PSYCHED FOR PSYCHROMTRICS

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OVERVIEW

- Review of Basics
- Space Conditions
- Part Loads
- Energy Recovery
- Condensation

Review of Basics

PSYCHOMETRICS DEFINED

THE SCIENCE THAT INVOLVES THE PROPERTIES OF MOIST AIR AND THE PROCESS IN WHICH THE TEMPERATURE AND/OR WATER VAPOR CONTENT OF THE MIXTURE ARE CHANGED

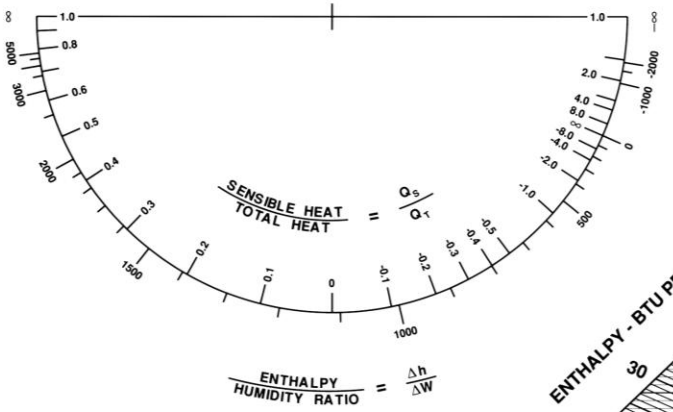
"UNDERSTANDING PSYCHROMETRICS"

ASHRAE PSYCHROMETRIC CHART NO. 1

NORMAL TEMPERATURE

BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY

SEA LEVEL



ENTHALPY - BTU PER POUND OF DRY AIR

SATURATION TEMPERATURE - °F

VOLUME - CU. FT. PER LB. DRY AIR

85 WET BULB TEMPERATURE - °F

RELATIVE HUMIDITY

DRY BULB TEMPERATURE - °F

HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR

Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho

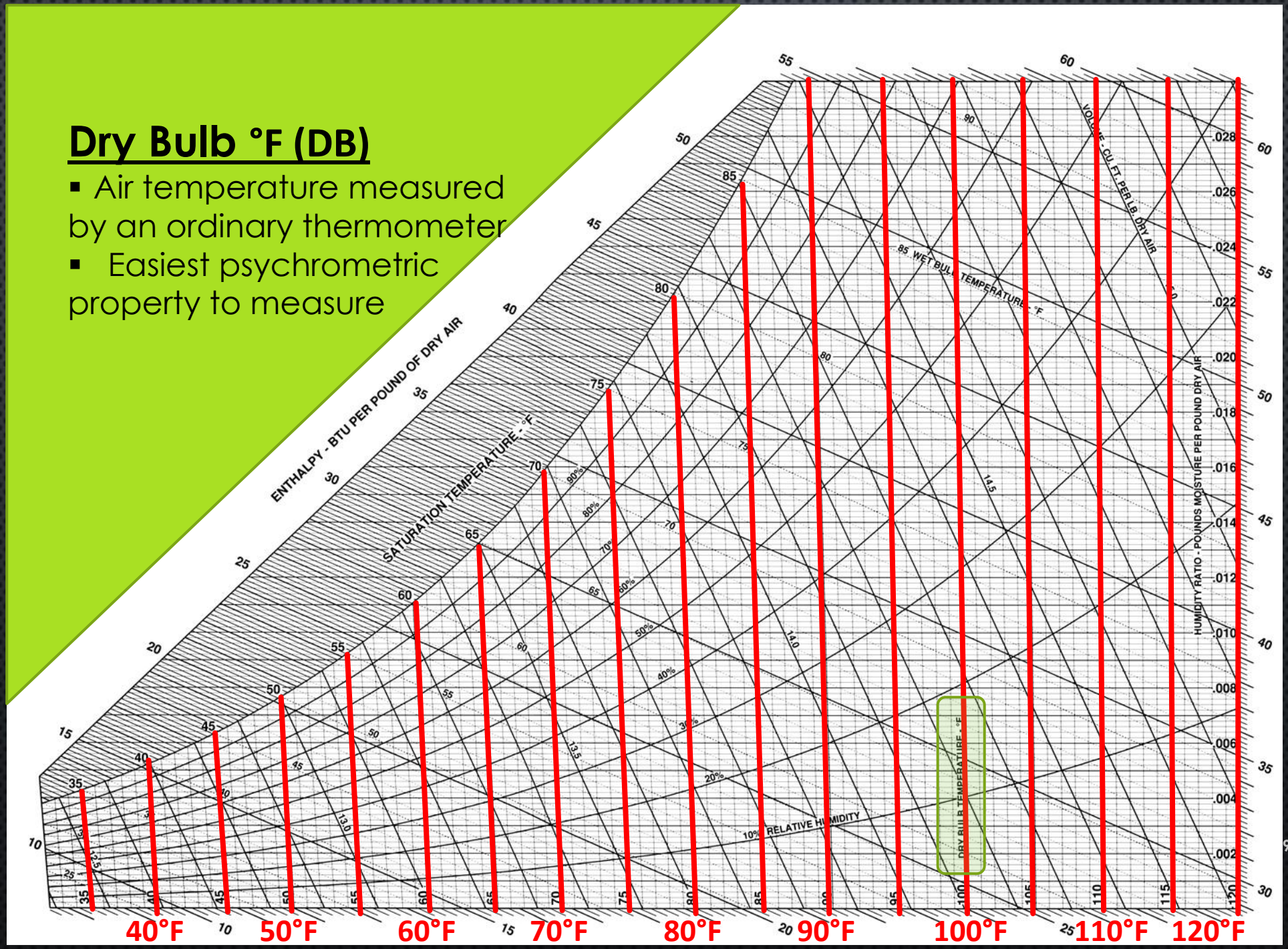
ENTHALPY - BTU PER POUND OF DRY AIR

ELEMENTS OF PSYCH CHART

- Dry-bulb temperature (DB)
- Wet-bulb temperature (WB)
- Relative humidity (RH)
- Humidity ratio (W or G)
- Dew-point temperature (DP)
- Specific enthalpy (h)
- Specific volume (v)

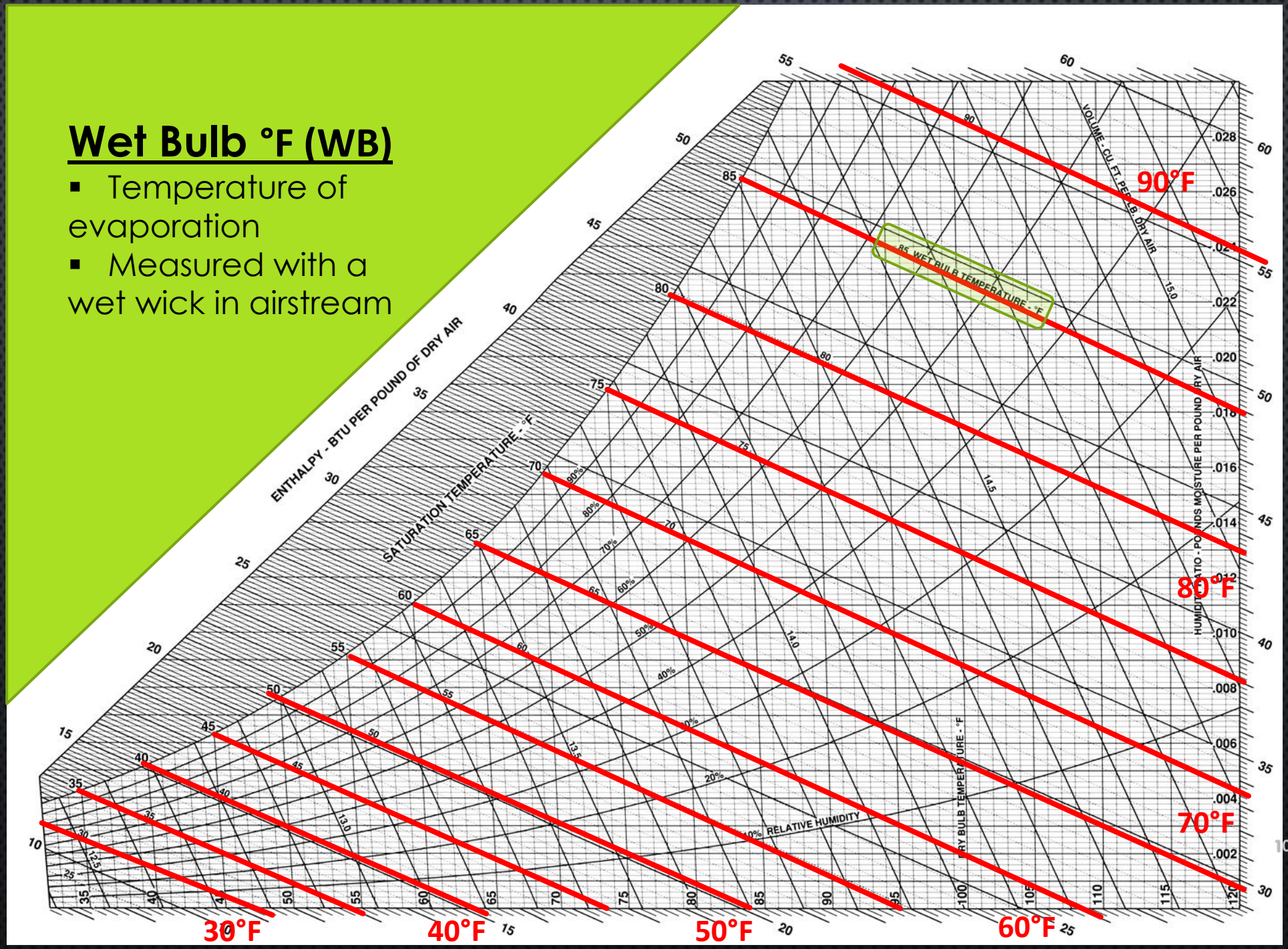
Dry Bulb °F (DB)

- Air temperature measured by an ordinary thermometer
- Easiest psychrometric property to measure



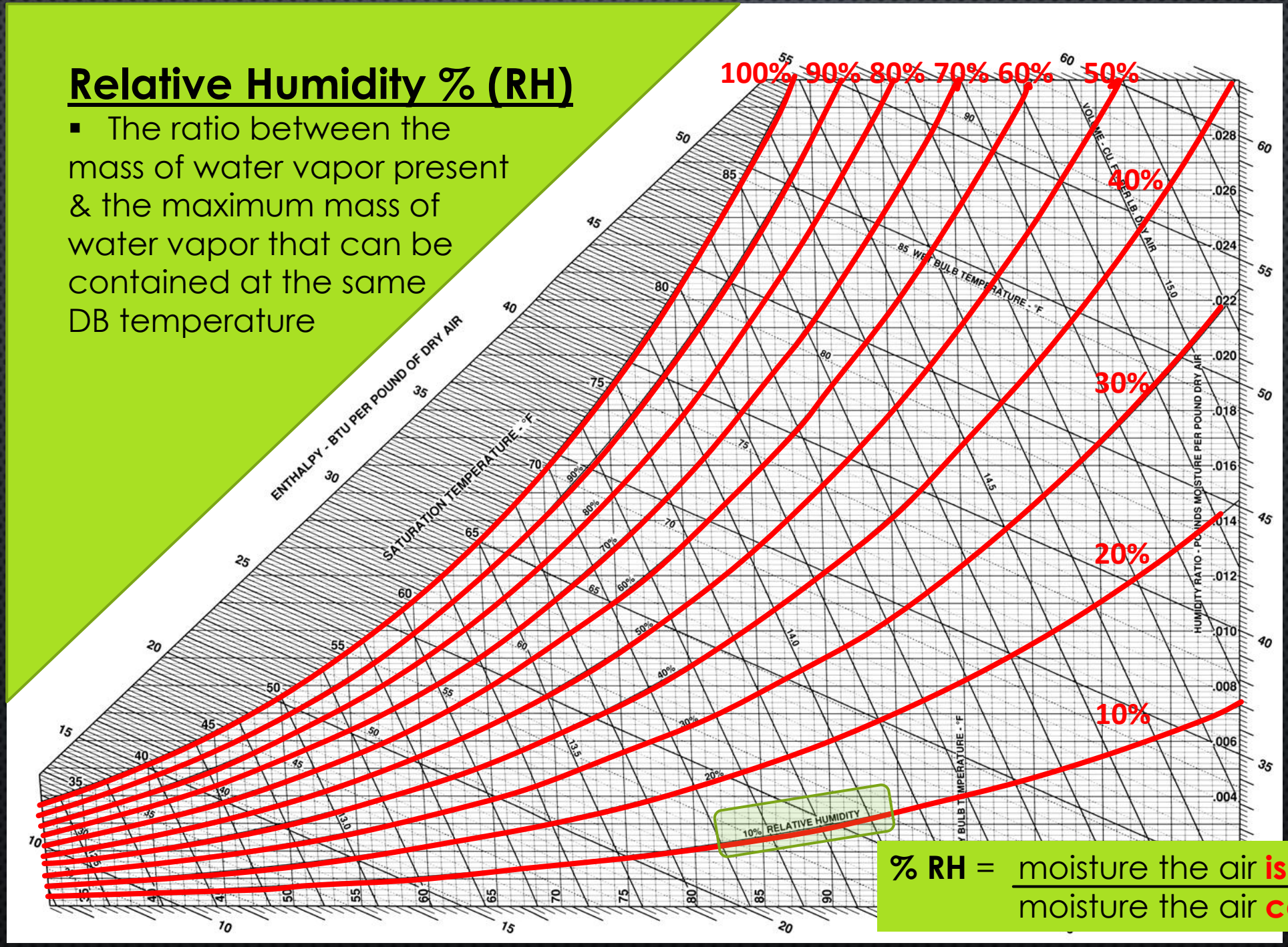
Wet Bulb °F (WB)

- Temperature of evaporation
- Measured with a wet wick in airstream



Relative Humidity % (RH)

- The ratio between the mass of water vapor present & the maximum mass of water vapor that can be contained at the same DB temperature



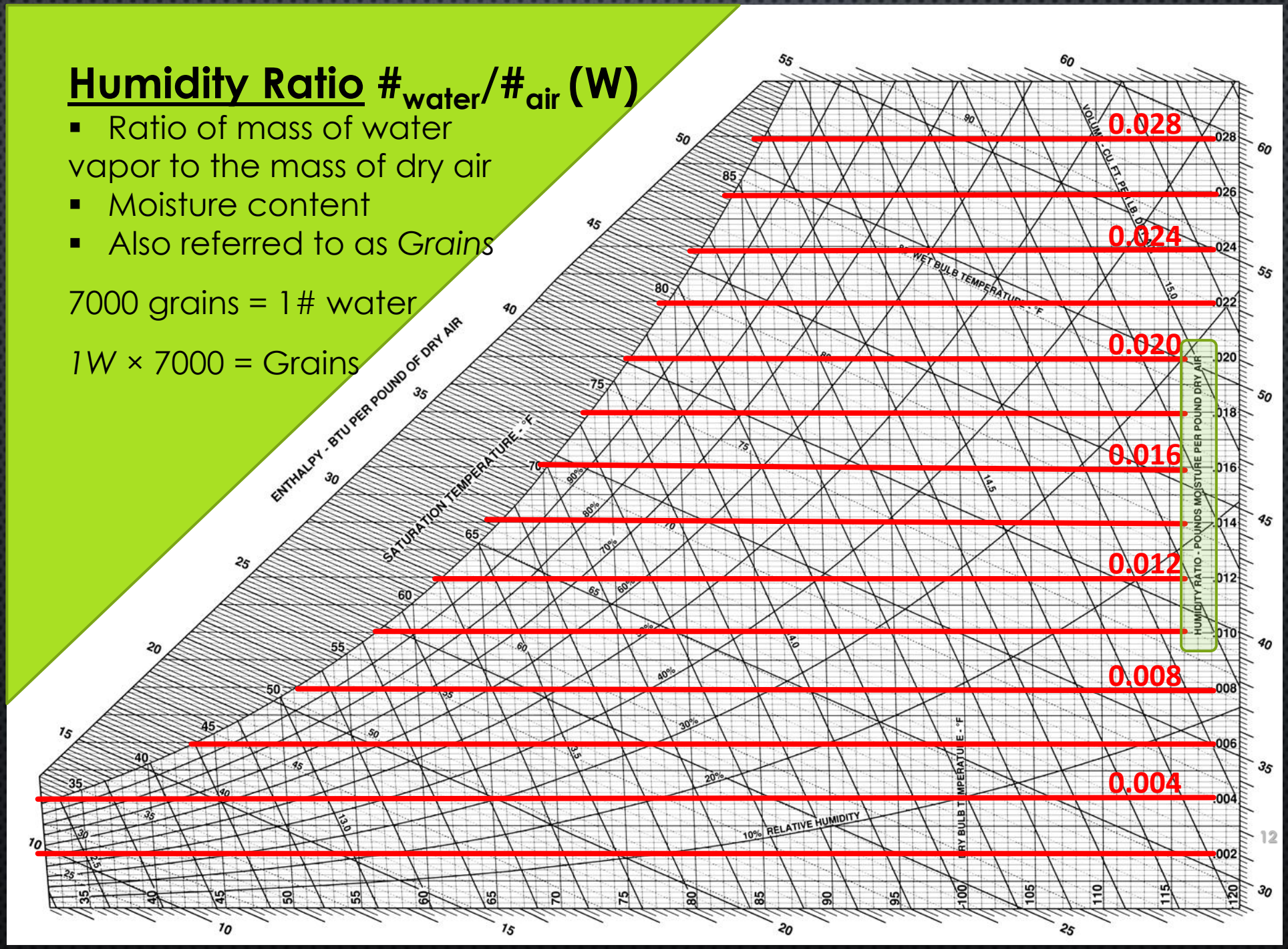
% RH = moisture the air **is** holding / moisture the air **can** hold

Humidity Ratio $\#_{water}/\#_{air}$ (W)

- Ratio of mass of water vapor to the mass of dry air
- Moisture content
- Also referred to as *Grains*

