

# ME 425

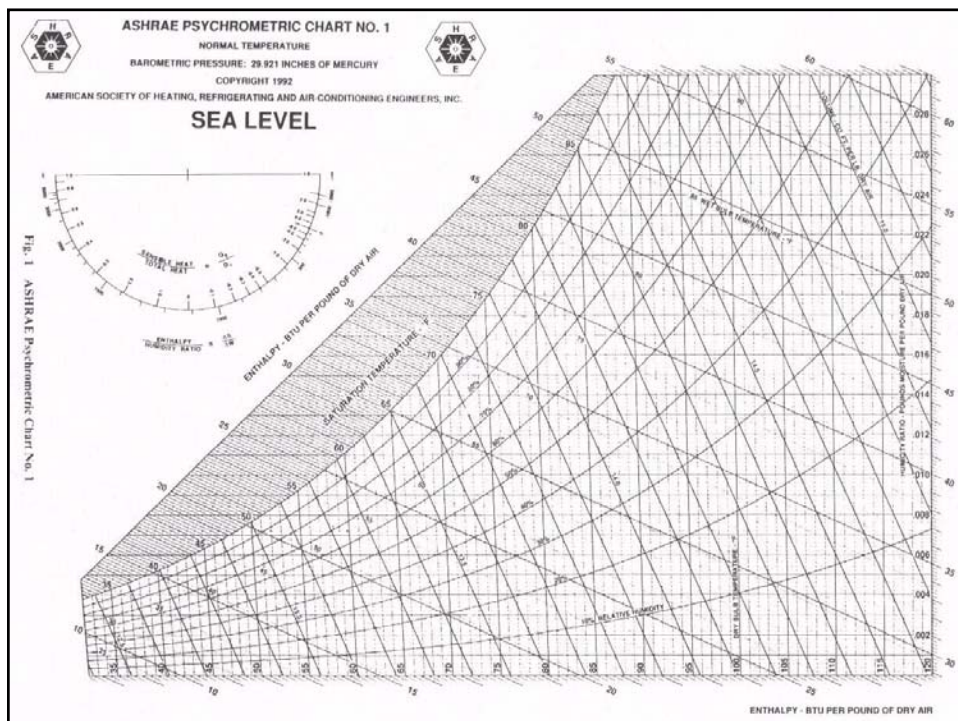
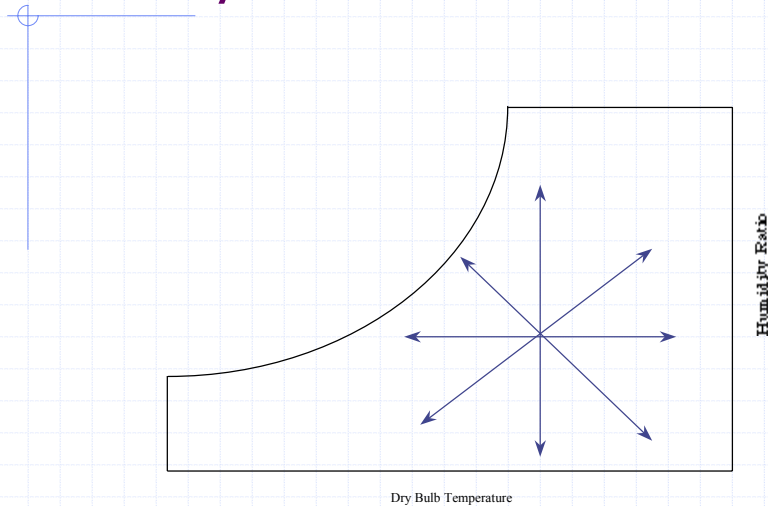
## *Psychrometrics & Coil Load*

Keith E. Elder, P.E.

