

SIEMENS
Ingenuity for Life

Space Pressurization: Concept and Practice

ASHRAE Boston Chapter Meeting
February 2026

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Course Description

Space Pressurization: Concept and Practice

Program teaches ventilation control design for critical pressurized spaces such as laboratories, clean rooms and health care facilities. Topics run from basic physics of pressurization, through air flow control technology and detailed design procedures. Covers goals and concepts behind pressurization. Emphasis on the importance of the room envelope. Explains the common control methods, and when to choose each one.

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Learning Objectives

Apply space pressurization as a tool
for contamination control

Recognize the effect of the room envelope
on successful pressurization

Select an appropriate pressurization control method
for an application

Design pressurization details for effective
contamination control

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Agenda

- | | |
|---|--|
| 1 | Introduction (concept, purpose, ...) 5 min |
| 2 | Physics: Infiltration and Containment 10 min |
| 3 | Pressurization Methods 10 min |
| 4 | Design Considerations 8 min |
| 5 | Summary and Contamination Control 8 min |

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Room Pressurization:

A ventilation technology that controls migration of air contaminants by inducing drafts between spaces



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Room pressurization

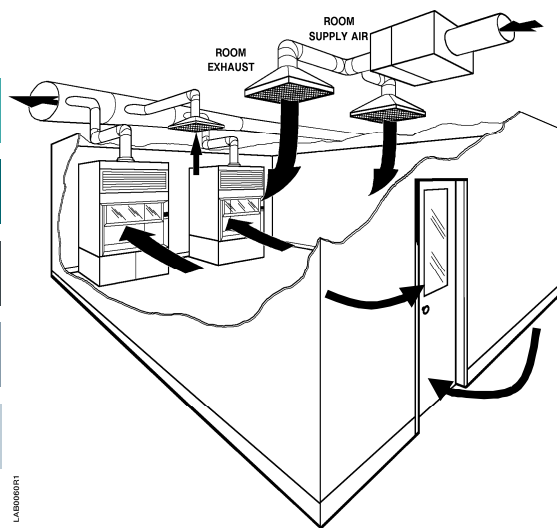
Exhaust system removes air

Supply system delivers less air

Room pressure is negative

Infiltration makes up the difference

Inward air flow contains pollutants



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Introduction: Who uses it? Why?

Biological and Chemical Laboratories

- prevent spread of airborne hazards

Hospital Isolation Rooms

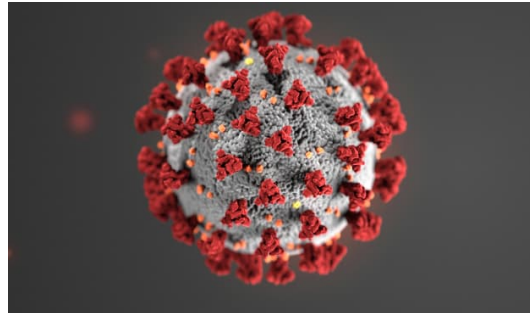
- protect patients and staff from germs

Hospital Pharmacies

- facilitate sterile compounding

Clean Manufacturing

- maintain product quality



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Introduction: Who else uses it?

Office towers

- control smoke in a fire; maintain exit path

Any Building

- separate rest rooms from other spaces

Restaurants

- keep kitchen smells out of the dining room

Any Building

- keep unconditioned OA out of occupied spaces

These uses are out of today's scope

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How do you define success?

Success

is control of
contaminants,
not flows and
pressure values



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Infiltration and containment

Infiltration: mechanical process

Velocity, Area, Pressure

Infiltration Curves

Importance of the Envelope

Select Pressurization Level

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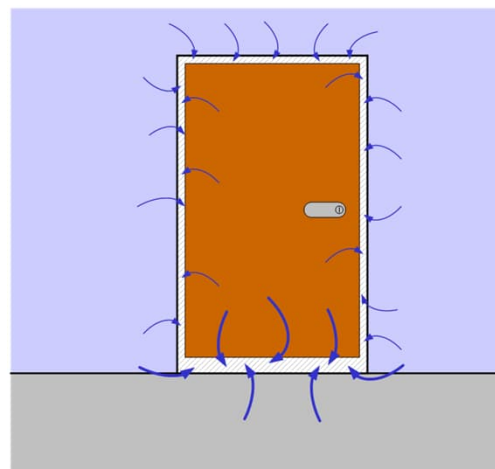
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Infiltration process: pressure, velocity, area, flow

