PhEn-602
Pharmaceutical Facility Design

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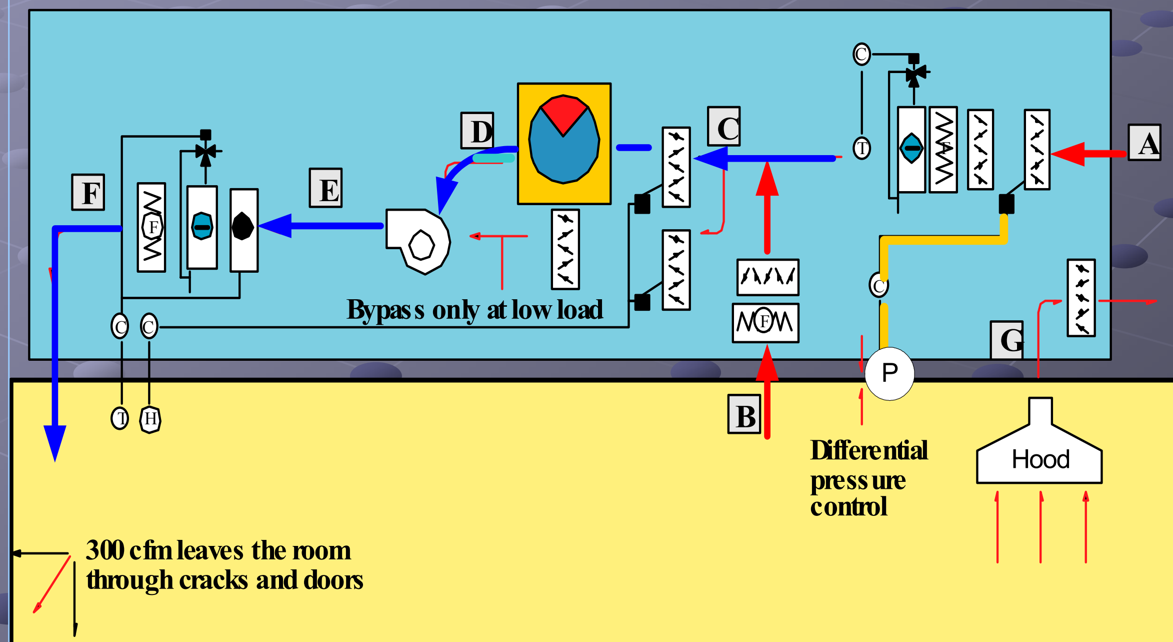
Notes #11

10% rh Room - Typical Schematic

	Location	Airflow (cfm)	Temp (° F)	Moisture (gr/lb)
Outside air	A	800	91	147
Return air	B	3000	70	11
Mixed air	C	3800	66	20
	D	3800	86	4
	E	3800	86	4
Supply air	F	3800	60	4
Exhaust air	G	500	70	11

Notes:

1. In this example, no heat gain across the supply fan
2. Pre-cooling coil between A and C provides for sensible cooling prior to dehumidification
3. Post-cooling coil reduces temperature prior to entry into room. Removes the sensible heat added during the dehumidification process.



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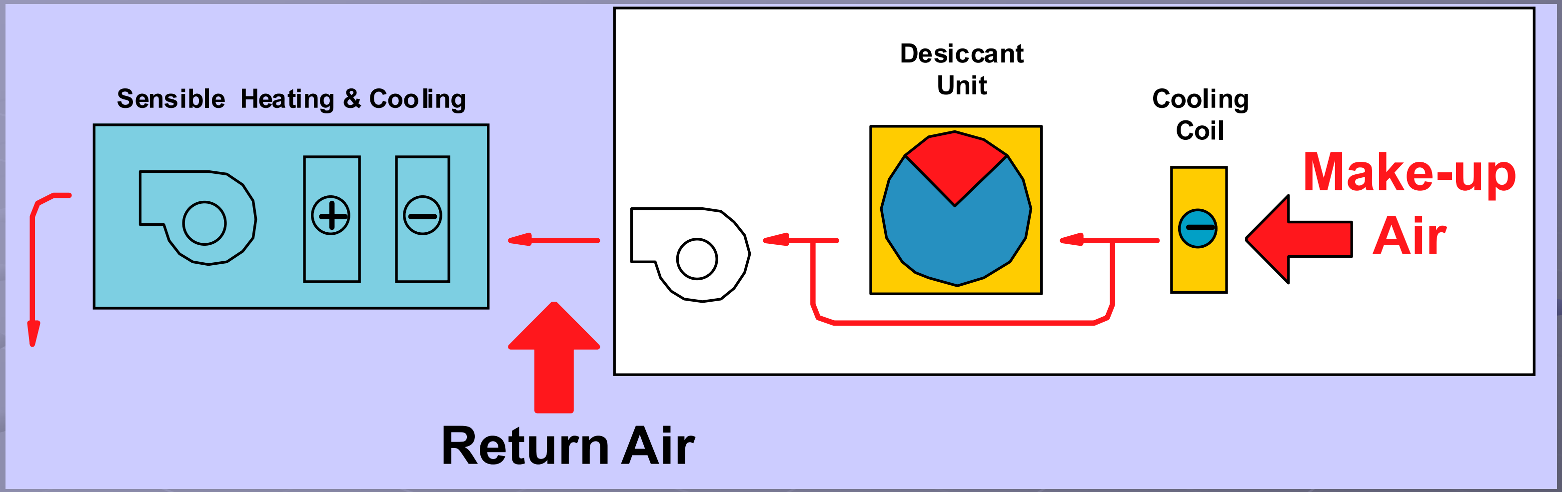
DH Handbook 7-

