Dedicated Outdoor Air Systems (DOAS)

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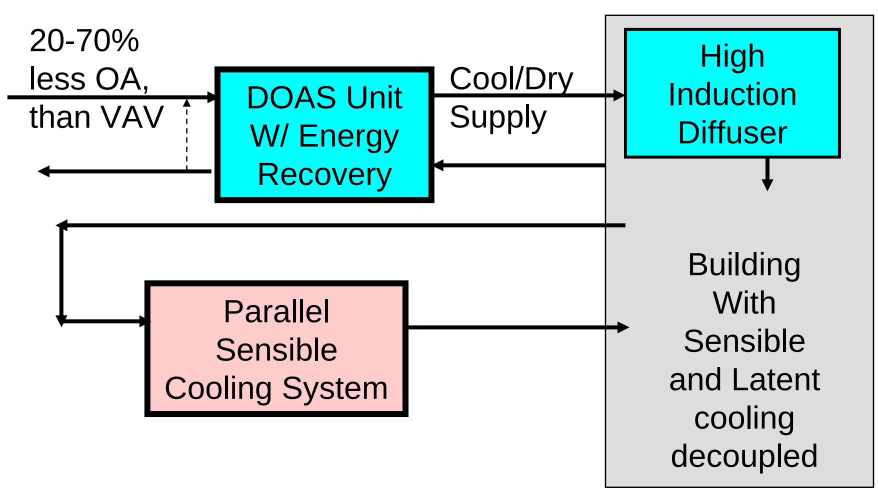
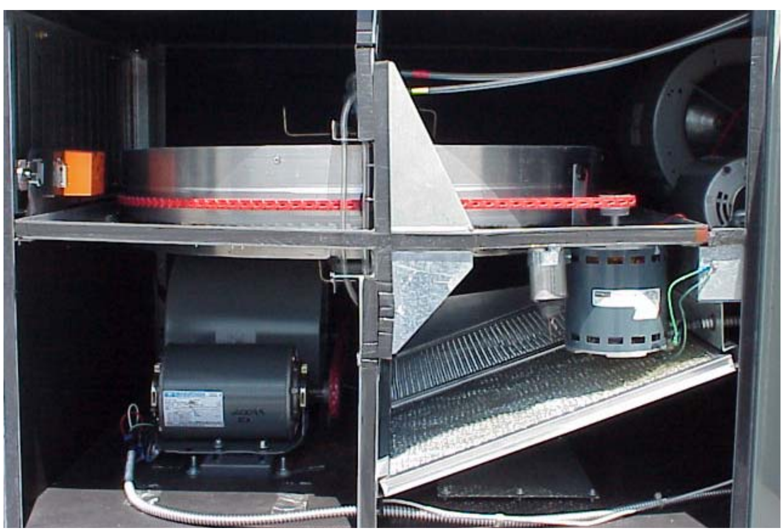
DOAS Defined for this presentation



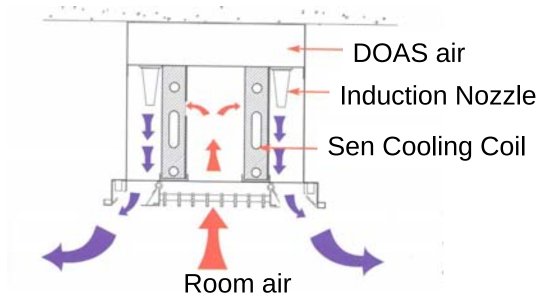
Key DOAS points:

1. 100% OA delivered to each zone via its own ductwork.
2. Flow rate generally as spec. by Std. 62.1-2007 or greater (LEED, Lat. Ctl)
3. Employ TER, per Std. 90.1-2007.
4. Generally CV.
5. Use to decouple space S/L loads—Dry.
6. Rarely supply at a neutral temperature.
7. Use HID, particularly where parallel sys does not use air.

