JACCO

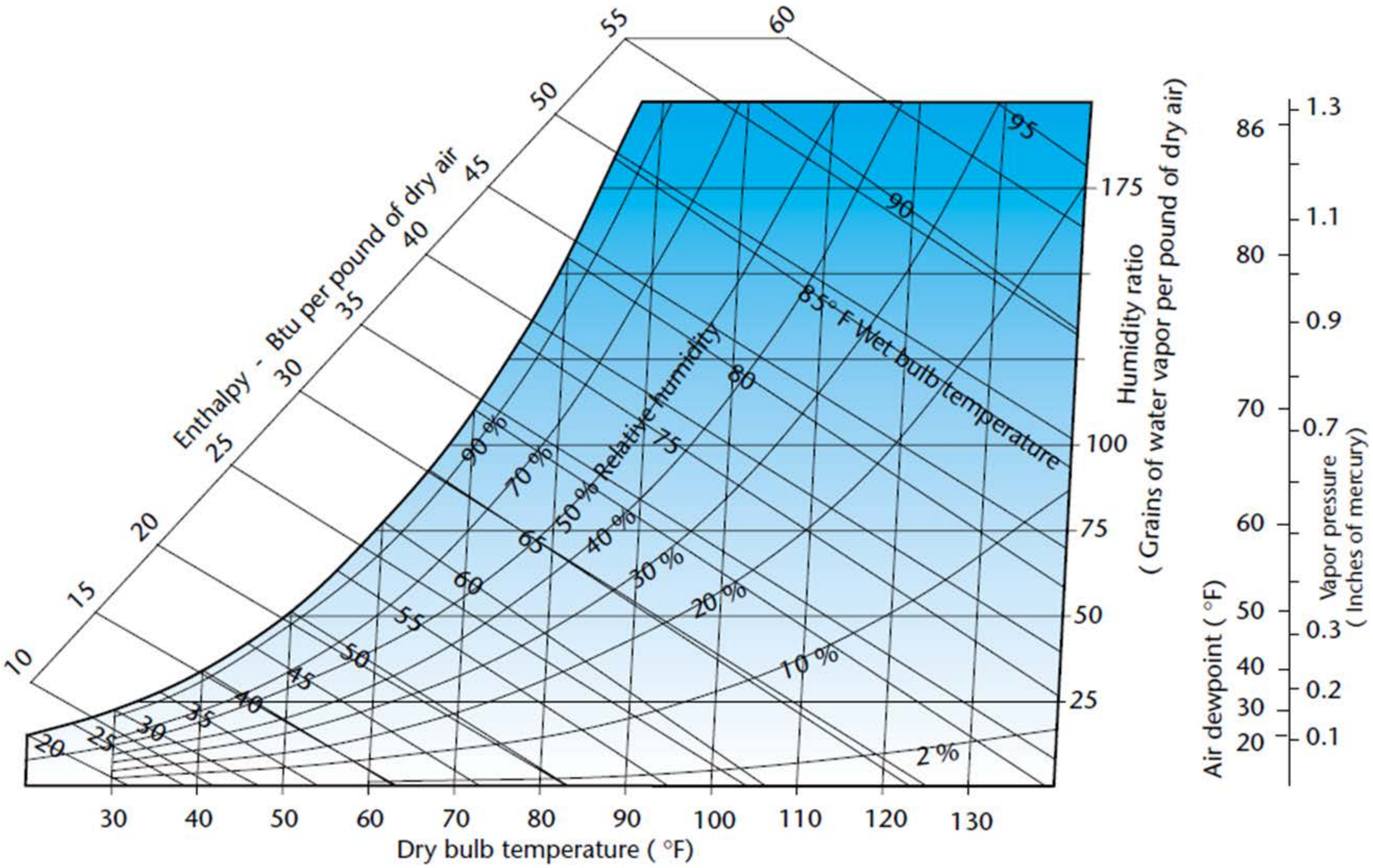
December 12, 2018

Advanced Desiccant Dehumidification Technologies

DESICCANT FUNDAMENTALS PSYCHROMETRICS REVIEW

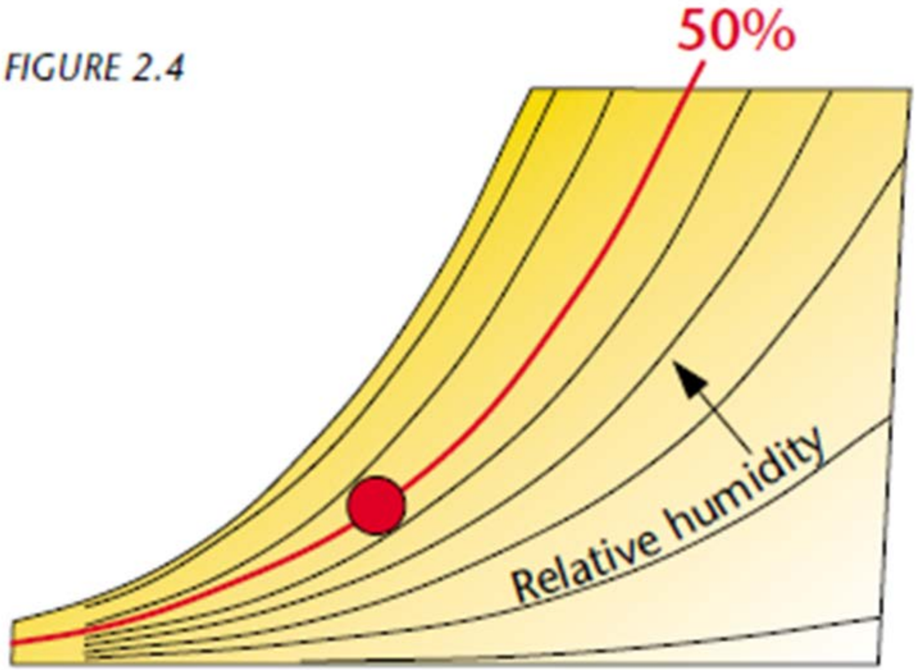
Mark Welker

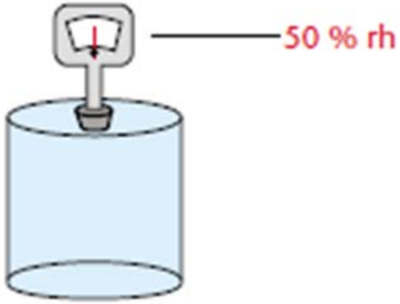
Psychrometric Chart:



Relative Humidity:

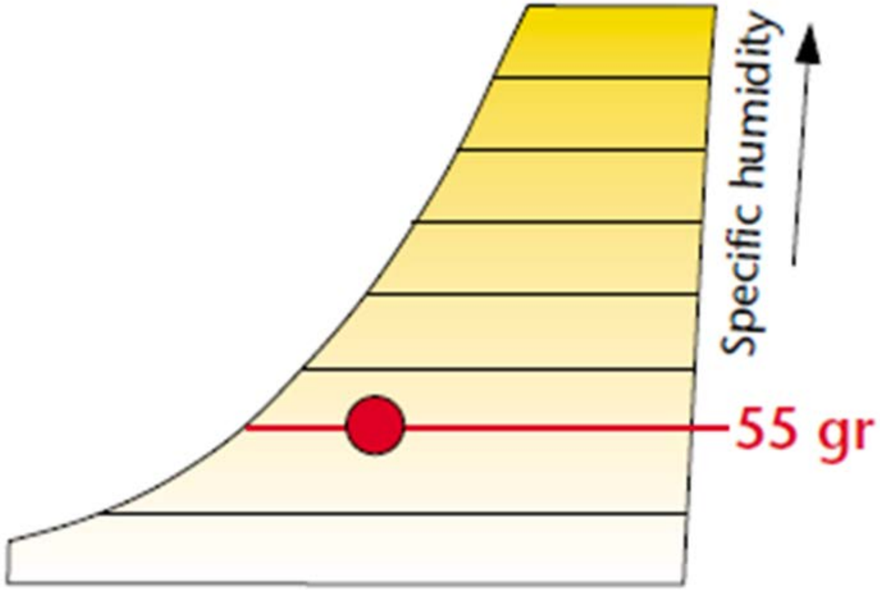
FIGURE 2.4

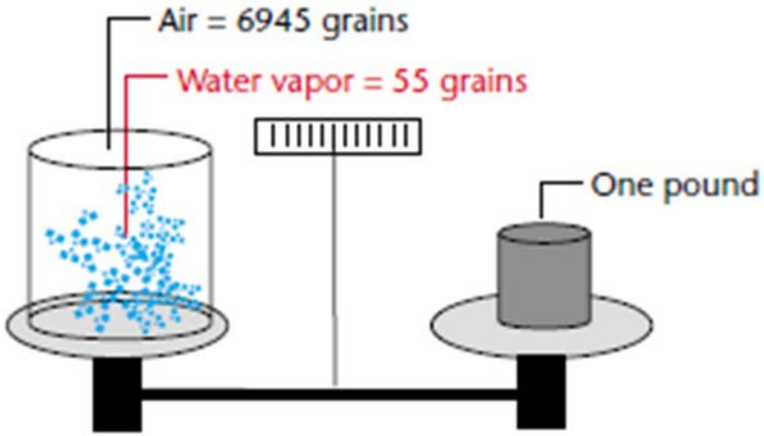




- Relative Humidity (%) is the ratio of:
  - Actual water vp in the air vs.
  - The water vp if the air were saturated at that same dry bulb temperature.
- Not an absolute value - dependant upon the db at which it was measured.

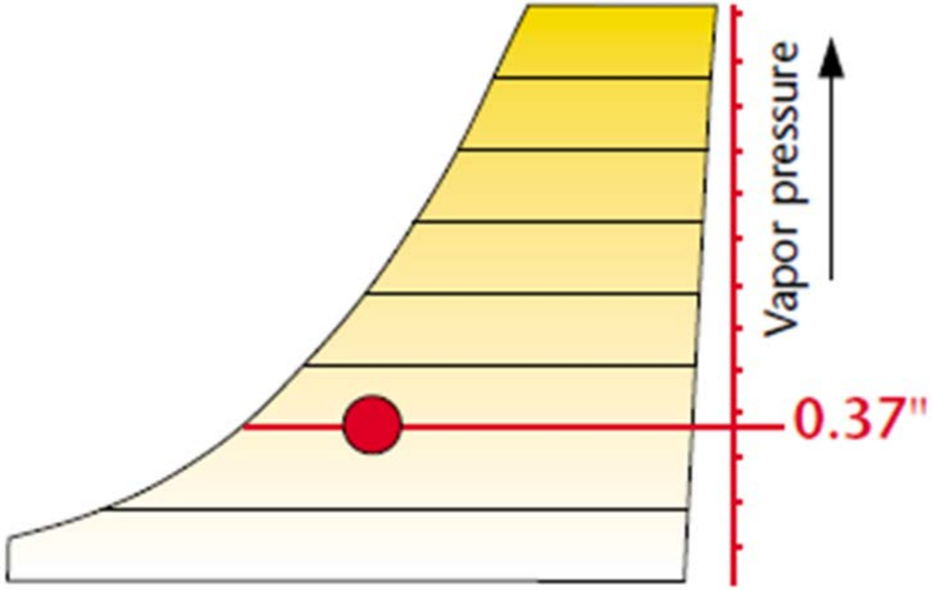
Humidity Ratio (Specific Humidity):

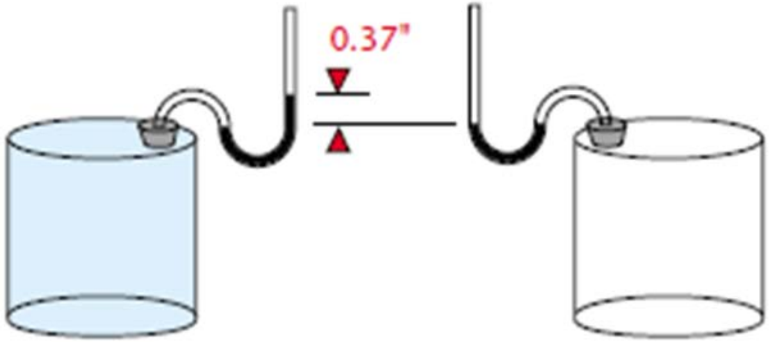




- ❑ Humidity Ratio (lb/lb or gr/lb) is the <u>absolute amount of moisture</u> in the air.
  - o This is like counting the water molecules and adding their weight together.
- ❑ There are 7000 grains in one pound of water.

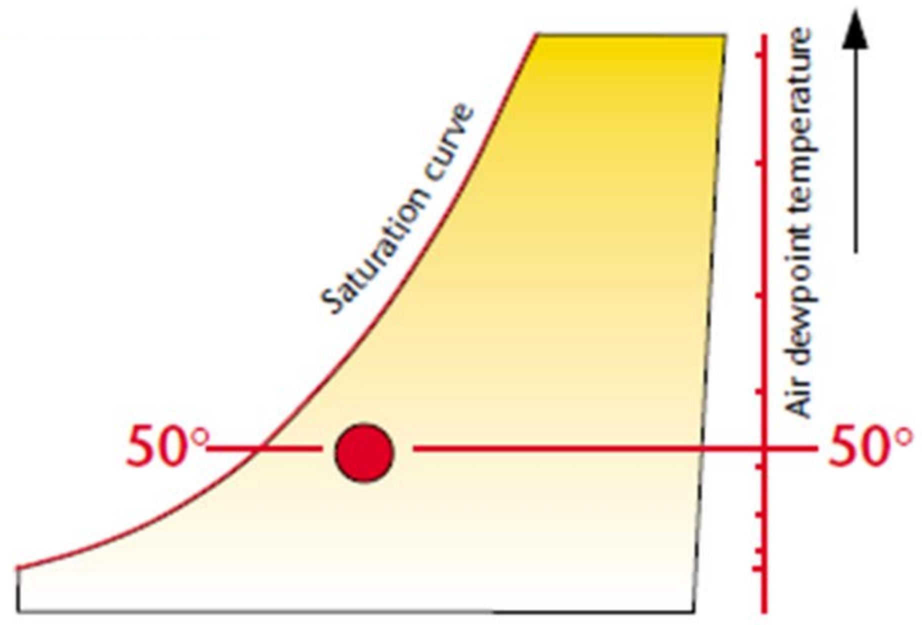
Vapor Pressure:





- Vapor Pressure (in. Hg) is the pressure exerted by water molecules on their surrounding environment. This is an absolute measurement.
  - Unit of measure is inches of mercury, which tells us how high the vapor pressure can lift a column of mercury due to its own pressure.
- This is the driving force behind how the desiccant dehumidifiers attract water molecules out of the air and into their surface.