10% rh Rooms - Other Considerations

- Temperature control is often as critical as humidity. Sensible heat load and uniformity requirements may determine system air flow volume.
- Reactivation energy can exceed installed cost within three years. To reduce energy cost, consider:
  - Reactivation energy modulation
  - Waste heat for pre-heat
  - Air-to-air heat exchanger
- The lower the humidity, the more critical the load calculations. Be sure to specify air leak rates in construction specs.
- When exhausting from low humidity room, air balance is absolutely

System 1- Dehumidify Only The Make-up Air



- Pre-cool the make-up air, then dry with desiccant
- When make-up air percent is high, this is usually the most economical system
- For example:
  - Semiconductor clean rooms
  - Pharmaceutical clean rooms above 25% rh
  - Hotels & motels

Change Reactivation Temperature

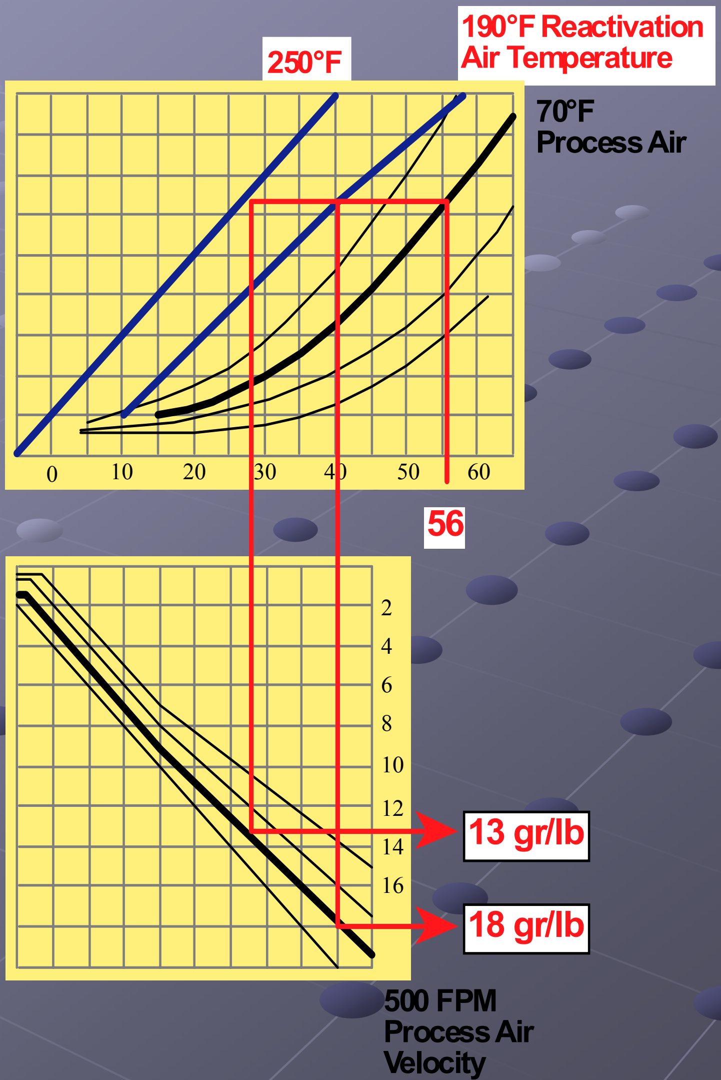
Basic Parameters:

Process Air

- 70°F
- 56 gr/lb
- 500 fpm

Reactivation Air

- 190 and 250°F

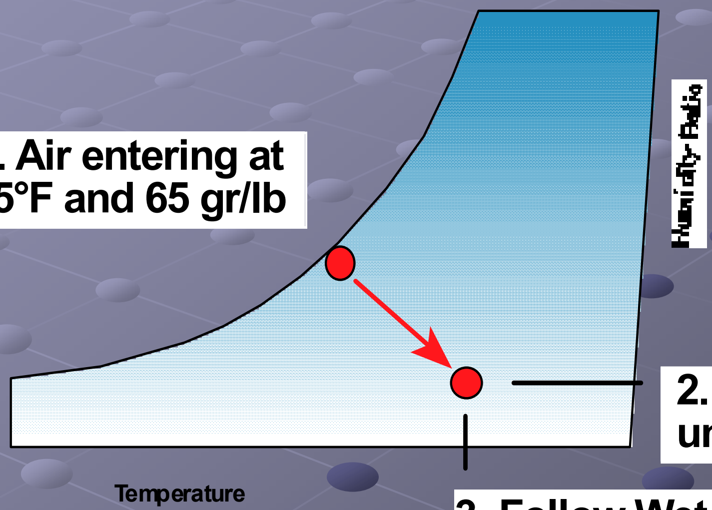


Process Air Temperature Rise

- In principle, the heat in the air leaving the dehumidifier equals the sum of:
  - Latent to sensible heat conversion
  - Plus heat carried over from reactivation to process

Rough Estimating Method For Process Outlet Temperature

Approximate by assuming a constant enthalpy, plus...........some heat carried over from reactivation:



1. Air entering at 55°F and 65 gr/lb

2. Air leaves the unit at 10 gr/lb

3. Follow Wet Bulb And Read Dry Bulb @ 10 gr/lb.......91°F

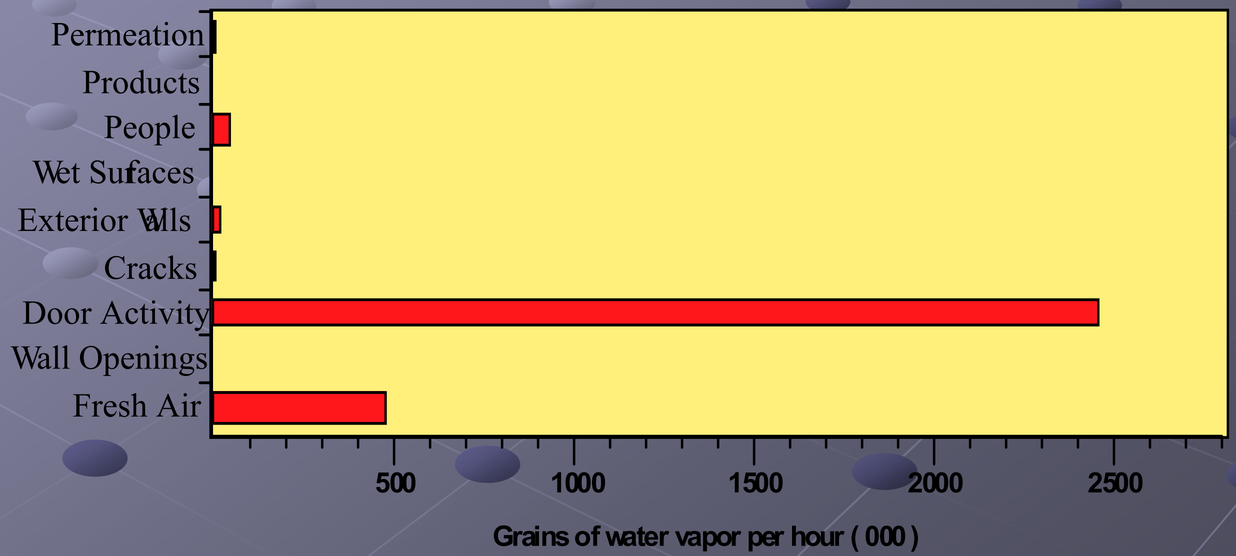
4. Add 15% for reactivation heat carryover:
91°F x 1.15 = ±105° Leaving Process

Types Of Dehumidification Systems

- Passive storage
- Active storage
- Product drying systems
- Industrial building HVAC systems
- Commercial and institutional HVAC systems

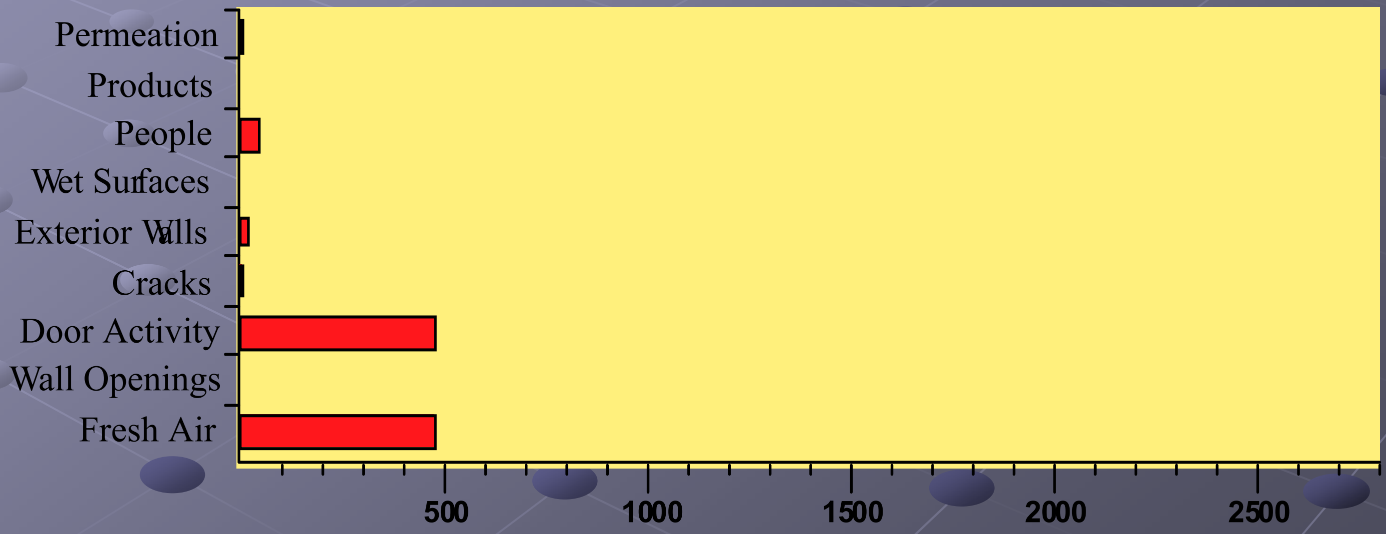
Active Storage - Refrigerated Warehouse

- The purposes of the project include preventing moisture adsorption by cartons and preventing ice build-up around doors and on floors
- Control levels depend on the purpose:
  - **Ice cream room = -10°F dew point, 3.2 gr/lb**
  - **Candy room = 50% rh, which at 50°F = 27 gr/lb**
  - **Loading dock = 33°F dew point, 27 gr/lb**
- Moisture load profile at the dock, held at 60°F, 27 gr/lb



Re-Calculated Load

- Load from first calculation totals 365 lbs/hr—very large!
- Adjusting assumptions makes the project affordable:
  - Door openings - change 15 trucks/hr x 3 min to 15 x 1 min
  - Total load drops from 365 to 90 lbs/hr
- New moisture load profile at the dock is:



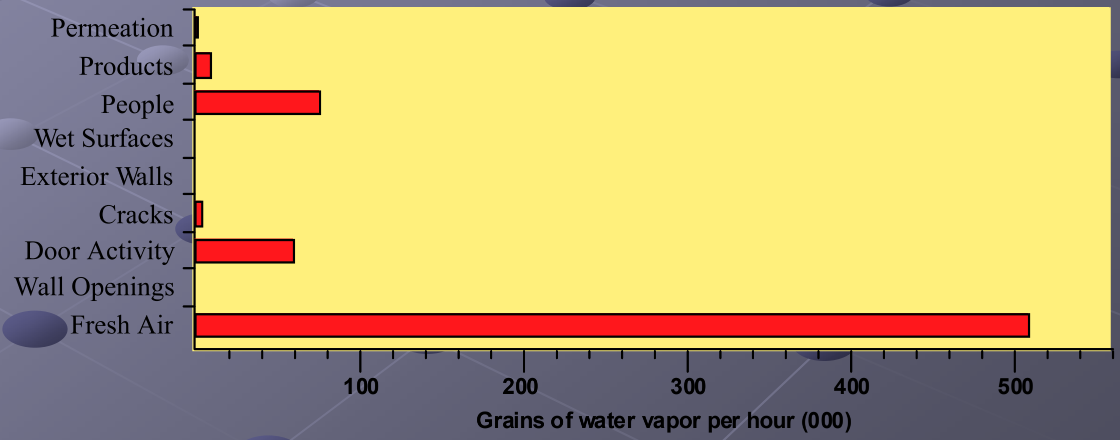
Optimizing Mixed Systems

- Many, many ways to design for a given project
- Decisions may include:
  - Minimize first cost? ... or operating cost?
  - Accept higher first cost for zero-cost future expansion?
  - Minimize costs ... but recognize capacity limitations?
- Ultimately, design decisions are governed by the project purpose ... hence the need for clear understanding before the project begins
- The “best” system design depends on which factors are most important to the user ... and these can change over the life of the system.

Industrial HVAC System Pharmaceutical Tableting Room

- Purpose: To prevent powders regaining moisture, which clogs presses, slows production and makes poor tablets
- Powders absorb based on rh, but to design a system, the engineer must define the humidity ratio:
  - **10% rh is maximum based on input from R&D**
  - **Comfort tolerance allows temp. to swing between 70 & 73°F**
  - **Engineer selects lowest temperature: 70°F, 10% = 11 gr/lb**

At 70°F, 11 gr/lb, the load profile looks like this:



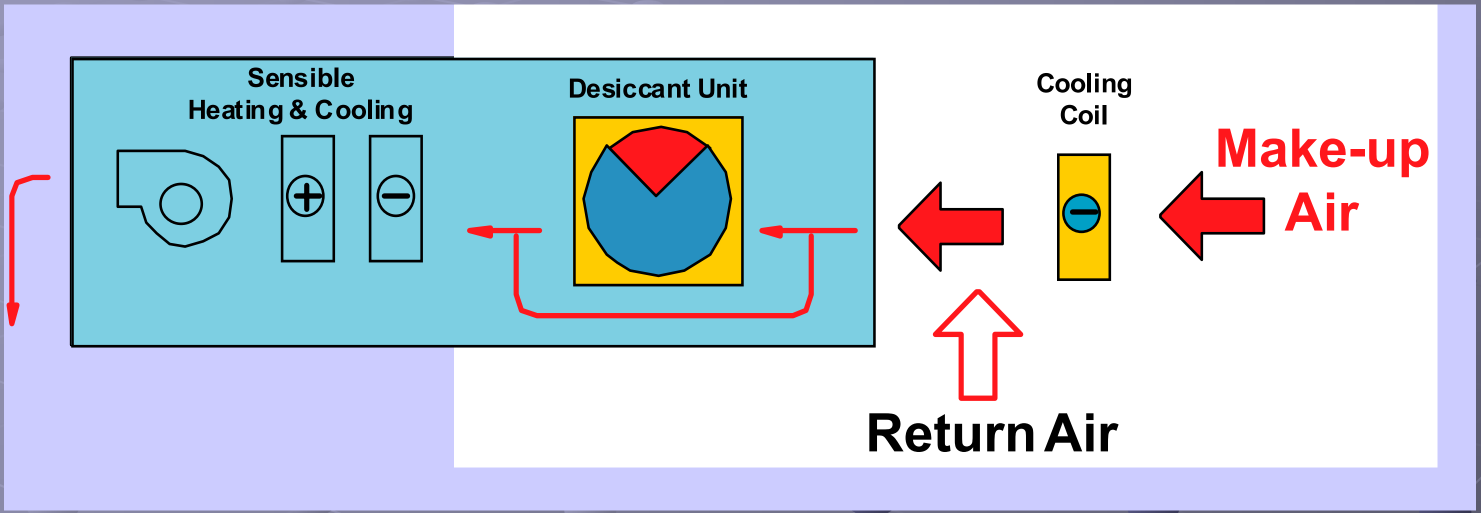
Five-step System Design Process

- 1. Establish the purpose for the project
- 2. Establish control levels and tolerances
- 3. Calculate heat and moisture loads
- 4. Select and position components
- 5. Select and locate controls