## Coils

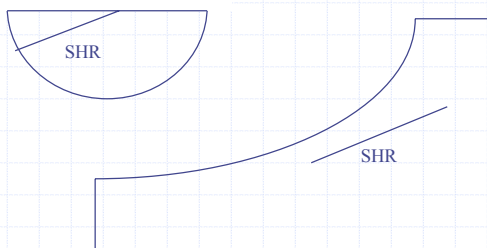
- ◆ Coils are the main devices for transferring energy to/from the airstream in an air-handling system.
- ◆ Heat Transfer Media
  - Hydronic Fluid (Water)
  - Steam
  - Direct Expansion
- ◆ Important Coil Load Concepts
  - Apparatus Dew Point
  - Bypass Factor

# The Psychrometric Chart



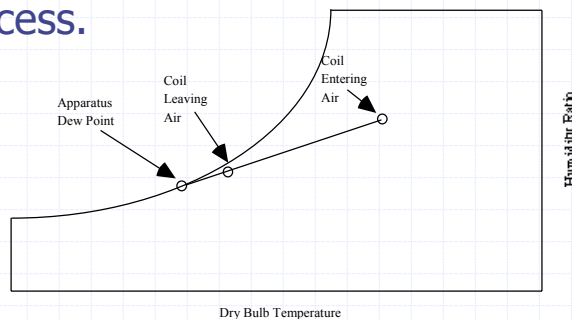
## Sensible Heat Ratio (SHR)

The ratio of space sensible cooling to total cooling is useful for plotting the slope of the path that supply air travels after introduction into the space.



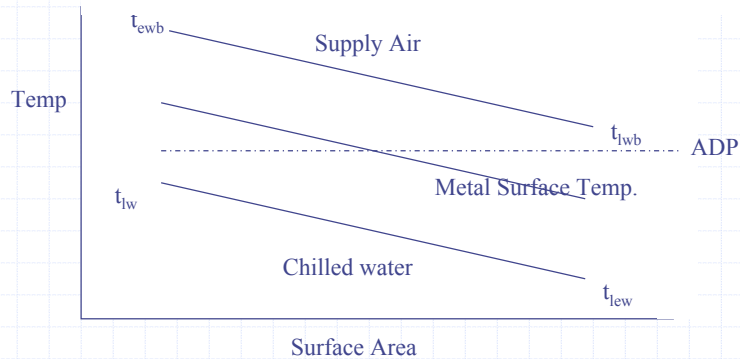
## Apparatus Dew Point

Apparatus dew point (ADP) is the coil surface dew point temperature required to accomplish a cooling/dehumidifying process.



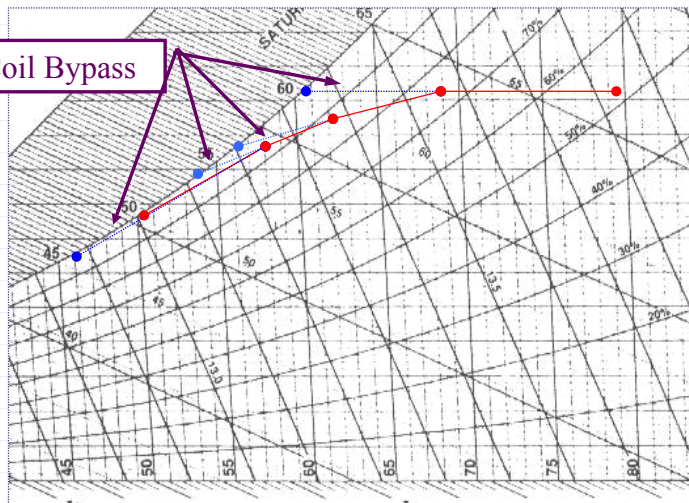
## Apparatus Dew Point

Relationship of ADP to Supply Air and Chilled Water temperatures



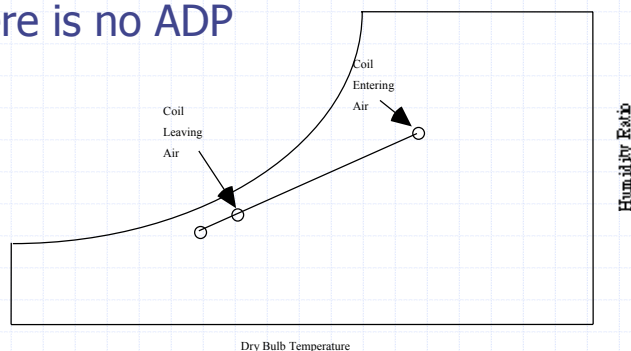
8-Row Coil  
80 fpf / 2 fps / 44 EWT / WTR = 10