Dew Point:

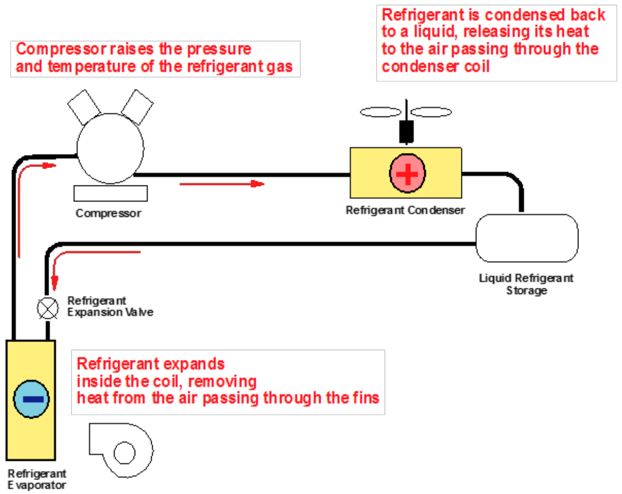


- Dew Point (°F) is the temperature where moisture will condense out of the air onto nearby surfaces forming “dew”.
- This is an absolute measurement.
- The higher amount of moisture in the air, the higher the dew point.

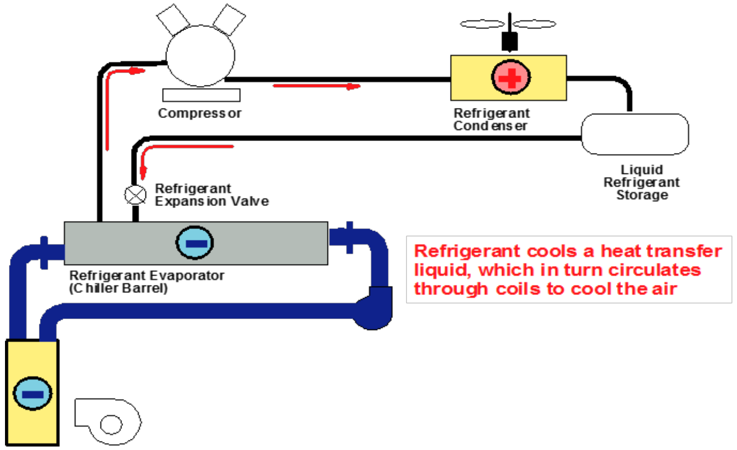
GENERAL OVERVIEW OF DEHUMIDIFICATION SYSTEMS

Common Mechanical Based Systems:

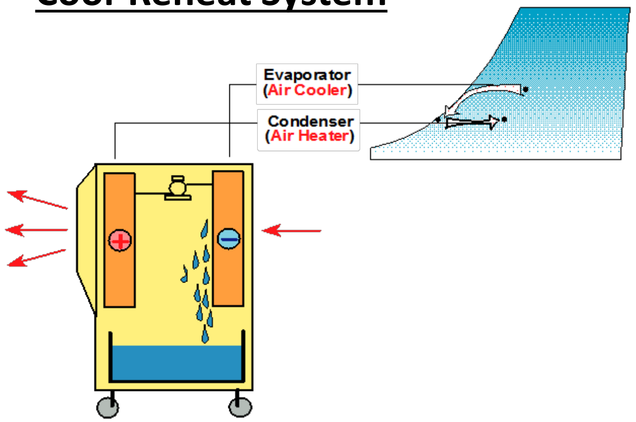
Direct Expansion System



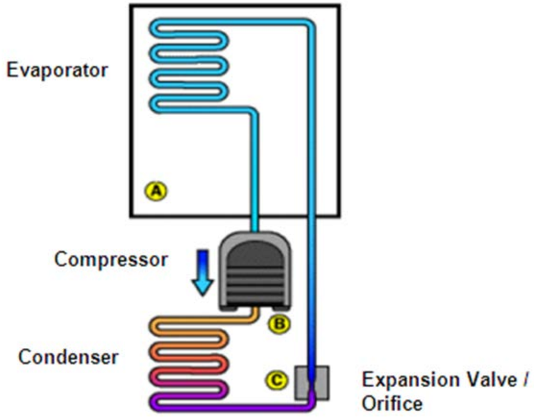
Chilled Water, Glycol or Brine System



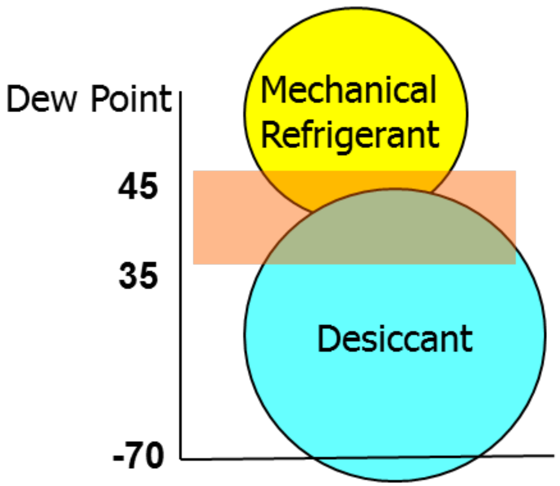
Cool-Reheat System

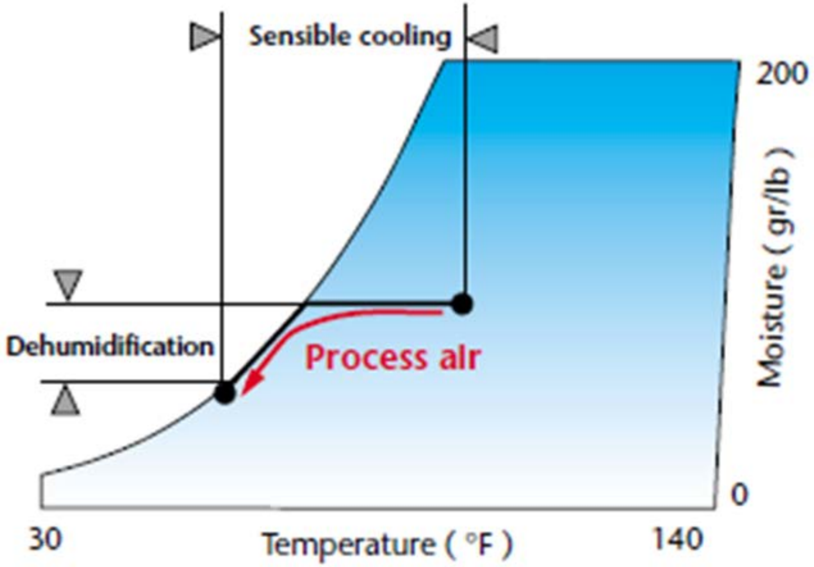


Ammonia Systems

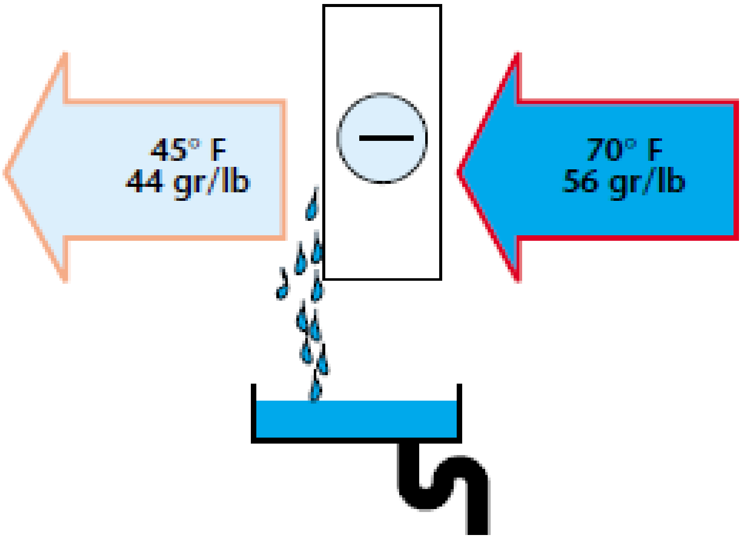


Mechanical vs Desiccant Application:





- Air is circulated over a cold coil and cooled to saturation.
- Relatively "Lower First Cost" type systems.



However…

- Dewpoint reduction is physically limited.
- Min CC LAT's: 43°F db/42.9°F wb (99.2% RH & 32°F SST).
- Running these systems at or below 32°F SST will:
  - Cause coils to frost up - requires HGRH Cycles to defrost
  - Defrosting is not Dehumidifying
  - If NOT Dehumidifying – what happens to your Control Level
  - Likely add reheat to meet required LAT conditions
  - Added Energy + Downtime = $$$

Refrigeration vs Desiccant

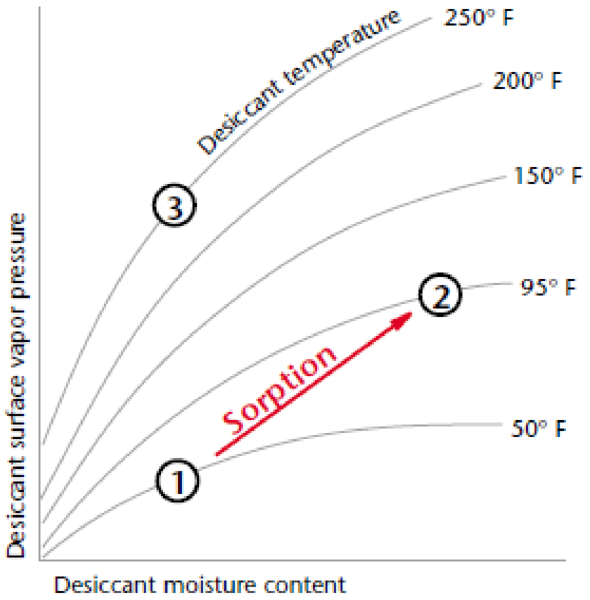
Mechanical System:
Deposition (Vapor to Solid):
Ice crystals form on surfaces w/o going through liquid phase

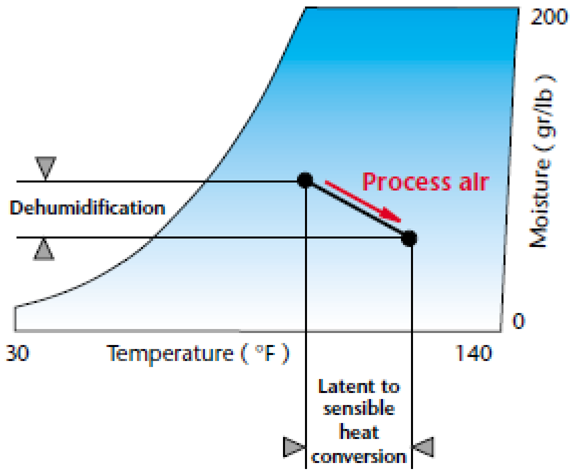
Desiccant System:
Sublimation (Solid to Vapor):
Ice crystals are removed from surfaces w/o going through liquid phase.

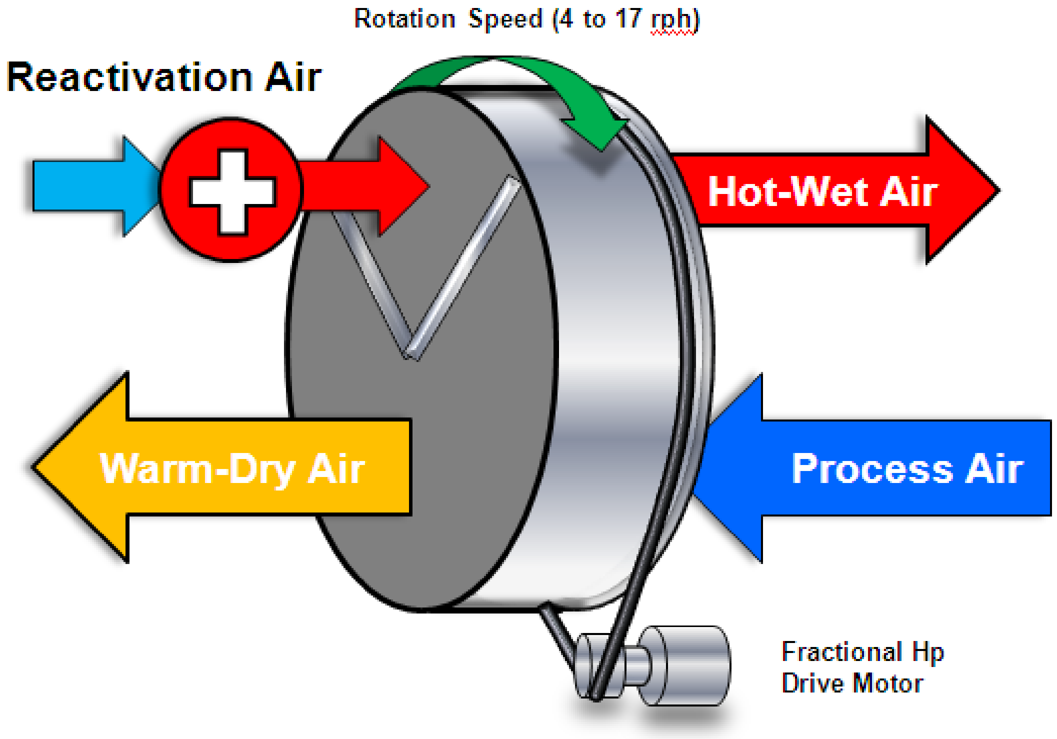
What Desiccant Dehumidification is NOT:

- NOT a Substitute for Cool/Reheat in Comfort Applications
- NOT an Energy Saving Scheme
- NOT a Cost Saving Scheme
- NOT a Heat Wheel