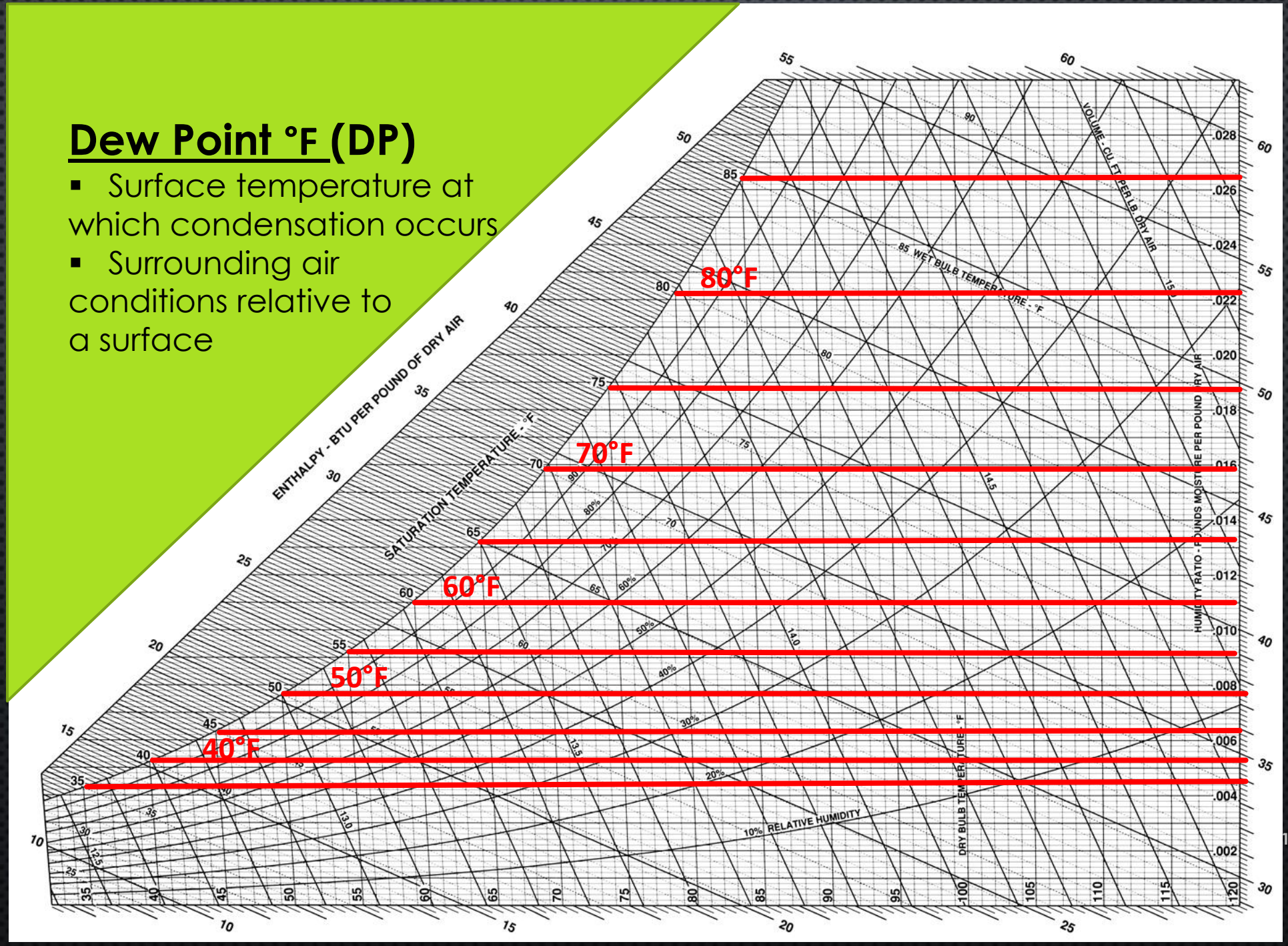
7000 grains = 1# water

1W × 7000 = Grains



Dew Point °F (DP)

- Surface temperature at which condensation occurs
- Surrounding air conditions relative to a surface



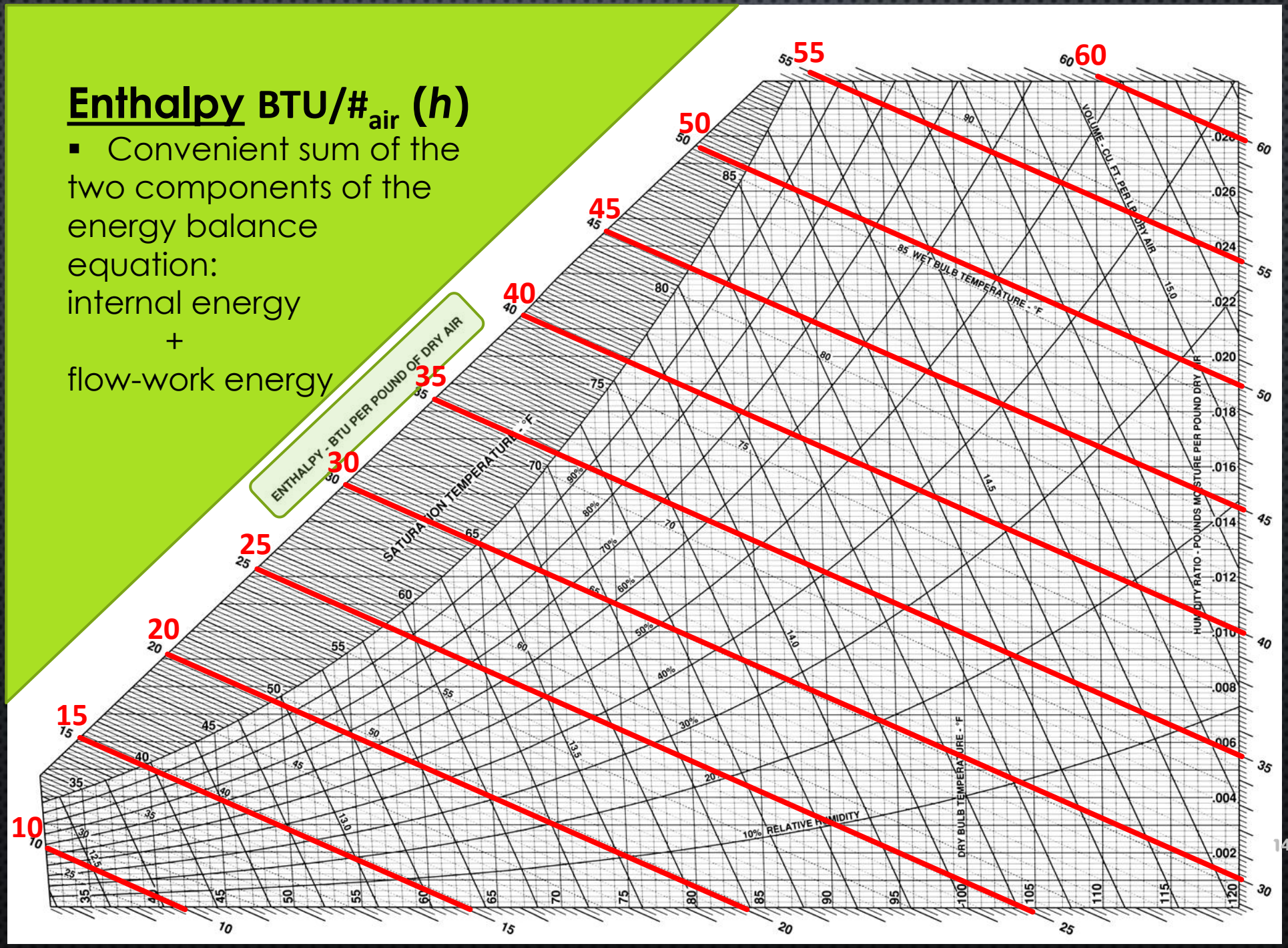
Enthalpy BTU/#$_{air}$ (h)

- Convenient sum of the two components of the energy balance equation:

internal energy

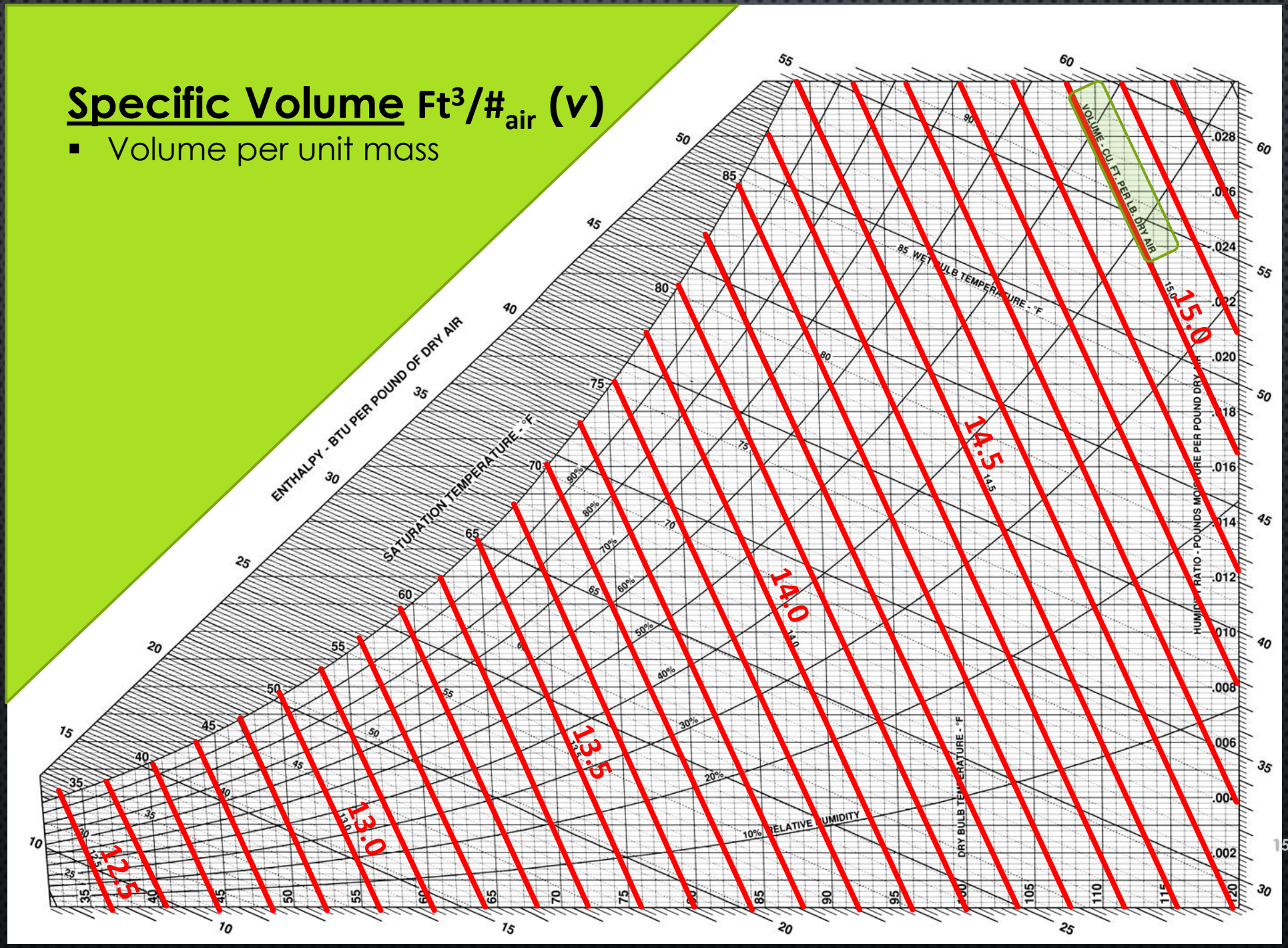
+

flow-work energy



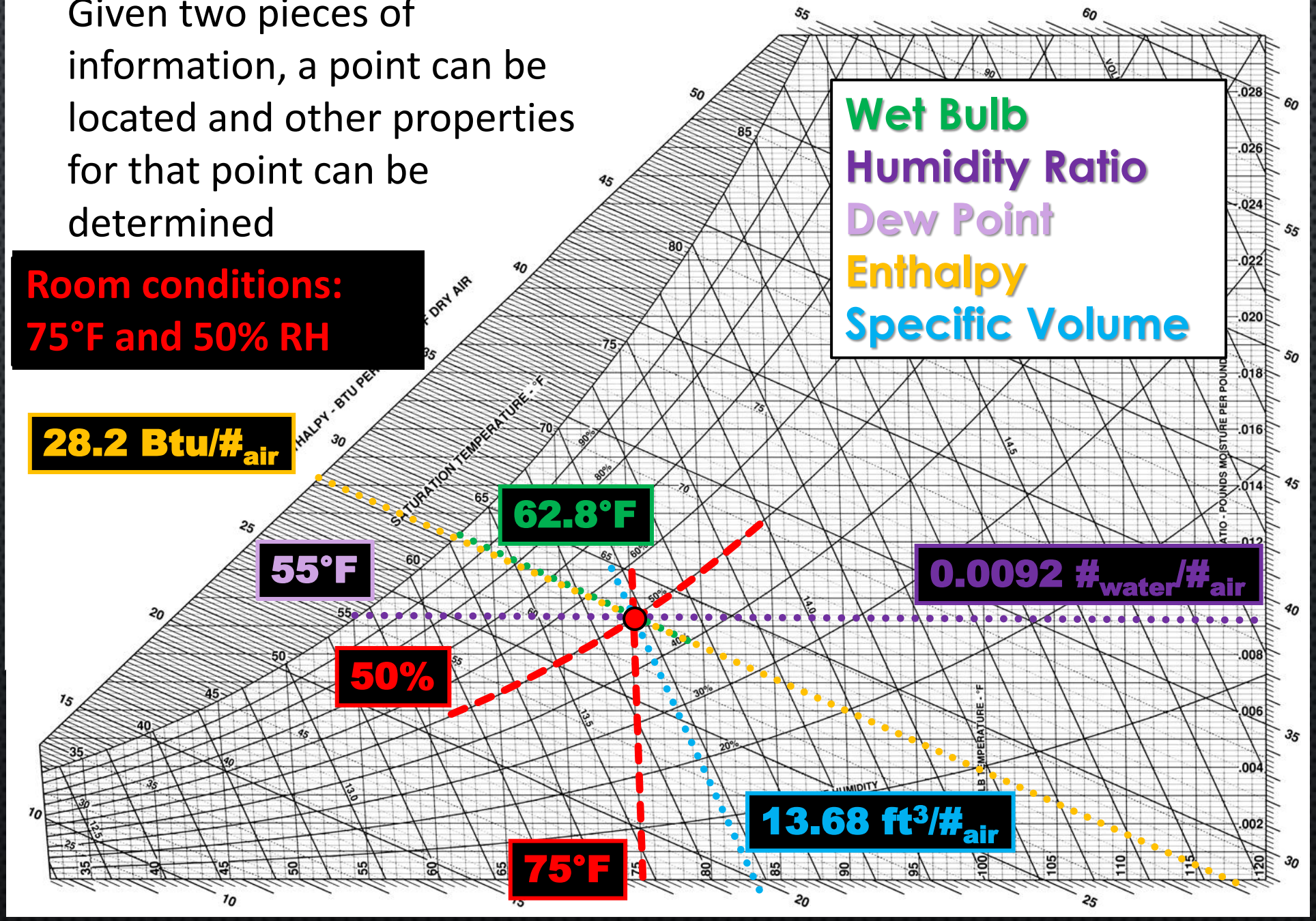
Specific Volume $Ft^3/\#_{air}$ (v)

- Volume per unit mass

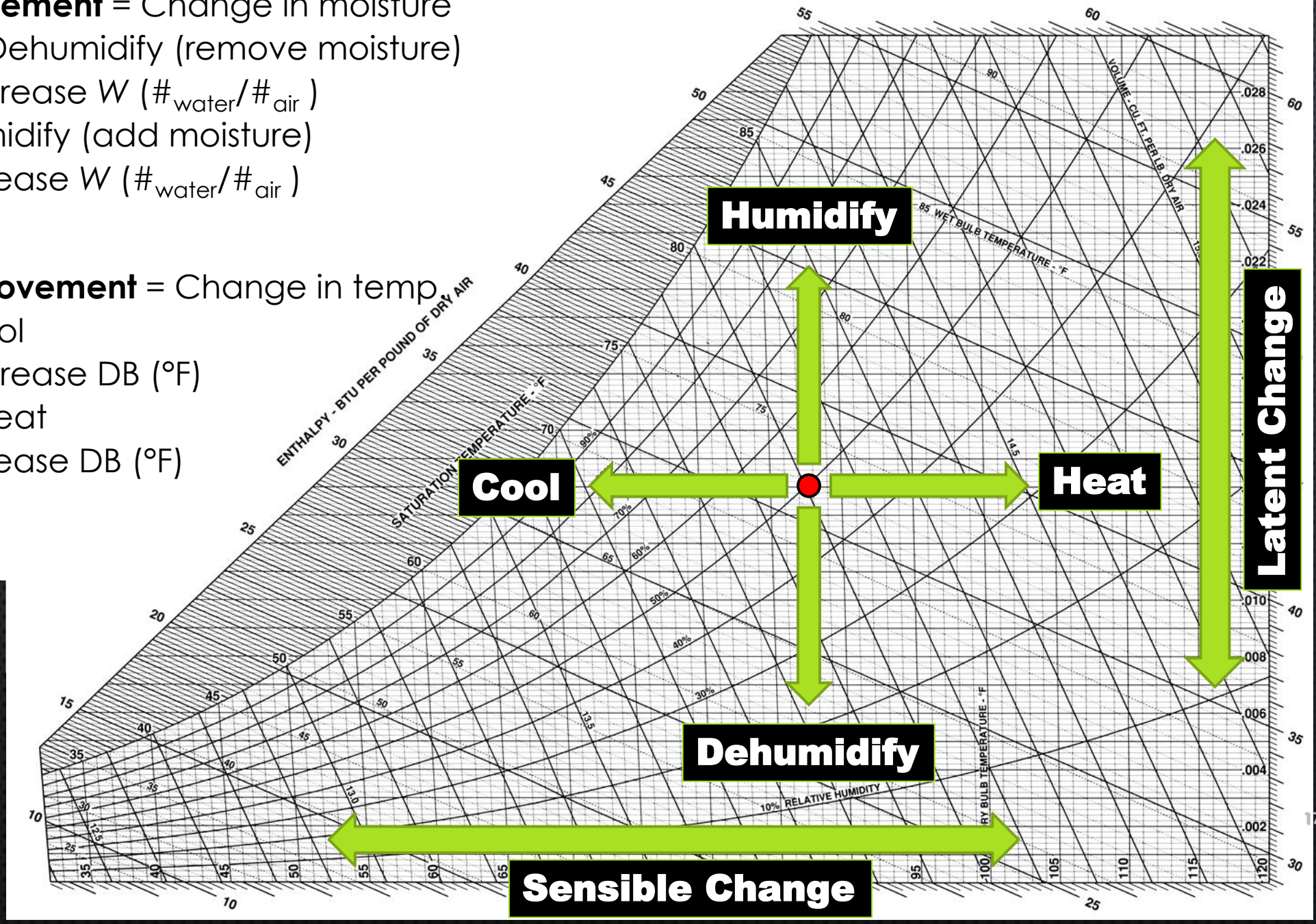


Given two pieces of information, a point can be located and other properties for that point can be determined

Room conditions:
75°F and 50% RH



- **Vertical movement** = Change in moisture
  - Down: Dehumidify (remove moisture)
    - Decrease *W* ($\#_{water}/\#_{air}$)
  - Up: Humidify (add moisture)
    - Increase *W* ($\#_{water}/\#_{air}$)
  - Latent
- **Horizontal movement** = Change in temp
  - Left: Cool
    - Decrease DB (°F)
  - Right: Heat
    - Increase DB (°F)
  - Sensible



Space Conditions

SPACE LOAD AND SPACE CONDITIONS

- Using a standard unit with a delivery air condition of 55°F /90%, what room conditions can be maintained for the following space:
- 40’x50’ classroom:
  - Envelope = 6,500 BTUh (all sensible)
  - Equipment & Lights = 1,700 BTUh (all sensible)
  - People = ?

