Airflow Measurement Systems

Greg Drensky

Who is Jacco

- Established 1968
  - Hudson, Ohio
  - Columbus, Ohio
  - Toledo, Ohio
- Focused on the Engineered Environment
  - Systems Knowledgeable
    - HVAC Systems
    - Service & Maintenance
    - Parts
- Full Circle Support
- 30 Minute Design

Who is Jacco

- Operations Group
  - Brenda Homjak
  - Mike Spangler
  - Chad Russell

Purpose Statement

The purpose of our Company is to solve our customers problems, in the most economical way, at all times optimizing the owning experience.

Application Engineering

Project Management

Commissioning and Training

Service & Support

Owner Satisfaction

Who is Jacco

- 30 Minute Design
  - –Unit Performance
  - –Drawing
  - –Weights
  - –Electrical
  - –Specifications?
  - –Sequence of Operation?
  - –Cartoon?
  - –Narrative?

Who is Jacco

2015 Seminars

Seminars	Instructor	Date
Psychrometrics	JKC	14-Jan
The Refrigeration Cycle	JKC	11-Feb
Energy Recovery	GAD	11-Mar
Applied Rooftop Systems	JKC	8-Apr
VRF Design & Installation	GAD	13-May
Geothermal Systems	GAD	10-Jun
Chilled Beam, Radiant Cooling & DOAS	JKC	12-Aug
Vertical Market Systems	GAD	9-Sep
Building Pressure & Air Flow Measurement	GAD	14-Oct
Controlling HVAC Systems - Sequence of Operations	JKC	11-Nov

JACCO

EBTRON

Accurate

Stable

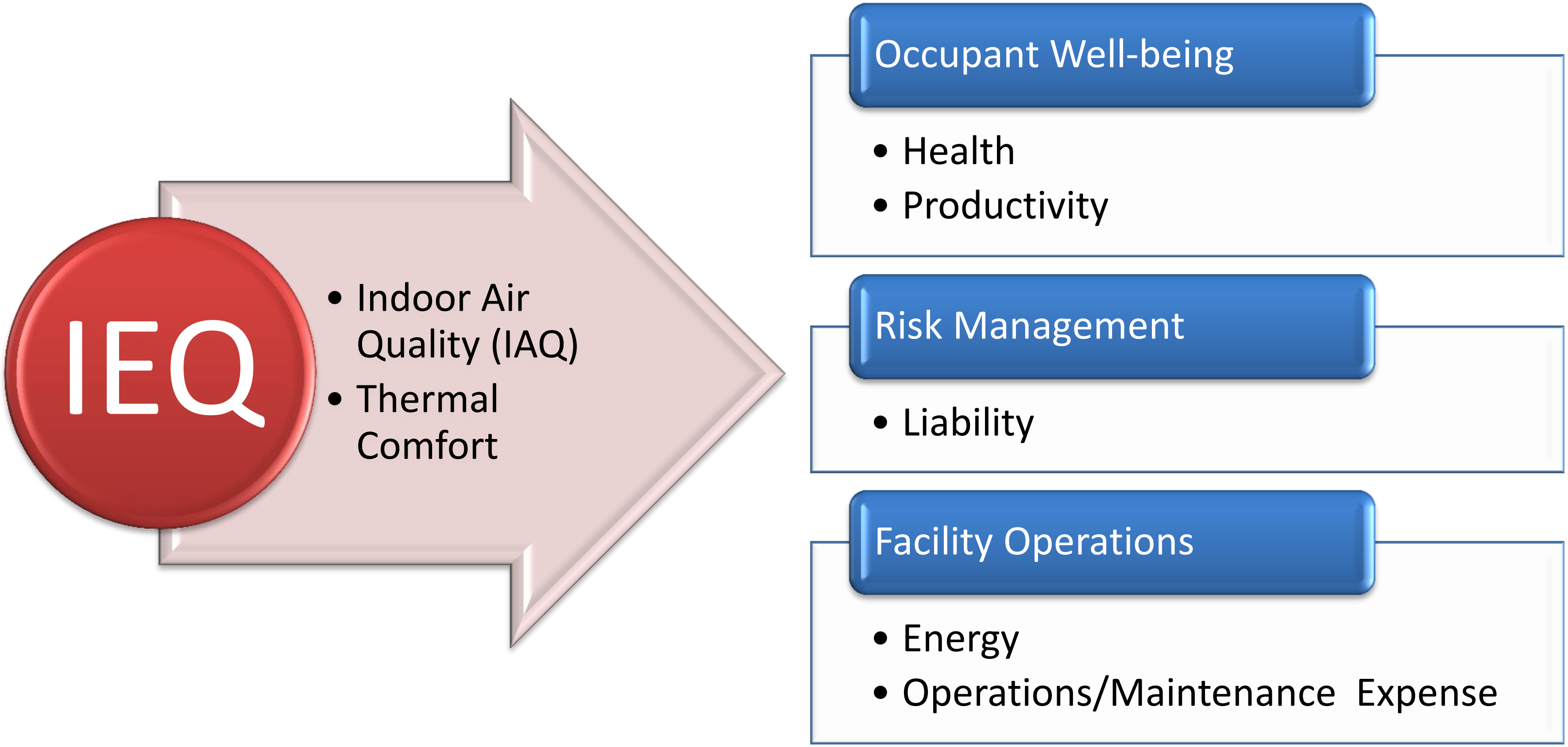
Reliable

Airflow Measurement Solutions

Agenda

- Why Measure & Control Outdoor Air Delivery?
  - Industry Updates
- Analyze Alternatives:
  - Fixed Outdoor Air Damper Position = No Control
  - Static Pressure Control Strategies
  - AFMS Pressurization Airflow Control Strategies
- Demand Control Ventilation
  - Outdoor Airflow Control Improves CO2-based Ventilation Control Systems
- Air Flow Measurement Technology
- Why Ebtron?
- Innovative ways Consulting Engineers are using Air Flow Monitoring to Enhance Building Designs

Indoor Environmental Quality



IEQ

- Indoor Air Quality (IAQ)
- Thermal Comfort

Occupant Well-being

- Health
- Productivity

Risk Management

- Liability

Facility Operations

- Energy
- Operations/Maintenance Expense

Airflow Measurement and IEQ

Outside Air Control

Building Pressure Control

Acceptable IEQ

Maintain Contaminants below Threshold Levels

Reduce Contaminant Sources

- Select low VOC emission building materials, carpets, furniture, etc.
- Provide proper filtration (filter bank integrity, replace filters).
- Reduce conditions that favor mold and fungal growth in or near the building envelope (leaks, improper **building pressure**).
- Avoid negative **building pressure** that transports unfiltered outside air into the building prior to HVAC filtration.
- Reduce conditions that favor mold and fungal growth in the HVAC system (maintain drain pans, maintain proper **outside and supply airflow rates**).

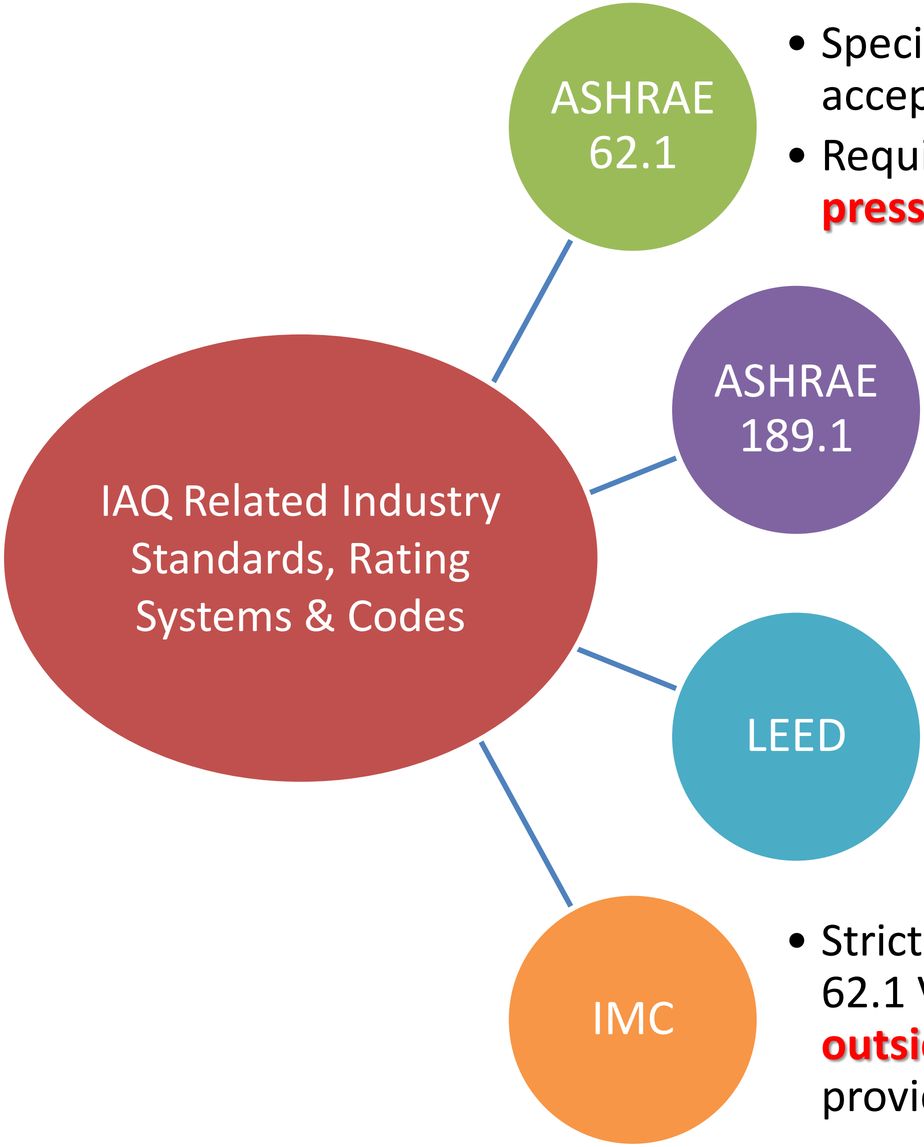
Replace Contaminants with Outdoor Air

- Provide proper **outside airflow rates** to maintain contaminant levels within the building below threshold levels.

Provide High Level Filtration when Necessary

- Filter specific contaminants of concern when outside air dilution ventilation is not enough to maintain threshold levels.

Follow Industry Standards, Rating Systems & Codes



IAQ Related Industry Standards, Rating Systems & Codes

ASHRAE 62.1

- Specifies **outside airflow rates** for acceptable IAQ.
- Requires positive **building pressurization** when dehumidifying.

ASHRAE 189.1

- Mandates outside **airflow measurement** on VAV systems.
- Requires quarterly verification of **outside airflow rates**.

LEED

- Currently awards 1 point for **outside airflow measurement.**

IMC

- Strict interpretation of ASHRAE 62.1 VRP requires specified **outside airflow rates** are provided for compliance.

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

1. PURPOSE

1.1 The purpose of this standard is to specify minimum ventilation rates and
other mea table to
human oc

specify minimum ventilation rates

1.2 This standard is intended for regulatory application to new buildings,
additions to existin ng buildings that
are identified in the

regulatory application

[new construction/additions]

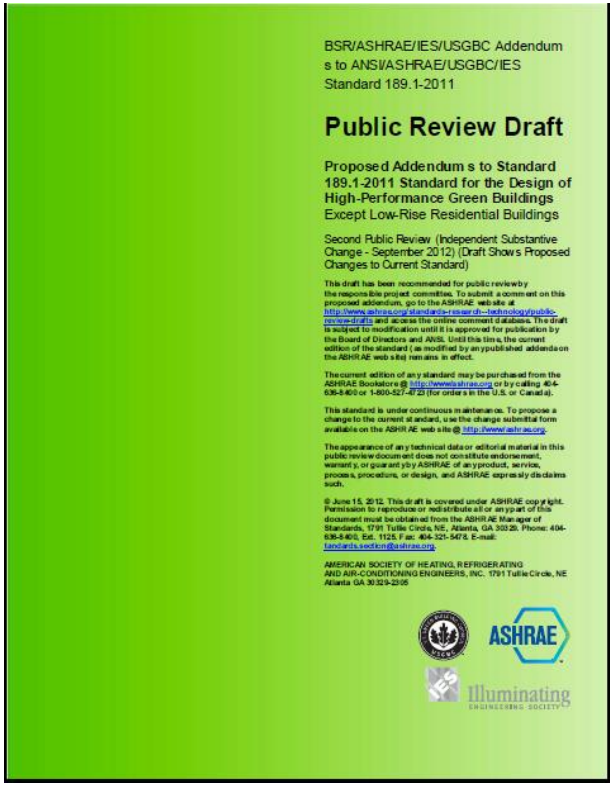
1.3 This standard is intended to be used to guide the improvement of indoor
air quality in existing bu

guide

[improve existing buildings]

ASHRAE 189.1-2011

(Proposed addendum s)



BSR/ASHRAE/IES/USGBC Addendum s to ANSI/ASHRAE/USGBC/IES Standard 189.1-2011

Public Review Draft

Proposed Addendum s to Standard 189.1-2011 Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

Second Public Review (Independent Substantive Change - September 2012) (Draft Shows Proposed Changes to Current Standard)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed addendum, go to the ASHRAE website at http://www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE web site) remains in effect.

The current edition of any standard may be purchased from the ASHRAE Bookstore @ http://www.ashrae.org or by calling 404-636-8400 or 1-800-527-4723 (for orders in the U.S. or Canada).

This standard is under continuous maintenance. To propose a change to the current standard, use the change submittal form available on the ASHRAE web site @ http://www.ashrae.org.

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHRAE expressly disclaims such.

AMERICAN SOCIETY OF HEATING, REFRIGERATING
AND AIR-CONDITIONING ENGINEERS, INC. 1791 Tullie Circle, NE
Atlanta GA 30329-2305

Important Note: *Addendum s* is in its second and final public review stage. Content variation with respect to airflow measurement is not substantially different from the parent document except where noted on the following slides.

ASHRAE 189.1-2011

(Proposed addendum s)

8.3.1.2 Outdoor Air Delivery Monitoring.

8.3.1.2.2 Monitoring Requirements. Each mechanical ventilation system shall have a permanently installed device to measure the *minimum outdoor airflow*, which meets the following requirements:

1. The device shall employ methods described in ASHRAE Standard 111.
2. The device shall have an accuracy **±10%** of the *minimum outdoor airflow.* Where the *minimum outdoor airflow* varies, as in *demand control ventilation* systems, the device shall maintain this accuracy over the entire range of occupancy and system operation.
3. The device shall be capable of notifying the building operator, either by activating a local indicator or by sending a signal to a building monitoring system, whenever an *outdoor air fault condition* exists. This notification shall require manual reset.

Exception: Constant volume air supply systems that do not employ *demand control ventilation* and that use an indicator to confirm that the intake damper is open to the position, determined during system startup and balancing, needed to maintain the design *minimum outdoor airflow*.

WHY EXEMPT?

Pressurization Control Helps Meet the Intent of LEED 2009: Better Performing Buildings

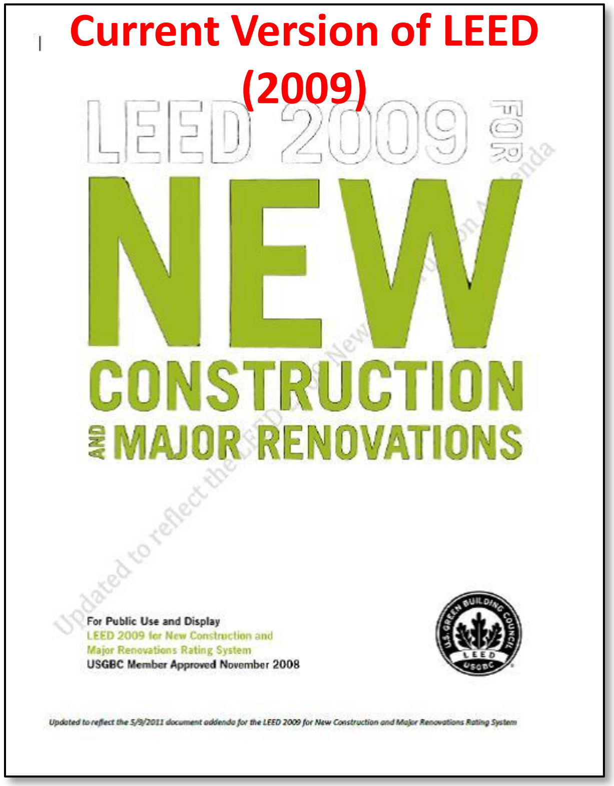
Prerequisite or Credit	Description	NC	SCHOOLS	CS
EA Prerequisite 1	Fundamental Commissioning	Required	Required	Required
EA Prerequisite 2	Minimum Energy Performance	Required	Required	Required
EA Credit 1	Optimize Energy Performance	1-19 points	1-19 points	3-21 points
EA Credit 3	Enhanced Commissioning	2 points	2 points	2 points
EA Credit 5	Measurement and Verification	3 points	2 points	NA
IEQ Prerequisite 1	Minimum IAQ Performance	Required	Required	Required
IEQ Prerequisite 2	ETS (tobacco smoke) Control	Required	Required	Required
IEQ Prerequisite 3	Minimum Acoustical Performance	NA	Required	NA
IEQ Credit 1	**Outdoor Air Delivery Monitoring**	**1 Point**	**1 Point**	**1 Point**
IEQ Credit 2	Increased Ventilation	1 Point	1 Point	1 Point
IEQ Credit 3/3.1	Construction Management Plan (constr.)	1 Point	1 Point	1 Point
IEQ Credit 3.2	Construction Management Plan (occup.)	1 Point	1 Point	NA
IEQ Credit 6.2	Controllability of Systems - Thermal	1 Point	1 Point	1 Point
IEQ Credit 7/7.1	Thermal Comfort - Design	1 Point	1 Point	1 Point
IEQ Credit 7.2	Thermal Comfort - Verification	1 Point	1 Point	NA
IEQ Credit 9	Enhanced Acoustical Performance	NA	1 Point	NA
IEQ Credit 10	Mold Prevention	NA	1 Point	NA
ID Credit 1	Innovation in Design	1-5 points	1-4 points	1-5 points

INDOOR ENVIRONMENTAL QUALITY (IEQ)
Credit 1: Outdoor Air Delivery Monitoring

Install permanent monitoring systems to ensure that the ventilation systems maintain design minimum requirements. Configure all monitoring equipment to generate an alarm when the airflow values or carbon dioxide levels vary by 10% or more from the design values via either a building automation system alarm to the building operator or a visual or audible alert to the building occupants.

Monitor CO_2 concentrations within all densely occupied spaces (those with a design occupant density of 25 people or more per 1,000 square feet).

Provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow with an accuracy of plus or minus 15% of the design minimum outdoor air rate, as defined by ASHRAE 62.1-2007 for mechanical ventilation systems where 20% or more of the design supply airflow serves nondensely occupied spaces.



Current Version of LEED (2009)

LEED 2009 FOR
NEW
CONSTRUCTION
AND MAJOR RENOVATIONS

For Public Use and Display
LEED 2009 for New Construction and
Major Renovations Rating System
USGBC Member Approved November 2008

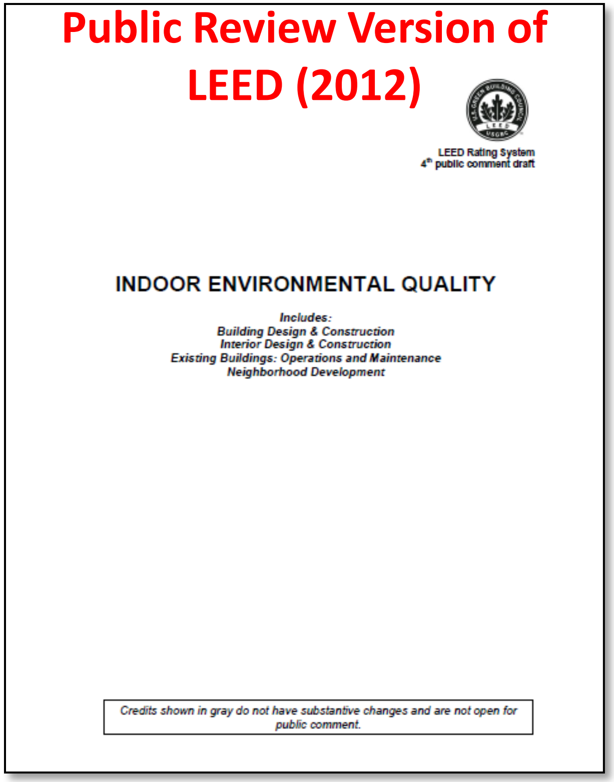
Updated to reflect the 5/9/2011 document addenda for the LEED 2009 for New Construction and Major Renovations Rating System

INDOOR ENVIRONMENTAL QUALITY (EQ)
EQ PREREQUISITE: MINIMUM INDOOR AIR QUALITY PERFORMANCE
Required Monitoring

For variable air volume systems, provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow. This device must measure the minimum outdoor air intake flow with an accuracy of +/–10% of the design minimum outdoor airflow rate, as defined by the ventilation requirements above. An alarm must indicate when the outdoor airflow value varies by 15% or more from the outdoor airflow setpoint.

For constant-volume systems, balance outdoor airflow to the design minimum outdoor airflow rate defined by ASHRAE Standard 62.1–2010 (with errata but without addenda2), or higher. Install a current transducer on the supply fan, an airflow switch, or similar monitoring device.

Public Review Version of LEED (2012)



LEED Rating System
4th public comment draft

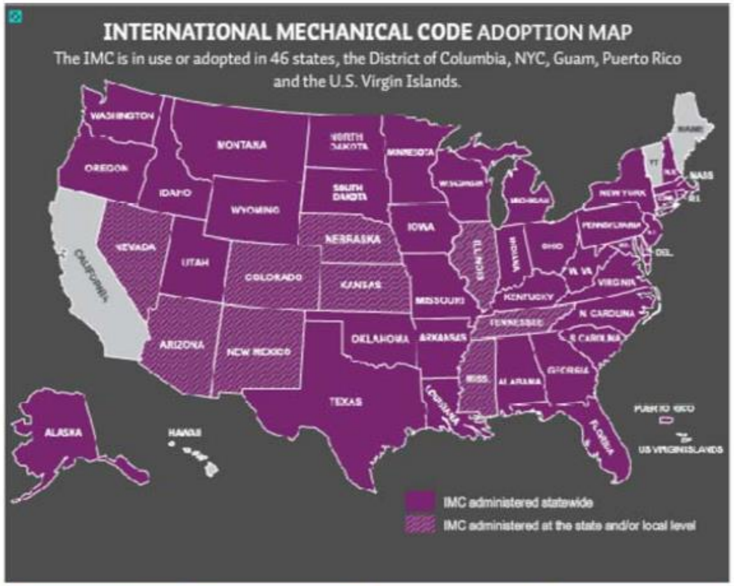
INDOOR ENVIRONMENTAL QUALITY

Includes:
Building Design & Construction
Interior Design & Construction
Existing Buildings: Operations and Maintenance
Neighborhood Development

Credits shown in gray do not have substantive changes and are not open for public comment.

The IMC is a STRICT interpretation of the ASHRAE Standard 62 *Ventilation Rate Procedure*

Updated: October, 2012

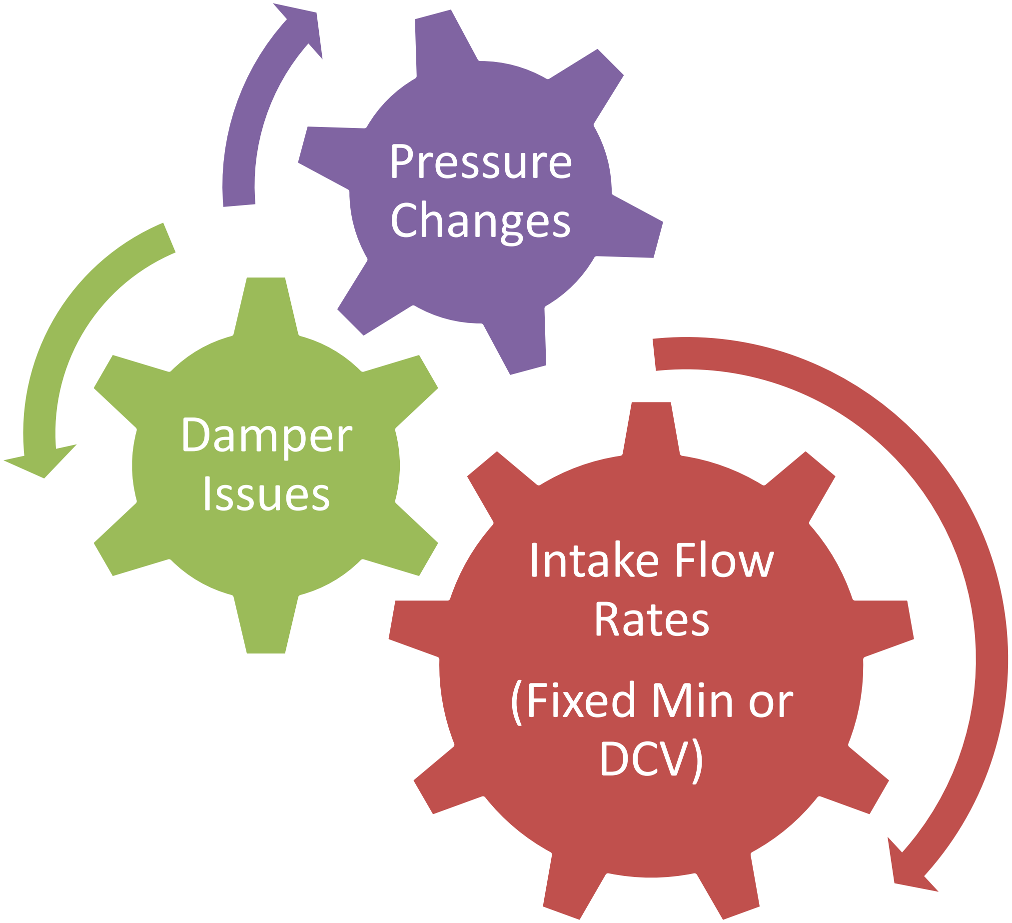


SECTION 405

SYSTEMS CONTROL

405.1 General. Mechanical ventilation systems shall be provided with manual or automatic controls that will operate such systems whenever the spaces are occupied. Air-conditioning systems that supply required *ventilation air* shall be provided with controls designed to **automatically maintain the required outdoor air supply rate** during occupancy.

ALL OA Intake Systems Require Measurement with Control

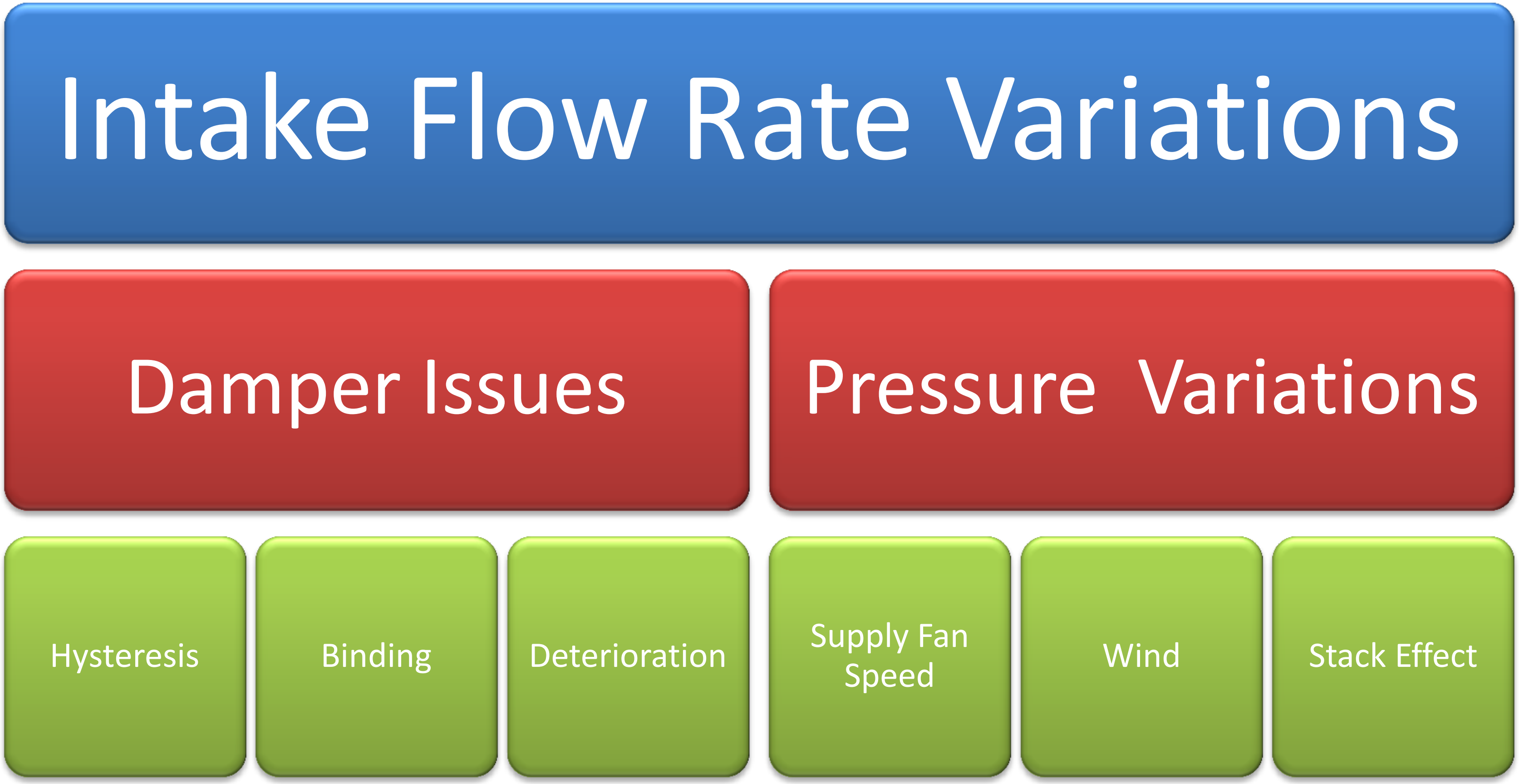


Pressure Changes

Damper Issues

Intake Flow Rates

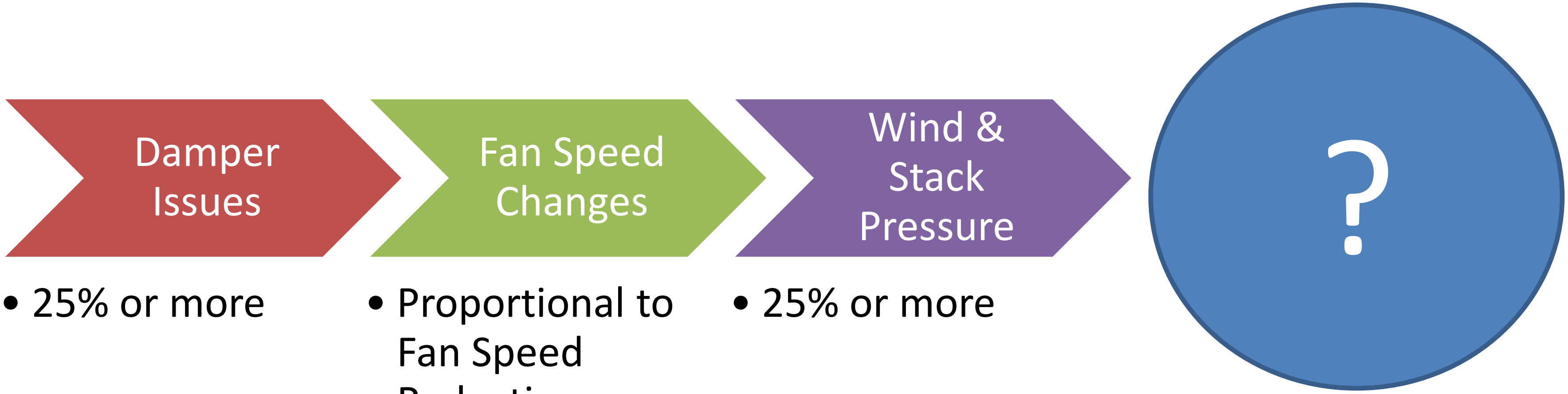
(Fixed Min or DCV)