Total Energy Recovery wheel



Parallel Terminal Systems



Chilled Beams

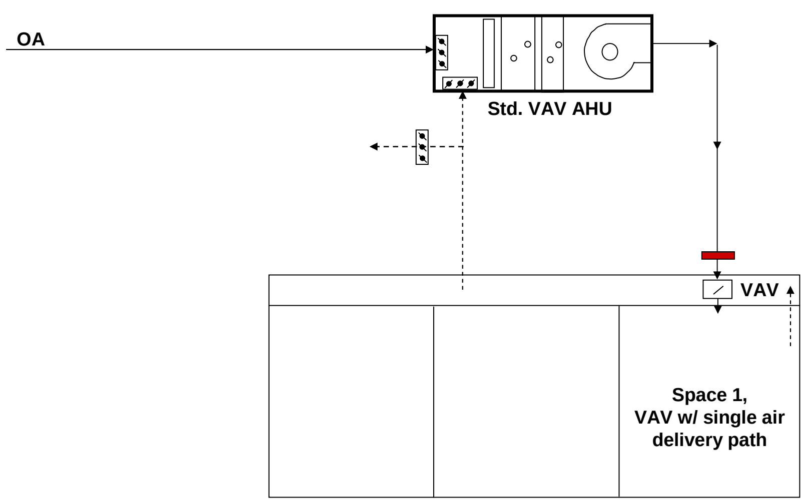
Fan Coil Units

Air Handling Units
CV or VAV

VRV
Multi-Splits

Unitary ACs
i.e. WSHP's

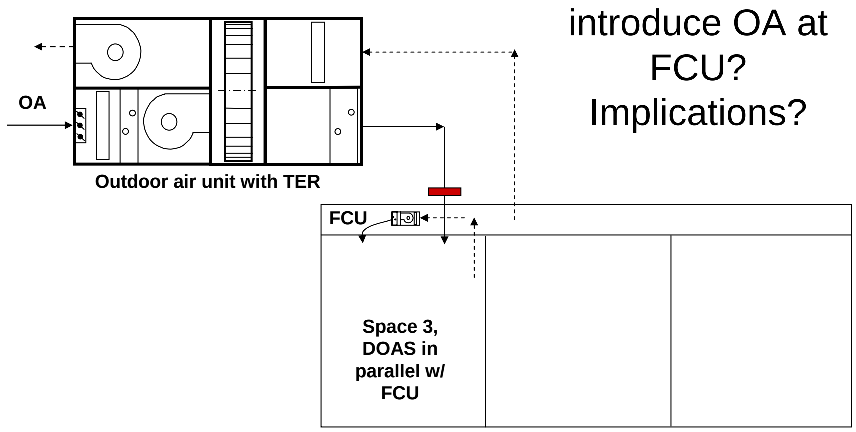
Standard VAV System



Inherent problems with VAV Systems

- Poor air distribution.
- Poor humidity control.
- Poor acoustical properties.
- Poor use of plenum and mechanical shaft space.
- Serious control problems, particularly with tracking return fan systems.
- Poor energy transport medium, air.
- Poor resistance to the threat of biological and chemical terrorism, and
- Poor and unpredictable ventilation performance.

DOAS with Parallel FCU



Other ways to introduce OA at FCU? Implications?

VAV problems solved with DOAS/parallel FCU

- **Poor air distribution.**
- **Poor humidity control.**
- Poor acoustical properties.
- Poor use of plenum and mechanical shaft space.
- **Serious control problems, particularly with tracking return fan systems**.
- Poor energy transport medium, air.
- **Poor resistance to the threat of biological and chemical terrorism,** and
- **Poor and unpredictable ventilation performance.**

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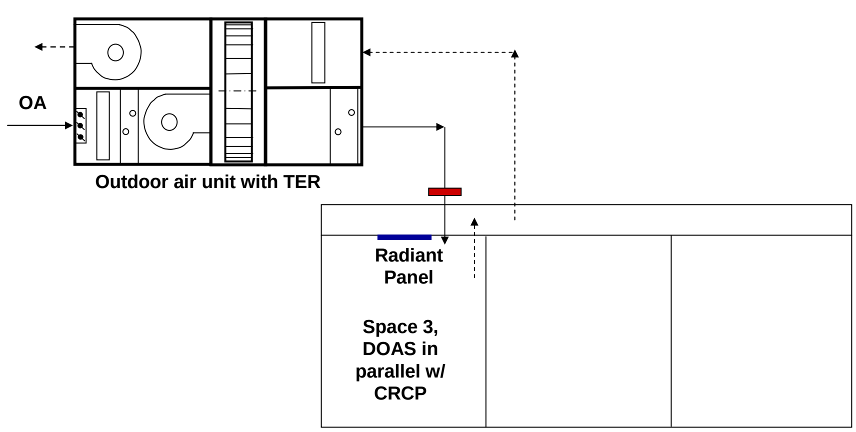
DOAS with Parallel Radiant



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VAV problems solved with DOAS/Radiant

- **Poor air distribution.**
- **Poor humidity control.**
- **Poor acoustical properties.**
- **Poor use of plenum and mechanical shaft space.**
- **Serious control problems, particularly with tracking return fan systems.**
- **Poor energy transport medium, air.**
- **Poor resistance to the threat of biological and chemical terrorism, and**
- **Poor and unpredictable ventilation performance**.

Additional benefits of DOAS/Radiant

Beside solving problems that have gone unsolved for over 35 years with conventional VAV systems, note the following benefits:

- Greater than 50% reduction in mechanical system operating cost compared to VAV.
- Equal or lower first cost.
- Simpler controls.
- Generates up to 80% of points needed for basic LEED certification**.**

Role of Total Energy Recovery

DOAS & Energy Recovery

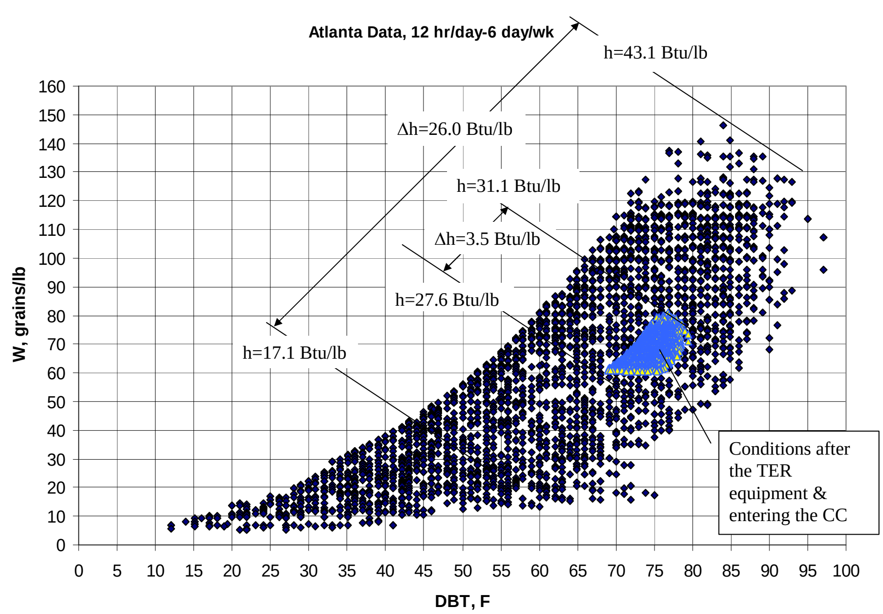
ASHRAE Standard 90.1-2007 in section 6.5.6.1 Exhaust Air Energy Recovery requires the following:

"Individual fan systems that have both a ***design supply air capacity of 5000 cfm*** or greater and have a ***minimum outside air supply of 70%*** or greater of the design supply air quantity shall have an energy recovery system ***with at least 50% total energy recovery effectiveness."***

Std 62.1-2007 allows its use with class 1-3 air.

