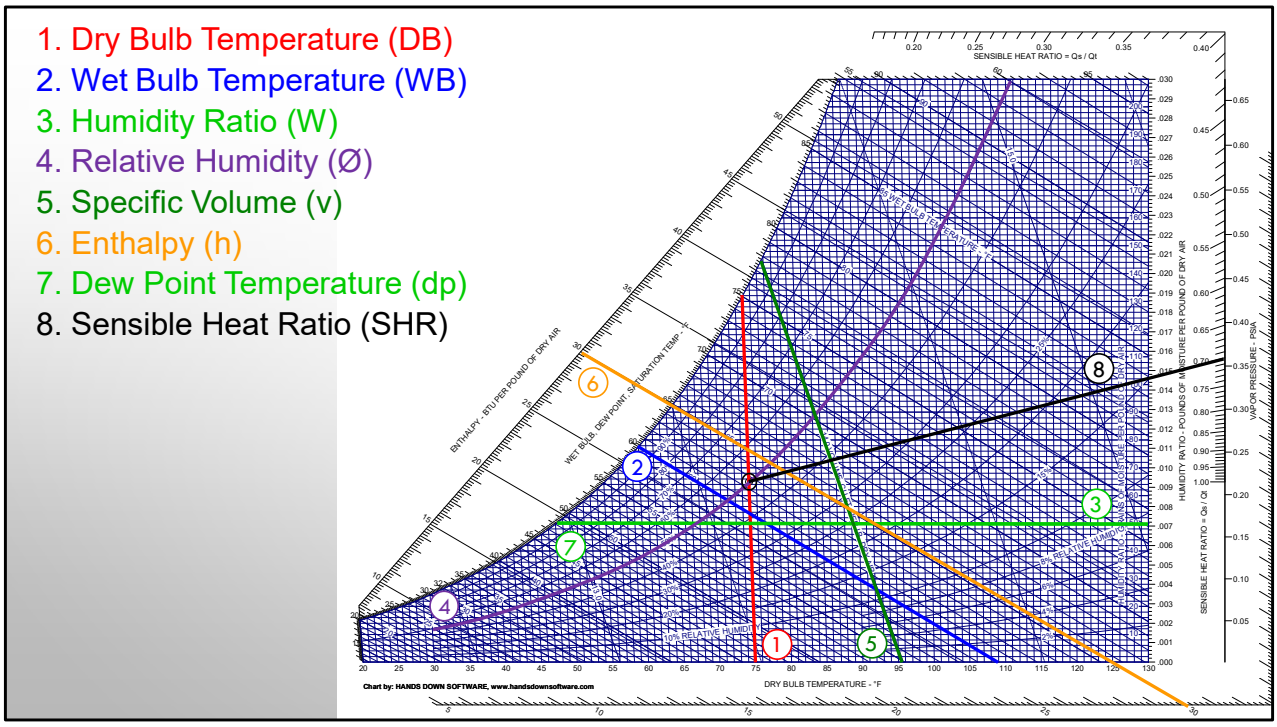
HUMIDITY & DX SYSTEMS

PROPERTIES OF AIR

- WHAT ARE THE ONLY TWO ABSOLUTES ON THE PSYCH CHART?

LP



1. **Dry Bulb Temperature (DB)** The temperature of air (°F).
2. **Wet Bulb Temperature (WB)** The temperature to which air can be cooled to by the adiabatic evaporation of water (°F).
3. **Humidity Ratio (W)** The ratio of the mass of water vapor to the mass of dry air in the air vapor mixture (lbw/lba) or grains water/grains air).
4. **Relative Humidity (Ø)** The ratio of the mole fraction of water vapor in the air vapor mixture to the mole fraction of water vapor saturated at the same temperature and pressure. For an ideal gas the relative humidity is the ratio of water pressure in the air vapor mixture to the water pressure of water saturated at the same dry bulb temperature (%).
5. **Specific volume (v)** The volume of air per pound of dry air (cu.ft./lba.)
6. **Enthalpy (h)** The energy content of the air vapor mixture per pound of dry air (Btu/lba).
7. **Dew Point Temperature (dp)** The temperature at which condensation of water vapor in an air vapor mixture occurs (°F).
8. **Sensible Heat Ratio (SHR)** The ratio of the sensible heat transferred to the total heat transferred in an air conditioning process.

RELATIVE HUMIDITY VS DEW POINT

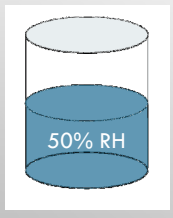
Relative humidity

How much water is in the air relative to what it can hold

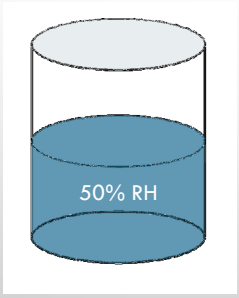
Dew point

Absolute measurement of the amount of water in the air

RELATIVE HUMIDITY



55 F



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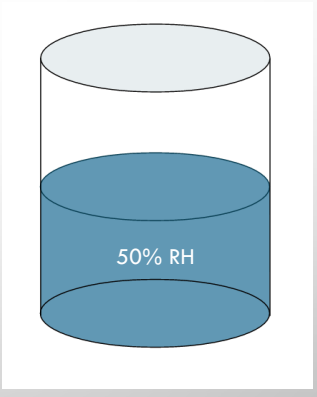
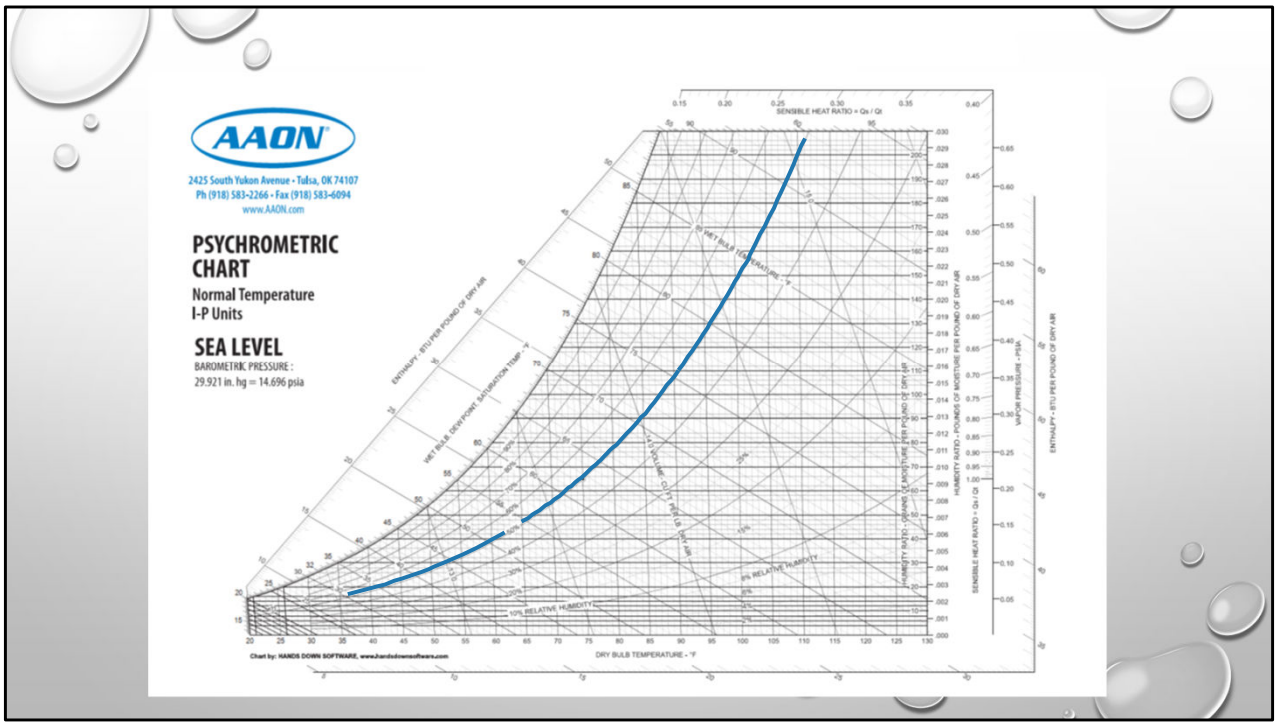