Intake Flow Rate Variations

- Damper Issues
  - Hysteresis
  - Binding
  - Deterioration
- Pressure Variations
  - Supply Fan Speed
  - Wind
  - Stack Effect

Cumulative Uncertainty on Non-controlled Intake Flow Rates During Minimum or DCV* Operation



Damper Issues

- 25% or more

Fan Speed Changes

- Proportional to Fan Speed Reduction

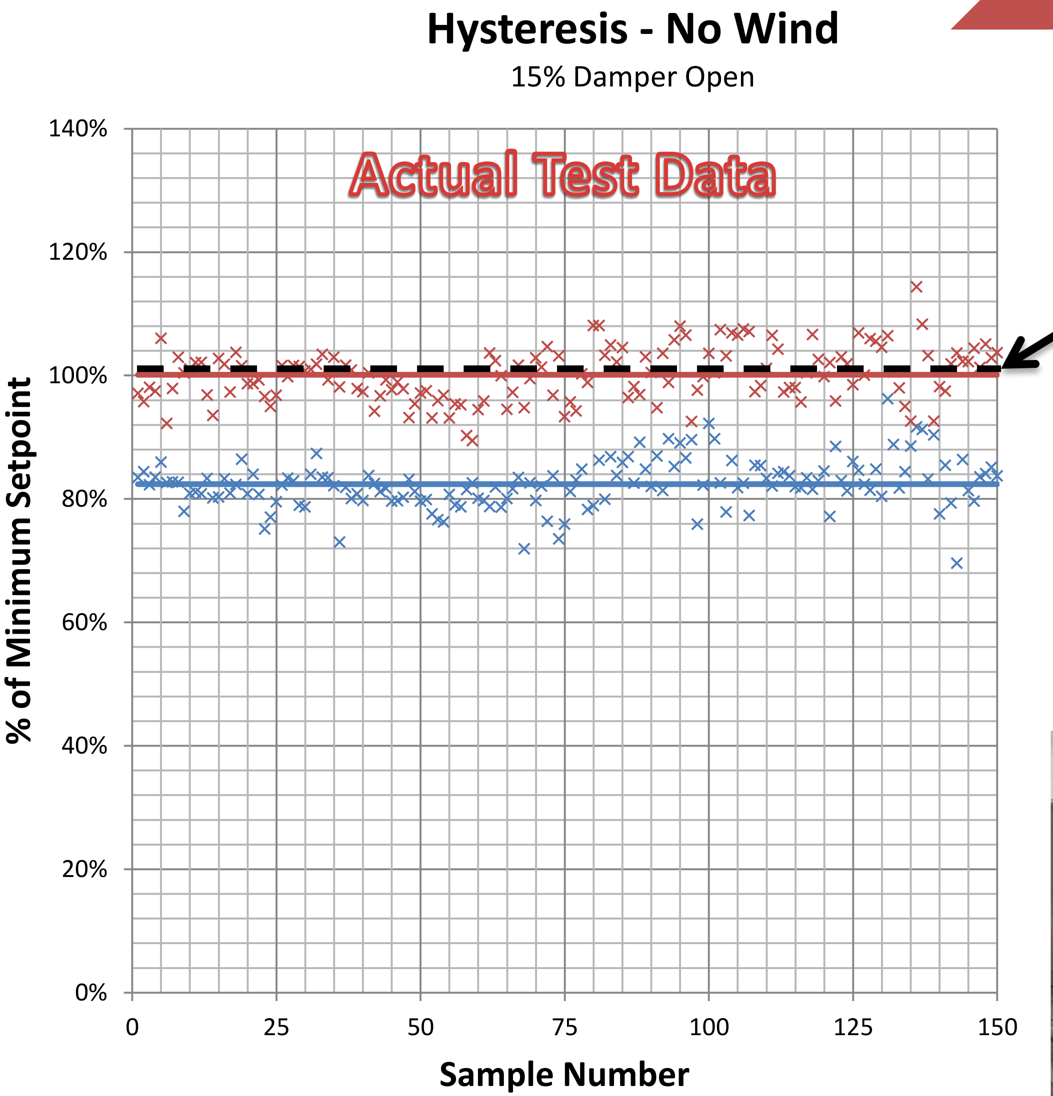
Wind & Stack Pressure

- 25% or more

?

* DCV Uncertainty is most critical at minimum and maximum expected populations.

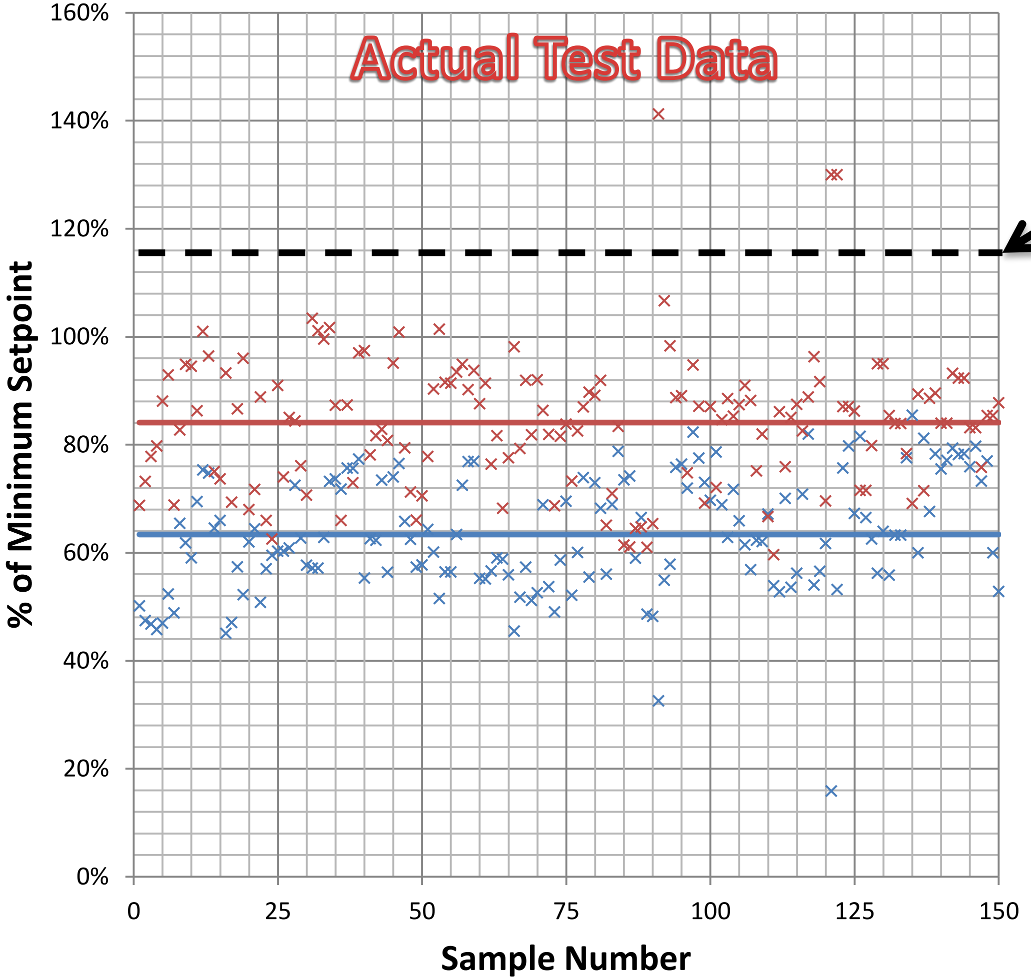
Damper Issues



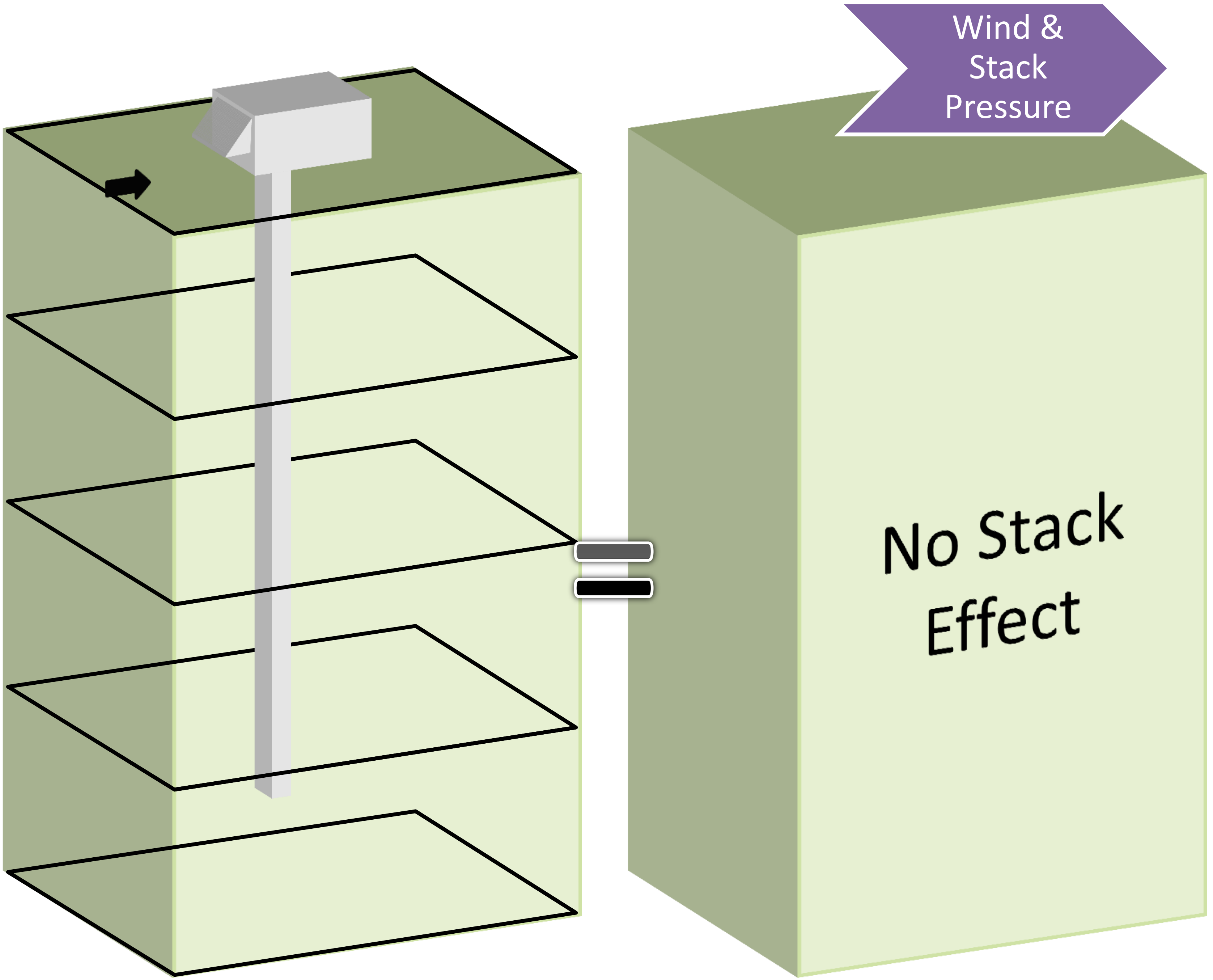
Wind &
Stack
Pressure

Hysteresis + 15 mph Cross Wind

15% Damper Open

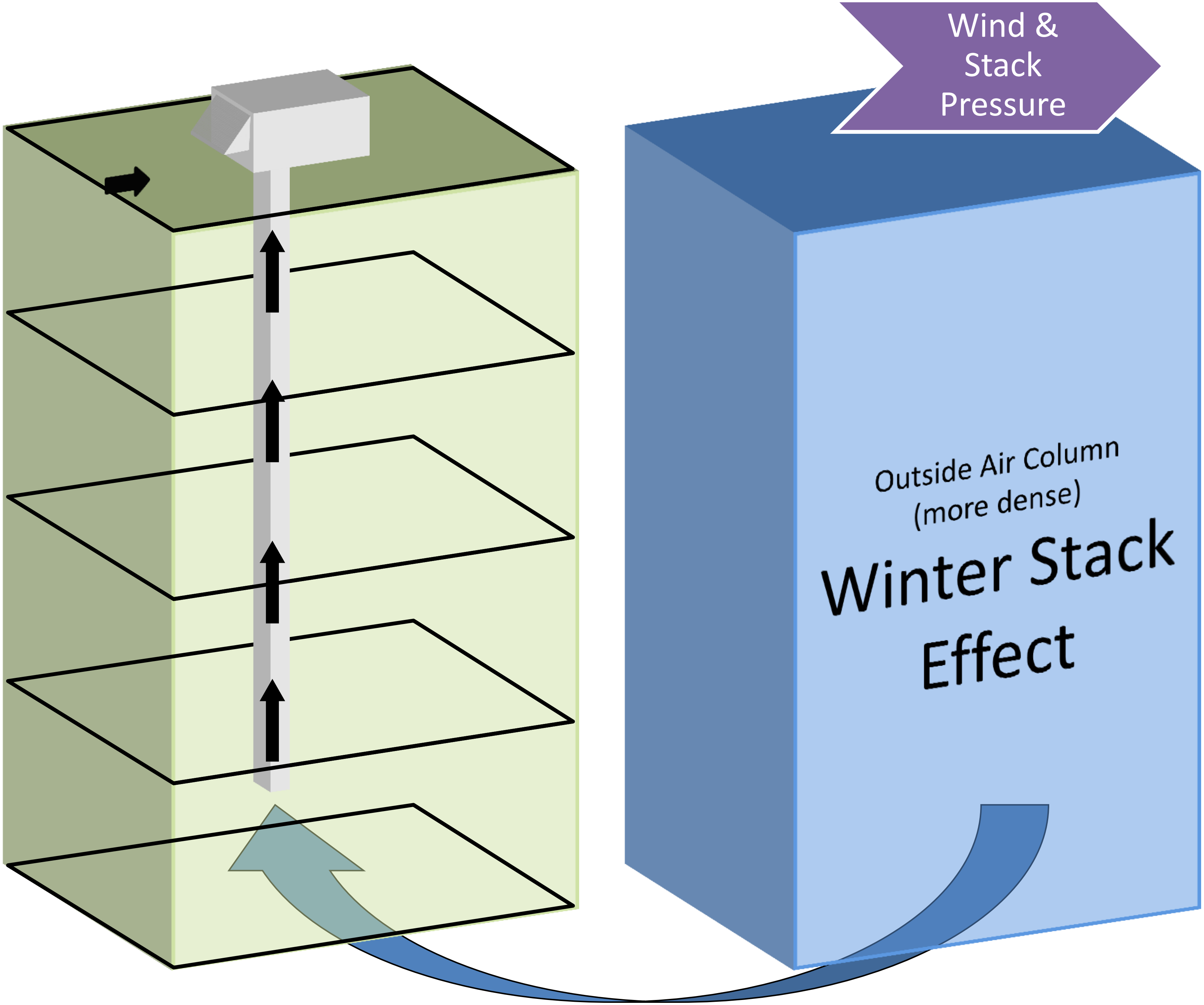


V_{ot} Setpoint



Wind &
Stack
Pressure

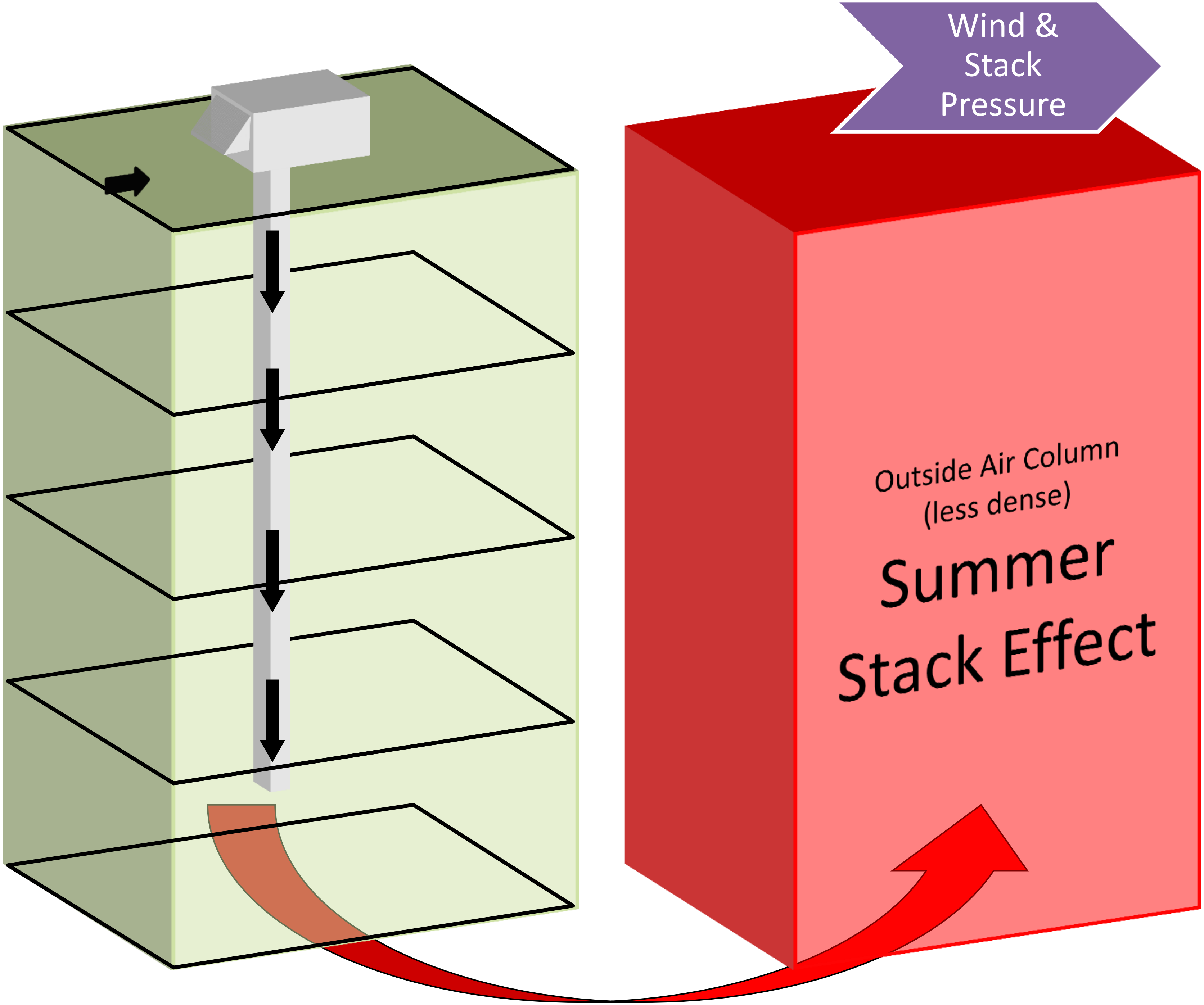
No Stack
Effect



Wind & Stack Pressure

Outside Air Column (more dense)

Winter Stack Effect


Wind &
Stack
Pressure
Outside Air Column
(less dense)
Summer
Stack Effect

The Logical Conclusion …

Damper Issues

Fan Speed

Wind & Stack

Monitor Outside Airflow

Control Outside Airflow

On ALL OA Intakes

Building Pressurization

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

5.9.2 Exfiltration. For a building, the ventilation system(s) shall be designed to ensure that the minimum outdoor air intake equals or exceeds the maximum exhaust airflow.

Note: Although individual zones within a building may be neutral or negative with respect to outdoors or to other zones, net positive mechanical intake airflow for the building as a whole reduces infiltration of untreated outdoor air.

The OA intake airflow shall exceed the exhaust airflow to maintain a net positive mechanical intake airflow to limit dirt/moisture migration.

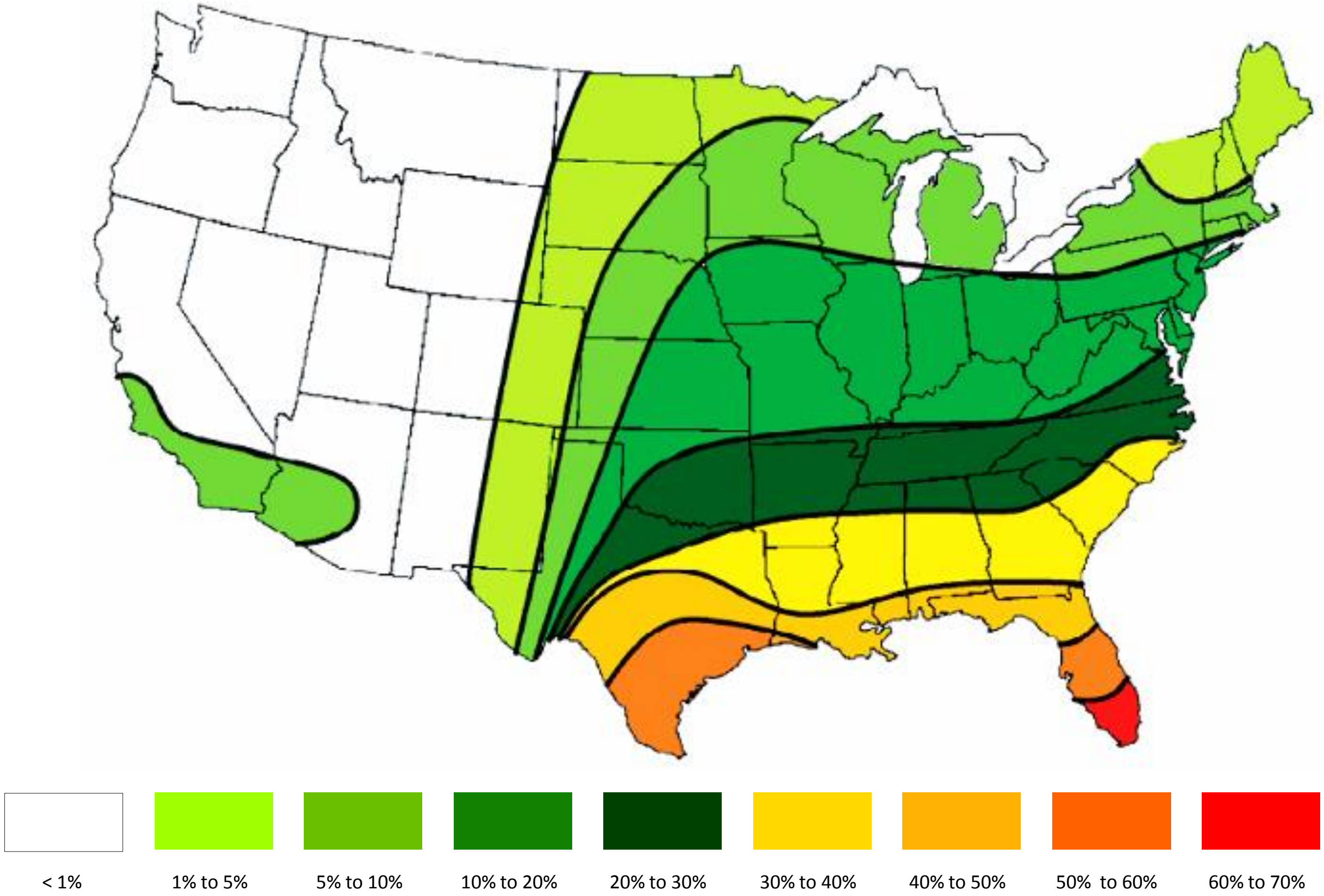
Negative pressure is an IEQ nightmare!

Mechanical Cooling

High Dew Point Regions

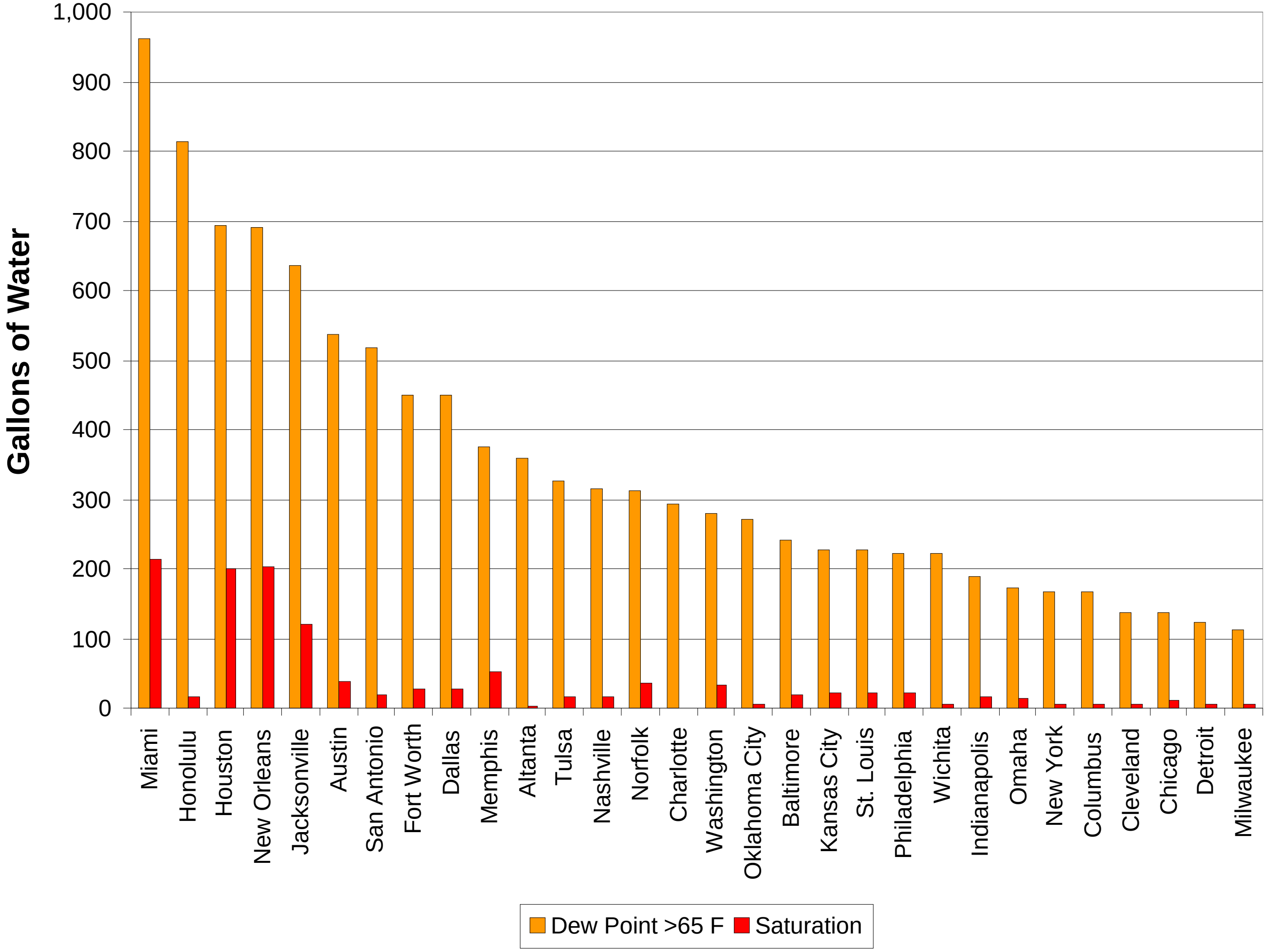
Percentage of year that the dew point exceeds 65 F

5 year hourly dry bulb and dew point analysis

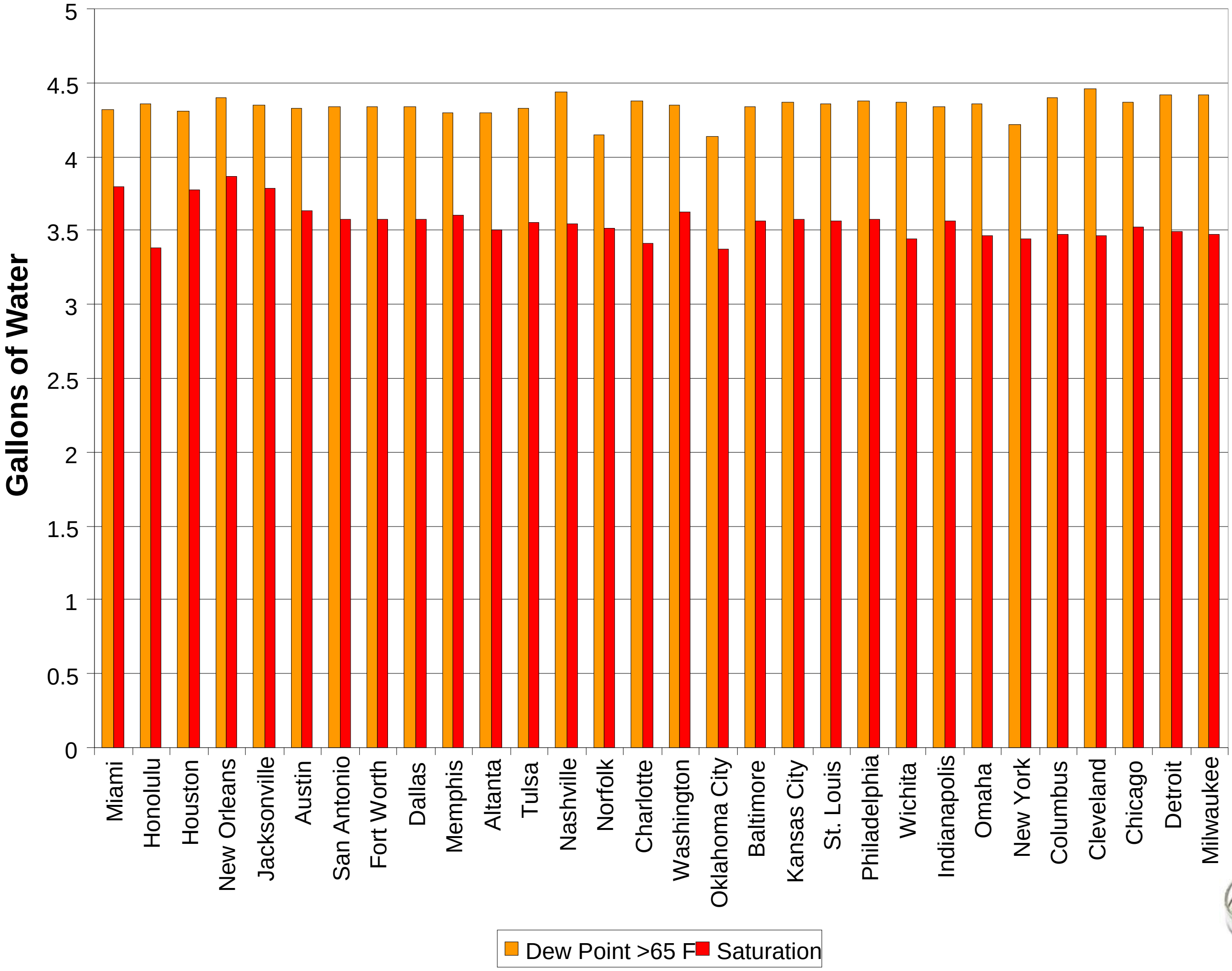


Data provided to EBTRON courtesy of the Forecast Institute, Inc.