Merits of using an TER (Enthalpy Wheel) with DOAS

- A significant reduction in the design OA load, reducing both the chiller size & the peak demand,
- A reduction in the annual OA cooling and dehumidify energy consumption,
- A significant reduction in the OA heating and humidification energy consumption (in the N)
- Conforms to ASHRAE Standard 90.1-2007
- A major reduction in the variability of the OA conditions entering the CC (critical w/ pkg.equip.)



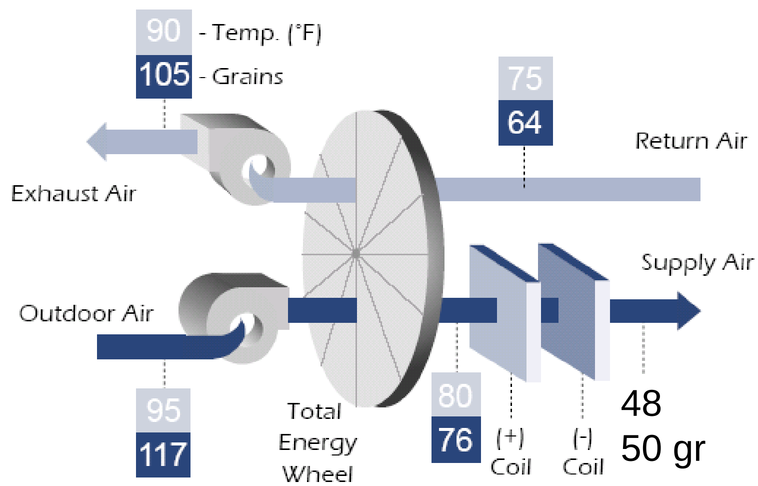
Implications of the Small Area on the Psychrometric Chart Entering the CC

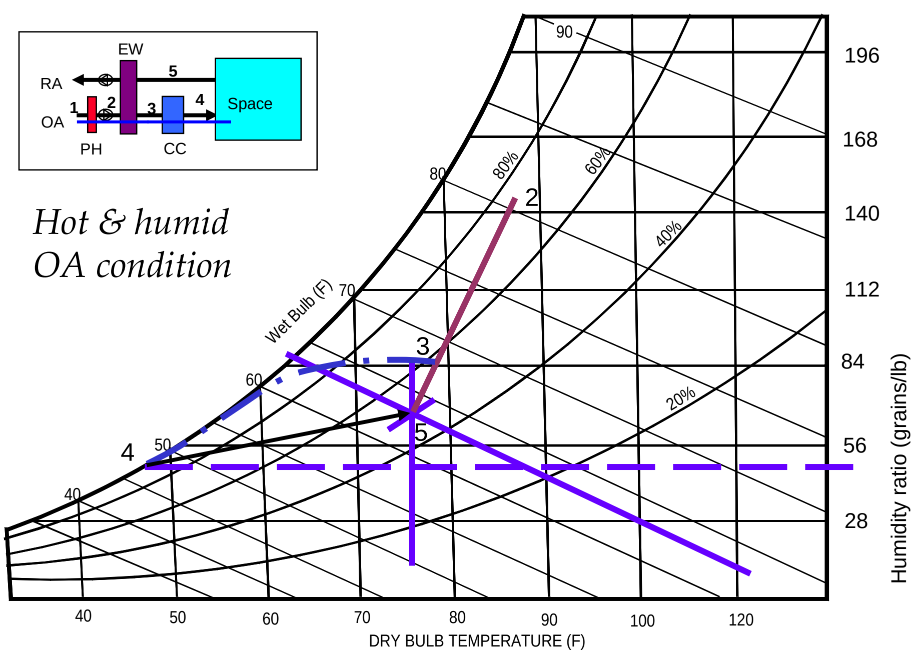
- Variation in the OA load on the CC ranges by only 25% (from a low of 75% to a max of 100%)
- At peak design load conditions, the enthalpy wheel reduces the OA load on the chiller by 46%when SA DPT=44F, ie doing part of the space sensible cooling and 100% of space latent cooling.

DOAS equipment on the market today

- I: Cooling equipment that adds sensible energy recovery or hot gas for central reheat.
- II: Cooling equipment that uses total energy recovery.
- III: Cooling equipment that uses total energy recovery and passive dehumidification wheels
- IV: Cooling equipment that uses active dehumidification wheels, generally without energy recovery.