95 F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PSYCHROMETRIC CHART
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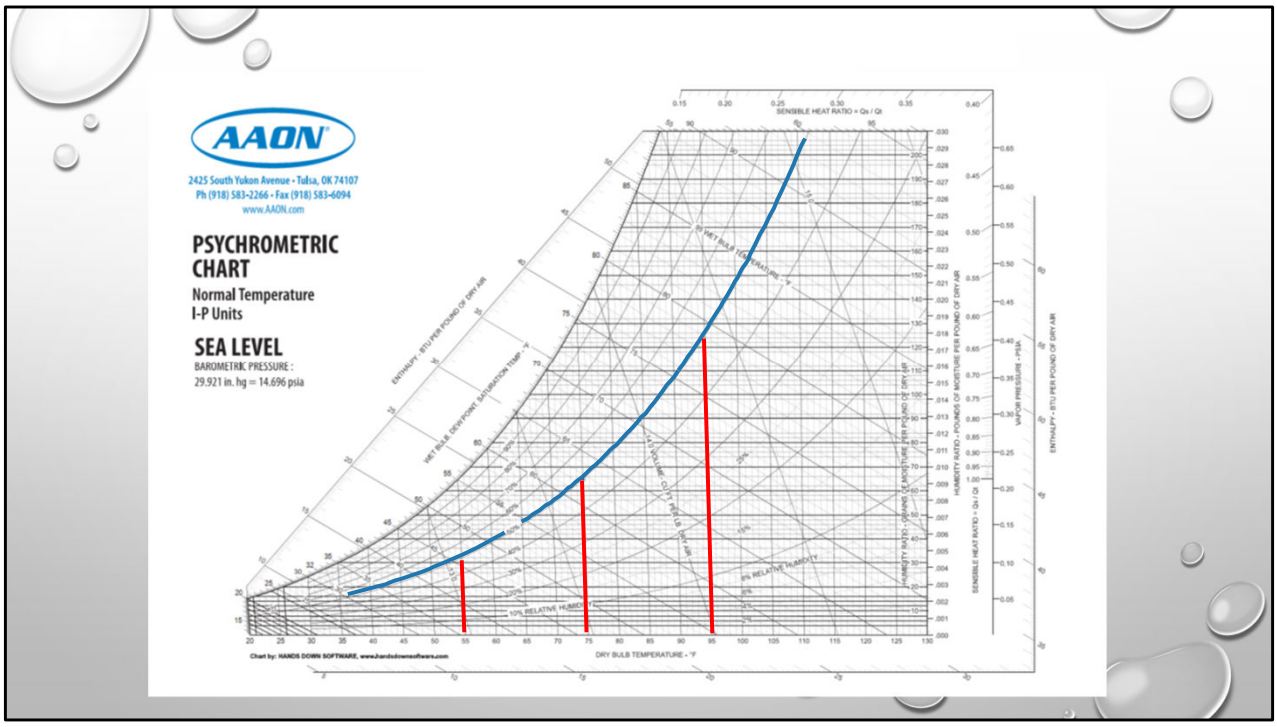
I-P Units
SEA LEVEL
BAROMETRIC PRESSURE :
29.921 in. hg = 14.696 psia
SENSIBLE HEAT RATIO = Qs / Qt
DRY BULB TEMPERATURE - °F
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com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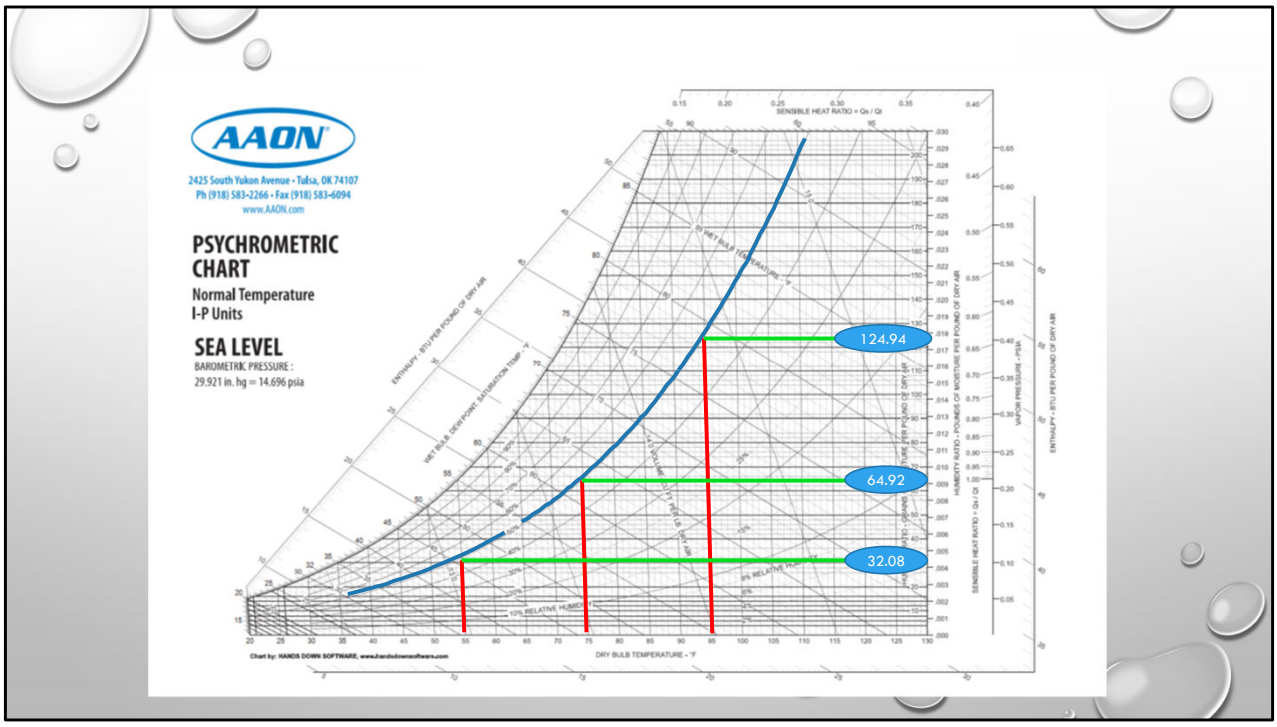
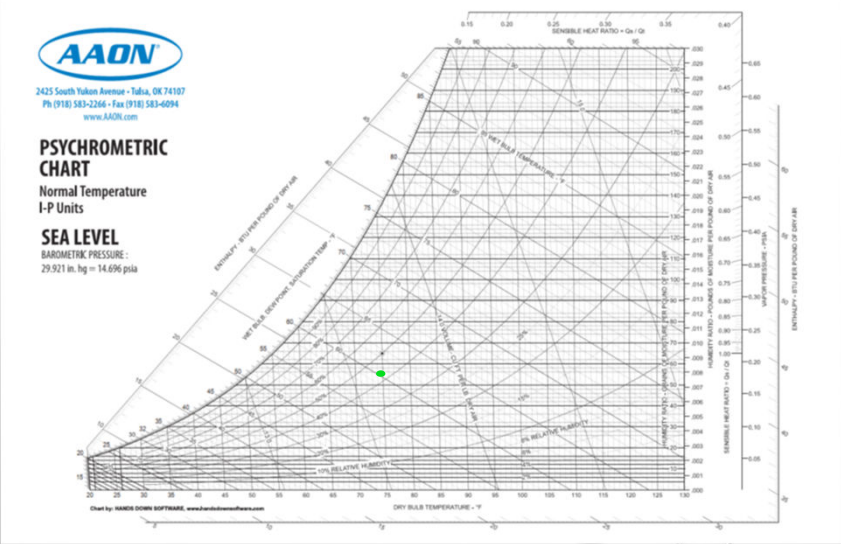


Humidity Ratio in grains

CONTROL SEQUENCE



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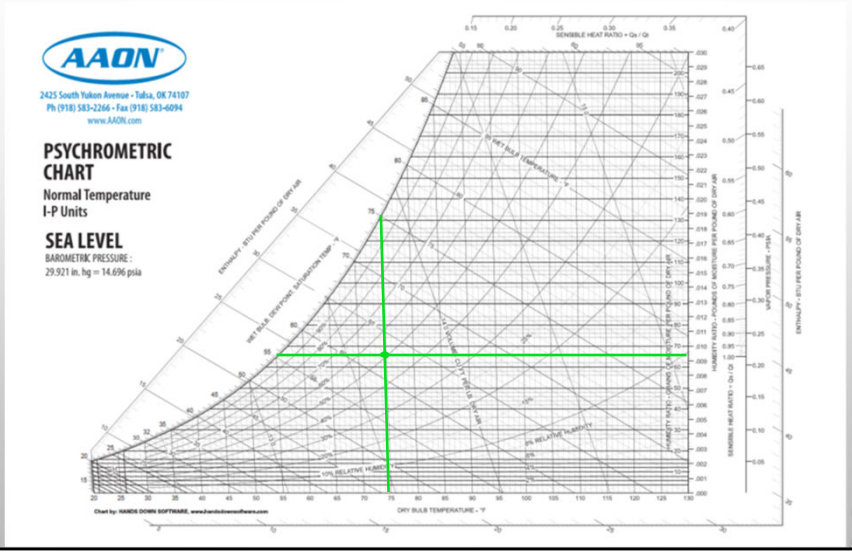

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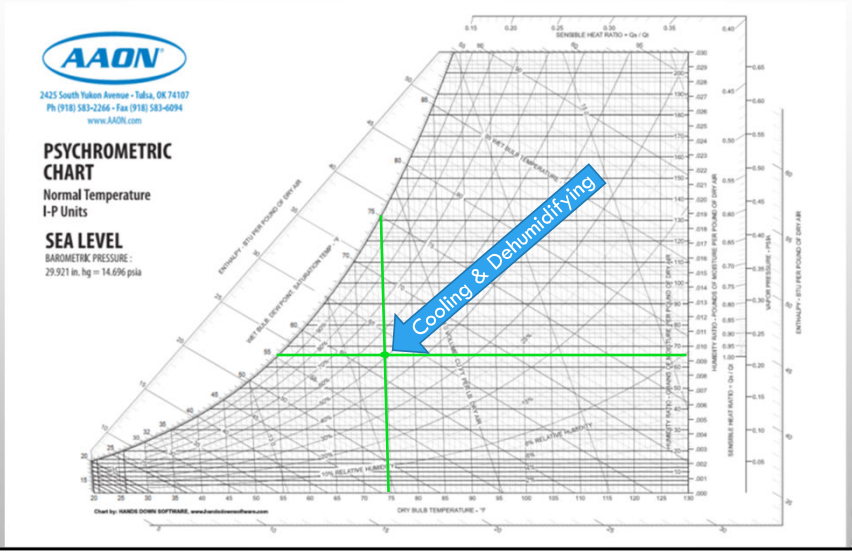

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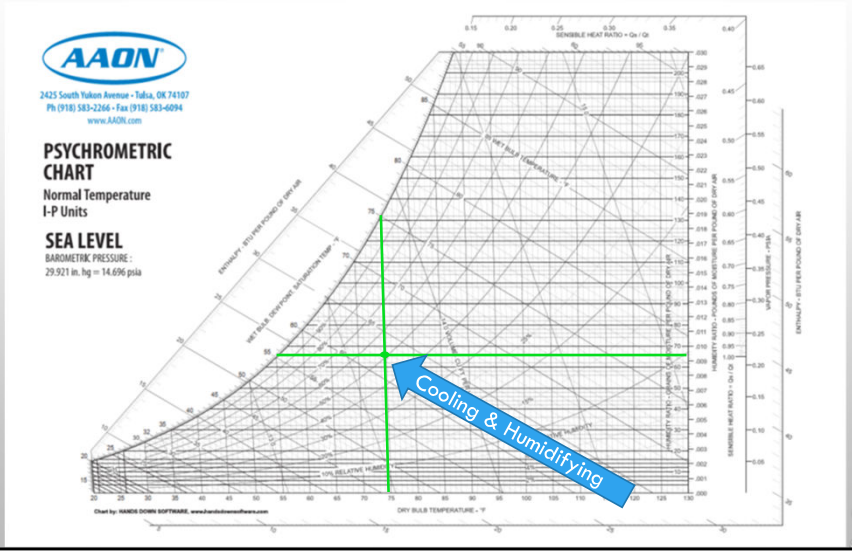