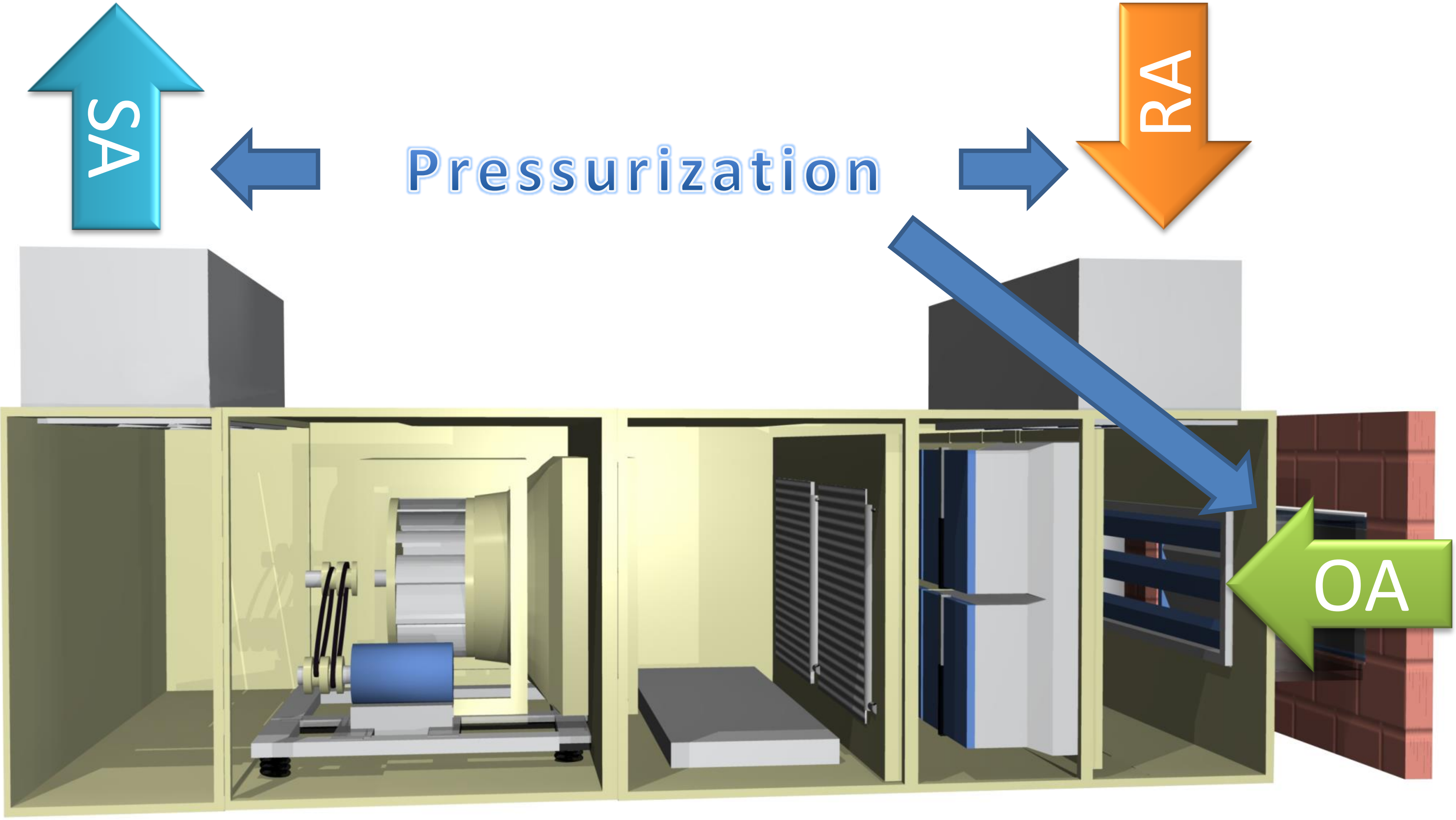
Annual Gallons of Water Transported Across the Building Envelope for every 1,000 CFM of Negative Airflow
First 30 of top 50 US Cities by Population (2000 Census)



Avg. Daily Gallons of Water Transported Across the Building Envelope for every 1,000 CFM of Negative Airflow (when outdoor conditions specified exist)

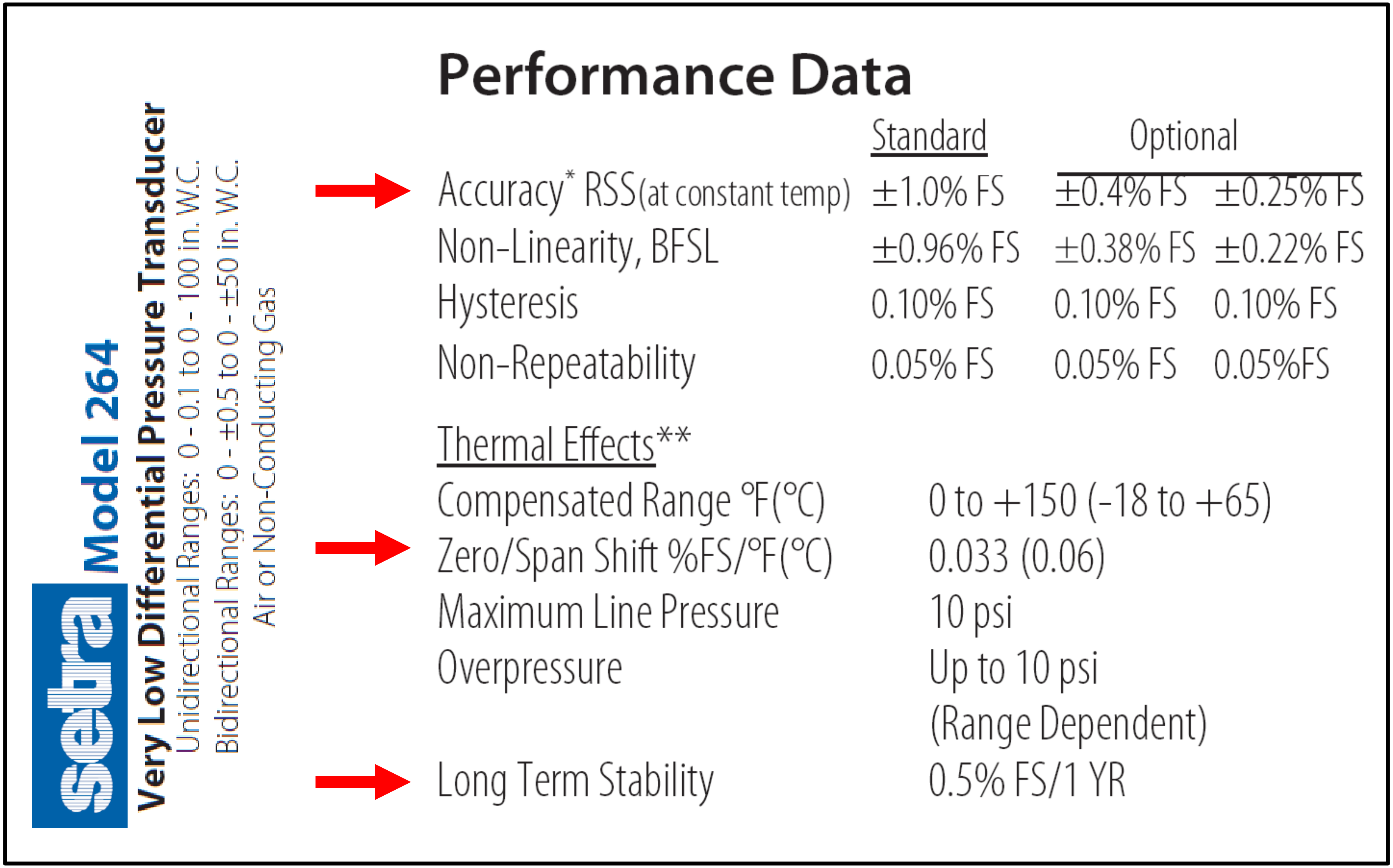


Airflow Measurement and IEQ



ACCURACY COUNTS!!!

Typical ΔP Transducer Error



Setra

Model 264

Very Low Differential Pressure Transducer

Unidirectional Ranges: 0 - 0.1 to 0 - 100 in. W.C.

Bidirectional Ranges: 0 - ±0.5 to 0 - ±50 in. W.C.

Air or Non-Conducting Gas

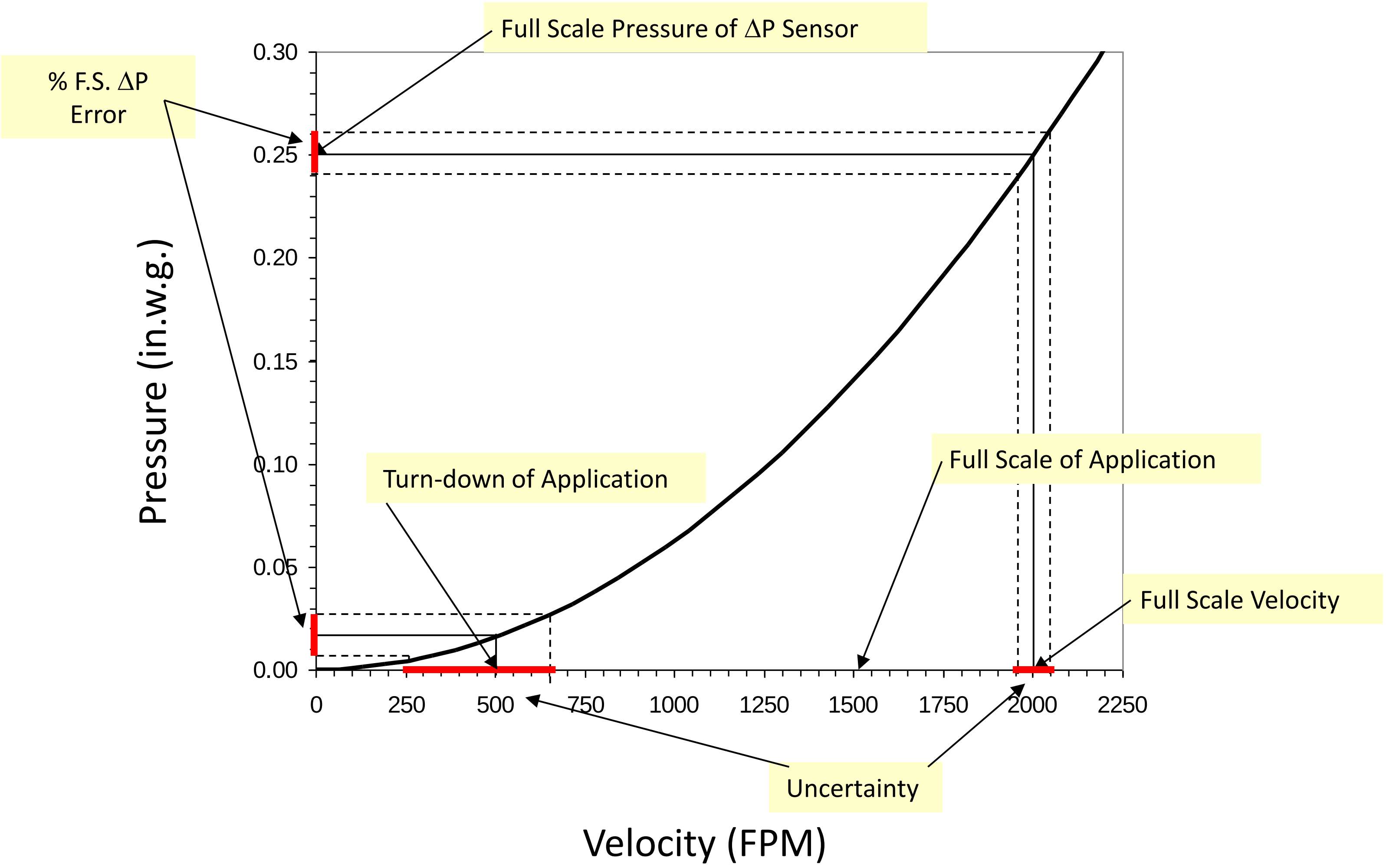
Performance Data

	Standard	Optional	
Accuracy* RSS (at constant temp)	±1.0% FS	±0.4% FS	±0.25% FS
Non-Linearity, BFSL	±0.96% FS	±0.38% FS	±0.22% FS
Hysteresis	0.10% FS	0.10% FS	0.10% FS
Non-Repeatability	0.05% FS	0.05% FS	0.05%FS

Thermal Effects**

Compensated Range °F(°C)	0 to +150 (-18 to +65)
Zero/Span Shift %FS/°F(°C)	0.033 (0.06)
Maximum Line Pressure	10 psi
Overpressure	Up to 10 psi (Range Dependent)
Long Term Stability	0.5% FS/1 YR

% F.S. Dilemma with ΔP Devices



VAV Tracking Example

System:

Total SA flow: 100,000 CFM

ΔCFM Setpoint: 10,000 CFM

Building Pressure Desired: 0.02 in.w.g.

Pressurization Flow: 5,000 CFM

Local Exhaust: 5,000 CFM

Max Turndown: 40%

SA Duct Area: 55.5 ft^2

RA Duct Area: 56.7 ft^2

Calculated Velocities:

Max velocity SA duct: 1,800 FPM

Min velocity SA duct: 720 FPM

Max velocity RA duct: 1,500 FPM

Min velocity RA duct: 500 FPM

Sensors:

DP sensor: 0 to 0.25 in.w.g., 1 % F.S.

Flow probe: Averaging pitot array

Test Conditions:

DP sensor located in mechanical room

Setup temperature: 70 ºF

Operating temperature: 100 ºF, 1 year after startup

Component Accuracies:

DP Sensor:

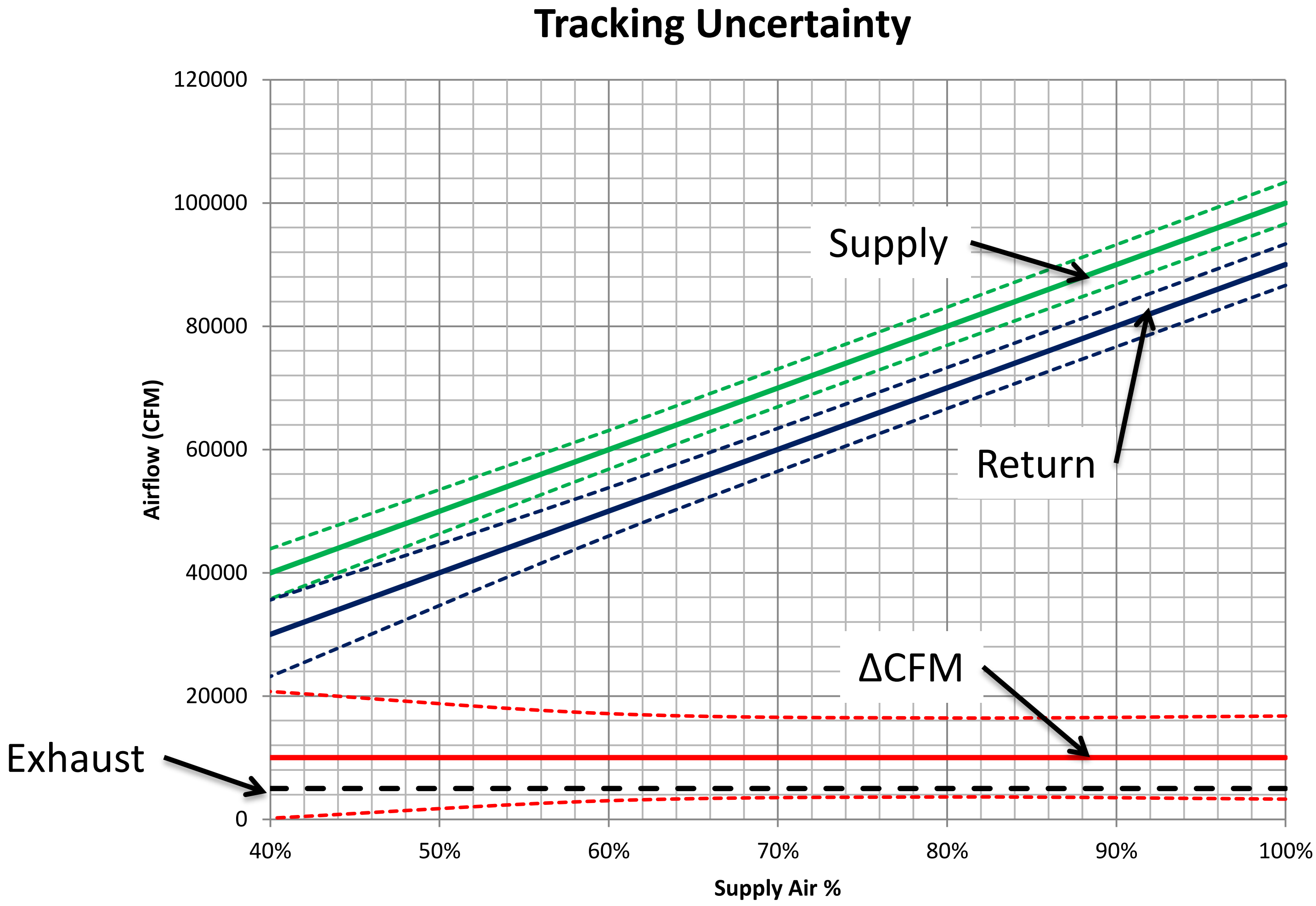
Total Accuracy = Accuracy + Temp Effect + Drift

1% F.S. + 1% F.S. + ½ % F.S. = 2 ½ % F.S.

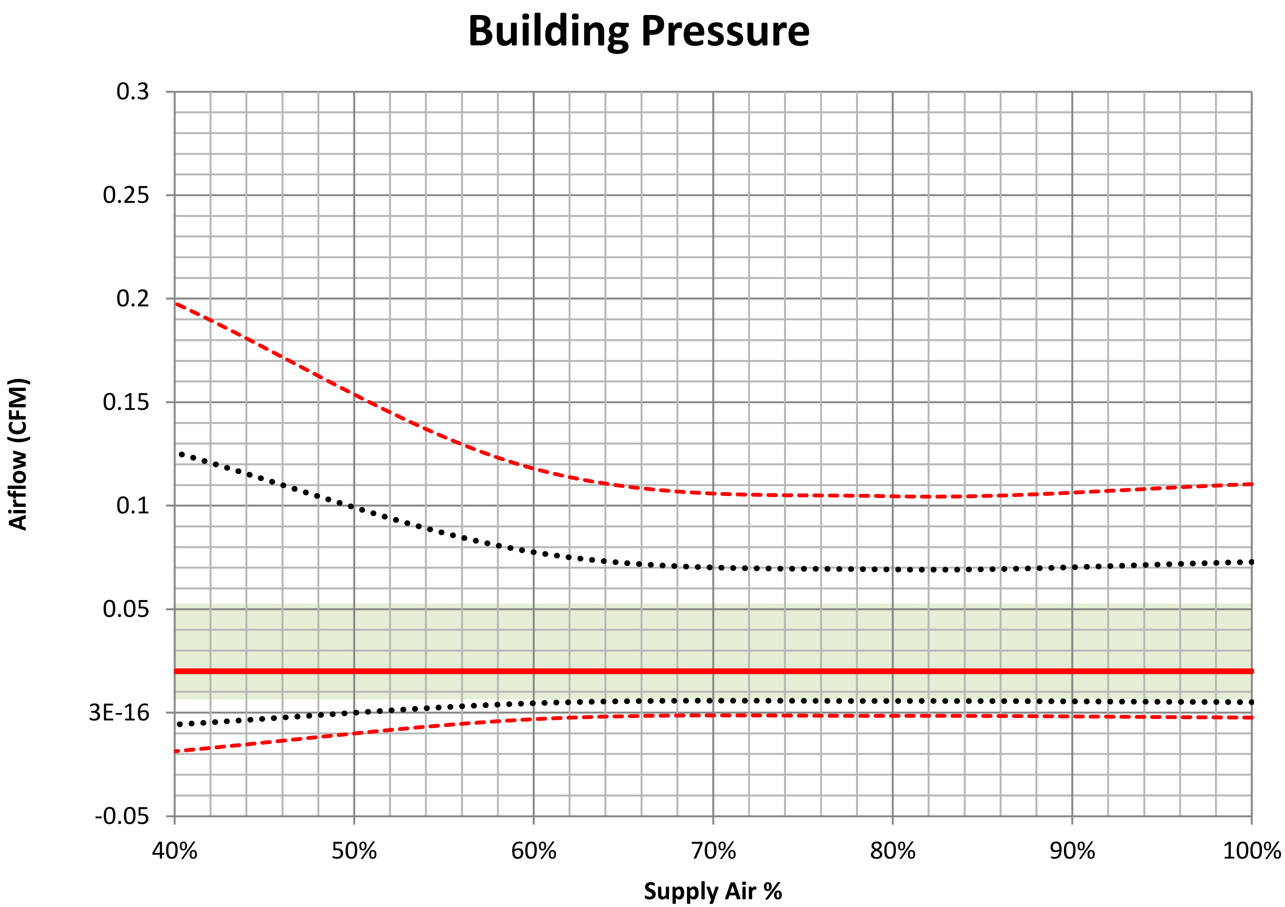
Airflow Measuring Device:

3% of reading

Pitot Array and Transducer



Pitot Array and Transducer



How did we come up with this?

- Determine the uncertainty of a 1%, 0 to 0.25 in.w.g. pressure transducer and pitot array at 500 FPM and 100 °F after 1 year?

1. Calculate the velocity pressure for 500 fpm:

   $$V=4005\sqrt{p_{vel}} \longrightarrow \left(\frac{V}{4005}\right)^2 = p_{vel}$$

   $p_{vel} = (500/4005)^2 = 0.0156$

2. Determine the transducer uncertainty % F.S.:

   1% F.S. (out of box) + 0.033% F.S./°F · 30 °F + 0.5% (1 year drift) = 2.5% F.S.

3. Determine the transducer uncertainty in in.w.g.

   2.5% · 0.25 = 0.00625 in.w.g.

4. Calculate the velocity after biasing the nominal pressure by the pressure uncertainty and reapplying the equation above (in this case the negative uncertainty)

   V = 4005 · sqrt(0.0156 – 0.00625) = 387 FPM or -22.6%

5. Add the array uncertainty (in this case we used 3% of reading)

   Total Uncertainty = sqrt(22.6%^{2} + 3%^{2}) = 22.8%

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Max Turndown: 40%

Fan Throat Velocities:

Max velocity: 10,000 FPM

Min velocity: 4,000 FPM

Sensors:

DP sensor: 0 to 25 in.w.g., 1 % F.S.

Flow probe: Piezo-ring

Test Conditions:

DP sensor located in mechanical room

Setup temperature: 70 ^{o}F

Operating temperature: 100 ^{o}F, 1 year after startup

Component Accuracies:

DP Sensor:

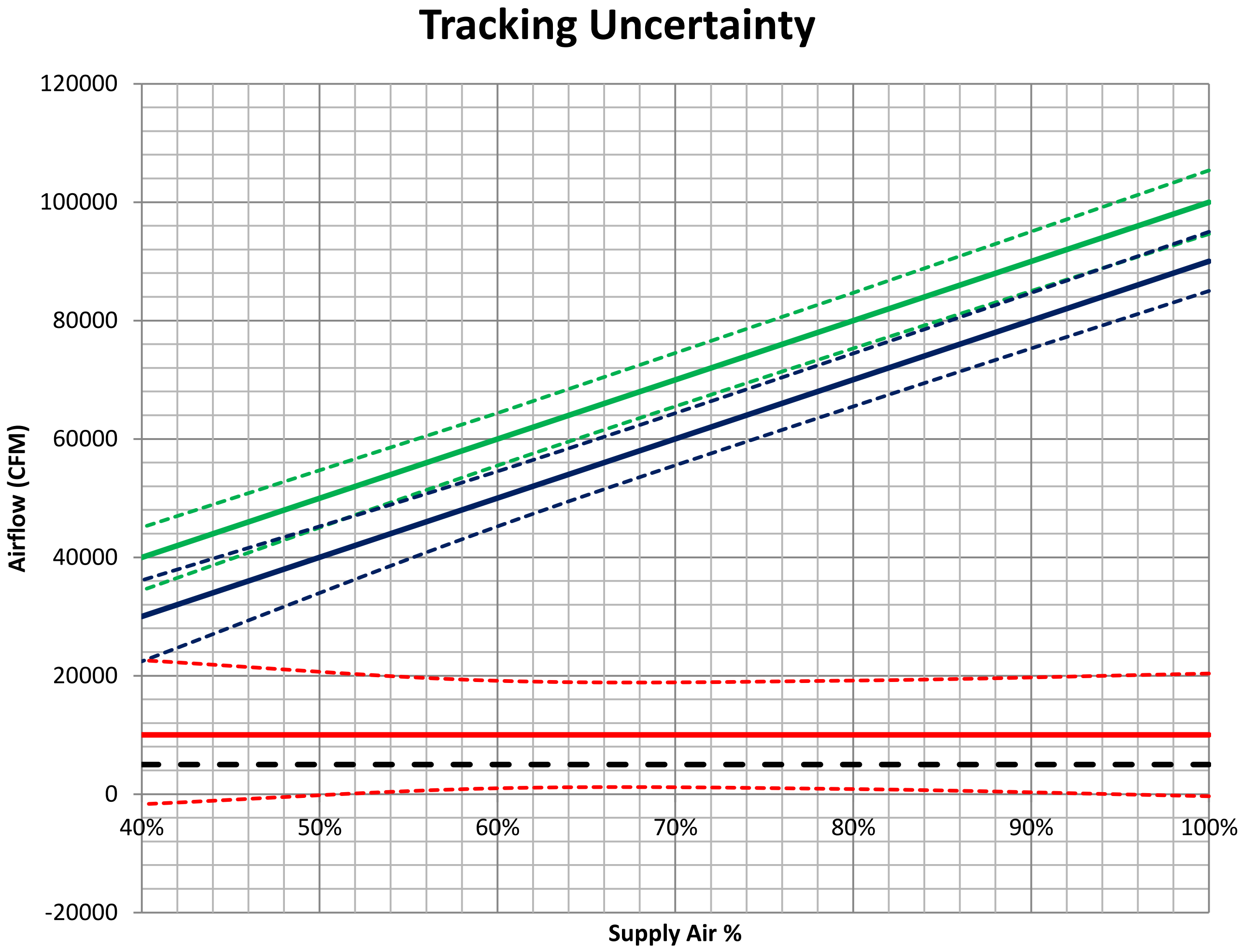
Total Accuracy = Accuracy + Temp Effect + Drift

1% F.S. + 1% F.S. + ½ % F.S. = 2 ½ % F.S.