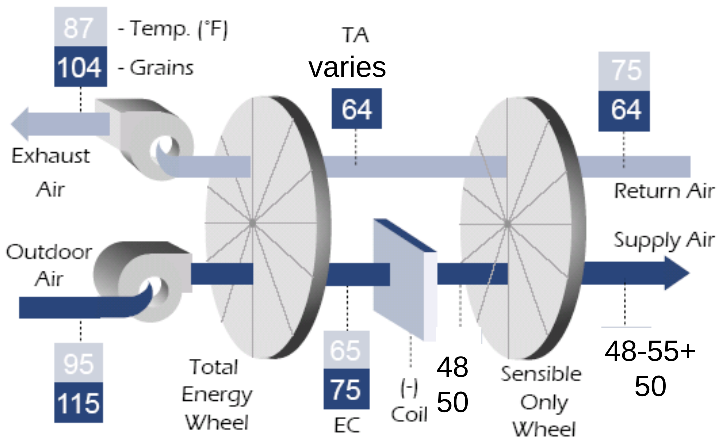
DOAS equipment on the market today



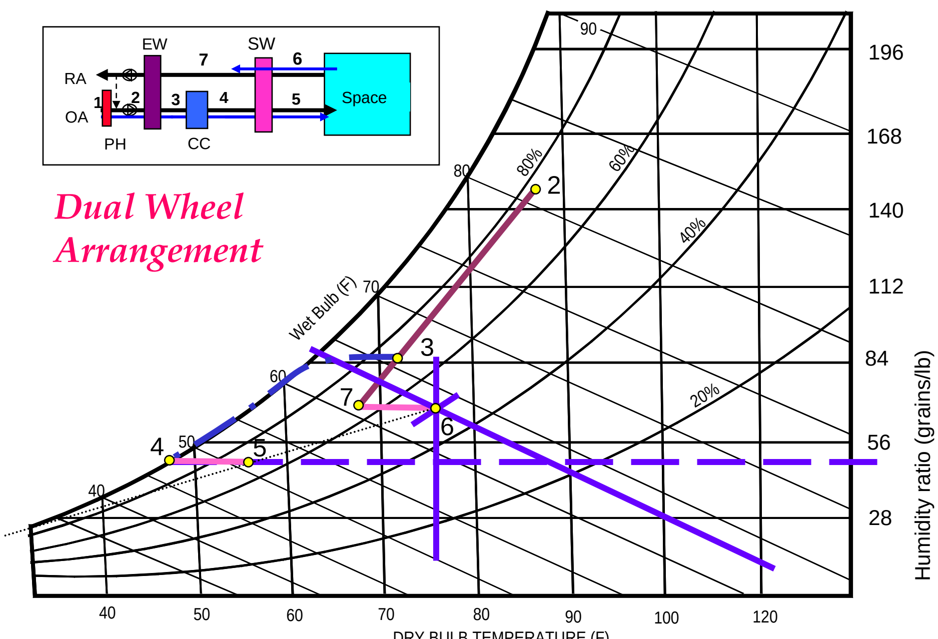


Hot & humid OA condition

DOAS equipment on the market today



Dual Wheel Arrangement

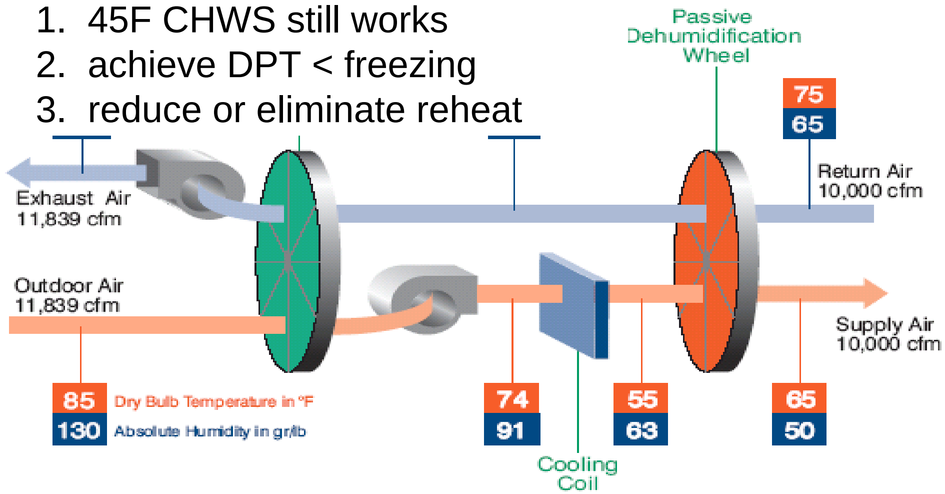


DOAS equipment on the market today

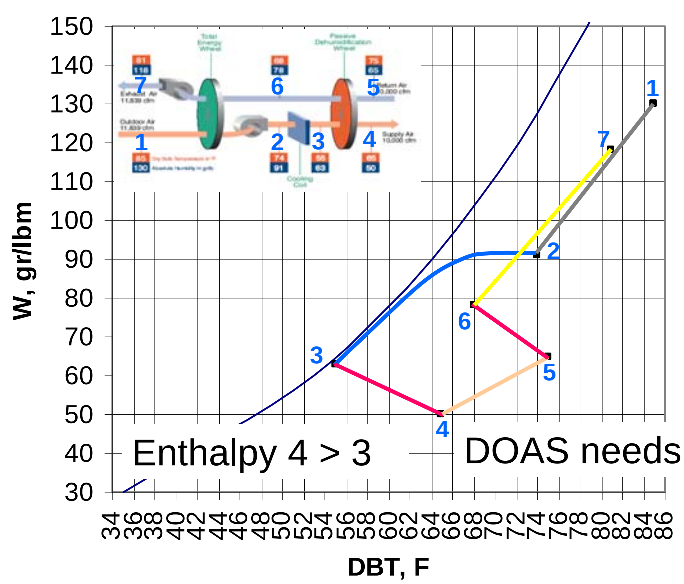
Desiccant added for 3 reasons:

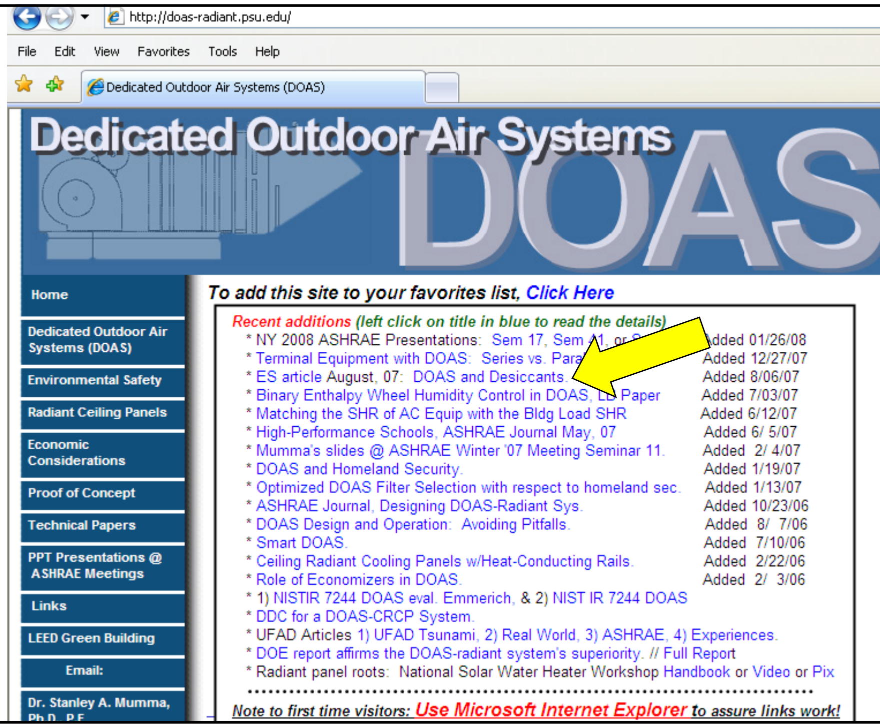
1. 45F CHWS still works
2. achieve DPT < freezing
3. reduce or eliminate reheat