Coil Bypass



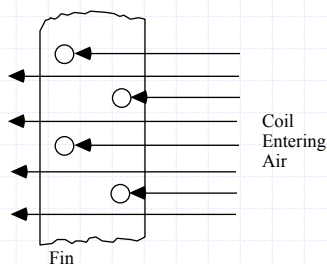
## Apparatus Dew Point

An ADP is essential to any cooling/dehumidifying process. The chart below shows an impossible process because there is no ADP



## Bypass Factor

Some of the air flowing through the coil impinges on the water tubes or the fins and is cooled to the ADP. Other air passes through unchanged.



The percentage of air that passes through the coil unchanged is called the bypass factor.

44EWT

PRIMA-FLO®

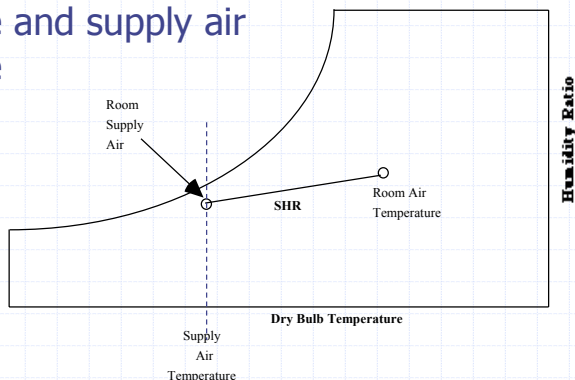
CHILLED WATER COOLING COIL CAPACITIES

EDB/EWB=80/67

			WTR=8									WTR=10											
FPM	ROW	FPM	400 FPM			500 FPM			600 FPM			700 FPM			800 FPM			900 FPM					
			MBH	LOD	LWB	MBH	LOD	LWB	MBH	LOD	LWB	MBH	LOD	LWB	MBH	LOD	LWB	MBH	LOD	LWB	MBH	LOD	LWB
2		80	6.5	67.8	62.1	7.1	68.8	62.8	7.5	69.7	63.3	8.0	70.3	63.6	8.2	68.0	62.3	8.7	69.0	62.9	9.2	70.3	63.7
		100	7.4	66.0	61.4	8.1	67.2	62.2	8.6	68.1	62.7	9.1	68.8	63.1	7.1	66.3	61.7	7.7	67.4	62.2	8.3	68.2	62.8
		120	8.1	64.5	60.8	8.9	65.7	61.6	9.5	66.6	62.2	10.1	67.4	62.7	7.8	64.8	61.1	8.5	65.9	61.8	9.2	66.8	62.4
		140	8.8	63.2	60.3	9.6	64.5	61.2	10.3	65.5	61.8	10.9	66.0	62.3	8.5	63.5	60.5	9.3	64.7	61.4	9.9	65.7	62.0
4		160	9.3	62.3	59.9	10.2	63.6	60.8	10.9	64.6	61.5	11.5	65.1	62.0	9.0	62.5	60.1	9.8	63.8	61.0	10.5	64.8	61.7
		180	11.3	60.9	58.2	12.5	62.1	59.3	13.5	63.2	60.1	14.4	64.2	60.7	10.9	61.0	58.6	12.0	62.4	59.6	13.0	63.5	60.4
		200	12.6	58.7	57.1	14.0	60.2	58.3	15.2	61.3	59.2	16.2	62.3	59.9	12.1	59.1	57.5	13.5	60.5	58.6	14.6	61.7	59.5
		220	13.6	57.2	56.2	15.2	58.7	57.4	16.6	59.9	58.4	17.7	60.9	59.2	13.1	57.6	56.8	14.7	59.2	57.4	16.0	60.2	58.7
6		240	14.6	56.0	55.4	16.2	57.6	56.7	17.7	58.8	57.8	18.8	59.8	58.6	14.0	56.5	55.9	15.7	57.9	56.1	17.0	59.1	58.1
