Fans, Ducts and Air Handling Systems: Design, Performance and Commissioning Issues

Dehumidification

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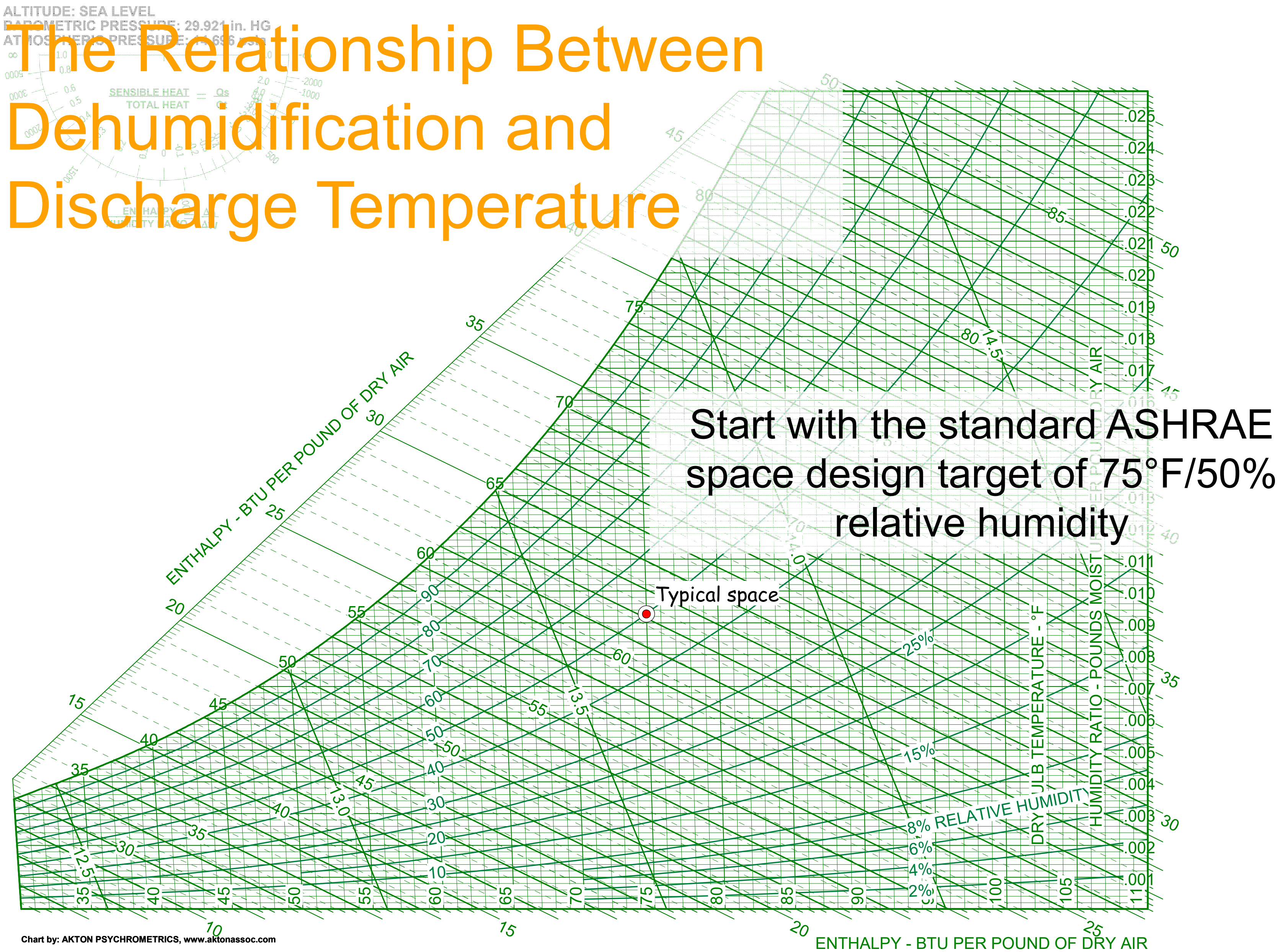
The Conventional Approach