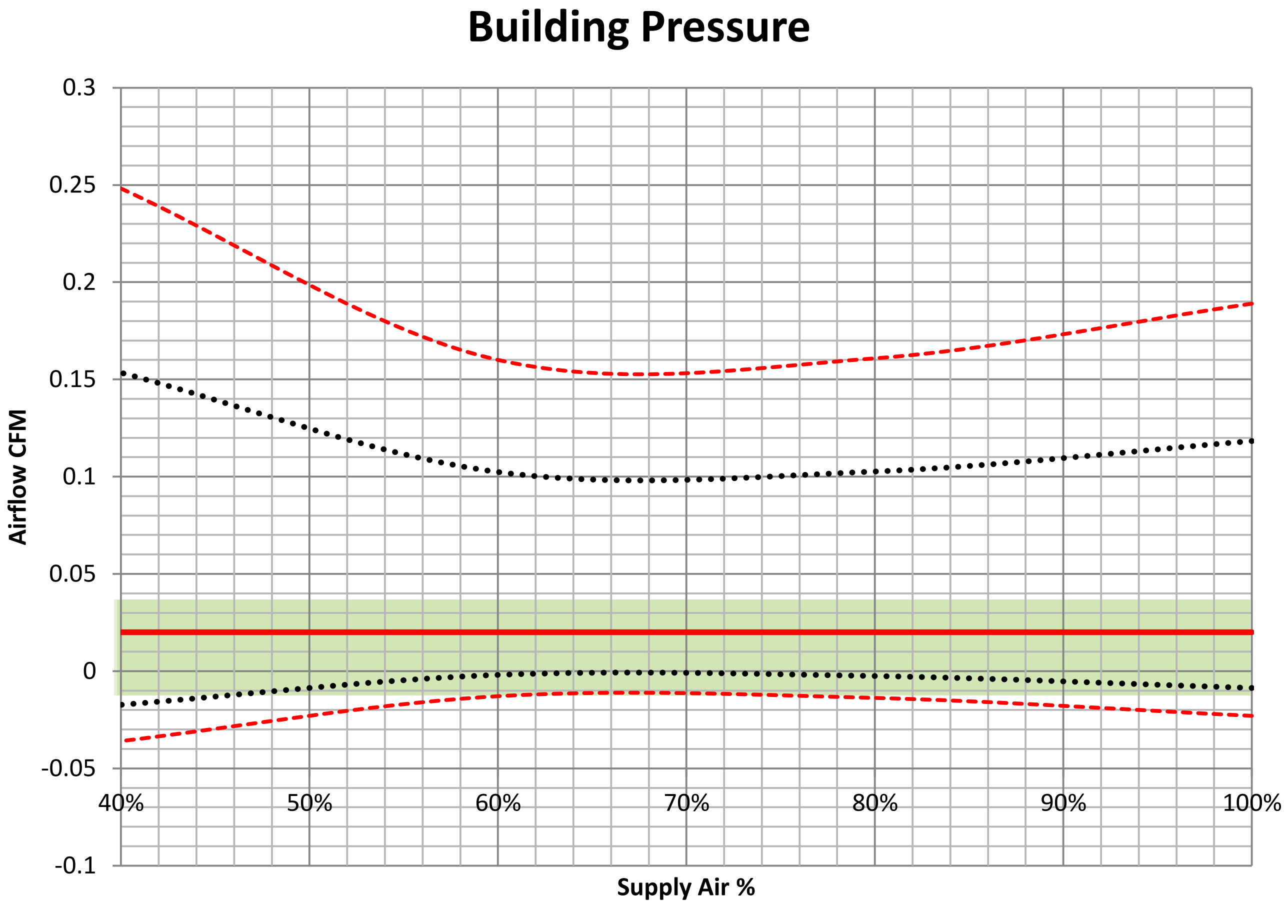
Airflow Measuring Device:

5% of reading

Piezo-ring and Transducer



Piezo-ring and Transducer



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Min velocity SA duct: 720 FPM

Max velocity RA duct: 1,500 FPM

Min velocity RA duct: 500 FPM

Sensors:

EBTRON Thermal Dispersion System (±2% of reading sensor accuracy)

Test Conditions:

Transmitter located in mechanical room

Setup temperature: 70 ºF

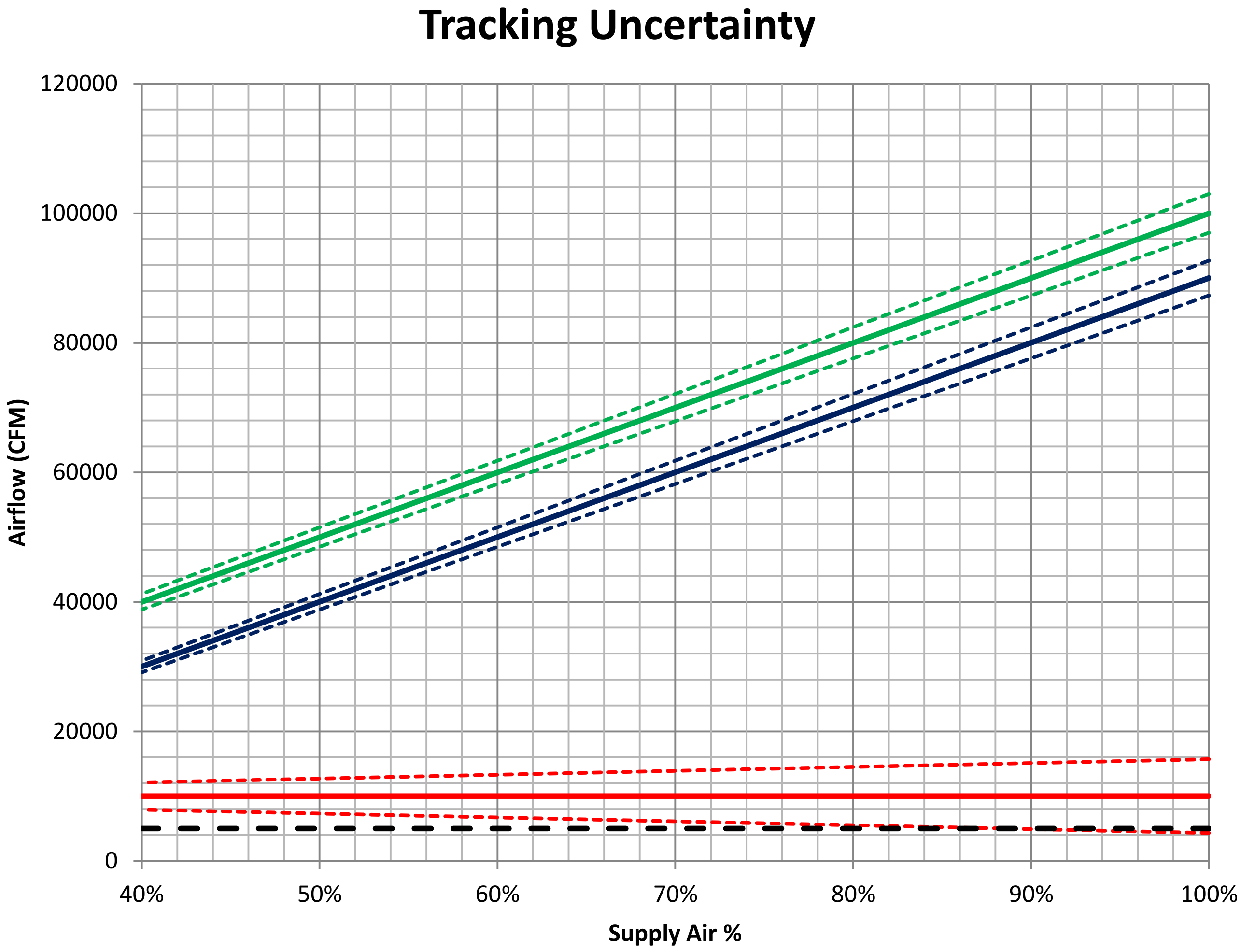
Operating temperature: 100 ºF, 1 year after startup

Component Accuracies:

System:

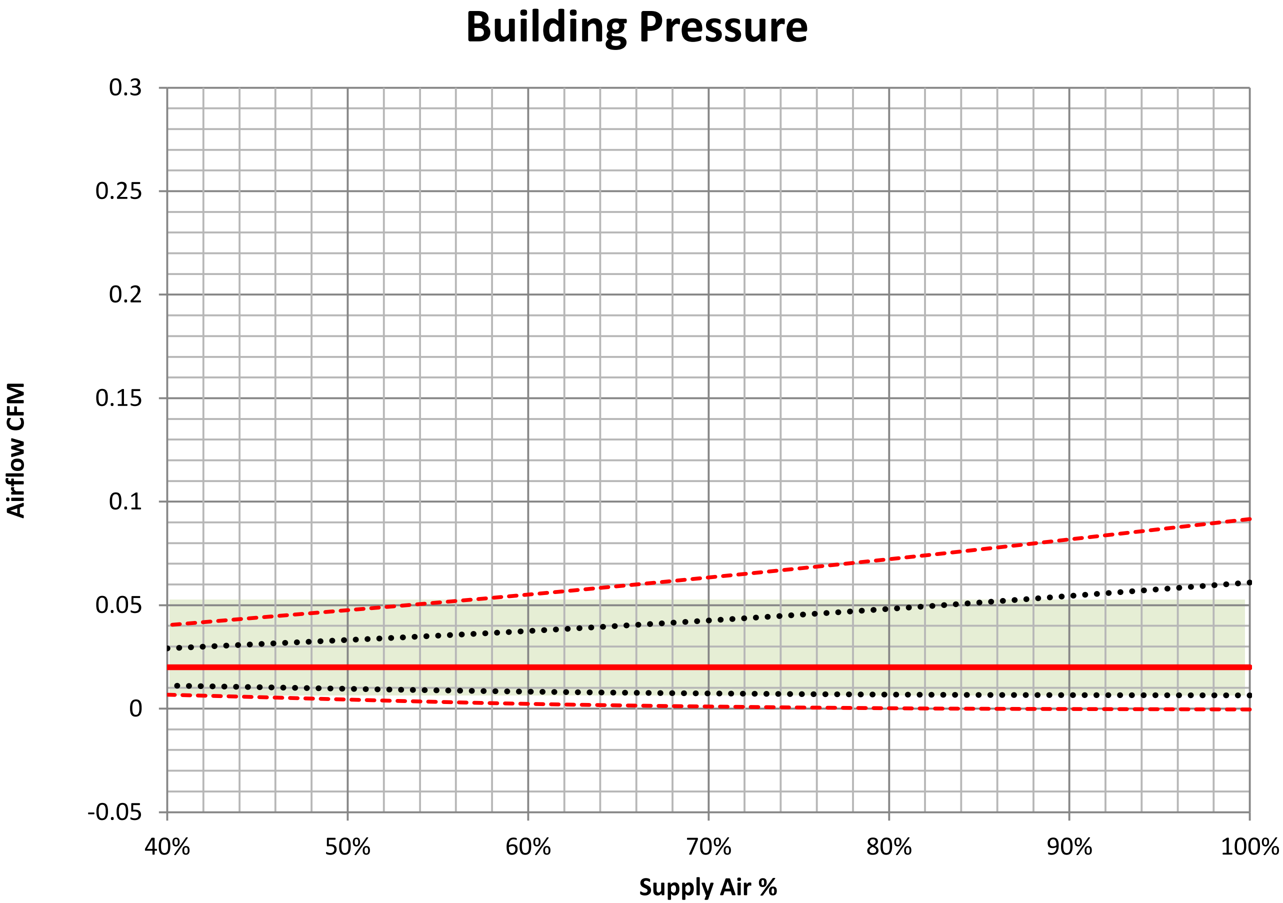
Installed accuracy: ±3% of reading

a measureable difference!



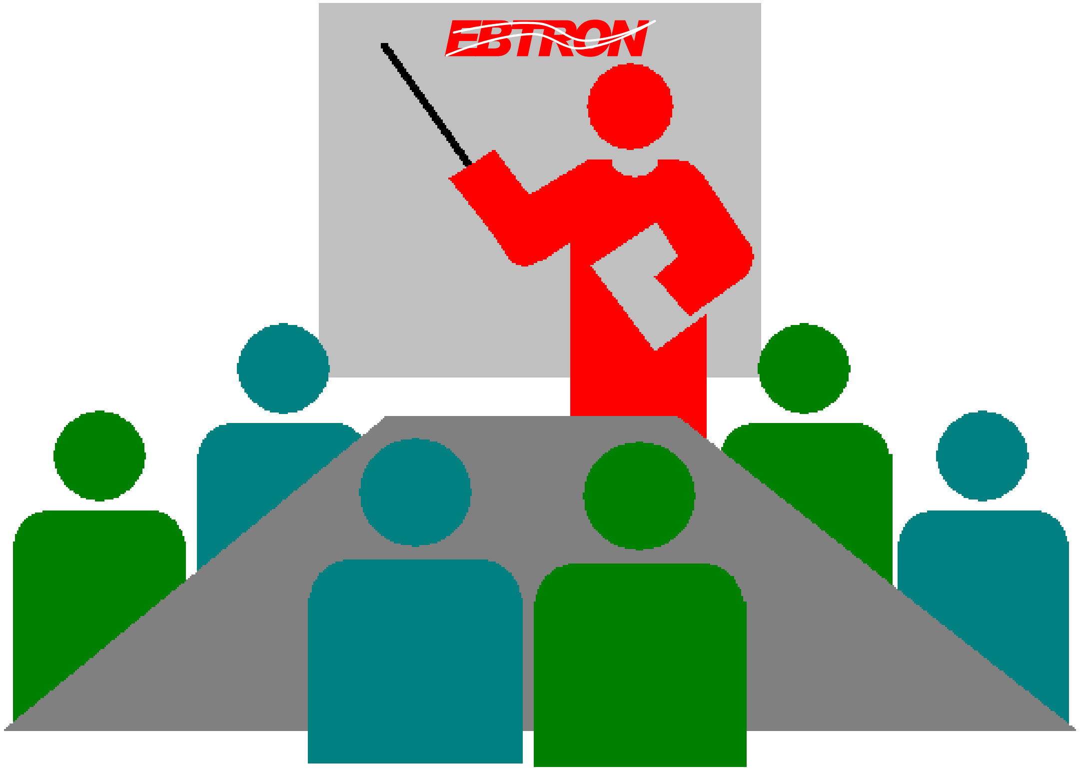
GTx116-P Duct & Plenum Probes

EBTRON a measureable difference!



GTx116-P Duct & Plenum Probes

Indoor Environmental Quality



Demand Control Ventilation

ASHRAE 62

CO_2, ASHRAE 62 and DCV

ASHRAE 62-1989 VRP

“Comfort (odor) criteria are likely to be satisfi ate is set so that 1000 ppm CO_2 is not exceeded.”

Misleading!
Out of Context!
Would NOT result in
Compliance!

ASHRAE 62-1999 and 2001 VRP

“Comfort (odor) criteria with respect to hum be satisfied if the ventilation results in indoor C n 700 ppm above the outdoor air concentration.”

Misleading!
Out of Context!
Would NOT result in
Compliance!

ASHRAE 62-2004 to present

All references to specific CO_2 levels removed

Damage Done!

CO_2 DCV …

- Outside air dampers or fans are modulated to maintain the space CO_2 level.
- CO_2 levels are often associated as a direct indication of indoor air quality – the lower the better.
  - Not true. Space CO_2 levels rarely exceed 2,000 ppm. CO_2 does not become a contaminant until levels exceed 5,000 ppm.
  - CO_2 is simply an indirect method to estimate the outside air CFM/person entering the space.
  - There are NUMEROUS assumptions made that affect how CO_2 DCV impacts IAQ.

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

DCV - Single Zone Systems

What's needed?

1. Real-time population estimate of the zone (P_z)

2. Heating/cooling mode to determine E_z

3. Outside airflow measuring device to measure V_{ot}

4. Controller to calculate V_{ot} and maintain setpoint:

$$V_{ot} = \{R_p \cdot P_z + R_a \cdot A_z\}/E_z$$

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

100% OA Systems

Single zone and multi-zone with single zone recirculating systems, radiant panels or chilled beams (not valid on multi-zone recirculating systems).

6.2.4 100% Outdoor Air Systems. For ventilation systems wherein one or more air handlers supply only *outdoor air* to one or more *ventilation zones*, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-4.

$$V_{ot} = \Sigma_{all\ zones} V_{oz} \qquad (6\text{-}4)$$

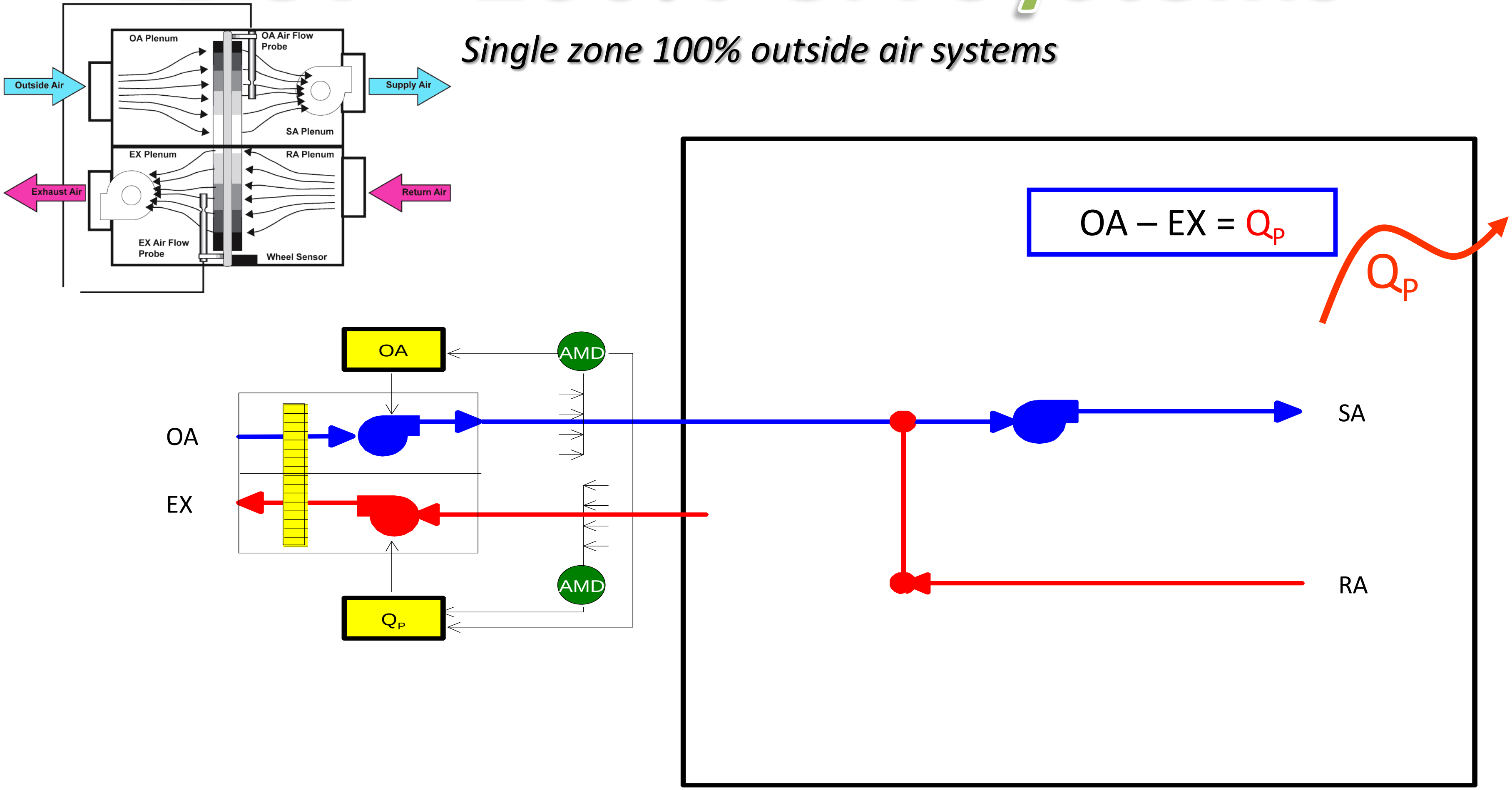
5. V_{ot} (outdoor air intake flow) is equal to the sum of all V_{oz}.

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the
2011 Supplement to 62.1-2010)

DCV - 100% OA Systems

Single zone 100% outside air systems



Note: In most DOAS systems E_z = 1 (tempered air)

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

DCV - 100% OA Systems

Single zone 100% outside air systems

What's needed?

1. Real-time population estimate of the zone (P_z)

2. Outside airflow measuring device to measure V_{ot}

3. Controller to calculate V_{ot} and maintain setpoint:

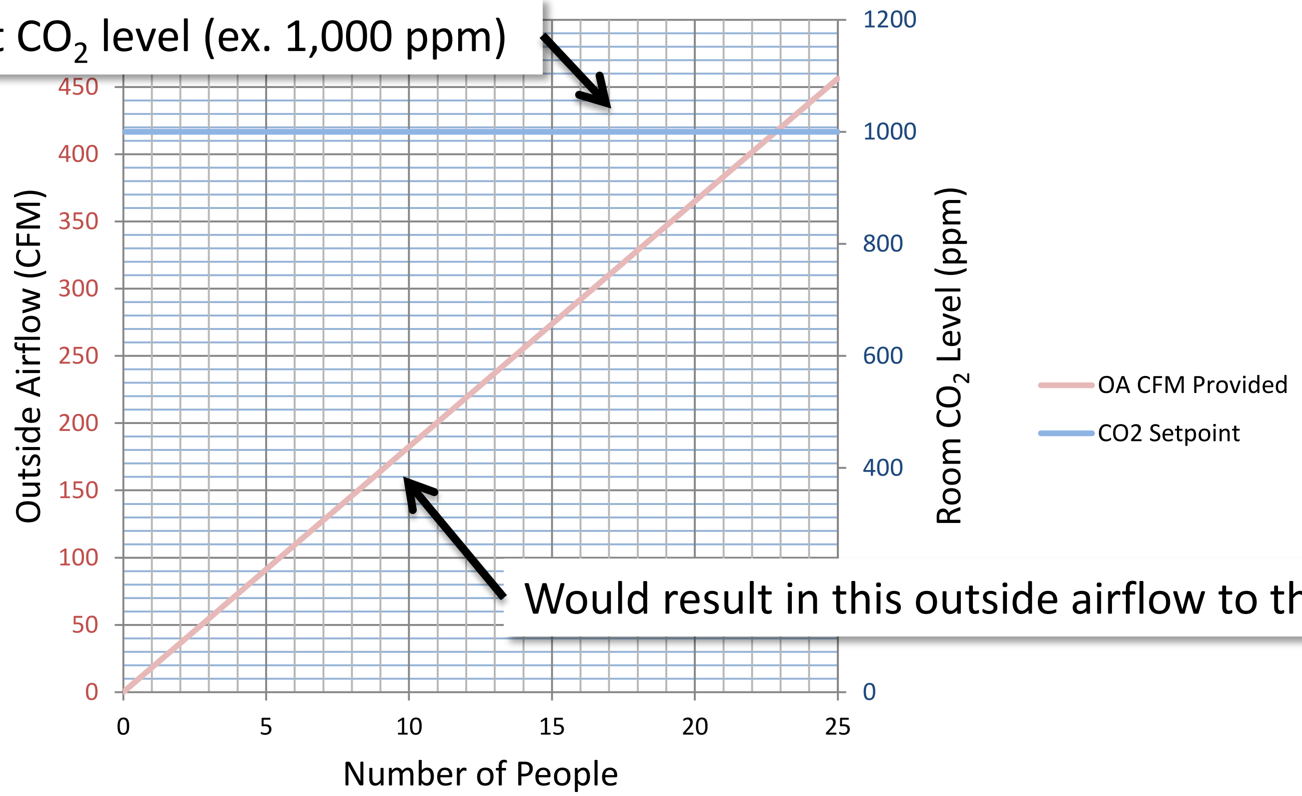
$$V_{ot} = \{R_p \cdot P_z + R_a \cdot A_z\}/E_z$$

Note: In most DOAS systems $E_z = 1$ (tempered air)

Single Setpoint CO_2 DCV

CO_2 DCV (1,000 sq.ft. classroom)

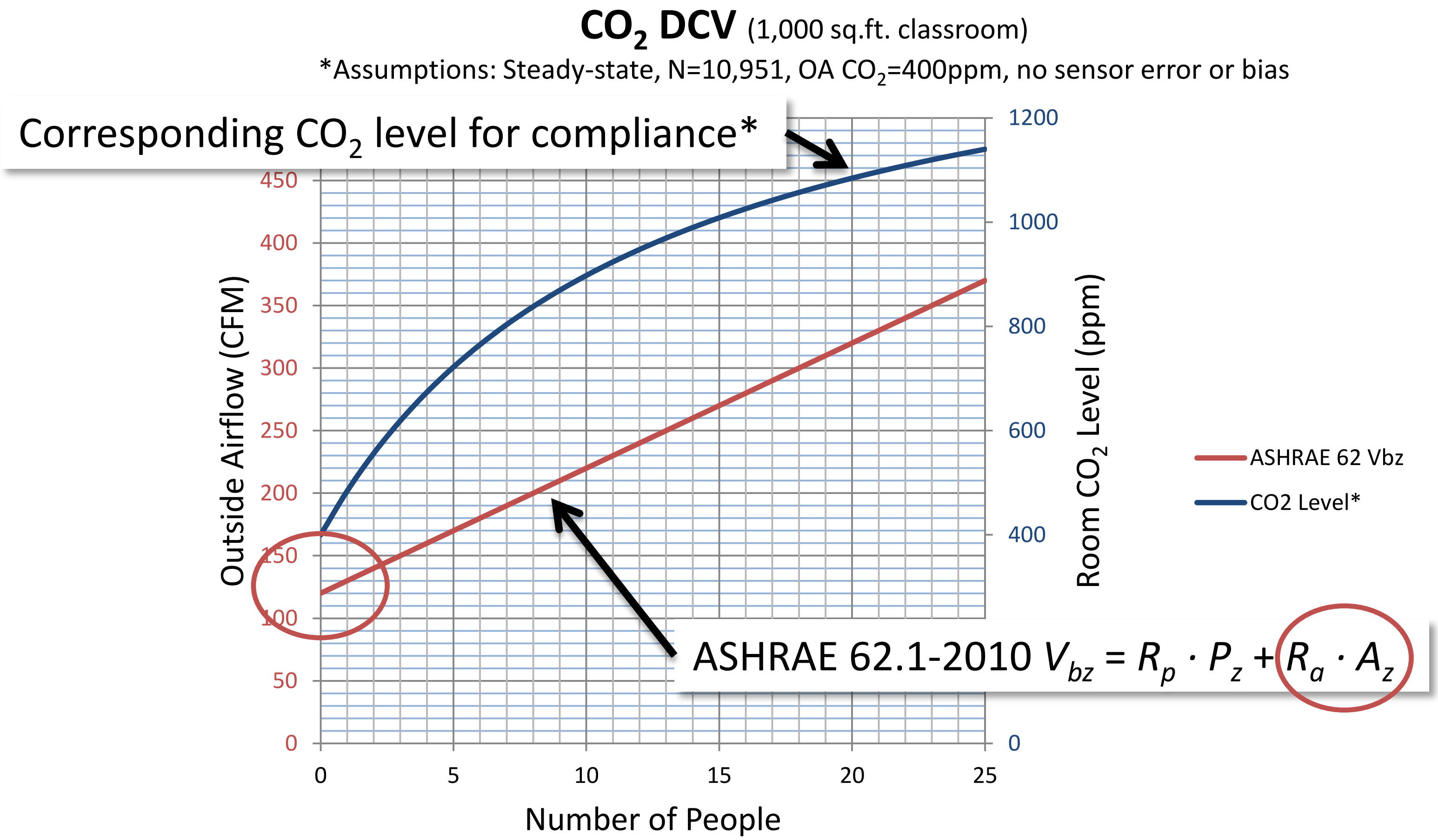
*Assumptions: Steady-state, N=10,951, OA CO_2=400ppm, no sensor error or bias



A constant CO_2 level (ex. 1,000 ppm)

Would result in this outside airflow to the space*

ASHRAE 62.1 Requirements



Corresponding CO_2 level for compliance*

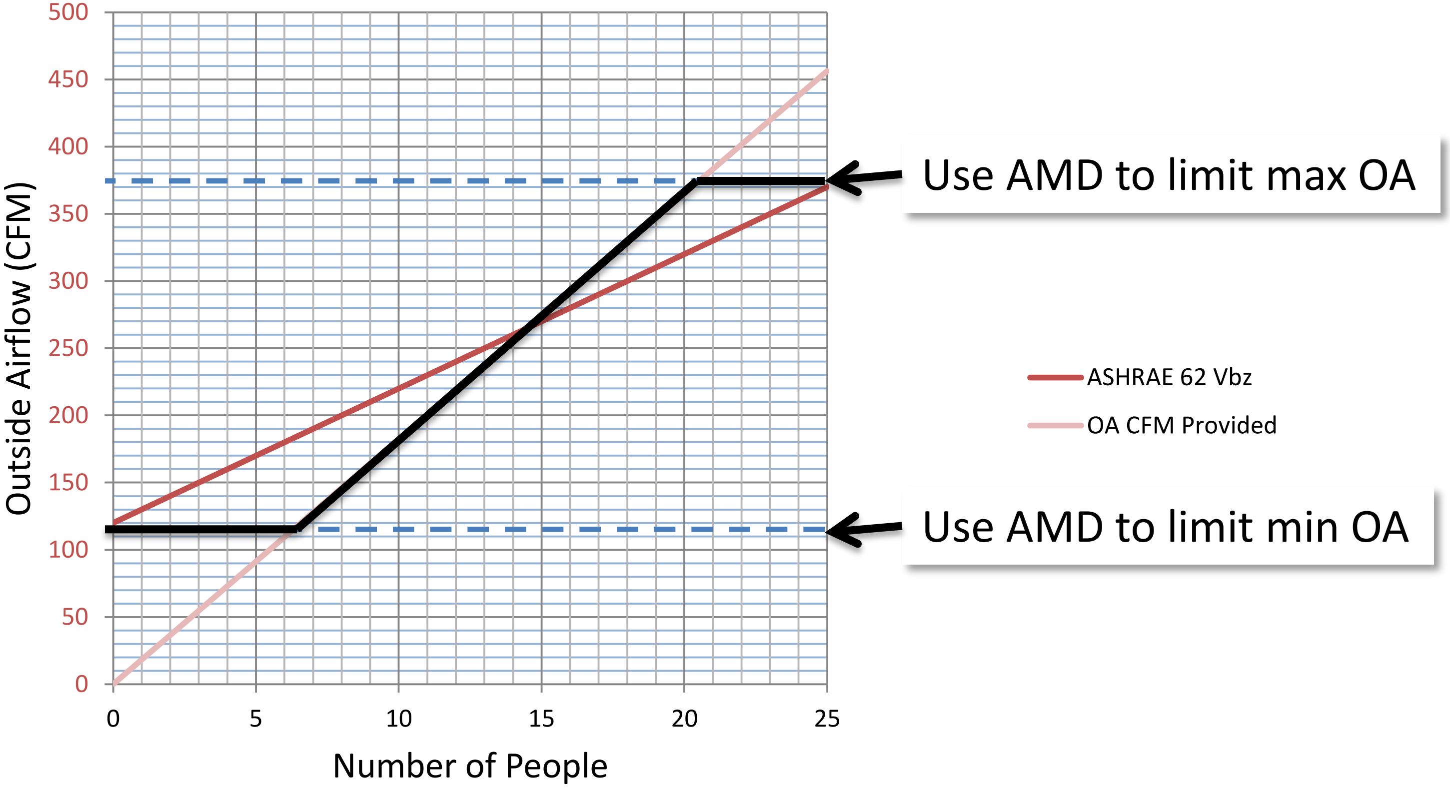
ASHRAE 62.1-2010 $V_{bz} = R_p \cdot P_z + R_a \cdot A_z$

OA AMD/CO_2 DCV

Reset OA airflow setpoint to maintain space CO_2 level

CO_2 DCV (1,000 sq.ft. classroom)

*Assumptions: Steady-state, N=10,951, OA CO_2=400ppm, no sensor error or bias

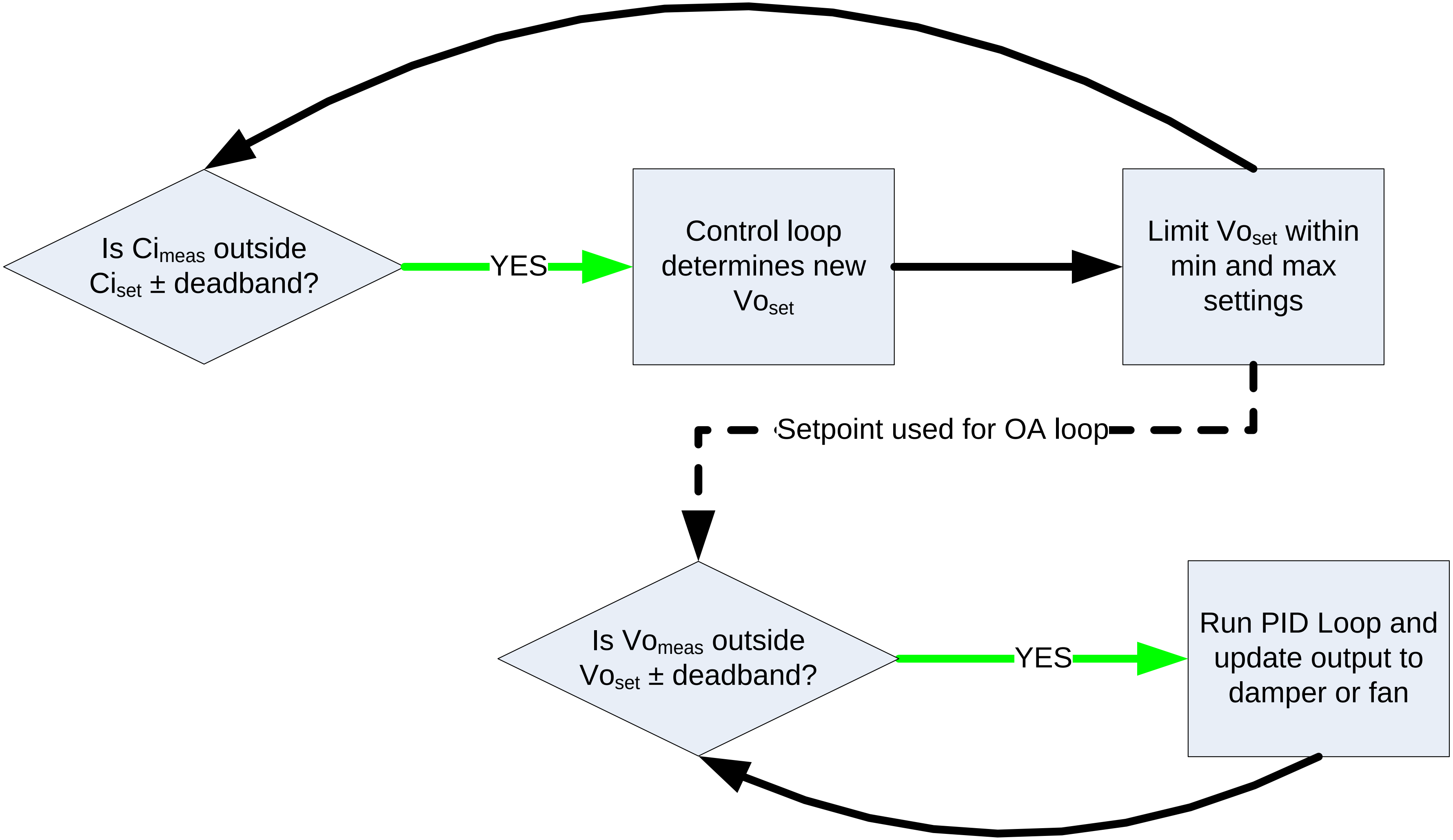


Use AMD to limit max OA

Use AMD to limit min OA

OA AMD/CO_2 DCV

Reset OA airflow setpoint to maintain space CO_2 level



Is Ci_{meas} outside Ci_{set} ± deadband?

