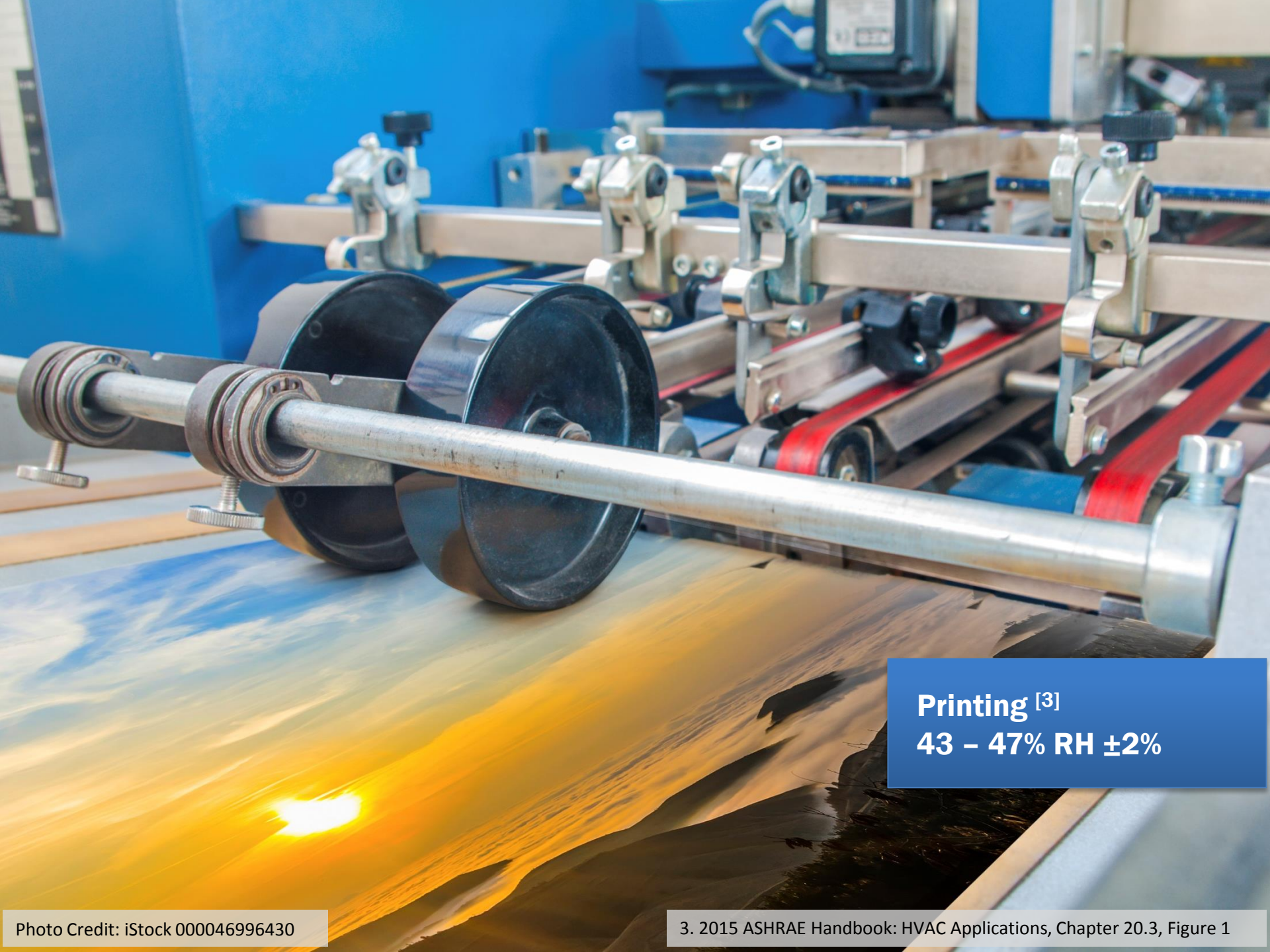
Photo Credit: iStock 000015139309

[1] 2015 ASHRAE Handbook: HVAC Applications, Chapter 14

Textiles [2]
50-70%

Photo Credit: iStock 000022275438

[2] 2015 ASHRAE Handbook: HVAC Applications, Chapter 21.2, Figure 1



Printing [3]
43 – 47% RH ±2%

Photo Credit: iStock 000046996430

3. 2015 ASHRAE Handbook: HVAC Applications, Chapter 20.3, Figure 1

Humidity Design Resources: More Information

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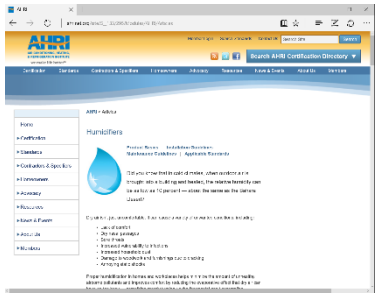
ASHRAE Handbooks

- 2016 Systems and Equipment Chapter 22
- 2015 HVAC Applications



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AHRI Humidifiers Section

- www.ahrinet.org
- Click Contractors and Specifiers

Photo Credit: N. Lea

Local Standards and Norms

- Codes, Federal Standards, etc.
- Euro Standard EN 15251:2007

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Fundamentals of Humidity: Summary

Humidity

- Relative to temperature
- High outdoor RH does not equal acceptable indoor RH

Humidity for People

- Evidence shows link between humidity and health
- Indoor RH 30 – 60%

Humidity for Process

- Many processes are moisture dependent
- Drying rates, dimensional stability, static, strength