The Relationship Between Dehumidification and Discharge Temperature

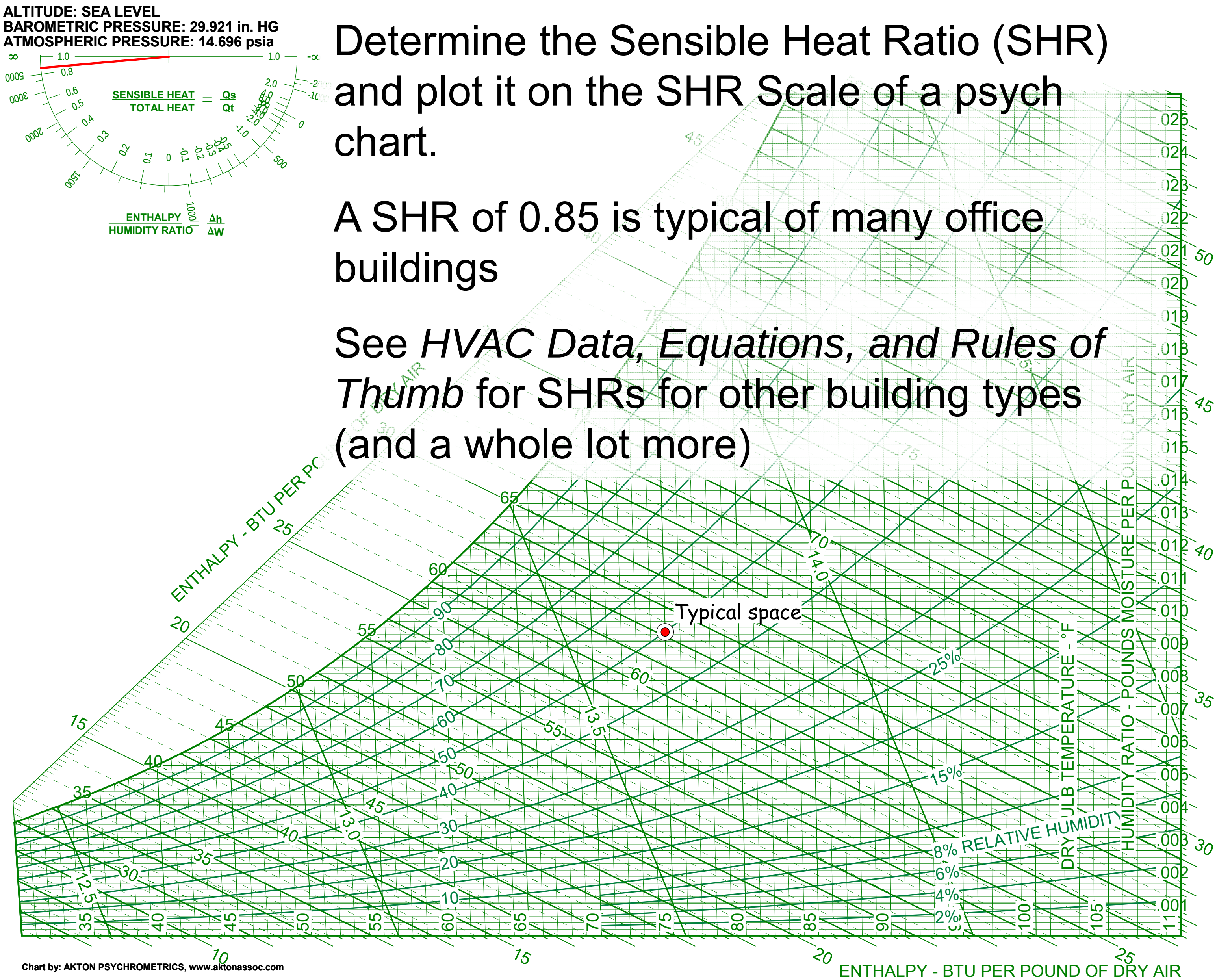


Start with the standard ASHRAE space design target of 75°F/50% relative humidity

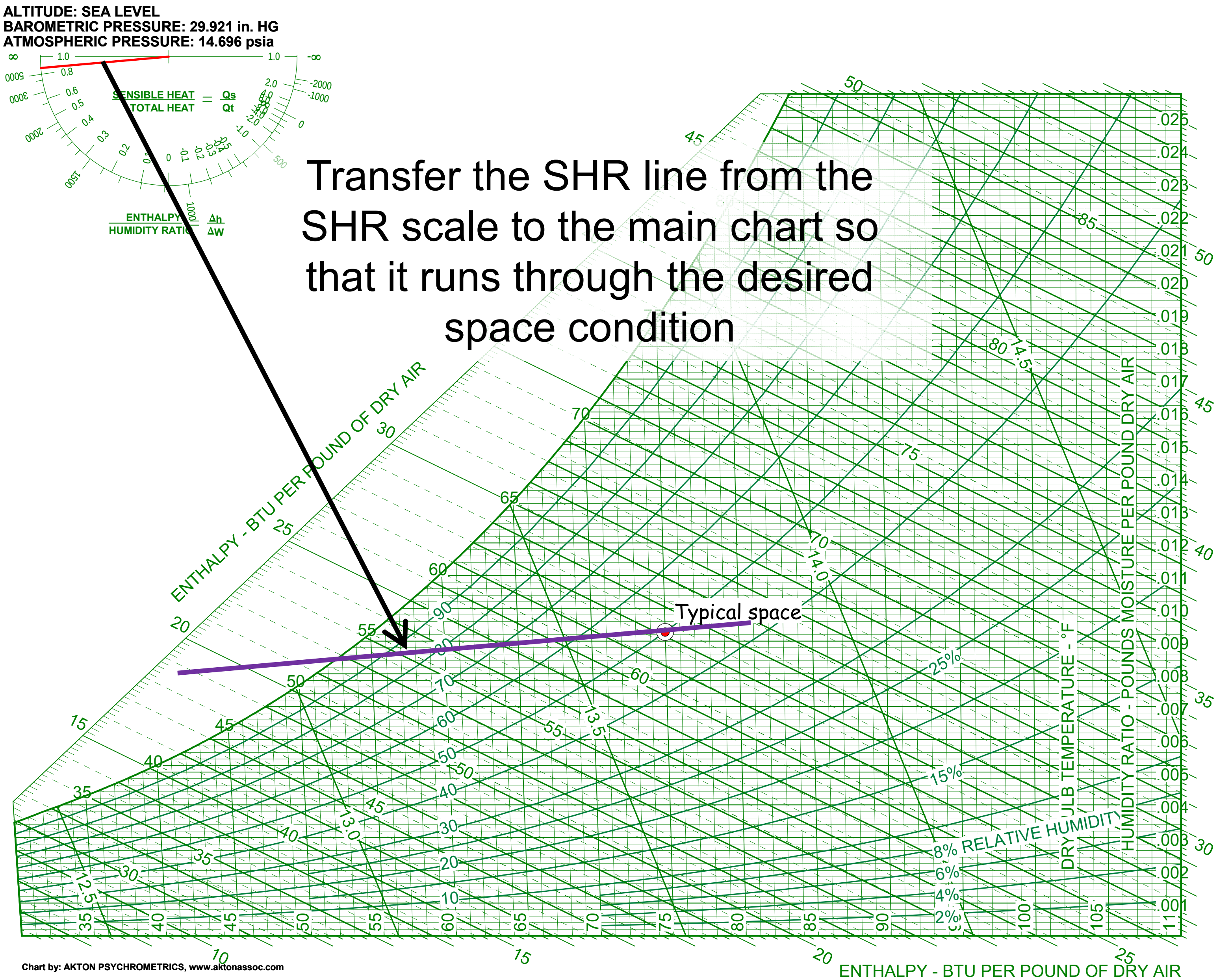
Determine the Sensible Heat Ratio (SHR) and plot it on the SHR Scale of a psych chart.

A SHR of 0.85 is typical of many office buildings

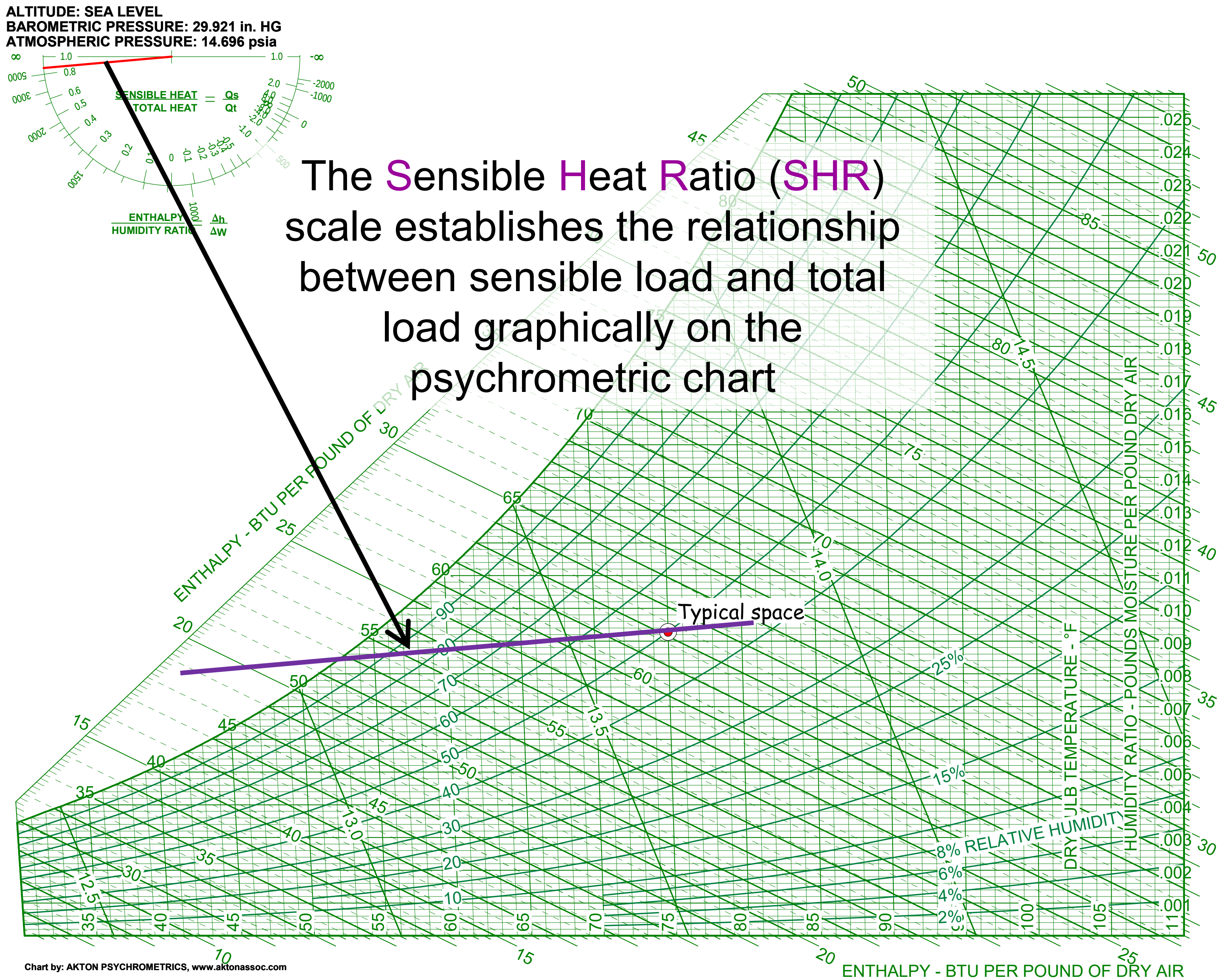
See *HVAC Data, Equations, and Rules of Thumb* for SHRs for other building types (and a whole lot more)