ASHRAE Handbook—Fundamentals, Chapter 18

Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity

Degree of Activity	Location	Total Heat, Btu/h		Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant[b]	
		Adult Male	Adjusted, M/F[a]			Low *V*	High *V*
Seated at theater	Theater	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store; retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant[c]	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph; light machine work	Factory	1000	1000	375	625		
Bowling[d]	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work; lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density	Air Class	OS (6.2.6.1.4)
	cfm/person	L/s-person	cfm/ft^2	L/s-m^2	#/1000 ft^2 or #/100 m^2		
Animal Facilities							
Animal exam room (veterinary office)	10	5	0.12	0.6	20	2	
Animal imaging (MRI/CT/PET)	10	5	0.18	0.9	20	3	
Animal operating rooms	10	5	0.18	0.9	20	3	
Animal postoperative recovery room	10	5	0.18	0.9	20	3	
Animal preparation rooms	10	5	0.18	0.9	20	3	
Animal procedure room	10	5	0.18	0.9	20	3	
Animal surgery scrub	10	5	0.18	0.9	20	3	
Large-animal holding room	10	5	0.18	0.9	20	3	
Necropsy	10	5	0.18	0.9	20	3	
Small-animal-cage room (static cages)	10	5	0.18	0.9	20	3	
Small-animal-cage room (ventilated cages)	10	5	0.18	0.9	20	3	
Correctional Facilities							
Booking/waiting	7.5	3.8	0.06	0.3	50	2	
Cell	5	2.5	0.12	0.6	25	2	
Dayroom	5	2.5	0.06	0.3	30	1	
Guard stations	5	2.5	0.06	0.3	15	1	
Educational Facilities							
Art classroom	10	5	0.18	0.9	20	2	
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25	1	
Classrooms (age 9 plus)	10	5	0.12	0.6	35	1	
Computer lab	10	5	0.12	0.6	25	1	
Daycare sickroom	10	5	0.18	0.9	25	3	
Daycare (through age 4)	10	5	0.18	0.9	25	2	
Lecture classroom	7.5	3.8	0.06	0.3	65	1	✓
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150	1	✓
Libraries	5	2.5	0.12	0.6	10		
Media center	10	5	0.12	0.6	25	1	
Multiuse assembly	7.5	3.8	0.06	0.3	100	1	✓
Music/theater/dance	10	5	0.06	0.3	35	1	✓
Science laboratories	10	5	0.18	0.9	25	2	

a. Outpatient facilities to which the rates apply are freestanding birth centers, urgent care centers, neighborhood clinics and physicians offices, Class 1 imaging facilities, outpatient psychiatric facilities, outpatient rehabilitation facilities, and outpatient dental facilities.
b. The requirements of this table provide for acceptable IAQ. The requirements of this table do not address the airborne transmission of airborne viruses, bacteria, and other infectious contagions.

Informative Note: These rates are intended only for outpatient dental clinics where the amount of nitrous oxide is limited. They are not intended for dental operatories in institutional buildings where nitrous oxide is piped.

STANDARD

ASHRAE®

ANSI/ASHRAE Standard 62.1-2019
(Supersedes ANSI/ASHRAE Standard 62.1-2016)
Includes ANSI/ASHRAE addenda listed in Appendix O

Ventilation for Acceptable Indoor Air Quality

See Appendix O for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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ANSI
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Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density
	cfm/ person	L/s-person	cfm/ft^2	L/s-m^2	#/1000 ft^2 or #/100 m^2
Educational Facilities					
Art classroom	10	5	0.18	0.9	20
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25
Classrooms (age 9 plus)	10	5	0.12	0.6	35
Computer lab	10	5	0.12	0.6	25
Daycare sickroom	10	5	0.18	0.9	25
Daycare (through age 4)	10	5	0.18	0.9	25
Lecture classroom	7.5	3.8	0.06	0.3	65
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150
Libraries	5	2.5	0.12	0.6	10
Media center	10	5	0.12	0.6	25
Multiuse assembly	7.5	3.8			
Music/theater/dance	10	5	0.06	0.3	35
Science laboratories	10	5	0.18	0.9	25

(40'x50') x (65 people/1000ft^2)= 130 people

SPACE LOAD AND SPACE CONDITIONS

- Using a standard unit with a delivery air condition of 55°F /90%, what room conditions can be maintained for the following space:
- 40'x50' classroom:
  - Envelope = 6,500 BTUh (all sensible)
  - Equipment & Lights = 1,700 BTUh (all sensible)
  - People = 245 BTUh/person x 130 people = 31,850 BTUh Sensible

    155 BTUh/person x 130 people = 20,150 BTUh Latent

SPACE LOAD AND SPACE CONDITIONS

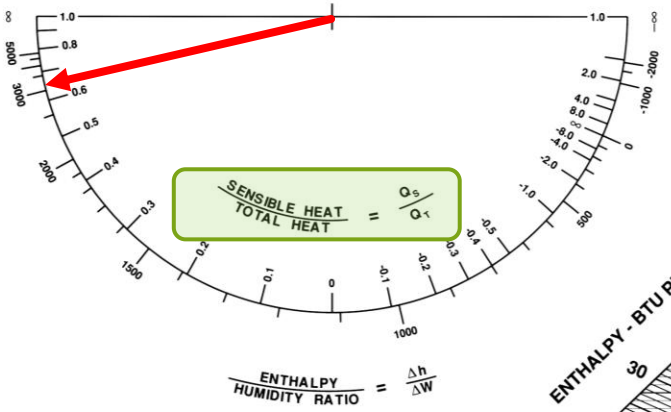
- Sensible Load: 40,050 BTUh
- Latent Load: 20,150 BTUh
- Total Load: 60,200 BTUh
- Sensible Heat Ratio: q_S/q_T = 40,050/60,200 = 0.665

ASHRAE PSYCHROMETRIC CHART NO. 1

NORMAL TEMPERATURE

BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY

SEA LEVEL



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ENTHALPY - BTU PER POUND OF DRY AIR

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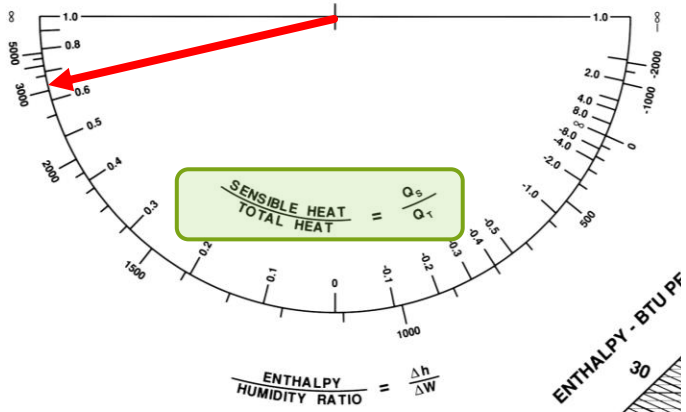

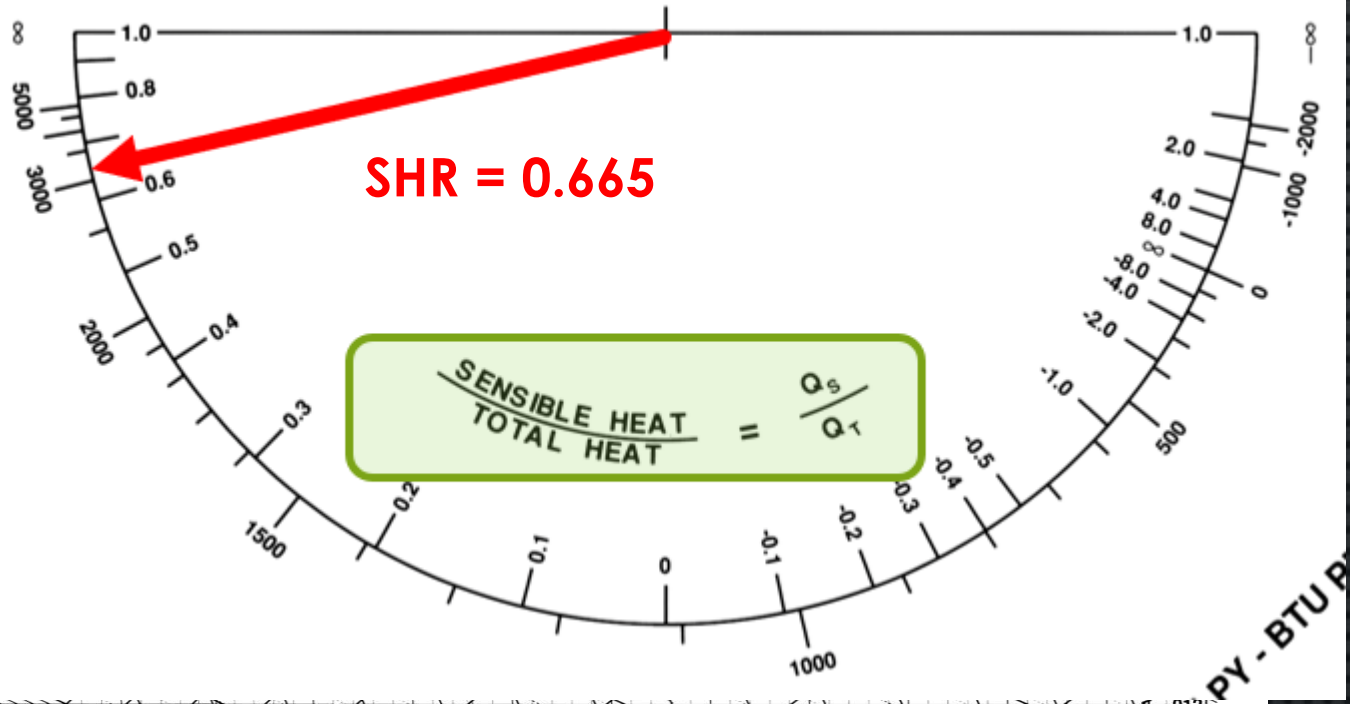

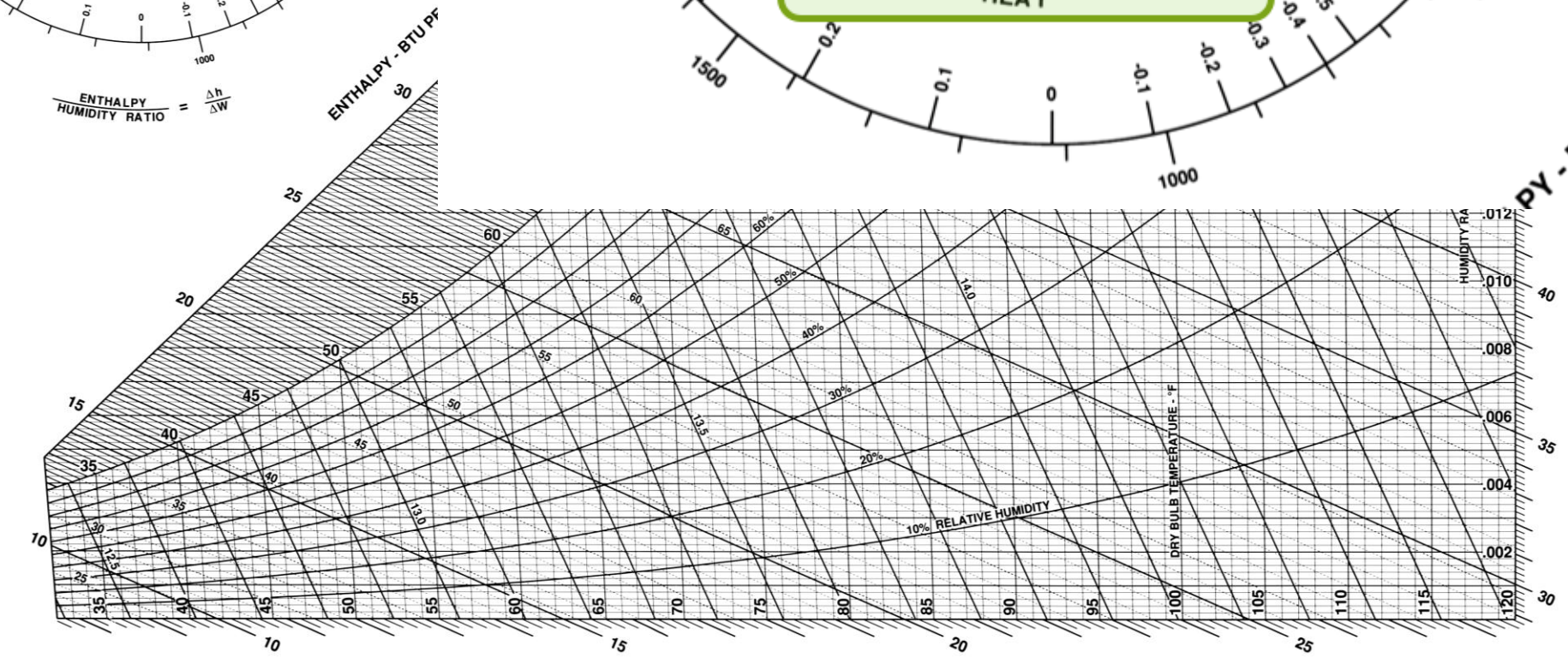

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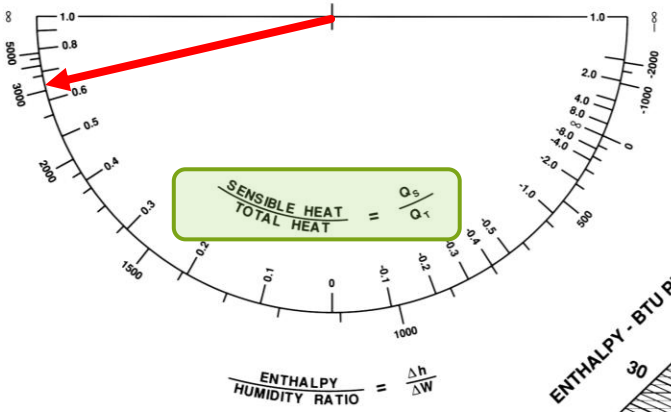

