Building Systems: HVAC

Committee on Microbiomes of the Built Environment
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Outline

• Ventilation Systems
• Moisture sources
• Low energy technologies
• Installation/Operation/Maintenance
• Summary
three ventilation systems

**Constant Volume**

**Basic System – Single Zone**
- One zone, one unit
- Direct temp control (lvg coil temp 55F to 75F)
- Indirect humidity, air cleaning, ventilation control
- Local ventilation
- Probably more of these than any other system

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**zone temperature determines AHU cooling capacity**
three ventilation systems

Constant Volume

Basic System – Single Zone

• Oh, yeah.
• Winter operation – there is a heating coil, too.
• Seldom direct control of rh or dp, so cold climates run dry in winter ...

Rooftop, unit ventilation, ptac

zone temperature determines AHU cooling capacity
three ventilation systems

Constant Volume – Design Load

<table>
<thead>
<tr>
<th></th>
<th>OA</th>
<th>RA'</th>
<th>MA'</th>
<th>SA'</th>
</tr>
</thead>
<tbody>
<tr>
<td>OA</td>
<td>96°F DB, 76°F WB</td>
<td>74°F DB, 52.4% RH</td>
<td>80.6°F DB</td>
<td>55.7°F DB</td>
</tr>
</tbody>
</table>

![Graph showing Constant Volume Design Load with OA, RA', MA', and SA']
three ventilation systems

Constant Volume – Part Load

OA
sensible 96°F DB, 76°F DP, 76°F WB, 84°F DB
latent 74°F DB, 74°F DB, 52.4% RH, 67% RH
RA' 80.6°F DB, 77°F DB
MA' 80.6°F DB, 77°F DB
SA' 55.7°F DB, 63°F DB

Zone rh rises at part load
three ventilation systems

**Constant Volume Plus - Cooling**

**CV Plus Reheat** (e.g.)

- Direct temp control (lvg clg coil temp 55F to 75F)
- Direct humidity control (htg coil off when cooling)
- Indirect air cleaning, ventilation control
- Local ventilation

Rooftop, unit ventilation, ptac

**zone temperature determines AHU cooling capacity**
three ventilation systems

Constant Volume Plus - Dehumidifying

CV Plus **Reheat** (e.g.)

- **Direct temp control** (lvg clg coil temp 55F)
- **Direct humidity control** (lvg htg coil temp 55F to 75F)
- Indirect air cleaning, ventilation control
- Local ventilation

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Zone temperature determines AHU reheat capacity
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Constant Volume Plus

OA
96°F DB, 76°F WB
76°F DP, 84°F DB

RA
74°F DB, 52.4% RH
74°F DB, 52.4% RH

CA
55.7°F DB
55.3°F DB

SA
55°F DB
63°F DB

Zone rh stays low at part load*

*part load
three ventilation systems

100% Outdoor Air System (DOAS)

Basic CV DOAS

- One OA unit, many zones
- Central neutral, dry outdoor air ... zones tend to be dry in winter in cold climates
- Central ventilation, air cleaning
- Local units for zone temp control
- Rising popularity

WSHP, fan-coil
three ventilation systems

100% Outdoor Air System Plus

Enhanced DOAS w/cold air and VAV

- Cold central temp (with cooling and reheat)
- Central air cleaning
- Central ventilation w/VAV for DCV
- Local units for zone temperature control

COLD conditioned-air temp determines AHU cooling capacity

WSHP, fan-coil
three ventilation systems

**Multiple-Zone System (VAV)**

**Variable Air Volume**

- One air handler, many zones, recirculating air
- Central air cleaning
- Central ventilation w/VAV for DCV
- Local boxes for zone temperature control by adjusting airflow
- Again, zones run dry in cold climates in winter

**Diagram Details**

- Supply air temp determines AHU cooling capacity
- 55F supply air temp
- Variable-speed fan