Infiltration is a physical process

Pressurization is an
engineered result

ASHRAE Handbook and
Ventilation Manual from
ACGIH model the process



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Pressure vs. velocity

Simple approach is to model the velocity with a discharge coefficient

ACGIH Industrial Ventilation: 7-3

$$v = 0.6(4000)\sqrt{\Delta P}$$

ASHRAE Fundamentals Handbook presents more complex model, but the result is nearly the same

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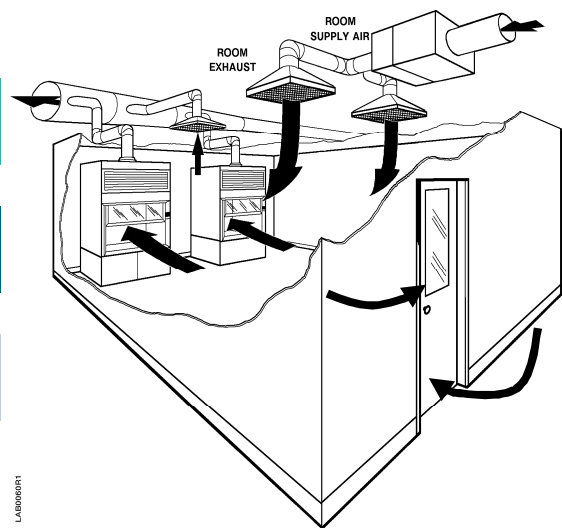
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Infiltration model for pressurization

Air velocity through gaps in envelope controls contaminants

Velocity related to pressure by orifice flow

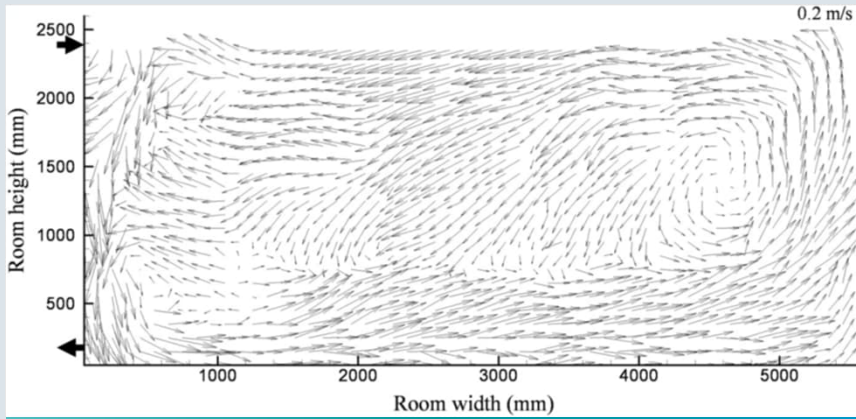
What velocity do we need?



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Reality of room air motion



"Particle Image Velocimetry." Photograph of flow field (2D) in cross-section of a room.
Zhao L., ASHRAE Transactions, DA-07-044

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Velocity and leakage area

Flow is velocity times area

ASHRAE Handbook HVAC Applications, puts it together:

$$Q = 2610 A \sqrt{\Delta P}$$

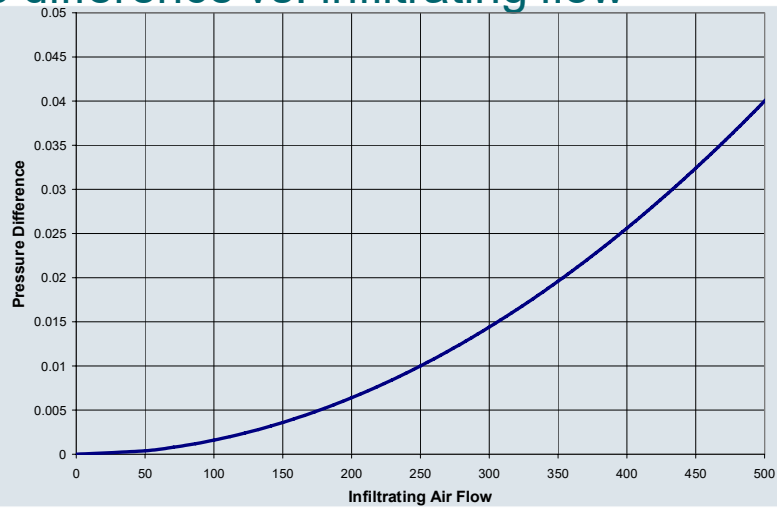
Q = infiltration flow, cfm
A = leakage area, sq. ft.
 ΔP = pressure across envelope, inwc