55°F/90%

ENTHALPY - BTU PER POUND OF DRY AIR

SATURATION TEMPERATURE - °F

85 WET BULB TEMPERATURE - °F

VOLUME - CU. FT. PER LB. DRY AIR

HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR

DRY BULB TEMPERATURE - °F

10% RELATIVE HUMIDITY

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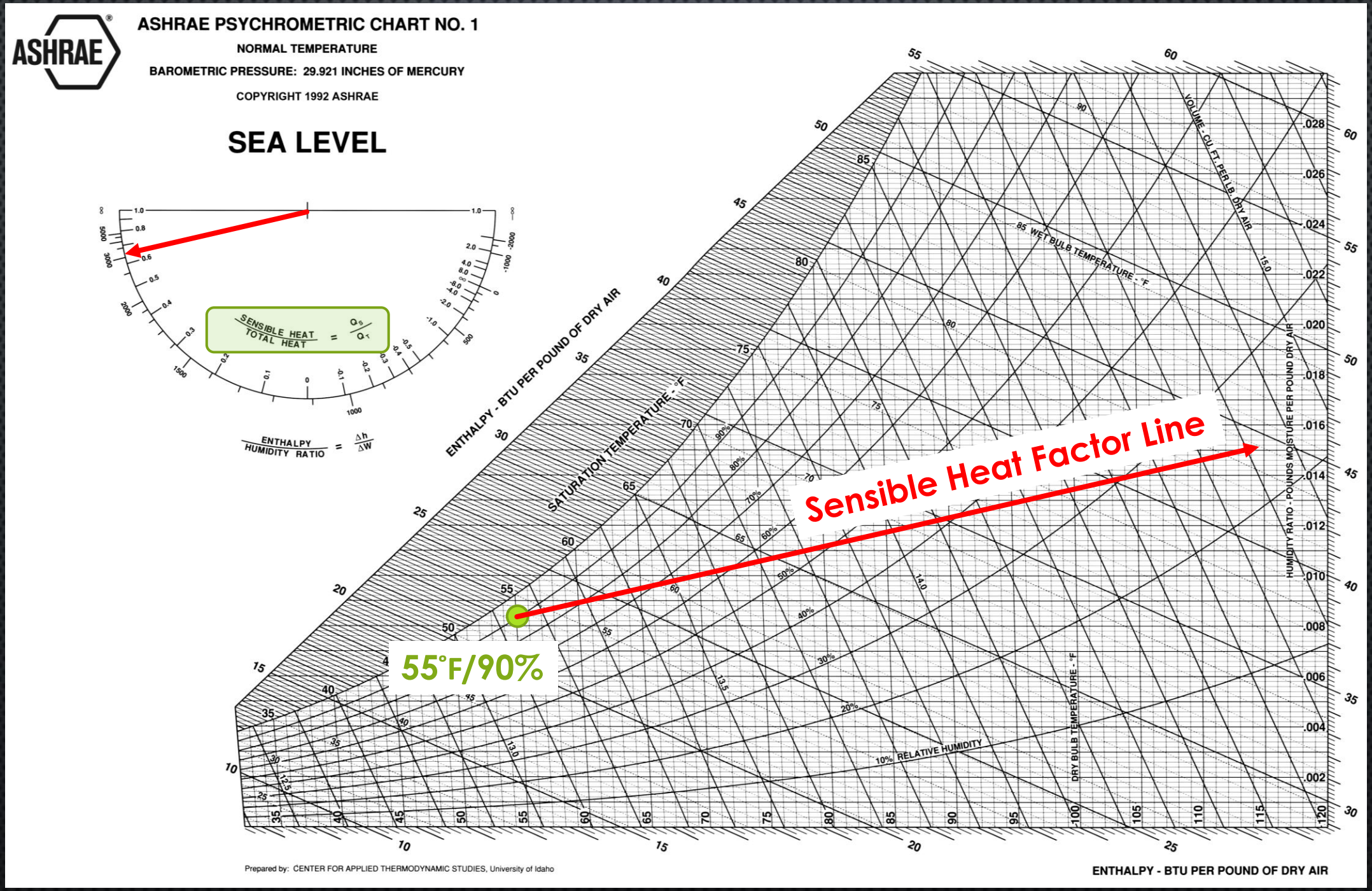
ENTHALPY - BTU PER POUND OF DRY AIR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NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
COPYRIGHT 1992 ASHRAE
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
Sensible Heat Factor Line
55°F/90%
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
VOLUME - CU. FT. PER LB. DRY AIR
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
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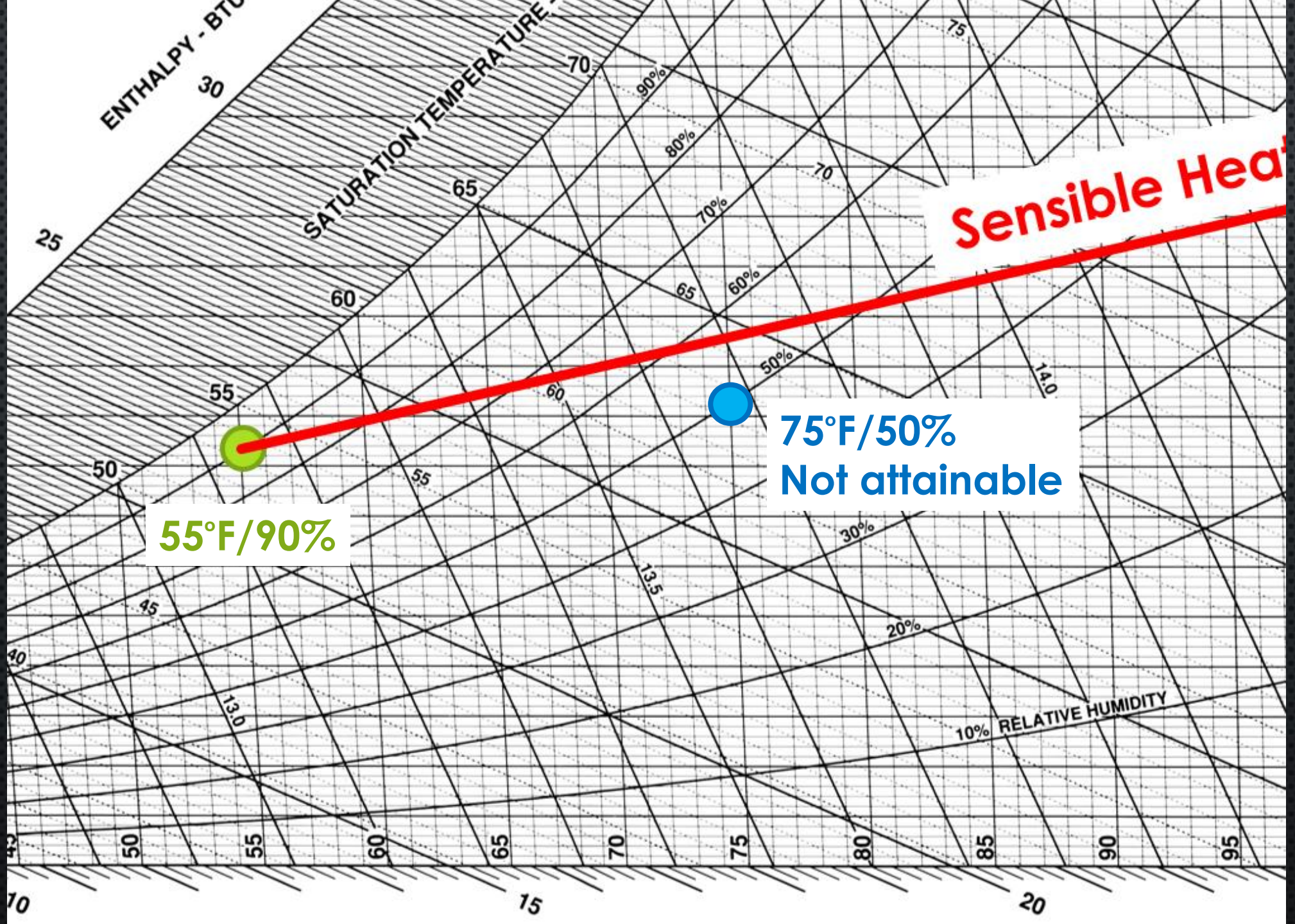
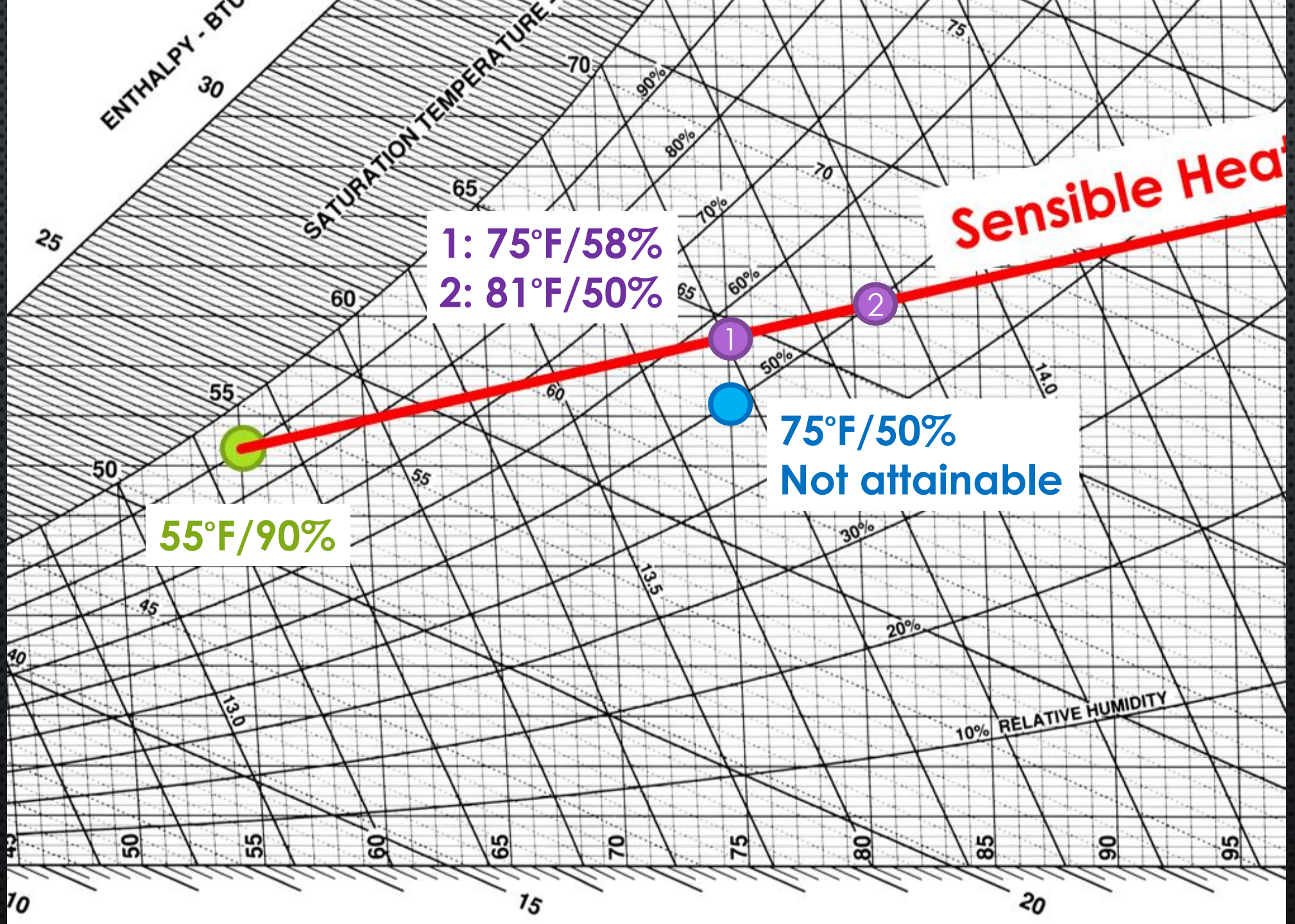
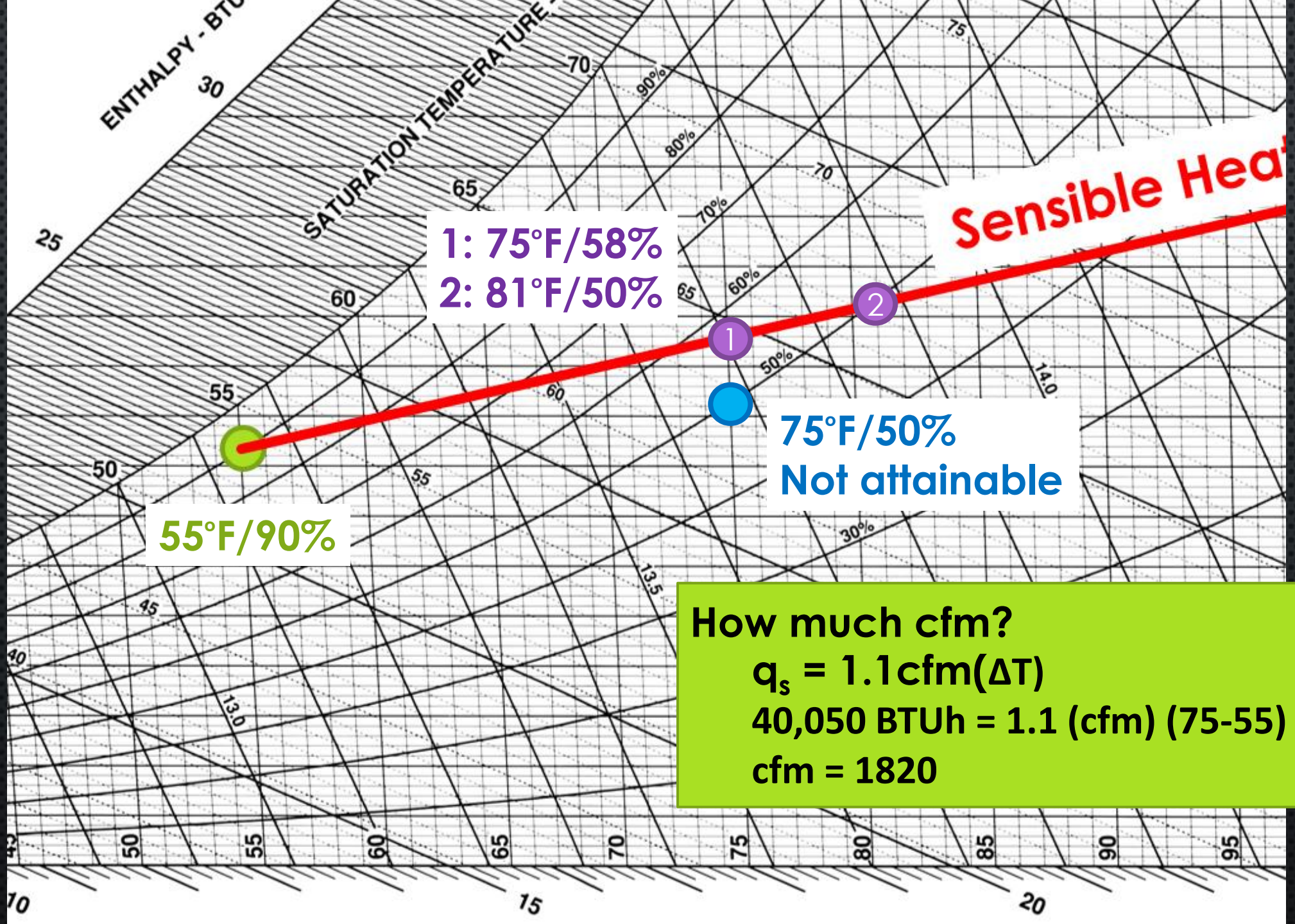

ENTHALPY - BTU
SATURATION TEMPERATURE
Sensible Hea
75°F/50%
Not attainable
55°F/90%
10% RELATIVE HUMIDITY


ENTHALPY - BTU
SATURATION TEMPERATURE
Sensible Hea
1: 75°F/58%
2: 81°F/50%
75°F/50%
Not attainable
55°F/90%
10% RELATIVE HUMIDITY


ENTHALPY - BTU
SATURATION TEMPERATURE
Sensible Hea
1: 75°F/58%
2: 81°F/50%
75°F/50%
Not attainable
55°F/90%
How much cfm?
q_s = 1.1cfm(ΔT)
40,050 BTUh = 1.1 (cfm) (75-55)
cfm = 1820

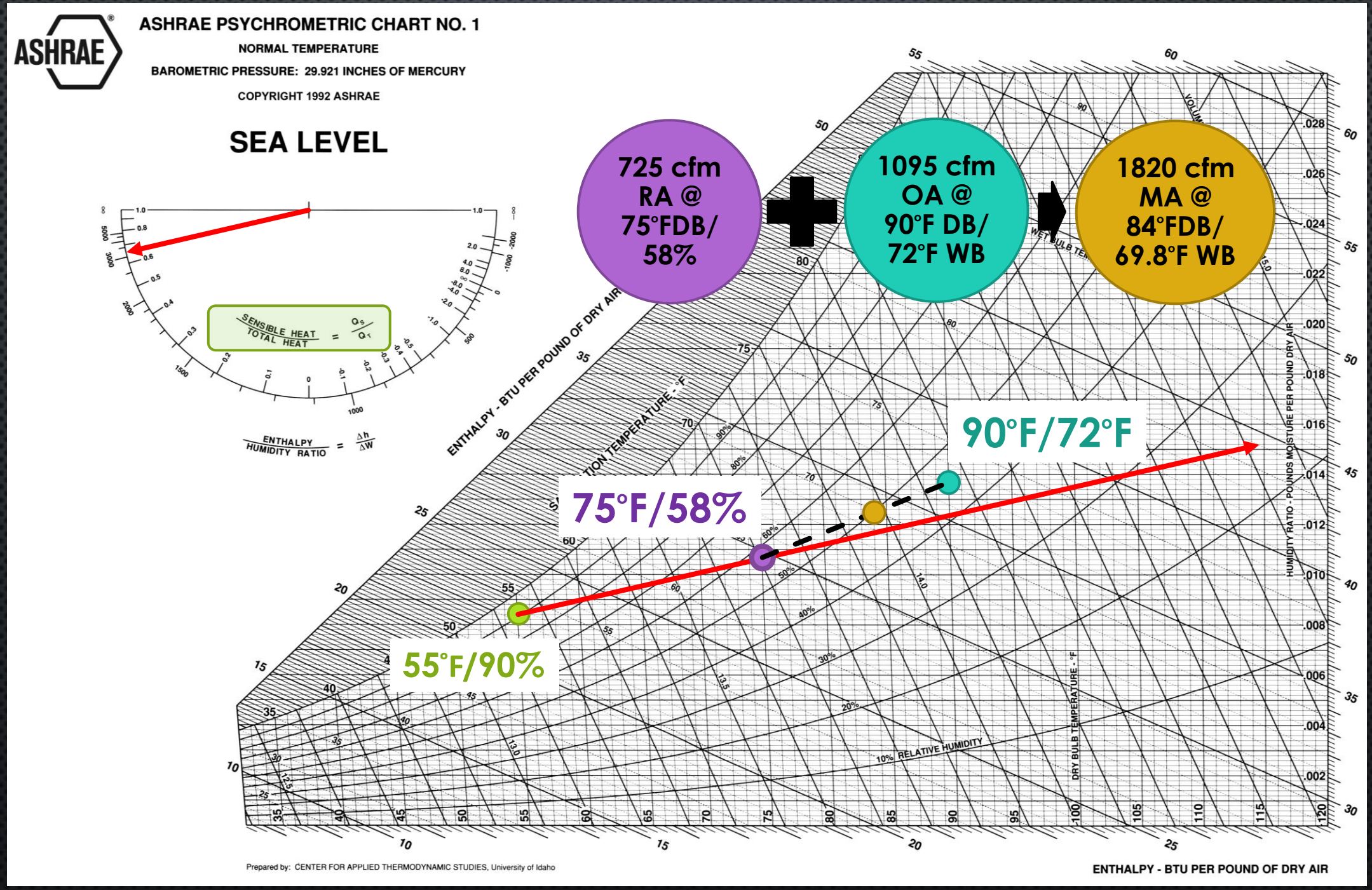
REQUIRED UNIT / COIL CAPACITY

- Room load is only one element – also dependent on ventilation
- Classroom with 130 people

Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density
	cfm/ person	L/s-person	cfm/ft^2	L/s-m^2	#/1000 ft^2 or #/100 m^2
Educational Facilities					
Art classroom	10	5	0.18	0.9	20
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25
Classrooms (age 9 plus)	10	5	0.12	0.6	35
Computer lab	10	5	0.12	0.6	25
Daycare sickroom	10	5	0.18	0.9	25
Daycare (through age 4)	10	5	0.18	0.9	25
Lecture classroom	7.5	3.8	0.06	0.3	65
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150
Libraries	5	2.5	0.12	0.6	10
Media center	10	5	0.12	0.6	25
Multiuse assembly	7.5	3.8	0.06	0.3	100
Music/theater/dance	10	5	0.06	0.3	35
Science laboratories	10	5	0.18	0.9	25