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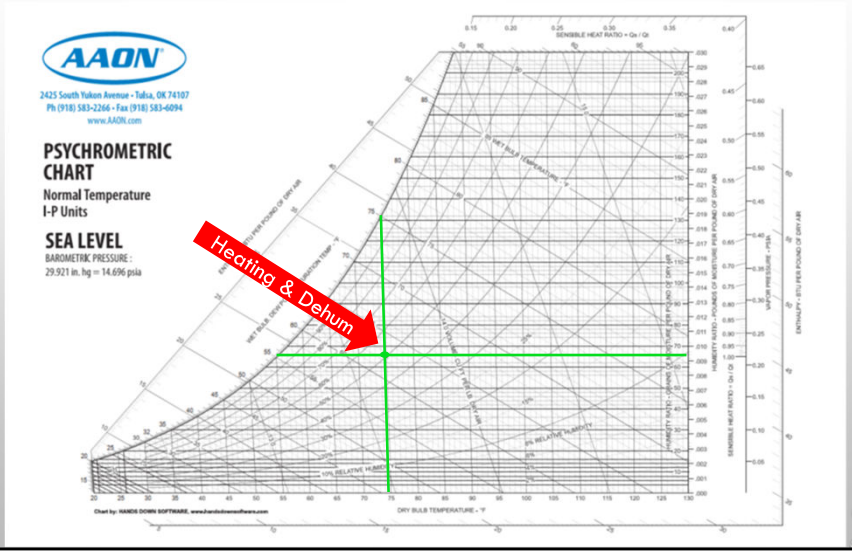

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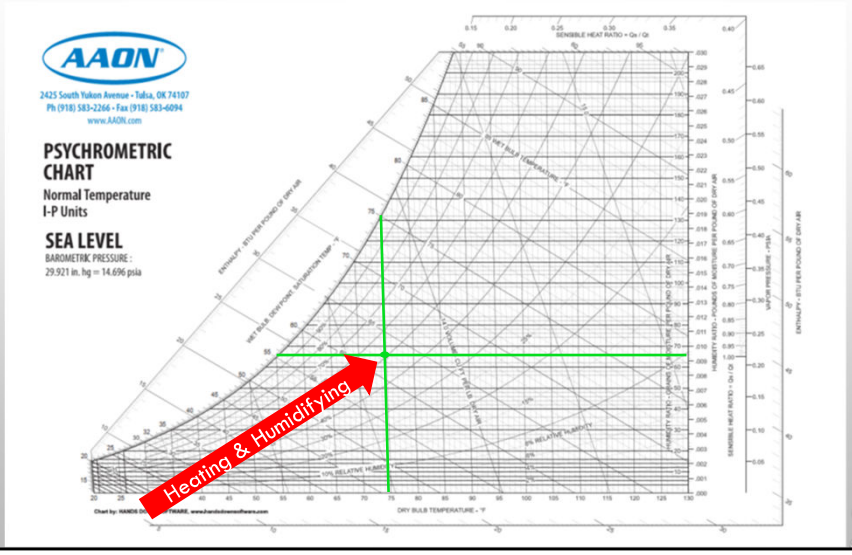
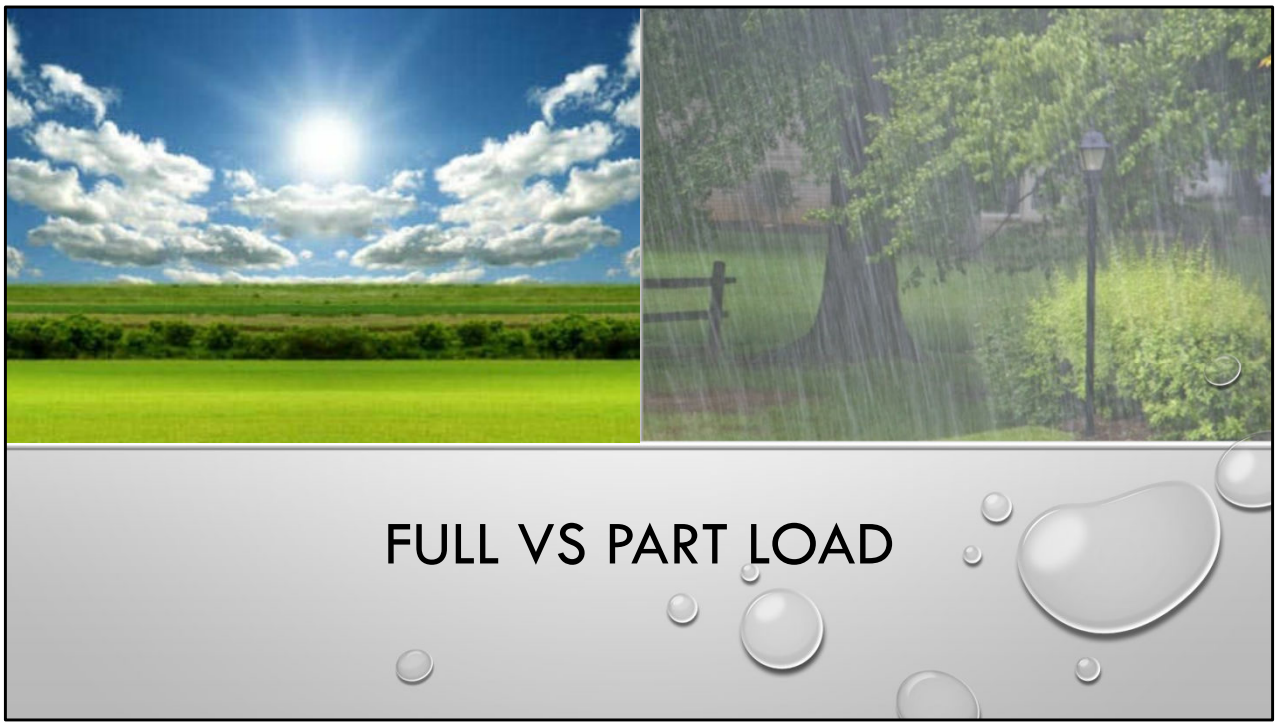
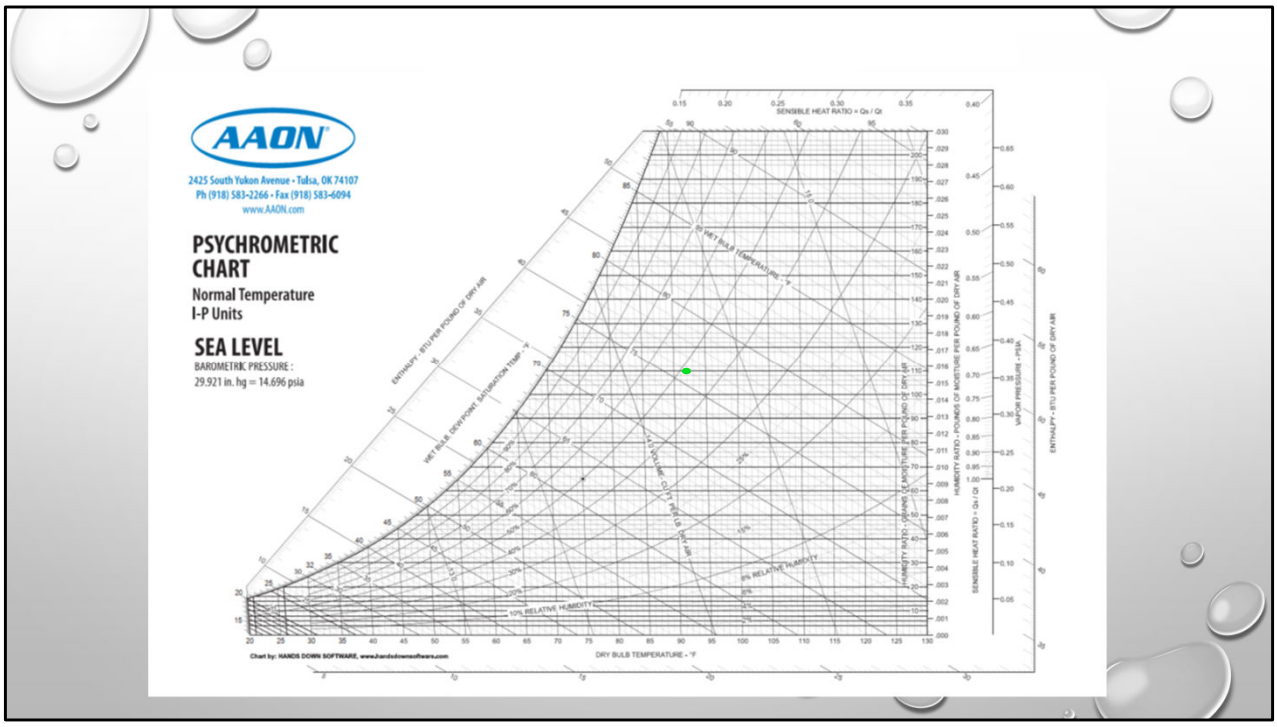