YES

Control loop determines new Vo_{set}

Limit Vo_{set} within min and max settings

Setpoint used for OA loop

Is Vo_{meas} outside Vo_{set} ± deadband?

YES

Run PID Loop and update output to damper or fan

ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

DCV - 100% OA Systems

Multi-zone with single zone recirculating systems, radiant panels or chilled beams (not valid on multi-zone recirculating systems).

What's needed?

1. Real-time population estimate of **each** zone (P_z)
2. Damper (or terminal box) and an airflow measuring device to measure V_{oz} at each zone.
3. Controller to calculate V_{oz} and maintain setpoint at each zone:

$$V_{oz} = \{R_p \cdot P_z + R_a \cdot A_z\}/E_z$$

Note: In most DOAS systems $E_z = 1$ (tempered air)

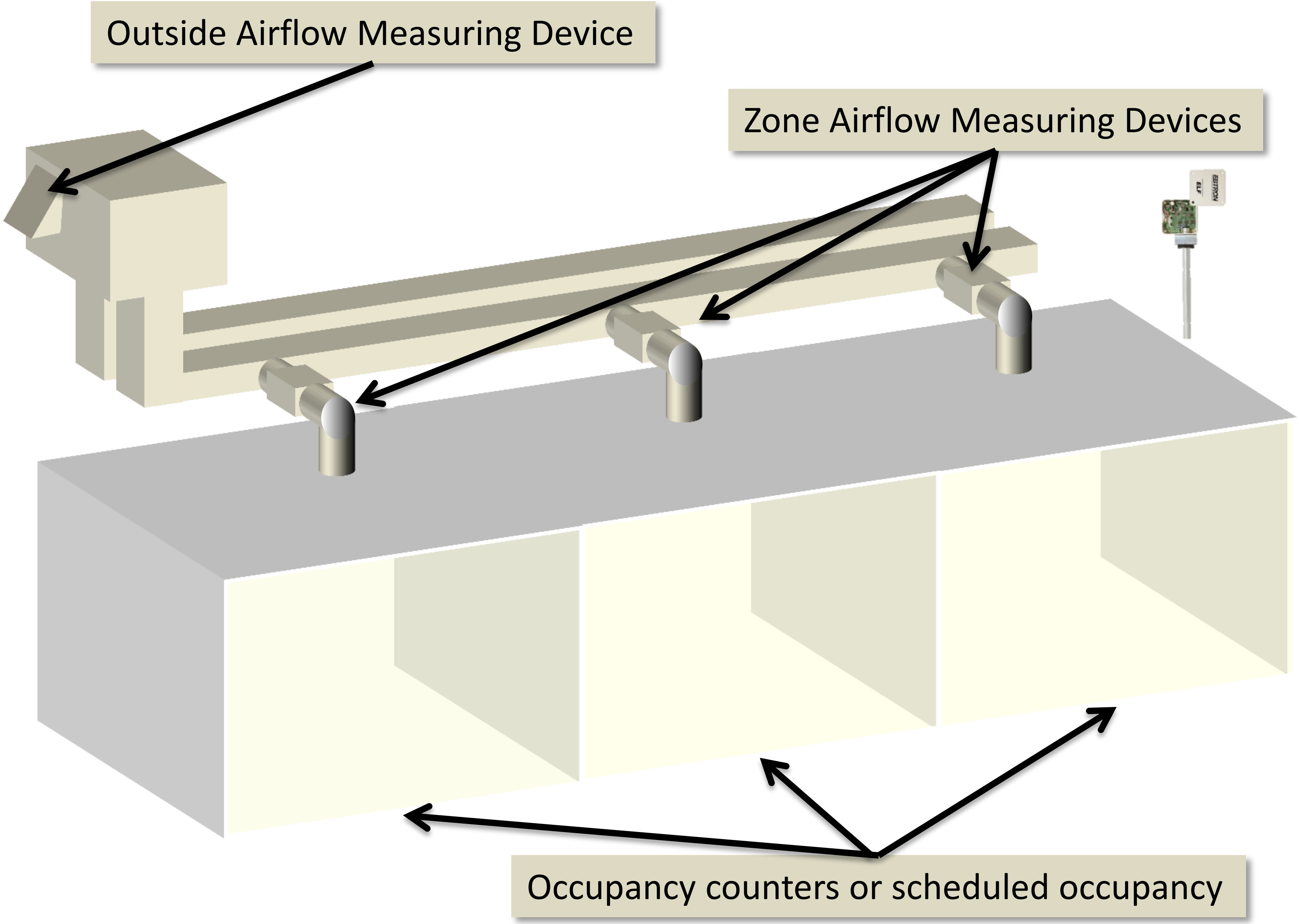
ASHRAE 62.1-2010

(Includes Addenda a, c, d, and e to 62.1-2010 published in the 2011 Supplement to 62.1-2010)

Multi-zone
Recirculating Systems

More complicated!

Method #1: Counters or schedules



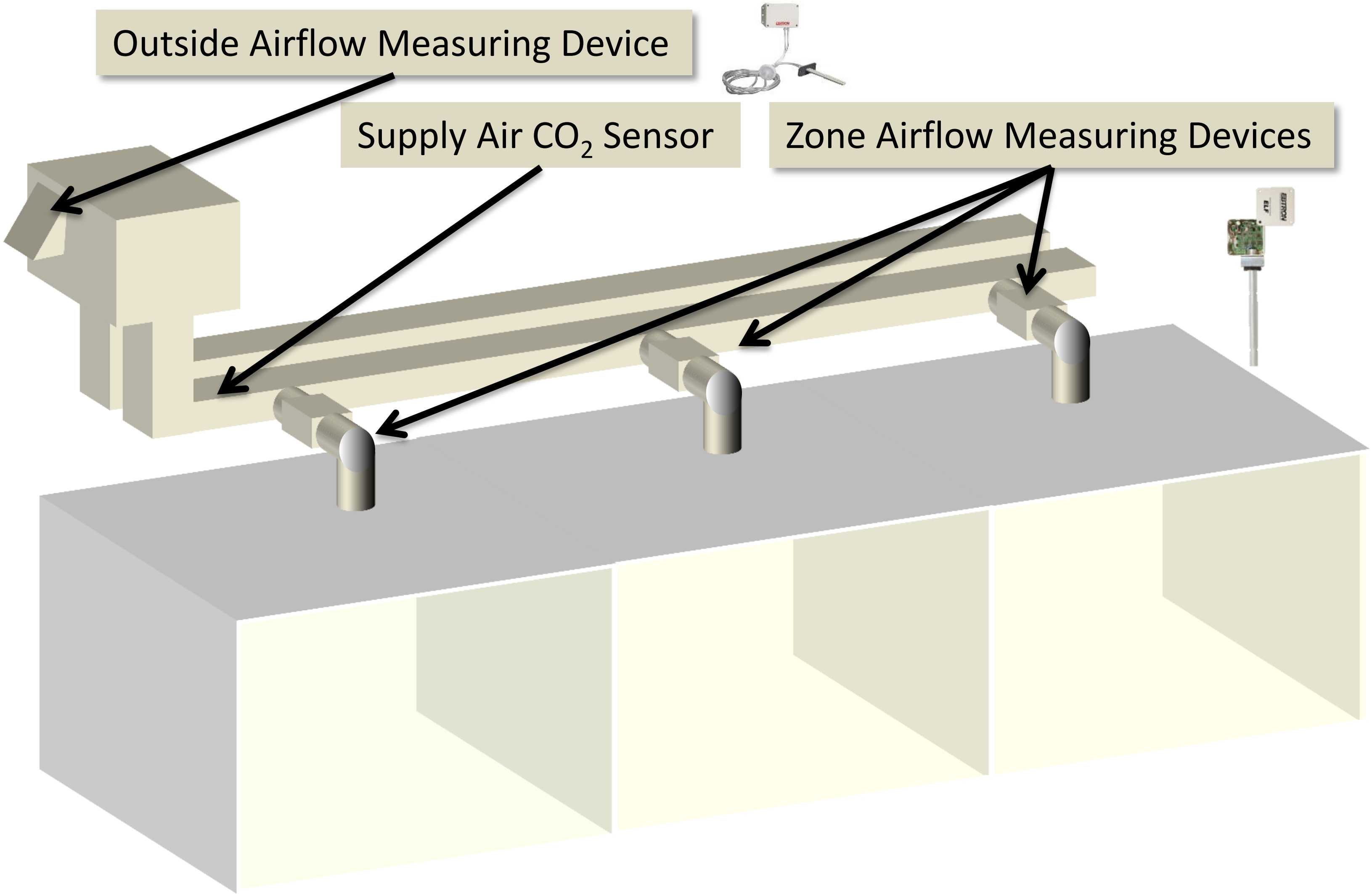
Outside Airflow Measuring Device

Zone Airflow Measuring Devices

Occupancy counters or scheduled occupancy

CLASSROOM EXAMPLE

Method #2: Total supply CO_2 / Zone Airflow



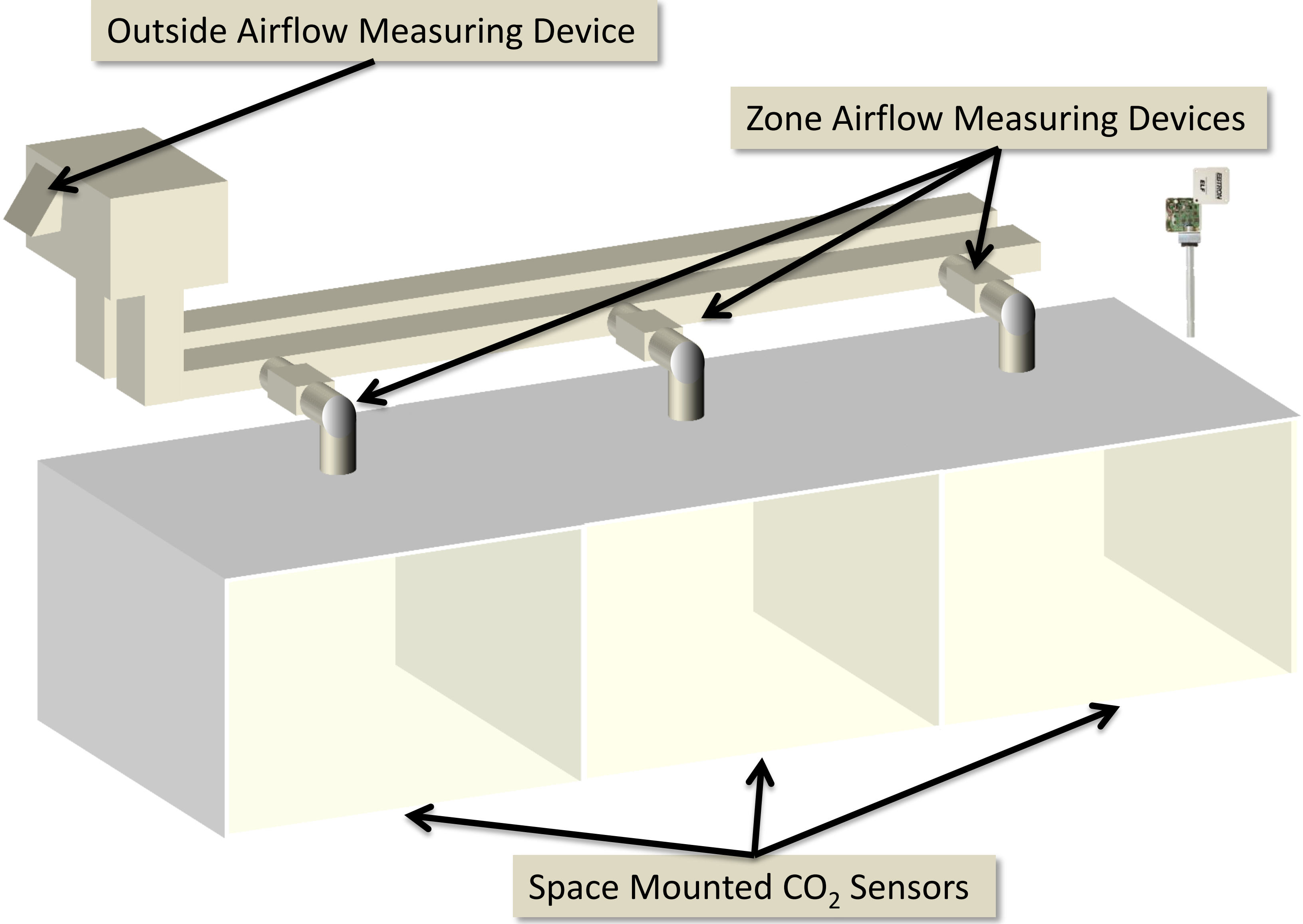
Outside Airflow Measuring Device

Supply Air CO_2 Sensor

Zone Airflow Measuring Devices

CLASSROOM EXAMPLE

Method #3: Space CO_2 / Zone Airflow



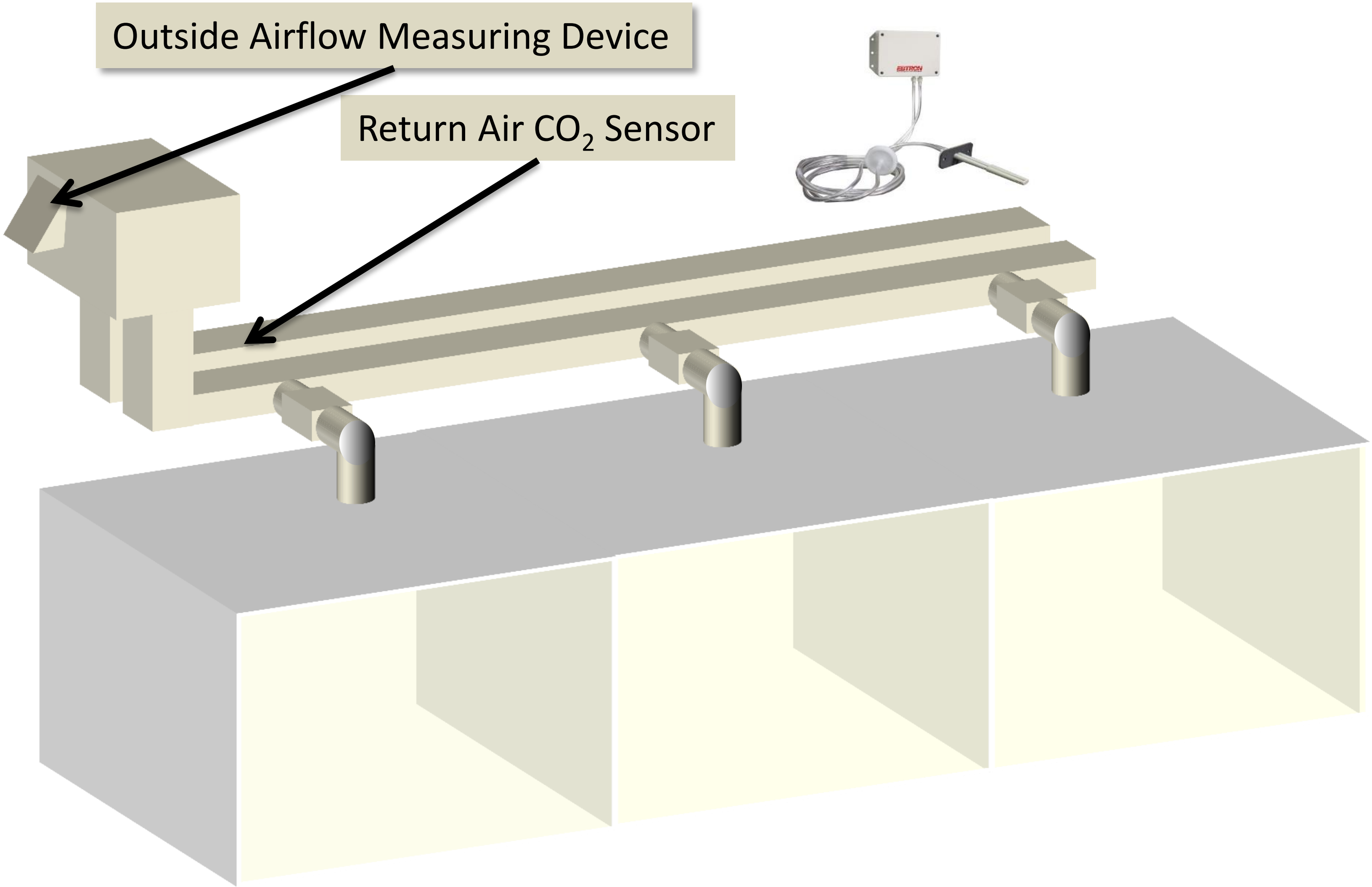
Outside Airflow Measuring Device

Zone Airflow Measuring Devices

Space Mounted CO_2 Sensors

CLASSROOM EXAMPLE

Method #4: Maintain total return air CO_2 level

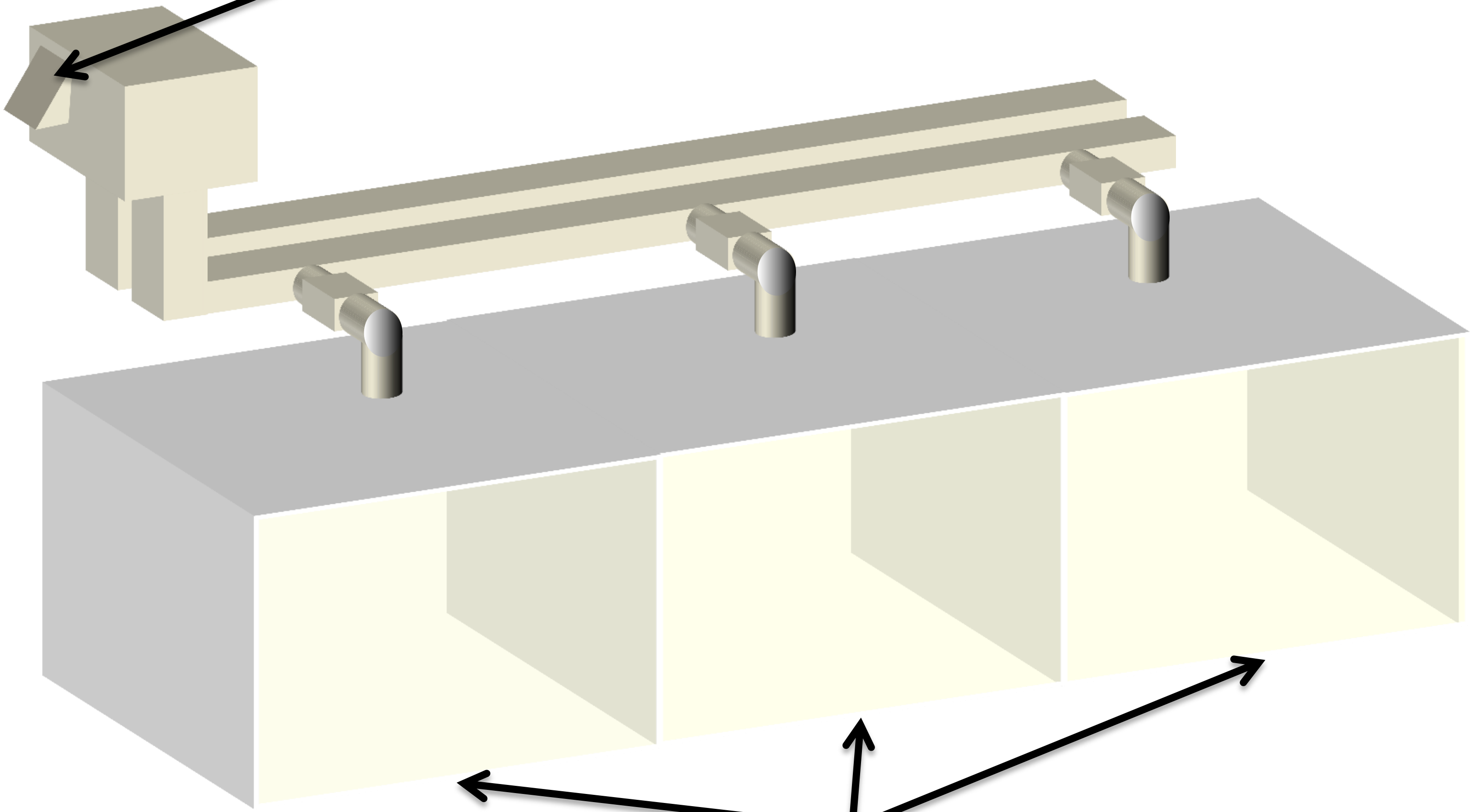


Outside Airflow Measuring Device

Return Air CO_2 Sensor

CLASSROOM EXAMPLE

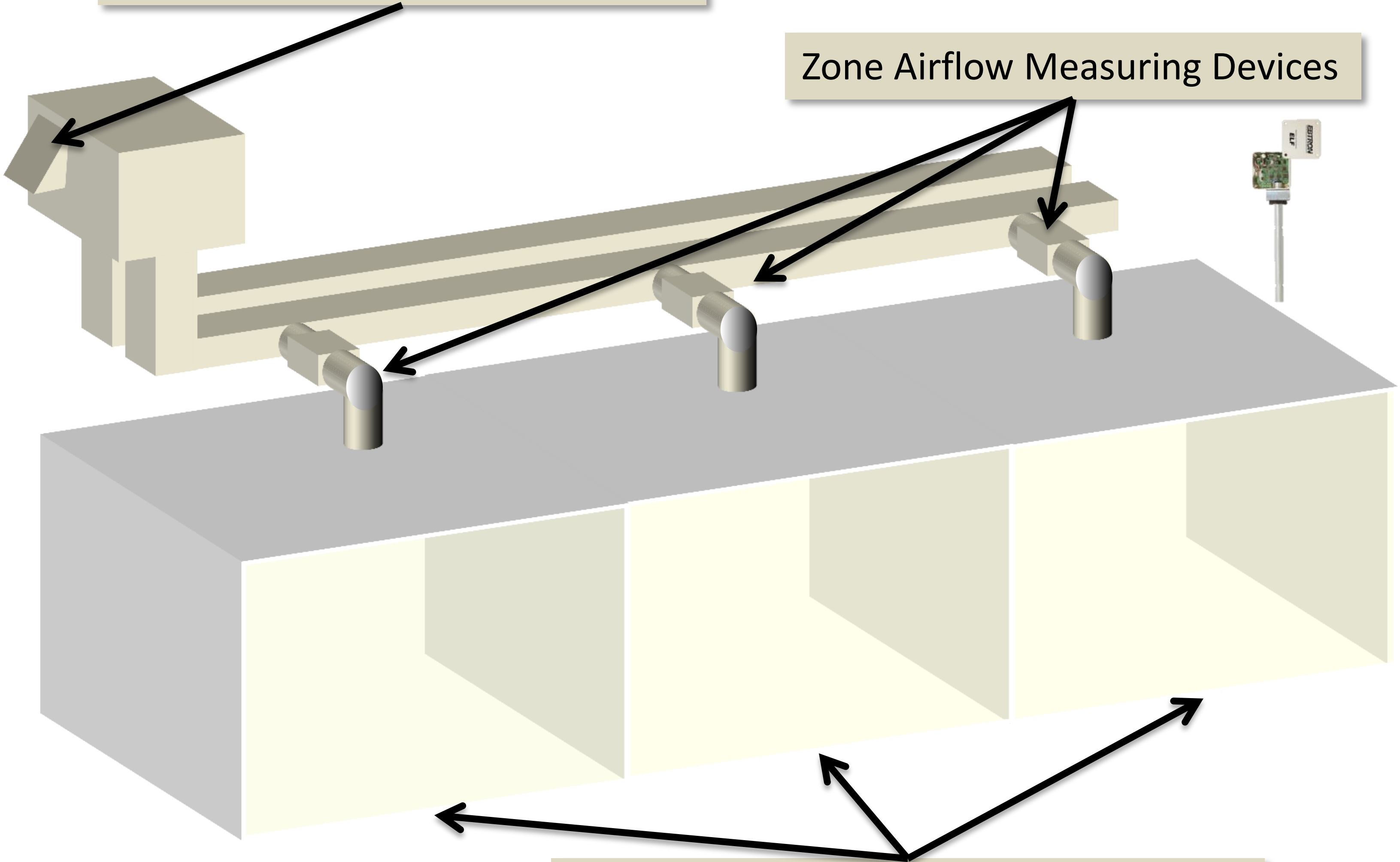
Method #5: No zone to exceed specified CO_2 level



Outside Airflow Measuring Device

Space Mounted CO_2 Sensors

Method #6: Zone airflow only (thermal load only DCV)