Project Criteria

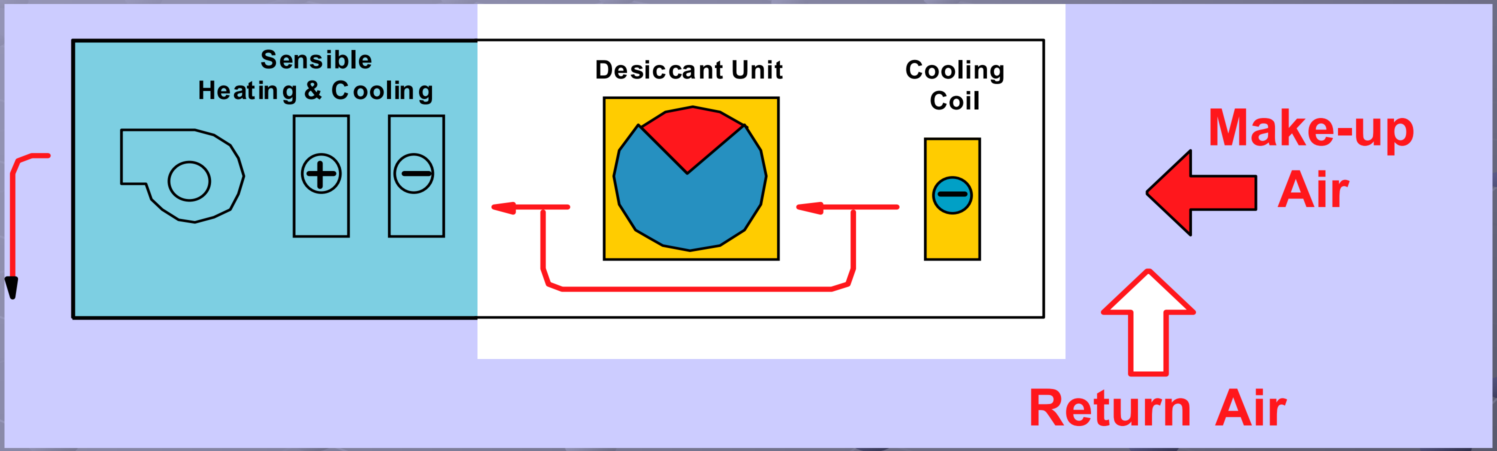
Project Purpose	Prevent clogging of packaging machinery for hard candy during peak summer production
Control levels	70° F ± 3° 35° F Dewpoint (30 gr/lb) +0 gr, -10 gr
Internal sensible heat load	100,000 Btu/h
Internal moisture load	181,800 gr/hr
Make-up air	400 scfm @ 95° F, 140 gr/lb (44.9 Btu/lb enthalpy)
Minimum delivered air temperature	55° F
Cooling available	Chilled water @ 45° F 10° F approach of the air to the coolant temperature

System 2
Pre-cool Make-up—Blend—Then DH



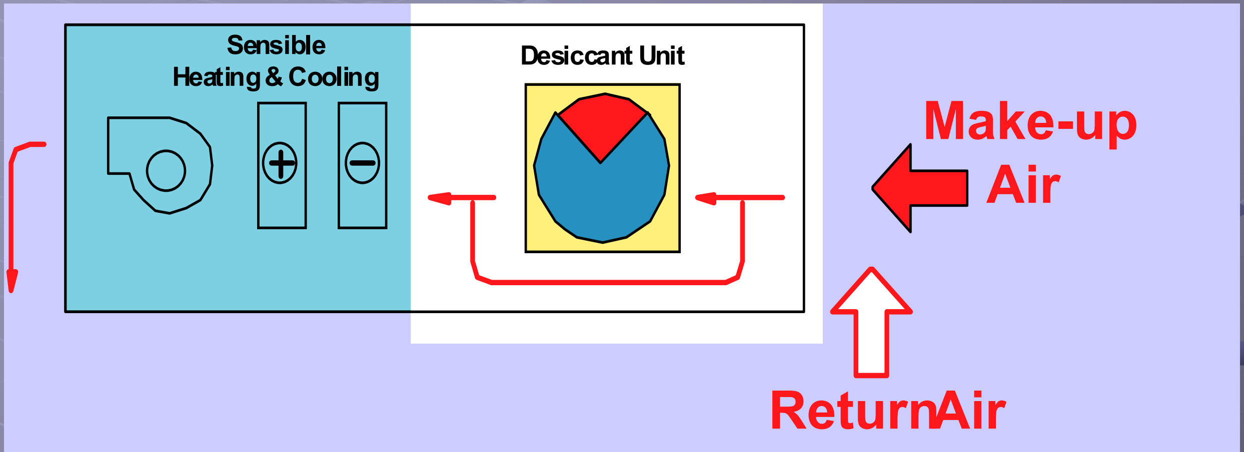
- Pre-cool the make-up air, blend that with the return air, then dry with desiccant.
- When make-up percent is high, but not high enough to remove all internal load if dry, this system is a good choice.
- For Example:
  - Supermarkets
  - General industrial building HVAC systems