JRT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SEA LEVEL
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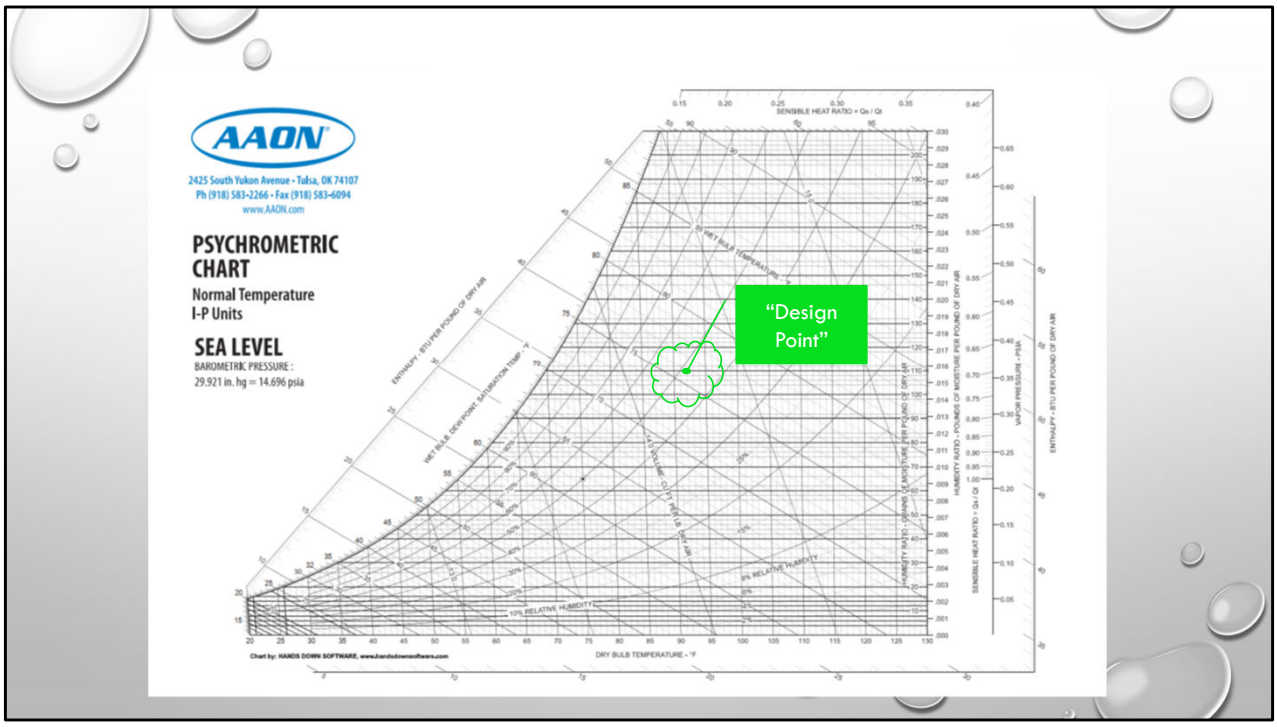
29.921 in. hg = 14.696 psia
SENSIBLE HEAT RATIO = Qs / Qt
WET BULB TEMPERATURE - °F
ENTHALPY - BTU PER POUND OF DRY AIR
WET BULB (OR DEW POINT) SATURATION TEMP - °F
VOLUME - CU FT PER LB DRY AIR
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
85% RELATIVE HUMIDITY
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °F
VAPOR PRESSURE - PSIA
SENSIBLE HEAT RATIO = Qs / Qt
HUMIDITY RATIO - POUNDS OF MOISTURE PER POUND OF DRY AIR
ENTHALPY - BTU PER POUND OF DRY AIR
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com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"Design Point"
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DRY BULB TEMPERATURE - °F
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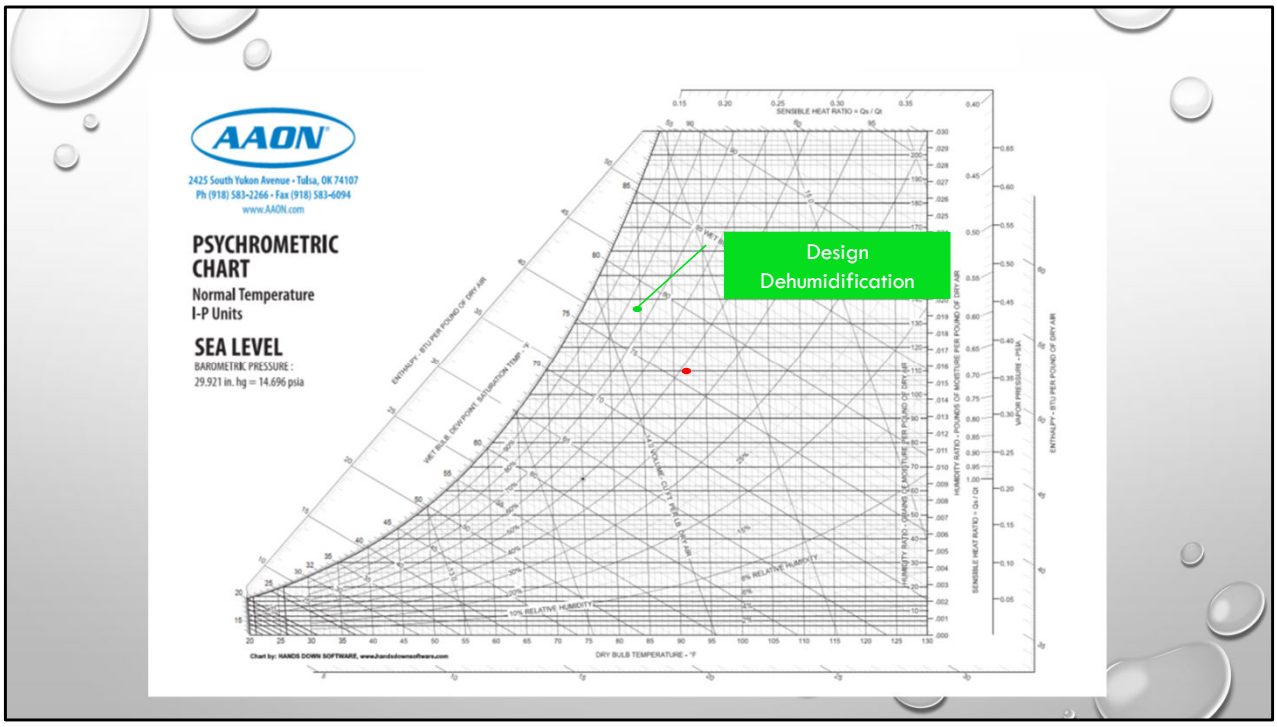
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Design Dehumidification
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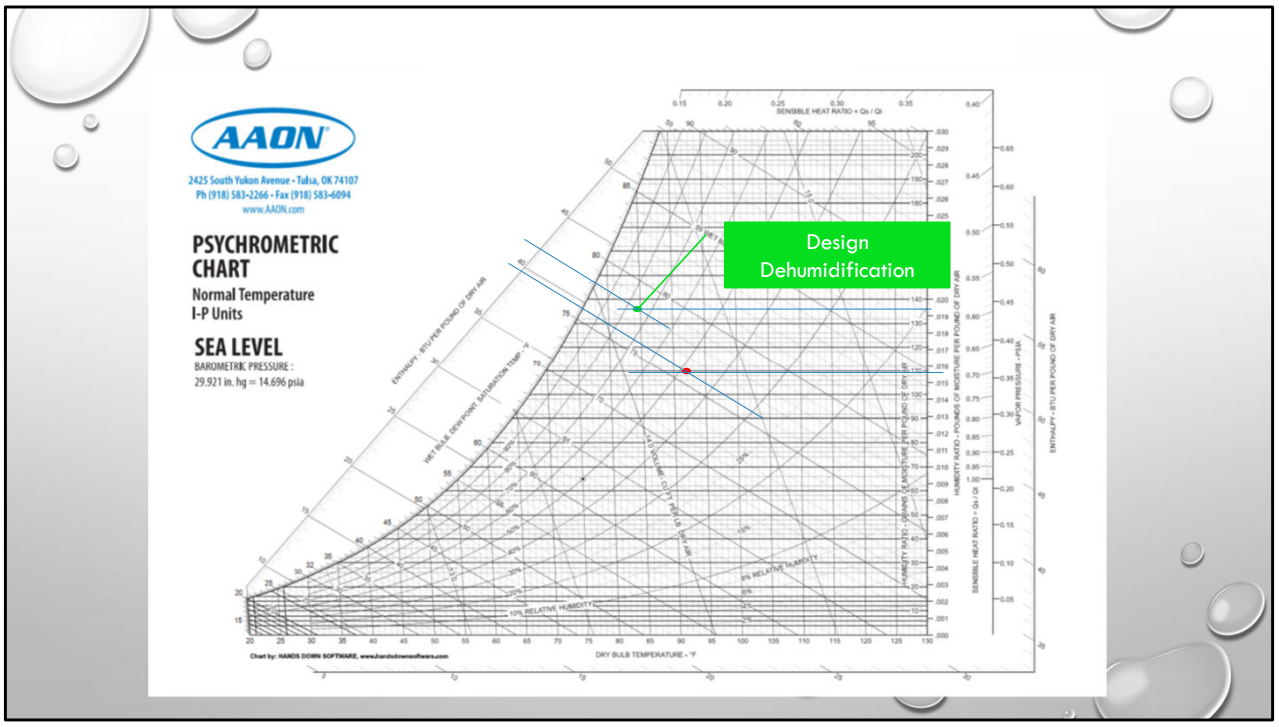
SENSIBLE HEAT RATIO = Qs / Qt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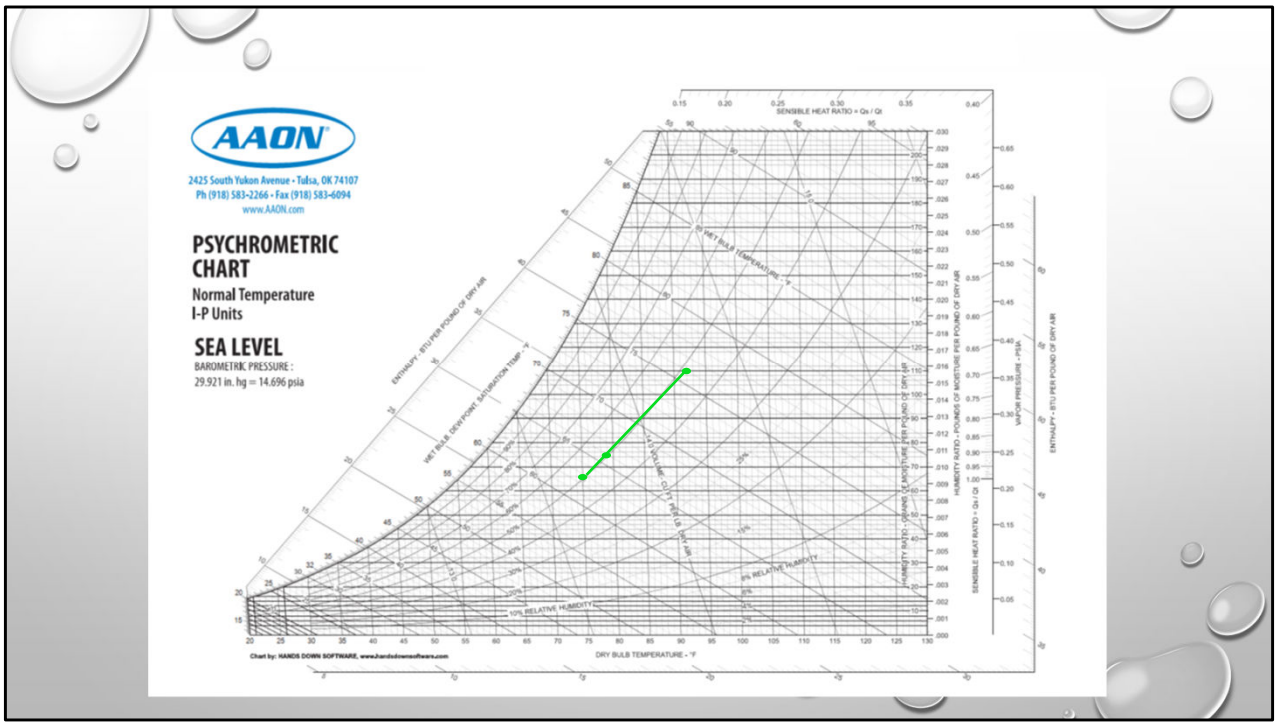
SENSIBLE HEAT RATIO = Qs / Qt
DRY BULB TEMPERATURE - °F
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