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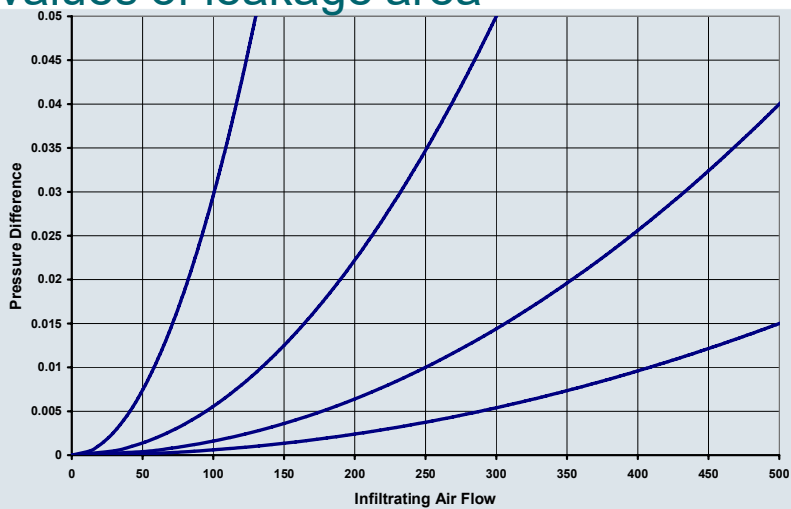
Infiltration curve: Pressure difference vs. infiltrating flow



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Infiltration curve: Several values of leakage area

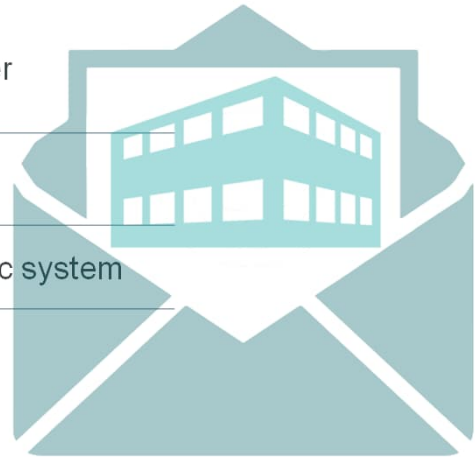


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Importance of the envelope

- Leakage area is main mechanical parameter in the pressurization system
- Like knowing the hx characteristics to apply a heating coil
- Like knowing the pipe diameter in a hydronic system