Outside Airflow Measuring Device

Zone Airflow Measuring Devices

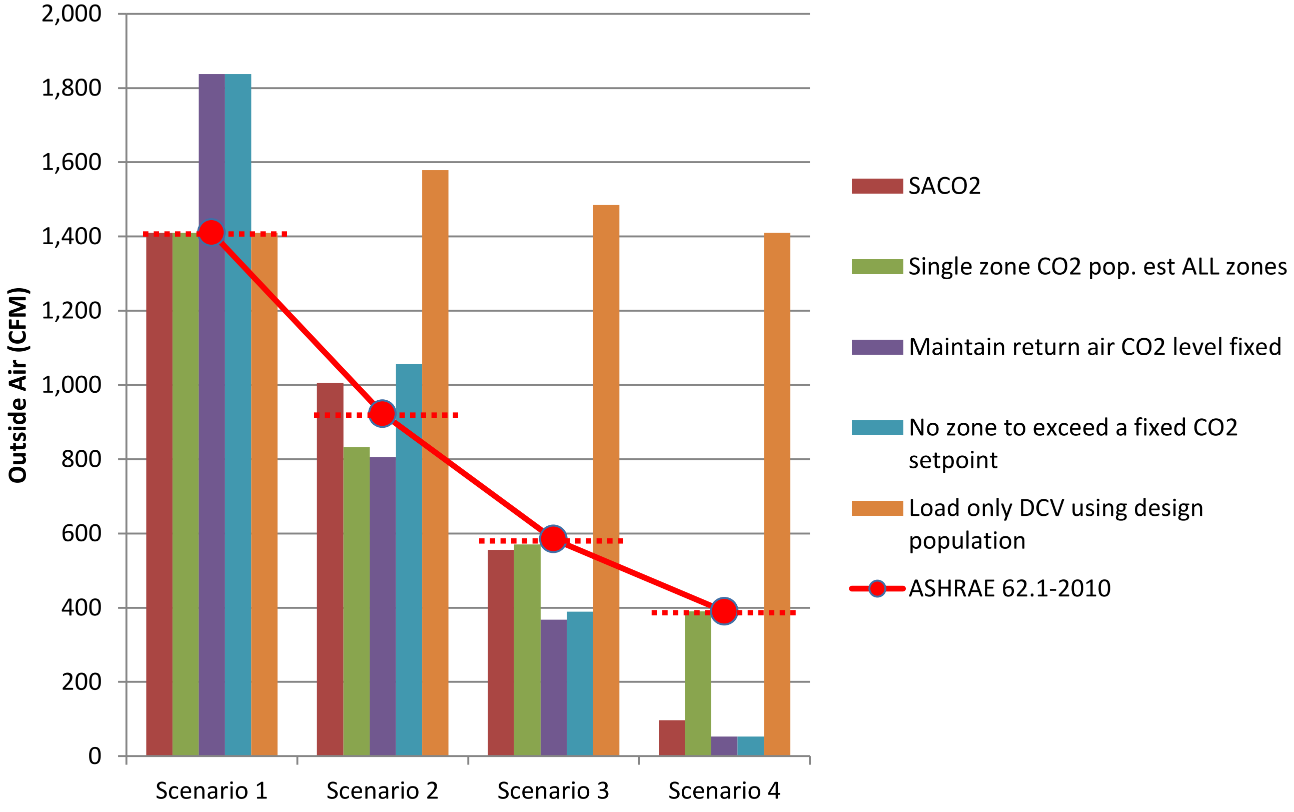
Maximum occupancy estimate for zones

CLASSROOM EXAMPLE

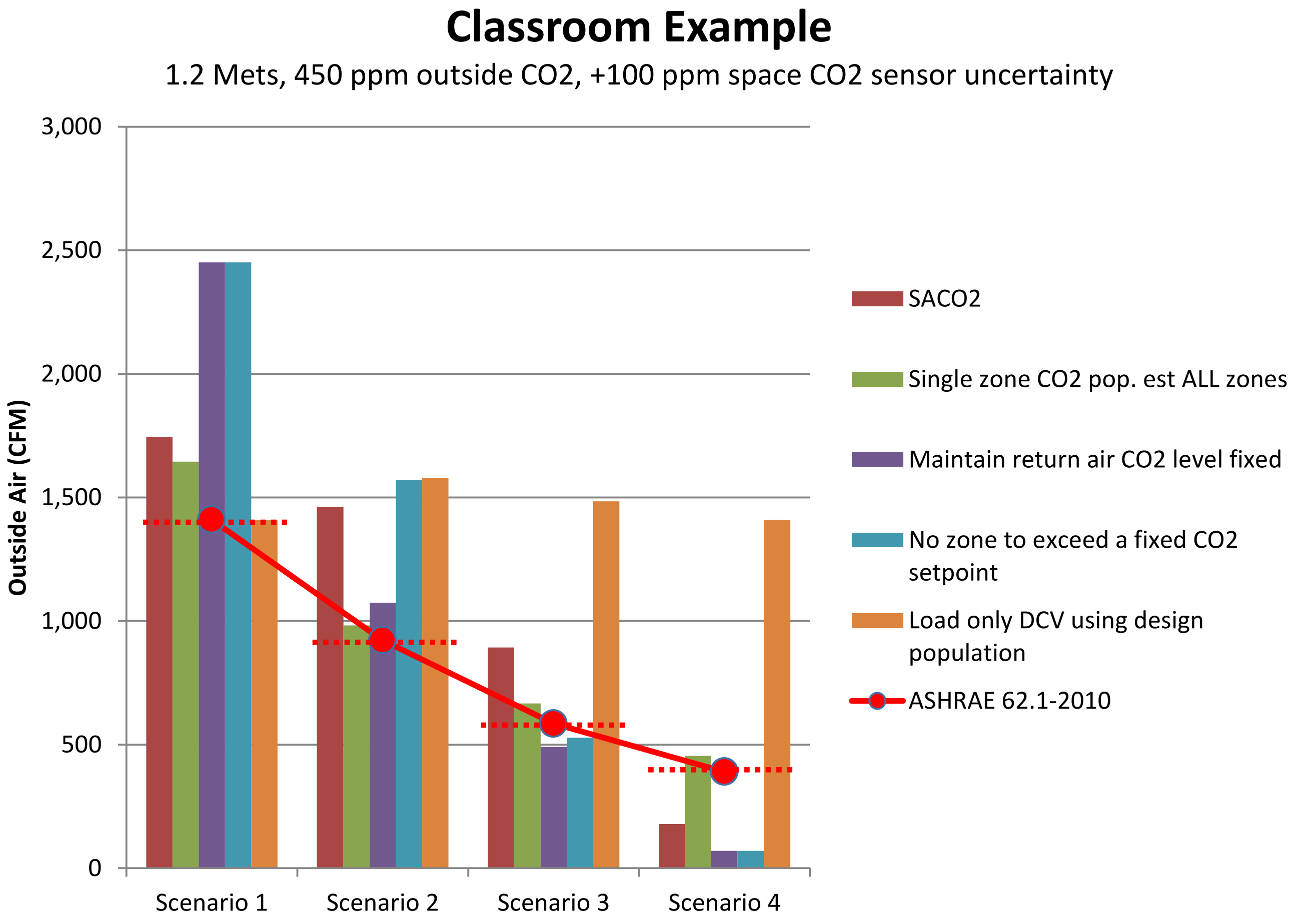
CLASSROOM EXAMPLE

Classroom Example

1.2 Mets, 400 ppm outside CO2, 0 ppm space CO2 sensor uncertainty



CLASSROOM EXAMPLE



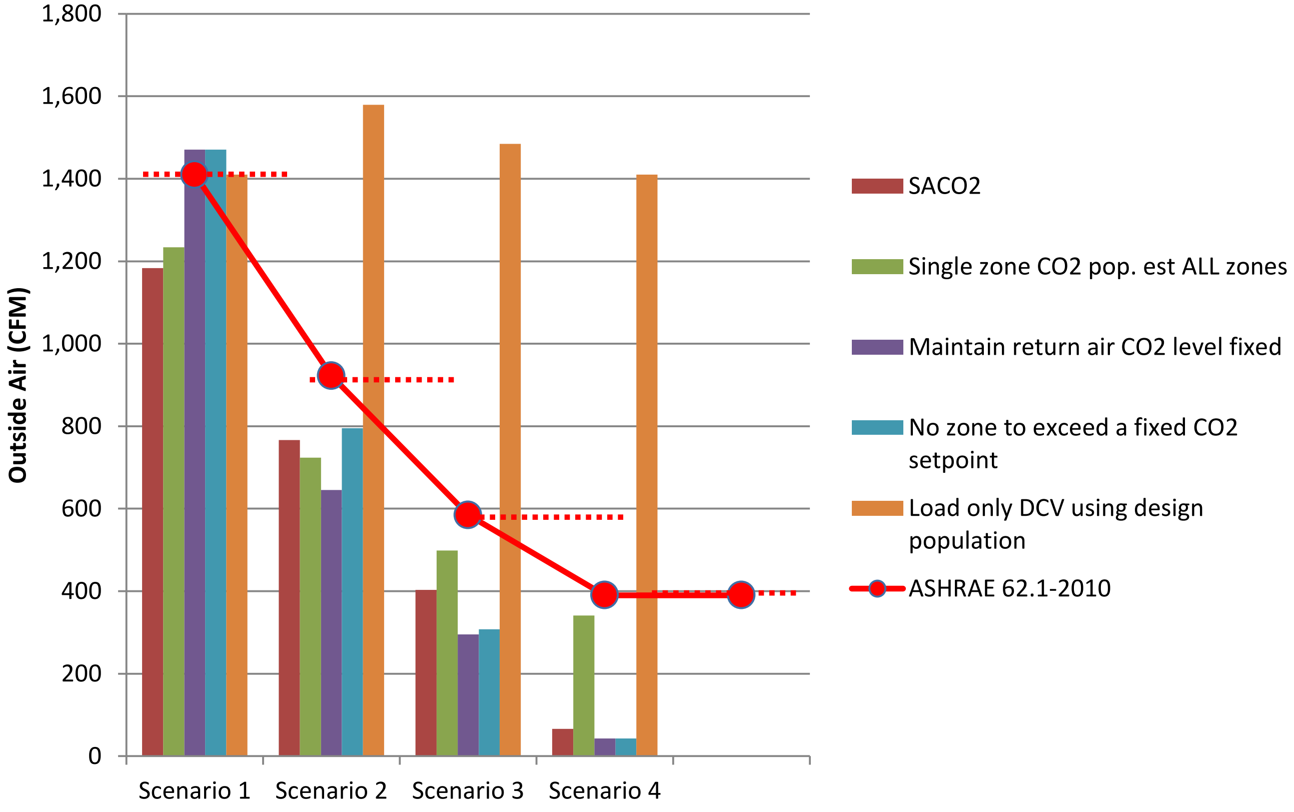
Classroom Example

1.2 Mets, 450 ppm outside CO2, +100 ppm space CO2 sensor uncertainty

CLASSROOM EXAMPLE

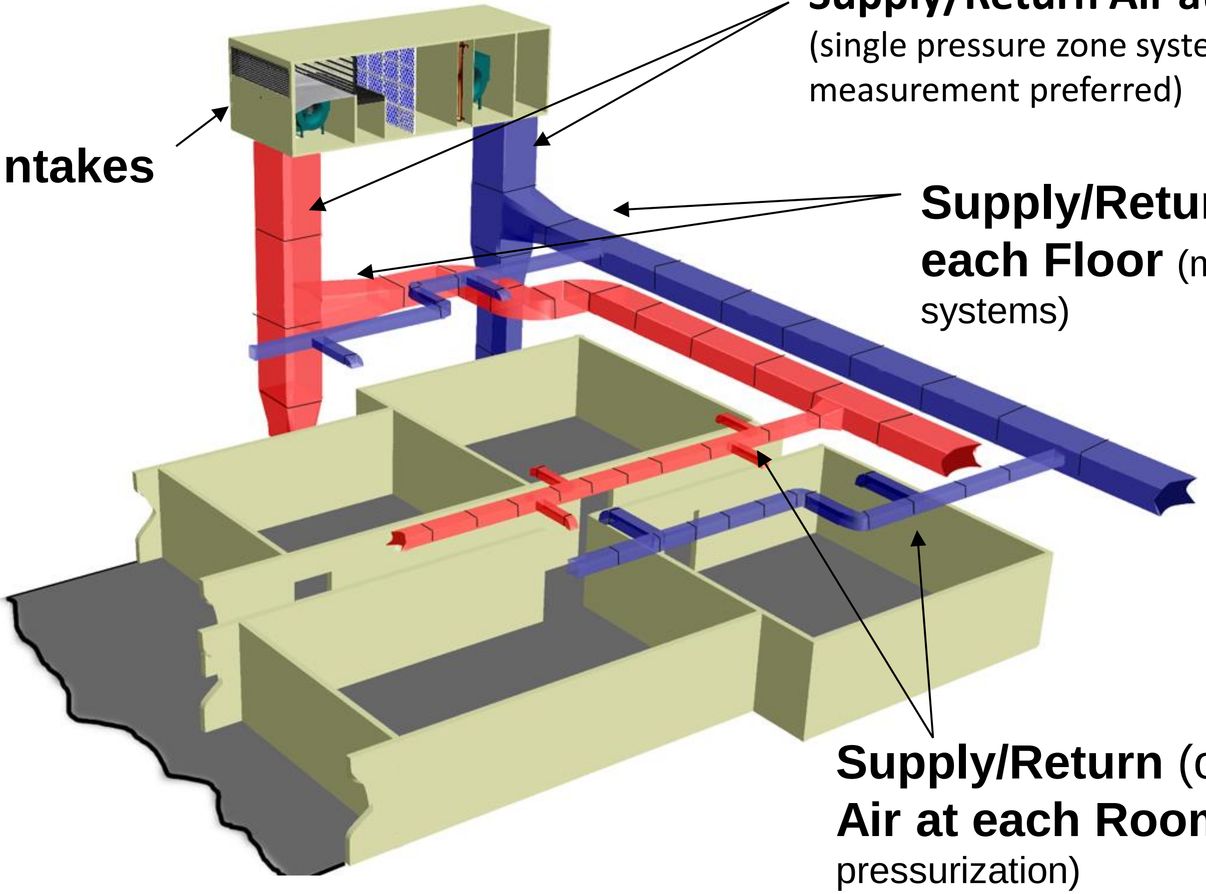
Classroom Example

1.2 Mets, 350 ppm outside CO2, -100 ppm space CO2 sensor uncertainty



Anatomy of a Healthy Building

Key Airflow Measurement Locations



Outside Air Intakes

Supply/Return Air at each AHU
(single pressure zone systems - duct measurement preferred)

Supply/Return Air at each Floor (multi-floor systems)

Supply/Return (or Exhaust) **Air at each Room** (room pressurization)

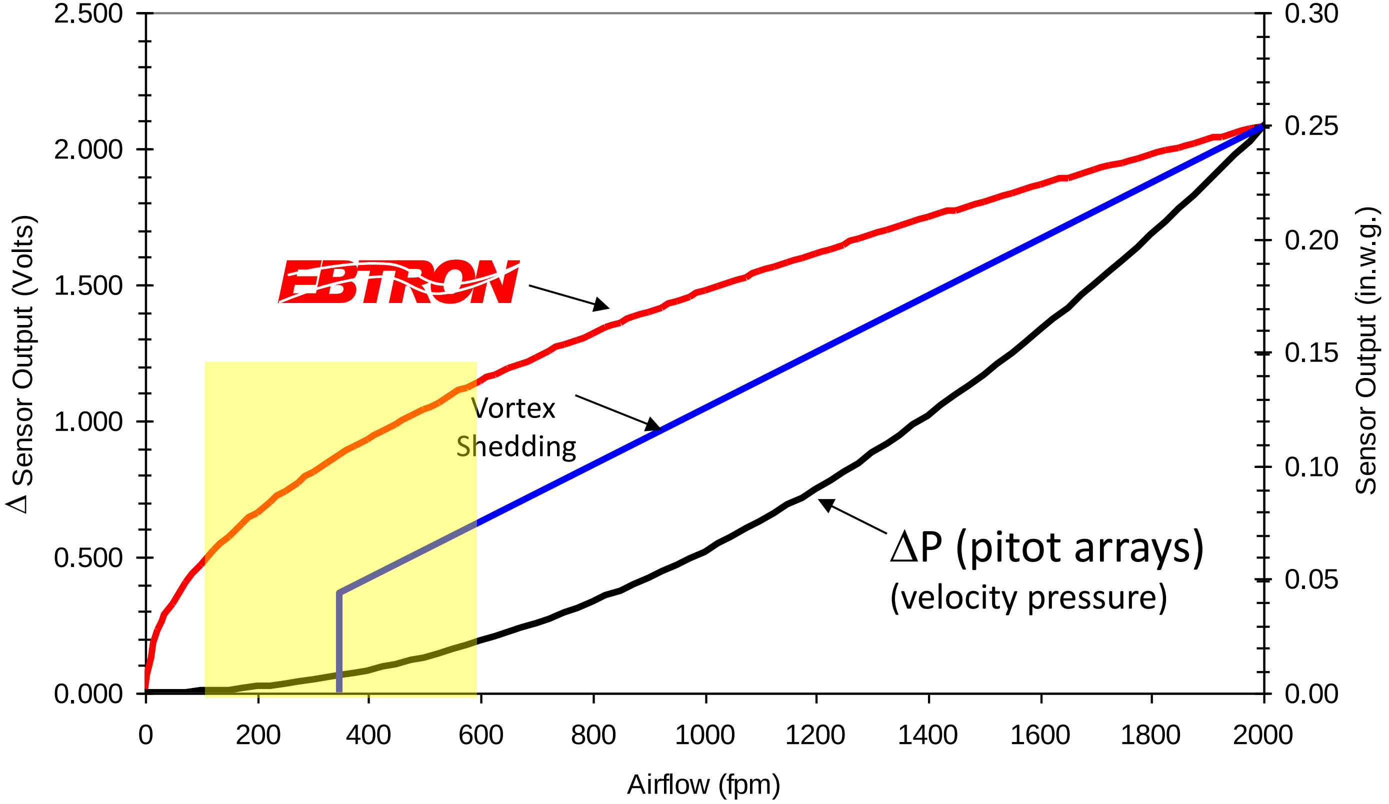
EBTRON

Thermal Dispersion Airflow Measurement

Technology Comparison

Technology Comparison

Ebtron Signal vs. ΔP and Vortex Shedding

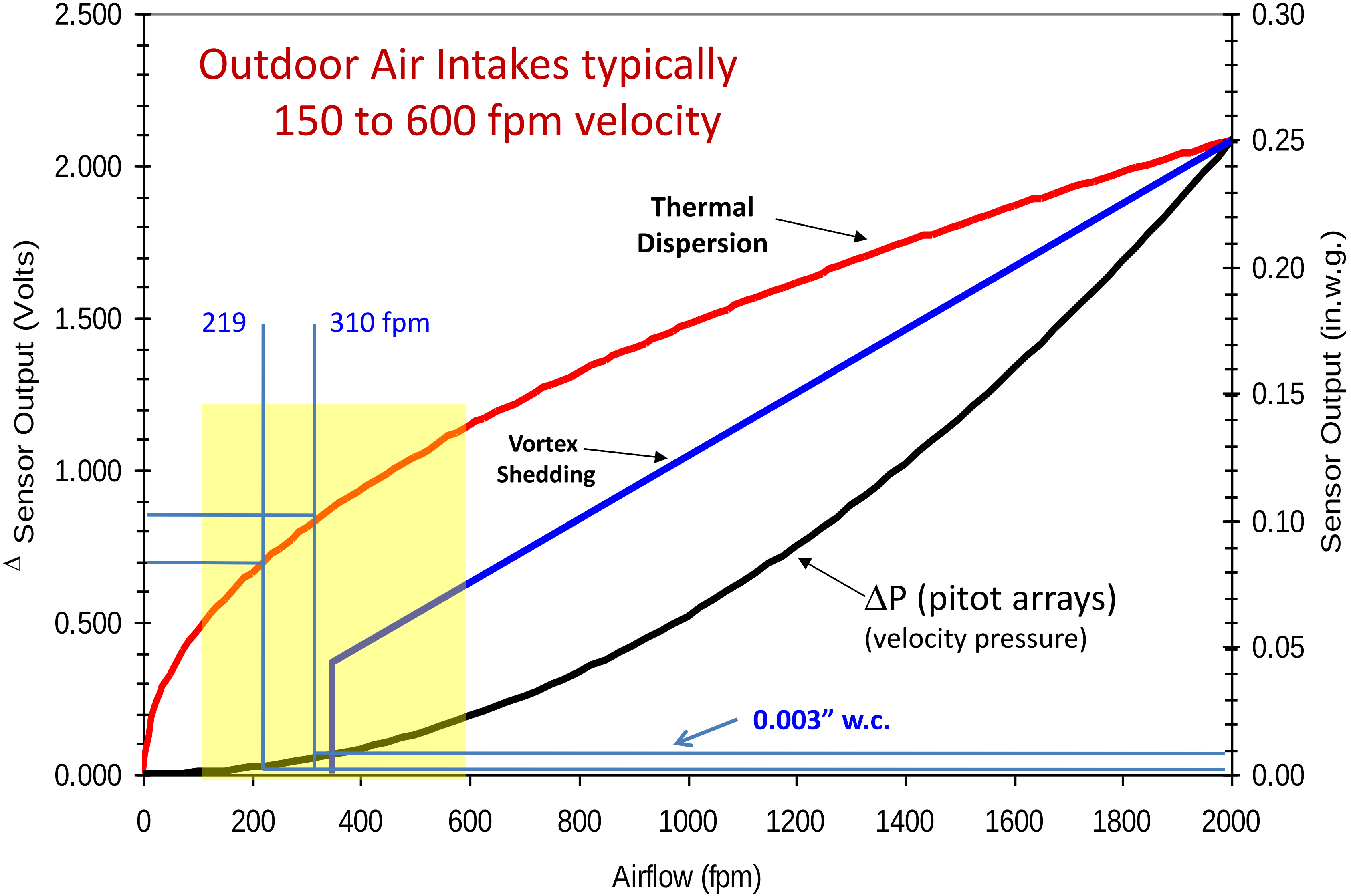


Ebtron’s technology has the best sensitivity at low airflows

Outdoor Air Intakes typically 150 to 600 fpm velocity

Technology Comparison

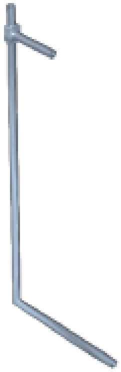
Thermal Dispersion has the Best Sensitivity at Low Airflows



Pitot Tubes and Arrays

Air Monitor Corporation, FAN-E

Averaging Pitot Array Stations with Honeycomb



Pitot-static Tube

Averaging Pitot Array Probes

Trane, Traq Damper

Combination Pitot Array & Dampers

Terminal Box Flow Ring/Cross

Ruskin, IAQ-50

Combination Pitot Array/Damper with Honeycomb

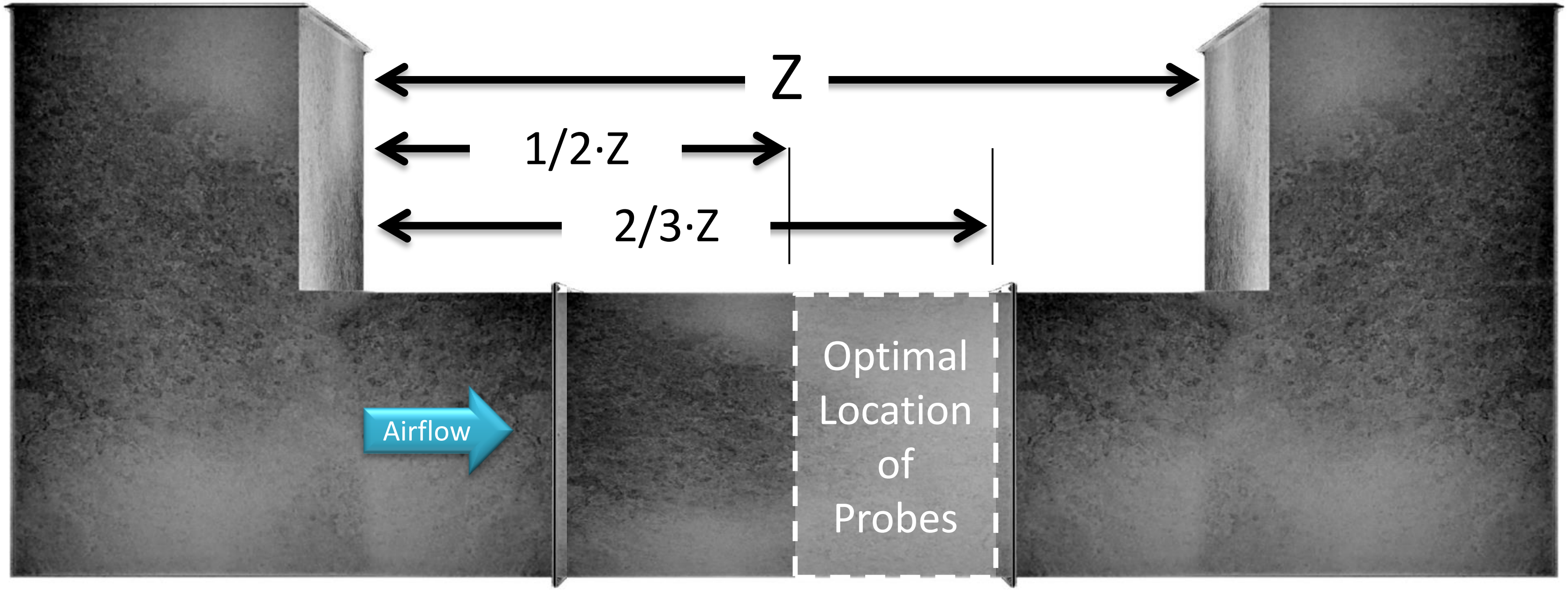
Application Assessment

Poor	Fair	Good	Best
Acceptable limit not met (not recommended)	Does not meet ***minimum placement*** locations but exceeds ***acceptable limit*** (may required field adjustment)	Meets ***minimum placement*** locations (field verification of some type suggested)	Meets ***suggested placement*** locations (set it, verify operation, and forget it)

EBTRON a measureable difference!

Go: Where to place probes

Between Duct Fittings

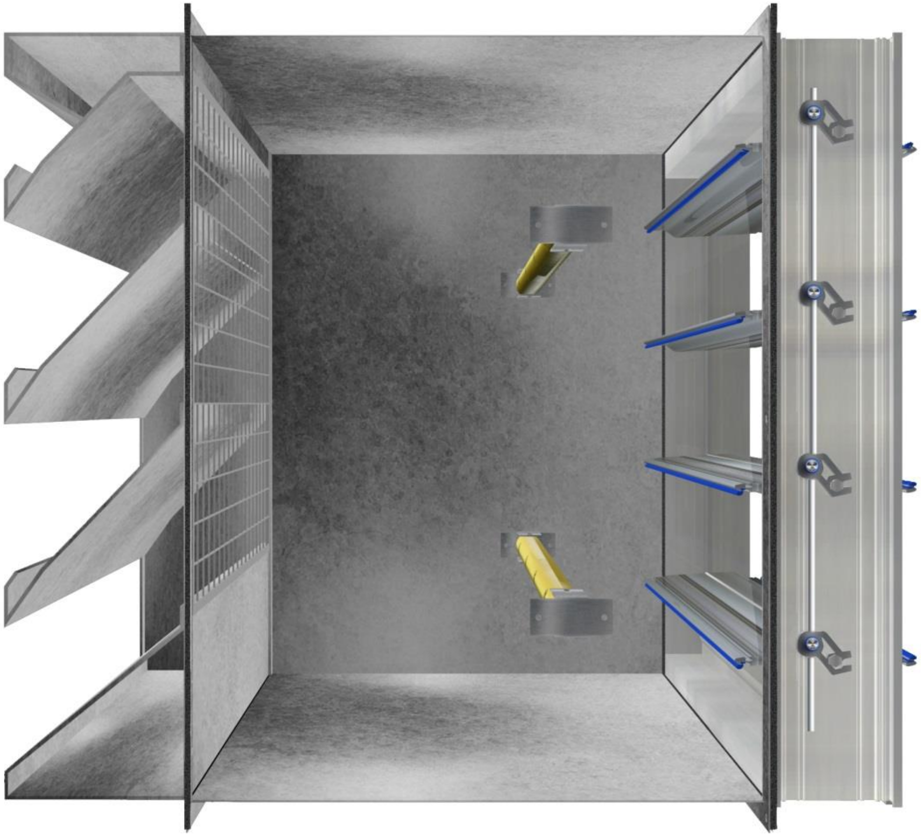


Z is in multiples of equivalent diameters (L + W)/2 based on up and downstream disturbances in ducted systems

EBTRON a measureable difference!

Go: Where to place probes

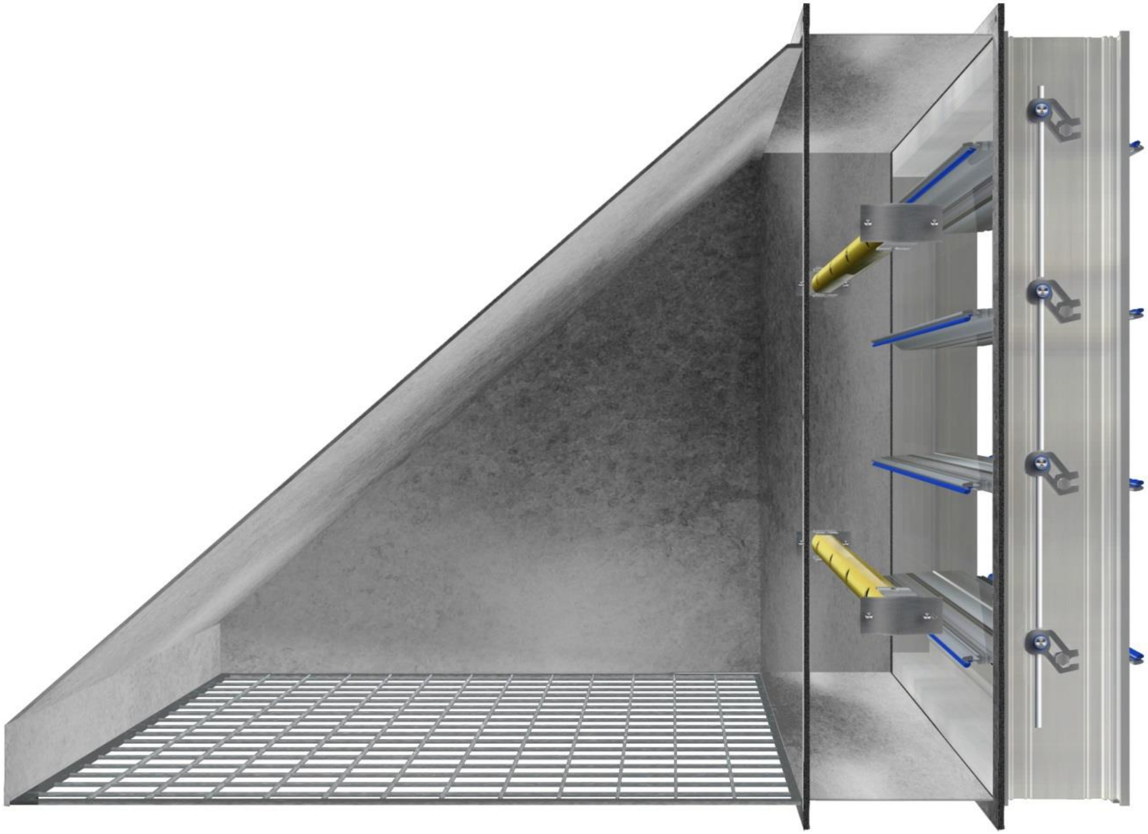
Outside Air Intake Applications



EBTRON a measureable difference!

Go: Where to place probes

Outside Air Intake Applications



The Real-world: Locating Probes

What to expect for “Best”

Best

Meets ***suggested placement*** locations (set it, verify operation, and forget it)

- Field adjustment is NOT recommended
- Look for system/verification issues if verification techniques indicate inaccuracy
- “Out-of-the-box” installed accuracy should be equal to or better than ± 3% of reading

The Real-world: Locating Probes

What to expect for “Good”

Good

Meets ***minimum placement*** locations (field verification of some type suggested)

- Field adjustment should not be required in most cases
- “Out-of-the-box” installed accuracy should approach or equal ± 3% of reading (3 to 5% for outside air intakes close coupled to louvers or hoods)

The Real-world: Locating Probes

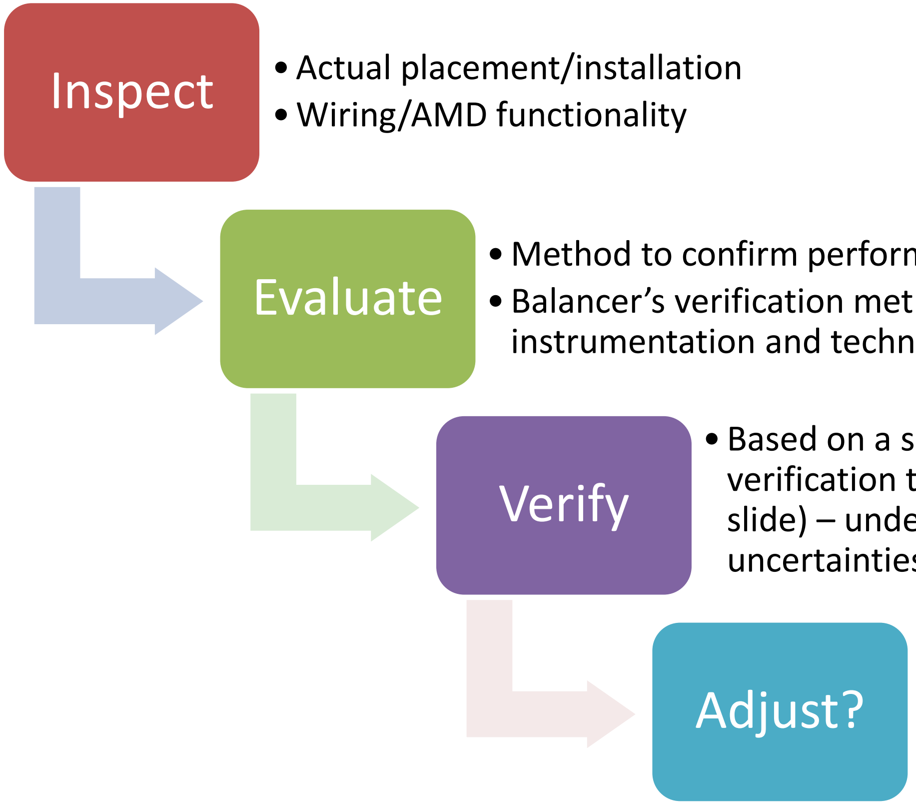
What to expect for "Fair"

Fair

Does not meet ***minimum placement*** locations but exceeds ***acceptable limit*** (may required field adjustment)

- AMD can be field adjusted, if airflow rate verification warrants, to fulfill the requirements of most applications
- Verification should be done at two airflow rates for variable air speed applications or one point for single air speed applications
- Reading may fluctuate more than in Good or Best locations but the average should be reliable.
- No statement of "out-of-the-box" installed accuracy can be made

Startup



Inspect

- Actual placement/installation
- Wiring/AMD functionality

Evaluate

- Method to confirm performance
- Balancer’s verification method, instrumentation and technique

Verify

- Based on a sound verification technique (next slide) – understand uncertainties

Adjust?