DESIGN COOLING VS DEHUMIDIFICATION

- HUMIDITY RATIO
  - COOLING – 105.92 GR/LB
  - DEHUMIDIFICATION – 135.48 GR/LB
  - 29.56 GR/LB
- @ 10,000 CFM
  - 190.5 LBS/HR WATER
  - 22.8 GPH WATER

- ENERGY CONTENT
  - COOLING – 39.12 BTU/LB
  - DEHUMIDIFICATION – 41.6 BTU/LB
  - 2.48 BTU/LB
- @ 10,000 CFM
  - 9.3 TONS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VOLUME - CU FT PER LB DRY AIR
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10% RELATIVE HUMIDITY
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
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ENTHALPY - BTU PER POUND OF DRY AIR
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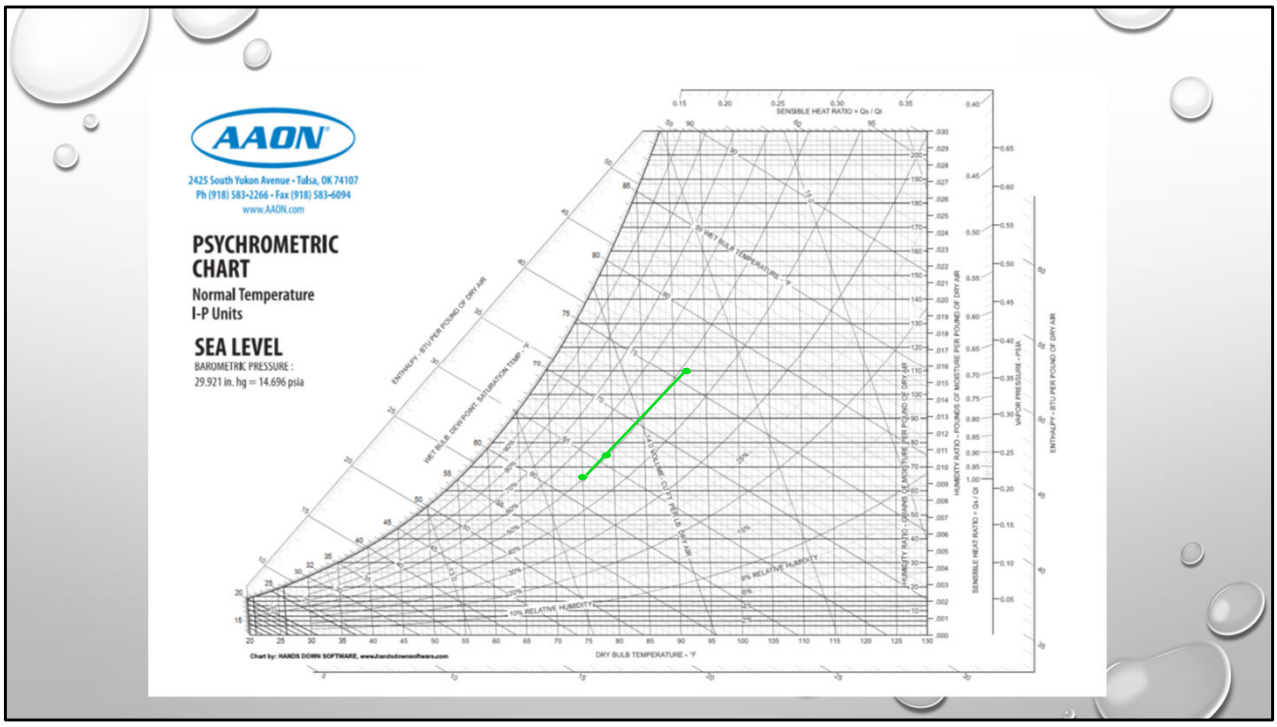
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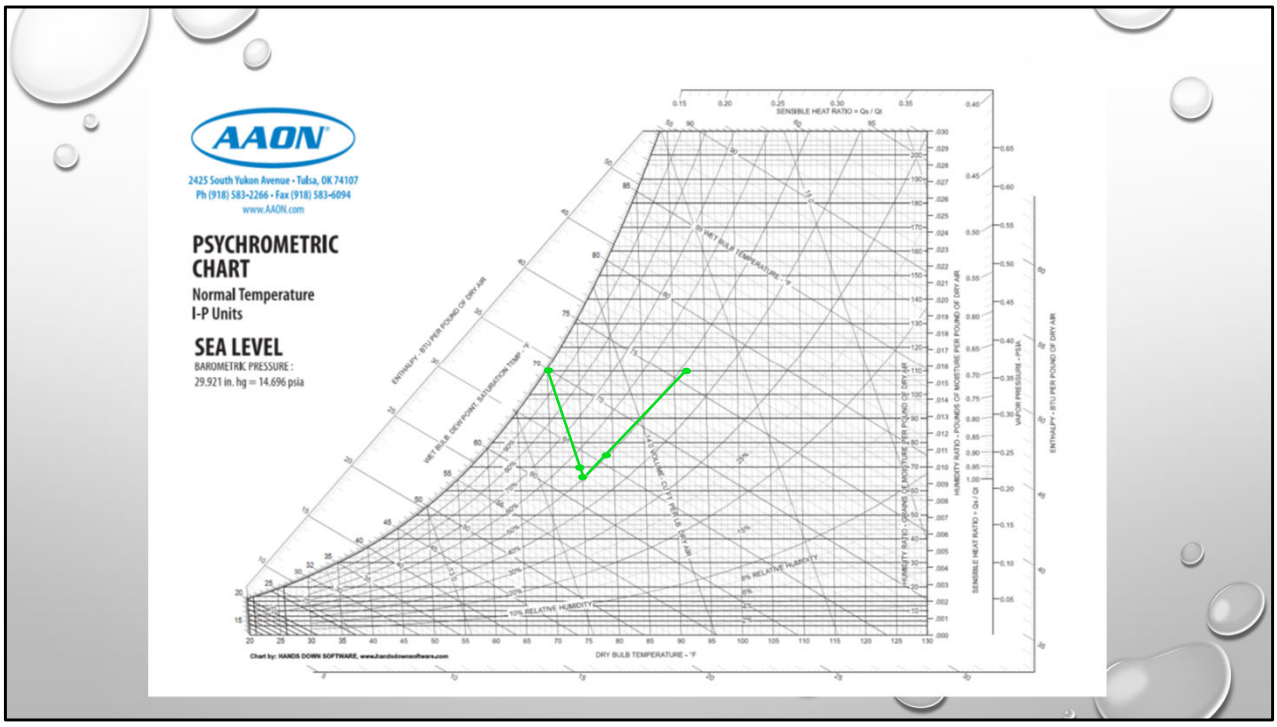
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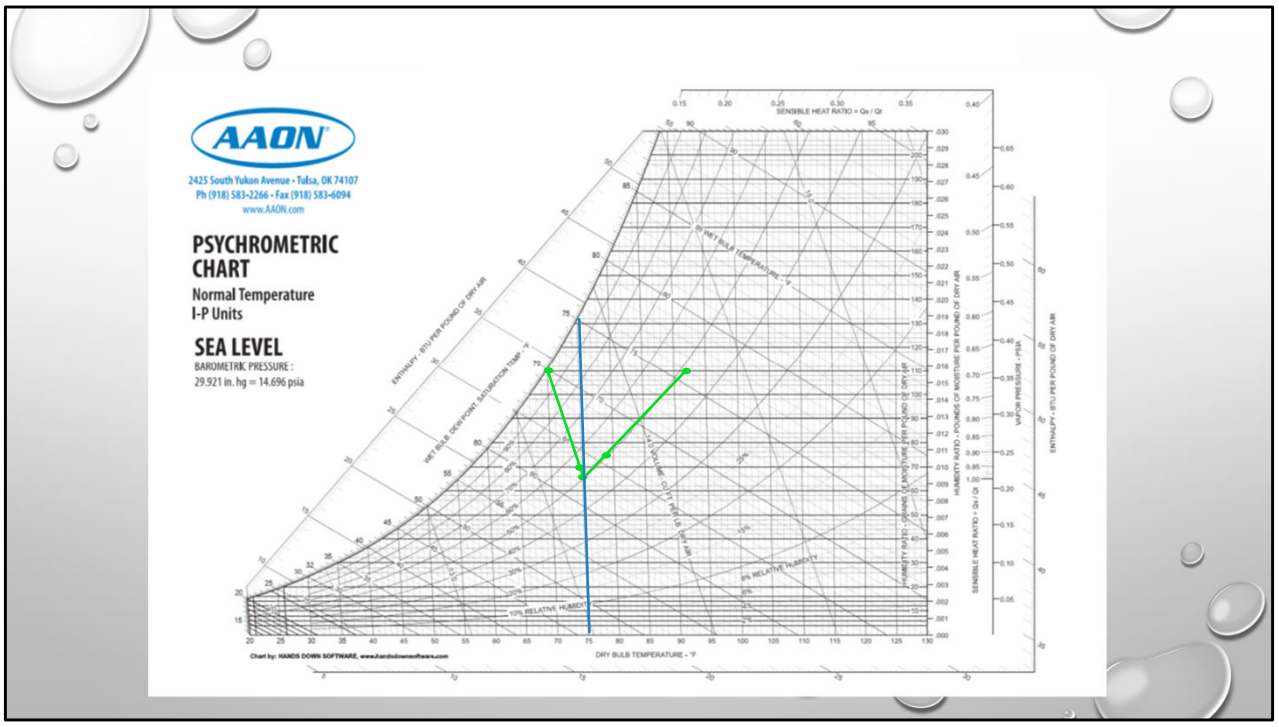
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VAPOR PRESSURE - PSIA
ENTHALPY - BTU PER POUND OF DRY AIR
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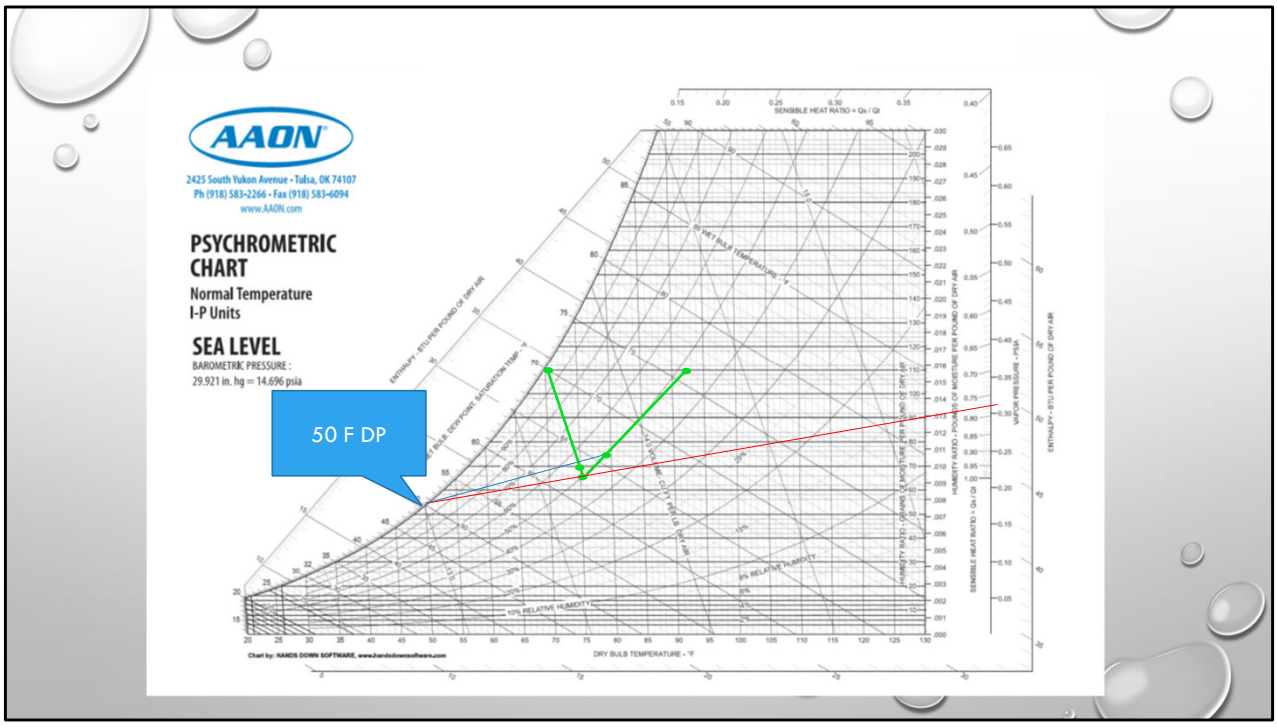
WHY DX SYSTEMS FAIL TO CONTROL HUMIDITY

