



Room Pressurization Solutions for Critical Spaces



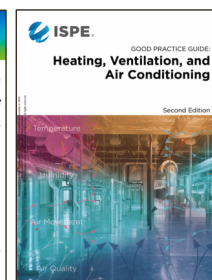
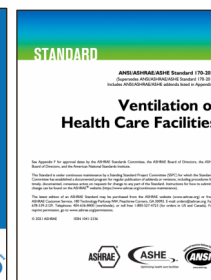
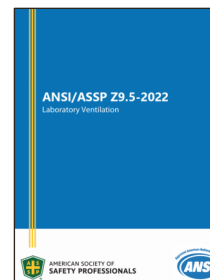
Curtis Carrick
Engineered Technical Sales

- + M.Sc Mechanical Engineering
- + 13+ years with Antec Controls and Price Industries

Room Pressurization Solutions for Critical Spaces

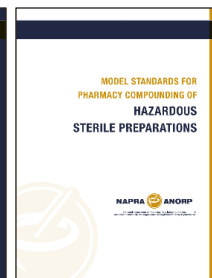
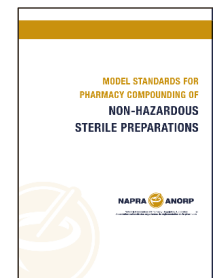
Agenda

- + Introduction
- + Room Pressure Control Methods
 - Flow Offset
 - Direct Pressure Control
- + Airflow Control Solutions
 - Airflow Measuring & Airflow Metering
 - Design Considerations
- + Application Considerations
 - Laboratories
 - Healthcare
- + Retrofit Solutions



Related standards:

- ANSI Z9.5 – 2022
- ASHRAE 170-2021
- ISPE GPG, 2nd Ed
- USP 797 & 800
- NAPRA – various
- And others...

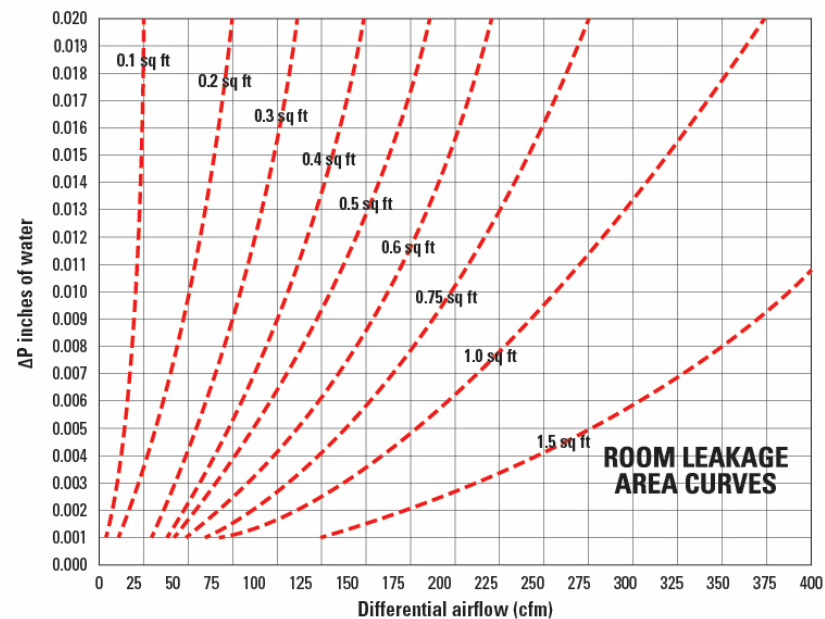


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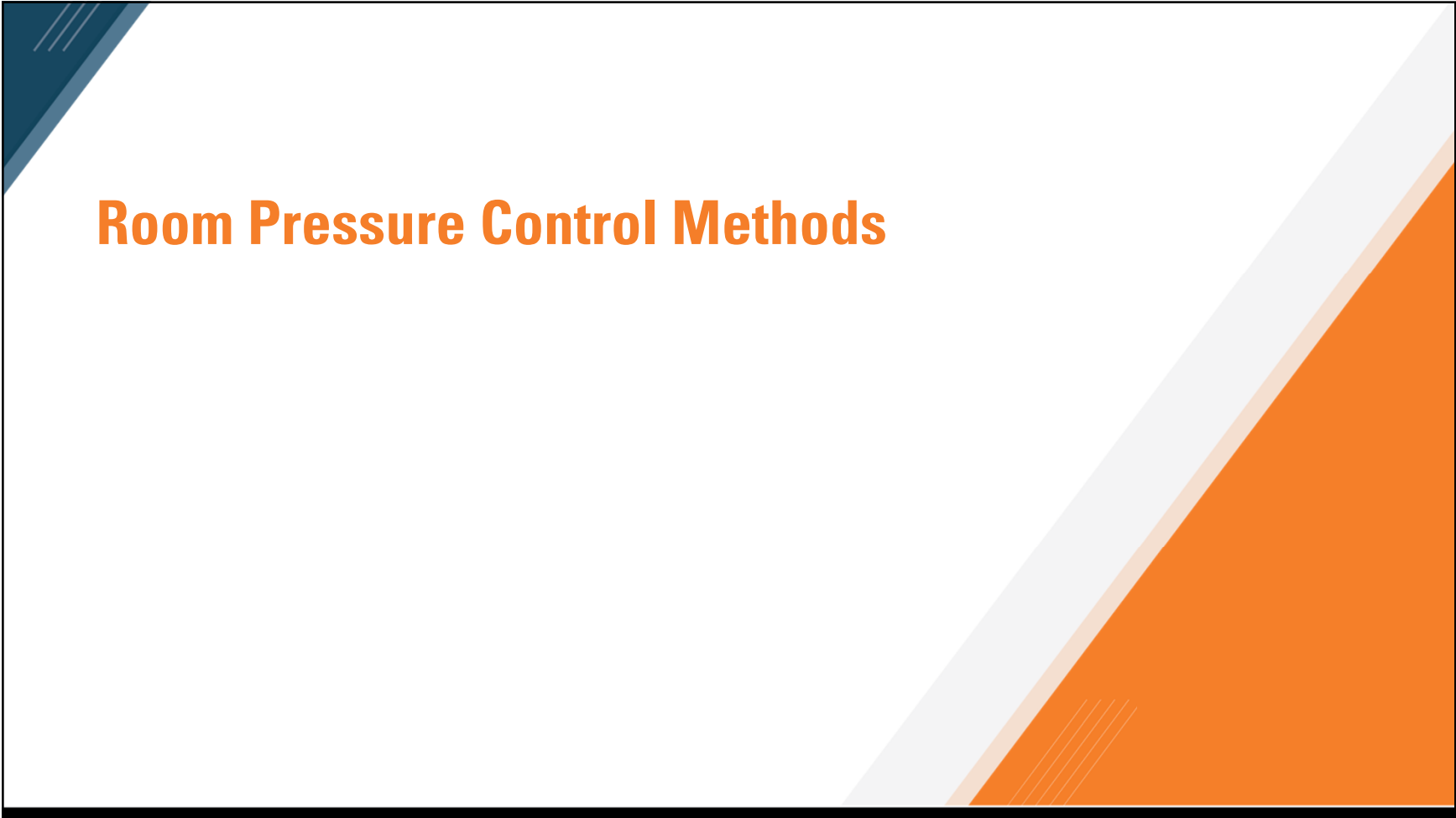
Room Pressurization Solutions for Critical Spaces