(40'x50')0.06cfm/ft^2
\+ (130 people)7.5cfm/person
1095 cfm outdoor air


ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
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SEA LEVEL
725 cfm RA @ 75°FDB/ 58%
1095 cfm OA @ 90°F DB/ 72°F WB
1820 cfm MA @ 84°FDB/ 69.8°F WB
90°F/72°F
75°F/58%
55°F/90%
SENSIBLE HEAT / TOTAL HEAT = Qs/Qt
ENTHALPY / HUMIDITY RATIO = Δh/ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
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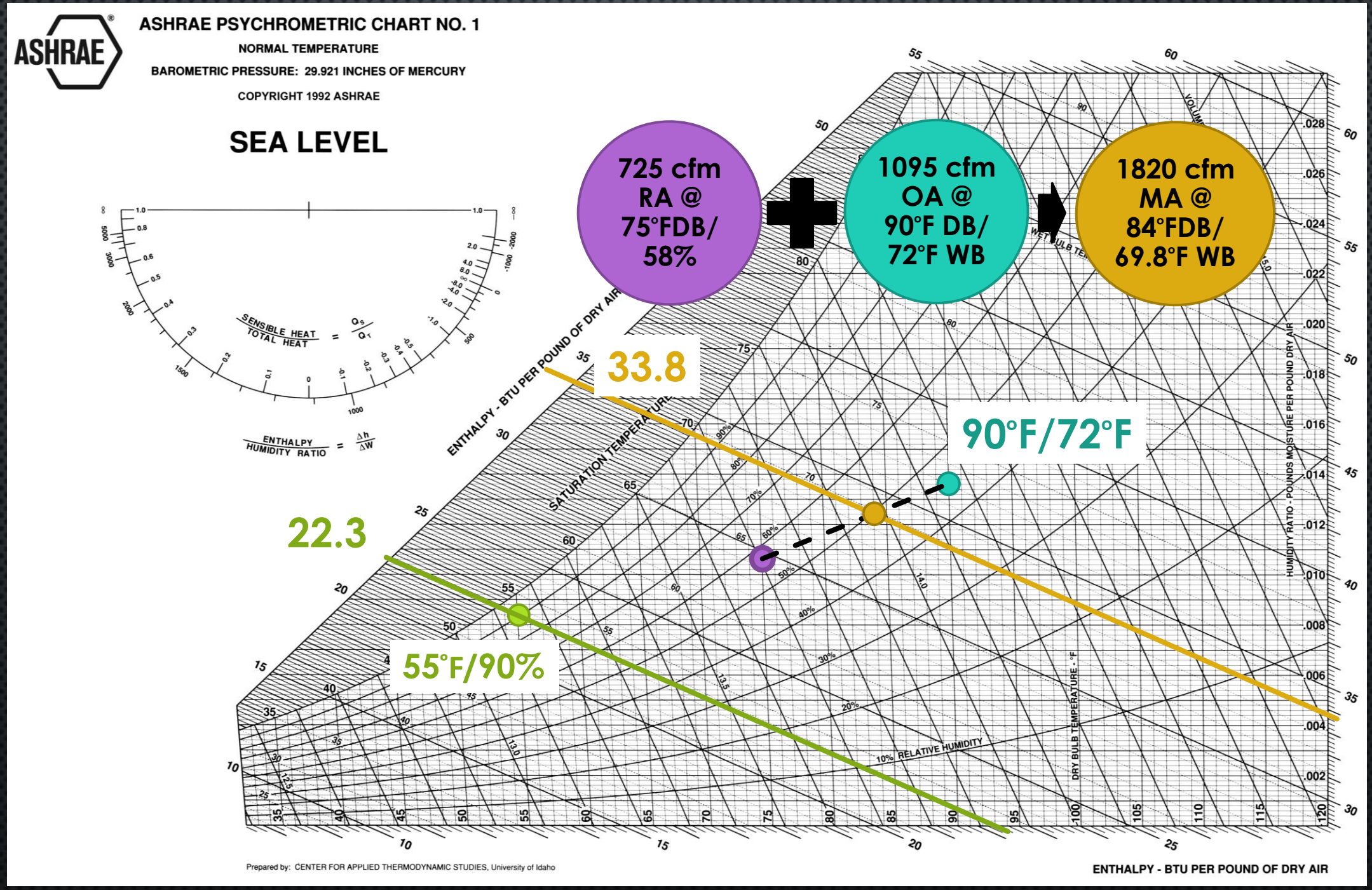
COIL LOAD (UNIT CAPACITY)

- $Q_T = 4.5 \text{ cfm } \Delta h$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33.8
22.3
90°F/72°F
55°F/90%
SENSIBLE HEAT / TOTAL HEAT = qs/qt
ENTHALPY / HUMIDITY RATIO = Δh/ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
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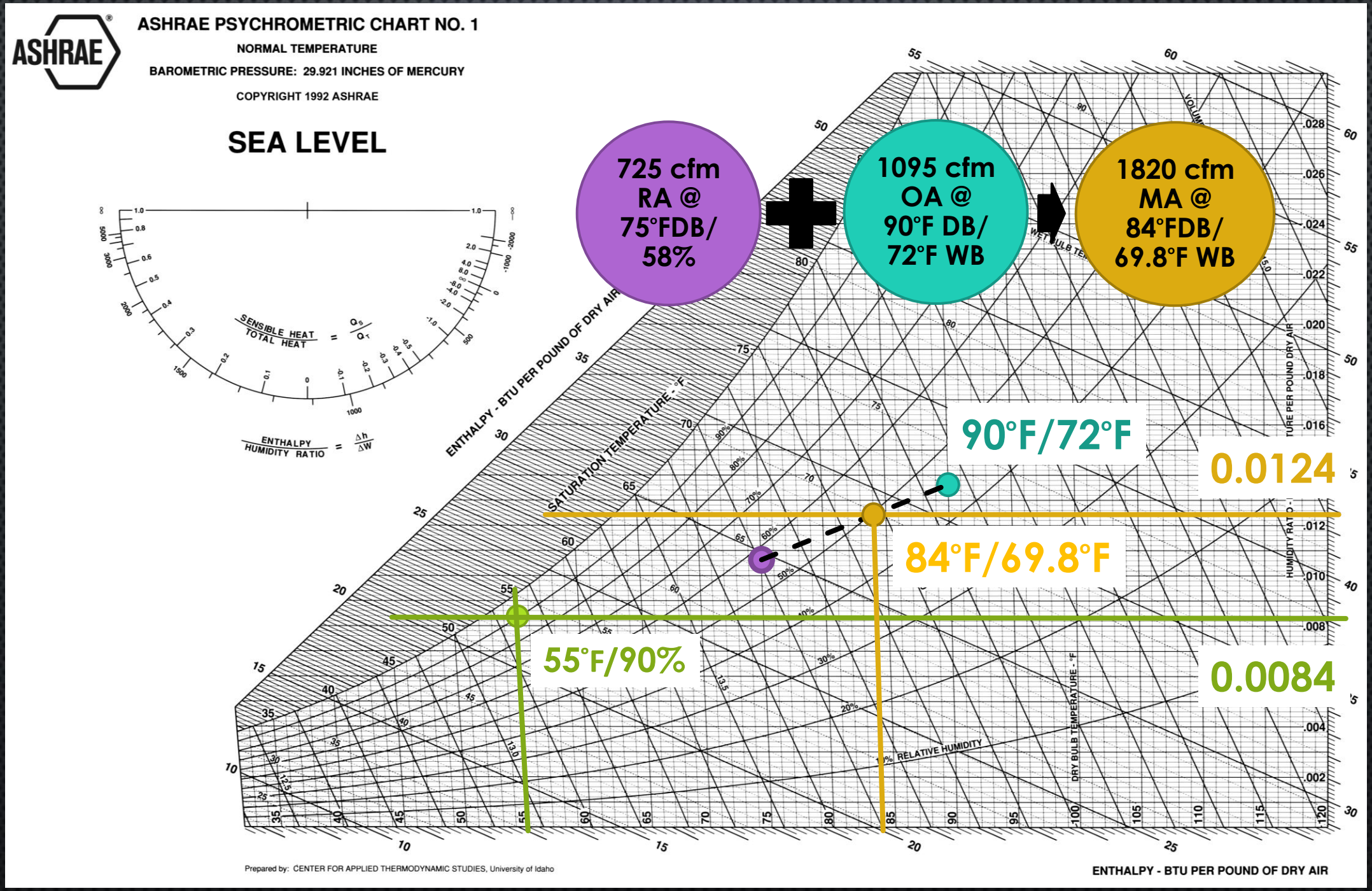
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR

COIL LOAD (UNIT CAPACITY)

- Q_T= 4.5 cfm Δh

  = 4.5 (1820)(33.8-22.3)

  = 94,185 BTUh → 94,185 BTUh/12,000 = 7.8 tons


ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
COPYRIGHT 1992 ASHRAE
SEA LEVEL
725 cfm RA @ 75°FDB/ 58%
1095 cfm OA @ 90°F DB/ 72°F WB
1820 cfm MA @ 84°FDB/ 69.8°F WB
90°F/72°F
0.0124
84°F/69.8°F
55°F/90%
0.0084
SENSIBLE HEAT / TOTAL HEAT = qs/qt
ENTHALPY / HUMIDITY RATIO = Δh/ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
% RELATIVE HUMIDITY
HUMIDITY RATIO - LB PER POUND DRY AIR
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR

COIL LOAD (UNIT CAPACITY)

- Q_T= 4.5 cfm Δh

  = 4.5 (1820)(33.8-22.3)

  = 94,185 BTUh → 94,185 BTUh/12,000 = 7.8 tons

- Q_s= 1.1 cfm ΔT

  = 1.1 (1820)(84-55)

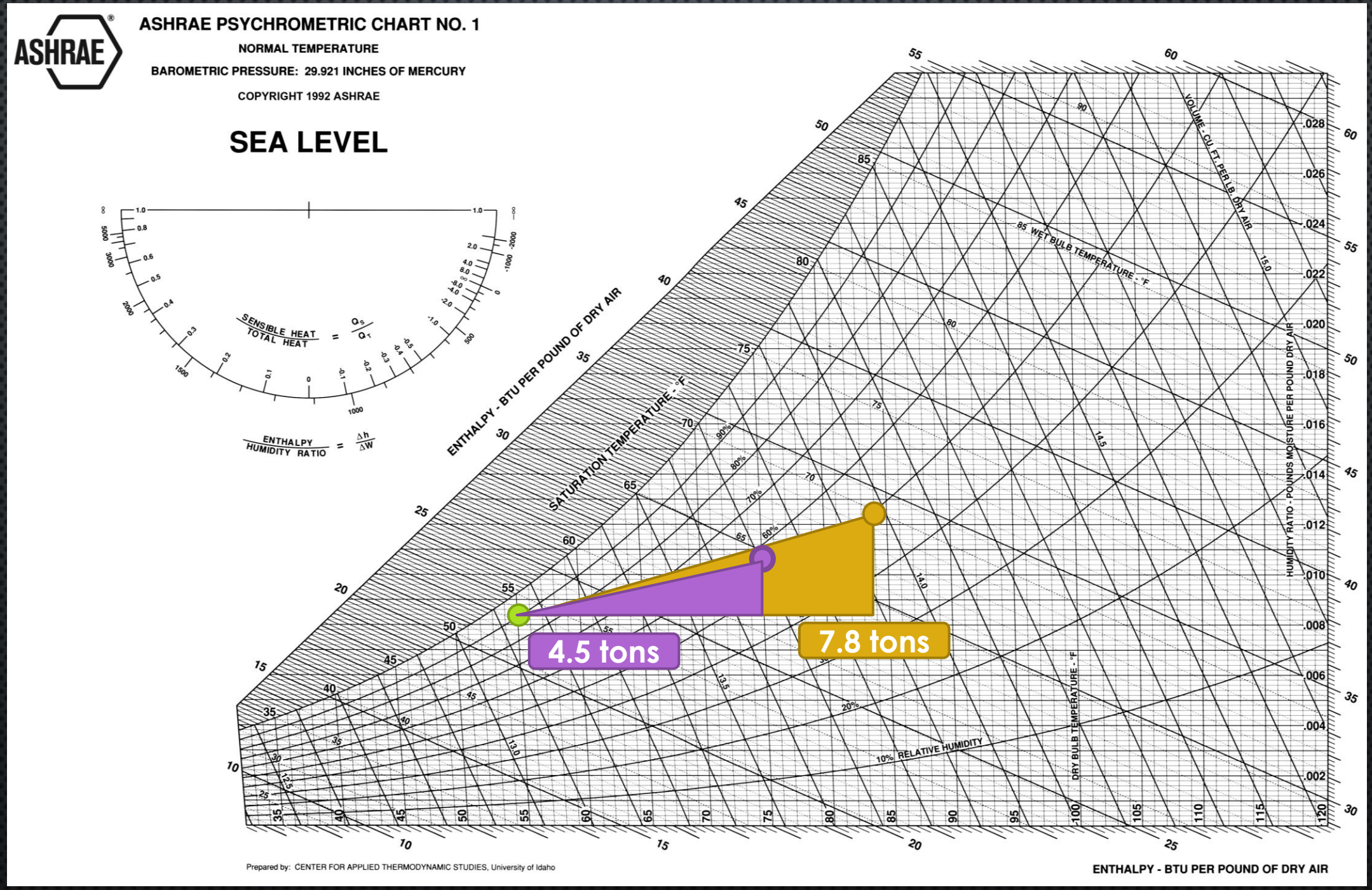
  = 58,058 BTUh

Q_L= 4840 cfm Δw

= 4840 (1820)(0.0124-0.0084)

= 35,235 BTUh

Q_T= 93,293 BTUh = 7.8 tons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NORMAL TEMPERATURE
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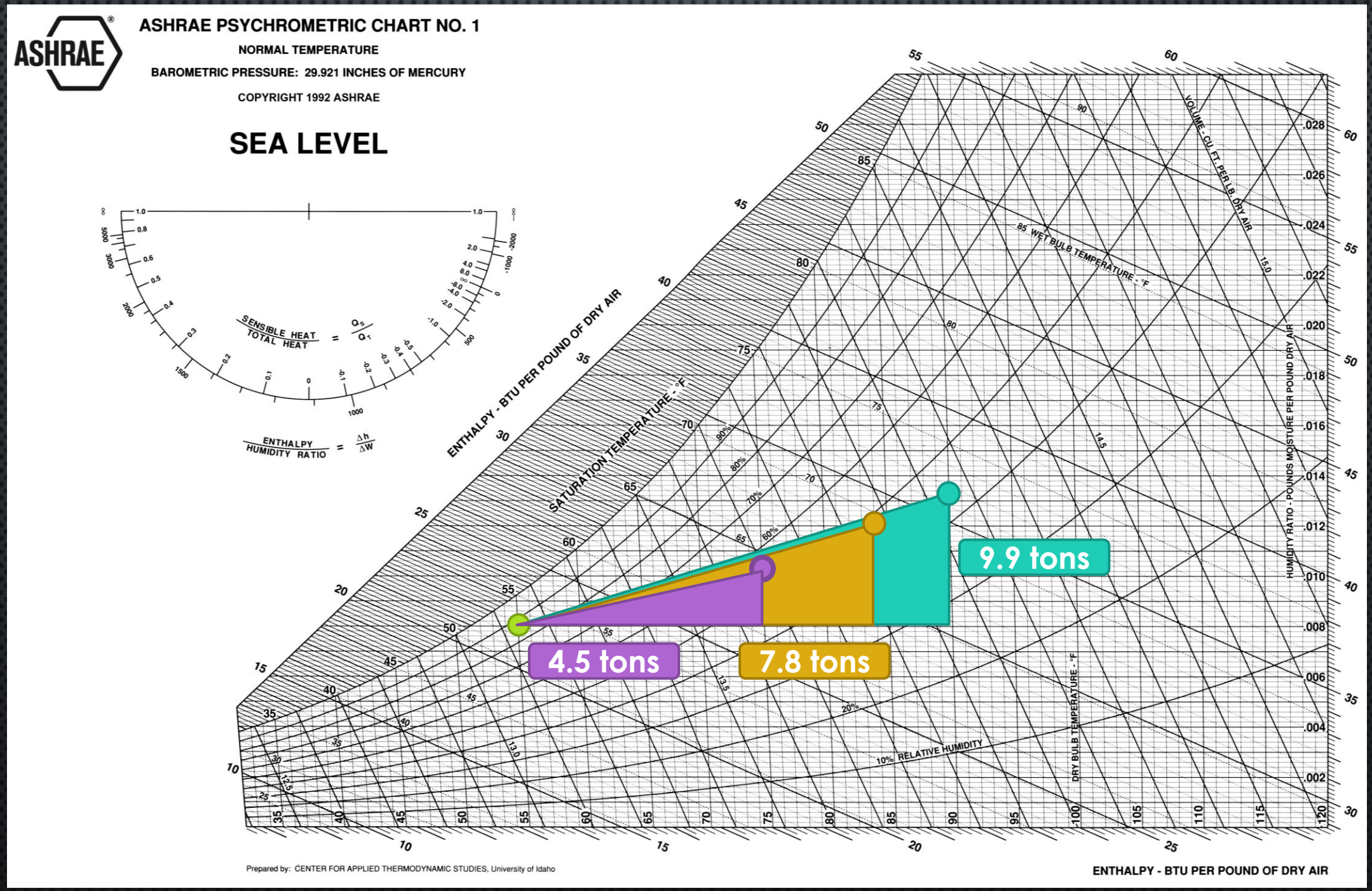
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
VOLUME - CU. FT. PER LB. DRY AIR
WET BULB TEMPERATURE - °F
RELATIVE HUMIDITY
4.5 tons
7.8 tons
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR


ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
COPYRIGHT 1992 ASHRAE
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
VOLUME - CU FT PER LB. DRY AIR
WET BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
9.9 tons
7.8 tons
4.5 tons
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR

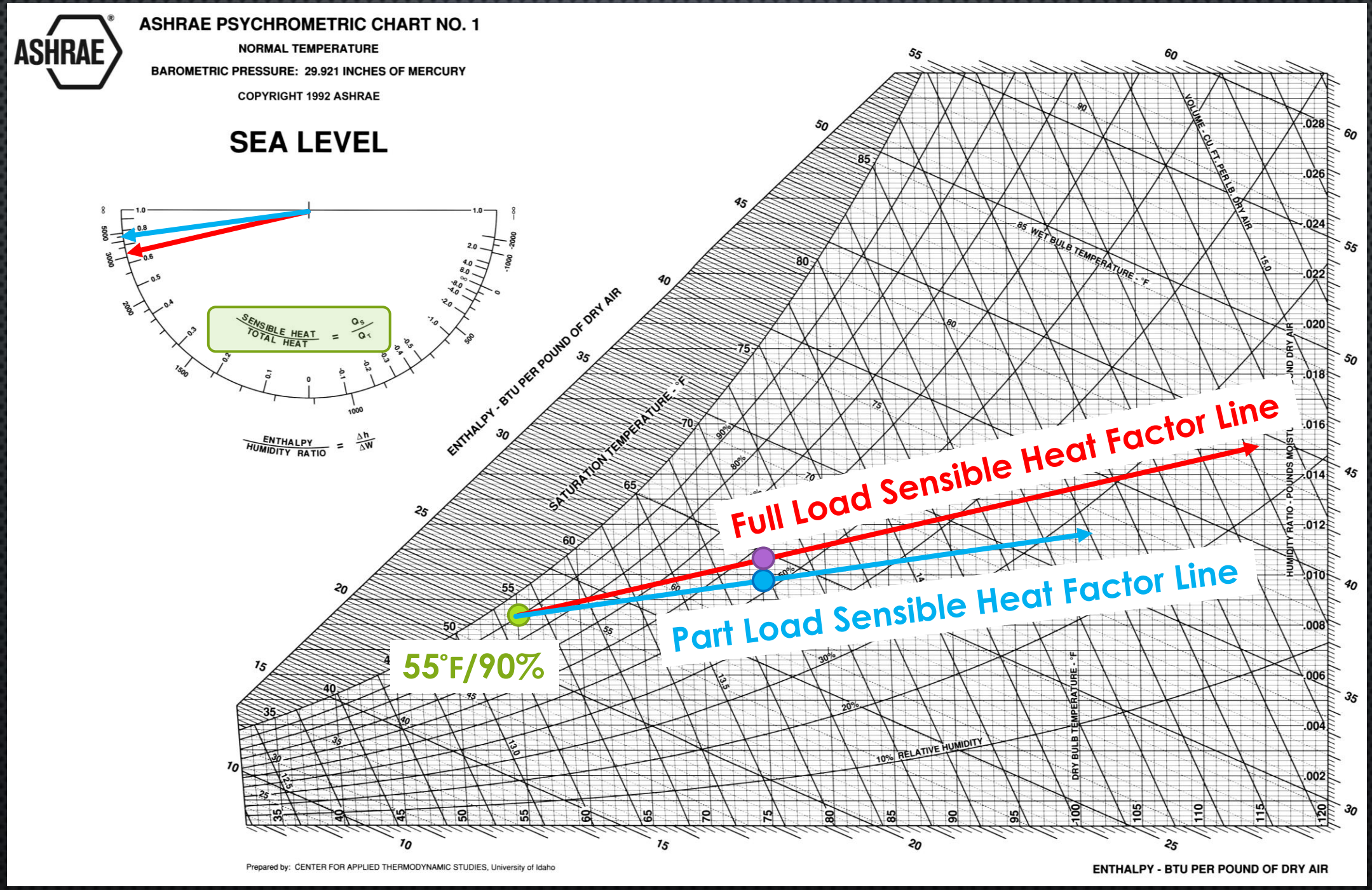
SMALL CLASS SIZE

- 40'x50' classroom (design peak → part load) :
  - Envelope = 6,500 BTUh
  - Equipment & Lights = 1,700 BTUh
  - People = 245 BTUh/person x 130 people = 31,850 BTUh Sensible
    245 BTUh/person x 30 people = 7,350 BTUh Sensible

    155 BTUh/person x 130 people = 20,150 BTUh Latent
    155 BTUh/person x 30 people = 4,650 BTUh Latent

SPACE LOAD AND SPACE CONDITIONS

- Sensible Load: 40,050 BTUh 15,550 BTUh
- Latent Load: 20,150 BTUh 4,650 BTUh
- Total Load: 60,200 BTUh 20,200 BTUh
- Sensible Heat Ratio: q_S/q_T = 40,050/60,200 = 0.665
  15,550/20,200 = 0.77


ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
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SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
VOLUME - CU. FT. PER LB. DRY AIR
85 WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
Full Load Sensible Heat Factor Line
Part Load Sensible Heat Factor Line
55°F/90%
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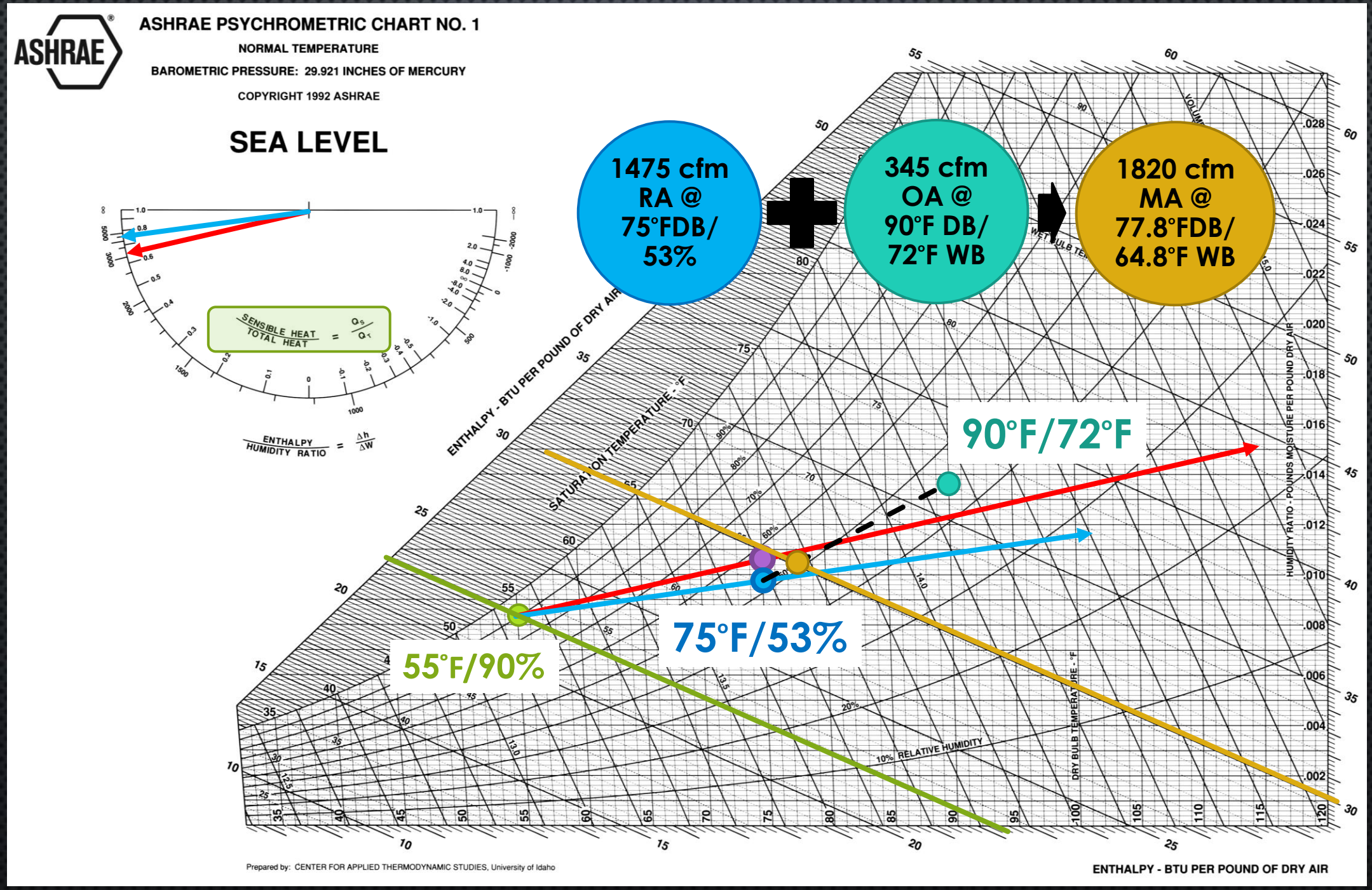
ENTHALPY - BTU PER POUND OF DRY AIR

Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density
	cfm/ person	L/s-person	cfm/ft^2	L/s-m^2	#/1000 ft^2 or #/100 m^2
Educational Facilities					
Art classroom	10	5	0.18	0.9	20
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25
Classrooms (age 9 plus)	10	5	0.12	0.6	35
Computer lab	10	5	0.12	0.6	25
Daycare sickroom	10	5	0.18	0.9	25
Daycare (through age 4)	10	5	0.18	0.9	25
Lecture classroom	7.5	3.8	0.06	0.3	65
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150
Libraries	5	2.5	0.12	0.6	10
Media center	10	5	0.12	0.6	25
Multiuse assembly	7.5	3.8	0.06	0.3	100
Music/theater/dance	10	5	0.06	0.3	35
Science laboratories	10	5	0.18	0.9	25

$$+\ \frac{(40'\text{x}50')0.06\text{cfm/ft}^2 + (30\text{ people})7.5\text{cfm/person}}{345\text{cfm outdoor air}}$$


ASHRAE PSYCHROMETRIC CHART NO. 1
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345 cfm OA @ 90°F DB/ 72°F WB
1820 cfm MA @ 77.8°FDB/ 64.8°F WB
90°F/72°F
75°F/53%
55°F/90%
SENSIBLE HEAT / TOTAL HEAT = Qs/Qt
ENTHALPY / HUMIDITY RATIO = Δh/ΔW
ENTHALPY - BTU PER POUND OF DRY AIR
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
SATURATION TEMPERATURE - °F
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR

REDUCED COIL LOAD

- Q_T= 4.5 cfm Δh

  = 4.5 (1820)(29.7-22.3)

  = 60,606 BTUh → 60,606 BTUh/12,000 = 5.1 tons

- Q_s= 1.1 cfm ΔT

  = 1.1 (1820)(77.8-55)

  = 45,645 BTUh

Q_L= 4840 cfm Δw

= 4840 (1820)(0.0102-0.0084)

= 15,856 BTUh

Q_T= 61,500 BTUh = 5.1 tons

UNIT SIZE IMPACT ON PERFORMANCE

- UNIT CAPACITY SELECTED @ PEAK = 8 TONS
- ONLY NEED 5 TONS WITH FEWER PEOPLE

This is GREAT!!!!

We have plenty of capacity

UNIT SIZE IMPACT ON PERFORMANCE

- Unit Capacity Selected @ Peak = 8 tons
- Only need 5 tons with fewer people

BUT….WAIT
What happens when you provide 8 tons of cooling to a space that only need 5 tons?

UNIT SIZE IMPACT ON PERFORMANCE

- UNIT CAPACITY SELECTED @ PEAK = 8 TONS
- ONLY NEED 5 TONS WITH FEWER PEOPLE

BUT….WAIT
What happens when you provide 8 tons of cooling to a space that only need 5 tons?

UNIT SIZE IMPACT ON PERFORMANCE

- Unit Capacity Selected @ Peak = 8 tons
- A **SIGNIFICANT** portion of the time the full 8 tons is not needed
  - Less people
  - Lower OA temperatures
  - Less solar load
  - Not all equipment/Lights on

UNIT SIZE IMPACT ON PERFORMANCE

- Unit Capacity Selected @ Peak = 8 tons
- A **SIGNIFICANT** portion of the time the full 8 tons is not needed
  - Less people
  - Lower OA temperatures
  - Less solar load
  - Not all equipment/Lights on

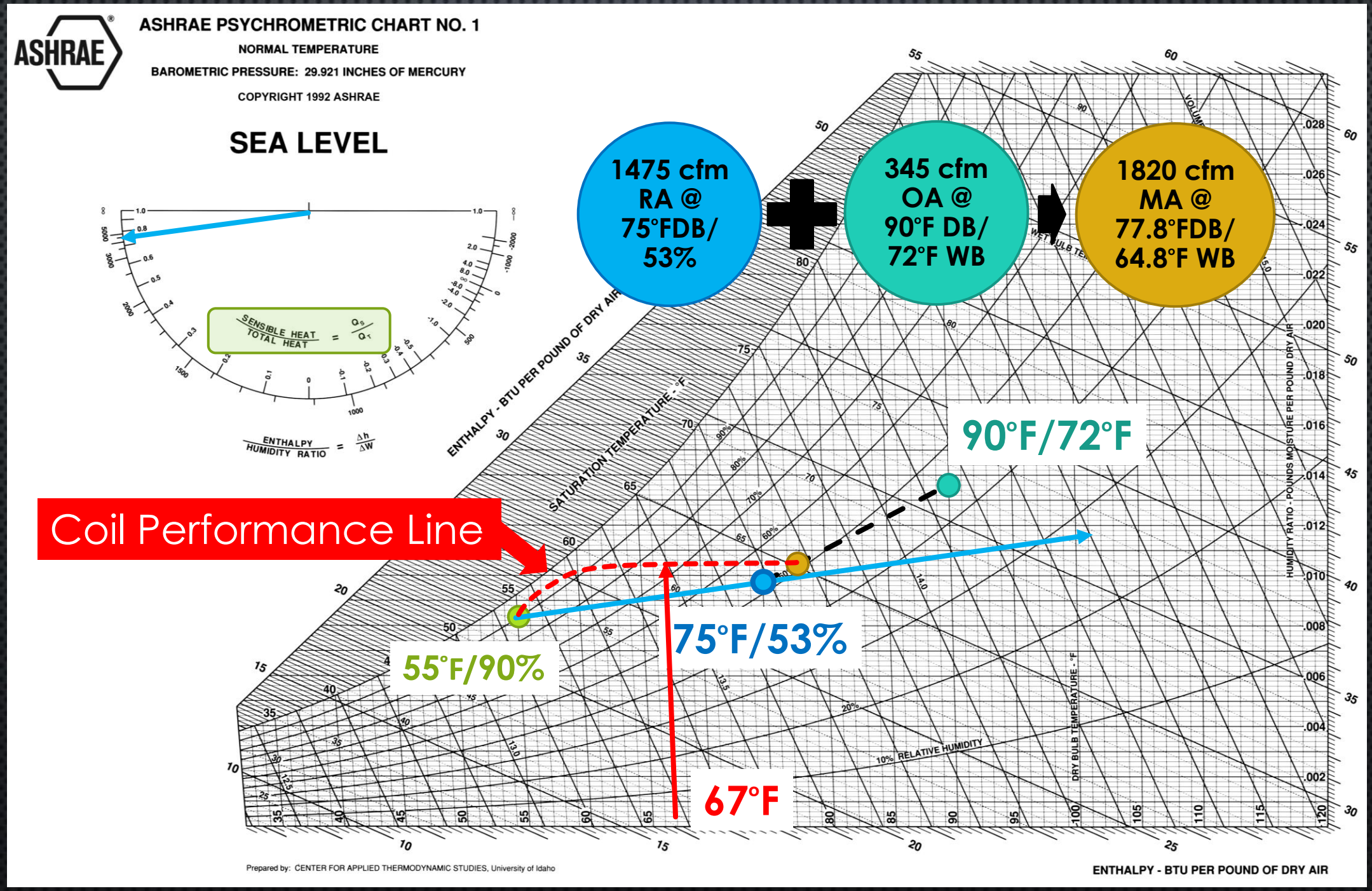
WHAT CAN WE DO?

UNIT SIZE IMPACT ON PERFORMANCE

$$q_s = 1.1\ CFM\ \Delta T$$

- Peak Load: 40,050 = 1.1 CFM (75-55) → 1820 cfm
- Reduced Sensible Load: 15,550 BTUh (fewer people)
- Reduced load, change ΔT or change airflow?

Option 1: Keep air flow = 1820 cfm; **Increase SA temp to 67˚F**


ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 29.921 INCHES OF MERCURY
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SEA LEVEL
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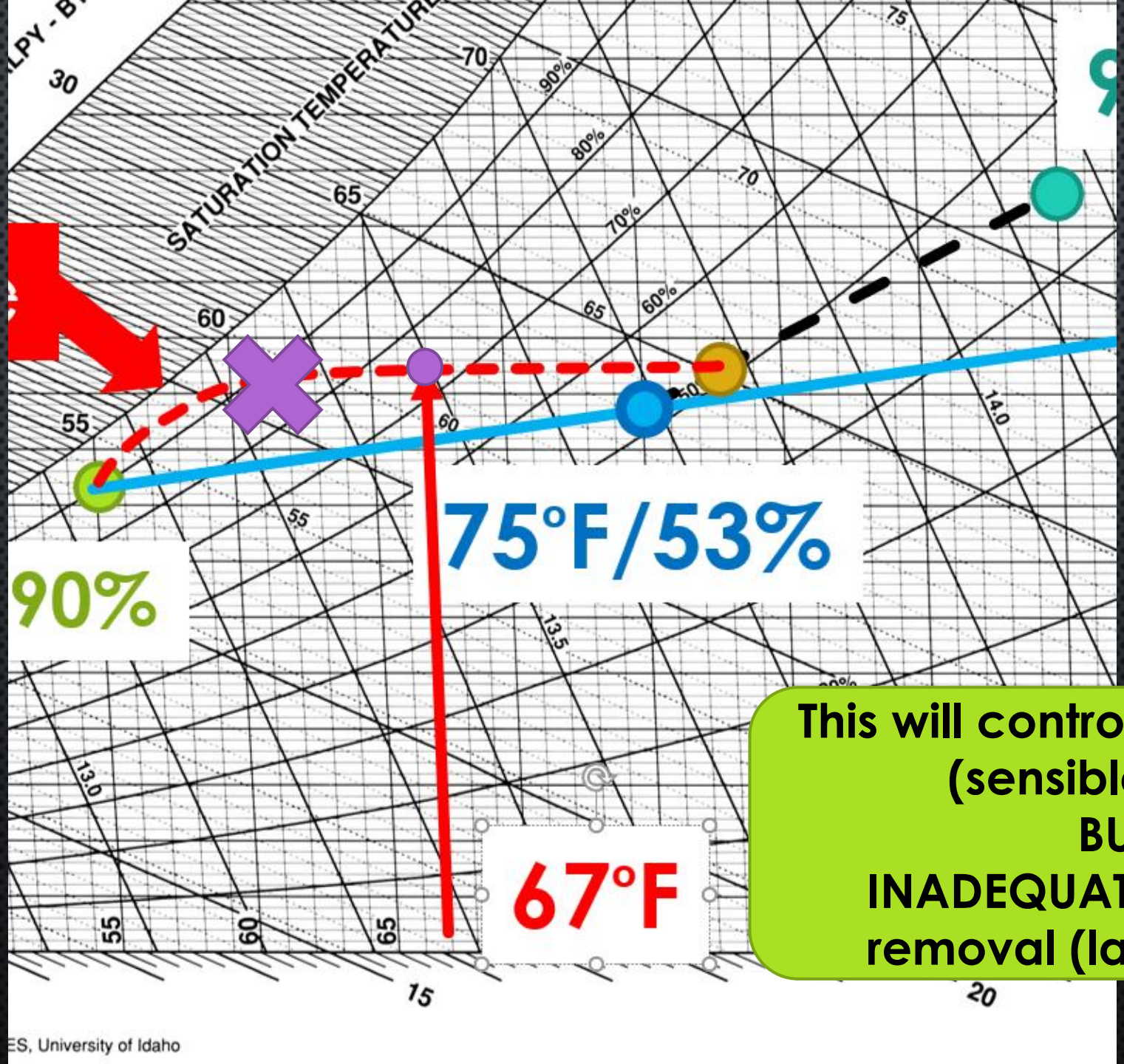
1475 cfm RA @ 75°FDB/ 53%
345 cfm OA @ 90°F DB/ 72°F WB
1820 cfm MA @ 77.8°FDB/ 64.8°F WB
90°F/72°F
75°F/53%
55°F/90%
67°F
Coil Performance Line
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR


SATURATION TEMPERATURE
75°F/53%
90%
67°F
This will control temperature (sensible load)
BUT
INADEQUATE moisture removal (latent load)!
ES, University of Idaho

UNIT SIZE IMPACT ON PERFORMANCE

$$q_s = 1.1\ CFM\ \Delta T$$

- Peak Load: 40,050 = 1.1 CFM (75-55) → 1820 cfm
- Reduced Sensible Load: 15,550 BTUh (fewer people)
- Reduced load, change ΔT or change airflow?