Dry Desiccant Systems: How They Work

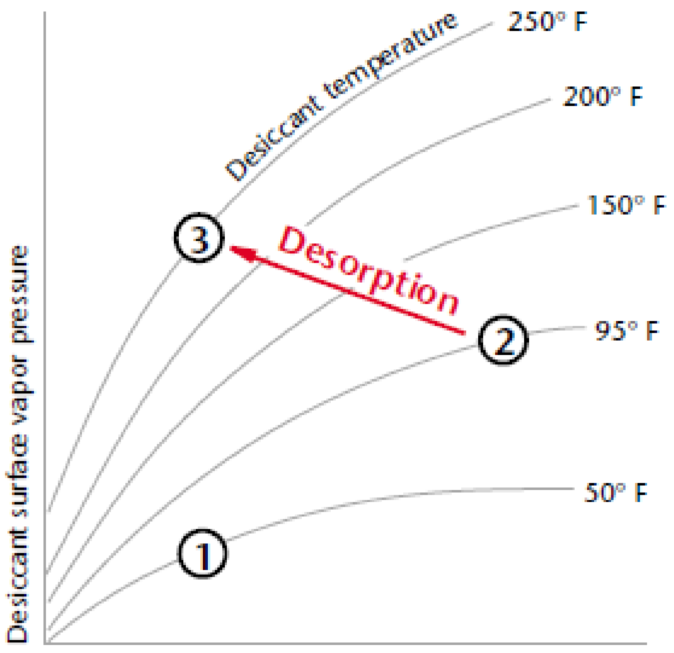


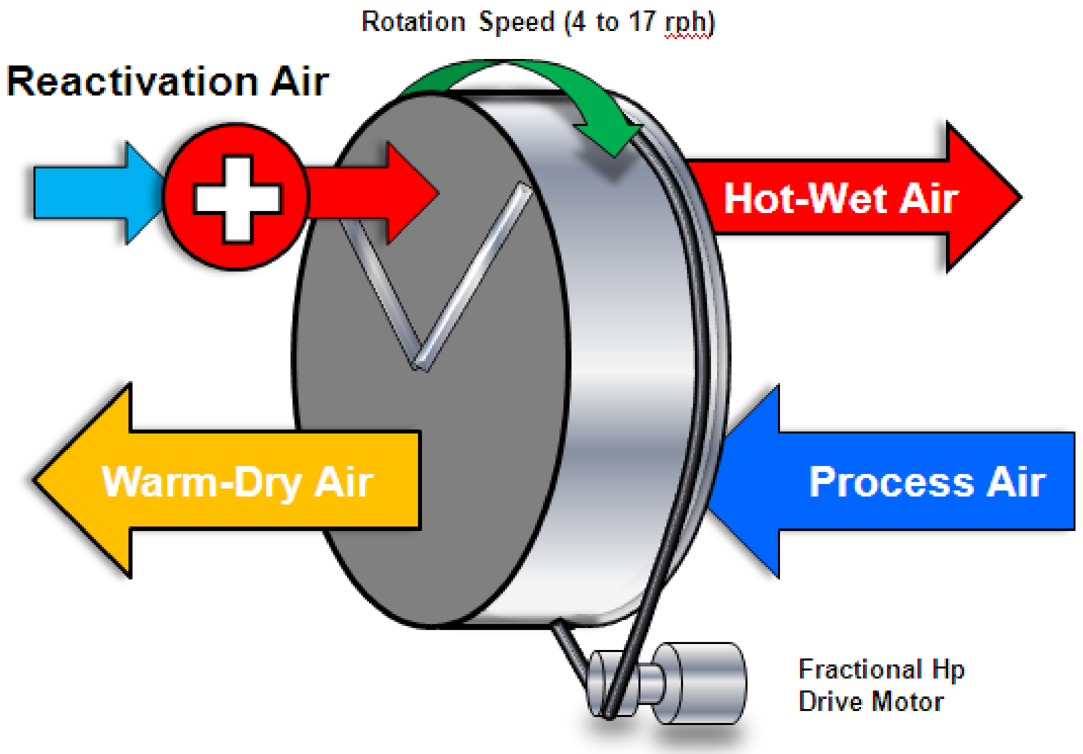




- Desiccants ad(b)sorb and release moisture based upon Δ vapor pressure.
- 3 - Phase Process:
  - 1. Sorption Phase:
    - o Desiccant ab(d)sorbs moisture.
    - o VP of desiccant is lower than that of the conditioned air stream.
    - o Rotor surface attracts moisture out of the process air.
    - o Process Air is Warm & Dry Because:
      1. Heat of Conversion.
      2. Some Reactivation Heat Carry Over.

Dry Desiccant Systems: How They Work

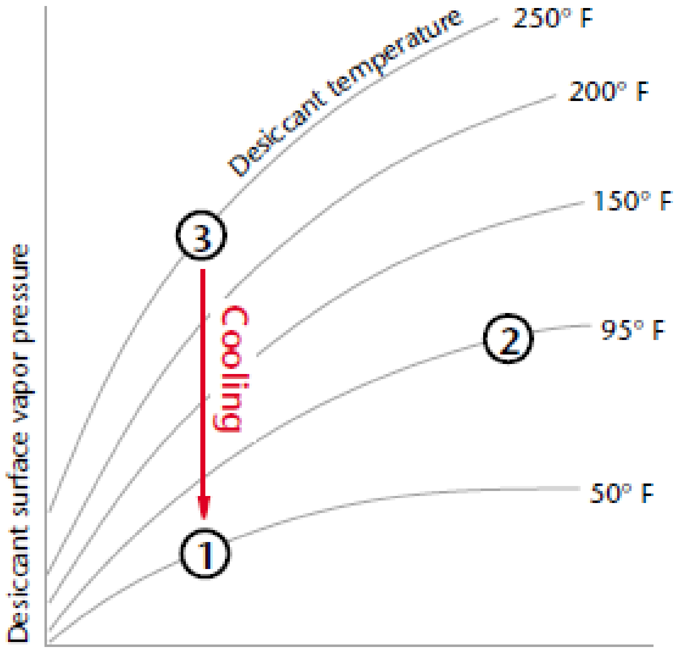


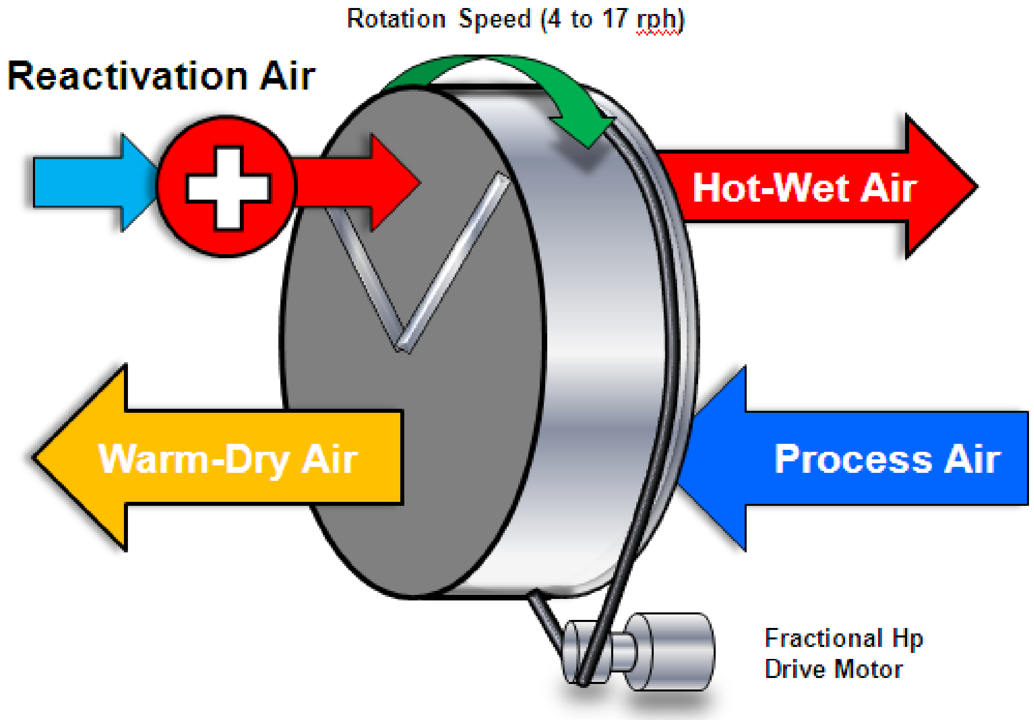


2. DESORPTION (REACTIVATION) PHASE:

- **Desiccant releases water.**
- VP of desiccant is higher than that of reactivation air stream.
- Moisture is passed into the reactivation air stream.
- **Activated by very hot air stream of 250+°F** (high temp & high moisture = high vapor pressure).

