Key Presentation Points

- Problems with common VAV systems.
- DOAS defined.
- Parallel sensible terminal equipment choices.
- System Selection Matrix.
- Issues
- Conclusions.
Current HVAC system of choice: VAV

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
- Poor and unpredictable ventilation performance
Poor & unpredictable vent’n performance.

AHU
6,000 cfm

% OA<sub>b</sub> = 60

OA<sub>b</sub> = 3,600 cfm

1,500 cfm

4,500 cfm

OA<sub>req'd</sub> = 900 cfm

OA<sub>req'd</sub> = 1,350 cfm

OA=2,250? (900+1,350) No!

Eq. for OA? Why not?

OA+(6,000-OA)*0.225=3,600

OA=2,903, ~30% more, but no LEED point

2,903-(900+1,350)=653

more than table 6-1 value

Where does the 653 cfm go?

Unvit ratio = 0.225

1,350/6,000

Can VAV limitations be overcome?

AHU
2,250 cfm

% OA<sub>b</sub> = 100

OA<sub>b</sub> = 2,250 cfm

1,350 cfm

OA<sub>req'd</sub> = 1,350 cfm

How is the space load handled, when 6,000 cfm required for a VAV?
DOAS Defined for This Presentation

- DOAS Unit w/ Energy Recovery
- Cool/Dry Supply
- High Induction Diffuser
- Building with Sensible and Latent Cooling Decoupled
- Pressurization
- 20%-70% less OA than VAV

Key DOAS Points

1. 100% OA delivered to each zone via its own ductwork
2. Flow rate generally as spec. by Std. 62.1 or greater (LEED, Latent. Ctrl)
3. Employ TER, per Std. 90.1
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 system does not use air
Total Energy Recovery (TER) Wheel

High Induction Diffuser

- Provides complete air mixing
- Evens temperature gradients in the space
- Eliminates short-circuiting between supply & return
- Increases ventilation effectiveness
Parallel Terminal Systems

- DOAS air
- Induction Nozzle
- Sen Cooling Coil
- Room air
- Chilled Beams
- Fan Coil Units
- Air Handling Units
  - CV or VAV
- VRV Multi-Splits
- Unitary ACs i.e., WSHPs
DOAS with Parallel VAV

VAV Problems Solved with DOAS/Parallel VAV

- 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
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- Poor and unpredictable ventilation performance
DOAS with Parallel FCU

Other ways to introduce OA at FCU? Implications?

Parallel vs. Series OA introduced for DOAS-FCU applications?

Parallel, Good  Series, Bad
Advantages of the correct paradigm parallel FCU-DOAS arrangement

- At low sensible cooling load conditions, the terminal equipment may be shut off — saving fan energy
- The terminal device fans may be downsized since they are not handling any of the ventilation air, reducing first cost
- The smaller terminal fans result in fan energy savings
- The cooling coils in the terminal FCU’s are not derated since they are handling only warm return air, resulting in smaller coils and further reducing first cost.
- Opportunity for plenum condensation is reduced since the ventilation air is not introduced into the plenum near the terminal equipment, for better IAQ

VAV Problems Solved with DOAS/Parallel FCU

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- Poor and unpredictable ventilation performance
DOAS with Parallel Radiant, or Chilled Beam

- 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
- Poor and unpredictable ventilation performance
**Additional Benefits of DOAS/Radiant-Chilled Beam**

Beside solving problems that have gone unsolved for nearly 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

**DOAS Equipment on the Market Today**

I: Equipment that adds sensible energy recovery or hot gas for central reheat

II: Equipment that uses total energy recovery

III: Equipment that uses total energy recovery and passive dehumidification wheels

IV: Equipment that uses active dehumidification wheels, generally without energy recovery
DOAS Equipment on the Market Today

Hot & humid OA condition

Dry Bulb Temperature (F) 40 50 60 70 80 90 100 120
Humidity ratio (grains/lb) 28 56 84 112 140 168 196

Space

O2: 80
H: 76
H & h: 117

Exhaust Air
Outdoor Air
Total Energy Wheel
Supply Air
Return Air

Temp. (°F)
Grains
O2
H
H & h
DOAS & Energy Recovery

ASHRAE Standard 90.1 and ASHRAE’s new Standard for the Design Of High Performance Green Buildings (189.1) both require DOAS systems to utilize TER for almost the entire USA regardless of system size as illustrated in the next slide. They also require that the total effectiveness be at least 50 and 60% respectively.

The Stds permit the use of class 1-3 air w/ TER.
1,603 hours in hot/humid region. 70% ε EW reduces peak load from 69T to 44T, (25T reduction) and saves 11,680 TH or $1,168/yr assuming 10,000 cfm OA, 1 kW/T, $0.10/kWh
## Selection matrix

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<td>5/10</td>
<td>8/16</td>
<td>254</td>
</tr>
</tbody>
</table>

- **Max points, 272: VAV 53%, DOAS-Rad 90%**

- Category Feature rating/score
- System performance in a category (i.e. 1st cost) rating 1-8 (8 Best): i.e. FCUw DOAS meeting 1st cost earns a 7
- Importance weighting of a category 1-5 (5 most important)
- Score: in a cell: product of importance weighting and system performance. i.e. for CRCP-DOAS in the category of Op $, the score is $4 \times 8 = 32$

**Conventional VAV 145 pts: DOAS-Rad 254 pts**
DOAS Issues

- Reserve capacity
- EW issues, including control
- SA Conditions
- 30% surplus OA for a LEED point
- Lost air side economizer
- Filtration/Terror resistance
- Pressurization/floor component
  62.1/unbalanced flow @ EW
- Toilet Exh/recirc. Air
- Direct/indirect evap. cool
Conclusion

- DOAS offers the following benefits:
  - Assured ventilation performance.
  - Excellent IEQ.
  - Low energy use compared to all air systems.
  - Much simpler controls compared to VAV.
  - Competitive first cost.

- Congratulations to those of you already designing/building/using DOAS !!!!!!!!