Labs21 Advanced Course Series

Low-Pressure-Drop HVAC Design for Laboratories

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Goal: Design for Low-Pressure Drop

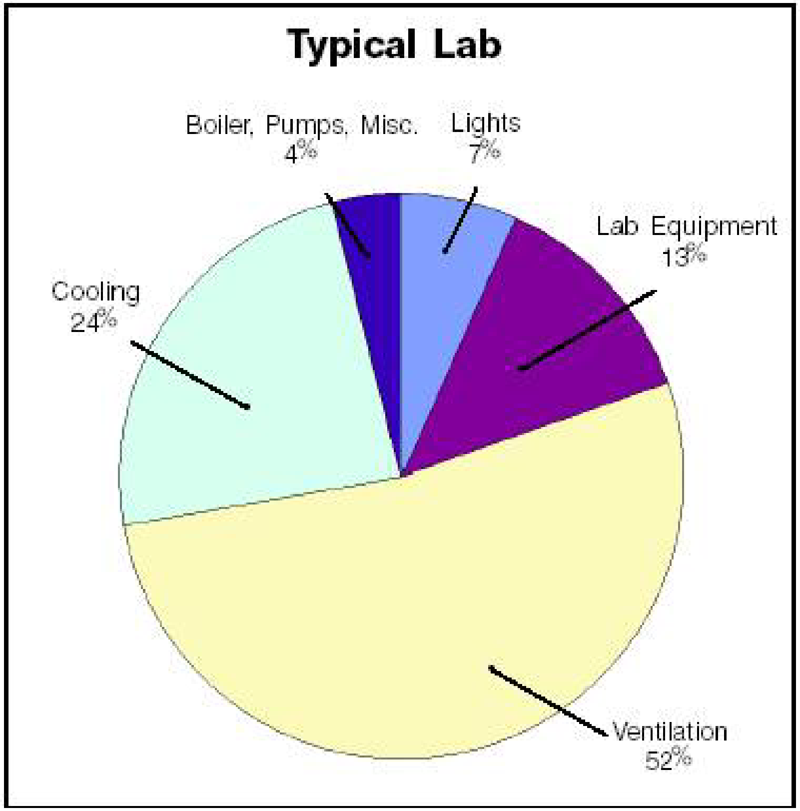
Objectives: At the end of this session, you will be able to:

- **Describe action items for each stage of the design process**
- **Describe low-pressure drop design options for each component in the air distribution system**
- **Identify standard, good and better design pressure-drop benchmarks for each component**

Outline

- **Overview**
- **Design Process**
- **Component Review**
  - Design Characteristics
  - Selection Considerations
  - Design Practice
  - Performance Example
- **Conclusion**

Overview – Laboratory Energy Use



Results from DOE-2 model of lab at Montana State University

- **Ventilation is always a large component**
  - % varies by lab type and location
- **15% savings in ventilation equivalent to total lighting energy use**

Overview - Ventilation Energy Use

Parameter	Savings Potential	Comment
Fan system efficiency	5%-15%	Minor potential, traditional design is often OK
Airflow	0%-60%	VAV[1] supply and exhaust systems provide big savings in fan and conditioning energy when compared with constant-flow systems; actual savings depend on facility usage
System pressure drop	30%-65%	Traditional design results in energy-intensive laboratory systems; large reductions are possible in numerous areas

$$\frac{\text{Airflow } (cfm) \times \text{System air pressure drop (in. w.g.)}}{\text{6345, constants factor} \times \text{Fan system efficiency, } \eta_{\text{fan}} \times \eta_{\text{motor}} \times \eta_{\text{drive}}} = \text{Fan input power (brake hp)}$$

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Design Process

- Programming
- Schematic Design
- Design Development

Design Process

- **Programming**
  - Review Design Intent Document.
  - Participate in design charrette.
  - Prioritize architectural and engineering goals.
  - Resolve codes and standards issues.
  - Ensure owner/user understands impacts.