Introduction

- + Difference between supply and exhaust creates pressurization
- + Pressurization yields directionality of transfer air across room boundary
 - From clean to less-clean spaces
- + Magnitude of pressurization can depend on:
 - Magnitude difference between supply and exhaust airflow
 - Room leakage
 - Local construction practices
 - Ceiling type
 - Door selection and sealing



DeLuga. "Differential airflow, pressure, have key relationship in pressurization." Lab Design 1997(2)



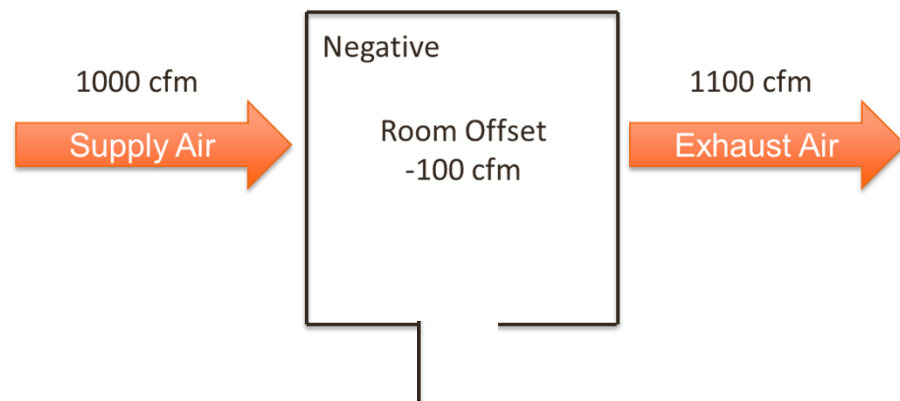
Room Pressure Control Methods

Room Pressurization Solutions for Critical Spaces

Room Pressure Control Methods

+ Volumetric (flow) offset control

- Maintains a constant CFM offset between supply and exhaust valves
 - Regardless of room mode: occupied, unoccupied, etc
- Independent of room pressure
- ANSI Z9.5
 - *Flow offset control is the most commonly applied approach*
- Room pressure sensor and door contact switches can be used for monitoring

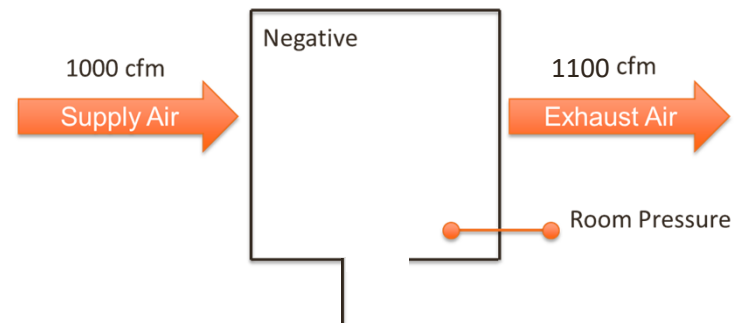


Room Pressurization Solutions for Critical Spaces

Room Pressure Control Methods

+ Direct pressure control

- Airflow adjustment based on room pressure
 - Regardless of room mode: occupied, unoccupied, etc
- Independent of room offset
- Room pressure sensor is required, and door contact switches are recommended
- ANSI Z9.5
 - *It is impractical to maintain a differential pressure across an open door*
- ASHRAE 170
 - *Short-term excursions from required pressure relationship shall be allowed while doors are moving or temporarily open*



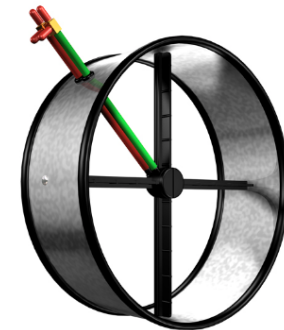
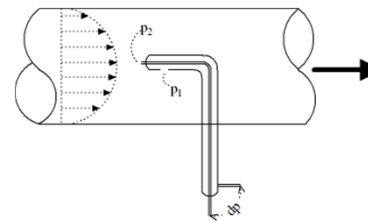
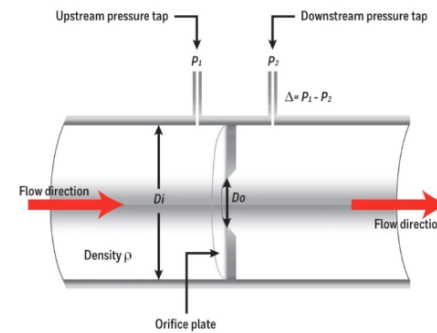
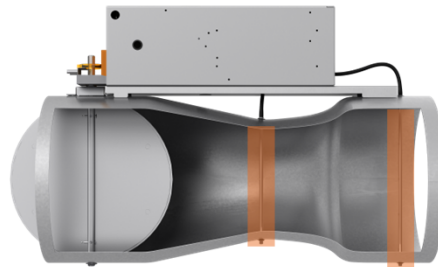