Industrial / Commercial Humidifiers and Selection – Done Right

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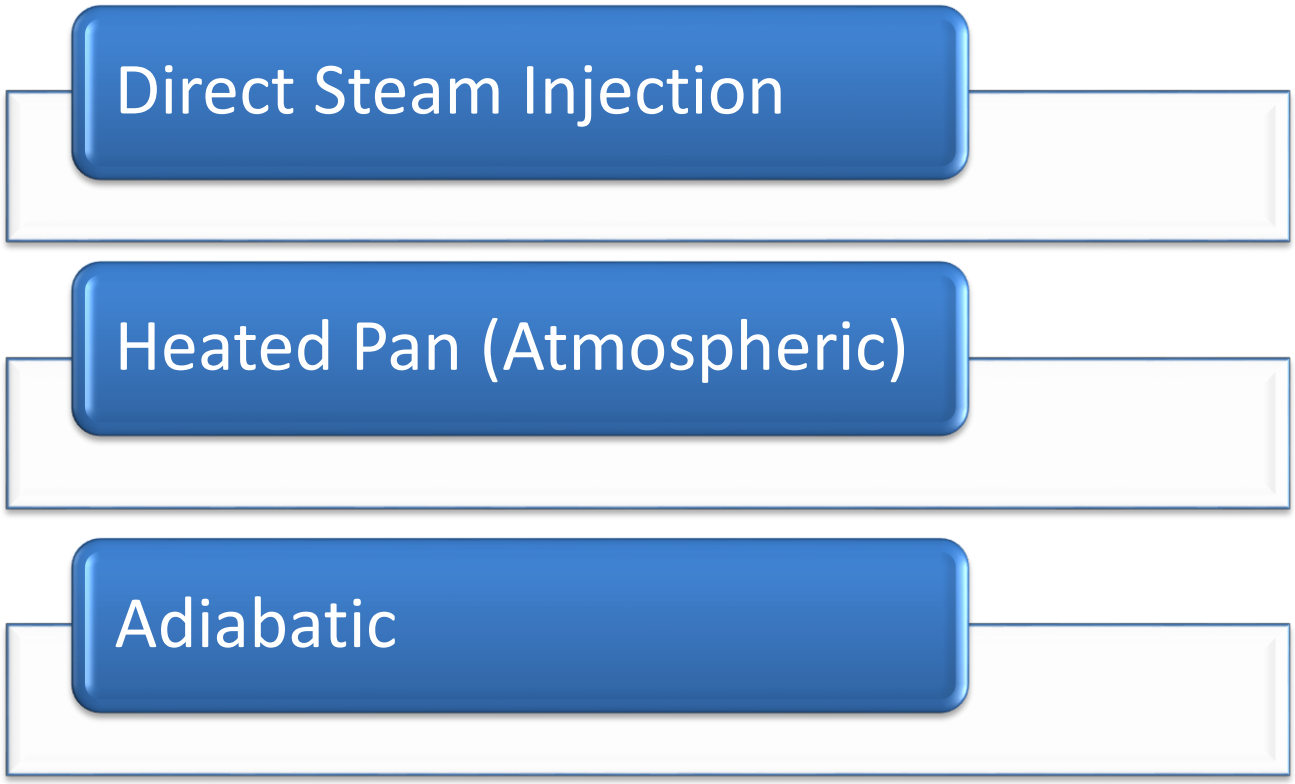
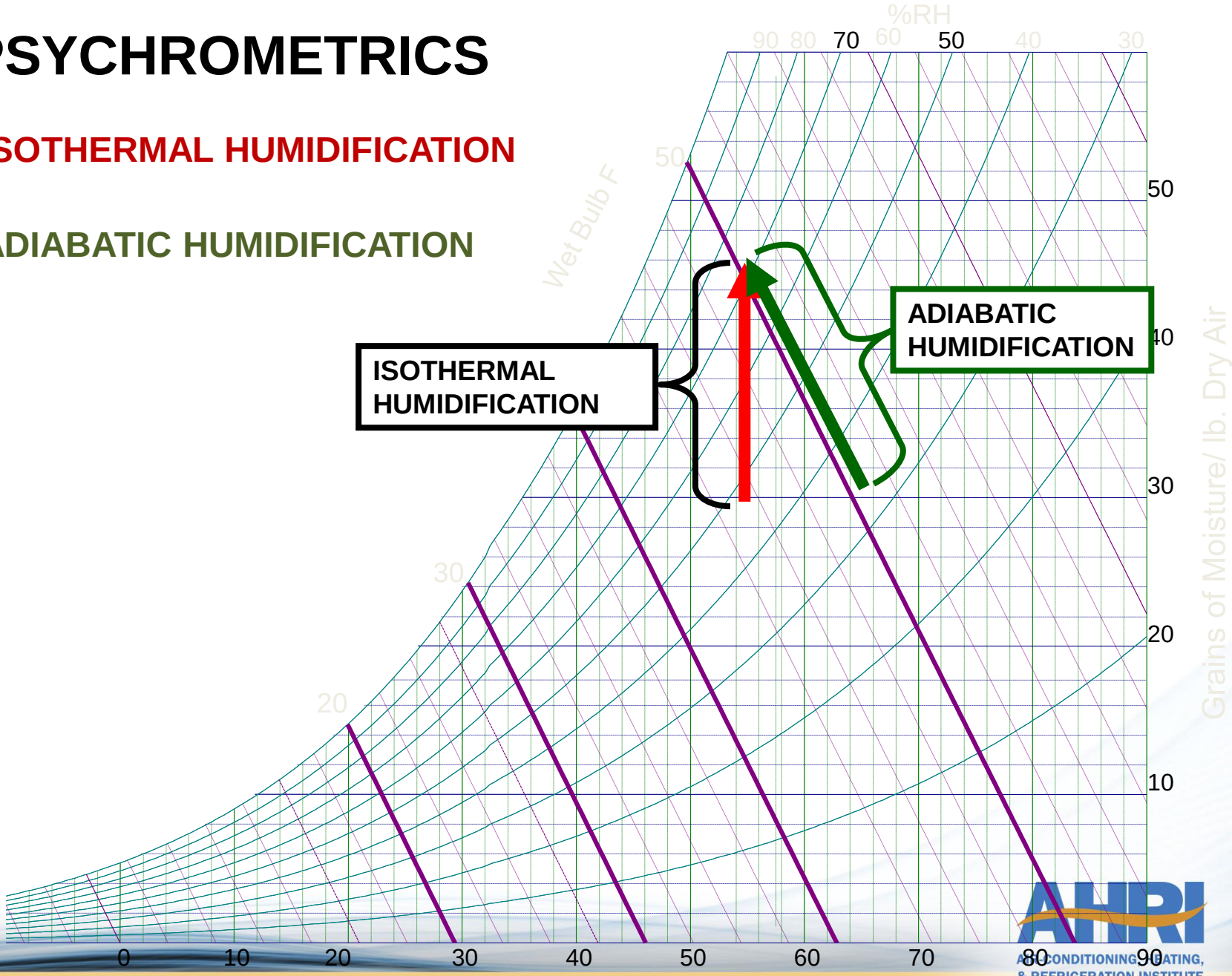
Methods of Humidification