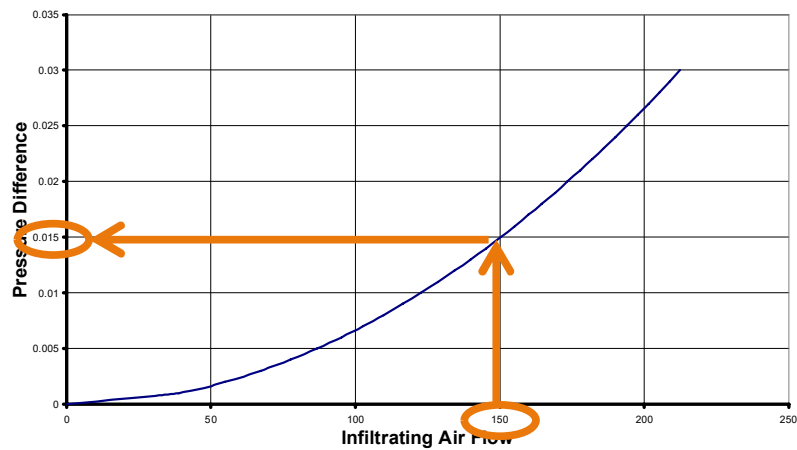


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Select pressurization level

Choose the flow offset
Let it determine the pressure

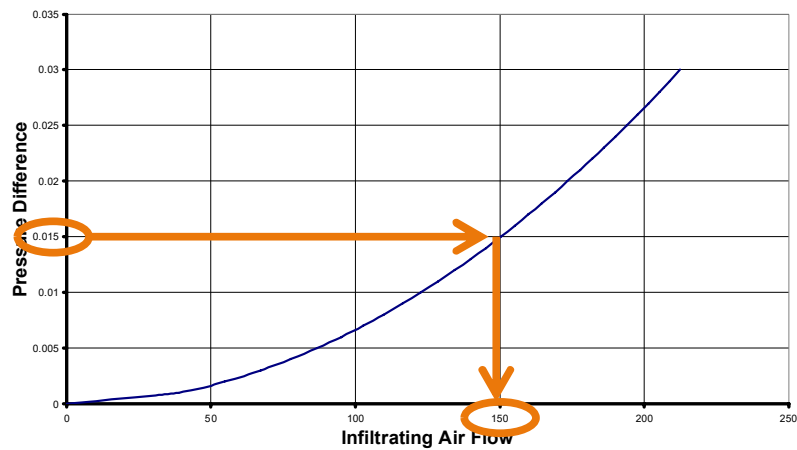


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Select pressurization level

Choose the pressure
Let it determine the flow offset



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Select pressurization level

Different ways to express the level of pressurization

- in terms of the pressure difference
- in terms of the infiltration flow

“Specify either the pressure
or the flow offset, not both.”

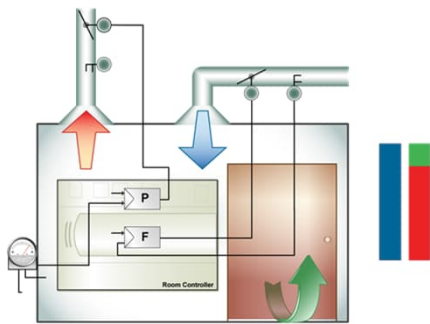
Unless you are trying to specify the envelope

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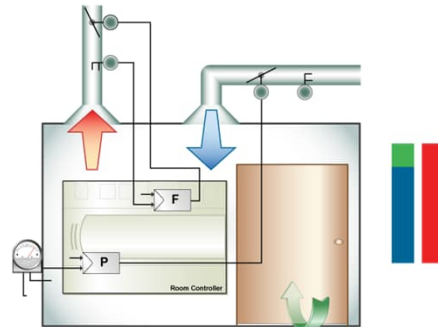
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Pressurization and contaminant control

Positive room pressure drives air and contaminants out



Negative room pressure draws air and contaminants in



Neutral room pressure exchanges air and contaminants both directions

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Control methods compared

Three widely-published methods

1 Space pressure feedback

2 Differential flow control

3 Cascade control

References:

2023 ASHRAE Handbook, HVAC Applications. Chapter 17 Laboratory Systems
Siemens Building Technologies: Doc #125-2412. Room Pressurization Control

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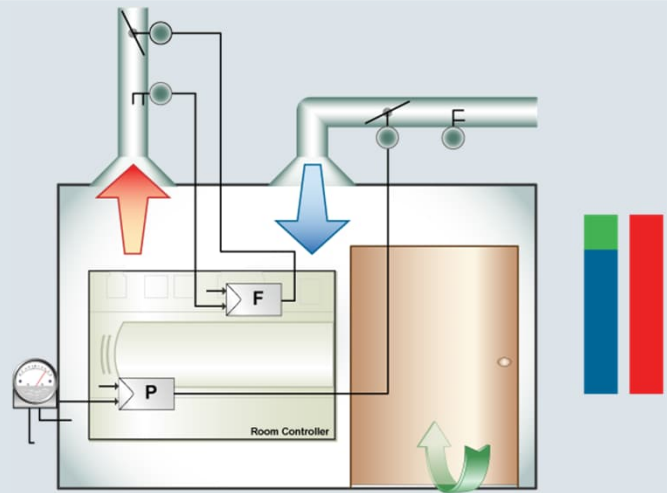
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Space pressure feedback