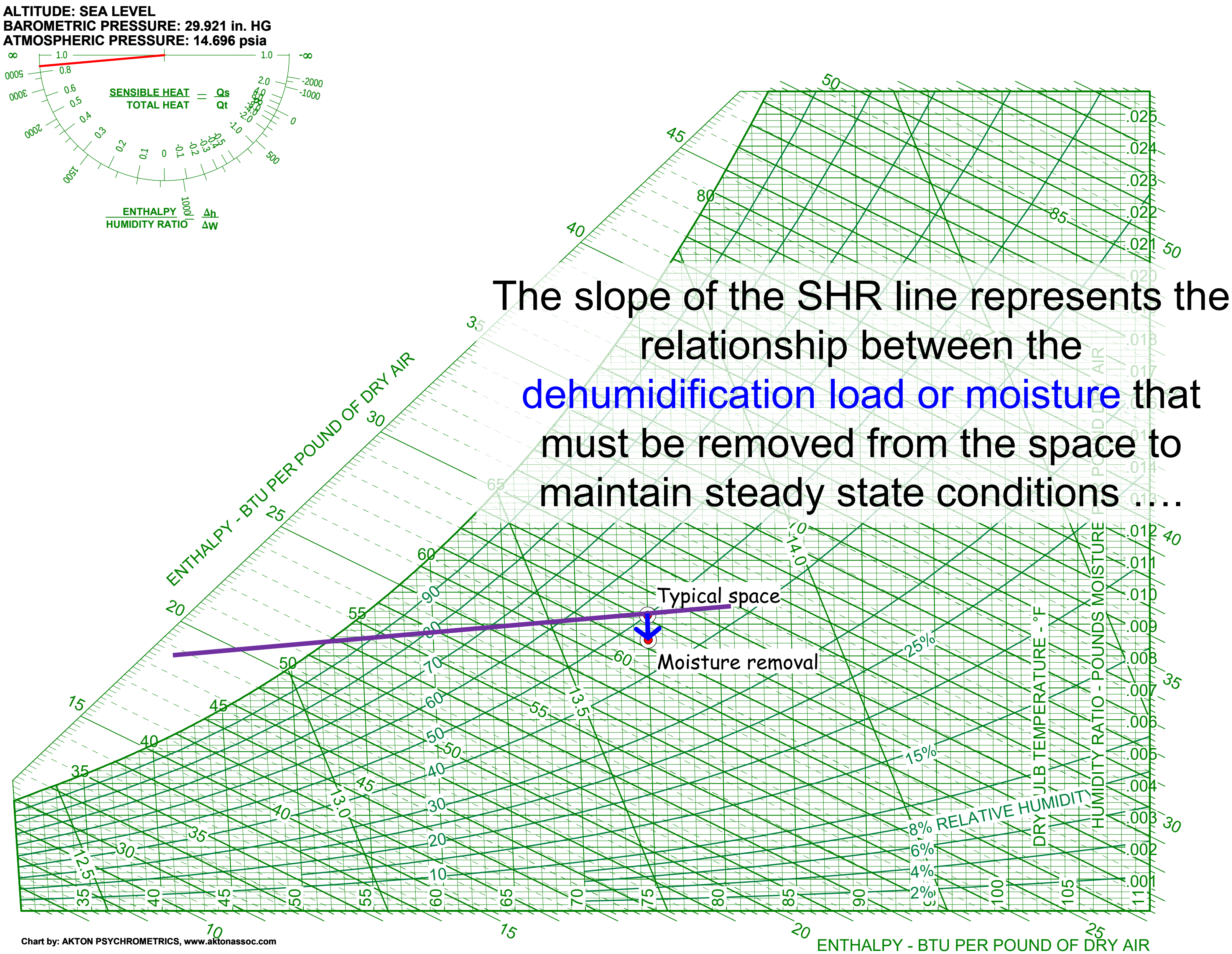


Transfer the SHR line from the SHR scale to the main chart so that it runs through the desired space condition



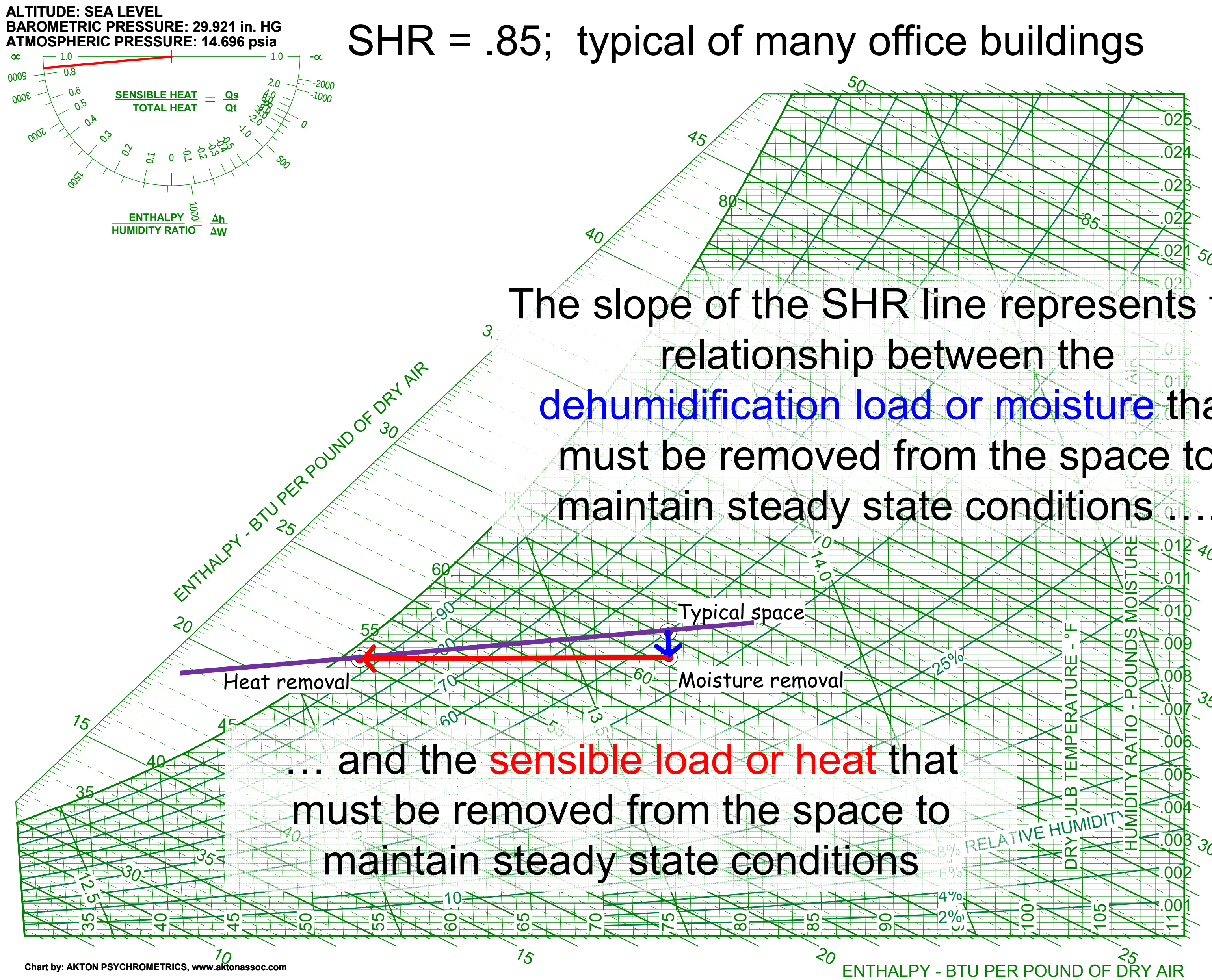
The Sensible Heat Ratio (SHR) scale establishes the relationship between sensible load and total load graphically on the psychrometric chart