PSYCHROMETRICS

-ISOTHERMAL HUMIDIFICATION

-ADIABATIC HUMIDIFICATION



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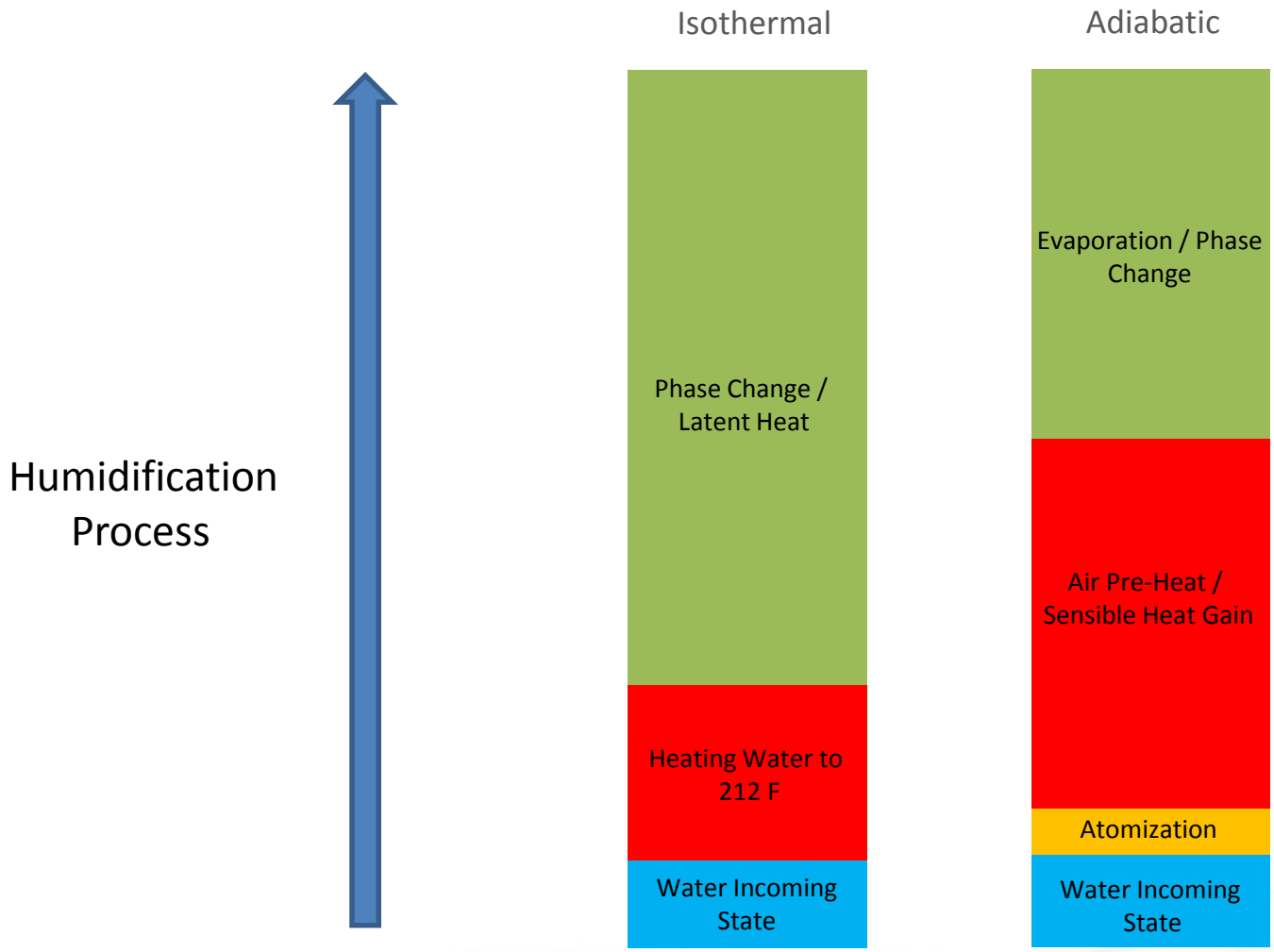
Isothermal vs. Adiabatic Energy Usage



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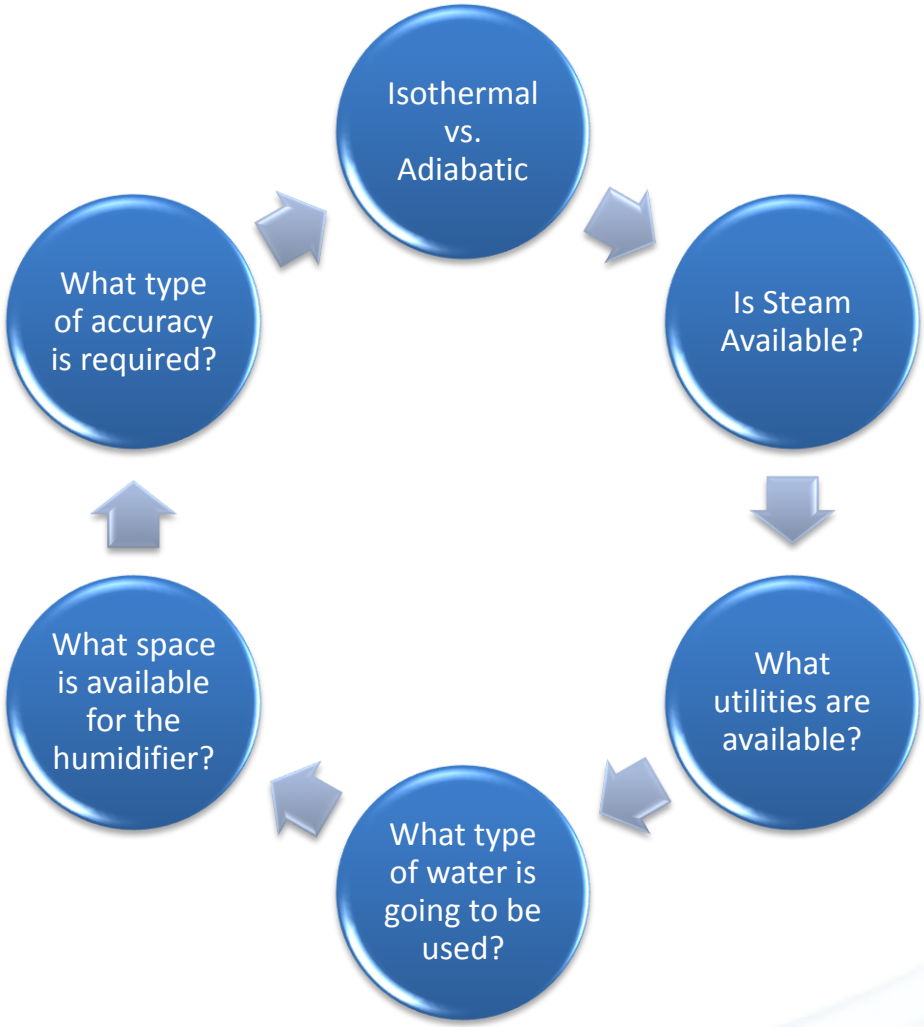
Humidifier Selection