Airflow Control Solutions

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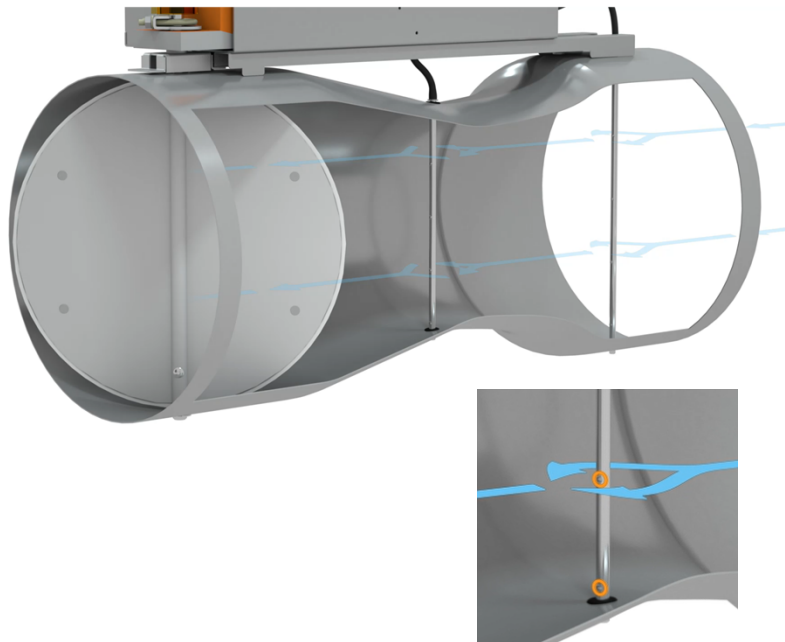
Airflow Measuring Solutions

- + Flow rate sensors, as defined by ASHRAE Fundamentals 2025, used for the express purpose of *sensing flow*.
 - ie. air must participate in the measurement!



Room Pressurization Solutions for Critical Spaces

Airflow Measuring – Design Considerations



Contamination Resistance

- + Consider airflow sensor type, and resistance to airborne contaminants
 - Exhaust valve applications (e.g. healthcare)
 - Airborne particulate tends to deposit on surfaces facing the airstream.
 - Captioned method:
 - Differential static pressure in venturi tube
 - Highly resistant to sensor fouling since static pressure is measured *behind* each post

Room Pressurization Solutions for Critical Spaces

Airflow Measuring – Design Considerations

Minimum Operating Pressure Drop

- + Tested in accordance with ASHRAE 130: 2016, with damper wide-open
 - Confirm expected minimum operating pressure drop in manufacturer's datasheets
 - Account for slightly more pressure in design, to ensure damper is controlling
- + Minimum operating pressure drop changes based on size and max design flow

Unit Size	Airflow															
Pressure Drop	< 0.01 in.w.c < 2.5 Pa		0.05 in.w.c 12.4 Pa		0.10 in.w.c 24.9 Pa		0.15 in.w.c 37.3 Pa		0.20 in.w.c 49.8 Pa		0.25 in.w.c 62.2 Pa		0.30 in.w.c 74.7 Pa		0.35 in.w.c 87.1 Pa	
	CFM	L/s	CFM	L/s	CFM	L/s	CFM	L/s	CFM	L/s	CFM	L/s	CFM	L/s	CFM	L/s
108	80	38	300	142	450	212	550	260	650	307	725	342	800	378	-	-
110	120	57	475	224	700	330	900	425	1075	507	1200	566	1300	614	-	-
112	180	85	750	354	1100	519	1400	661	1600	755	1800	850	-	-	-	-
114	250	118	1200	566	1800	850	2250	1062	2500	1180	-	-	-	-	-	-
212	360	170	1300	614	1900	897	2350	1109	2700	1274	3050	1439	3325	1569	3600	1699
214	500	236	2000	944	2800	1321	3500	1652	4000	1888	4500	2124	5000	2360	-	-

Room Pressurization Solutions for Critical Spaces

Airflow Measuring – Design Considerations

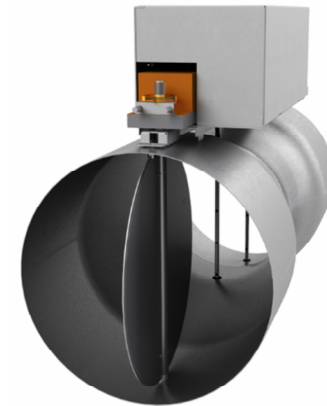
Minimum Operating Pressure Drop

- + Valve design tends to be a function of the airflow sensor technology
- + Solutions that maximize the airflow area will lower air velocity, and generally result in a lower pressure drop
 - From I2SLs Best Practice Guide: An Introduction to Low-Energy Laboratory Design

Pressure drop varies with the square of the velocity while power varies with the cube of the velocity. A 30% reduction in velocity when demand is low cuts the pressure drop associated with distribution in half and lowers the associated power by nearly two-thirds. Variable-speed systems take advantage of these opportunities to save energy. In laboratories, this not only lowers fan energy but also the energy required to condition ventilation.

-International Institute for Sustainable Laboratories (I2SL)

https://www.i2sl.org/files/ugd/59662e_55af362c316f48d184e98911a93a64b5.pdf



Room Pressurization Solutions for Critical Spaces

Airflow Measuring – Design Considerations

Fan Static Reset

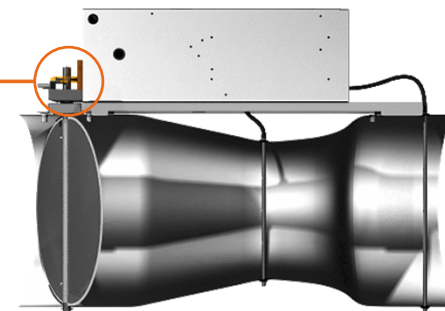
- + Described in ASHRAE 90.1: 2022 – VAV Setpoint Reset (Section 6.5.3.2.3)
- + Reset AHU SP setpoint until *one zone damper is nearly wide open*
- + Reduces yearly operational costs
- + Typically, this occurs at end of line valve on design leg from air handler, but **recommended** to test and verify for all modes of room usage

6.5.3.2.3 VAV Set-Point Reset

For multiple-zone *VAV* systems having a total fan system motor nameplate horsepower exceeding 5 hp with *DDC* of individual zones reporting to the central control panel, static pressure set point shall be reset based on the zone requiring the most pressure; i.e., the set point is reset lower until one zone damper is nearly wide open. Controls shall provide the following:

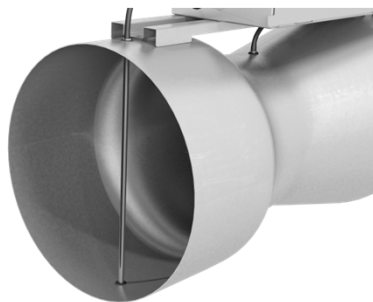
- Monitor zone damper positions or other indicator of need for static pressure.
- Automatically detect those zones that may be excessively driving the reset logic and generate an alarm to the system operator.
- Readily allow operator removal of zones from the reset algorithm.