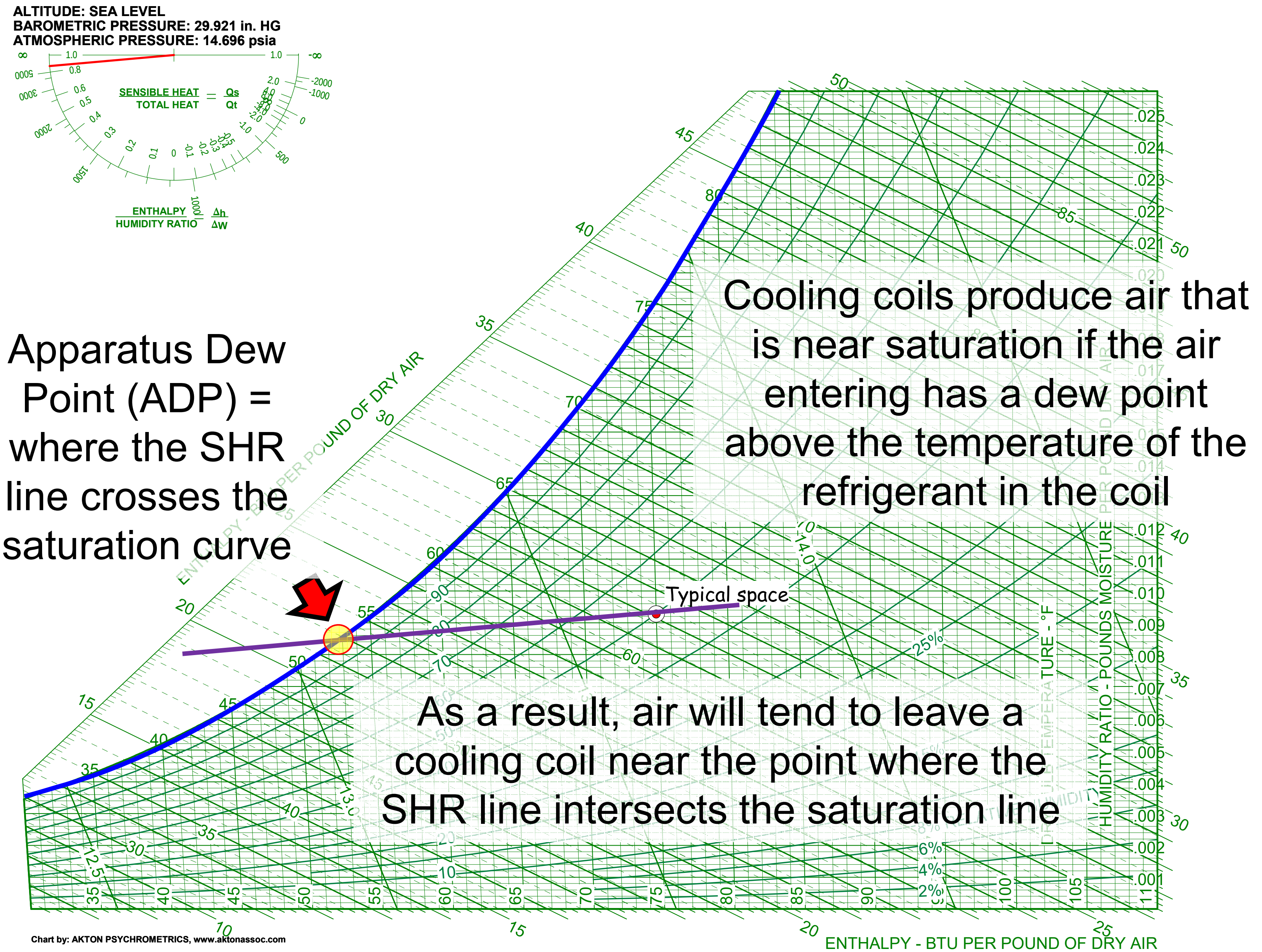
The slope of the SHR line represents the relationship between the dehumidification load or moisture that must be removed from the space to maintain steady state conditions ….

SHR = .85; typical of many office buildings



The slope of the SHR line represents the relationship between the dehumidification load or moisture that must be removed from the space to maintain steady state conditions ….

… and the sensible load or heat that must be removed from the space to maintain steady state conditions



Apparatus Dew Point (ADP) = where the SHR line crosses the saturation curve

Cooling coils produce air that is near saturation if the air entering has a dew point above the temperature of the refrigerant in the coil

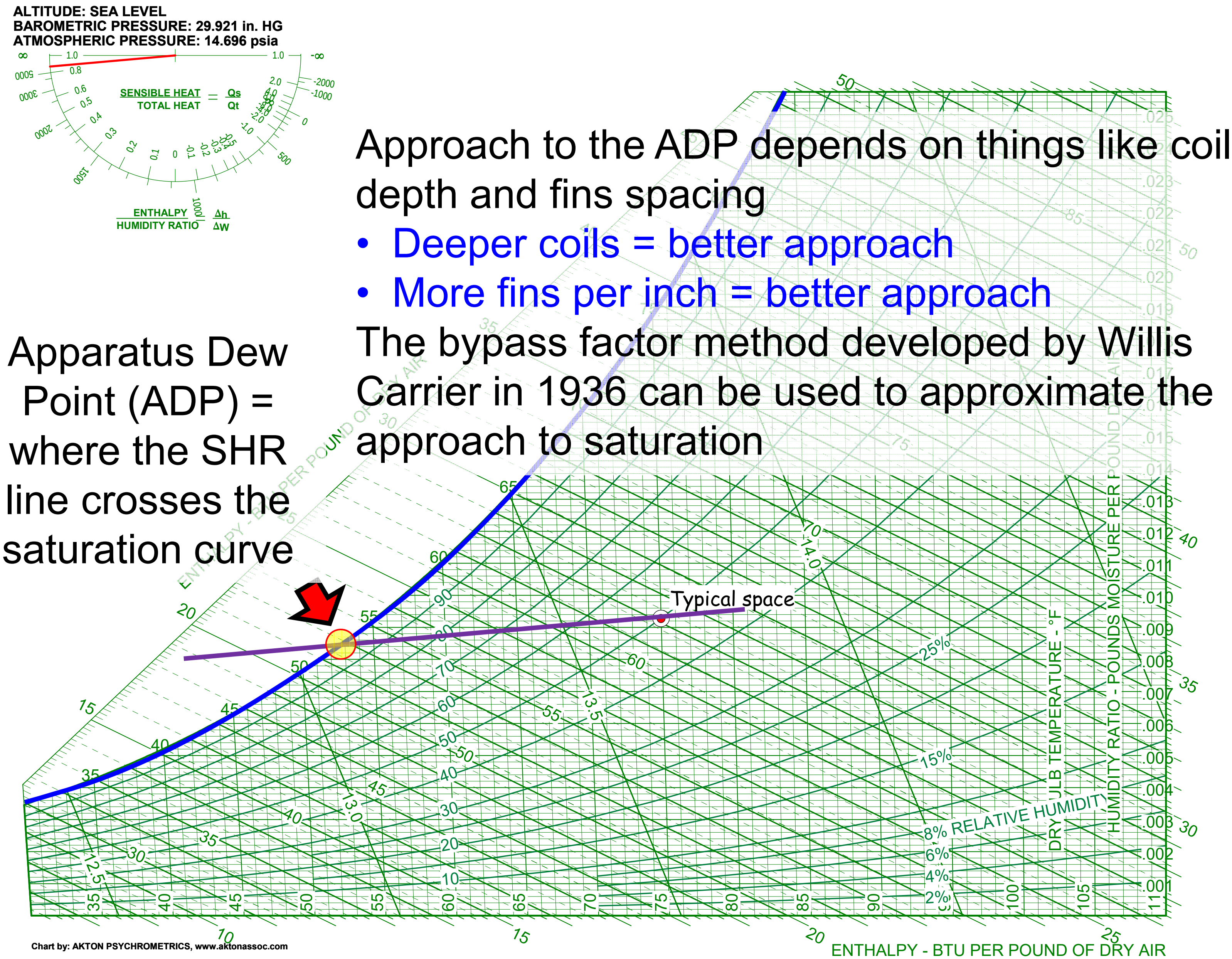
As a result, air will tend to leave a cooling coil near the point where the SHR line intersects the saturation line