Measure pressure difference across room boundary

Compare to selected setpoint

Adjust supply flow or exhaust to maintain pressure difference



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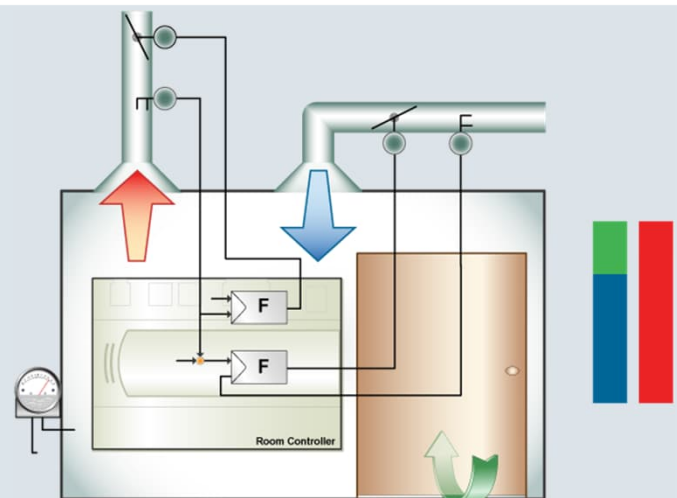
Differential flow control

Carefully control air supply to room

Carefully control all exhaust from room

Enforce a difference between supply and exhaust

Select the size of the difference to reliably contain pollutants



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Cascade control

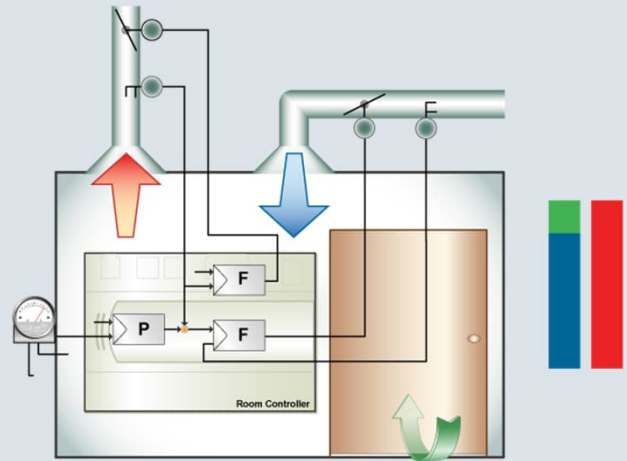
Measure pressure difference across room boundary

Compare to selected setpoint

Control supply and exhaust flow

Enforce a difference between them

Dynamically adjust flow difference to maintain pressure setpoint



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Selecting a control method

Factors that affect selection

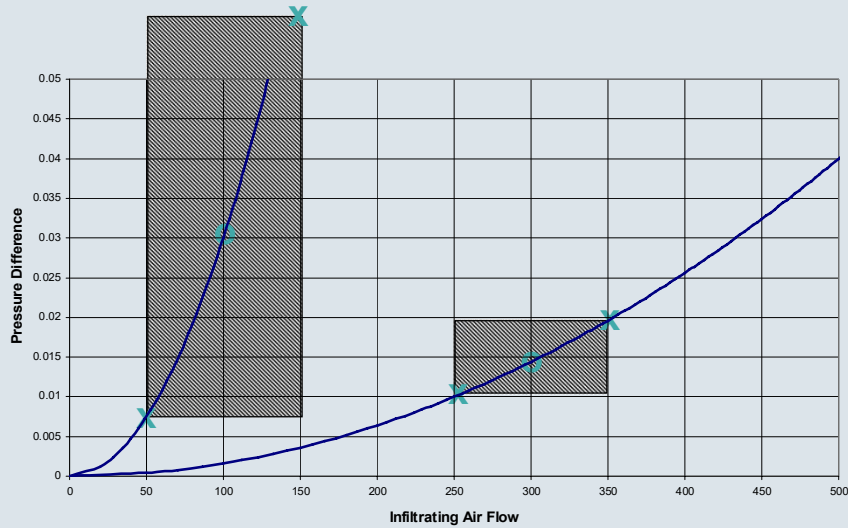
- 1 Tightness of envelope
- 2 Number of pressure levels needed
- 3 Speed of disturbances and response
- 4 Duct conditions for flow measurement

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Reference: 2010 ASHRAE Handbook, HVAC Applications. Chapter 17 Laboratory Systems, page 16.12