System 3
Blend Make-up And Return Air Before Dehumidification Cooling



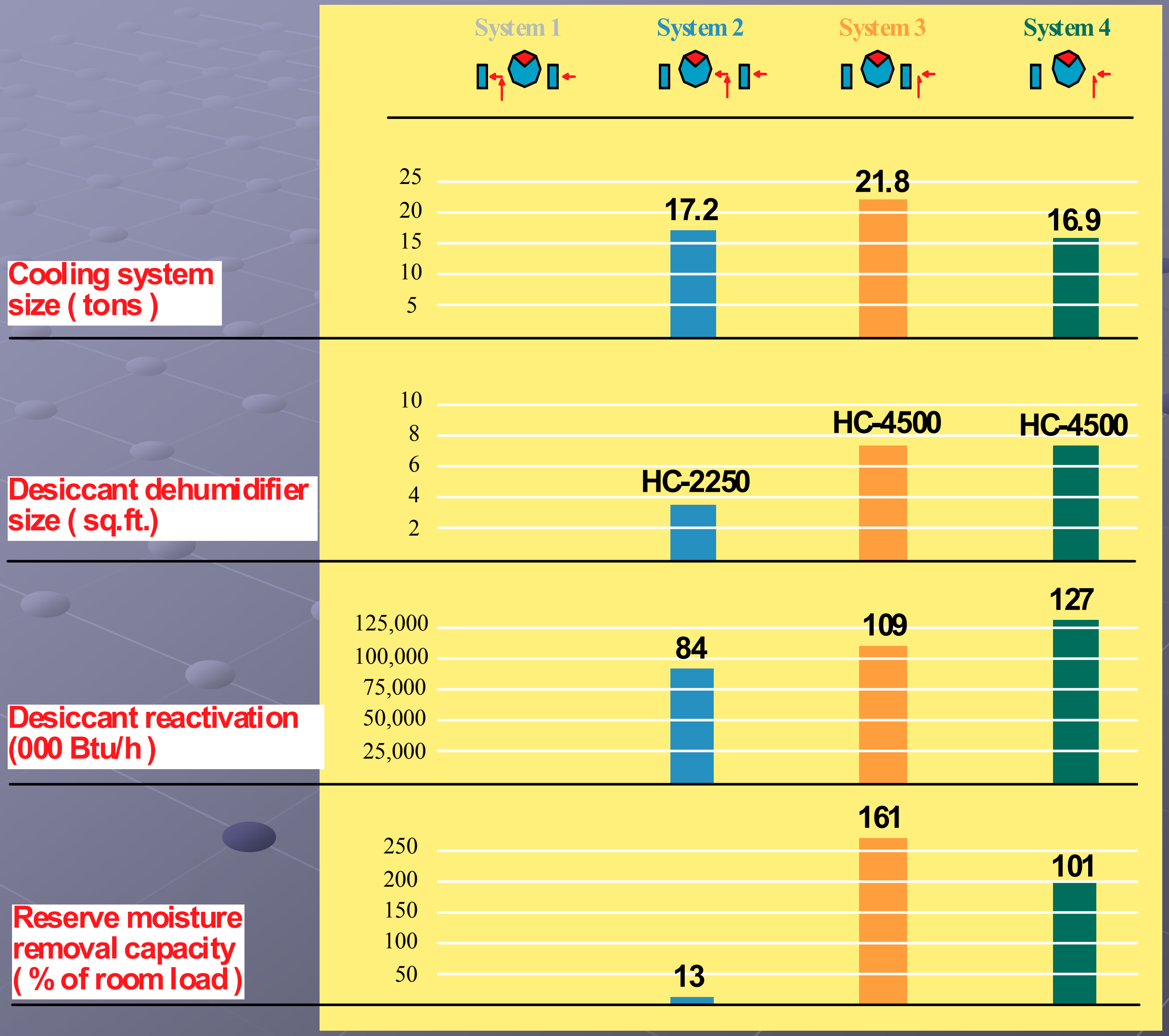
- Blend the make-up air with return air before cooling
- When makeup air percent is very low and moisture control level low as well, this system is a good choice
- Pre-cooling in front of DH allows slight performance improvement—useful at low control levels
- For example: Product processing below 10% rh