		260	15.2	55.2	54.8	17.0	56.8	56.2	18.5	58.0	57.3	19.8	59.1	58.2	14.8	55.7	55.2	16.4	57.2	56.5	17.9	58.4	57.6
		280	14.9	56.1	55.0	16.7	57.6	56.4	18.3	58.9	57.4	19.7	60.0	58.2	14.3	56.6	55.5	16.1	58.1	56.8	17.6	59.3	57.8
		300	16.3	54.3	53.8	18.4	55.9	55.1	20.3	57.1	56.3	21.8	58.2	57.1	15.7	54.9	54.3	17.8	56.4	55.4	19.5	57.6	56.7
8		320	17.3	53.0	52.7	19.6	54.5	54.2	21.8	55.8	55.3	23.5	56.9	56.3	16.8	53.8	53.3	18.1	55.6	54.8	21.1	56.9	55.7
		340	18.2	52.1	51.9	20.8	53.6	53.4	23.0	54.9	54.6	24.9	56.0	55.6	17.6	52.8	52.5	20.2	54.1	53.9	22.3	55.3	55.1
		360	18.9	51.4	51.3	21.8	52.9	52.8	23.9	54.2	54.0	25.9	55.3	55.1	18.3	51.9	51.8	21.0	53.4	53.2	23.2	54.7	54.5
		380	17.5	53.0	52.6	20.0	54.6	54.0	22.1	55.9	55.1	24.0	57.0	56.1	16.9	53.8	53.1	18.3	55.1	54.3	21.4	56.3	55.6
10		400	18.9	51.5	51.3	21.8	52.9	52.7	24.2	54.2	53.9	26.3	55.3	54.9	18.3	52.0	51.8	21.1	53.5	53.2	23.4	54.7	54.4
		420	19.9	50.4	50.3	23.1	51.8	51.7	25.8	53.0	52.8	28.1	54.1	53.9	19.3	50.9	50.8	22.4	52.9	52.7	25.0	53.5	53.4
		440	20.7	49.6	49.5	24.1	51.0	50.9	27.0	52.2	52.1	29.8	53.3	53.2	20.1	50.1	50.0	23.4	51.5	51.4	26.2	52.7	52.6
		460	21.3	48.0	48.0	24.8	50.4	50.3	27.9	51.6	51.5	30.5	52.7	52.6	20.7	49.5	49.4	24.2	50.9	50.8	27.1	52.2	52.1
12		480	7.4	67.0	61.4	8.0	68.2	62.2	8.6	69.1	62.7	9.1	69.8	63.1	7.0	67.3	61.7	7.7	68.4	62.4	8.3	69.3	62.8
		500	8.5	65.1	60.6	9.3	66.3	61.3	10.1	67.3	62.0	10.7	68.0	62.4	8.1	65.4	60.9	8.9	66.6	61.6	9.6	67.5	62.2
		520	9.5	63.3	59.7	10.5	64.6	60.6	11.3	65.7	61.3	12.0	66.5	61.8	9.1	63.7	60.1	10.0	64.9	60.9	10.8	65.9	61.5
		540	10.3	61.9	59.0	11.4	63.2	60.0	12.3	64.3	60.7	13.1	65.3	61.3	9.9	62.3	59.4	11.0	63.5	60.3	11.8	64.6	61.0