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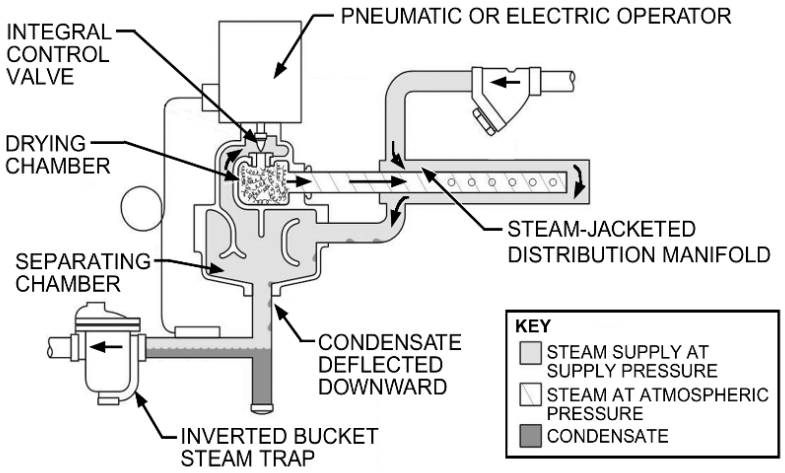
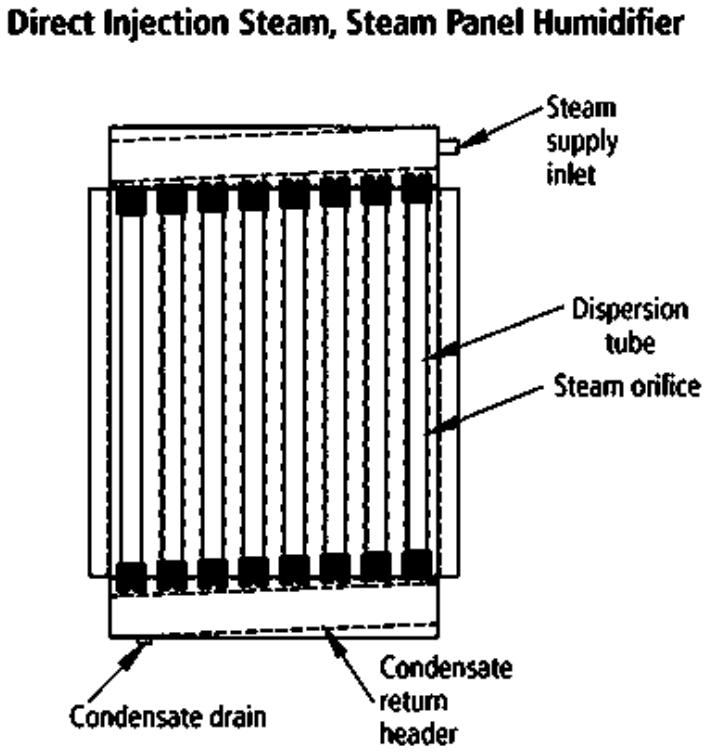
Information for Load (Capacity) Required

- **Where is the Humidity going to be added to the air?**
  - Duct / AHU
    - Tunnel size (H x W x L)
    - Airflow
    - Temp of Air at this point
    - Amount of Outside Air / Conditions of that air
  - Room
    - Dimensions of Space
    - Air Changes per Hour (# of Doors and Windows)
- **What conditions are you trying to achieve?**