System 4
Blend Before DH - No Pre-cool

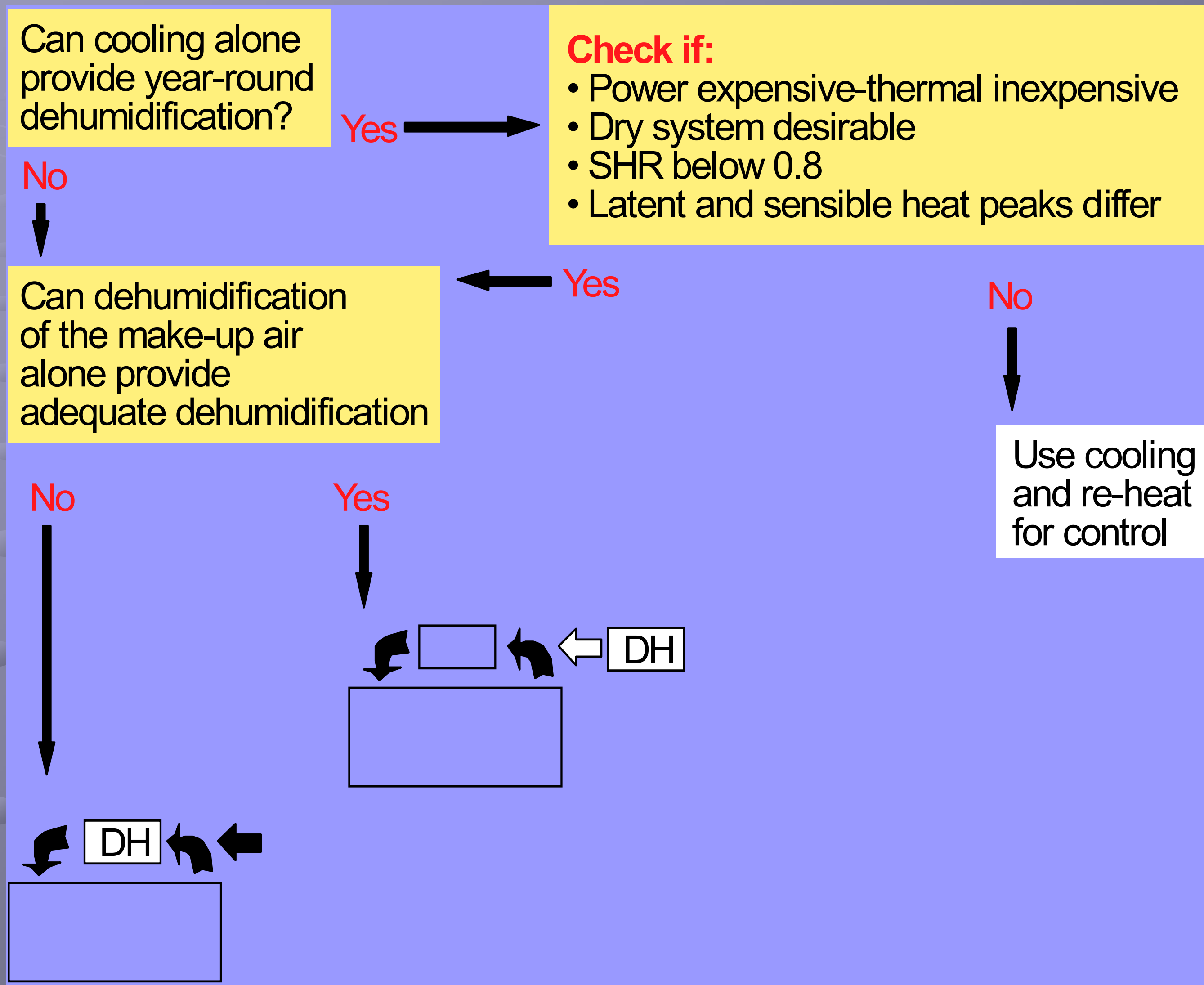


- Blend make-up and return air before DH with no pre-cooling.
- When make-up air is very low and control level is mid-range, this system may be best.
- For example:
  - Candy packaging
  - Electronics assembly
  - Pharmaceutical packaging

Comparing Systems For This Project



Choosing A System Configuration



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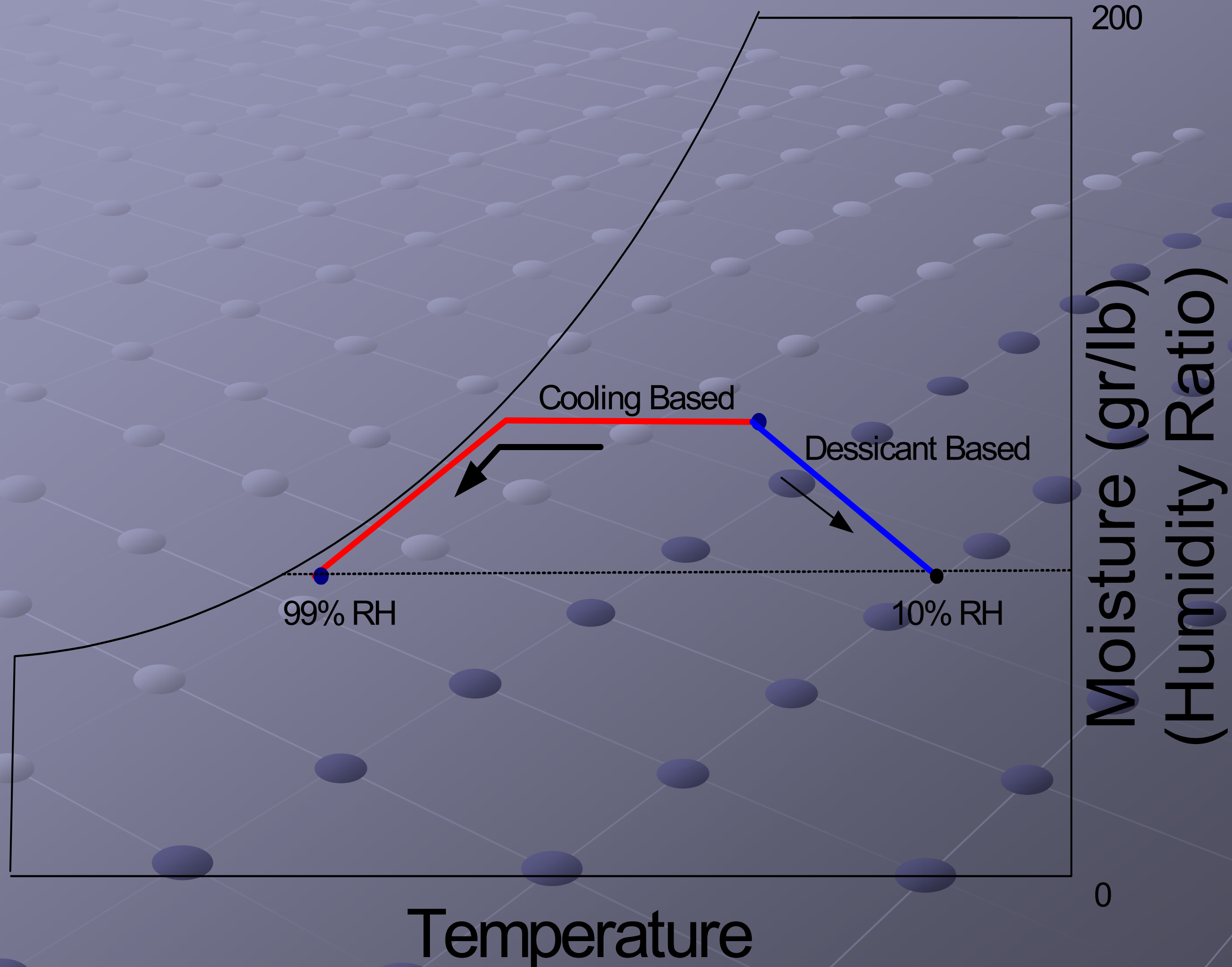


When do you use desiccant-based dehumidification over cooling-based dehumidification?