- SENSIBLE ONLY MACHINES
  - 3 ROW COILS
  - ~400 CFM/TON
    - UNSTABLE AT LOW CFM/TON
  - USUALLY DESIGNED FOR A 15-20 F TEMPERATURE SUPPRESSION

LP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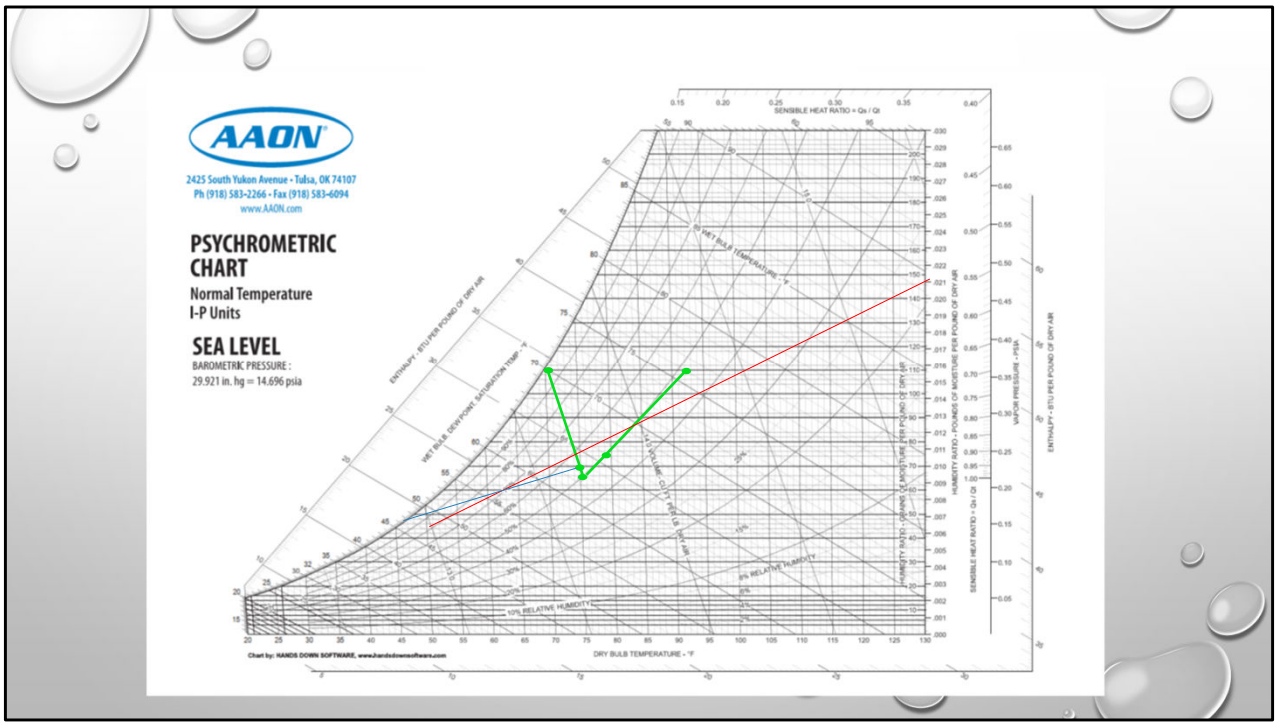
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WET BULB DEW POINT - SATURATION TEMP. - °F
SPECIFIC VOLUME - CUFT PER LB. DRY AIR
10% RELATIVE HUMIDITY
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
HUMIDITY RATIO - POUNDS OF MOISTURE PER POUND OF DRY AIR
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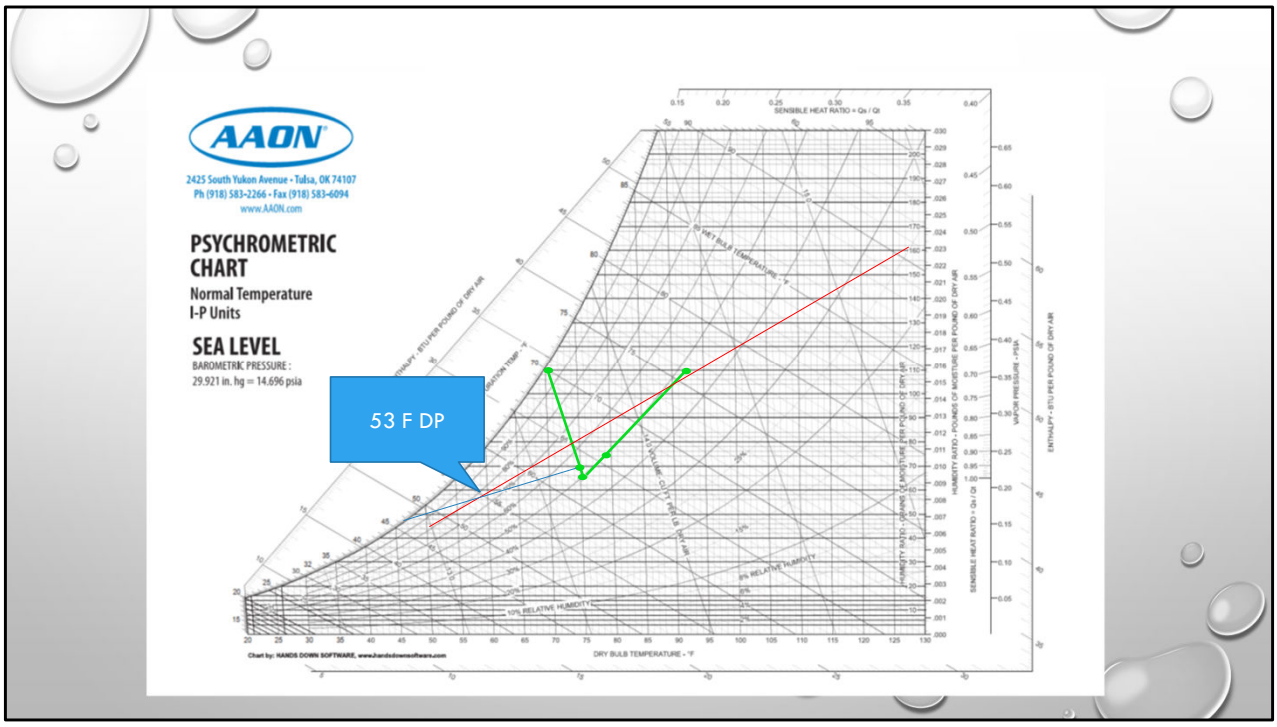
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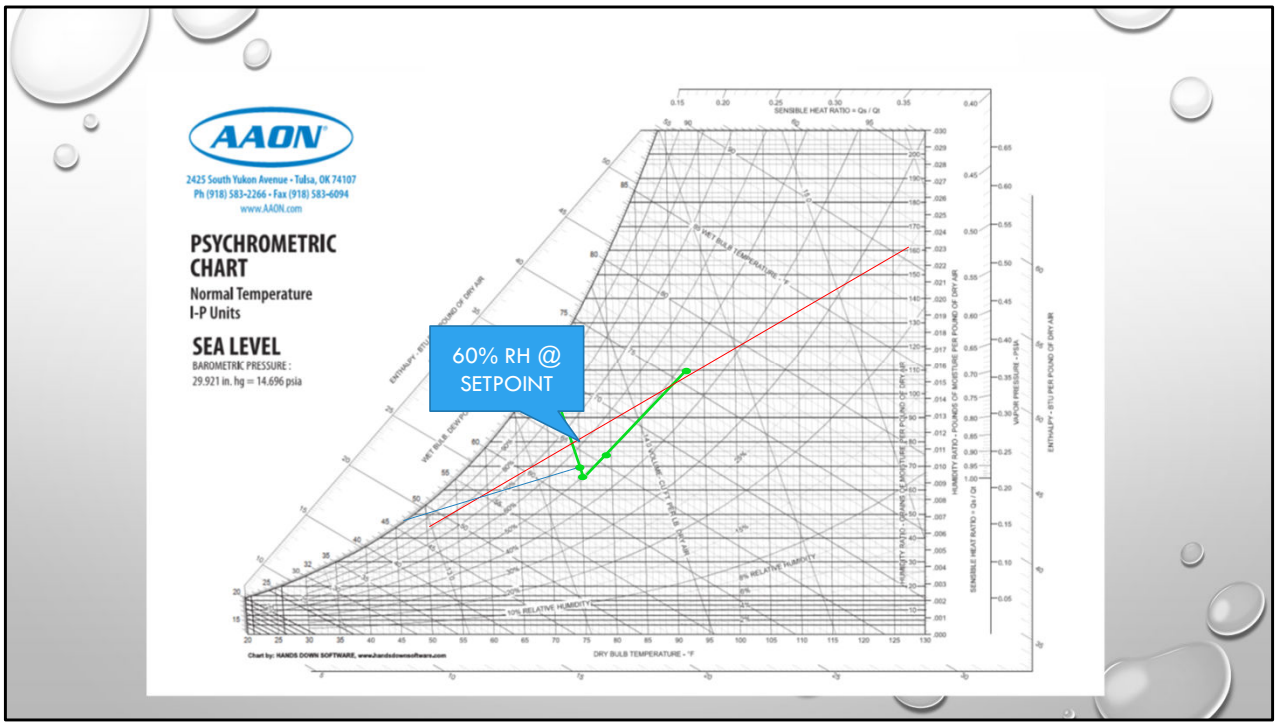
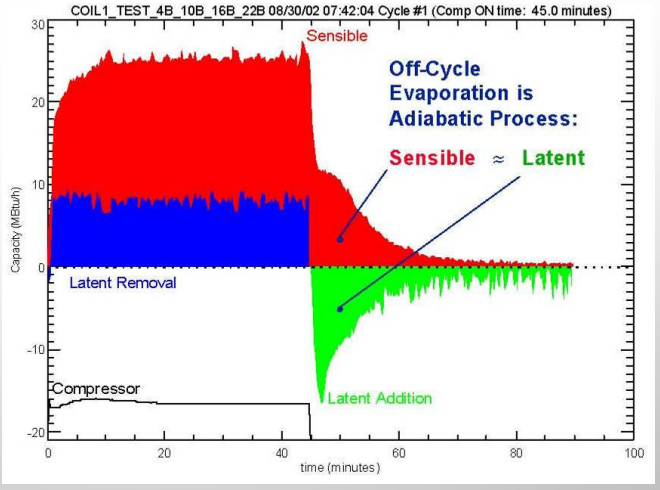