Design Process

- **Schematic design: low-pressure-drop design**
  - Provide sufficient mechanical space.
  - Simplify lab layout.
  - Expand utility service spaces.
  - Use duct layout with straight runs and manifolded exhausts.
  - Set targets for system pressure drop.

Design Process

- **Design development : low-pressure-drop design**
  - Size components with reduced face velocity.
  - Do not use standard rules of thumb.
  - Include pressure-drop in device selection criterion.
  - Specify larger, more direct ductwork.
  - Remove zone coils from primary air supply.
  - Consider: radiant floors/ceilings, fan coils, baseboards.
  - Ensure value engineering includes life-cycle cost and first-cost savings from: downsized components, energy use, and maintenance.

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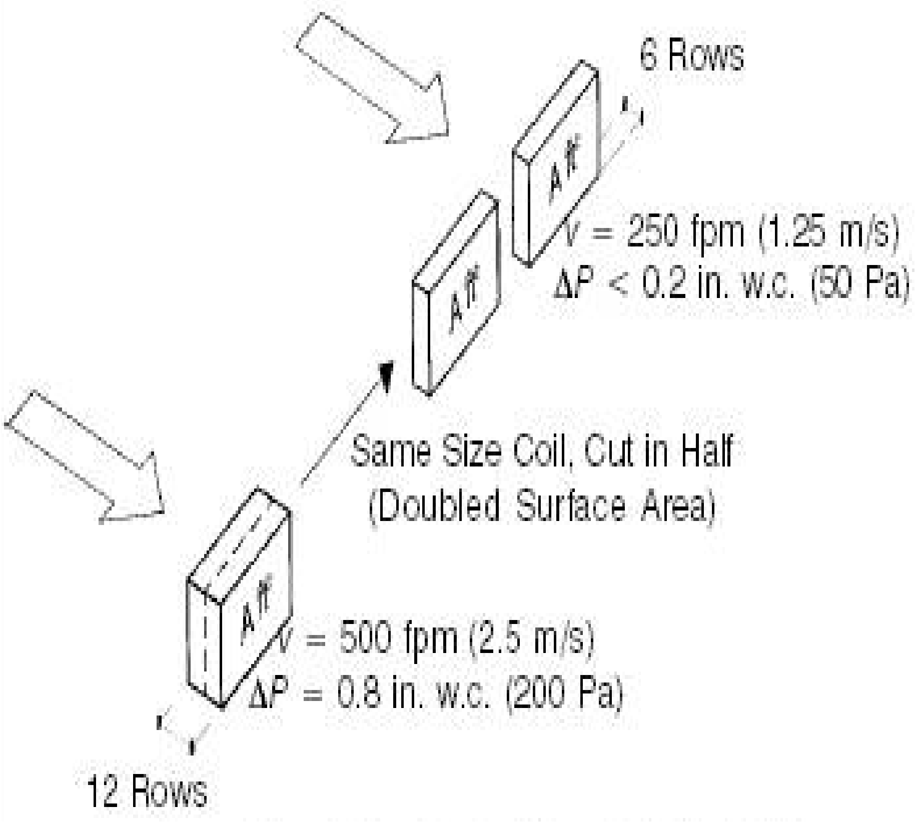
Component Review

- **Low-pressure-drop components:**
  - Air handling units
  - Energy recovery devices
  - Variable Air Volume devices
  - Zone coils
  - Ductwork
  - Exhaust stacks
  - Noise attenuation

Air Handling Unit – *Design Characteristics*

- **Standard design practice based on 500 FPM**
  - Rule of thumb for offices
  - Note labs are typically 8760 hrs vs. 4000 hrs for offices.
- **Power is reduced by square of velocity reduction**
  - 25% face velocity reduction yields 44% power reduction
  - Greater than a fourfold △P reduction with one-half face velocity



Air Handling Unit – *Additional Benefits…*

- **Lower pressure fans**
  - Less fan motor HP
  - Smaller, less expensive VFD
  - Less vibration and noise, and lower rpm – better bearing life
  - Less costly casing
  - Reduced system leakage
- **Reduced pressure drop filters**
  - Increase filter life
  - Reduce bypass leakage
  - Improves aerodynamics through all elements