Approach to the ADP depends on things like coil depth and fins spacing

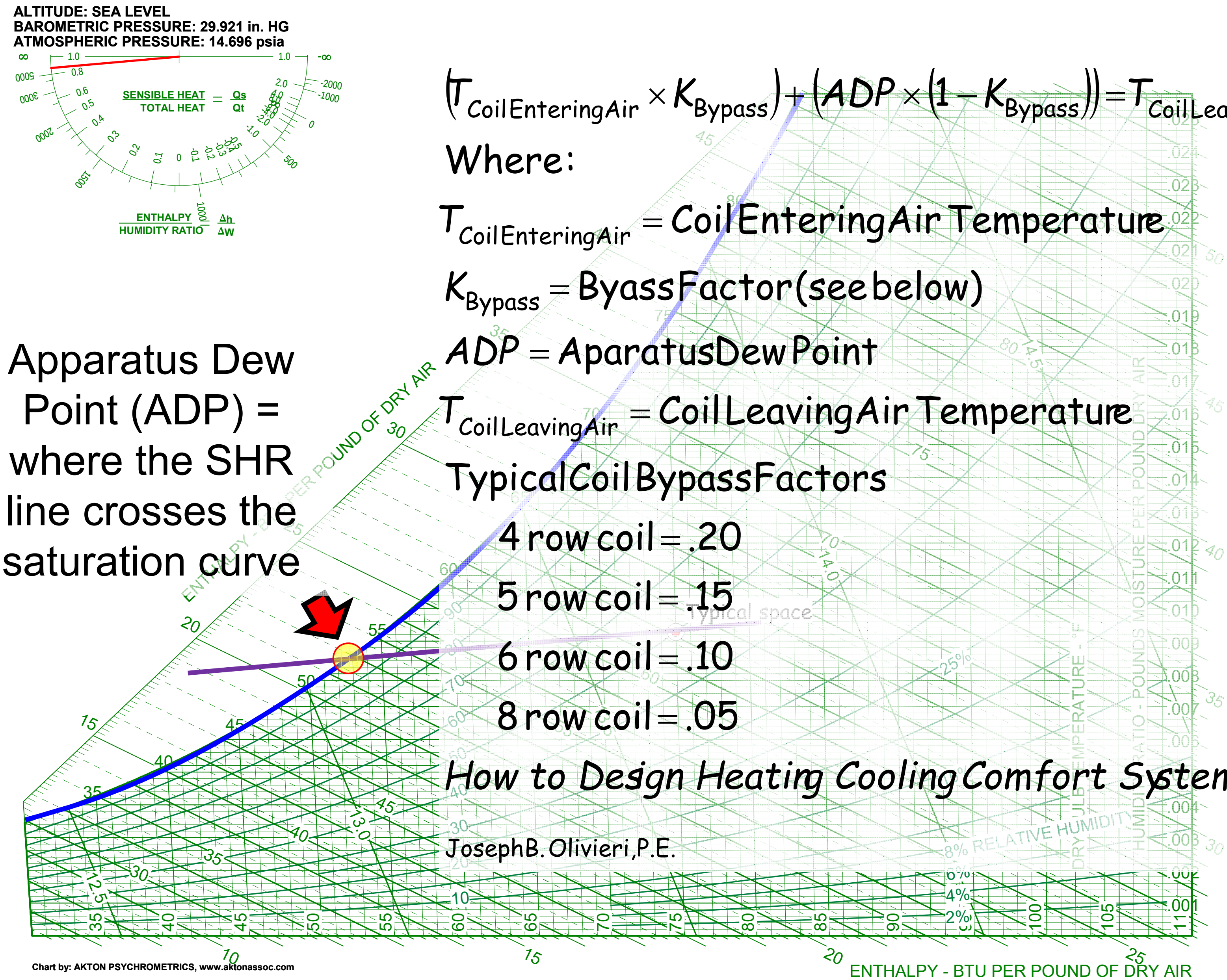
- Deeper coils = better approach
- More fins per inch = better approach

The bypass factor method developed by Willis Carrier in 1936 can be used to approximate the approach to saturation

Apparatus Dew Point (ADP) = where the SHR line crosses the saturation curve



Apparatus Dew Point (ADP) = where the SHR line crosses the saturation curve



$$\left(T_{CoilEnteringAir} \times K_{Bypass}\right) + \left(ADP \times \left(1 - K_{Bypass}\right)\right) = T_{CoilLeavingAir}$$

Where:

$T_{CoilEnteringAir}$ = Coil Entering Air Temperature

K_{Bypass} = Byass Factor (see below)