If the SHR of the space is lower than the SHR of the HVAC equipment serving the space, then the humidity level of the space will increase.

ON/OFF COMPRESSORS

Evaporation effect of On/Off compressors due to cycling



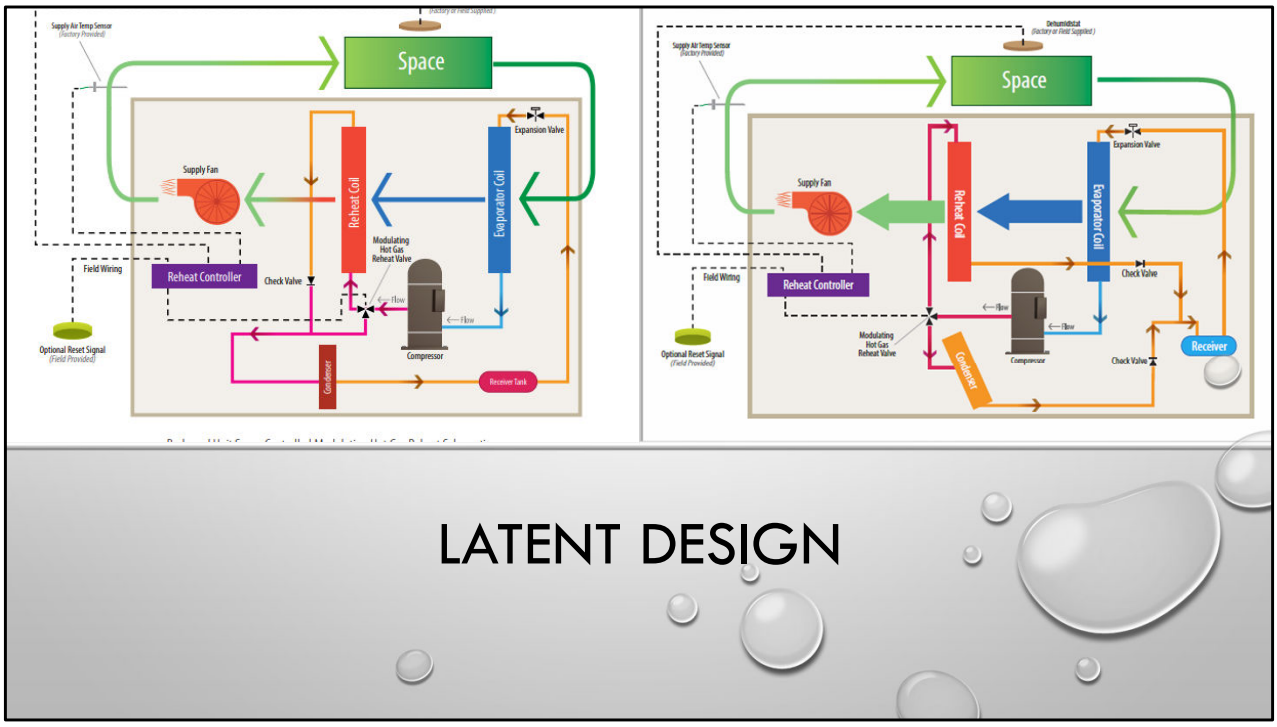
Courtesy of DOE/NETL Project #DE-FC26-01NT41253

Another adverse effect of using on-off compressors is independent of the system choice. The cycling of a compressor has an effect on the humidity introduced to a room or zone.

While the compressor is running and if the evaporator coil is cold enough, moisture is removed from the air through condensation. This condensation runs off the evaporator coil into the condensate pan and is directed out of a rooftop unit. The coil is wet because of the condensation effect created by a cold evaporator coil and moist air.

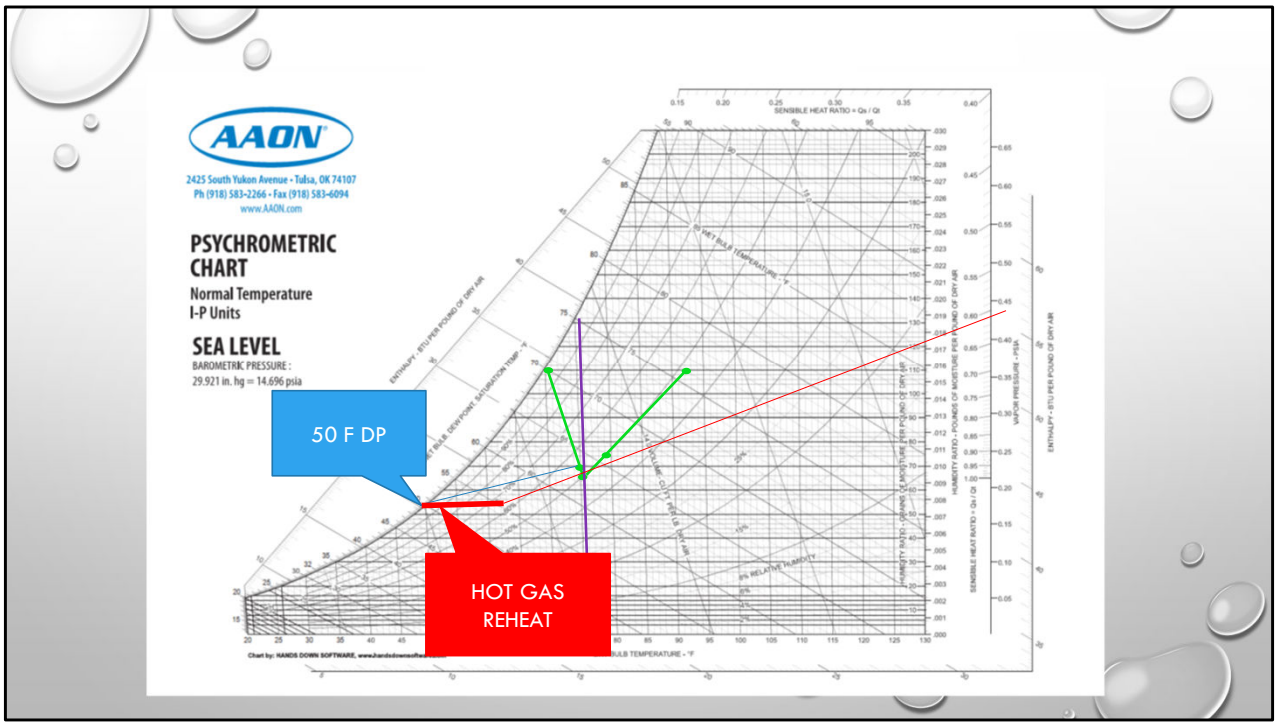
When a compressor cycles off, refrigerant is no longer expanded as it enters the evaporator coil. The evaporator coil warms up and no longer condenses moisture from the air stream. The air stream is passing through a wet, but inactive, evaporator coil. This air stream picks up the water resident on the coil. As the air stream evaporates, the moisture on the evaporator coil cools the air stream adiabatically though evaporation.
As that occurs the humidity ratio in the air stream increases. This continues until the coil is dried or the compressor cycles back on again.