Type 3

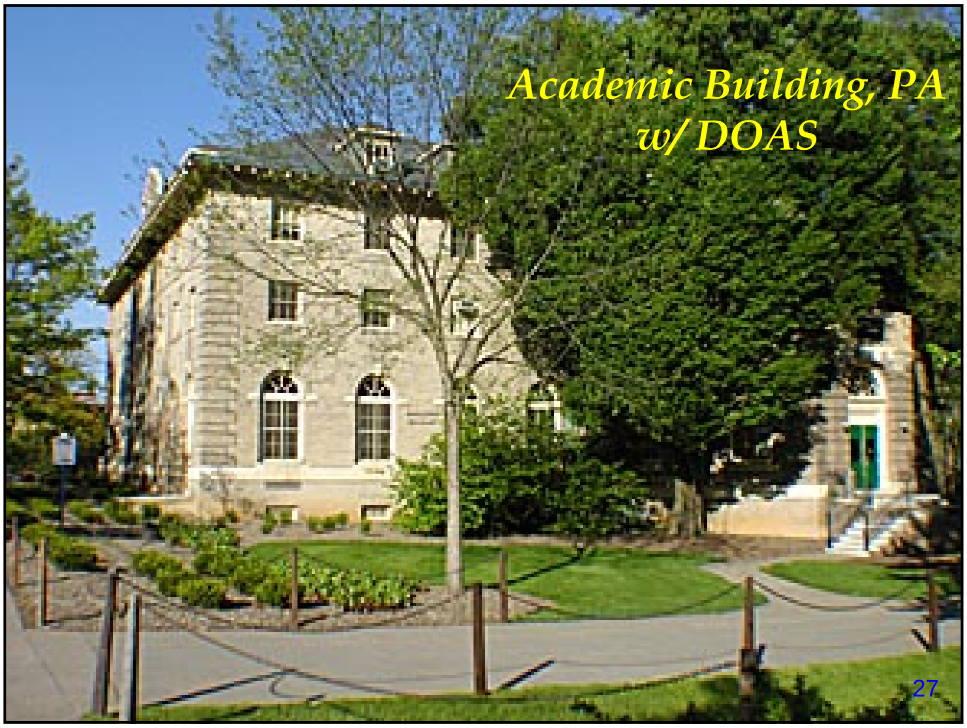


Process on the Psych Chart





Some ATC Design Issues
and
DOAS in a Campus building, with FCUs and CRCPs.