**Diagram Components**

- OA: Outside Air
- EA: Exhaust Air
- RA: Return Air
- MA: Make-up Air
- C: Coil
- Filter
- Space

**Legend**

- T: Temperature
three ventilation systems

Some Other Ventilation Systems

• Other VAV
  • Series and parallel fan-powered VAV
  • Dual-fan dual-duct VAV

• Natural Ventilation – Engineered openings or operable windows
  • Must be a mixed-mode system
  • Can passively cool during economizer conditions
  • NA must be “off” (closed) during heating and cooling modes
  • Does not filter or dehumidify during NA operation
  • Really works best in temperate climates

• And so on ...
Outline

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• Operating modes
• Moisture sources
• Low energy technologies
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operating modes

From Max Heating to Max Cooling ...

- Most climates ...
  - Heat in winter
  - Can (must) use economizer cooling for some conditions
- Need mechanical cooling in summer
*Alaska = Zones 7, 8
Hawaii = Zone 1a

U.S. climate zones*

[Map of the United States with climate zones labeled]

- **1a very hot**
- **1b very hot**
- **2a hot**
- **2b hot**
- **3a warm, humid**
- **3b warm, humid**
- **4a warm**
- **4b warm**
- **5a cool**
- **5b cool**
- **6a cold**
- **6b cold**
- **7a very cold**
- **7b very cold**
- **8a subarctic**
- **8b subarctic**

[Legend for climate zones]

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moisture sources

Liquid Water Examples

• Anytime ...
  • Leaks in envelope, pipes, valves
  • Cleaning processes – carpet shampooing, mopping

• When cooling ...
  • Condensate on cooling coils
  • Coil water droplet carryover (due to increased air velocity – dirty filter)
  • Drain pan overflow or spitting traps (often poor design or installation)
  • Condensate on pipes, ducts (usually due to damage)

• When heating ...
  • Condensate on windows
  • Condensate on and in walls ... in general, it’s too dry in winter in cold climates
moisture sources

Water Vapor Examples

• Anytime, but can be reduced
  • Vapor pressure diffusion (usually low)
  • Infiltration of moist air (can be high in summer – wind and weather and bldg)
  • Exfiltration of “moist” air (can be high in winter – wind, stack effect in winter)
  • Evaporation – pools, fountains, cleaning processes (usually low)

• Anytime, but must be dealt with
  • Viable people (well, depends on population density, activity)
  • Outdoor air for ventilation (can be high in summer – depends on climate)
moisture sources

What to Do?

• You will have moisture sources
• Design building to minimize sources
• Design HVAC to reduce moisture
• Control moisture with high limit (like 62F dp or 65% rh) (this, of course, takes equipment and energy)
• Perhaps, design with low limit in future (comfort, health)
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low energy technologies

Examples for the Future

• Reduced cooling load
  • Low energy lights
  • Window shading/treatment
  • High efficiency office equipment

• System trends
  • Perhaps more VAV (even one-zone VAV on the rise)
  • Perhaps more 100% OA systems (separate loads to control rh)
  • More efficient filters (MERV 8 to MERV 13)
  • Increased ventilation (+30%)
  • Increased control complexity (more economizer, less reheat, more DCV)
  • All trends change traditional system operation and maintenance
low energy technologies

Examples for the Future

• Reduced cooling load ...
  • May increase heating energy, depending on bldg/climate
  • May increase zone relative humidity, depending on system type

• System trends
  • VAV reduces rh rise, but increases system complexity
  • 100% OA (DOAS) reduces rh rise, but adds significant complexity
  • High efficiency filtration adds to operating cost
  • Increase OA adds operating cost and rh control complexity
  • Increase complexity reduces likelihood of long-term success w/o training
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Summary

- There are many types of system
- System choice depends on (for example)
  - Climate
  - Building type
  - Budget
  - Operating staff
- VAV, DOAS future bodes well for reduced rh and particle control
- As cooling loads drop, rh may rise, but complexity certainly rises
Building Systems: HVAC

Questions?

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