Overview of Desiccant History

- **Applied Industrially ≥1930s / Commercially ≥1980s**
- **Industrial**
  - Moisture sensitive production/storage
  - Major markets: pharmaceuticals and food/beverage
- **Commercial**
  - Dry air benefits for refrigeration processes: supermarkets, ice arenas, and cold warehouses
  - Humidity control for higher ventilation air volumes: hospitals, theaters, schools, restaurants, etc.

Desiccants in Industry

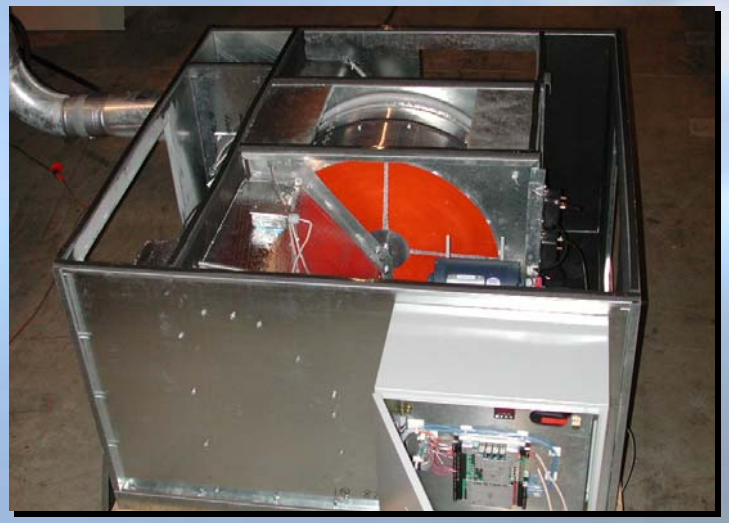
Industrial Market Drivers

"Good product in the winter time, bad product in the summer time!"

- Dew Point (DP) below 45°F
- Relative Humidity (RH) below 45%
- Higher value production/storage targets
- Heavy duty desiccant equipment
- Premium price equipment

But...

- Large economic benefit to processes/products



NEED: Predictable, reliable, and profitable year round operation.

Desiccants in Industry

5 types of uses in Industry

Application

- Corrosion prevention
- Condensation prevention
- Mold/mildew prevention
- Moisture regain prevention
- Product drying

Control Level

- <35%RH
- Dew Point of 3 to 5°F < coldest surface
- <70%RH (onset of mold)
- %RH Air = % H20 of material
- %RH Air = % H20 of material
  (at lower temperature)

Desiccants in the Commercial/Institutional Sector

Commercial Market Drivers

Process Applications

- Refrigeration processes
- Drier air = lower loads on refrigeration system
- Target levels <45%RH
- Conventional AC can't control to lower RH

NEED: Cost effective humidity control for lower RH setpoints

IAQ Applications

- Indoor Air Quality (IAQ)
- IAQ = Outside Air (OA) per ASHRAE 62-89
- OA high in humidity
- Conventional AC loses humidity control at higher OA levels