Damper position monitored through actuator position feedback

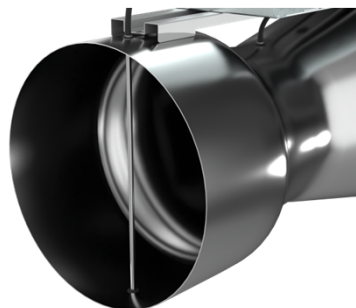


Room Pressurization Solutions for Critical Spaces

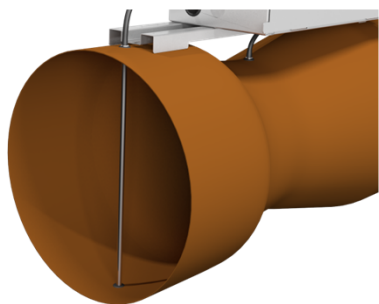
Airflow Measuring – Design Considerations



Aluminum



Stainless Steel



Phenolic Coating

Chemical Compatibility

- + Depending on the project application and expected chemical hazards, valve material or finishes may need to be selected to protect the operation of the valve
 - Most commonly a consideration for valves serving fume hood exhaust
 - Typical options:
 - Aluminum
 - Phenolic coated aluminum
 - 304 stainless steel
 - 316 stainless steel
- + **Recommended:** consult safety plan for lab (if available) to review list of chemicals.

Room Pressurization Solutions for Critical Spaces

Airflow Measuring – Design Considerations



Installation

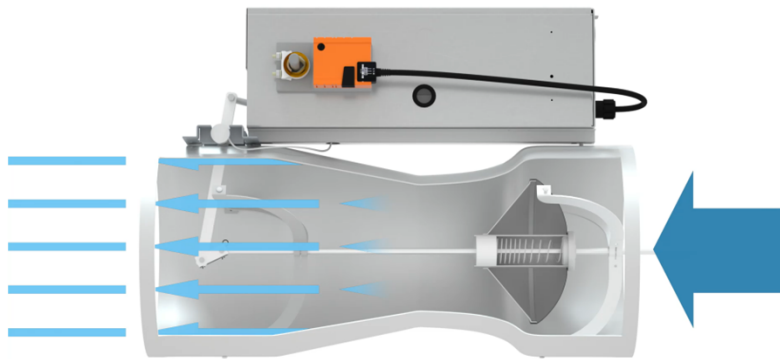
- + Typically:
 - Do not require lengths of straight duct upstream nor downstream to achieve catalog $\pm 5\%$ accuracy
 - Installation orientation does not need to be specified
 - 10:1 turndown is sufficient to achieve full benefit of unoccupied turndown in most applications



Airflow Metering

Room Pressurization Solutions for Critical Spaces

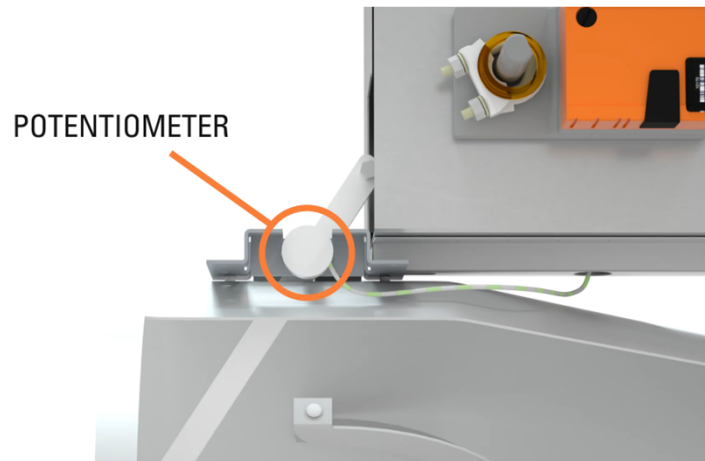
Airflow Metering Solutions



- + Decoupling of duct pressure from flow setpoint adjustment
 - Duct pressure: Spring & Cone
 - Increase in duct pressure, cone compresses, reducing airflow area
 - Decrease in duct pressure, cone extends, increasing airflow area
 - Flow setpoint adjustment: Position Measurement
- + Airflow measurement occurs at the factory, creating a unique position-to-airflow curve for each valve
- + Potentiometer feeds position back to controller, to verify current position

Room Pressurization Solutions for Critical Spaces

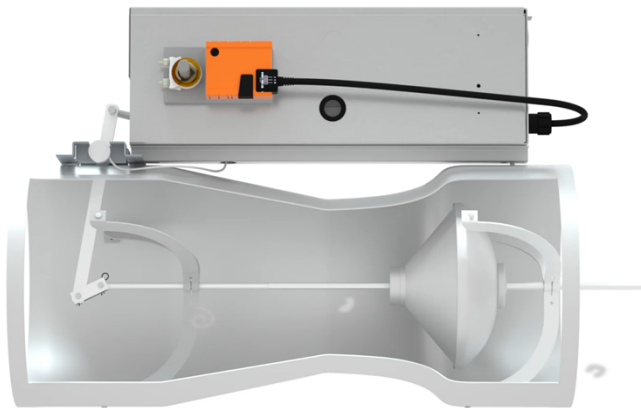
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Room Pressurization Solutions for Critical Spaces

Airflow Metering – Design Considerations



Contamination Resistance

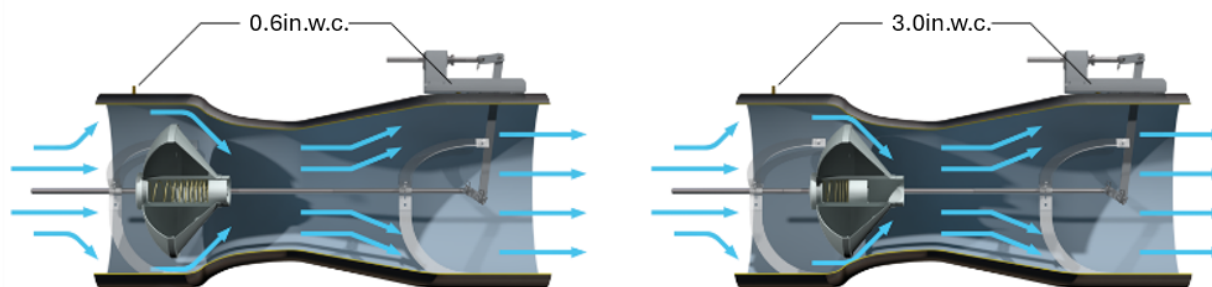
- + By design, widely considered the most resistant to airborne contaminants of available airflow control solutions
 - Exhaust valve applications (e.g. healthcare)
 - No airflow sensor, nothing to contaminate
 - Robust: Historically, the most critical space installs of all airflow control solutions in North America, in the widest range of air qualities