Dry Desiccant Systems: How They Work

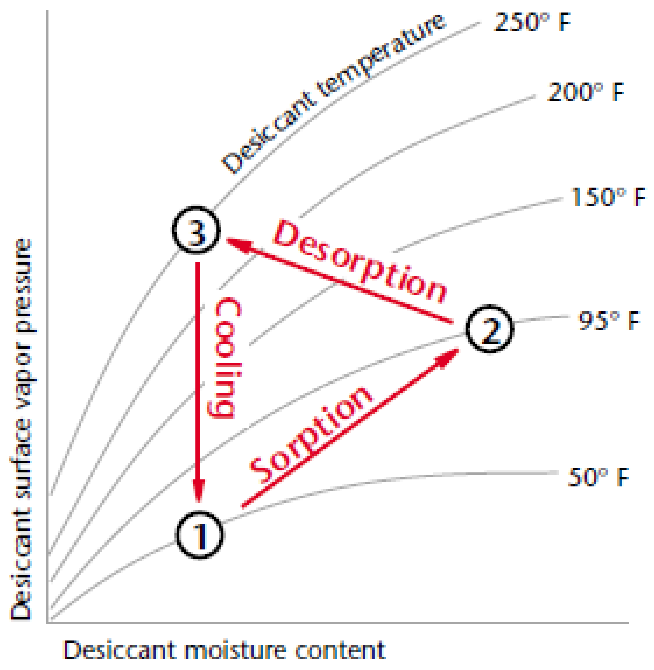


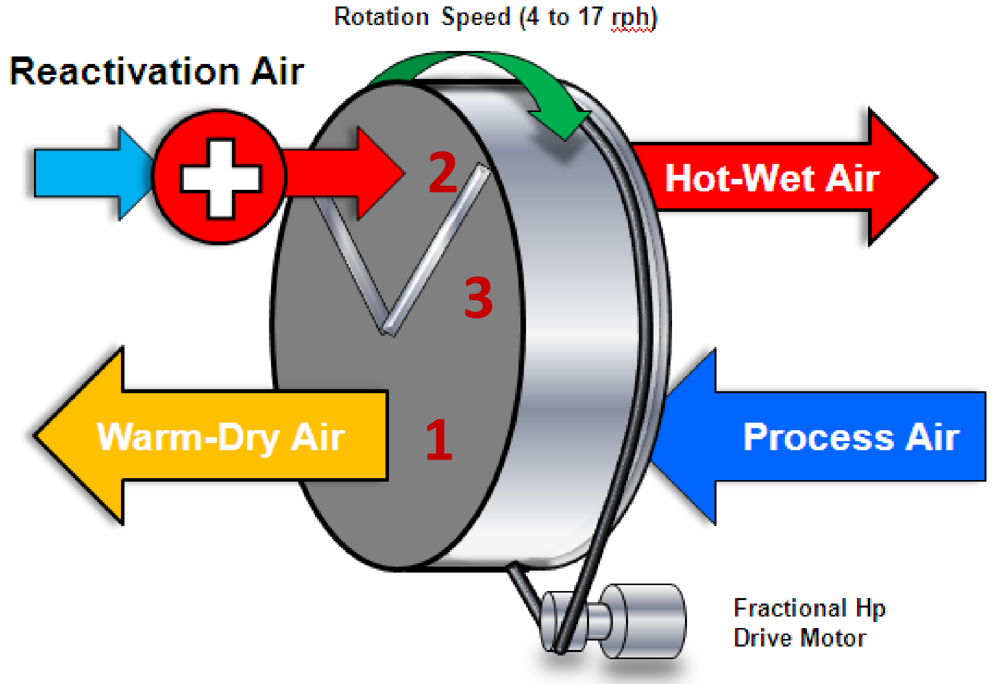


3. COOLING PHASE:

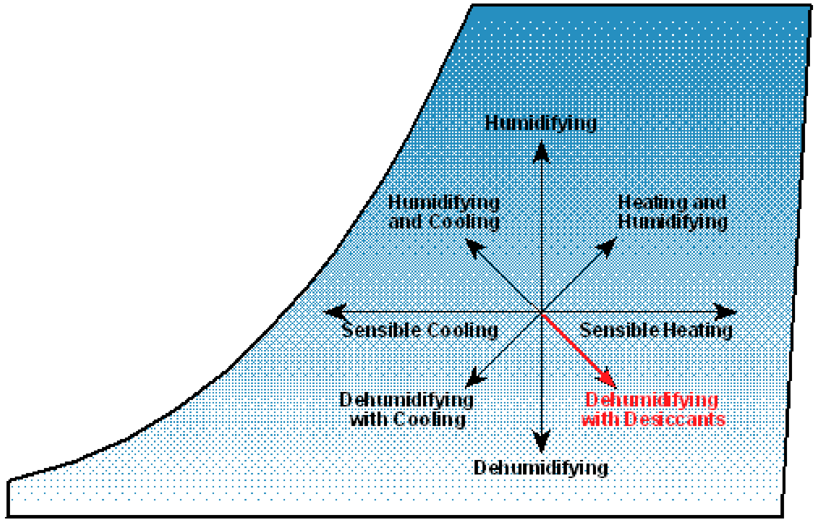
- Desiccant cools to original state.
- VP of desiccant is lower than the conditioned air stream.
- Wheel’s surface is warm and dry (~110 to 135°F).
- Needs to be cooled before ad(b)sorbtion occurs (low temp & low moisture = low VP).
- Optimal Range: 50 to 90°F.

Dry Desiccant Systems: How They Work





- VP differential dictates where moisture migrates
  - Even against air flow direction
- Efficient year round:
  - Colder air actually increases the wheel's efficiency. Desiccant is at optimum performance at 50F to 55F
- Will not "over cool" space or require defrosting cycles. This means consistent controllable humidity and temperature independent of one another



APPLICATIONS

Welker's Rules of Engagement

First Rule: **Do as much moisture removal as possible with refrigeration.**

Second Rule: **See First Rule.**

Applications That BENEFIT from DESICCANT DEHUMIDIFICATION

- Very Dry Air Required
- Independent Control of Temperature/ Humidity
- Fog or Condensation Control
- Control of Dripping (Excessive Condensation)
- Enhanced Indoor Air Quality
- Improved Safety & Comfort
- Structural Decay (Corrosion) Prevention
- Mold or Bacteria Control
- Improved Process Operation

Understanding the Application Requirements

Inside Conditions - How Dry?