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Tightness of envelope



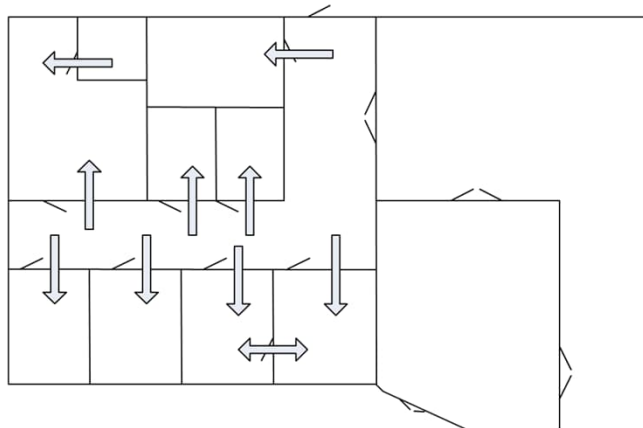
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Number of pressure levels

Relatively simple requirement

2-levels, OK for Differential Flow Tracking

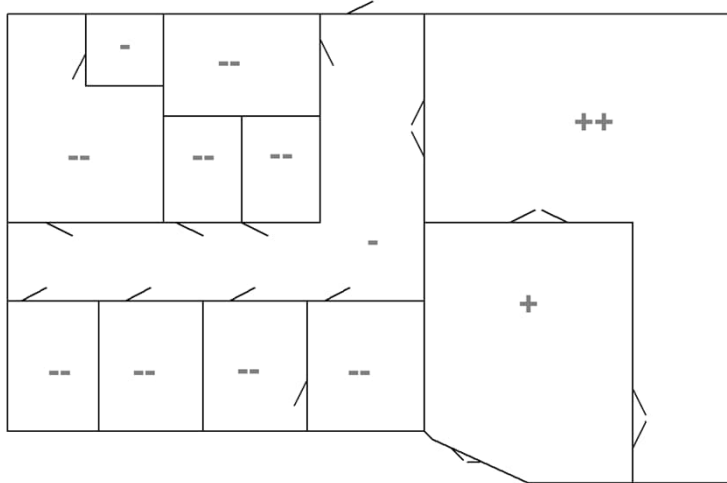


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Number of pressure levels

Indicate intended relative pressure levels



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Design considerations: Effect of air flow accuracy

Numerical illustration

	Nominal value	Error
Exhaust flow	1000	+/- 100
Supply flow	850	+/- 85
Transfer flow	150	+/- 185

Base flow control accuracy on desired infiltration
ANSI Z9.5, Laboratory Ventilation

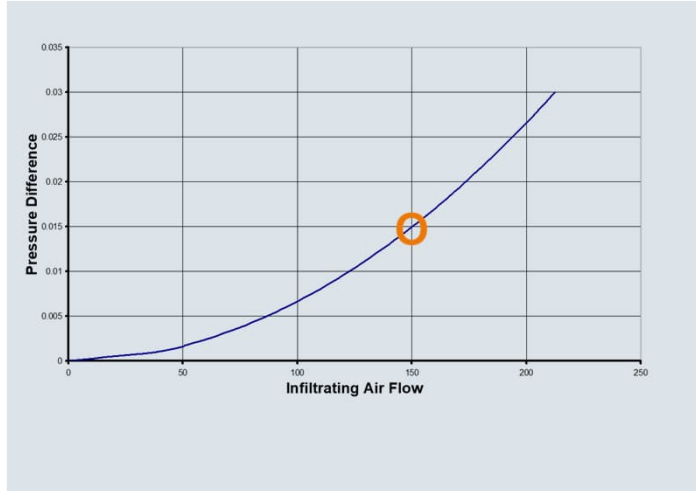
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Select pressurization level

Based on leakage area

Example: 150 cfm
for $\frac{1}{2}$ square foot



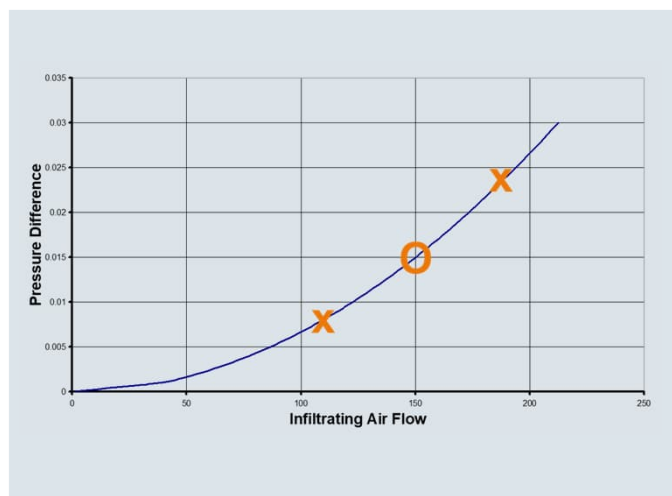
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Select accuracy target