Room Pressurization Solutions for Critical Spaces

Airflow Metering – Design Considerations

Operating Pressure

- + Spring/cone requires pressure drop across valve to be maintained in a range
- + Valve pressure range must be specified:
 - LOW PRESSURE: 0.3in.w.c – 3.0in.w.c.
 - MEDIUM PRESSURE: 0.6in.w.c. – 3.0in.w.c. (shown below)
- + Pressure drop is measured at built-in measuring locations on valve



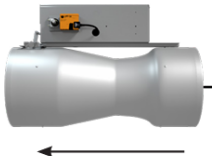
Room Pressurization Solutions for Critical Spaces

Airflow Metering – Design Considerations

Operating Pressure

- + Specifying LOW or MEDIUM pressure affects the available airflow range
 - LOW pressure venturi valves have a lower max airflow than equivalent MEDIUM pressure valves

Horizontal Configuration Flow Ranges

AIRFLOW DIRECTION	Size	Low Pressure		Medium Pressure	
		L/s	CFM	L/s	CFM
	108	17-236	35-500	17-330	35-700
	110	24-260	50-550	24-472	50-1000
	112	42-566	90-1200	42-708	90-1500
	114	94-660	200-1400	94-1180	200-2500
	210	48-519	100-1100	48-944	100-2000
	212	84-1132	180-2400	84-1416	180-3000
	214	189-1320	400-2800	188-2360	400-5000
	312	126-1699	270-3600	126-2124	270-4500
	314	282-1980	600-4200	282-3540	600-7500
	412	168-2264	360-4800	168-2832	360-6000
	414	376-2640	800-5600	376-4720	800-10000

Room Pressurization Solutions for Critical Spaces

Airflow Metering – Design Considerations

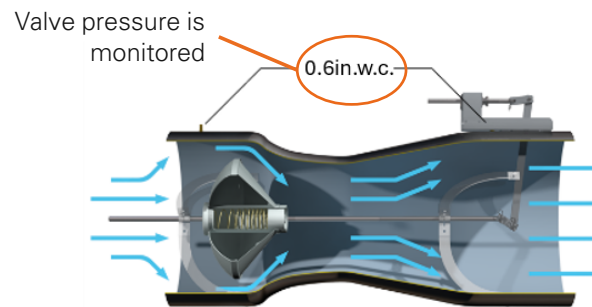
Fan Static Reset

- + Described in ASHRAE 90.1: 2022 – VAV Setpoint Reset (Section 6.5.3.2.3)
- + Reset AHU SP setpoint until *one venturi valve is just above its minimum operating pressure*
- + Reduces yearly operational costs
- + Typically, this occurs at end of line valve on design leg from air handler, but **recommended** to test and verify for all modes of room usage

6.5.3.2.3 VAV Set-Point Reset

For multiple-zone *VAV* systems having a total fan system motor nameplate horsepower exceeding 5 hp with *DDC* of individual zones reporting to the central control panel, static pressure set point shall be *reset* based on the zone requiring the most pressure; i.e., the set point is reset lower until one zone damper is nearly wide open. Controls shall provide the following:

- Monitor zone damper positions or other indicator of need for static pressure.
- Automatically detect those zones that may be excessively driving the *reset* logic and generate an alarm to the *system* operator.
- Readily allow operator removal of zones from the *reset* algorithm.



Room Pressurization Solutions for Critical Spaces

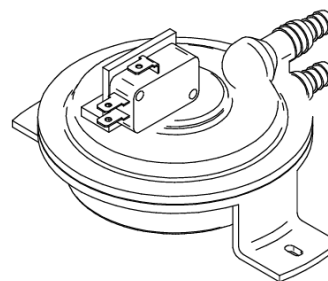
Airflow Metering – Design Considerations

Fan Static Reset

- + **Recommended:** specify a solution with pressure transducer
 - Allows for active measurement of real-time valve operating pressure, and intentional resetting of fan static setpoint.
 - Maximizes energy savings while maintaining safety.

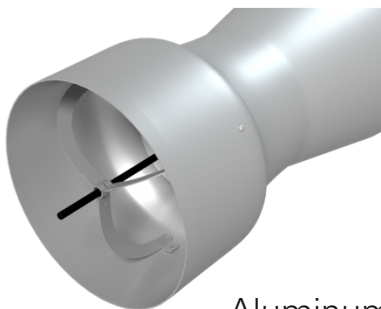


- + Minimum requirement: specify a solution with a low-pressure switch
 - Communicates a contact closure, used to signal a valve pressure alarm when valve pressure drops below minimum.
 - Less effective than pressure transducer to maximize energy savings.

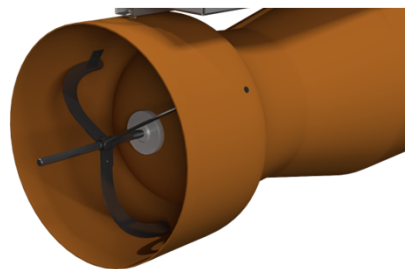


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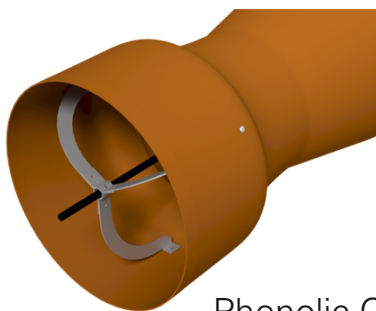
Airflow Metering – Design Considerations



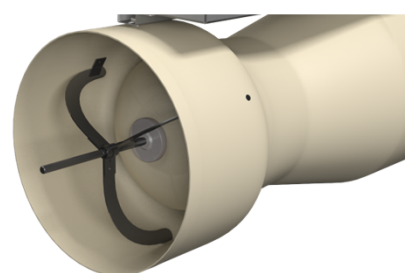
Aluminum



Phenolic Class 2



Phenolic Class 1



Kynar

Chemical Compatibility

- + Depending on the project application and expected chemical hazards, valve material or finishes may need to be selected to protect the operation of the valve
 - Most commonly a consideration for valves serving fume hood exhaust
 - Typical options:
 - Aluminum
 - Phenolic Coating: Class 1
 - Includes stainless steel internal hardware
 - Phenolic Coating: Class 2
 - Includes PFA Teflon coated internal hardware
 - Kynar Coating
- + **Recommended:** consult safety plan for lab (if available) to review list of chemicals.