Academic Building, PA
w/ DOAS
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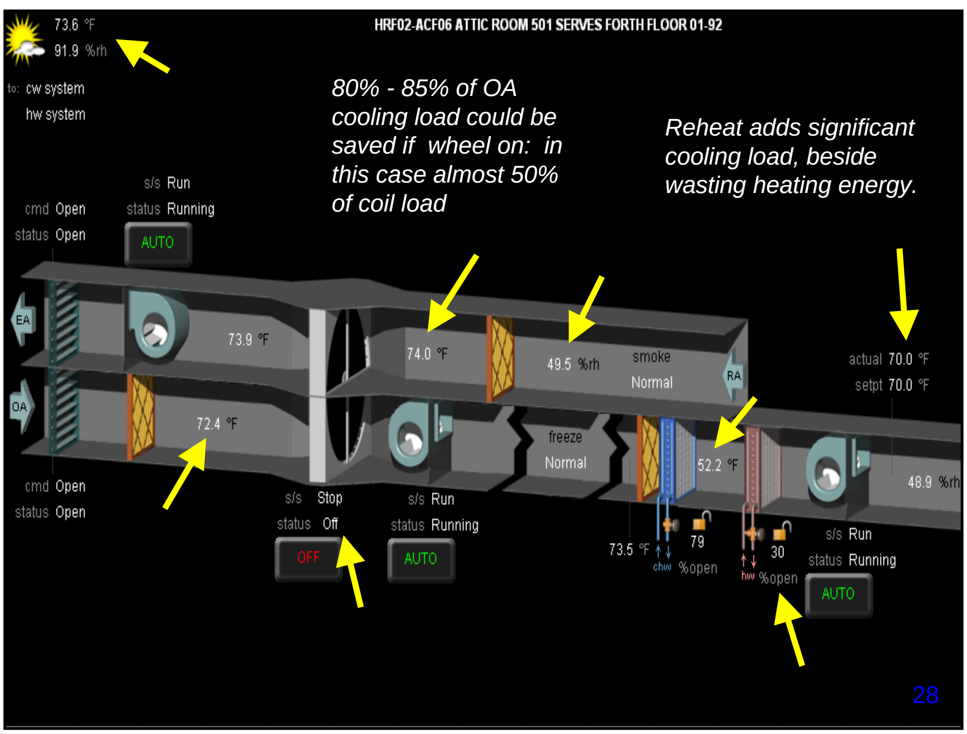
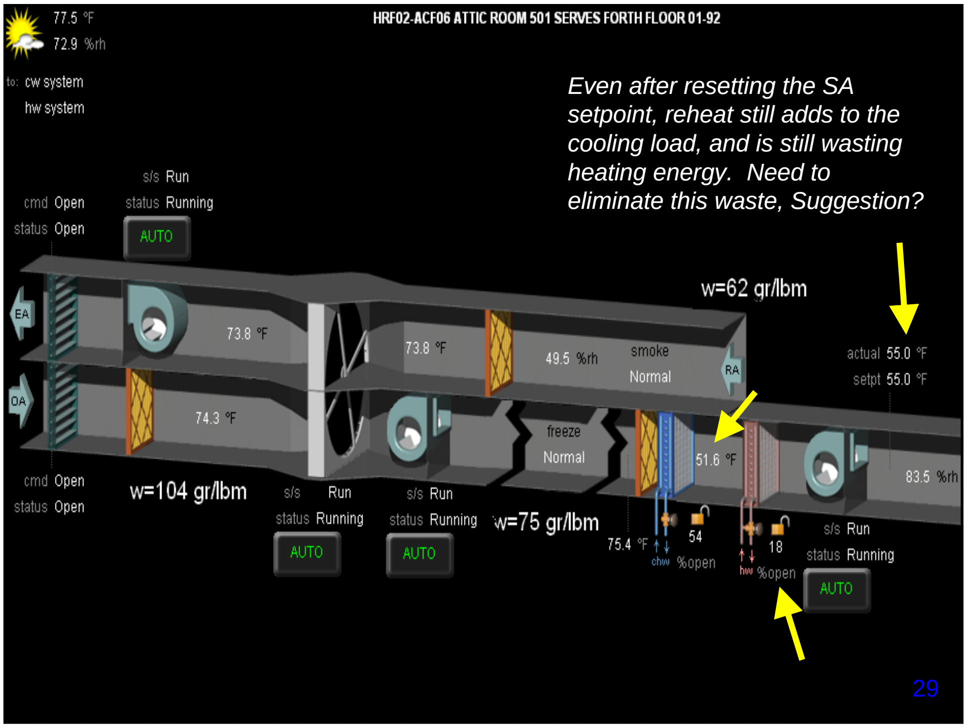
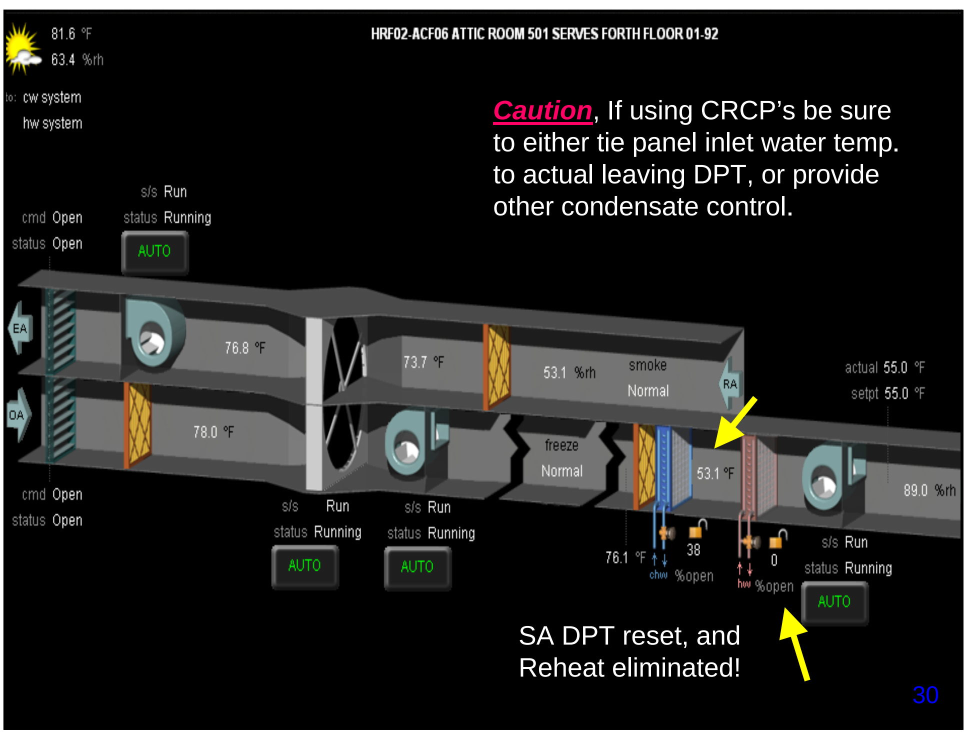

73.6 °F
91.9 %rh
HRF02-ACF06 ATTIC ROOM 501 SERVES FORTH FLOOR 01-92
to: cw system
hw system
80% - 85% of OA cooling load could be saved if wheel on: in this case almost 50% of coil load
Reheat adds significant cooling load, beside wasting heating energy.
s/s Run
status Running
cmd Open
status Open
AUTO
EA
OA
73.9 °F
72.4 °F
74.0 °F
49.5 %rh
smoke
Normal
RA
actual 70.0 °F
setpt 70.0 °F
freeze
Normal
52.2 °F
48.9 %rh
cmd Open
status Open
s/s Stop
status Off
OFF
s/s Run
status Running
AUTO
73.5 °F
chw
79
%open
hw
30
%open
s/s Run
status Running
AUTO
28


HRF02-ACF06 ATTIC ROOM 501 SERVES FORTH FLOOR 01-92
77.5 °F
72.9 %rh
to: cw system
hw system
Even after resetting the SA setpoint, reheat still adds to the cooling load, and is still wasting heating energy. Need to eliminate this waste, Suggestion?
s/s Run
status Running
AUTO
cmd Open
status Open
EA
OA
73.8 °F
74.3 °F
73.8 °F
49.5 %rh
smoke
Normal
RA
w=62 gr/lbm
actual 55.0 °F
setpt 55.0 °F
freeze
Normal
51.6 °F
83.5 %rh
cmd Open
status Open
w=104 gr/lbm
s/s Run
status Running
AUTO
s/s Run
status Running
AUTO
w=75 gr/lbm
75.4 °F
54
chw %open
18
hw %open
s/s Run
status Running
AUTO
29