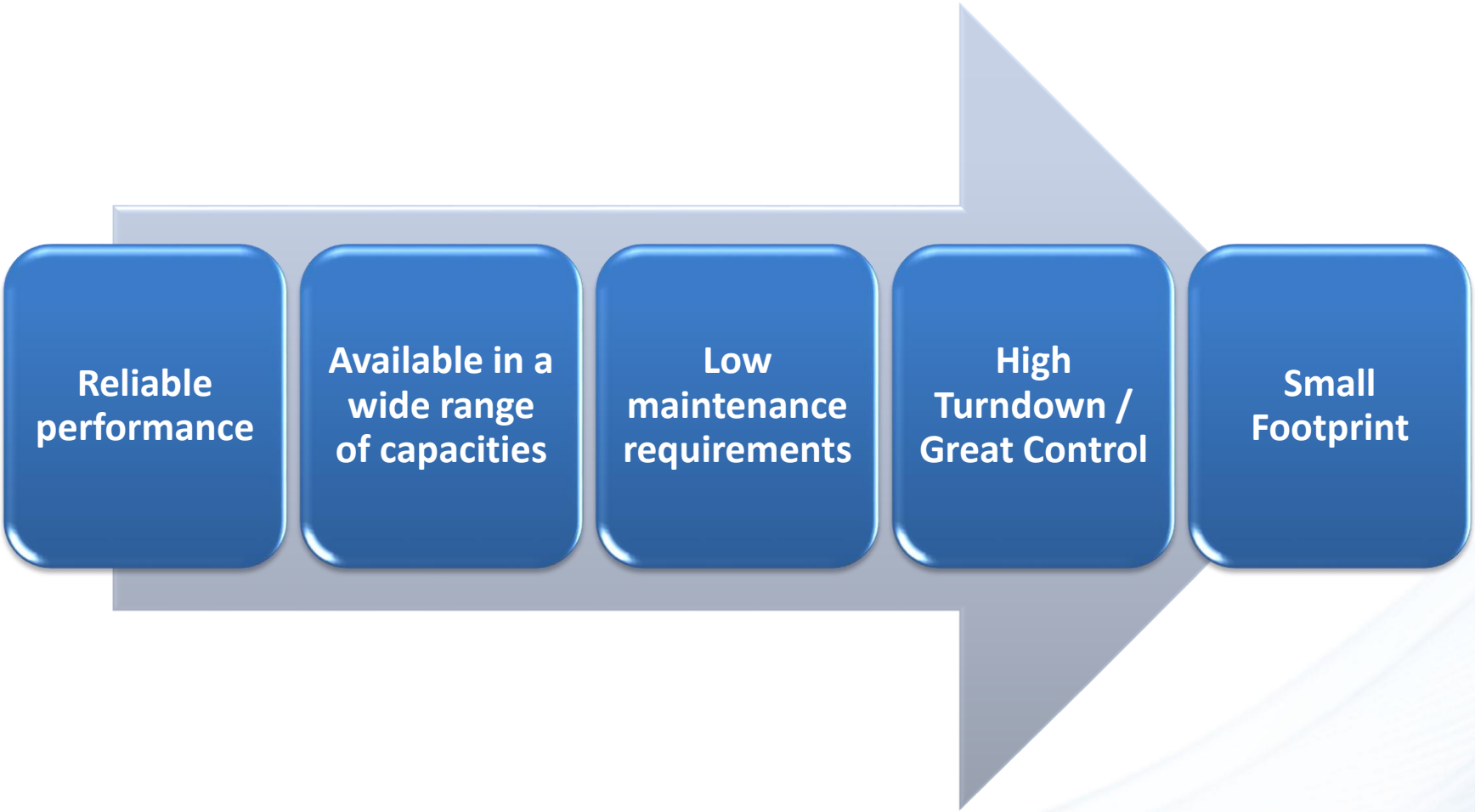
Direct Steam Injection



B. JACKETED STEAM HUMIDIFIER
(Courtesy of Armstrong International, Inc.)



Direct Steam Advantages



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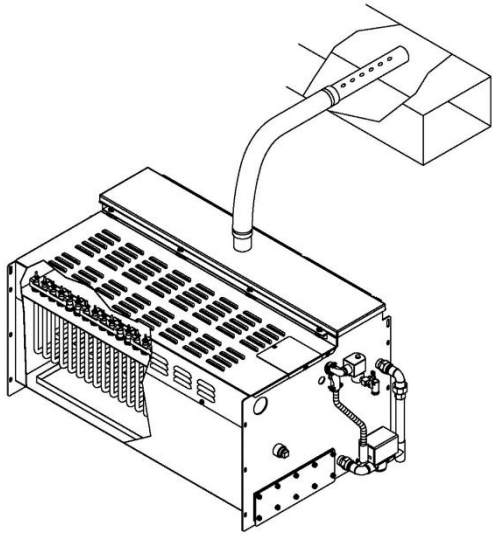
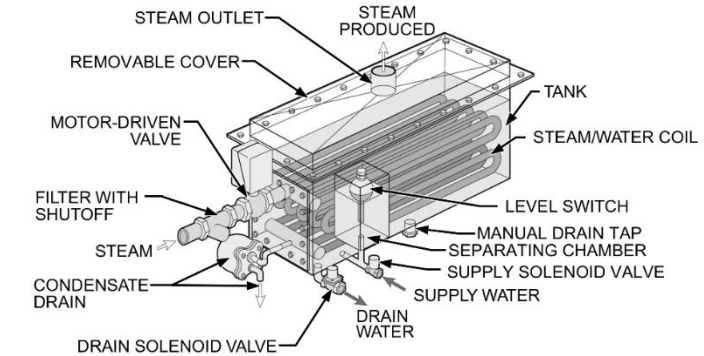
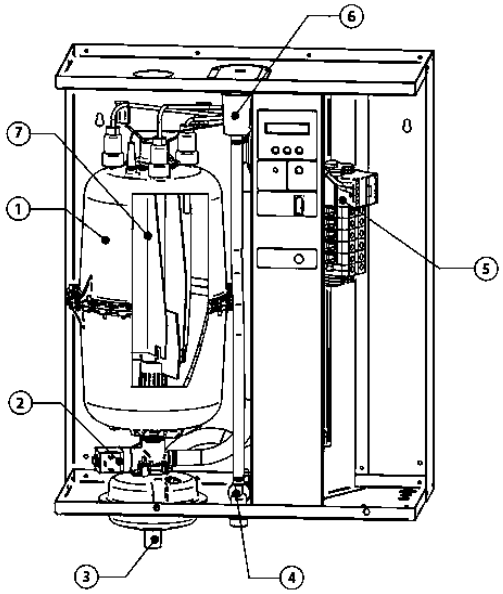
Heated Pan (Atmospheric)

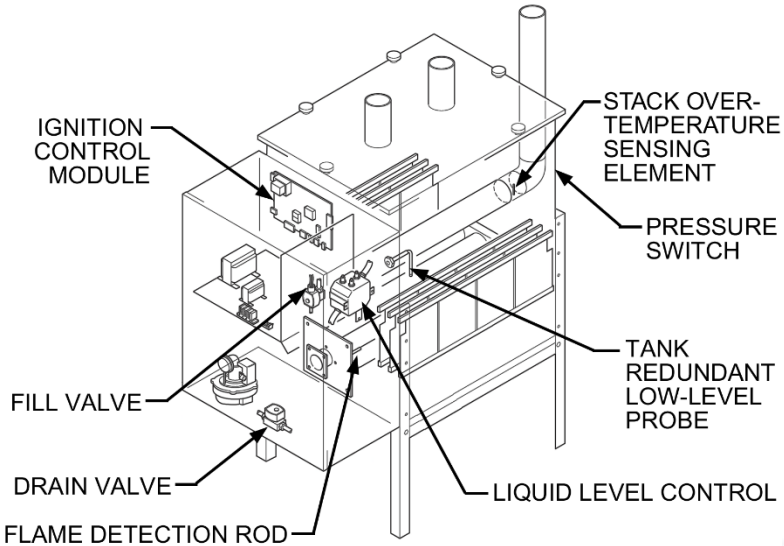


F. SELF-CONTAINED ELECTRIC RESISTANCE HUMIDIFIER



A. STEAM- OR HOT-WATER-HEATED PAN STEAM-GENERATED HUMIDIFIER



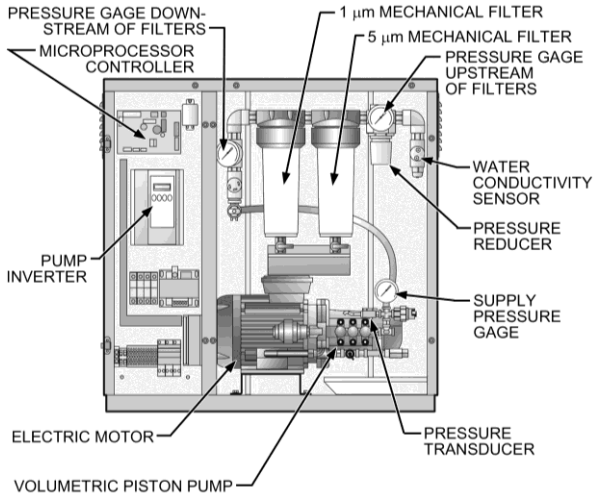


H. GAS-FIRED STEAM HUMIDIFIER

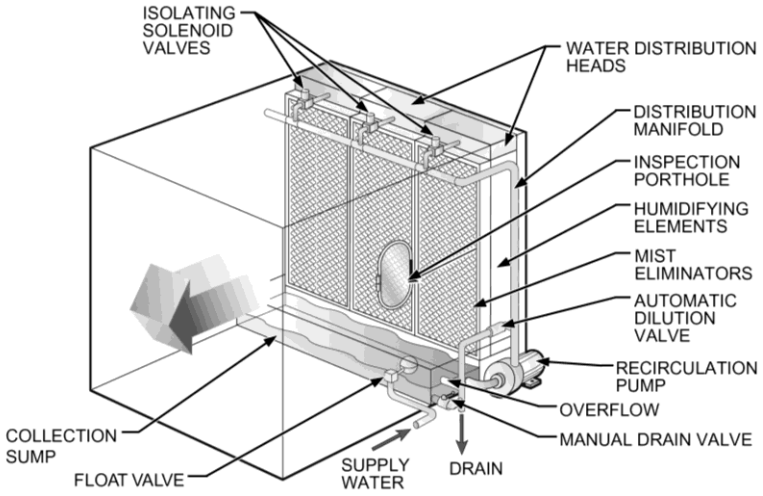
Heated Pan Advantages

Electric Units	• Compact size • Good Control / Turndown • Self-diagnostics
Gas Units	• Low Energy Cost • Higher Capacities • Self-diagnostics
Steam to Steam Units	• Available in a wide range of sizes and high output capabilities • Reliable operation