Room Pressurization Solutions for Critical Spaces

Airflow Metering – Design Considerations



Installation

- + Typically:
 - Do not require lengths of straight duct upstream nor downstream to achieve catalog 5% accuracy
 - Installation orientation must be specified prior to order
 - Horizontal
 - Vertical upflow
 - Vertical downflow
 - 20:1 turndown is widest available airflow range per valve size on the market (while maintaining stated accuracy)



Applications

Room Pressurization Solutions for Critical Spaces

Applications – Laboratories

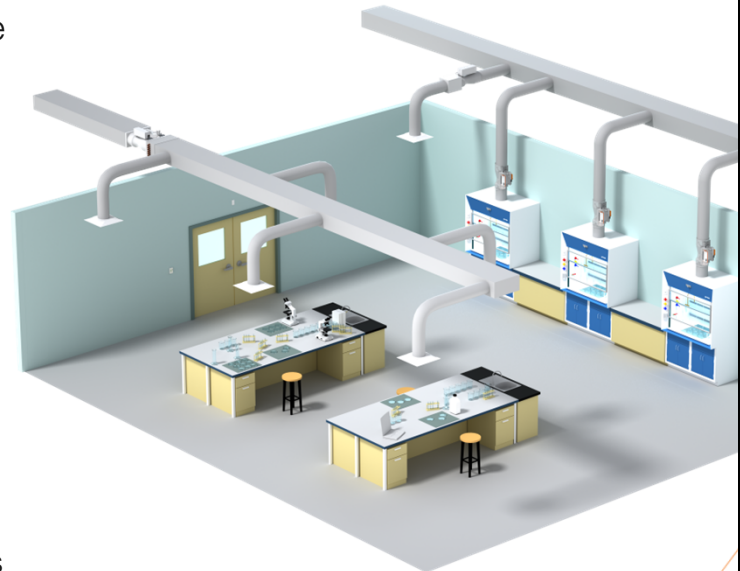
- + A room equipped for scientific experimentation, research, or education using chemicals that may be harmful to humans
 - Synthesis Labs
 - » Used for organic or inorganic reactions for a wide variety of chemicals
 - » May use flammable solvents, volatile reagents, toxic, and/or reactive chemicals and compounds
 - Teaching Labs
 - » Commonly located in higher ed and/or institutional settings
 - » Larger groups with sightlines for instructor to see equipment to prevent potential hazards



Room Pressurization Solutions for Critical Spaces

Applications – Laboratories

- + A room equipped for scientific experimentation, research, or education using chemicals that may be harmful to humans
 - Biological Labs
 - » Used for conducting experiments and research on living organisms
 - » Require specialized equipment like laminar flow hoods
 - Hospital or Clinical Labs
 - » Provide chemical or biological testing of specimens associated with patient care
- + Typically 100% exhaust to outdoors (ie. no return back to AHU)
 - Expensive to operate, so owners look for opportunities to reduce energy consumption



Room Pressurization Solutions for Critical Spaces

Applications – Laboratories (Fume Hoods)

- + **Purpose:** Capture, Contain, Dilute, Exhaust
- + Lots of varieties:
 - Benchtop (captioned)
 - Walk-in
 - Pass-through, etc.
- + Lots of sash types:
 - Vertical (captioned)
 - Horizontal
 - Combination
- + VAV fume hoods require high speed actuation
 - Once there is a high-speed actuator in a lab, all valves serving that space generally require high speed actuation!



Room Pressurization Solutions for Critical Spaces

Applications – Laboratories (Fume Hoods)

+ Fume hood control options to measure sash open area:

- Sash position
- Sidewall velocity
- Hybrid



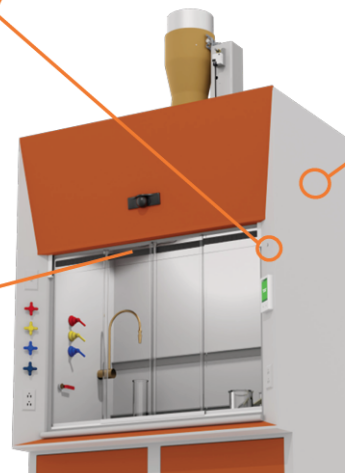
Sidewall Sensing



Sash Position Sensing



Sash Position Sensing



Room Pressurization Solutions for Critical Spaces

Applications – Laboratories (Fume Hoods)

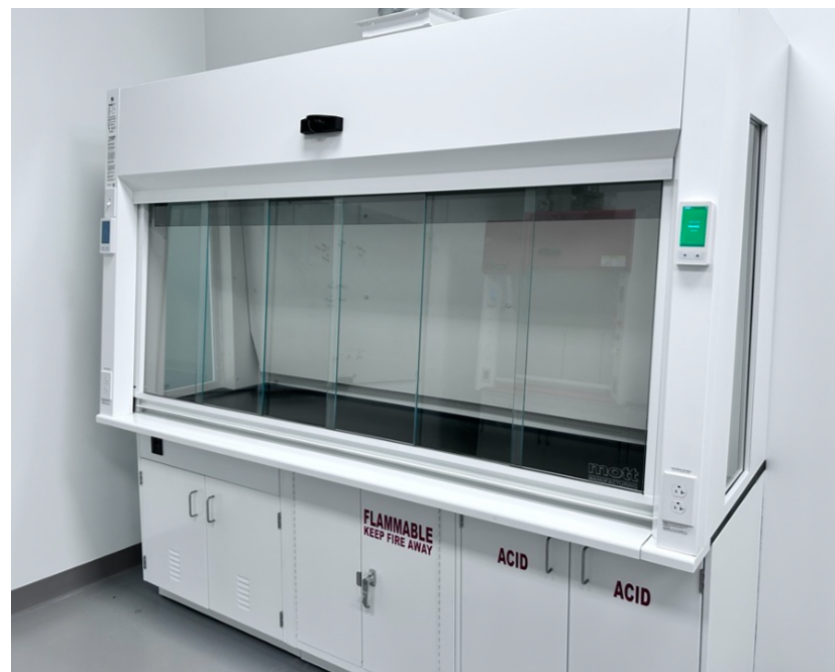
- + Max design flow for each hood:
 - Typically based on 'working height' or 'sash open position'
 - 100 FPM face velocity is common, but fume hood supplier's datasheet must confirm target face velocity is appropriate
 - Presence sensors can be very effective at reducing energy usage in facilities with poor sash management!
- + Min design flow for each hood:
 - Typically based on a desired hood interior ACH to control vapor concentrations at sash closed
 - ANSI Z9.5 refers to research indicating fume hood air changes per hour in range of 150 – 375
 - Reducing hood flow rate can reduce energy consumption, but hood flow rate must also be based on risk assessment and specifications!