HRF02-ACF06 ATTIC ROOM 501 SERVES FORTH FLOOR 01-92
81.6 °F
63.4 %rh
to: cw system
hw system
Caution, If using CRCP's be sure to either tie panel inlet water temp. to actual leaving DPT, or provide other condensate control.
s/s Run
status Running
AUTO
cmd Open
status Open
EA
OA
76.8 °F
78.0 °F
73.7 °F
53.1 %rh
smoke
Normal
RA
actual 55.0 °F
setpt 55.0 °F
freeze
Normal
53.1 °F
89.0 %rh
cmd Open
status Open
s/s Run
status Running
AUTO
s/s Run
status Running
AUTO
76.1 °F
38
chw %open
0
hw %open
s/s Run
status Running
AUTO
SA DPT reset, and Reheat eliminated!
30

A few other DOAS Applications

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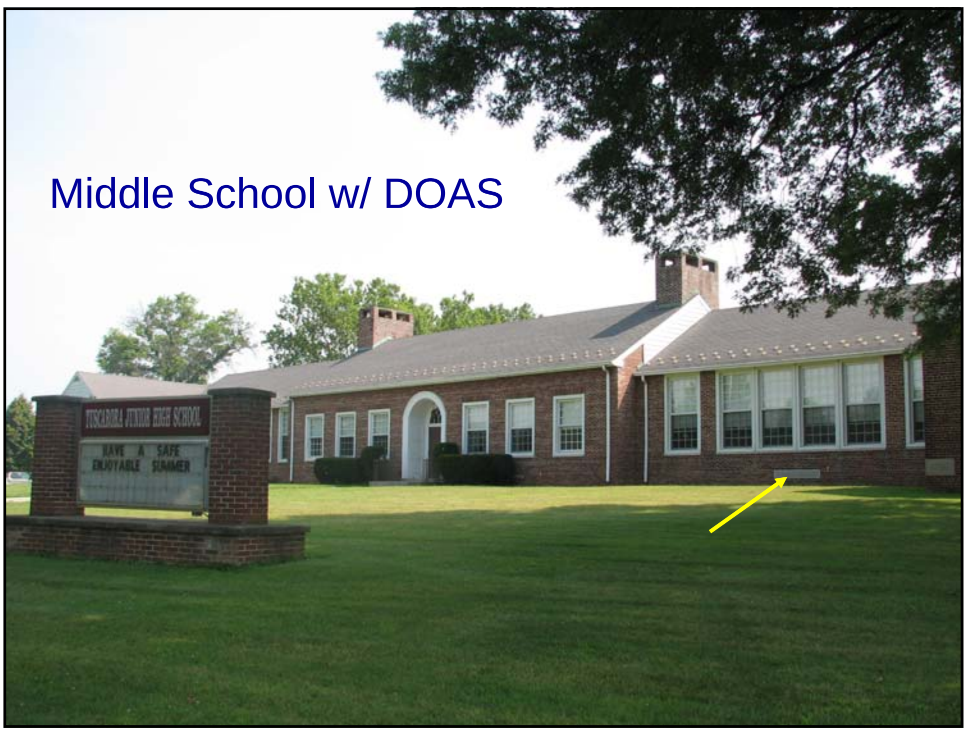
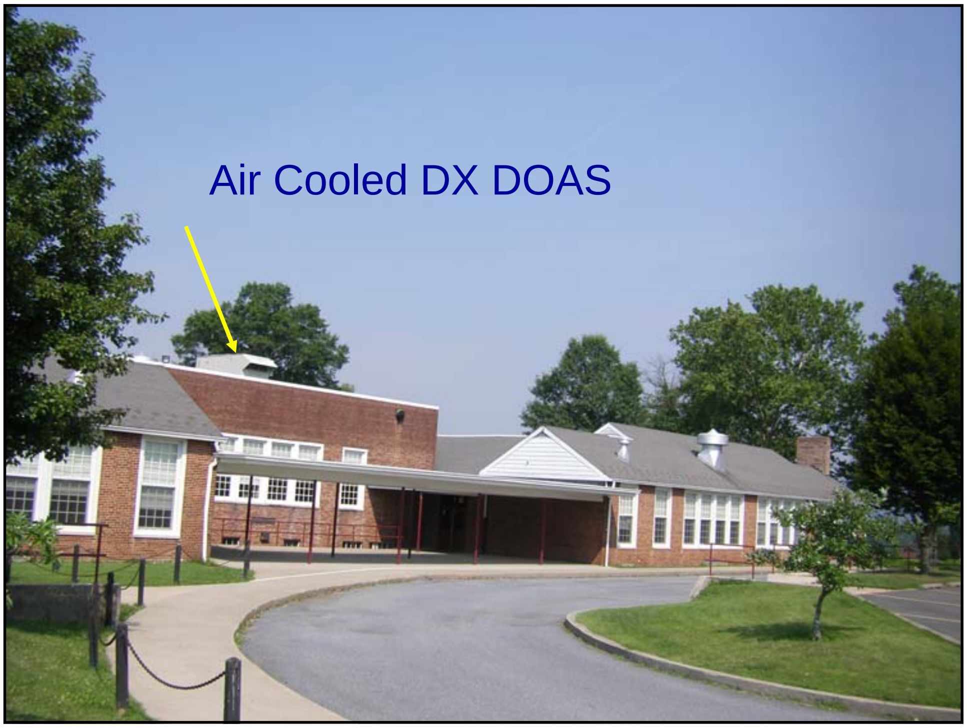
ASHRAE HDQ DOAS
VRV Outdoor Units