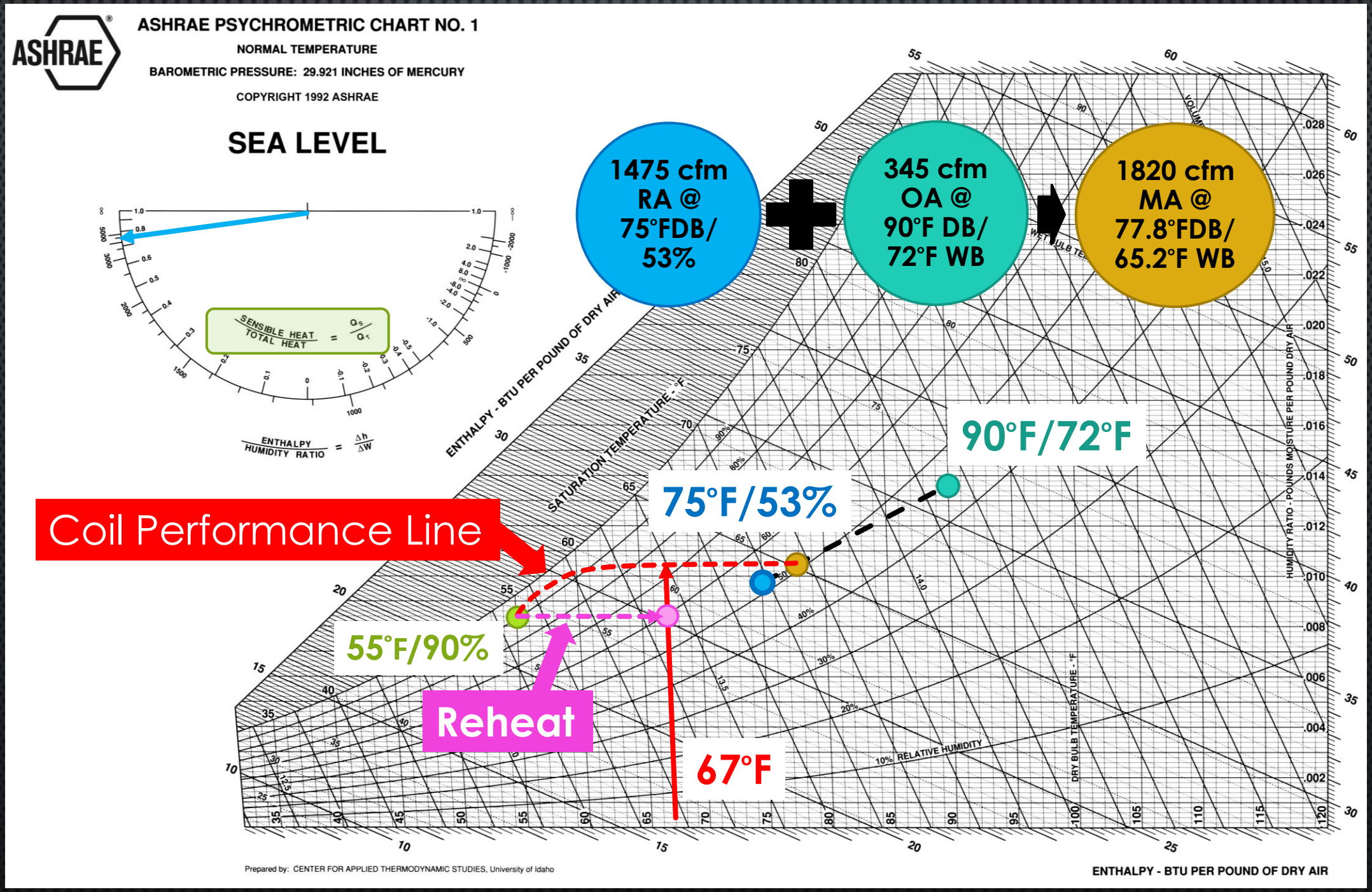
  Option 1: Keep air flow = 1820 cfm; **Increase SA temp to 67˚F**

  Option 2: Keep ΔT = 20˚F; **Reduce airflow = 705 cfm**

Need to ensure adequate ventilation & space pressure

SOLUTIONS

- Depends on the System Type, Application, and Priorities
  - Reheat
    - Use when the air volume cannot be altered
    - Best if waste heat is used
    - Potential for increased fan & reheat energy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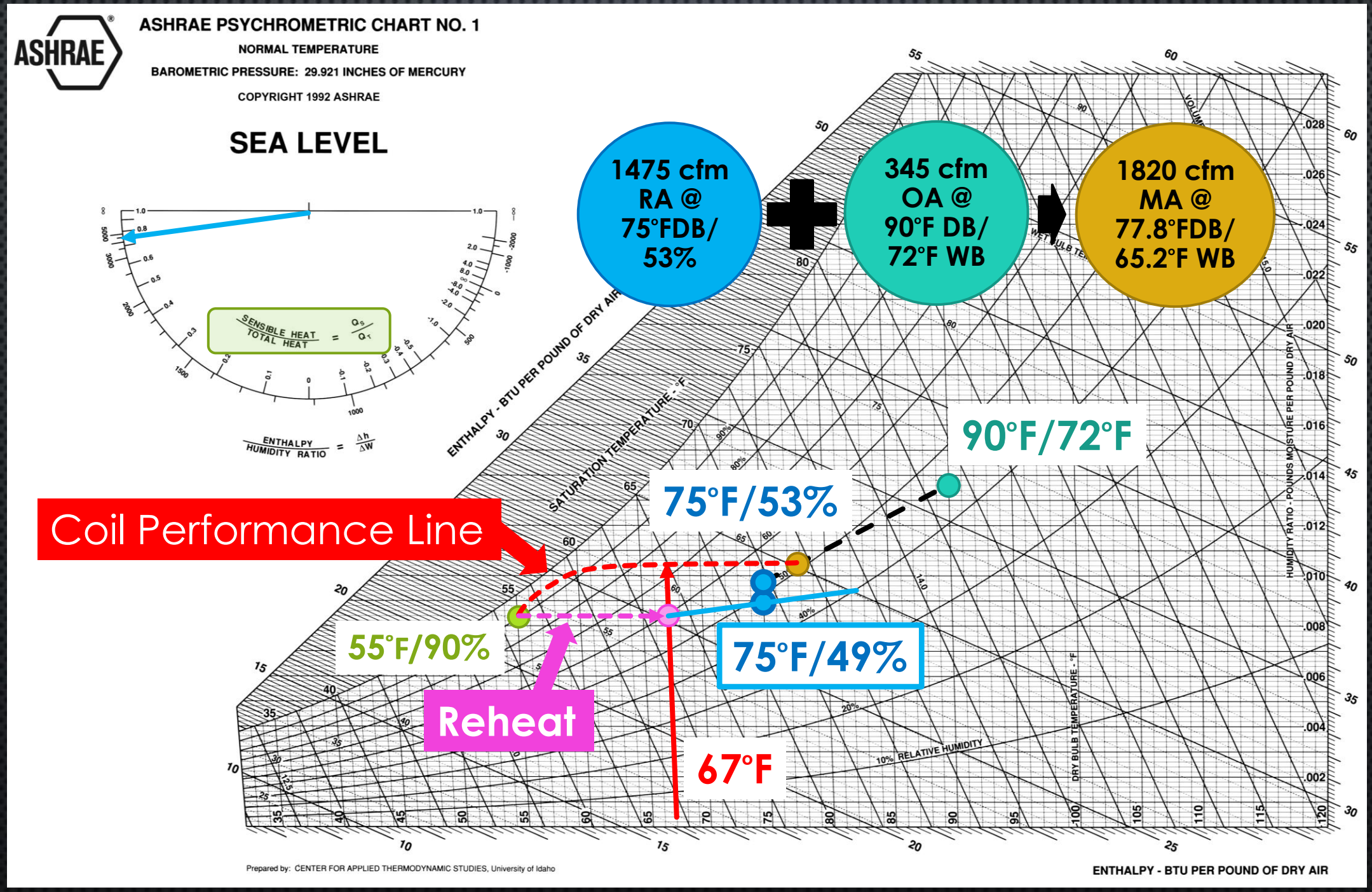
1820 cfm MA @ 77.8°FDB/ 65.2°F WB
90°F/72°F
75°F/53%
Coil Performance Line
55°F/90%
Reheat
67°F
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR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SEA LEVEL
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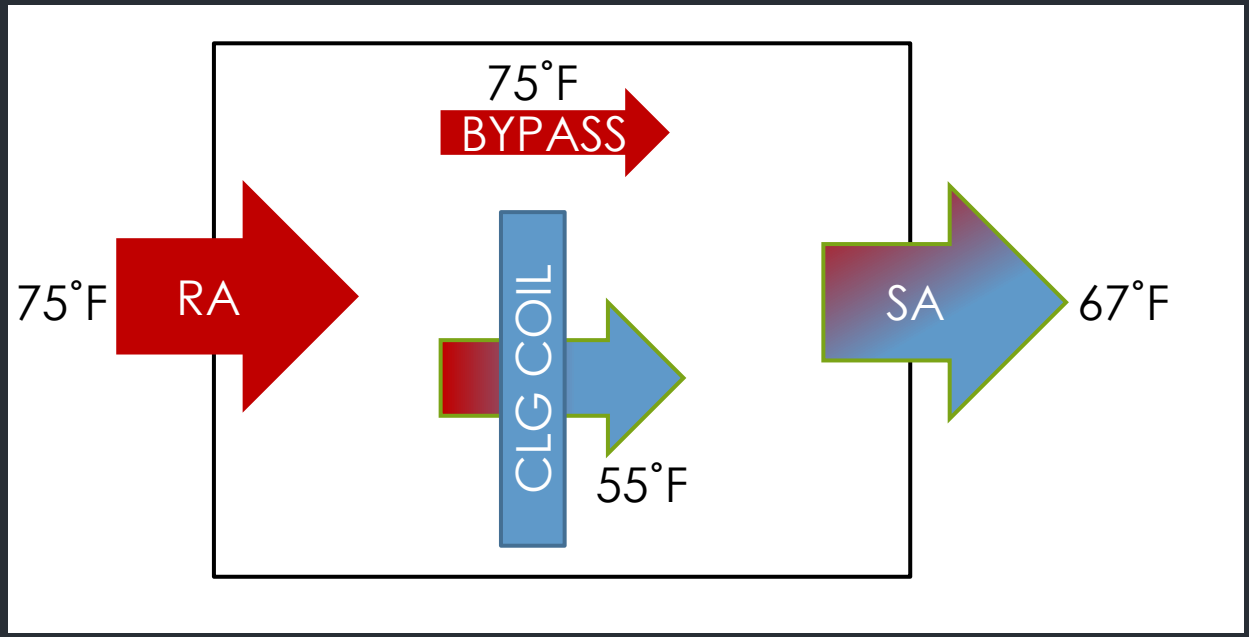
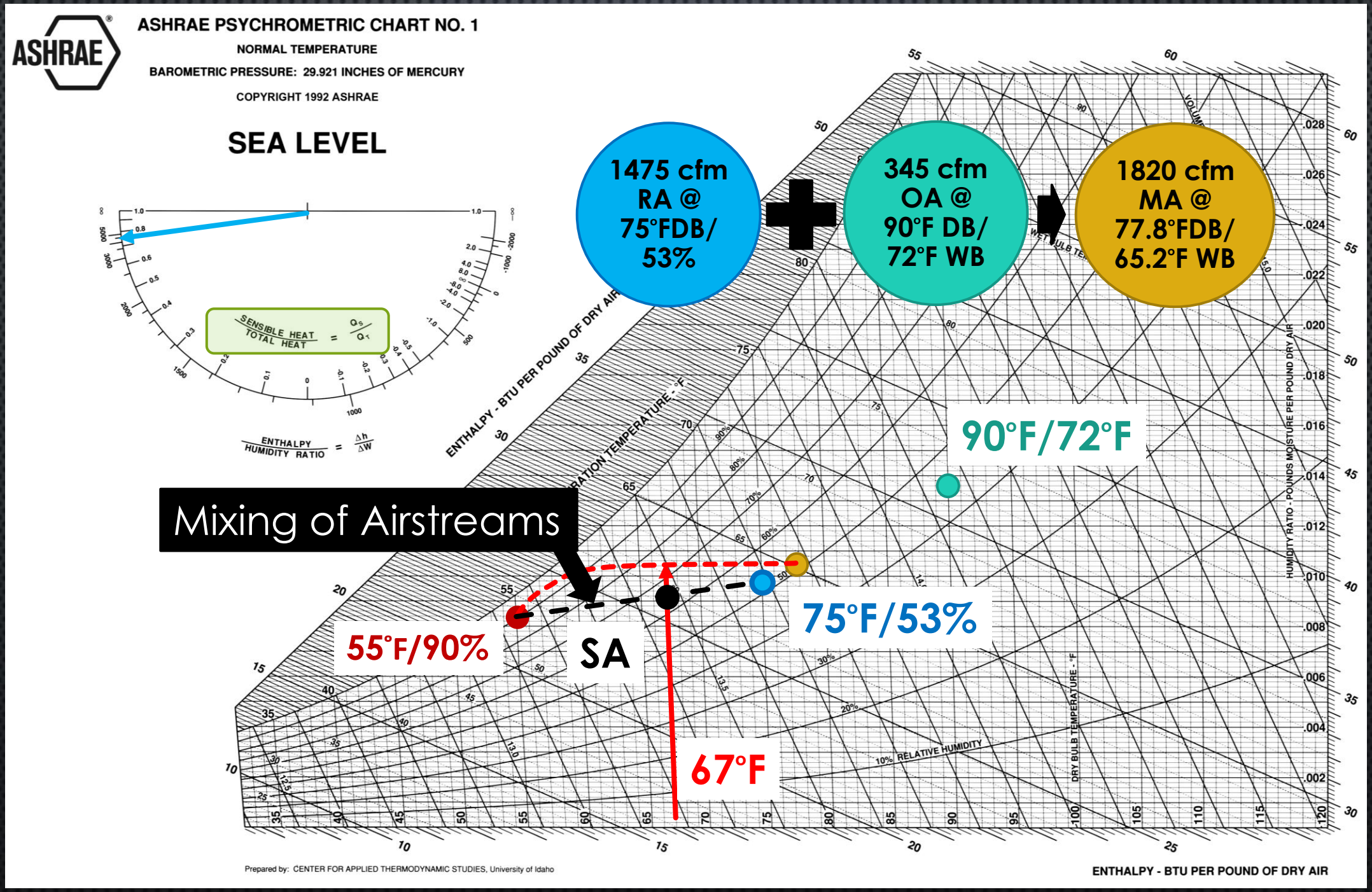
1820 cfm MA @ 77.8°FDB/ 65.2°F WB
90°F/72°F
75°F/53%
Coil Performance Line
55°F/90%
75°F/49%
Reheat
67°F
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho

SOLUTIONS

- Depends on the System Type, Application, and Priorities
  - Reheat
  - Face and bypass coils
    - Confirm unit ability
    - Maintain airflow volume

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SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Q
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
1475 cfm RA @ 75°FDB/ 53%
345 cfm OA @ 90°F DB/ 72°F WB
1820 cfm MA @ 77.8°FDB/ 65.2°F WB
90°F/72°F
Mixing of Airstreams
55°F/90%
SA
75°F/53%
67°F
ENTHALPY - BTU PER POUND OF DRY AIR
HUMIDITY RATIO - POUNDS MOISTURE PER POUND DRY AIR
DRY BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho
ENTHALPY - BTU PER POUND OF DRY AIR