Room Pressurization Solutions for Critical Spaces

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Room Pressurization Solutions for Critical Spaces

Applications – Laboratories (Fume Hoods)

- + Room Air Change Rate
 - 6-12 ACH is typical
 - 8 ACH offers desirable dilution performance, with diminishing returns above 12 ACH
 - ASHRAE Laboratory Design Guide Chapter 11 - Controls
- + Diversity
 - Opportunity to reduce energy, and typically found in:
 - Hood dense laboratories
 - Retrofits accounting for limitations to existing infrastructure



NOTE: Diversity is a system design concept that can justify sizing components for a total load that is less than the sum of the individual peak demands. A system that is designed with full flow capacity for all hoods simultaneously is designed for 100% Usage Factor or no diversity.

- ANSI Z9.5, Section 6.2.2

Room Pressurization Solutions for Critical Spaces

Applications – Isolation Rooms

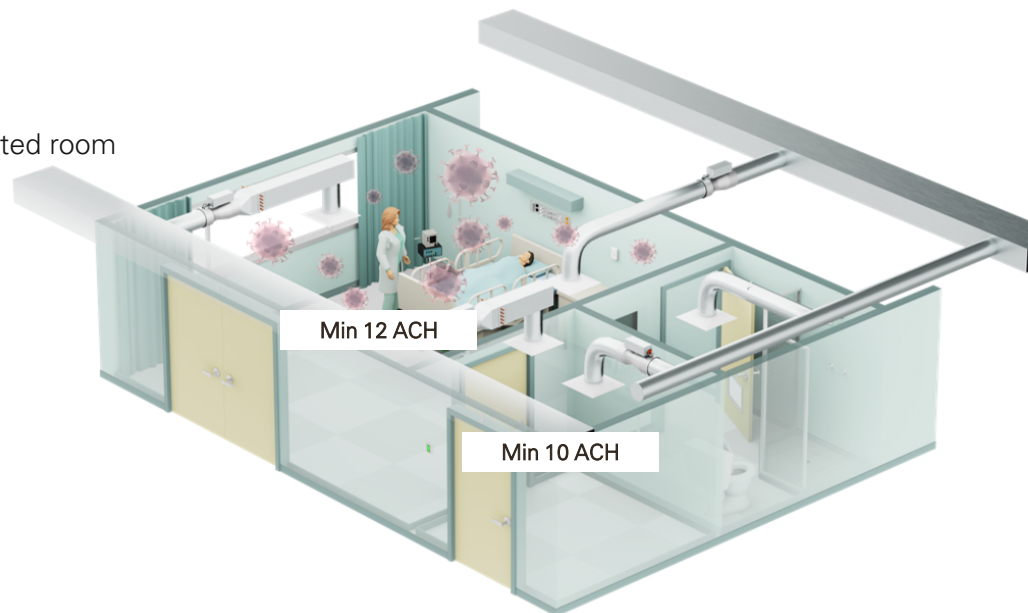
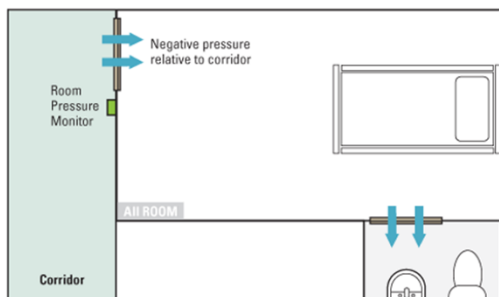
- + Patient room with pressurization controls, impacting the directionality of transfer air to/from the space to adjacent areas
- + Room Types:
 - Airborne Infection Isolation (AII)
 - Protective Environment (PE)
 - Combination AII-PE



Room Pressurization Solutions for Critical Spaces

Applications – Airborne Infection Isolation (AII)

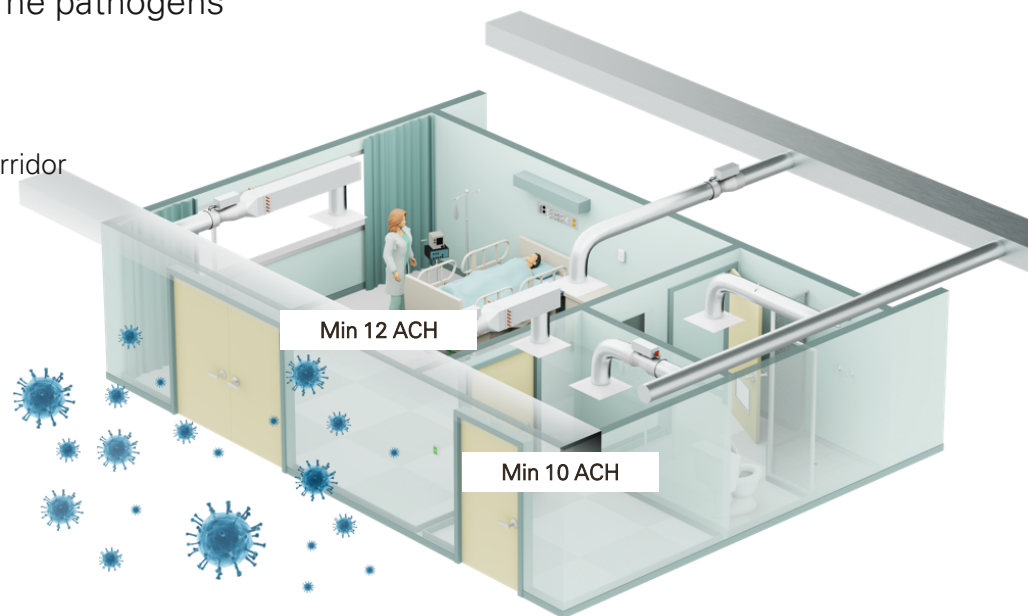
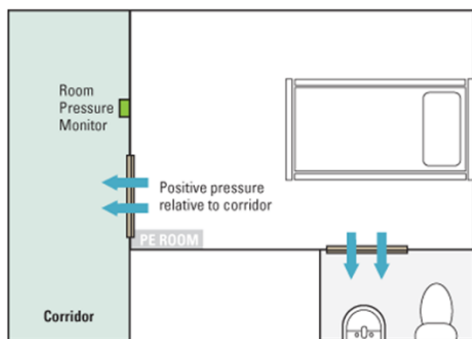
- + A patient room which isolates a patient infected with a communicable disease, typically spread by airborne droplets
- + Pressurization:
 - Negative
 - Supply < Exhaust
 - Air transfers from corridor to the isolated room
 - Unoccupied turndown allowed