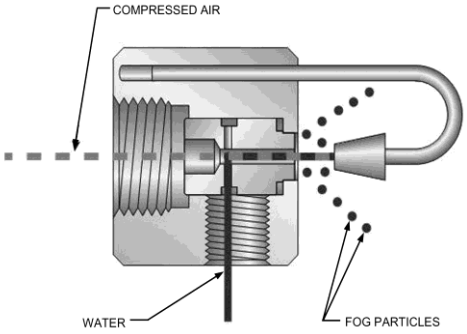
Adiabatic Humidifiers



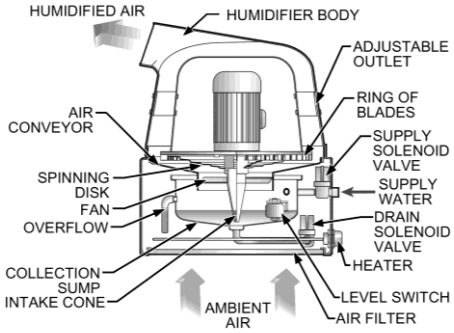
D. HIGH-PRESSURE ATOMIZING STATION



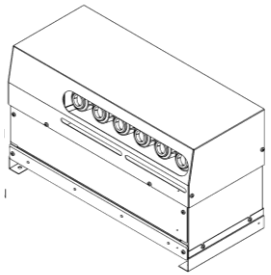
H. RIGID-MEDIA HUMIDIFIER



G. COMPRESSED-AIR NOZZLE



C. CENTRIFUGAL ATOMIZING HUMIDIFIER



B. ULTRASONIC HUMIDIFIER

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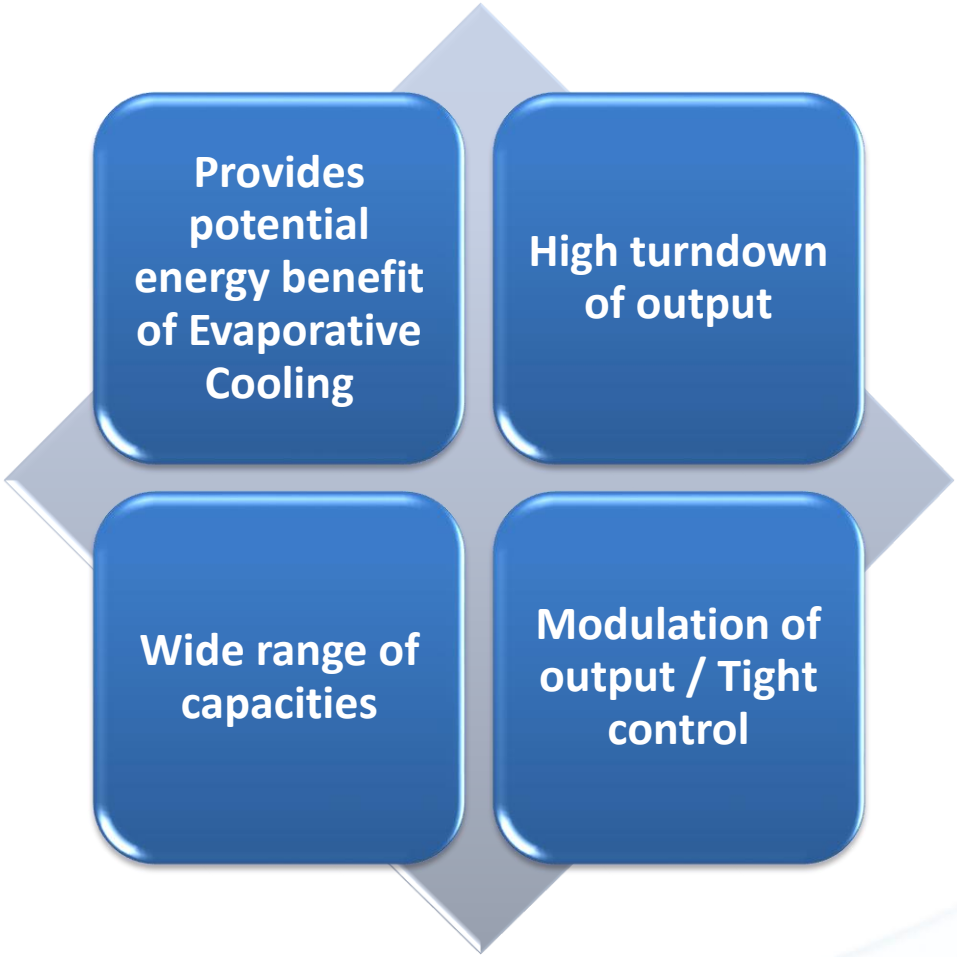
Adiabatic Humidifier Advantages



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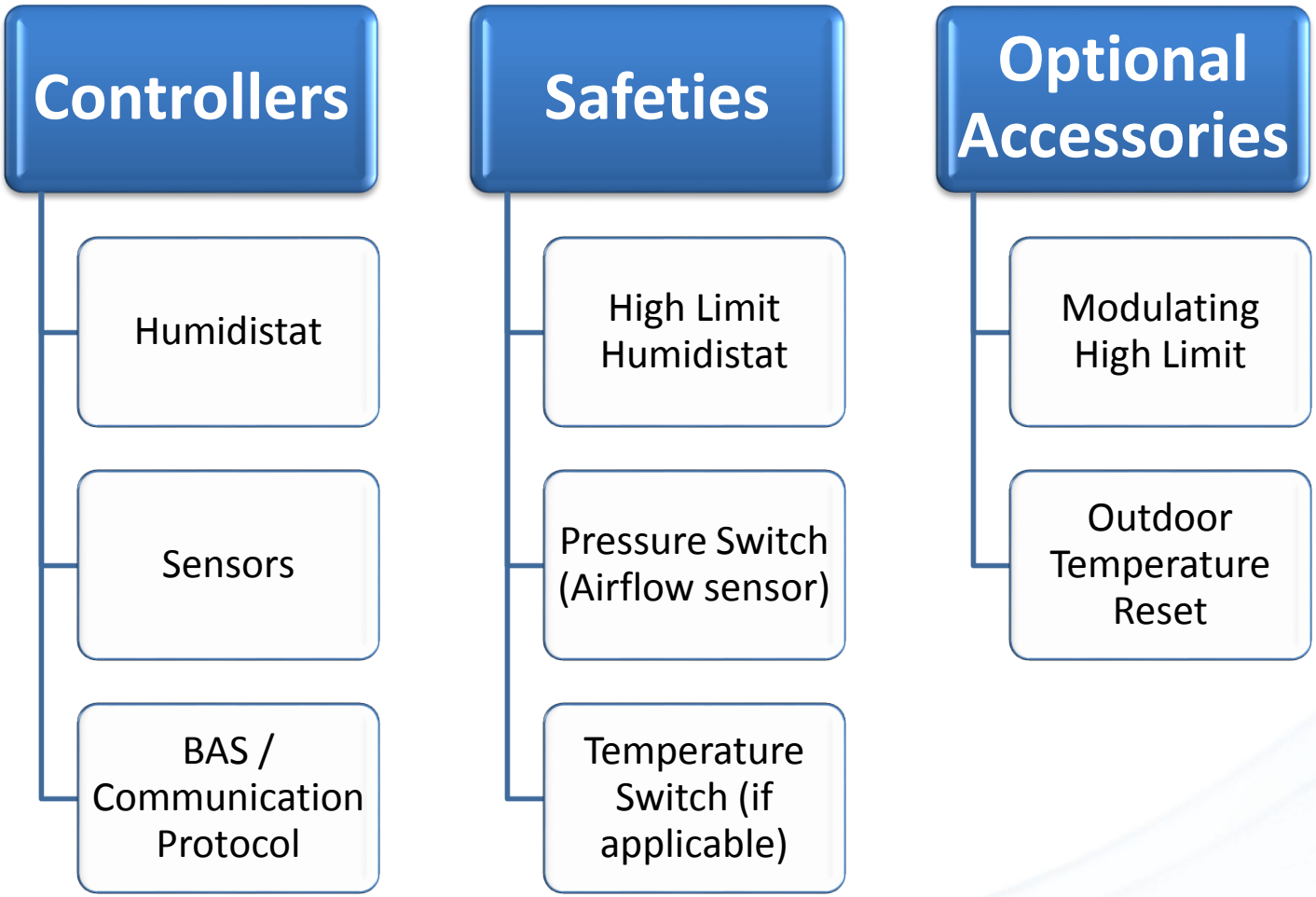
Humidity Control



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Who to consult?