Air Handling Unit – *Selection Considerations…*

- **Coil performance at low face velocities**
  - Laminar air flow between fins
  - Coil design for velocities < 500 FPM require close review
- **AHU unit enclosure and plenum layout**
  - Ensure even airflow over entire coil, especially below 200 FPM
- **Coil selections**
  - Review with manufacturer
  - Research case studies and actual performance

Air Handling Unit – First-Cost Implications…

- **Enclosure larger and more expensive**
  - Cost for most other components reduced
- **Fan motor size reduced 25%-50%**
  - Requires smaller VFD, wiring, circuits, breakers, and emergency power source
  - Less heat added to air stream – reduced cooling demand
- **Greater face area requires more filters**
  - Increased change interval
  - Reduced maintenance

Net first-cost increase usually minimal, if any.

Air Handling Unit – Space Concerns…

- **Minimal additional floor space**
  - Example: reducing 20,000 CFM unit face velocity by 25% increases width of unit by 2 ft; requires additional 50 sq.ft. (assuming height cannot be increased at all)
- **Negligible architectural impact when designed early**
- **Can impact size and configuration of other elements**
  - Designer should use right-sizing

Air Handling Unit – Design Practice…

Standard:	**500 fpm**	**2.7” w.g.**
Good:	**400 fpm**	**1.7” w.g.**
Better:	**300 fpm**	**1.0” w.g.**

- Includes ΔP for coil, humidifier, intake damper, and clean 30% and 85% efficient filters,

Air Handling Unit – Design Practice…

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Energy Recovery Devices

- **Factors that improve energy recovery economics include:**
  - Colder climates (e.g. more than 3,000 heating degree-days)
  - High exhaust ratesLong service life
  - High utility rates
- **Consider increase pressure drop impact.**
- **Evaluate evaporative cooling in exhaust stream**
  - Increases cooling energy recovery without adding moisture to supply air.

Energy Recovery Devices

- **Enthalpy wheels: low-pressure-drop units**
  - Smaller applications: easily sized
  - Larger applications: watch first costs
  - Supply and exhaust adjacency: convoluted duct runs result in higher pressure drop; careful architectural design and duct layout needed

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Energy Recovery Devices…

- **Flat-plate heat exchangers**
  - Specify low-pressure-drop exchangers
  - Requires adjacency of exhaust and supply
  - Use 0.25” w.g. supply pressure drop; equal or lower on exhaust.

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Energy Recovery Devices…

- **Heat pipe systems**
  - Requires adjacency of exhaust and supply
  - Usually sized for high pressure drop (>1” w.g.) to minimize cost

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Energy Recovery Devices…

- **Run-around coils**
  - Numerous coil options increase design flexibility
  - Supply and exhaust duct adjacency not required

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Energy Recovery Devices – Design Practice

Standard: 1.00" w.g.

Good: 0.60" w.g.

Better: 0.35" w.g.

- Pressure drop per air stream
- Upstream filters will increase pressure drop:
  0.27" @ 500 fpm, 0.18" @ 400 fpm, 0.10" @ 300 fpm

Energy Recovery Devices – Performance Example

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Variable Air Volume – design characteristics

- **VAV fume hood distribution**
  - Direct, pressure-independent airflow control
    - 0.3” to 0.6” w.g. drop across airflow valve
  - Velocity airflow control
    - Remote “through-the-wall” sensor
    - 0.05” w.g. drop across “butterfly” control damper
- **Comparable control accuracy and repeatability**
- **Caution: other design requirements affect choice**

Variable Air Volume – design practice

- **Standard:** **N/A (constant volume)**
- **Good:** **0.3 - 0.6” w.g.**
- **Better:** **0.1” w.g.**

Variable Air Volume – Performance Example

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Zone Coils – Design Characteristics

- **Standard Practice: Use zone reheat coils without regard**
  - Zone coils add pressure drop to system continuously.
- **Good Practice: Reduce zone coil impact**
  - Select low-face-velocity coil
  - Minimize number of coils
- **Better Practice: Eliminate zone coil**
  - Radiant heating/cooling
  - Remote fan coils
    - Will not mix air between zones
    - No impact on space pressurization and ventilation rates
    - May require education/approval of code officials

Zone Coils – Design Practice...