NEED: Cost effective humidity control for humid OA treatment

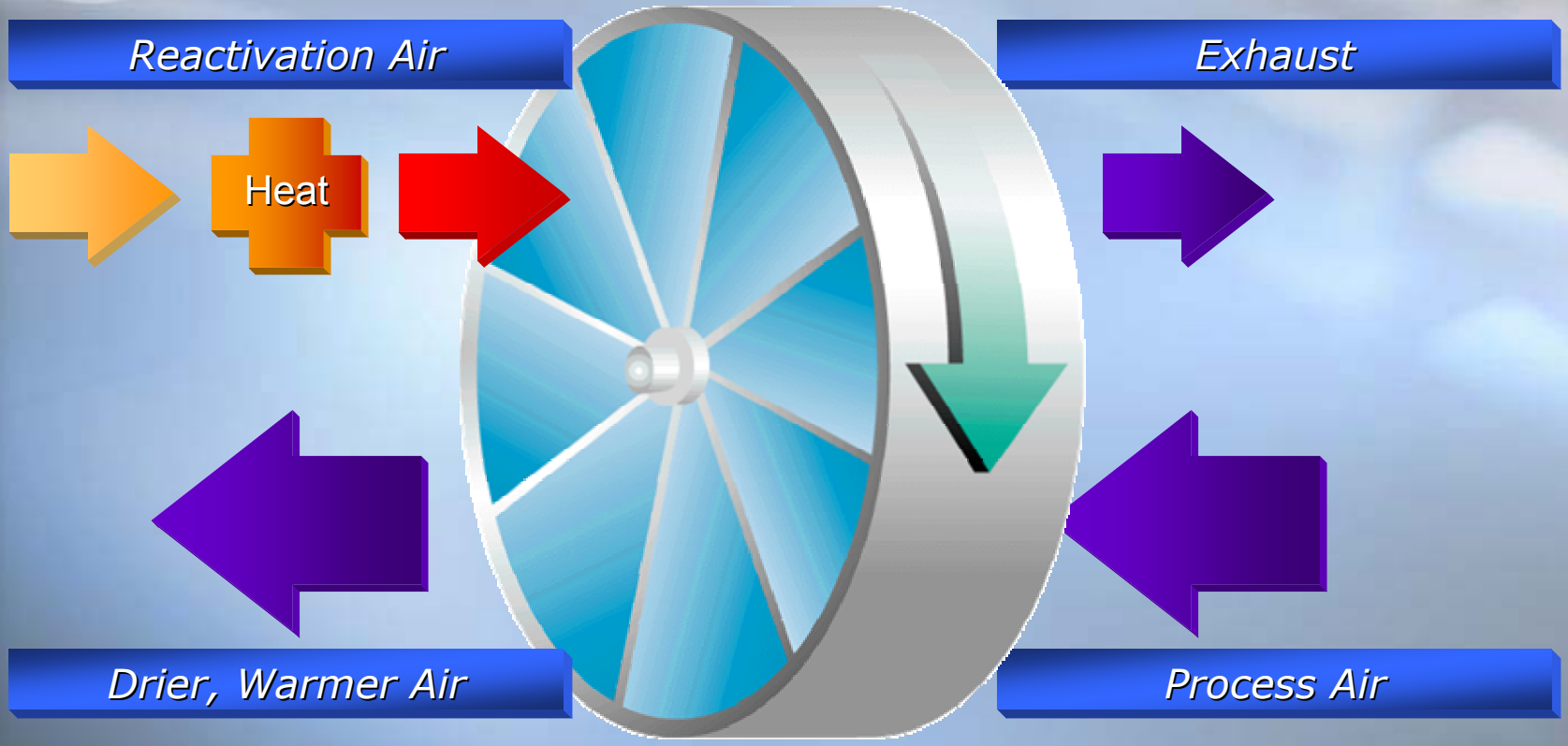
Desiccants Meet the Challenge

How desiccants answer needs of the new millennium

- In 1989, ASHRAE Standard 62-89 increased outside air flow
- Outside air brings high moisture loads
  - Since 1997, ASHRAE Handbook of Fundamentals contain Dew Point design values
- Most IAQ problems caused by lack of ventilation and/or excess moisture
- Cost of desiccants for commercial building is now 50% less than in 1986

Desiccant Dehumidification

Active Desiccant Wheels



Desiccant Dehumidification Advantages/Disadvantages

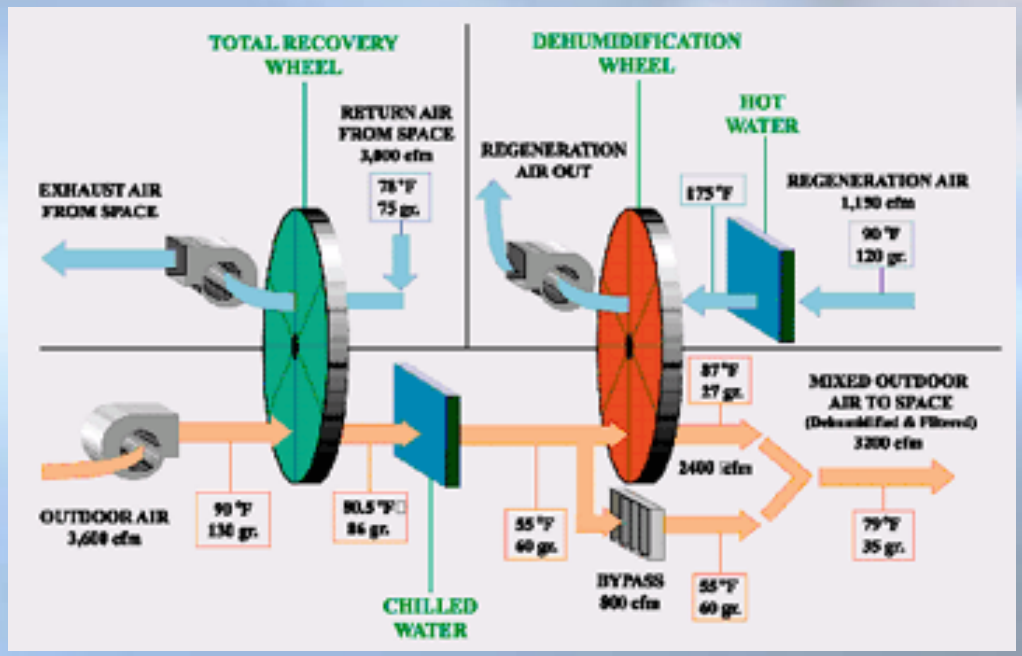
Advantages and Limitations of Active Desiccants

- **Advantages**
  - Tremendous DH capacity (at any dew point)
  - Easy to control in response to changing loads
  - Uses low-cost energy (gas or waste heat)
  - Does not need exhaust air

- **Limitations**
  - Relatively high equipment cost/cfm, best used on ventilation air
  - Converts water vapor to heat (post-cooling required)
  - For best economics, must reduce excess cooling capacity in the rest of the system