- Dry enough to achieve the maximum economic benefit–and no drier.
- Humidity control projects are often the result of summer problems
- So ... What is the moisture condition during the winter when no problem occurs?
- Wide range of parameters / requirements - "No Silver Bullet"

Food Plant Applications:

- Temperature: -40 - 80+F
- Humidity: 1 - 50% RH
- Pressurization: Negative to Positive
- Ventilation: 0 - 100% OA
- Filtration: 30% - HEPA

Dry Storage Applications:

- Temperature: 30+F
- Humidity: 0 - 50% RH
- Pressurization: Negative to Positive
- Ventilation: 0-100% OA
- Filtration: 30% - HEPA

Pharmaceutical Applications:

- Temperature: 55 - 200F
- Humidity: 10 - 70% RH
- Pressurization: Negative to Positive
- Ventilation: 0 - 100% OA
- Filtration: 30% - HEPA

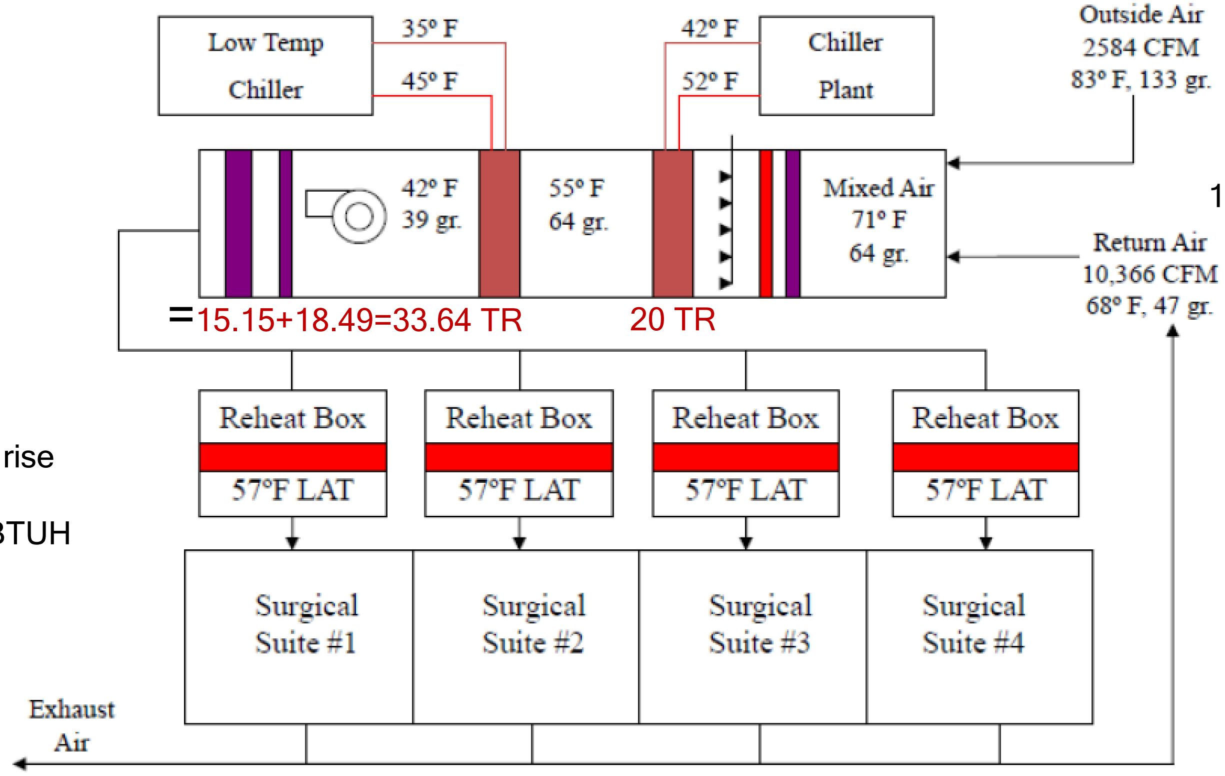
Manufacturing Process Applications:

- Temperature: 55 - 200F
- Humidity: 0.1 - 70% RH
- Pressurization: Negative to Positive
- Ventilation: 0 - 100% OA
- Filtration: 30% - HEPA

General Application Categories

- Corrosion Prevention
- Condensation Prevention
- Mold & Fungus Prevention
- Moisture Regain Prevention
- Product Drying