14		560	11.1	60.7	58.4	12.2	62.2	59.5	13.2	63.3	60.3	14.0	64.3	60.9	10.6	61.1	58.8	11.8	62.5	59.8	12.7	63.6	60.5
		580	12.6	59.5	57.1	14.0	61.0	58.3	15.3	62.2	59.1	16.3	63.2	59.9	12.0	60.0	57.6	13.4	61.4	58.7	14.8	62.6	59.5
		600	14.1	57.3	55.8	15.9	58.8	57.0	17.4	60.0	57.9	18.7	61.1	58.7	13.5	57.9	56.3	15.2	59.3	57.4	16.7	60.5	58.3
		620	15.4	55.6	54.6	17.4	57.1	55.9	19.2	58.3	56.9	20.7	59.4	57.7	14.8	56.1	55.1	16.8	57.6	56.3	18.4	58.8	57.3
16		640	16.4	54.2	53.6	18.7	55.9	55.0	20.6	57.0	56.1	22.2	58.1	57.0	15.8	54.8	54.2	18.0	56.3	55.5	19.8	57.5	56.5
		660	17.3	53.2	52.8	19.7	54.9	54.2	21.7	56.1	55.4	23.4	57.2	56.4	16.7	53.8	53.4	19.0	55.3	54.7	21.0	56.6	55.8
		680	16.3	54.8	53.8	18.4	56.4	55.1	20.4	57.7	56.2	22.1	58.8	57.1	15.6	55.4	54.4	17.7	56.9	55.8	19.8	58.2	56.7
		700	17.8	52.9	52.3	20.5	54.3	53.8	22.8	55.6	54.7	24.8	56.7	55.7	17.2	53.4	52.9	19.8	54.9	54.2	22.0	56.1	55.2
18		720	18.1	51.4	51.1	22.1	52.8	52.4	24.7	54.0	53.6	27.0	55.1	54.5	18.5	51.9	51.7	21.4	53.4	53.0	23.9	54.8	54.1
		740	20.0	50.3	50.1	23.3	51.7	51.5	26.3	52.9	52.6	28.7	54.0	53.7	19.4	50.8	50.7	22.8	52.2	52.0	25.3	53.4	53.2
		760	20.8	49.5	49.4	24.3	50.9	50.7	27.3	52.1	51.9	30.0	53.2	53.0	20.2	50.0	49.9	23.6	51.4	51.3	26.5	52.6	52.4
		780	18.8	51.7	51.3	21.8	53.2	52.7	24.3	54.5	53.8	26.6	55.6	54.7	18.2	52.3	51.9	21.0	53.8	53.2	23.5	55.1	54.3
20		800	20.3	50.1	49.9	23.8	51.4	51.1	26.8	52.6	52.3	29.4	53.7	53.2	19.7	50.6	50.4	23.0	52.0	51.7	25.9	53.2	52.8
		820	21.4	48.8	48.7	25.2	50.1	50.0	28.6	51.2	51.1	31.6	52.3	52.1	20.8	49.4	49.3	24.5	50.8	50.5	27.8	51.8	51.6
		840	22.2	48.0	47.9	26.3	49.2	49.1	30.0	50.3	50.2	33.2	51.3	51.2	21.7	48.5	48.4	25.7	49.7	49.6	29.2	50.8	50.7
		860	22.8	47.4	47.3	27.2	48.5	48.4	31.0	49.6	49.5	34.5	50.6	50.5	22.3	47.9	47.8	26.5	49.0	48.9	30.2	50.1	50.0