ADP = Aparatus Dew Point

$T_{CoilLeavingAir}$ = Coil Leaving Air Temperature

Typical Coil Bypass Factors

4 row coil = .20

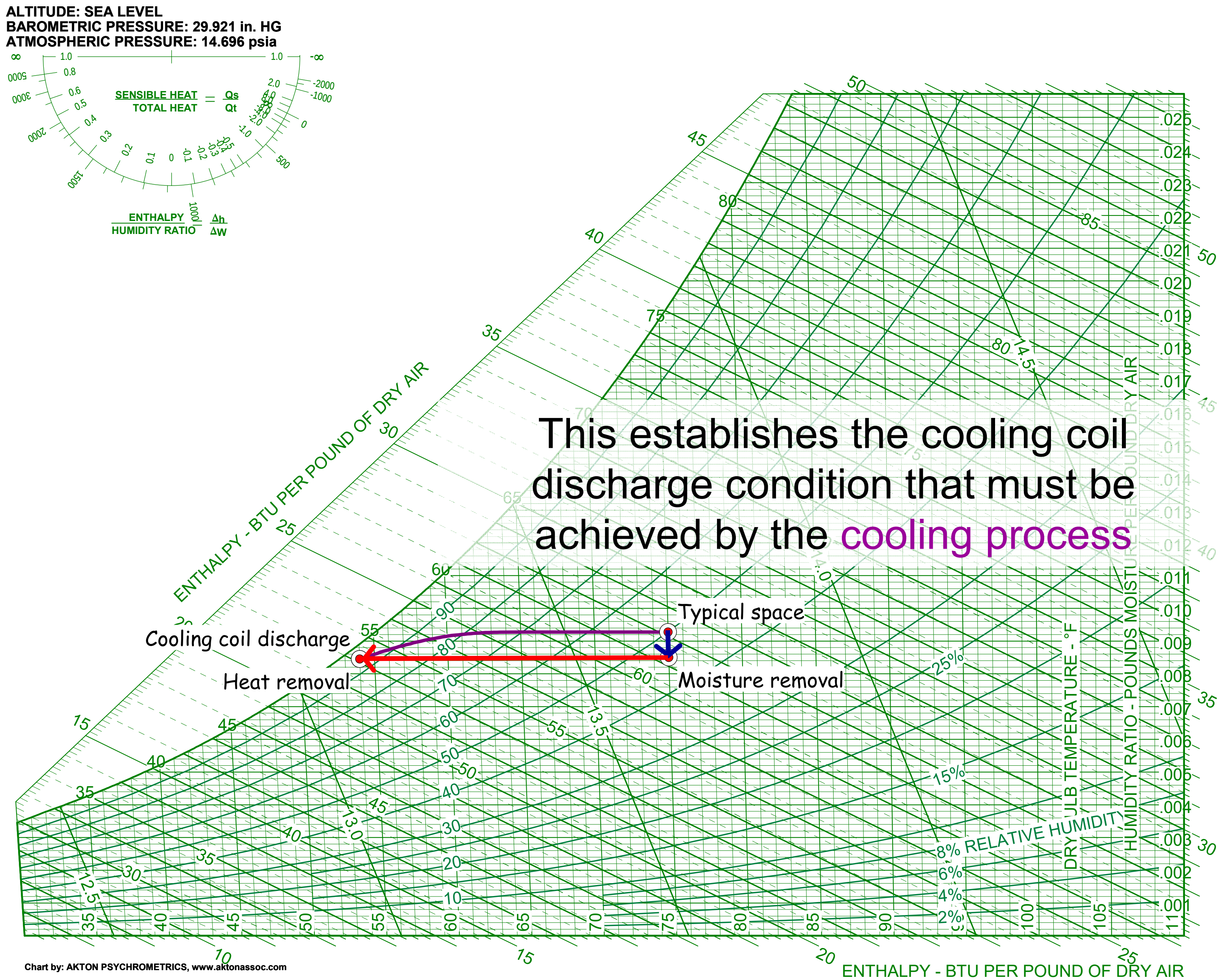
5 row coil = .15

6 row coil = .10

8 row coil = .05

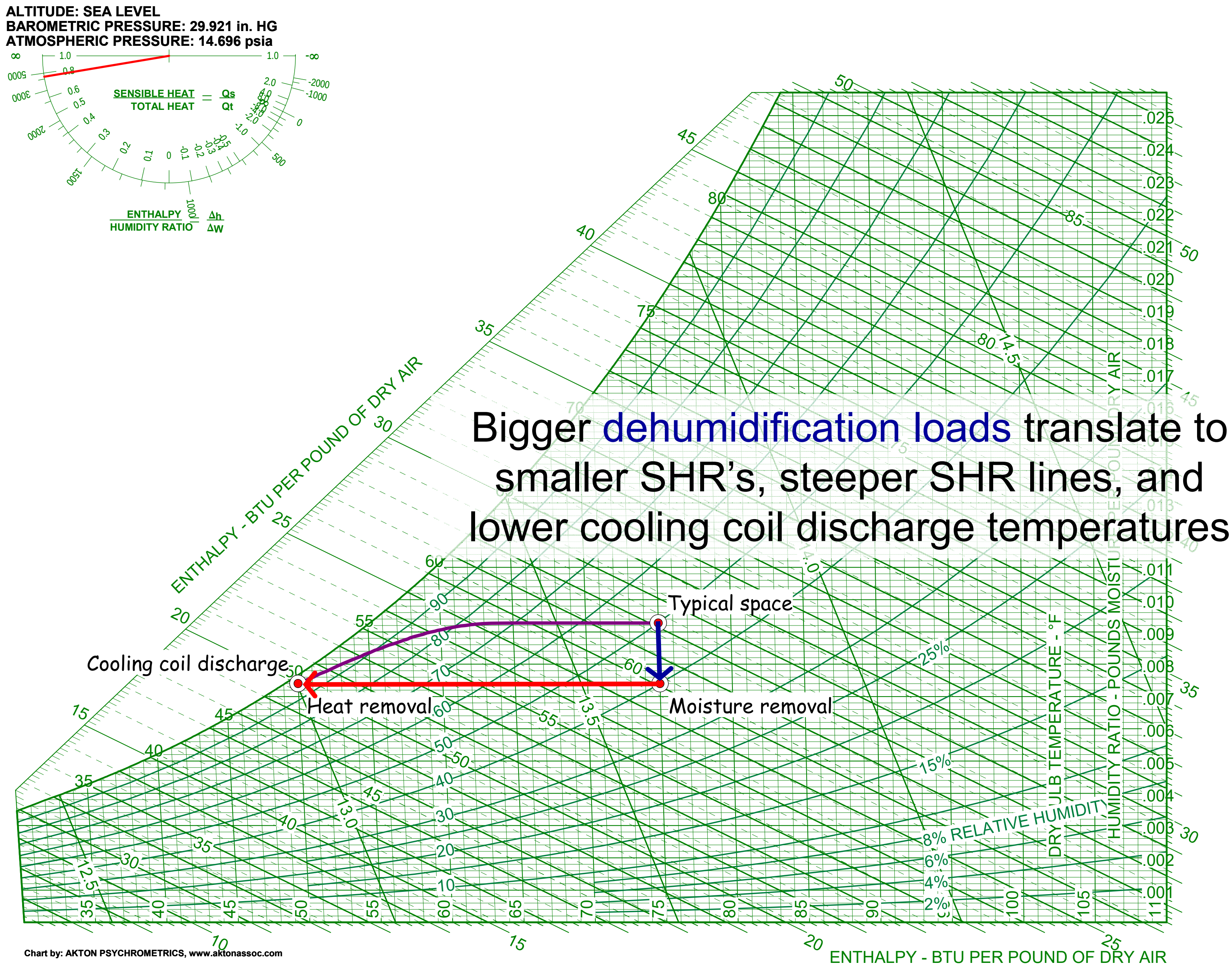
How to Design Heating Cooling Comfort Systems

Joseph B. Olivieri, P.E.



This establishes the cooling coil discharge condition that must be achieved by the cooling process

Bigger dehumidification loads translate to smaller SHR's, steeper SHR lines, and lower cooling coil discharge temperatures