Hospitals:
Conventional Cool-Reheat System



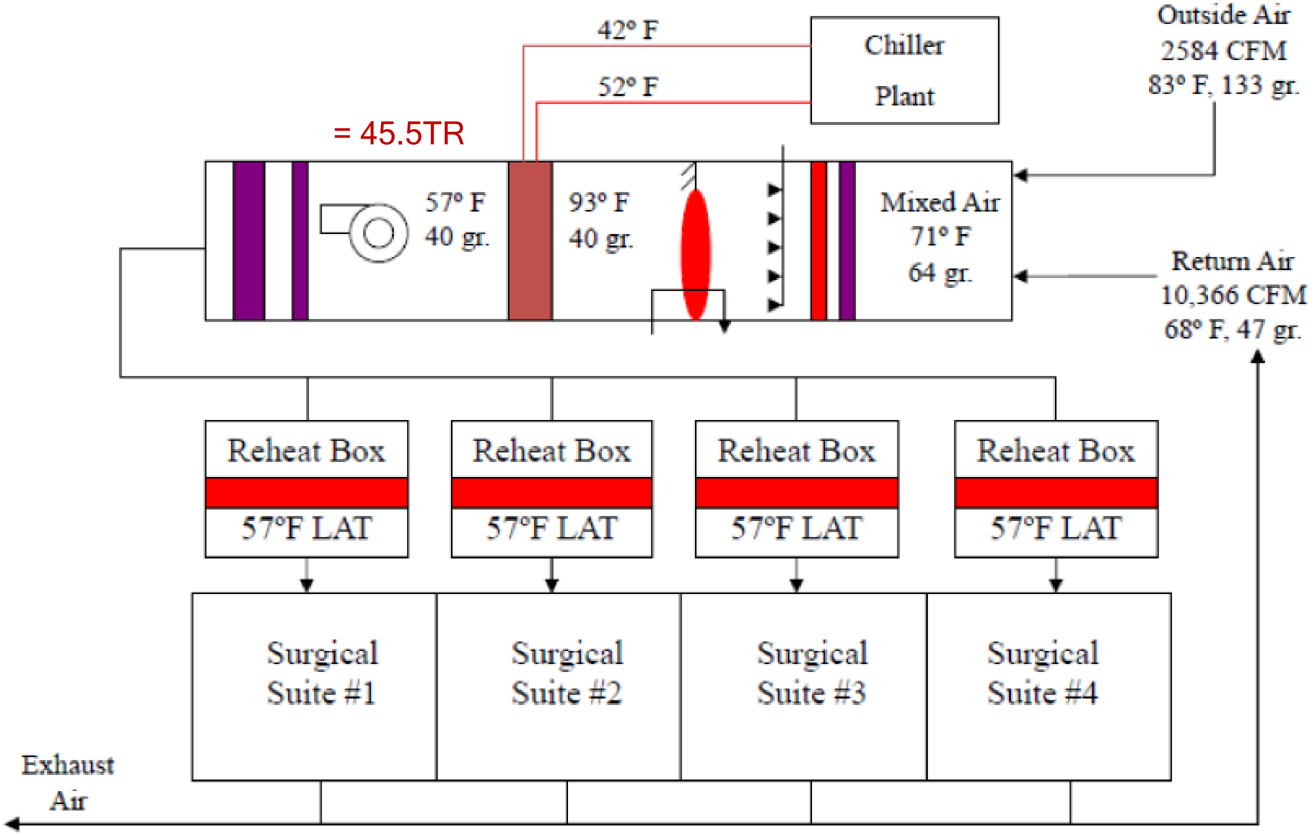
12,950 CFM SA

+209,790 BTUH for 15 deg heat rise

Total BTUH = approx. 840,000 BTUH

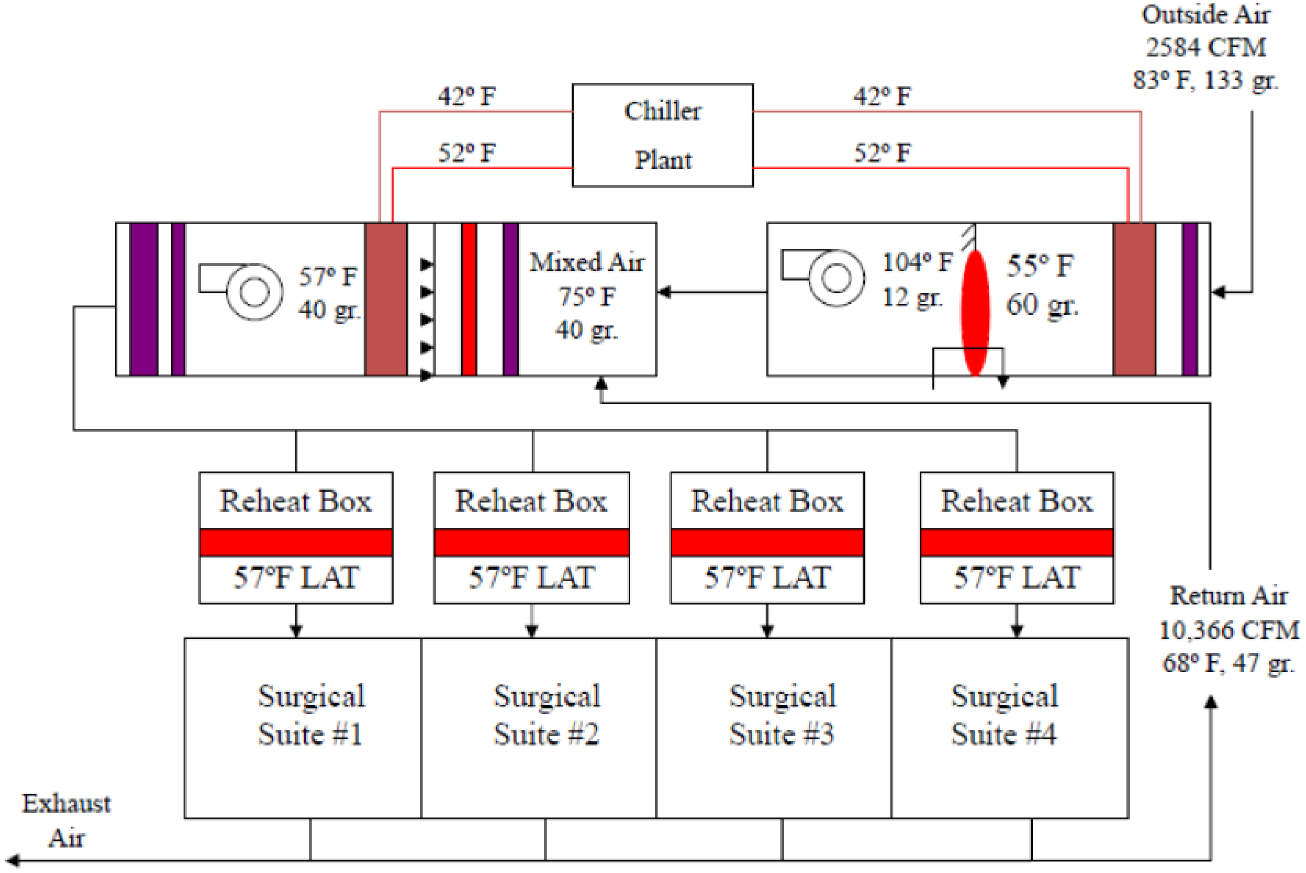
- Utilizes chiller plant to minimize low temperature chiller tonnage

Hospitals:
Desiccant System



- Eliminates low temperature chiller and reduces required tonnage

Hospitals:
Split-Stream Desiccant System



- Can be configured to work with existing installations

Animal Surgical Center Retrofit : Maintain at 62-63 dry bulb and 39-40% RH.
Existing 7.5 Ton AHU @ 3,000 CFM (space maintained at 37 degree dew point - DHU supplies 24 deg dew point / mixed provides 32.1 degree dew point)

AIR MIXTURE

	1st AIR STREAM:	
900	CFM	1,800
62	TEMP	62
32.5	GR/LB	32.5
	2nd AIR STREAM:	
300	CFM	1,200
84	TEMP	109.6
130	GR/LB	18.1
	MIXTURE=	
1,200	CFM	3,000
67.5	TEMP	81.0
56.9	GR/LB	26.7

VFB DEHUMIDIFIER PERFORMANCE:

TEMP IN	67.5	
GR. IN	56.9	
=	109.6	TEMP. OUT
	18.1	GR. OUT

LBS. PER HOUR MOISTURE REMOVAL

CFM	3,000		
GR. IN	32.5		
GR. OUT	18.1	14.4	Δ GRAINS
=	27.77 LB/HR	666.5	LB/DAY
	194,400 GR/HR	4,665,600	GR/DAY
	3.3 GAL/HR	79.9	GAL/DAY
	26.6 PINTS/HR	639.3	PINTS/DAY

PRE-COOLING

CFM	0		AMB. TEMP =	95
WB IN	0.0		SST =	ERR
WB OUT	0.0			SEE ENG
TOTAL COOLING CAP. =		#VALUE!	BTUH	
		#VALUE!	TONS	
COND. UNIT SIZE REQ. =		SEE ENG	TON	
H_2O IN	42			
H_2O OUT	52			
	=	#VALUE!	GPM	
GLYCOL Y/N	N	#VALUE!	" PIPE DIA.	
COIL AREA, SF @ VELOCITY =		0.0	400	FPM
PRELIM. SIZE: W x H =			0.0	inches

POST-COOLING

CFM	3,000		AMB. TEMP =	95
DB IN	81.0		SST =	45
DB OUT	55.0			
TOTAL COOLING CAP. =		84,240	BTUH	
		7.0	TONS	
COND. UNIT SIZE REQ. =		7.5	TON	
H_2O IN	42			
H_2O OUT	52			
	=	16.8	GPM	
GLYCOL Y/N	N	1	" PIPE DIA.	
COIL AREA, SF @ VELOCITY =		5.0	600	FPM
PRELIM. SIZE: W x H =		39	18.8	inches

Objective

Stop Condensation on Chilled Molds

- Allow Production during humid weather
- Increase production cycle times
- Reduce waste product

Dehumidified Plastic Mold Enclousure

- Desiccant Dehumidification with chilled water precooling allows very dry supply air
- Reactivation energy is provided by natural gas
- Postcooling is available to temper the supply air, if required