## Coil Selection

- ◆ Start With Space Conditions
- ◆ Find the intersection of the SHR with desired room temperature and supply air temperature

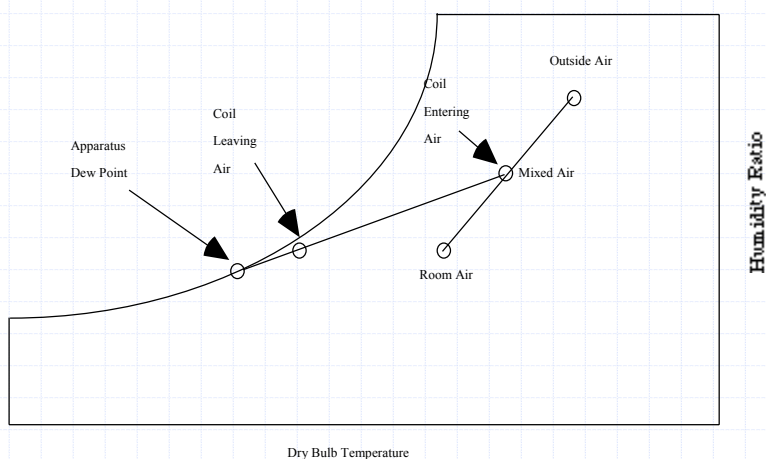


## Coil Selection

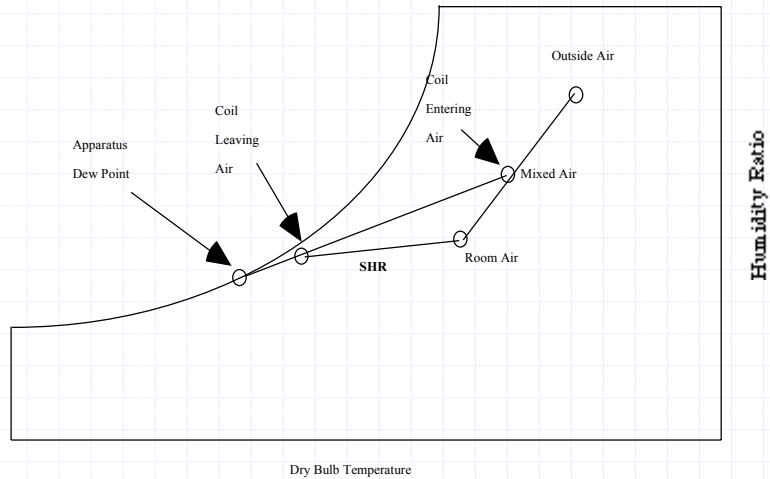
Determine Outside Air Requirements Using ASHRAE Standard 62

Offices	20 CFM per person
Schools	15 CFM per person
Bars	30 CFM per person
Smoking Lounges	60 CFM per person
Corridors	0.05 CFM/ft <sup>2</sup>

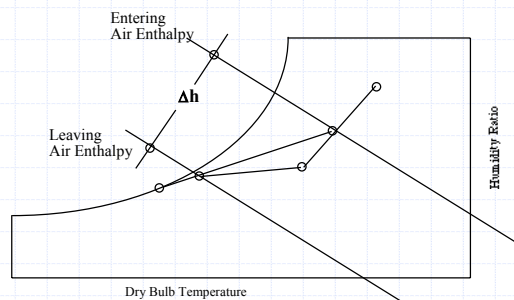
## Plot Entering/Leaving Conditions



## Define Process in Complete Cycle



## Determine Required Coil Capacity



Coil Capacity Requirement

$$Q_{\text{coil}} = 4.5 \times \text{CFM} \times \Delta h$$

## Coil Load Calculation Example

Determine the minimum cooling coil load and required chilled water flow for a system serving an office space with a sensible cooling load of 30,800 Btu/h and a latent load of 13,500 Btu/h?

Indoor design conditions are 75°F/50% RH, and Outdoor design conditions are 85°F DB/70°F WB.

The minimum ventilation air is 25% of the total supply air which is delivered at 55°F. The fan selected is a 70% efficient "draw-through" arrangement, and delivers air at 4.0 inches total pressure.

No manufacturer's coil data is available. Assume 10°F chilled water temperature rise through the coil.