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Residential Humidifiers and Selection – Done Right

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Residential - Humidification Done Right

Health

Comfort

Preservation

Energy Savings

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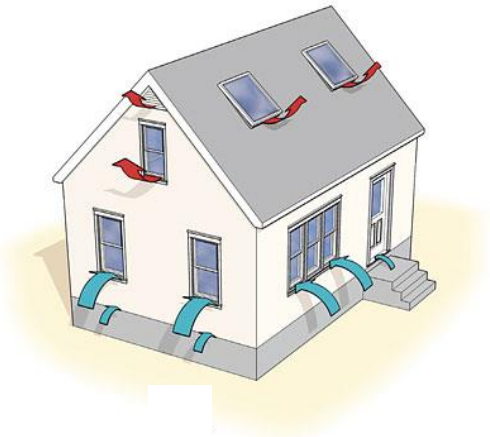
Relative Humidity – Dry Air

Dry outdoor air !

Enters the house!



The house gets very Dry !

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Changing Building Envelopes and HVAC Equipment

- **Today it is common to encounter:**
- Small equipment rooms, tight workspaces…
- Equipment and plenum size limitations…
- Various air volumes with various run times…
- Heat pumps with lower plenum temperatures
- Hydronic or radiant heating equipment
- Modulating furnaces
- Tight construction
- Various ventilation rates

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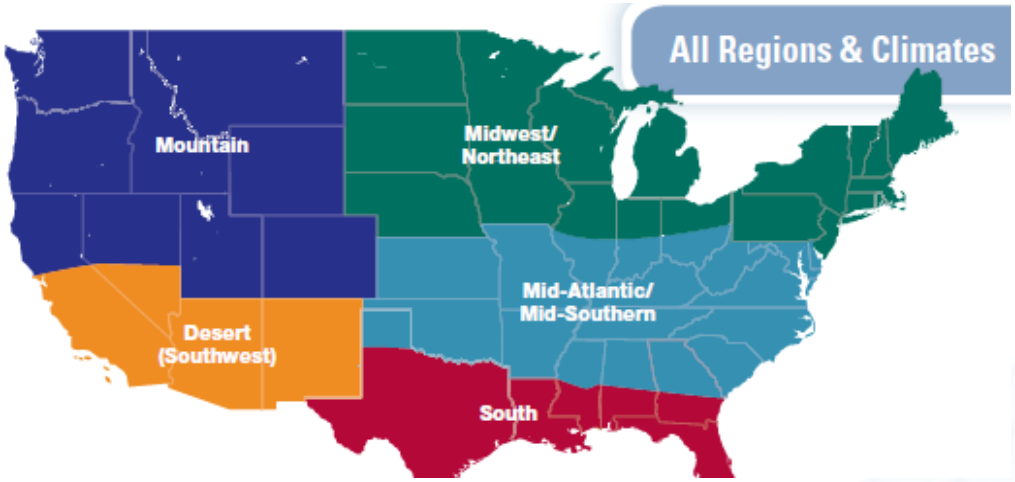
Key Humidifier Application Criteria

- **HVAC Equipment:**
  - Type of HVAC equipment
  - HVAC equipment physical size
  - Location of HVAC equipment
  - Plenum temperatures
  - Airflow distribution and zoning
  - HVAC controls

Key Application Criteria

- **Humidification Load:**
- House size
- Physical Characteristics
- Occupants
- Geographic Location



- **Water characteristics :**
- Hard, soft or softened
- Hot or cold
- Conductivity
- City or well/septic

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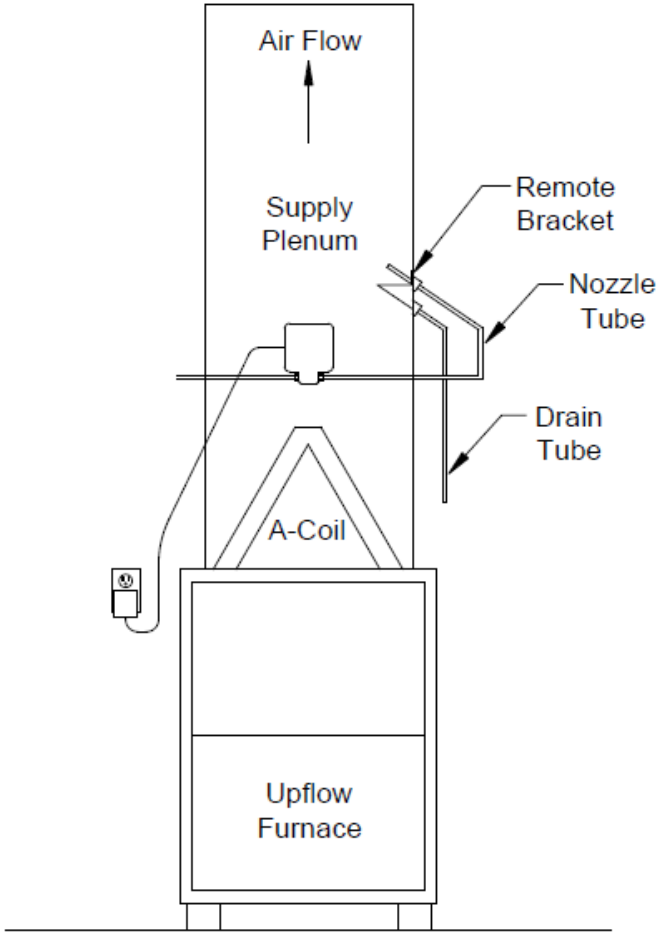
Residential Humidity Solutions

- Atomizing
- Evaporative
  - Fan-Powered
  - Bypass
- Steam
  - Resistive
  - Electrode

Atomizing Humidifiers

Advantages

- Install on Heat/Cool Systems
- Install on Heat Pump Systems
- Works with demineralized water
- Adiabatic