Standard: 0.42” w.g.

Good: 0.20” w.g.

Better: 0.00” w.g. (no coils)

Zone Coils – Performance Example

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Ductwork – Design Characteristics

- **Use conventional methods to design low-pressure ductwork**
- **Consider using 0.05” w.g. drop per 100 ft vs. 0.1” w.g. drop per 100 ft (common in office buildings)**
- **Manifold fume hood exhaust ductwork**
  - Augments energy recovery systems
  - Enhances efficient stack design
  - Reduces construction and maintenance

Ductwork – Selection Considerations

- **Larger ductwork advantages**
  - Provides flexibility for future flow requirements
  - Contributes to quieter system operation
- **Incremental cost minimal**
  - Reduces complexity; fewer contraction fittings and shorter, more direct layout
  - Increases construction efficiency; fewer sizes

Ductwork – Design Practice

Standard: 4.50" w.g.

Good: 2.25" w.g.

Better: 1.10" w.g.

- Total for supply and exhaust

Ductwork – Performance Example

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Exhaust Stack – Design Characteristics

- **VAV fume hood system**
  - Requires bypass air for constant stack velocity
  - Enhances safety with redundant fans.
  - Increases efficiency over CV system
    - Does not uses indoor conditioned air for dilution.

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Exhaust Stack – Selection Considerations

- **Multiple stacks with multiple fans**
  - Use common exhaust plenum
  - Vary fan speed as exhaust volume reduces
  - Control multiple fans for redundancy
  - Include fan isolation dampers or back-draft dampers

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Exhaust Stack – Design Practice

Standard: **0.7" w.g.**
(CV – full design flow through entire system)

Good: **0.7" w.g.**
(VAV – full design flow through fan & stack only)

Better: **0.75" w.g.**
(averaging half design flow w/ multiple stacks)

Exhaust Stack – Performance Example

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Noise Attenuation – Design Characteristics

- **Low-pressure ductwork design can avoid need for silencers or other sound attenuation devices**
  - UC Irvine and Santa Barbara proscribes using silencers

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Noise Attenuation – Design Practice

- **Standard: 1.0” w.g.**
- **Good: 0.25” w.g.**
- **Better: 0” w.g. (no devices)**
  - - Total for supply and exhaust

Noise Attenuation – Performance Example

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Summary of Design Practice

	Standard	Good	Better
Air handling units	500 FPM	400 FPM	300 FPM
Energy recovery devices	1.00” w.g.	0.60” w.g.	0.35” w.g.
VAV devices	N/A	0.3-0.6” w.g.	0.1” w.g.
Zone coils	0.42” w.g.	0.20” w.g.	0 (no coils)
Ductwork	4.50” w.g.	2.25” w.g.	1.10”w.g.
Exhaust stacks	0.7” w.g. CV	0.7” w.g. VAV	0.75” w.g. mult. stack
Noise attenuation	1.0” w.g.	0.25” w.g.	0 (no device)

LEED 2.1 and ASHRAE 90.1

- **ASHRAE 90.1 fan power limitations are very difficult to meet for ventilation intensive labs**
- **ASHRAE does not allow credit for low pressure design**
  - USGBC allows credit as exceptional calculation method

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
<20,000 cfm	1.2 hp/1000 cfm	1.7 hp/1000 cfm
>20,000 cfm	1.1 hp/1000 cfm	1.5 hp/1000 cfm

LEED for Labs and Labs21

- **Labs21 guidelines adjusts ASHRAE limits**
  - Proposed for LEED for Labs
  - Explicitly allows credit for low-pressure design.

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
<20,000 cfm	2.2 hp/1000 cfm	3.1 hp/1000 cfm
>20,000 cfm	2.0 hp/1000 cfm	2.8 hp/1000 cfm

The laboratory fan power limitations are calculated using a static pressure ratio of 9.15” w.g./5” w.g.