## Coil Load Example

$$q_{\text{sensible}} = m C_p \Delta T$$

For air at  $\rho = 0.075 \text{ lb}_m/\text{ft}^3$  and  $C_p = 0.24$

$$q_{\text{sensible}} = 1.08 \times \text{CFM} \times \Delta T$$

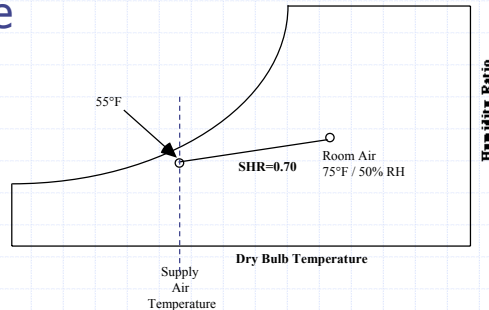
$$\text{CFM} = \frac{q_{\text{sensible}}}{(1.10 \times \Delta T)} = \frac{30,800}{1.10 (75 - 55)}$$

$$\text{CFM} = 1400$$

$$\text{SHR} = \frac{30,800}{30,800 + 13,500} = 0.70$$

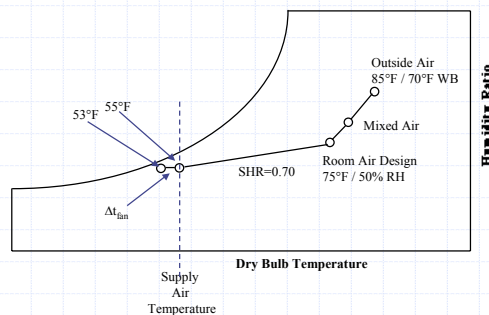
## Coil Load Example

- ◆ Plot Space Conditions of 75°F/50% RH
- ◆ Find the intersection of the SHR line with space temperature and supply air temperature



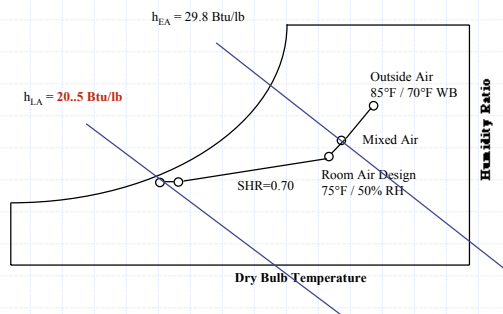
## Coil Load Example

- ◆ Plot Outdoor Conditions of 85°F/ 70°F WB
- ◆ Locate Mixed Air Condition (25% OA)
- ◆ Account for Fan  $\Delta t$



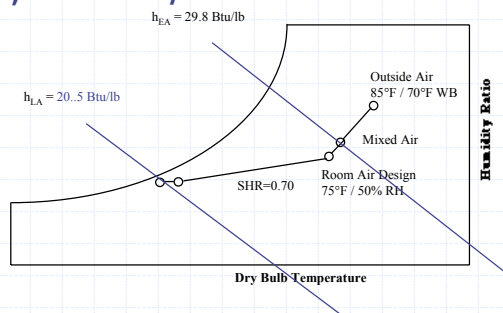
## Coil Load Example

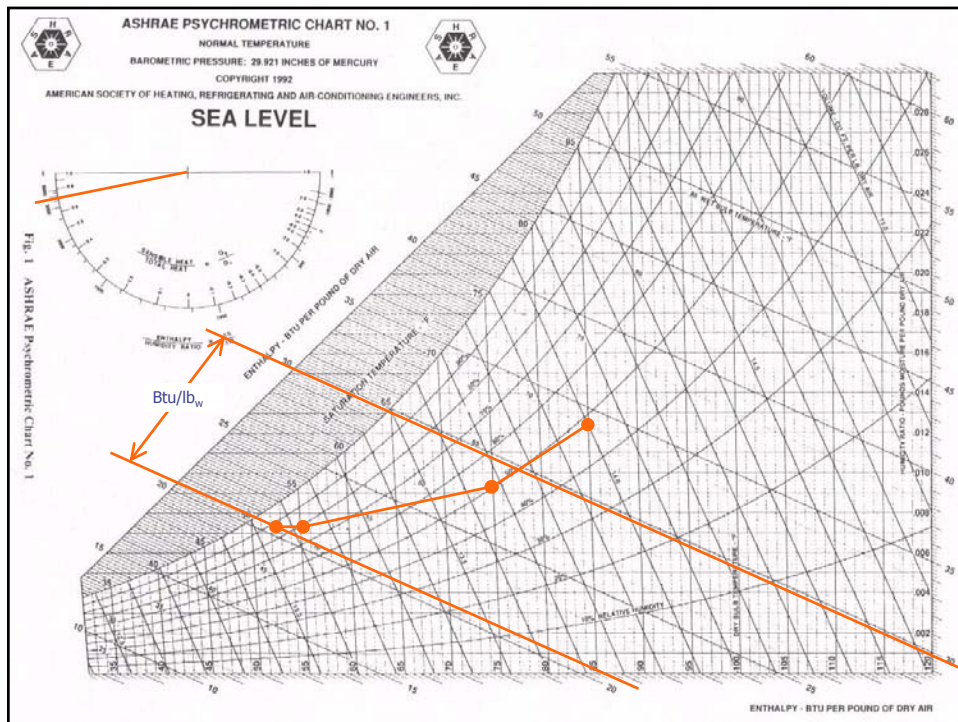
- ◆ Determine enthalpy for coil entering and leaving conditions