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Evaporative Humidifiers

Advantages

Install on Heat/Cool Systems
Install on Heat Pump Systems

Adiabatic

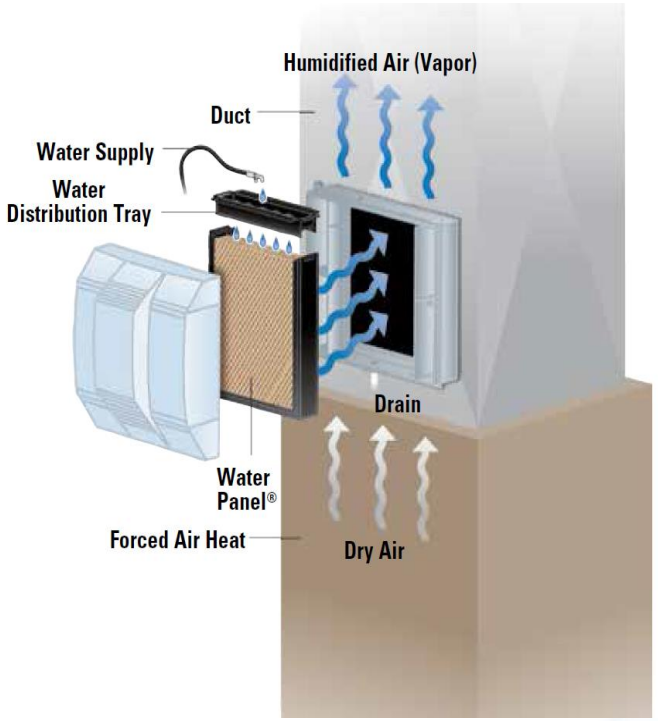
Many sizes and capacities

Low water usage models

Use hot water for higher capacity

Powered or bypass humidifiers

Various control options



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Steam Humidifiers

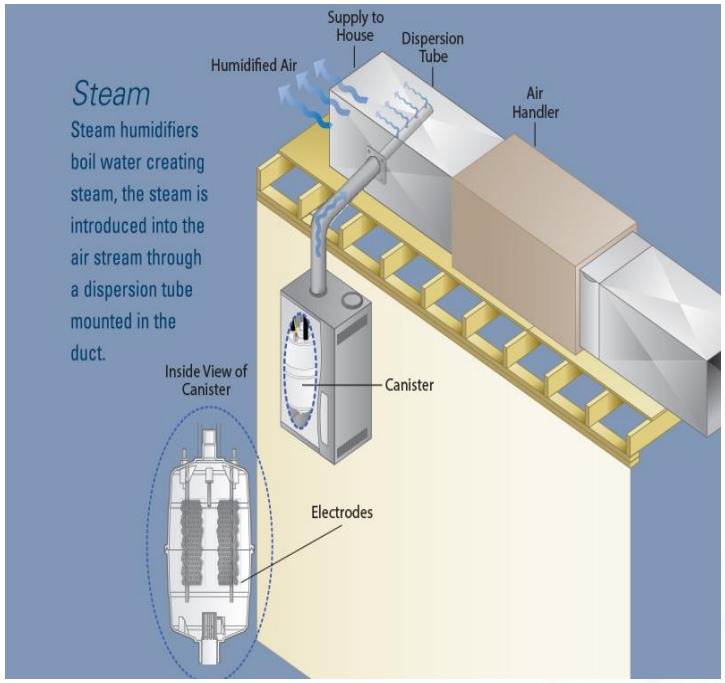
Advantages

Install with any HVAC systems:

- Radiant or Hydronic Heating
- Heat/Cool Systems
- Heat Pump Systems
- Ducted Systems

Used in:

- All type of Climates
- Small Equipment Closets
- Stand Alone Operation
- Modulating Controls
- High Capacity Needs



Resistive and Electrode Humidifiers

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Control Strategies

Manual control

Automatic Controls

Modulating Controls

IAQ Thermostats

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AHRI Guideline

- **AHRI Guideline for Residential Humidifier Humidification Load; equipment selection; installation practices; and servicing practices.**

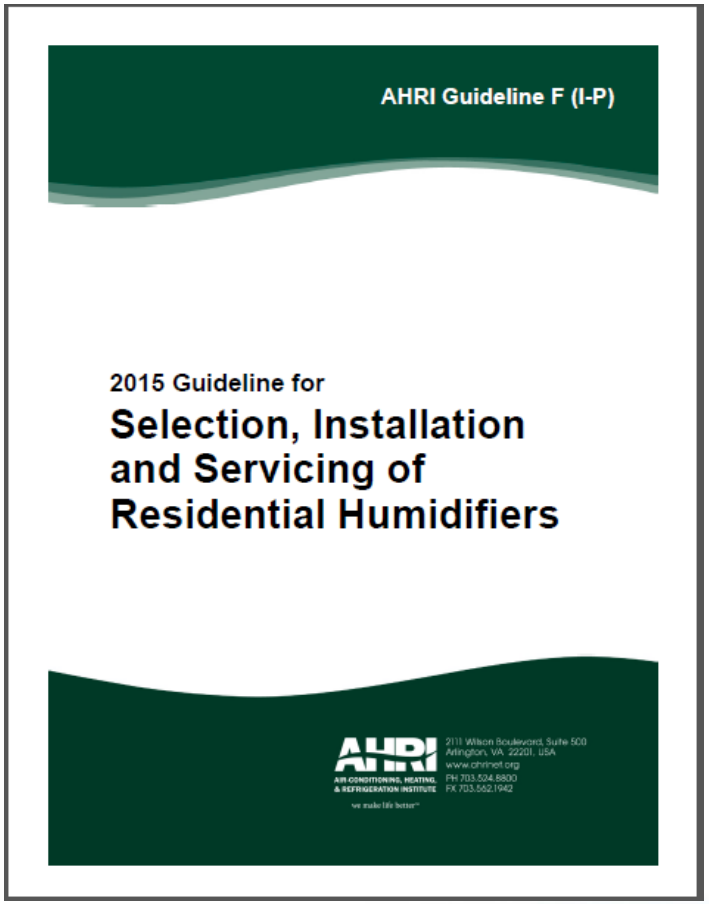

Table 1. Humidification Load Required, gal/day[1,2]

Type of Construction	Volume of Building, ft³							
	8,000	10,000	12,000	16,000	20,000	24,000	32,000	40,000
Tight	3.3	4.2	5.0	6.7	8.3	10.0	13.4	16.7
Average	6.7	8.3	10.0	13.4	16.7	20.0	26.7	33.4
Loose	10.0	12.5	15.0	20.0	25.0	30.1	40.1	50.1

Notes:
1. Loads shown in the table are based on indoor conditions of 70°F and 35% RH with 20°F and 70% RH outdoors.
2. An amount of 2.0 gallons per day may be deducted from these figures if it is desired to take credit for internal sources of moisture (based on a family of four).

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In summary

Residential humidification is needed.

- **Select proper humidifier based on:**
  - Building construction
  - HVAC equipment
  - Humidification systems
  - Controls
  - Customer expectations

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Questions

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