Desiccant Dehumidification

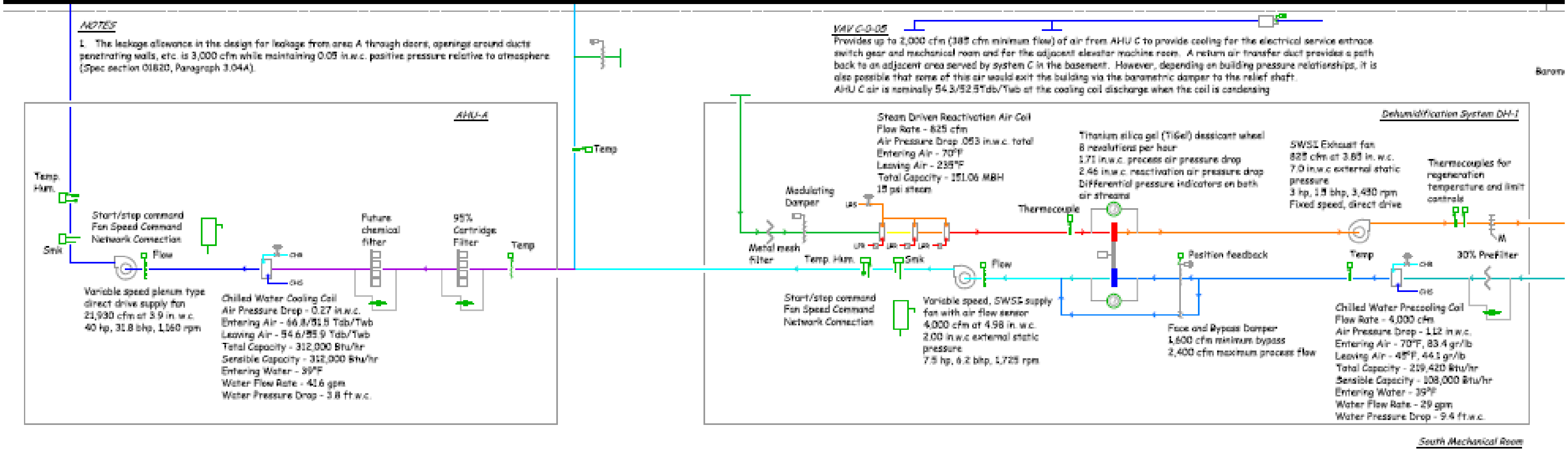
An alternative to the conventional approach

Desiccant Dehumidification

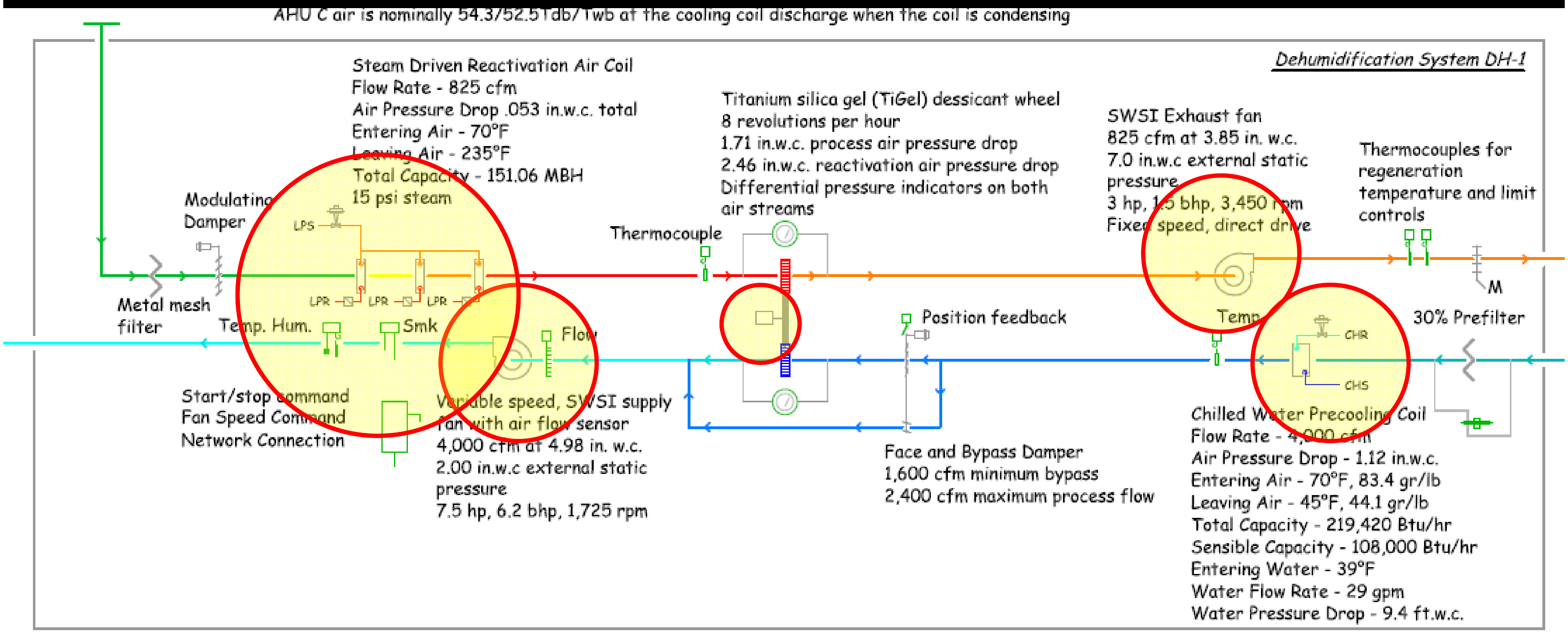
An alternative to the conventional approach

- A technique for achieving very low humidity levels that would otherwise be difficult to achieve
- Chemical process in which the water vapor either interact with the surface of a desiccant (adsorption) or permeates the desiccant (absorption)
- Water gives up latent energy in the process so the temperature tends to rise in the process stream
- Most HVAC equipment regenerates the desiccant by blowing hot (250°F or higher) air across the desiccant

A Desiccant System Applied to Supplement a Conventional AHU



A Desiccant System Applied to Supplement a Conventional AHU



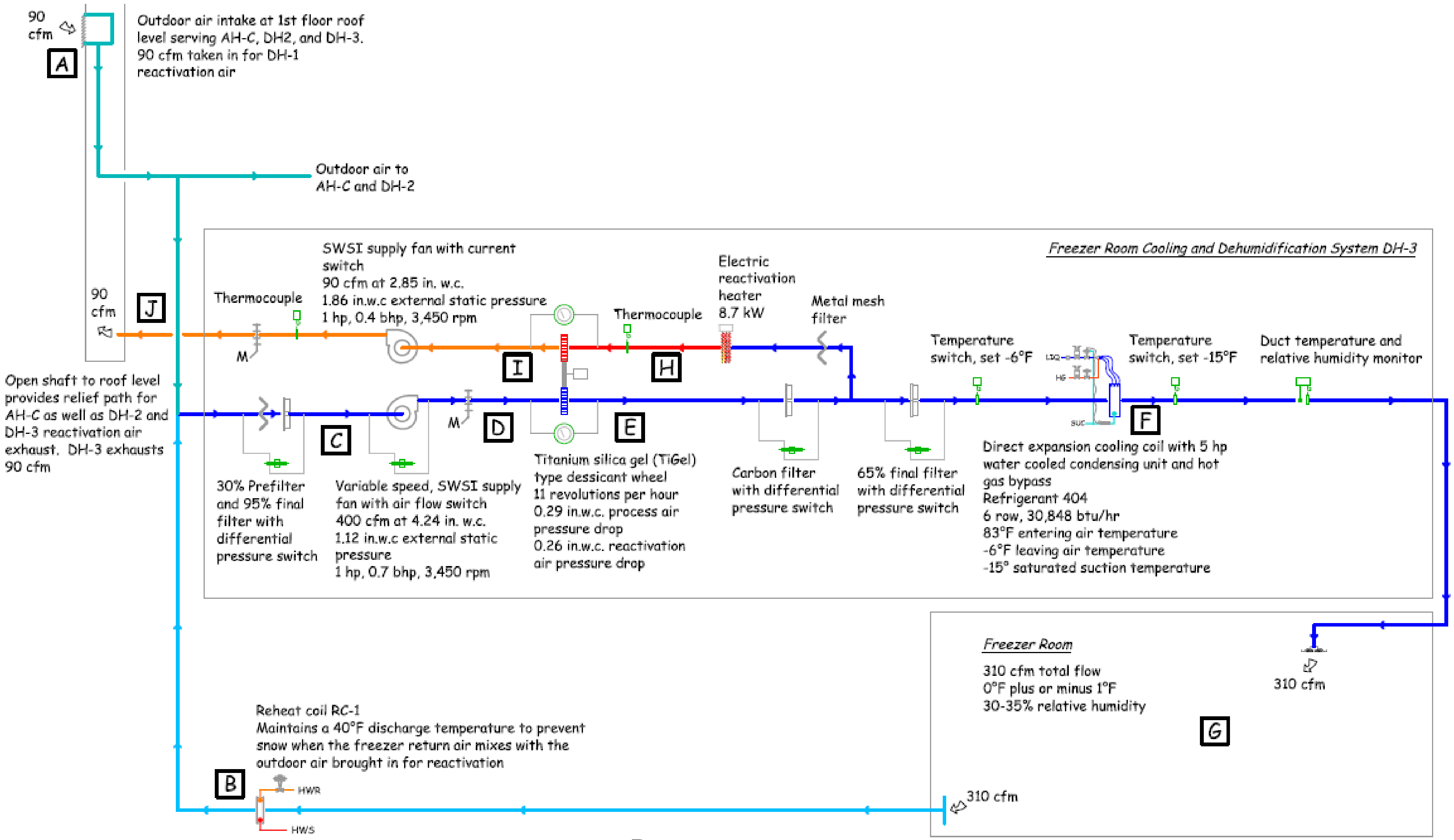
A Desiccant System Applied to Supplement a Conventional AHU