- Only when you are certain the airflow measuring device is inaccurate

Verification Methods

Best

- Compare to EBTRON in closed loop (requires low leakage dampers)

Good

- Compare to EBTRON in same path (requires low leakage dampers)
- Compare to calibrated handheld equipment at airflow rates and locations suitable for the device

Fair

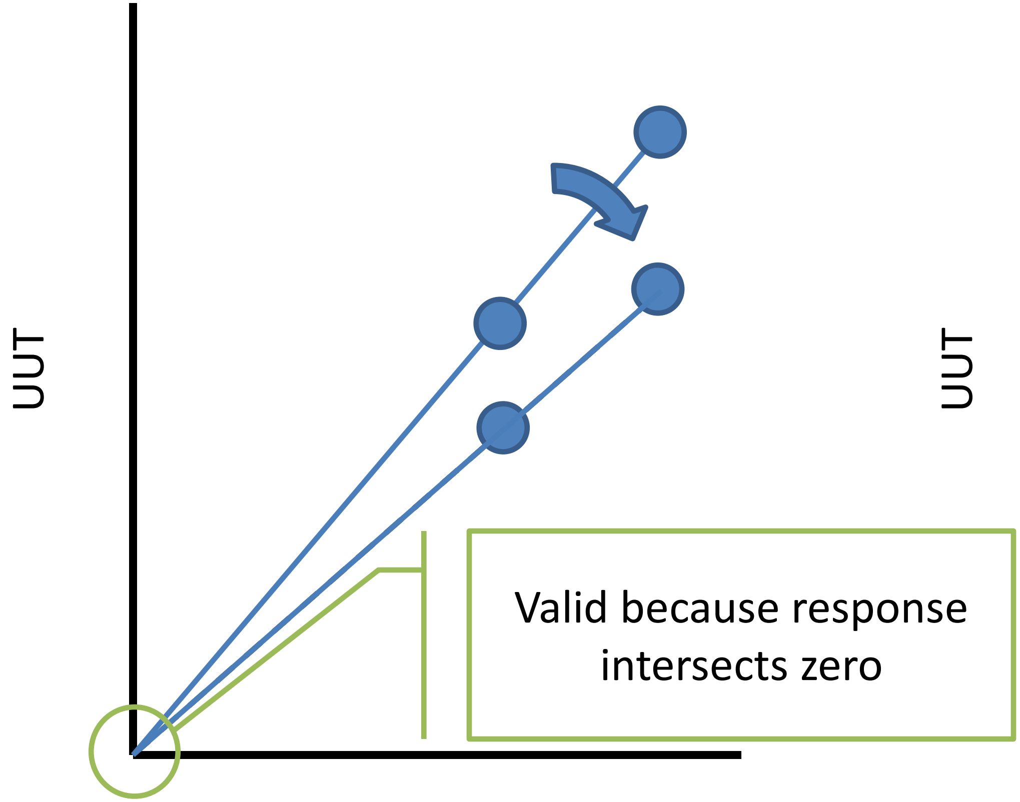
- Compare to sum of calibrated handheld equipment or hoods at multiple locations at airflow rates and locations suitable for the device

Poor

- Compare to improperly applied or calibrated handheld instruments
- Compare to fan curves based on fan speed and pressure drop
- Compare to temperature mixing methods (OA)

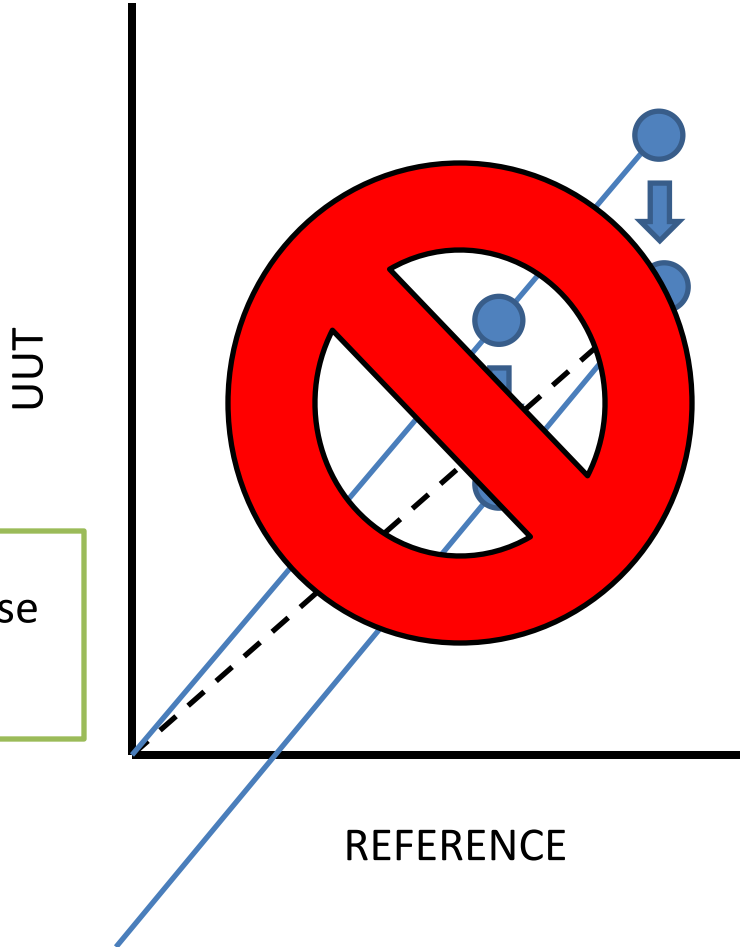
When you must adjust

One-point Gain Adjustment



Valid because response intersects zero

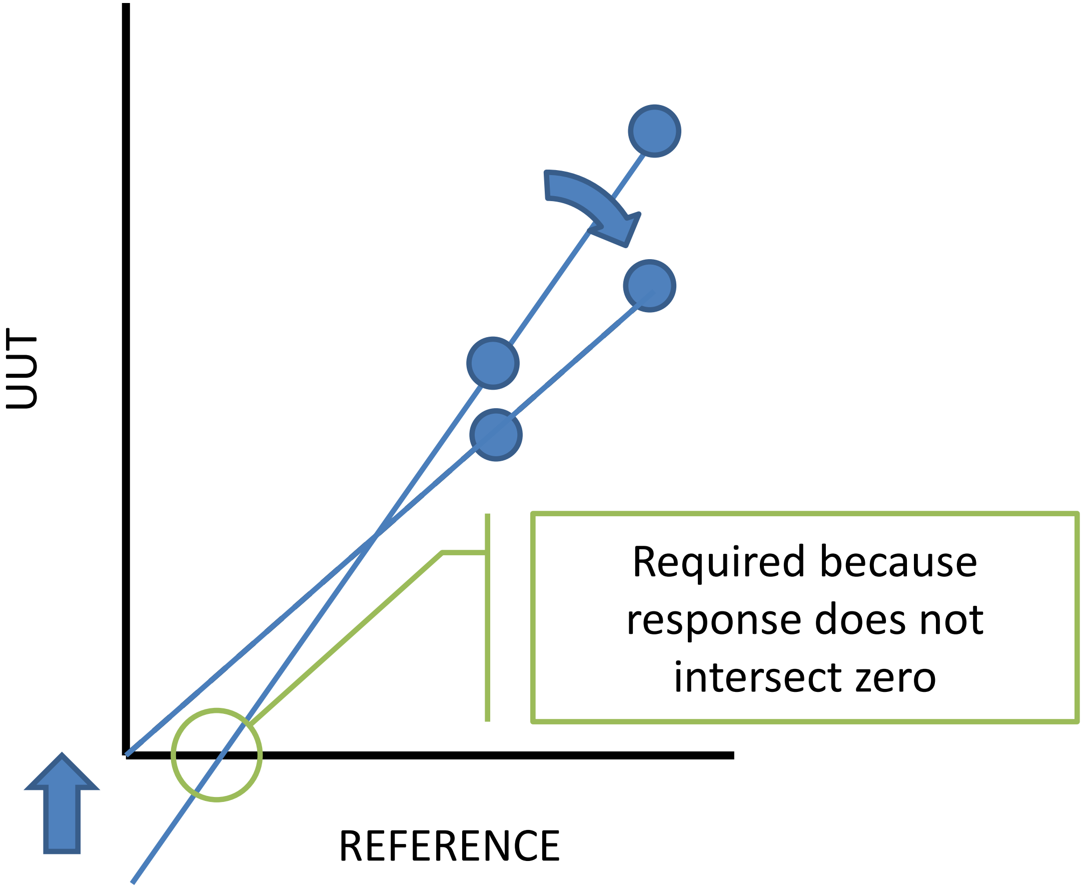
One-point Offset Adjustment



EBTRON a measureable difference!

When you must adjust

Two-point Offset-Gain Adjustment



Required because response does not intersect zero

Making Adjustments

Field-cal Wizard (Gold & Hybrid)

- Transmitter prompts user for one or two point adjustment. Reference airflow rates are directly entered in transmitter by user when measurements are taken. Transmitter samples and automatically makes offset/gain calculations.

Enter Slope and Intercept (Gold & Hybrid)

- Slope and intercept calculated by user is entered in transmitter.

Live Adjustment (Gold and Hybrid)

- Pushbutton offset/gain adjustments are made in real-time by comparing reference airflow rates to LCD output.

At Host Control System (Gold, Hybrid or ELF)

EBTRON

Thermal Dispersion Airflow Measurement

Why Choose Ebtron?

Ebtron History

- Leader in commercial HVAC airflow measurement for 25+ years
- Introduced our first microprocessor-based thermal dispersion airflow meter in 1986
- Moved to Loris, SC (20 mi from Myrtle Beach) in 1994
- Advantage product line introduced in 2001
- ~75 employees and a 5 building campus
- 80+ representatives

Ebtron = Support & Training

- Our Representatives – excellent pre-sale & post-sale support
- Factory Support
  - Tested, Proven Installation Guidelines
  - Application Assistance (Inside Sales)
    - Review building drawings & recommend products & placement upon request
    - Review all incoming orders over $5K
  - Dedicated Technical Support Group
- Product Performance & Reliability
- Industry-Leading Educational Programs
  - ‘Bring-A-Guest’ Seminars
  - ‘Lunch & Learns’
  - Webinars

EBTRON a measureable difference!

Accuracy

- True *percent-of-reading* airflow accuracy from 0 to 5,000 FPM
- NIST traceable 16 point airflow & temperature calibration
- Highest sensor density of any airflow measurement device

Stability

- Superior bead-in-glass thermistor probes (waterproof design)
- Microprocessor-based transmitters with high performance ADC
- Industrial rated integrated circuits and gold plated interconnects

Reliability

- Watchdog timer circuitry
- Fused and protected power and signal circuitry
- UL and BTL tested and listed – 3 year standard warranty

Connectivity

- Isolated analog, RS-485, Ethernet and Lon output options
- Combination output cards on Gold Series transmitters
- Airflow, velocity weighted temperature and alarm outputs

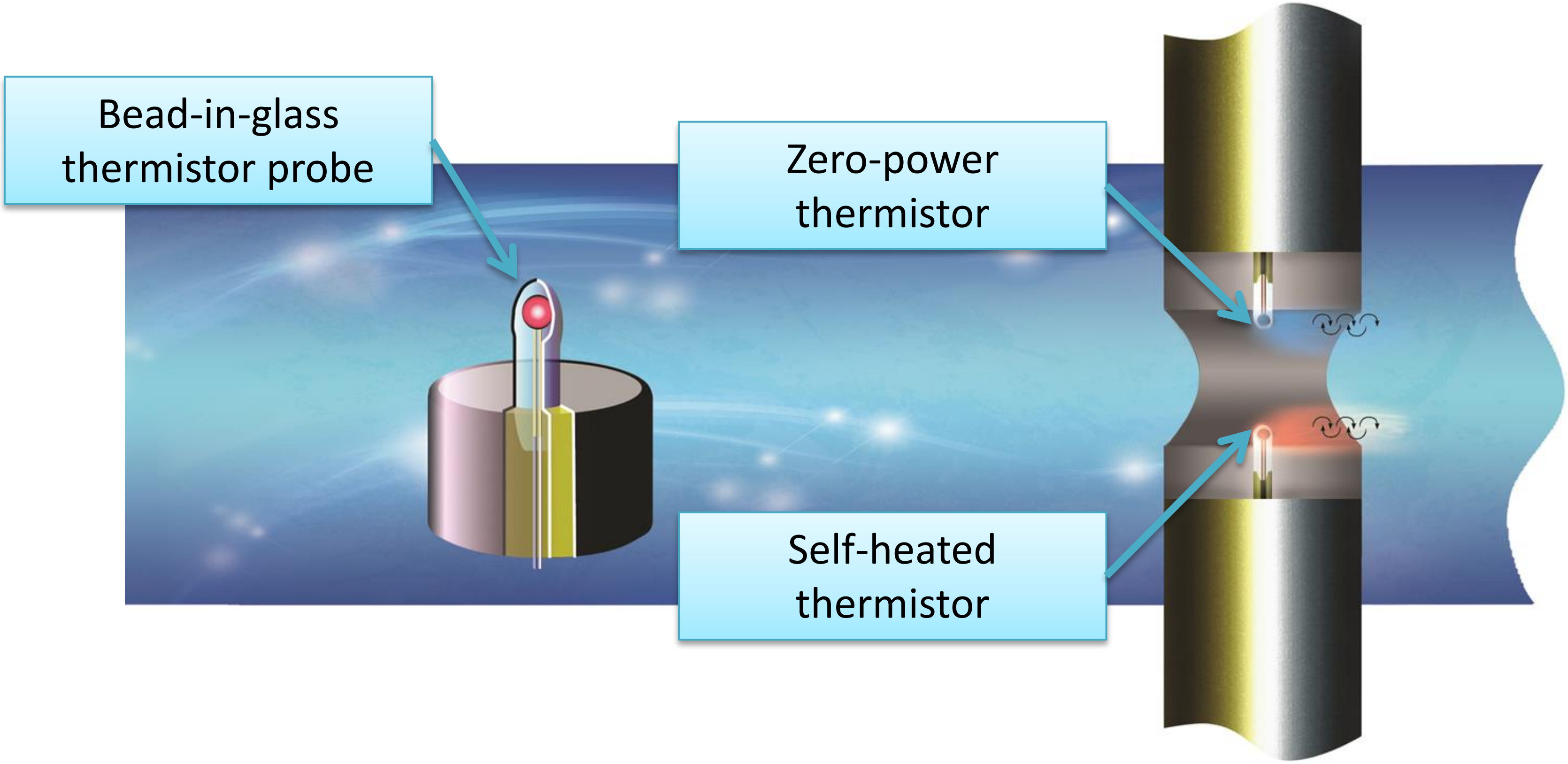
EBTRON Thermal Dispersion Technology

Velocity

ΔT

Power

$$Q = \frac{\kappa A}{d}\left[B + C\left(\frac{\rho v d}{\mu}\right)^{m}\right](T_H - T_A)$$



Bead-in-glass thermistor probe

Zero-power thermistor

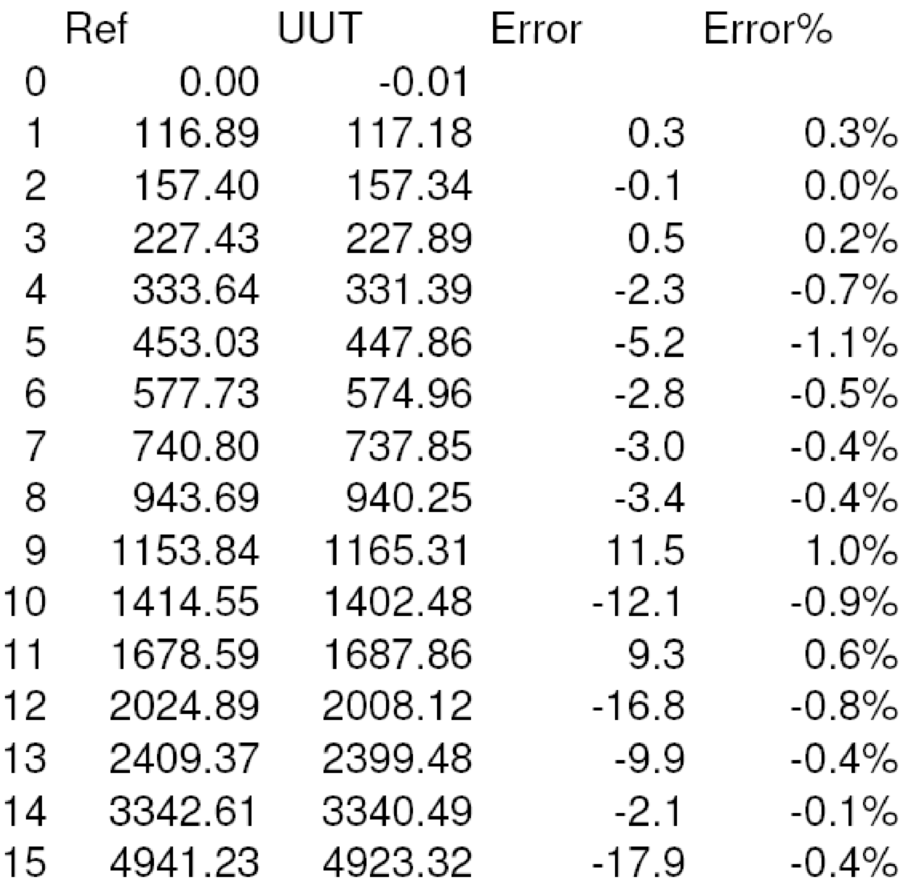
Self-heated thermistor

EBTRON performance matters!

EBTRON Standard

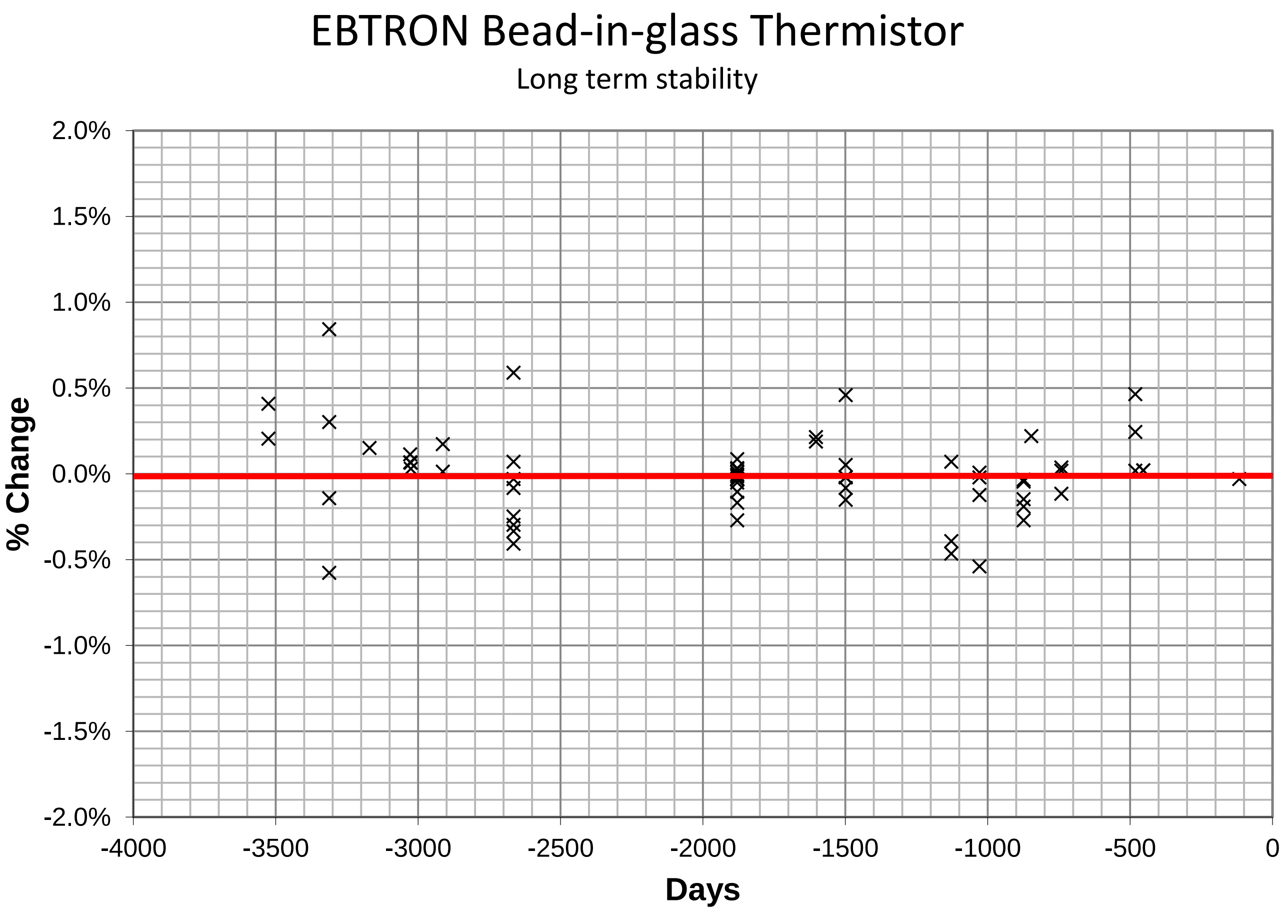
NIST Airspeed (VNIST), [fpm]	IUT Output (VIUT), [fpm]	Expanded Uncertainty, [%]
115.92	116.03	1.43
175.58	175.83	1.09
219.59	219.83	0.81
268.35	266.31	1.18
316.32	314.61	1.03
366.59	365.41	0.82
419.39	417.92	0.76
462.72	462.39	0.67
506.95	506.91	0.71
744.49	743.96	0.68
1035.1	1033.5	0.73
1190.7	1187.8	0.67
1438.0	1434.1	0.67
1772.5	1765.7	0.65
2050.1	2040.6	0.64
2488.3	2476.0	0.64
2986.9	2975.0	0.67
3382.5	3367.2	0.68
3984.5	3963.2	0.70
4988.1	4959.6	0.67
5990.8	5965.3	0.88
6979.2	6941.6	0.87
7993.3	7937.7	0.65

Typical Production Unit Calibration Report



	Ref	UUT	Error	Error%
0	0.00	-0.01		
1	116.89	117.18	0.3	0.3%
2	157.40	157.34	-0.1	0.0%
3	227.43	227.89	0.5	0.2%
4	333.64	331.39	-2.3	-0.7%
5	453.03	447.86	-5.2	-1.1%
6	577.73	574.96	-2.8	-0.5%
7	740.80	737.85	-3.0	-0.4%
8	943.69	940.25	-3.4	-0.4%
9	1153.84	1165.31	11.5	1.0%
10	1414.55	1402.48	-12.1	-0.9%
11	1678.59	1687.86	9.3	0.6%
12	2024.89	2008.12	-16.8	-0.8%
13	2409.37	2399.48	-9.9	-0.4%
14	3342.61	3340.49	-2.1	-0.1%
15	4941.23	4923.32	-17.9	-0.4%

EBTRON long term stability!

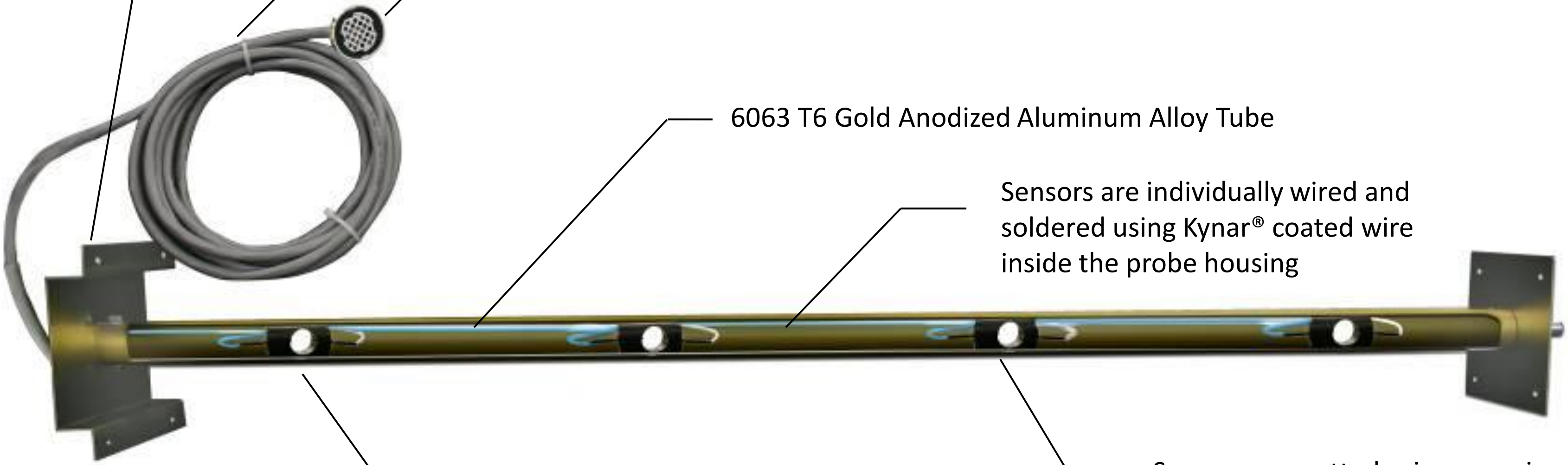


EBTRON Bead-in-glass Thermistor

Long term stability

EBTRON the GOLD standard!

GTx116-P Duct & Plenum Probes



304 SS Mounting Brackets

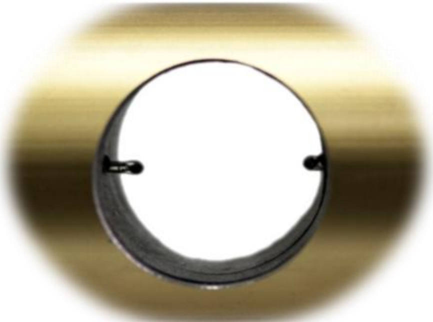
Durable FEP Plenum Rated Cable

Positive Locking Cable Plug w/Gold Pin Interconnects

6063 T6 Gold Anodized Aluminum Alloy Tube

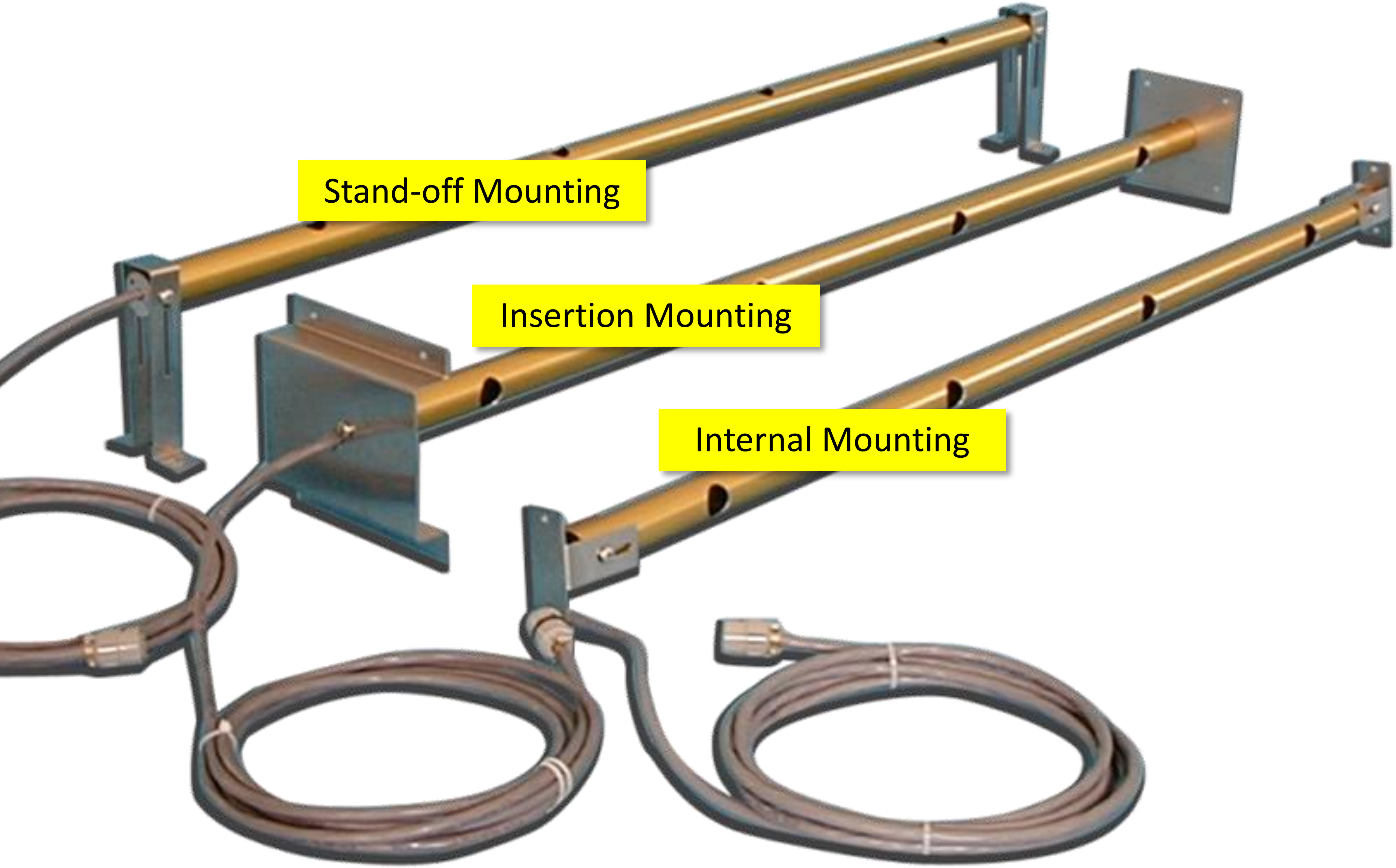
Sensors are individually wired and soldered using Kynar® coated wire inside the probe housing

Individual Sensors use two stable bead-in-glass thermistors for accurate and stable measurement



Sensors are potted using a marine grade waterproof expoxy

GTx116-P Flexible Mounting Options



Stand-off Mounting

Insertion Mounting

Internal Mounting

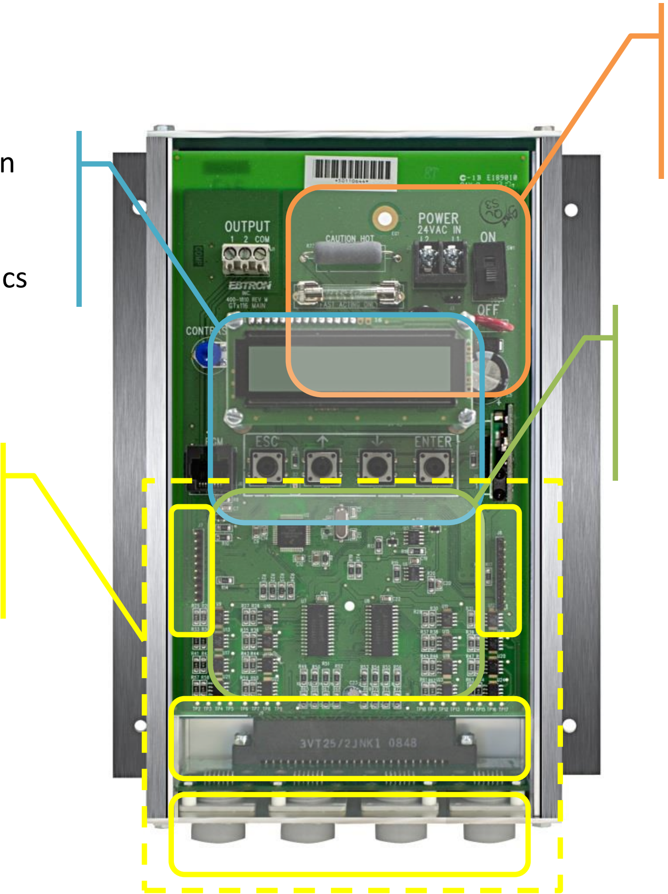
EBTRON the GOLD standard!

TAMCO EBTRON

AIR-IQ AIR FLOW MEASUREMENT SOLUTION

EBTRON the GOLD standard!

GTx116-P Superior Transmitter Design



Easy to use pushbutton interface for custom configuration *(not required)* and diagnostics

Over-voltage and over-current protected switching power supply

Powerful 32- bit microcomputer with 32 channel precision volt meter

Gold-plated PCB interconnects, plug and receptacle pins

EBTRON the GOLD standard!

GTx116-P Unsurpassed Connectivity Choices

Snap-in Output Cards for the Ultimate Connectivity Flexibility!