## Coil Load Example

$$\begin{aligned}
 \text{◆ } q_{\text{coil}} &= 4.5 \times \text{CFM} \times \Delta h \\
 &= 4.5 \times 1400 \times (29.8 - 20.5) \\
 &= 58,590 \text{ Btu/hr}
 \end{aligned}$$





## Determine Chilled Water Flow

$$q_{\text{total}} = m C_p \Delta T$$

For water at  $\rho = 62.34 \text{ lb}_m/\text{ft}^3$  and  $C_p = 1.0$

$$q_{\text{total}} = 500 \times \text{GPM} \times \Delta T$$

$$\text{GPM} = \frac{q_{\text{coil}}}{(500 \times \Delta T)} = \frac{58,590}{(500 \times 10^\circ\text{F})}$$

$$= 11.7 \text{ GPM}$$

## Unitary Equipment

### Performance data (cont)

#### COOLING CAPACITIES

48DJ,DK,DS/50DJ,DK084 (80-TON)												
Temp (F) Air Ent Cond (Edb)		Evap Air — Cfm/BF										
		16,000/0.02			20,000/0.03			24,000/0.04			28,000/0.0	
		Evap Air — Ewb (F)										
		72	67	62	72	67	62	72	67	62	72	67
85	TC	1002	916	836	1055	967	885	1091	1002	921	1119	1029
	SHC	479	572	660	516	631	742	551	688	818	585	741
	kW	79.1	75.3	71.3	81.3	77.5	73.9	83.0	79.1	75.5	84.2	80.2
95	TC	962	878	799	1010	925	845	1044	957	881	1066	982
	SHC	462	554	642	499	613	723	534	669	797	566	722
	kW	84.5	80.2	76.2	86.9	82.6	78.5	88.5	84.3	80.3	89.8	85.5
105	TC	917	837	763	961	880	805	991	910	837	1015	933
	SHC	444	535	623	479	593	703	514	649	775	548	702
	kW	89.5	85.0	80.4	92.1	87.4	83.1	93.9	89.2	85.0	95.2	90.5
115	TC	871	794	722	912	833	762	940	861	793	957	882
	SHC	425	515	603	462	574	682	496	629	752	528	681
	kW	94.6	89.4	84.6	97.2	92.1	87.4	99.0	93.9	89.4	100.3	95.3

## Homework

- ◆ Read 05F6.14-6.21
- ◆ What is the coil load for the following?
  - Indoor 76 °F/45% RH - Outdoor 82/66°F
  - Load (Btu/h) 100,000 Sensible - 40,000 Latent
  - Supply air 55°F through draw-through fan
  - Fan Total Pressure = 3 in w.c.
  - Fan Efficiency = 60%
  - Outside air = 50% of total supply
- ◆ Be able to work this problem not necessary to turn in