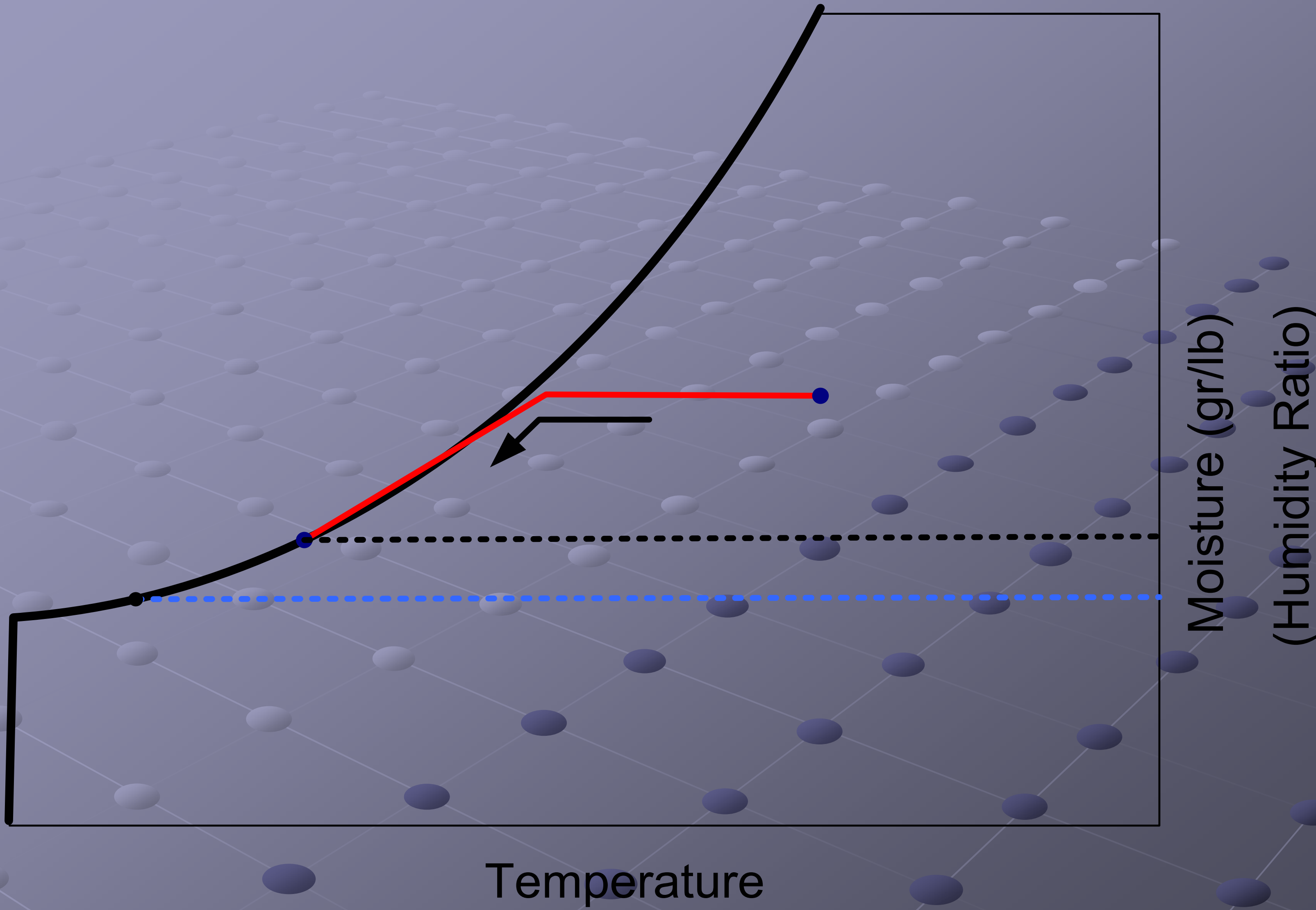
- The answer can be obtained from the psychrometric chart……depends on temperature of the cooling medium, and the desired conditions in the space.
- A cooling coil (cooling based dehumidifier) using chilled water at 43 deg F can provide down to 45 degree dewpoint. 45 deg supply air temperature may or may not meet your desired room conditions.
- If you use a DX coil (refrigerant) can typically go as low as 40 F dewpoint.

Examples:

- **<u>Example # 1:</u>**
- Chilled water cooling coil using 45 deg chilled water. Desired room condition: 68 deg F, 45% RH.
- We can meet these conditions, depending on load in space.
- **<u>Example #2</u>**:
- Chilled water cooling coil using 45 deg chilled water. Desired room condition: 63 deg F, 40% RH.
- Required dewpoint is about 41 F. Can't do it – must go to refrigeration on cooling coil or desiccant.

Examples:

- **Example #3:**
- DX (refrigerant direct expansion) cooling coil using providing 40 deg dew point. Desired room condition: 64 deg F, 45% RH.
- *Can* meet these conditions, depending on load in space. Dewpoint needed is about 41 F – slightly above the achievable 40 F.
- **Example #4:**
- DX (refrigerant direct expansion) cooling coil using providing 40 deg dew point. Desired room condition: 62 deg F, 40% RH.
- *Cannot* meet these conditions. Need to go to desiccant-based dehumidification. Why? 62/40 corresponds to a 36 deg dew point – lower than the 40 deg dew point achievable with refrigerant.


Moisture (gr/lb)
(Humidity Ratio)
Temperature

Designing for Temperature and RH Control

- For cleanroom operations, generally target 68 °F as the design temperature, with a tolerance of typically +/- 2 °F.
- Relative Humidity generally maintained between 30 % and 60%. Some designers use 30% - 50%.
- If the product has specific temperature and humidity requirements, those take precedence.
- Typically, we maintain temperature by installing reheat coils in the ductwork.
- Reheat coils typically fed by hot-water
- Alternatives:
  - Can also be fed by steam
  - Electric

Designing for Temperature and RH Control

- For aseptic filling rooms and other areas where operators are heavily gowned, often design for lower temperatures and RH levels.
- No specific levels are accepted by industry, but some design for 62 - 64 °F and 30 – 50 % RH.