Middle School w/ DOAS
HAVE A SAFE
ENJOYABLE SUMMER


Air Cooled DX DOAS

DOE Report: Ranking of DOAS and parallel Radiant Cooling

Energy Consumption Characteristics of Commercial Building HVAC Systems: Volume III, Energy Savings Potential

Available at:
http://doas-radiant.psu.edu/DOE_report.pdf

Table 4-1: Energy Savings Potential Summary for 15 Options

Technology Option	Technology Status	Technical Energy Savings Potential (quads)
Adaptive/Fuzzy Logic Controls	New	0.23
Dedicated Outdoor Air Systems	Current	0.45
Displacement Ventilation	Current	0.20
Electronically Commutated Permanent Magnet Motors	Current	0.15
Enthalpy/Energy Recovery Heat Exchangers for Ventilation	Current	0.55
Heat Pumps for Cold Climates (Zero-Degree Heat Pump)	Advanced	0.1
Improved Duct Sealing	Current/New	0.23
Liquid Desiccant Air Conditioners	Advanced	0.2 / 0.06[12]
Microenvironments / Occupancy-Based Control	Current	0.07
Microchannel Heat Exchanger	New	0.11
Novel Cool Storage	Current	0.2 / 0.03[13]
Radiant Ceiling Cooling / Chilled Beam	Current	0.6
Smaller Centrifugal Compressors	Advanced	0.15
System/Component Diagnostics	New	0.45
Variable Refrigerant Volume/Flow	Current	0.3

#3 (Dedicated Outdoor Air Systems)

#2 (Enthalpy/Energy Recovery Heat Exchangers for Ventilation)

#1 (Radiant Ceiling Cooling / Chilled Beam)

Both DOAS and Radiant have instant paybacks

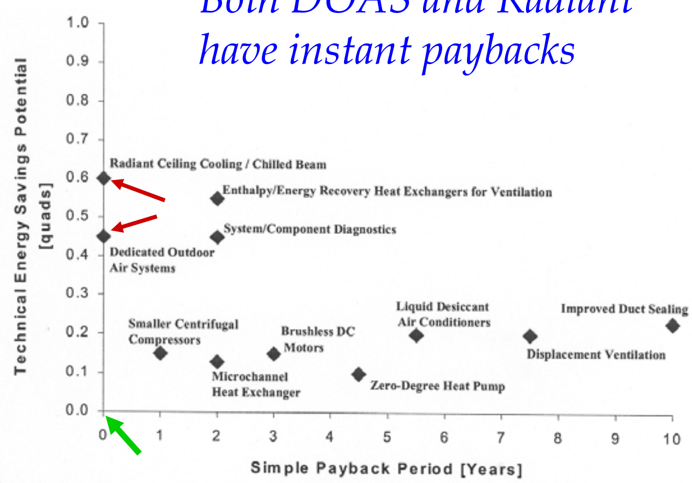


Figure 5-2: Estimated Technical Energy Savings Potential and Simple Payback Periods for the 15 Options

Mumma Preferred equipment choices

- Always consider dual path DOAS to the spaces, and use where it makes sense.
- I have yet to find a DOAS application where EW's should not be used, when controlled properly.
- In most situations, use mechanical refrigeration to dehumidify, even if it means increasing the ventilation rate above the Std. 62.1 minimums. Choice is supported by the ASHRAE research.
- To achieve the low temperature chilled water economically, use OPAC where cost effective.
- The DOAS principles being applied in the ASHRAE LEED Green Gold renovation of the Atlanta HDQ

Conclusion

- It is time to select systems that solve the inherent problems of VAV,
- While retaining the advantages of VAV,
- At equal or lower first cost,
- With lower operating cost,
- And achieves superior humidity control, thermal comfort, and health and productivity.

(1) What has ASHRAE supported research found?
(2) How should the OA be introduced in DOAS-FCU applications?
(3) Can the thermal and fire protection hydronic systems be integrated?
(4) How do you address the concerns of condensation, capacity and cost when using DOAS-Radiant systems
(5) Where do the energy benefits come from when using DOAS vs. VAV?
(6) Are the DOAS controls more complex than VAV?
(7) How is heating done with DOAS systems?
(8) Are DOAS systems comfortable?
(9) What is the economic impact of improved IEQ with DOAS?
(10) Is DCV beneficial in DOAS applications?
(11) Can system degradation be detected and avoided in DOAS applications?
(12) Are ASHRAE air change criteria met w/ DOAS?
(13) Are the high induction diffusers capable of providing good ADPI?
(14) Have your DOAS-radiant applications ever experienced condensation problems? If not why not?
(15) Is it possible to create unacceptable cold drafts, even with high induction diffusers, when untempered OA is used to provide cooling on a 0ºF winter day?
(16) How do DOAS's perform under the threat of terrorist activities?
(17) What are common pitfalls to be avoided when applying DOAS?
(18) Why is it necessary to provide more OA to a VAV system than a DOAS?
(19) Fundamentally how do ceiling radiant panels behave thermally?
(20) Fundamentally how do active chilled beams behave thermally?
(21) Fundamentally how do passive chilled beams behave thermally?
(22) How do you respond to this NIST report quote?: "The more complex DOAS system modeling still showed latent cooling being provided by WSHP's in the zones".
(23) What is the impact of the loss of air side economizer operation?
(24) Can DOAS generate LEED Green Building Rating Points?
(25) What Are Others Saying About DOAS
(26) How Important is Envelope Integrity?
(27) How is ASHRAE HDQ renovation "walking the talk"?
(28) How does a chilled floor behave?
(29) How is the design SA DPT determined?
(30) What are the design steps?
(31) Can you illustrate the DOAS performance for non-hot and wet conditions?
(32) Do DOAS-hydronic parallel systems actually exist in the US?
(33) How do your recommend responding to a "Code Orange" air quality alert?