Room Pressurization Solutions for Critical Spaces

Applications – Protective Environment (PE)

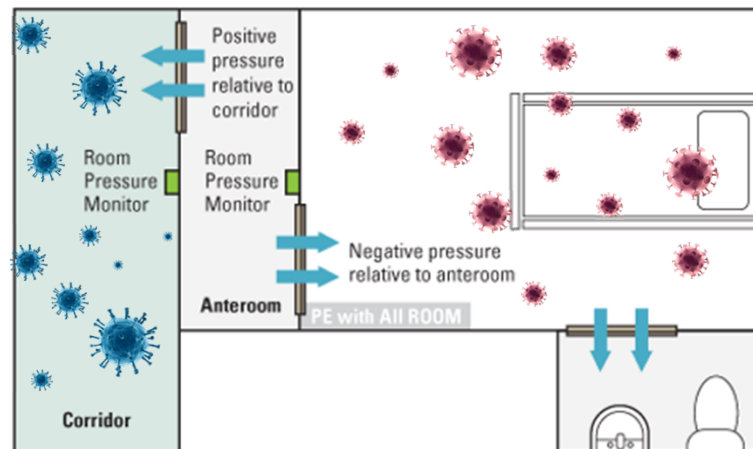
- + A patient room which protects a high-risk immunocompromised patient from human and environmental airborne pathogens
- + Pressurization:
 - Positive
 - Supply > Exhaust
 - Air transfers from isolated room to corridor
 - No turndown allowed



Room Pressurization Solutions for Critical Spaces

Applications – Combination AII/PE

- + Patient has both:
 - a communicable disease, AND
 - a compromised immune system
- + Need to protect both the patient in the isolation room, and building occupants from the infected patient
 - Patient room is negatively pressurized
 - Anteroom is positively pressurized, and acts as a bubble airlock between the corridor and the isolation room
 - No turndown allowed



Room Pressurization Solutions for Critical Spaces

Applications – Operating Room

- + Patient is in a sensitive state, and requires an aseptic environment during surgery

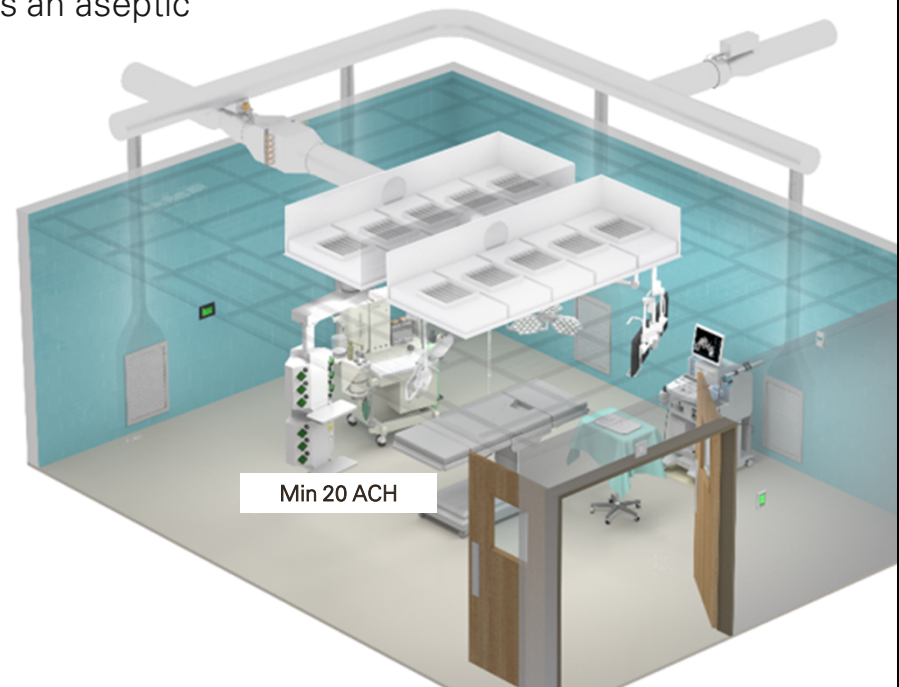
- General Surgery
- Emergency or Trauma Room
- Endoscopy

- + Pressurization

- Positive
- Supply > Exhaust
- Unoccupied turndown allowed

- + Airflow pattern

- Clean and filtered air washes over patient
- Contaminants carried away to corners
- Returns low on opposite walls of room





Retrofit Solutions

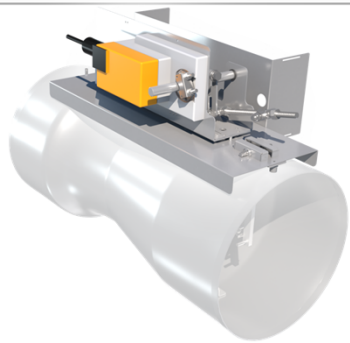
Room Pressurization Solutions for Critical Spaces

Retrofit Solutions

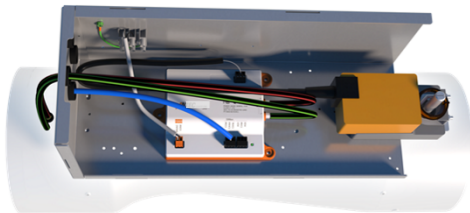


Room Pressurization Solutions for Critical Spaces

Retrofit Solutions



Flow Metering



Flow Measuring

- + Opportunity to replace obsolete electronics, leaving the original valve body in place
 - Confirm original valve bodies are in good condition
- + Scope of work will change slightly depending on valve type
- + Reduces:
 - **Capital cost expenditure:** replace controls only, less labor
 - **Downtime:** get room operational faster
 - **Barriers to performing work:** budgets tend to be tight

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The slide features decorative geometric elements in the corners. The top-left corner has a dark blue triangle with three white diagonal lines. The bottom-right corner has a large orange triangle with a light gray border and three white diagonal lines.

Questions?

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