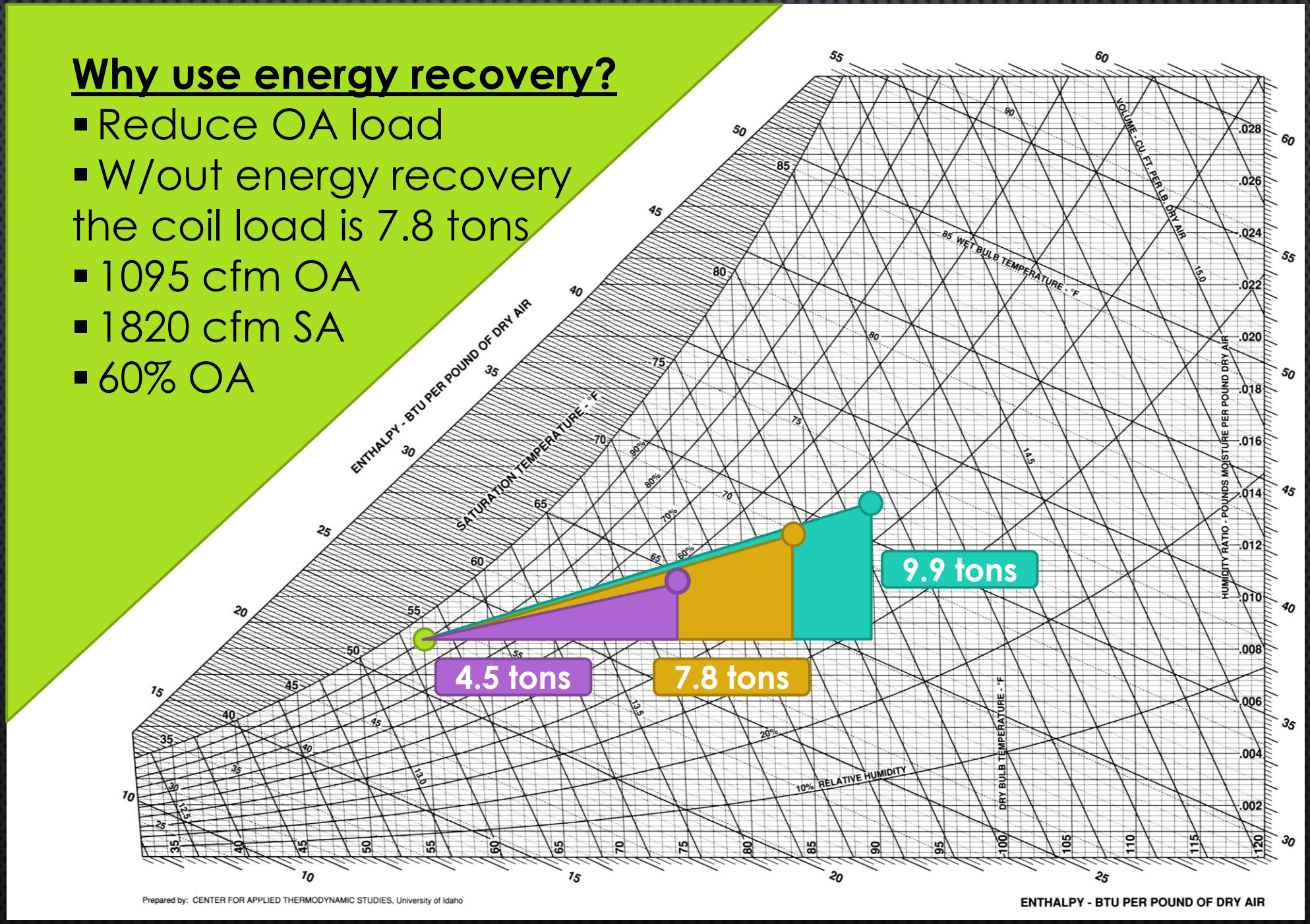
SOLUTIONS

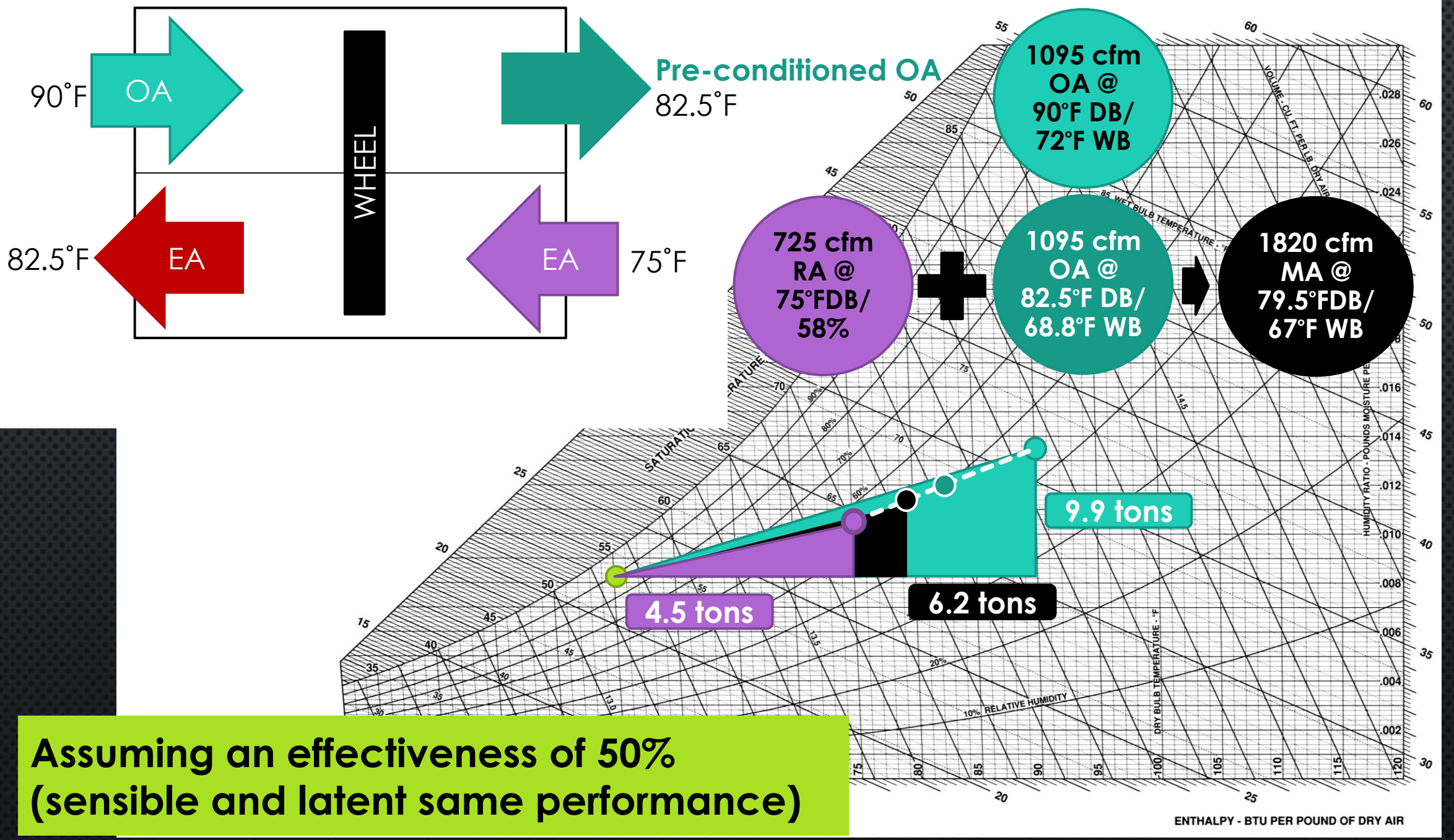
- Depends on the System Type, Application, and Priorities
  - Reheat
  - Face and bypass coils
  - Multiple units or Staged/modulating compressors

Energy Recovery

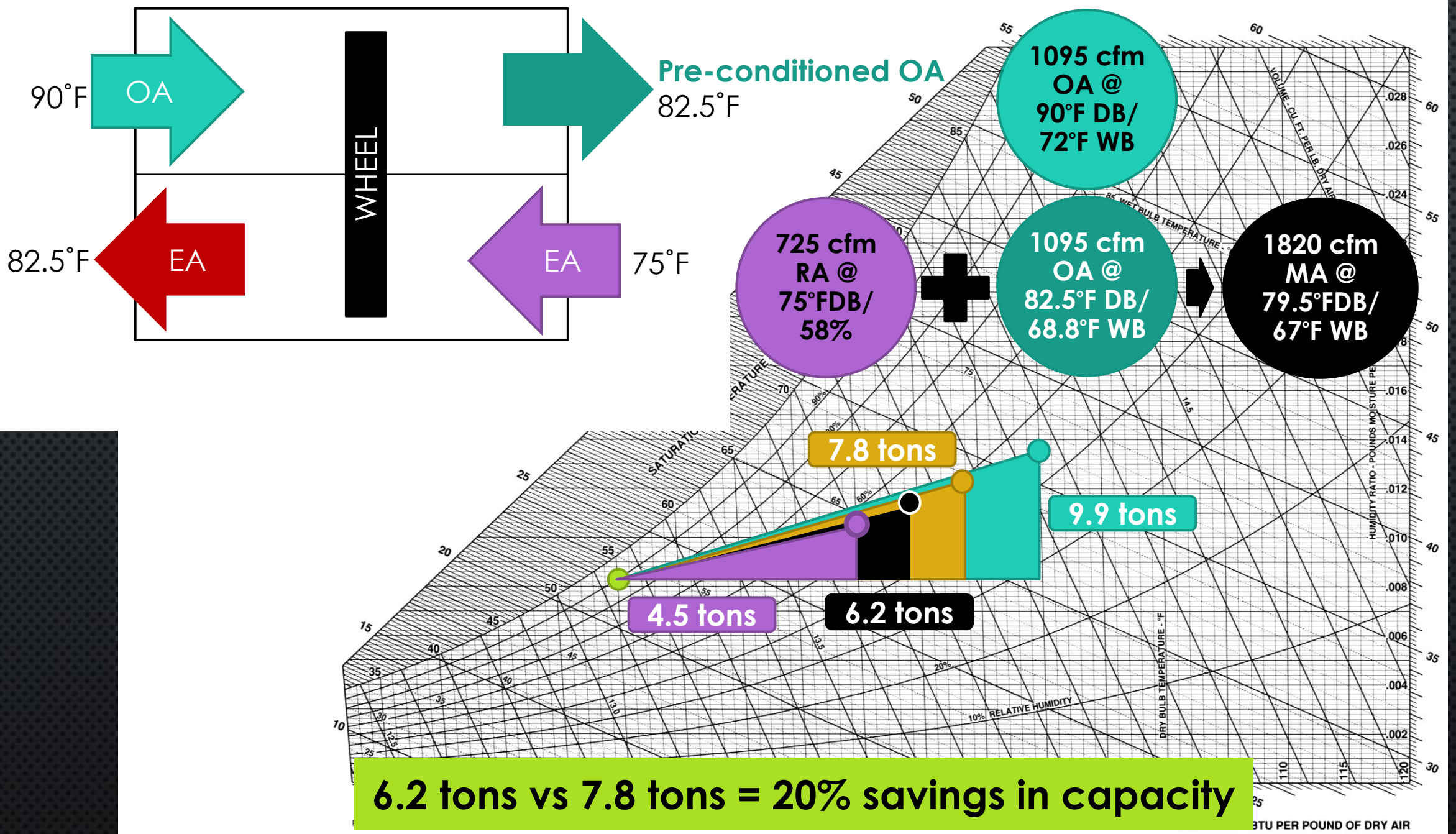
Why use energy recovery?

- Reduce OA load
- W/out energy recovery the coil load is 7.8 tons
- 1095 cfm OA
- 1820 cfm SA
- 60% OA



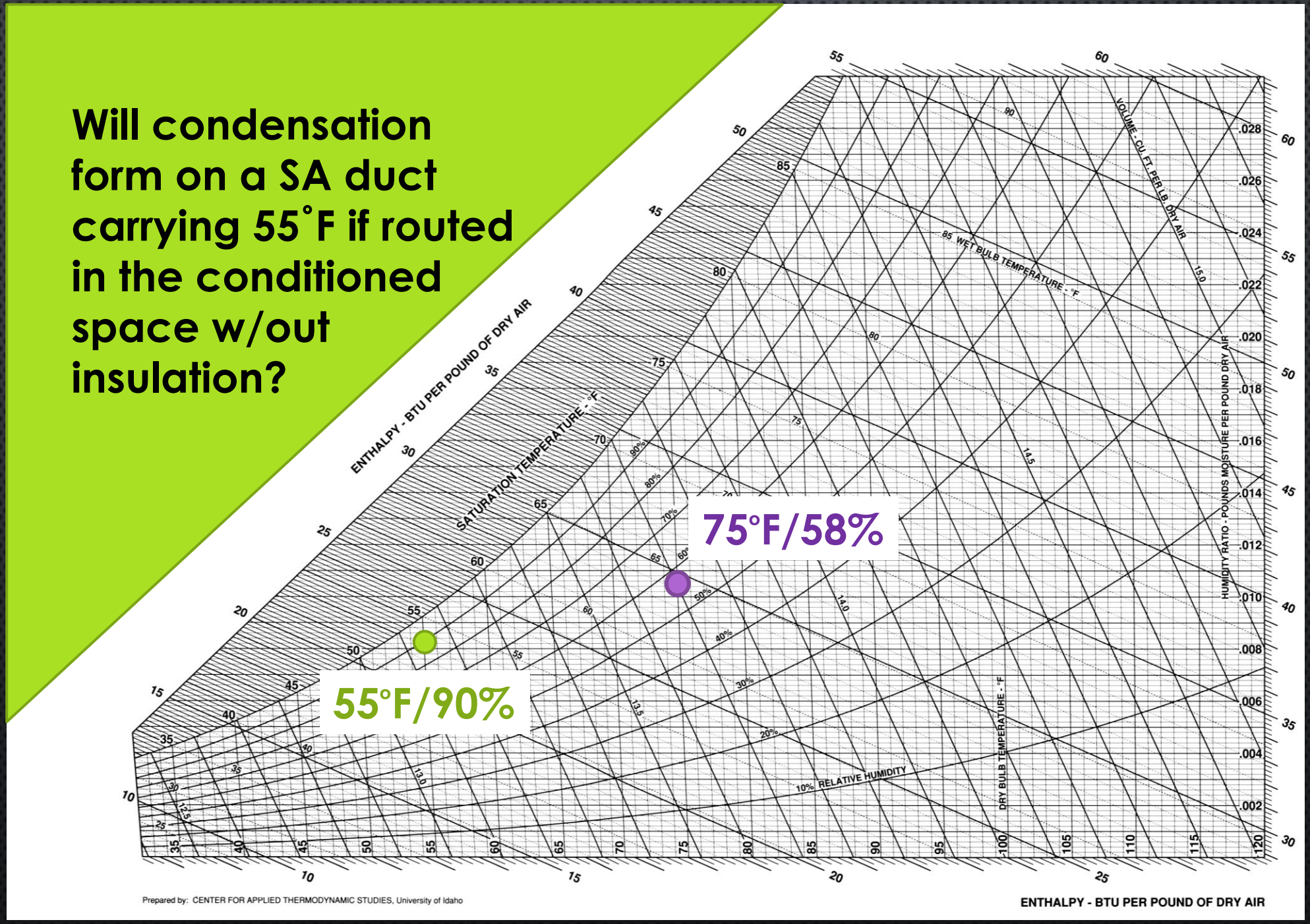


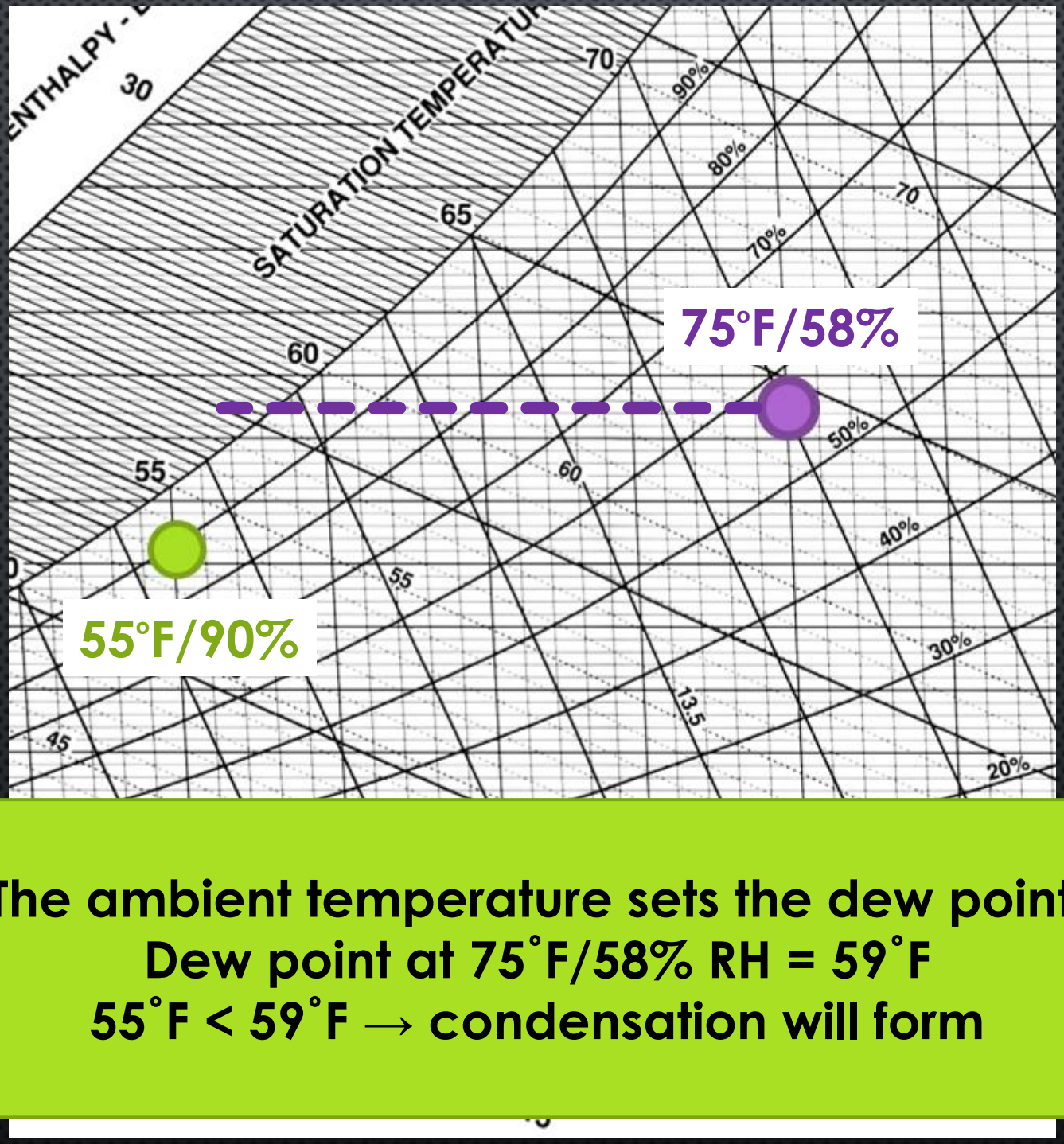
Assuming an effectiveness of 50%
(sensible and latent same performance)


90˚F
OA
WHEEL
Pre-conditioned OA
82.5˚F
82.5˚F
EA
EA
75˚F
1095 cfm
OA @
90°F DB/
72°F WB
725 cfm
RA @
75°FDB/
58%
1095 cfm
OA @
82.5°F DB/
68.8°F WB
1820 cfm
MA @
79.5°FDB/
67°F WB
7.8 tons
9.9 tons
4.5 tons
6.2 tons
6.2 tons vs 7.8 tons = 20% savings in capacity

CONDENSATION

Will condensation form on a SA duct carrying 55˚F if routed in the conditioned space w/out insulation?





The ambient temperature sets the dew point.
Dew point at 75˚F/58% RH = 59˚F
55˚F < 59˚F → condensation will form

QUESTIONS

JULIA KEEN

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