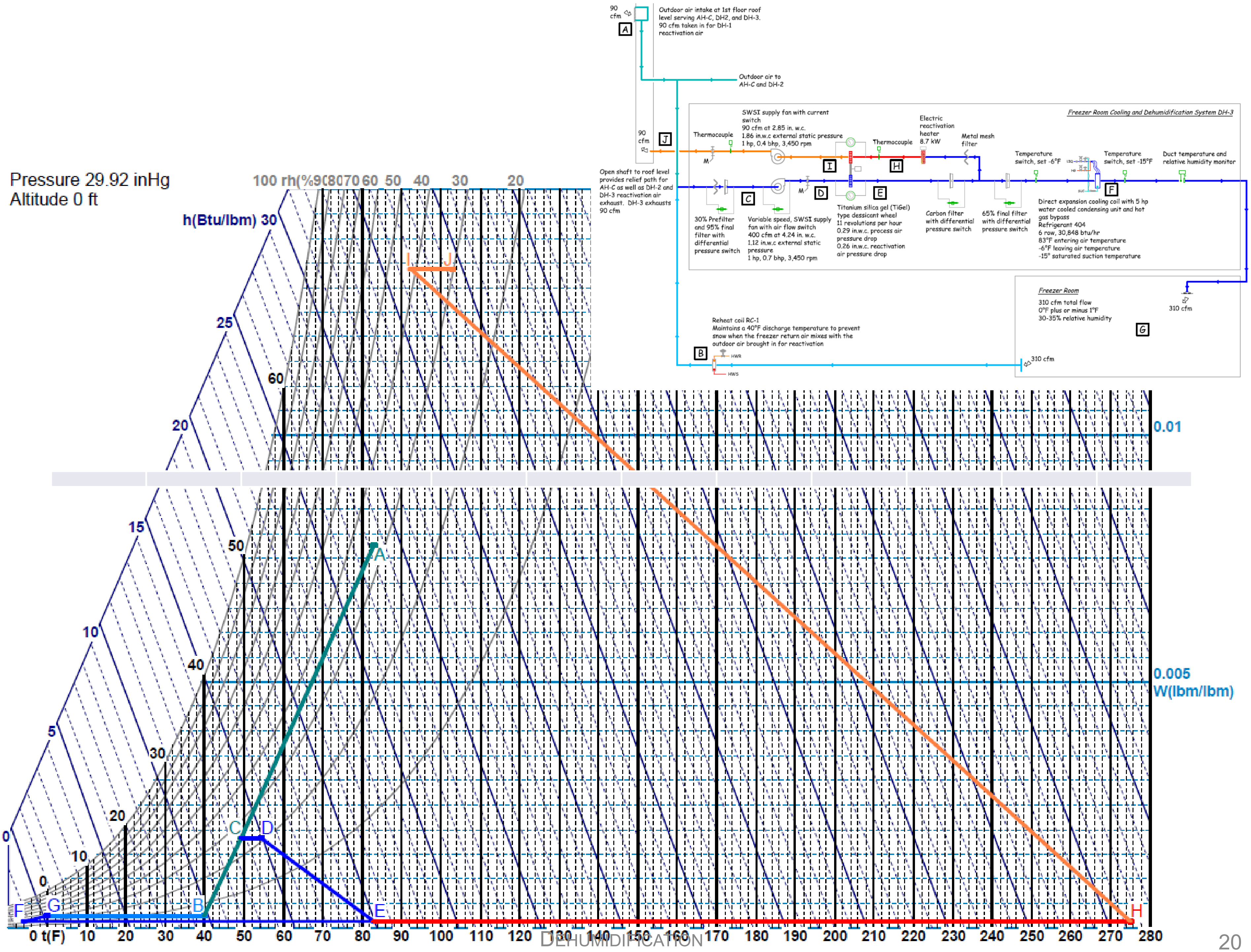
In this case energy was saved relative to a conventional approach because:

- Archival storage requirements set the air change rate and the humidity level
- Conventional dehumidification would have required a 39°F supply air temperature
- There were very few sensible gains
- The air change requirements at a 39°F supply air temperature would have required significant reheat round the clock

Dehumidification requires energy no matter how you do it

A Desiccant System Dedicated to a Very Cold, Dry Archival Storage Requirement





Pressure 29.92 inHg
Altitude 0 ft
100 rh(%) 90 80 70 60 50 40 30 20
h(Btu/lbm) 30
25
20
15
10
5
0
60
50
40
30
20
10
0
0.01
0.005
W(lbm/lbm)
0 t(F) 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
A
B
C
D
E
F
G
H
I
J
90 cfm
Outdoor air intake at 1st floor roof level serving AH-C, DH2, and DH-3. 90 cfm taken in for DH-1 reactivation air
Outdoor air to AH-C and DH-2
Freezer Room Cooling and Dehumidification System DH-3
Thermocouple
SWSI supply fan with current switch
90 cfm at 2.85 in. w.c.
1.86 in.w.c external static pressure
1 hp, 0.4 bhp, 3,450 rpm
Electric reactivation heater
8.7 kW
Metal mesh filter
Temperature switch, set -6°F
Temperature switch, set -15°F
Duct temperature and relative humidity monitor
Open shaft to roof level provides relief path for AH-C as well as DH-2 and DH-3 reactivation air exhaust. DH-3 exhausts 90 cfm
30% Prefilter and 95% final filter with differential pressure switch
Variable speed, SWSI supply fan with air flow switch
400 cfm at 4.24 in. w.c.
1.12 in.w.c external static pressure
1 hp, 0.7 bhp, 3,450 rpm
Titanium silica gel (TiGel) type dessicant wheel
11 revolutions per hour
0.29 in.w.c. process air pressure drop
0.26 in.w.c. reactivation air pressure drop
Carbon filter with differential pressure switch
65% final filter with differential pressure switch
Direct expansion cooling coil with 5 hp water cooled condensing unit and hot gas bypass
Refrigerant 404
6 row, 30,848 btu/hr
83°F entering air temperature
-6°F leaving air temperature
-15° saturated suction temperature
Freezer Room
310 cfm total flow
0°F plus or minus 1°F
30-35% relative humidity
310 cfm
Reheat coil RC-1
Maintains a 40°F discharge temperature to prevent snow when the freezer return air mixes with the outdoor air brought in for reactivation
HWR
HWS