So in addition to swings in space temperature, the cycling of a compressor will also cause swings in humidity levels. All this has an undesirable effect on the space conditions.



LATENT DESIGN

JRT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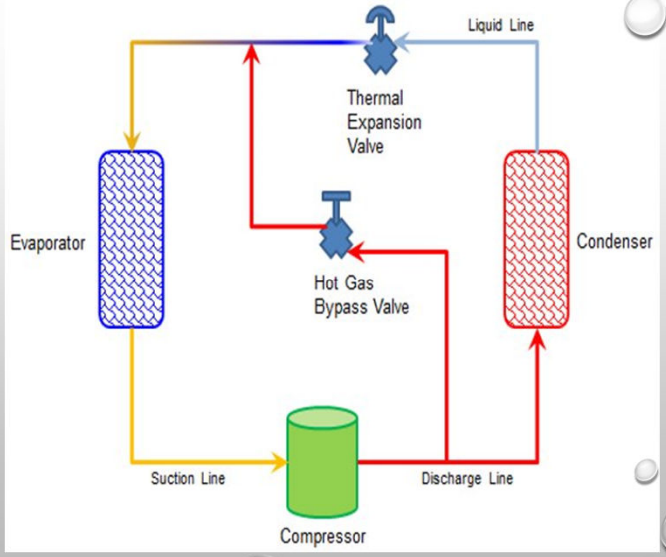
50 F DP
HOT GAS REHEAT

COMPRESSOR TYPES

- DIGITAL SCROLL COMPRESSOR
  - GREAT TURN DOWN <20%
  - ROBUST (NO OIL CONSIDERATIONS)
  - NOISE CONSIDERATIONS
- VFD SCROLL COMPRESSOR
  - TURN DOWN LIMITED TO 36-38 HZ
  - BEST PART LOAD EFFICIENCY
  - OIL RETURN CONSIDERATIONS

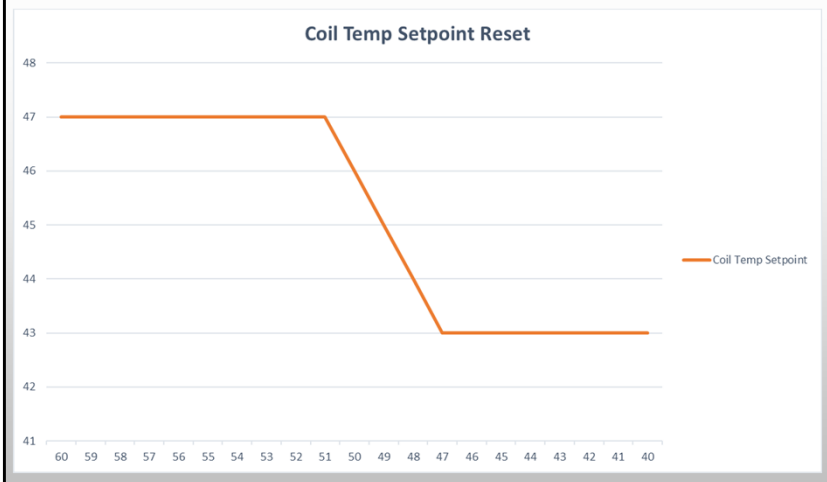
HOT GAS BYPASS

- NO FREEZING OF THE EVAPORATOR
- IN CASES OF RETROFIT FOR OVERSIZED EQUIPMENT
- IN CASES WHERE A SPEED OR VFD CONTROLLED COMPRESSOR CANNOT MODULATE LOW ENOUGH FOR CONTROL PURPOSES BECAUSE OF CONCERNS REGARDING OIL RETURN
- NOT HUMIDITY CONTROL

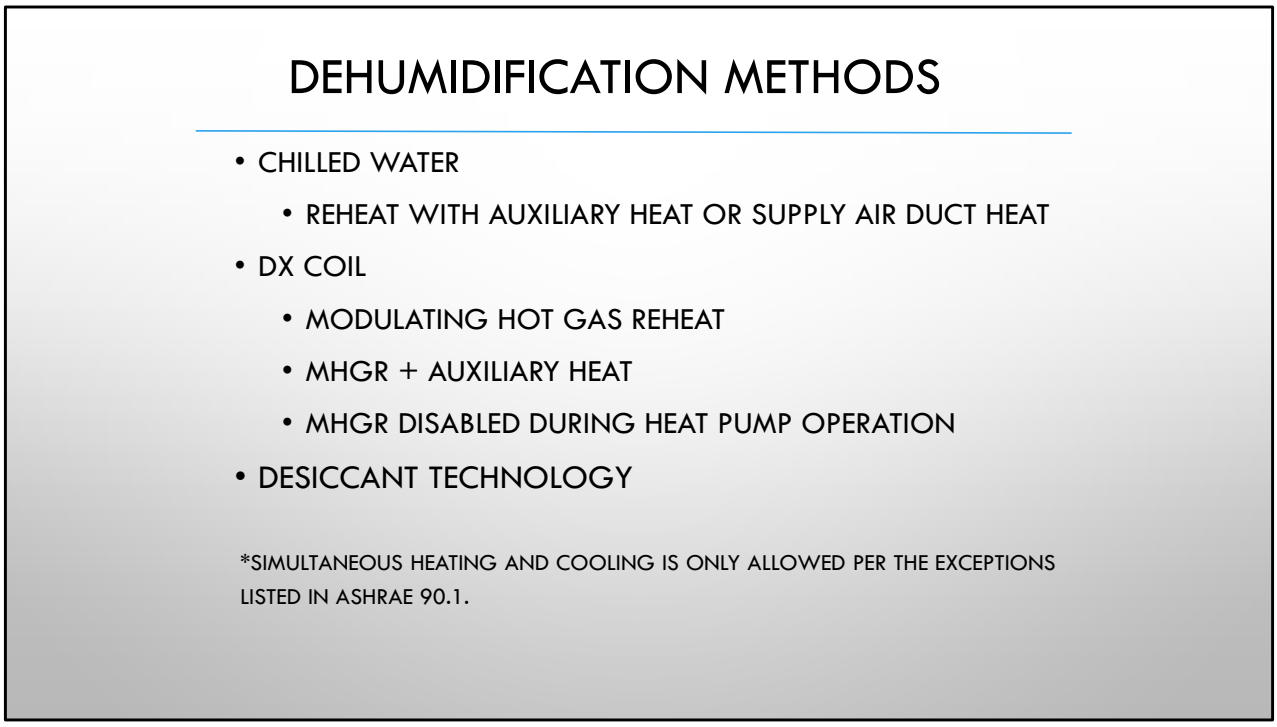


CONTROL STRATEGY

- CONTROLLING DX SYSTEMS AT LOW LOADS (<TURN DOWN) IS STILL A CHALLENGE?
- SO WHAT DO YOU DO?



DISCHARGE AIR TEMP RESET



LP

The modulating hot gas reheat valve modulates based on the supply air temperature. For example, if you want to maintain a 72F supply air temperature, the modulating valve will feed hot gas to the reheat coil until that temperature is reached. Sometimes the full amount of discharge gas goes through the reheat coil and sometimes only a percentage goes through the reheat coil while the remaining goes through the condenser coil.

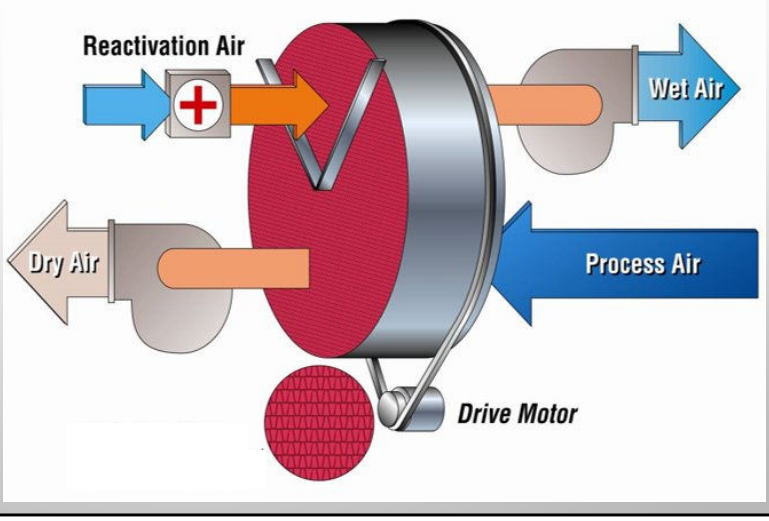
Precision control for humidity also comes down to what type of compressors are in the system. You will get the highest precision with dual digital. The digital + 2-stage compressor or VFD + 2-stage compressor will give you nearly the same precision control with a higher unit IEER than the dual digital unit. With the transition to the lag circuit reheat, you can gain more cooling capacity control with a more cost effective option.

Reheat is limited to the airflow rate that is required to comply with code or accreditation standard, whether that code is derived from ASHRAE Standard 62.1 or

ASHRAE/ASHE Standard 170, or some other standard.
Exceptions also include zones where 75% of the energy used for reheating is provided from site-recovered energy (including condenser heat).

DESICCANT DEHUMIDIFICATION

- BELOW 40 F DP
- USE LESS OA



SEQUENCE OF OPERATIONS FOR UNITS WITH MULTIPLE COMPRESSORS

- **TRANITION FROM COOLING MODE TO DEHUMIDIFICATION**
  - 1ST COMP ON EACH REFRIGERATION SYSTEM STAYS ACTIVE. LAG COMP ACTIVATES FOR DEHUM. IF COIL SUCTION TEMP FALLS TOO LOW, 1ST COMP STAGES OFF (LIGHT LOAD CONDITIONS).
- **TRANSITION FROM DEHUMIDIFICATION MODE TO COOLING**
  - 2ND COMP REMAINS ACTIVE AND 1ST COMP ACTIVATES (IF IT IS OFF). 2ND COMP STAGES OFF IF SUPPLY AIR GETS TOO COLD

LP