Based on need
to control contaminants

Not product spec's



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Derive flow control accuracy

Base flow control accuracy on desired infiltration
Select allowable error on supply and exhaust
for resulting transfer accuracy

	Nominal value	Error
Exhaust flow	1000	+/- 30
Supply flow	850	+/- 30
Transfer flow	150	+/- 45

Combine errors with square root of sum of squares

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Derive Flow Control Accuracy

For VAV:

Consider accuracy across range of flow values

Pressurization specs easier to meet at low flow

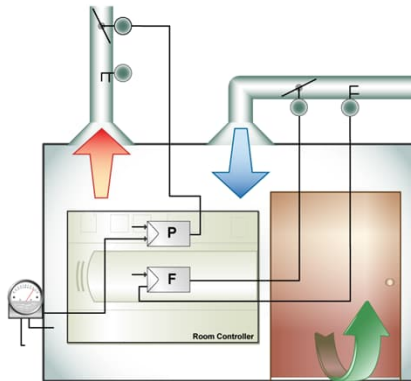
	Nominal value	Error
Exhaust flow	1000	+/- 30
	200	+/- 30
Supply flow	850	+/- 30
	50	+/- 30
Transfer flow	150	+/- 45

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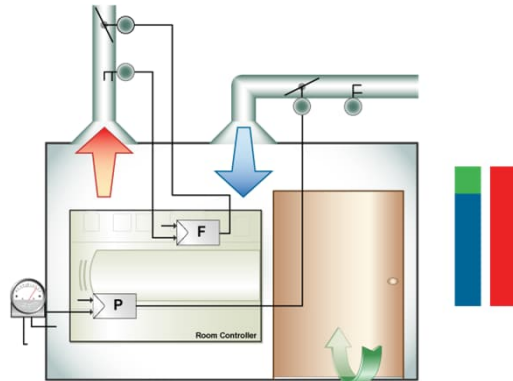
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Design considerations: Which terminal does pressurization

Exhaust tracks supply



Supply tracks exhaust



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Design considerations: Room pressure monitor



Design standards call
for installed monitor

Operating standards call
for "periodic check"

Failure mode analysis
justifies monitor as a
device separate from
the controller

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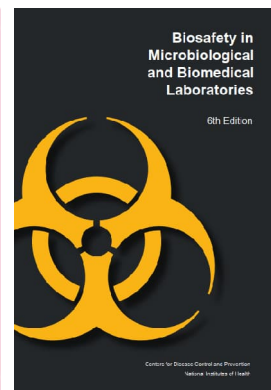
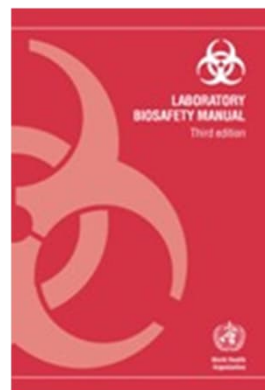
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Pressurization and contaminant control

Contaminant control can be very important or only slightly important

Biosafety standards recognize range of hazards and range of responses

Engineering and commissioning should match effort and solutions to needs



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Levels of contaminant control

Pressurization is one tool

Door is another

- BSL 1 – Laboratories should have doors
- BSL 2 – Doors should be self-closing
- BSL 3 – Series of two self-closing doors
- BSL 4 – Airlock with air tight doors



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Summary

Space pressurization: tool for contamination control,
not a 'magic shield'

Envelope leakage is main mechanical parameter

Several HVAC control methods

- Differential flow control is used most often
- Choice usually driven by envelope

Monitor operation with equipment and procedures

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Assessment questions

1. Name two kinds of spaces where pressurization is important.
(laboratories, healthcare spaces, clean manufacturing)
2. Identify 1 method of pressurization control
(direct pressure feedback, flow offset, or cascade control)
3. Which pressurization method is most effective for when the door is open? (trick question, no method works with an open door)
4. What is the most important physical characteristic of a room for pressurization design? (envelope leakage area)
5. Which is the physical goal, room pressure, differential air flow, containment? (containment)

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Questions?

Answers!

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Contact

Jim Coogan
Principal Application
Engineer

Siemens Smart Infrastructure

E-mail
jim.coogan@
siemens.com