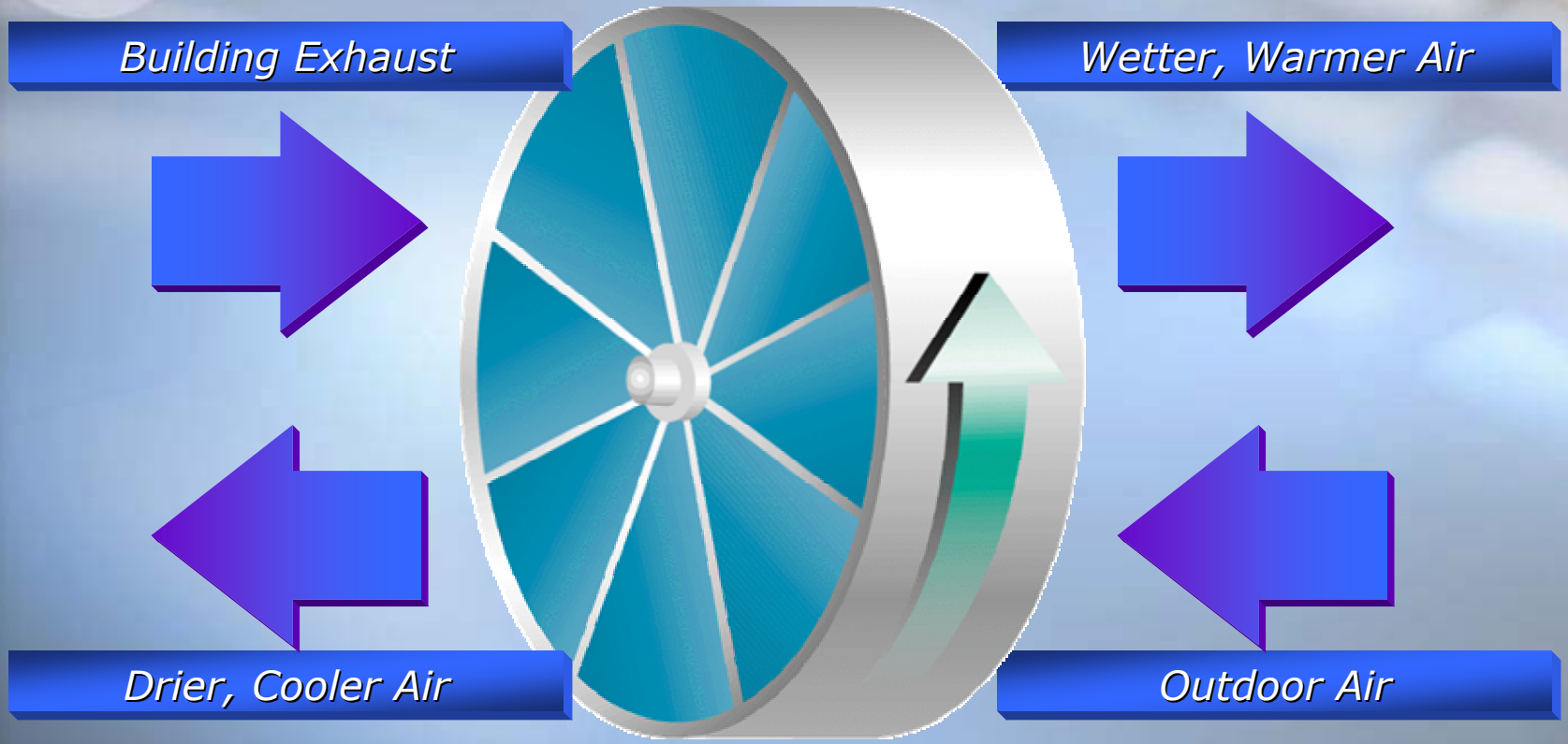
Desiccant Enthalpy Exchange Hybrid Systems

- Desiccant exchanges outdoor air latent load to building exhaust air
- Humidity load is mitigated but downstream air conditioning/post cooling must still control moisture level in the building
- Post coolers
  - Downsized standard cooling coil; indirect evaporative



Enthalpy Exchange

Passive Desiccant Wheels



Enthalpy Exchange Advantages/Disadvantages

Advantages and Limitations of Passive Desiccant Wheels

- **Advantages**
  - Low-cost add-ons now available for low-cost rooftops
  - Reduces peak load when outdoor sensible load is high
  - Can reduce net installed cost of both heating and cooling equipment (big savings)

- **Limitations**
  - Exhaust must be brought back to ventilation air inlet
  - Non-functional for dehumidification during many hours per year (60-75°F hours)
  - Performance depends on dryness of exhaust air. Humidity load is mitigated but downstream air conditioning/post cooling must still control moisture level in the building

Desiccant Dehumidification Hybrid Systems

- Desiccants transfer latent load to sensible load
- Many desiccant systems include a heat exchanger placed after the desiccant wheel to transfer the sensible load from the process air to the reactivation air
  - Plate-type, lowest, 40 to 60% efficient
  - Heat wheel, highest cost, 80 to 90% efficient
  - Heat pipe, middle cost, 55 to 75% efficient
- Post coolers
  - Downsized standard cooling coil; indirect evaporative