GTC116-P (Standard)
Two field selectable 0-5, 0-10 VDC or 4-20 mA isolated outputs
One field selectable RS-485 BACnet MS/TP or Modbus-RTU output

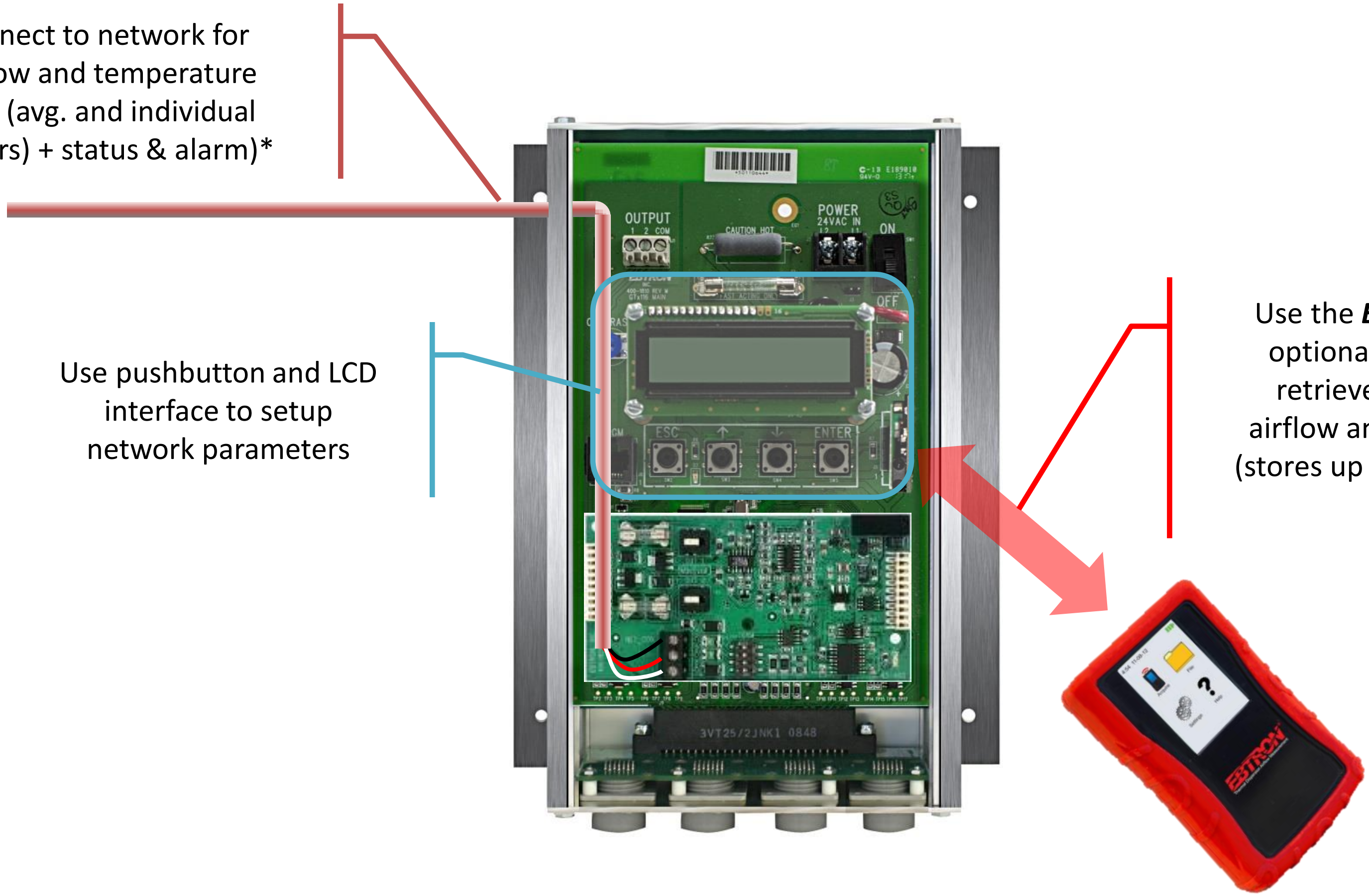
GTM116-P
Two field selectable 0-5, 0-10 VDC or 4-20 mA isolated outputs
One field selectable Ethernet BACnet I/P or Modbus TCP output

GTL116-P
Lonworks

GTD116-P
USB thumb-drive datalogger, logs average airflow and temperature plus airflow and temperature readings of individual sensors with time stamp

the GOLD standard!

GTx116-P Added Functionality



Connect to network for airflow and temperature data (avg. and individual sensors) + status & alarm)*

Use pushbutton and LCD interface to setup network parameters

Use the ***EB-Link Reader*** with optional ***EB-Link*** IR card to retrieve individual sensor airflow and temperature data (stores up to 32 locations – USB interface)

** GTX116 RS-485 Shown*

EBTRON Small Duct Option

Hybrid Series HTx104-P

GTx116
Transmitter

HTx104
Transmitter

GTx116-P/HTx104-P Comparison

- HTx104-P is designed for small ducts (approx. 4 ft^2 or less) or larger duct applications that do not require out-of-the-box installed accuracy
  - 4 sensors max.
- Uses same probe technology as Gold Series
- Same as Gold Series with the following exceptions:
  - Uses DIN receptacles and plugs without gold plating
  - Only available with dual analog output signals ***OR*** RS-485 (no plug-in cards)
  - No *EB-Link* option
- Slightly lower cost for same size duct

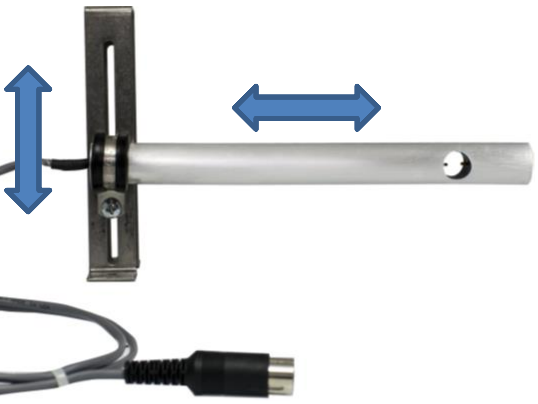
EBTRON Specialty Measurement

Hybrid Series HTx104-U

0-2,000 FPM, 3% of reading accuracy (typ.)

Airflow and Temperature Measurement

Available in 8” or 16” probe lengths



RTU OA Intakes (3 to 12.5 tons)

Desiccant Wheel ERVs <48”

EBTRON Small Round Duct Options

HTx104-T and ELF

0-3,000 FPM, calibrated in duct sized wind tunnels, 3% of reading installed accuracy (typ.)
Specifically designed for small round ducts and terminal box applications

HTx104-T/ELF Comparison

- Both use –T probes specifically designed and calibrated for round ducts ≤ 16”
- Both HTx104-T and ELF are available with an RS-485 BACnet option
- HTx104-T transmitter can be remotely mounted, ELF cannot be
- HTx104-T has more power and signal protection than ELF
- ELF base version only has airflow output only (no temperature)
- ELF does not have an LCD display or pushbutton user interface
- ELF has a significantly lower cost

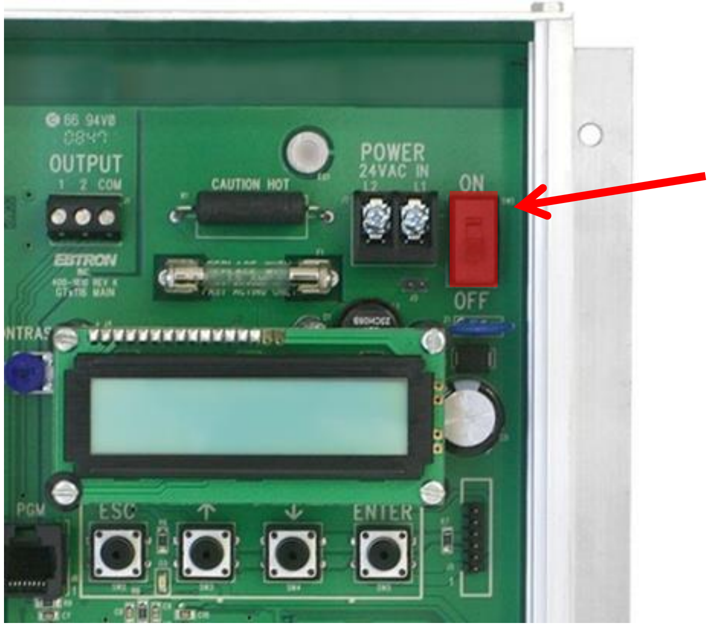
EBTRON

Thermal Dispersion Airflow Measurement

Innovative Solutions
Real Applications
That Other Engineers Utilize Ebtron

Ebtron Products Save Time & Money

- Reduces set-up costs
  - Simple product installation
    - Installed by Controls Contractor not the Mechanical Contractor
  - Start-Up Procedure
    - No ‘K’ factors or ‘pressure-to-velocity’ conversions
    - Turn Power Switch to ON … done
  - TAB goes from calibration to verification (when installed per guidelines)



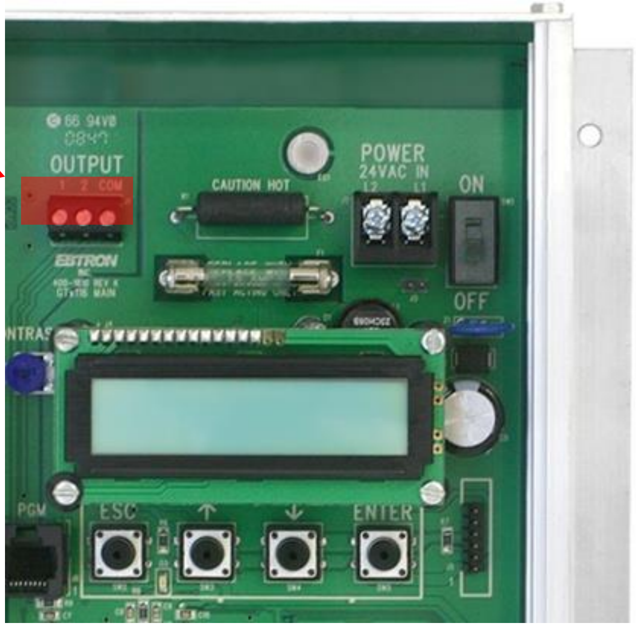
Start-Up Procedure
Step 1: Turn Power ON
Step 2: Replace Cover

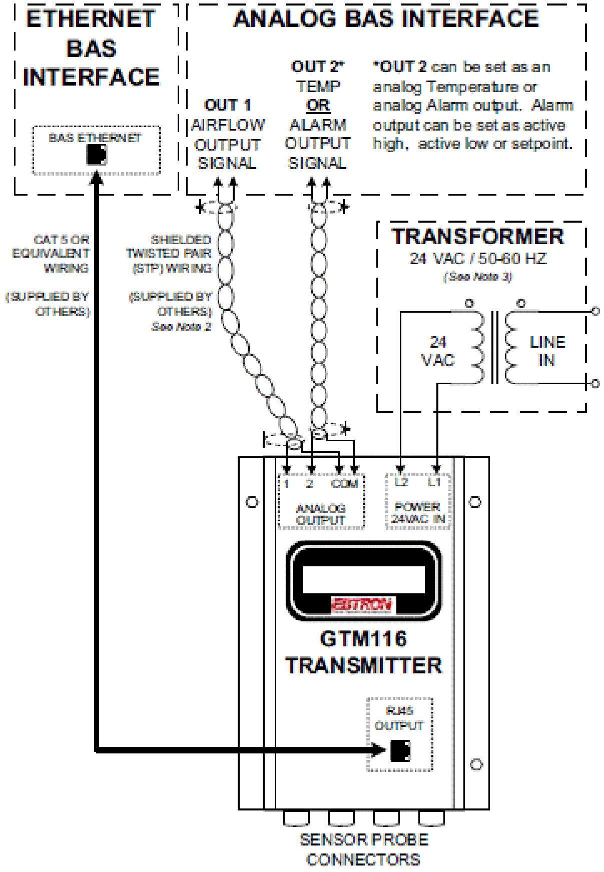
Ebtron Products Save Time & Money

- Free Temperature Output (Gold)
  - Saves material and installation costs of a temperature sensor ($125+ Savings)
  - Excellent Accuracy (+/- 0.15ºF)

Two Analog Outputs

1. Airflow
2. Temperature





*OUT 2 can be set as an analog Temperature or analog Alarm output. Alarm output can be set as active high, active low or setpoint.

Arithmetic vs. Weighted Temperature Example

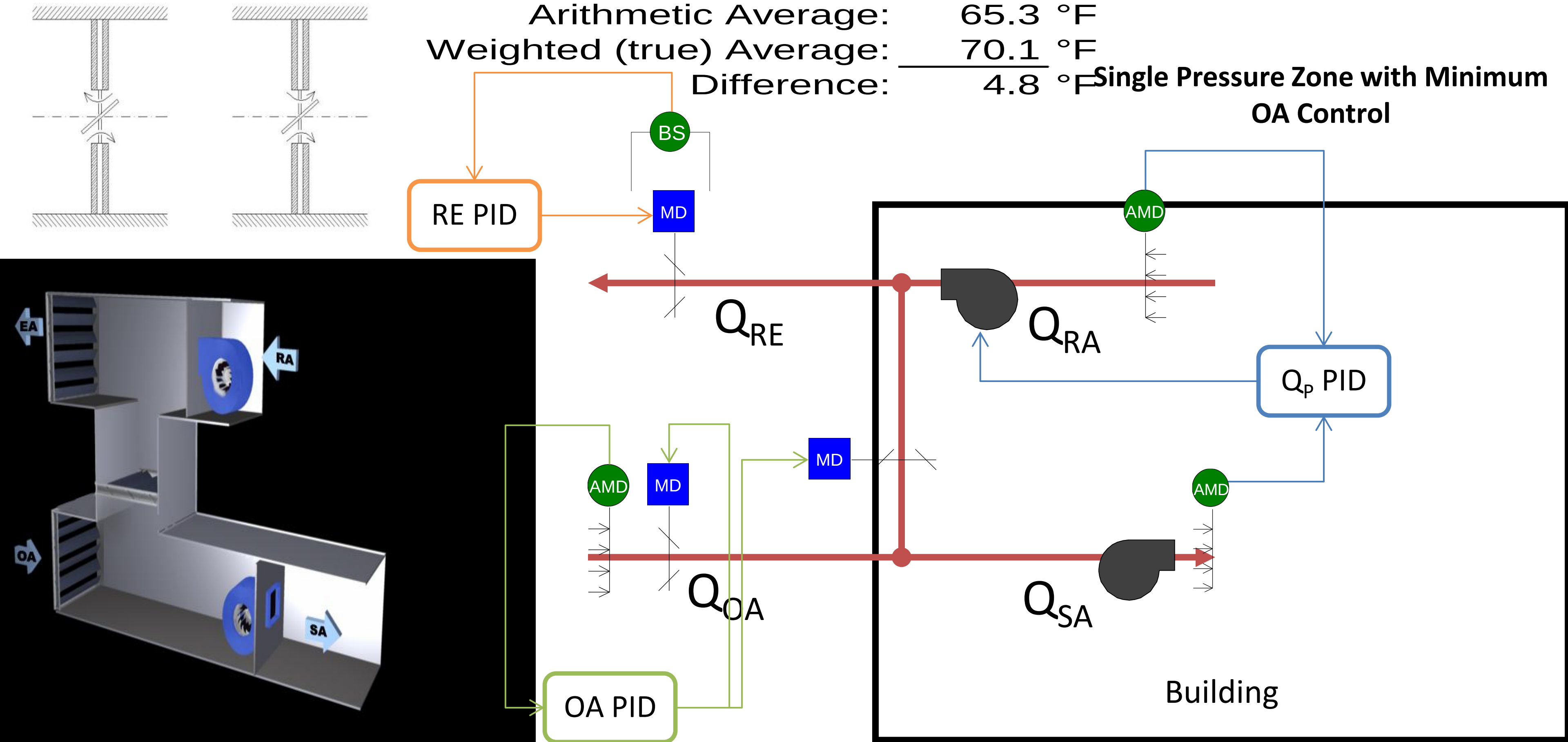
Measurement Location: Mixed Air Stream

Velocity Profile (FPM)			
1646	1431	1418	1426
1184	1195	1217	1024
783	561	685	788
519	445	358	460

Temperature Profile (°F)			
82.4	81.1	80.3	80.4
70.6	69.9	69.8	68.0
60.3	59.9	60.1	61.9
49.8	49.9	51.0	49.7

Arithmetic Average: 65.3 °F
Weighted (true) Average: 70.1 °F
Difference: 4.8 °F

Single Pressure Zone with Minimum OA Control



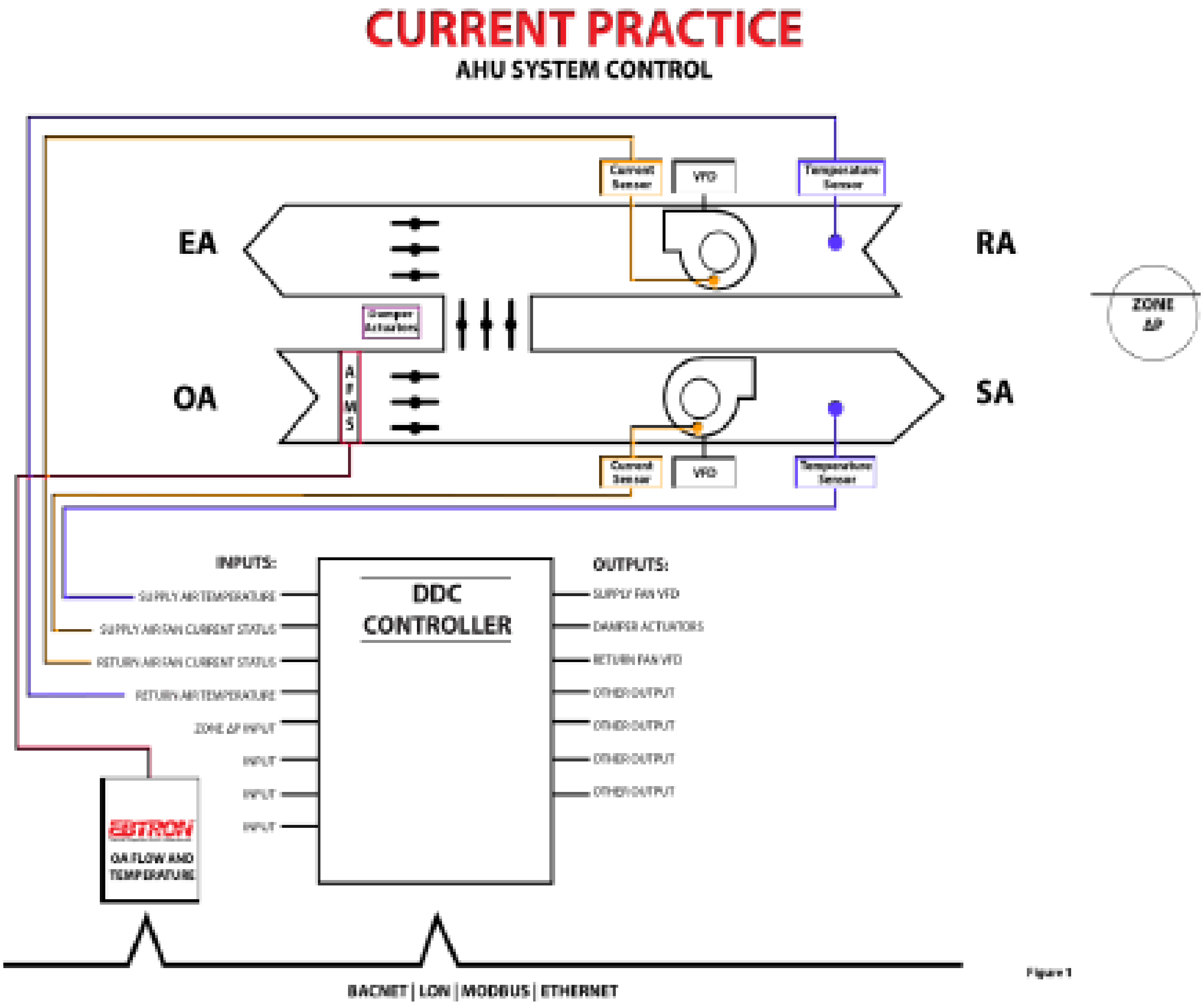


Figure 1. Current Practice – AHU System Control

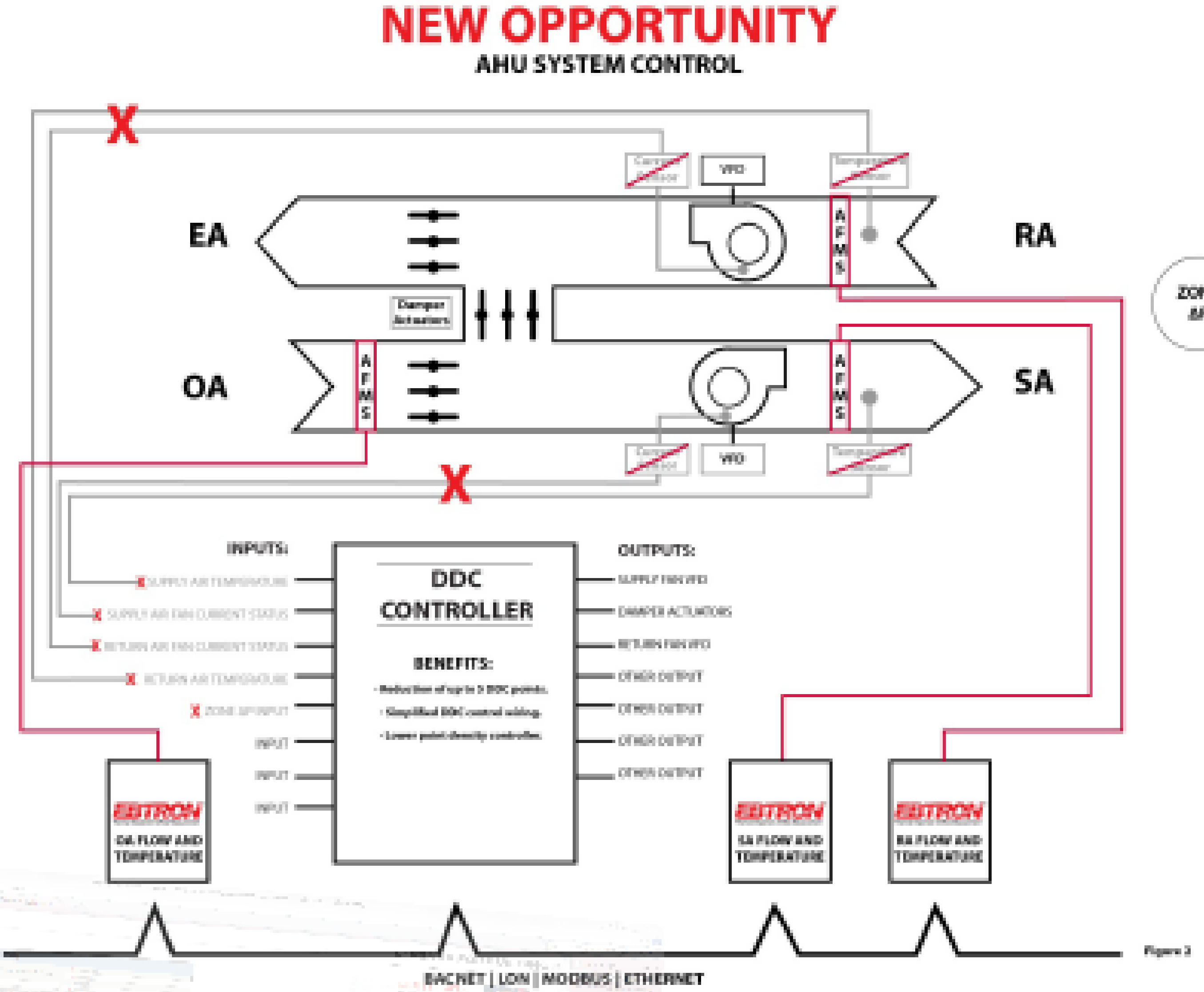
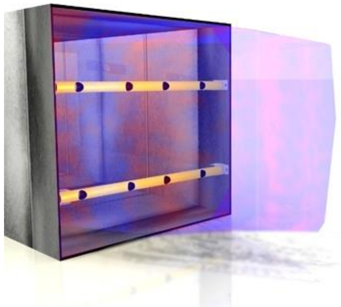


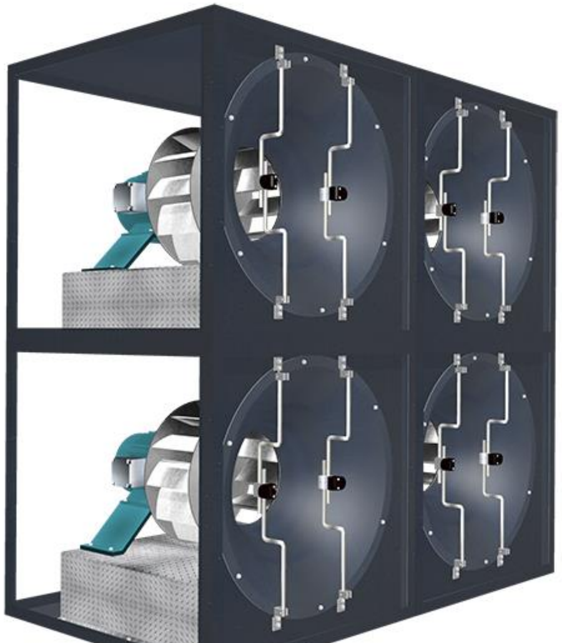
Figure 2. Cost-Effective Solution – AHU System Control

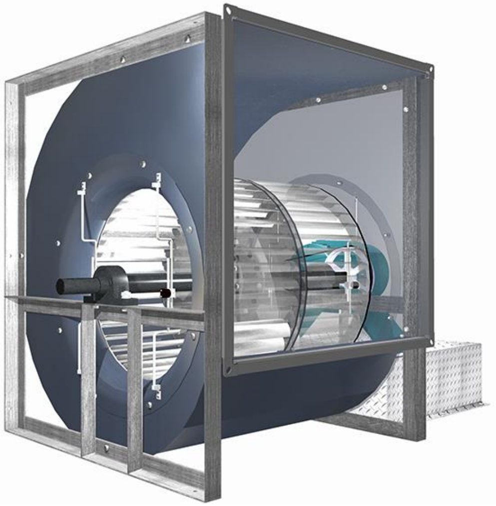
What about Fan Arrays

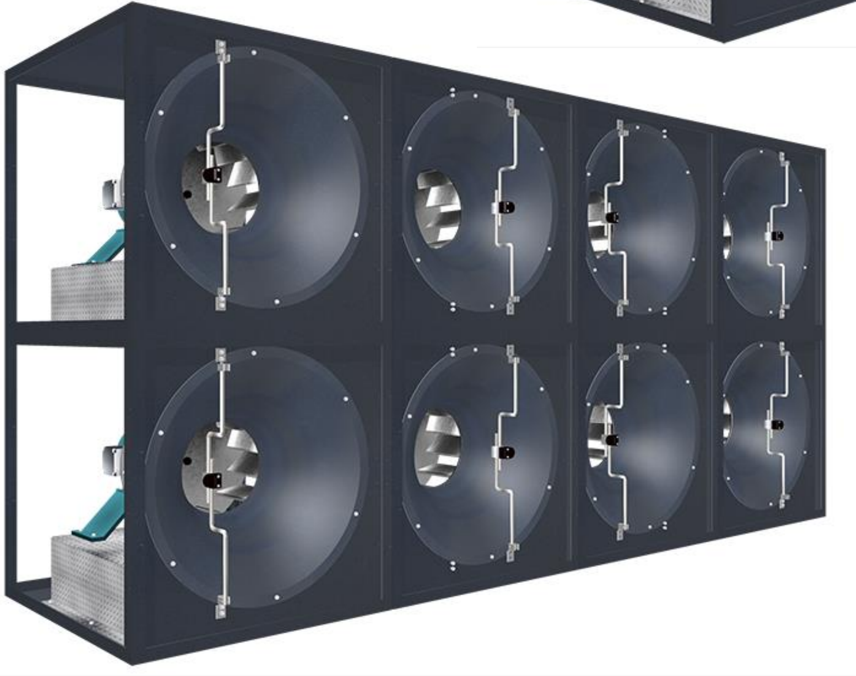
One Drive Controls Multiple Fans?

Micro Drive Back To A PLC?

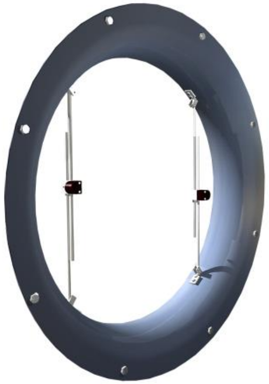
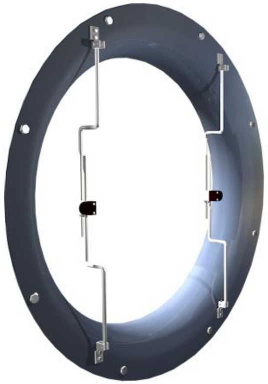


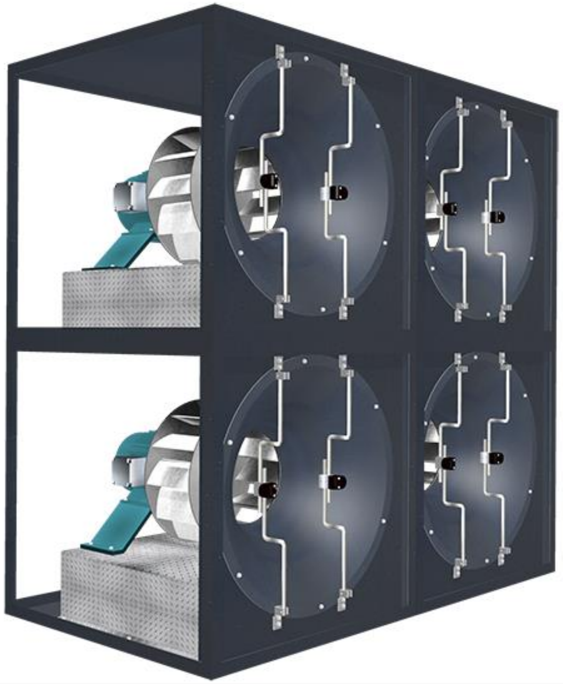






Mounting Options:

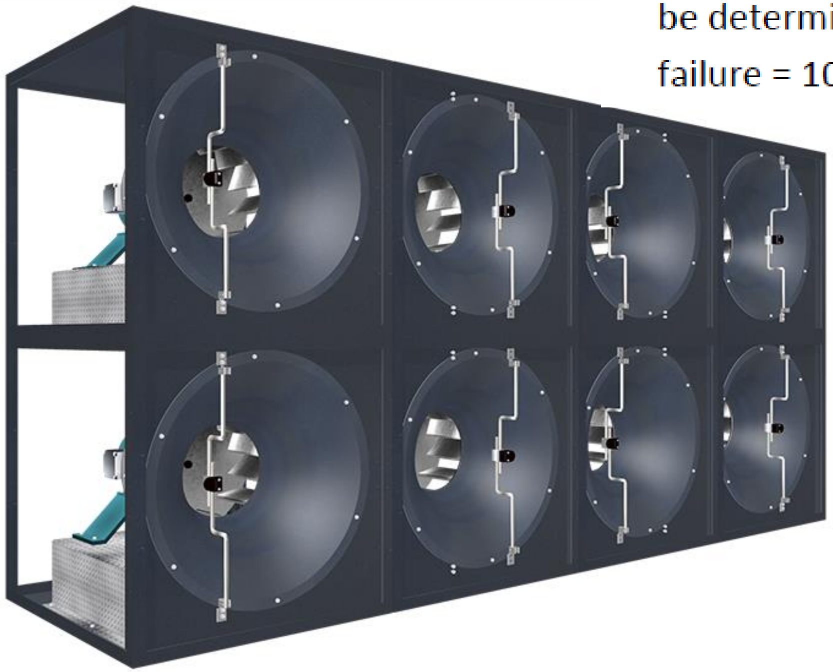
✓Throat 	✓Face 	✓ Forward 	✓Flare 



INDIVIDUAL FAN ALARMING METHODS

MINIMUM	User defined minimum FPM or CFM
DEVIATION	User defined % deviation from median FPM or CFM of all fans
% MAXIMUM	% deviation from maximum velocity stored of each individual fan

The *Fan Alarm* is available via the network or by assignment of the alarm to the second analog output, AO2, on GTC108 and GTM108 models. Fan failure on the analog output can be determined by the magnitude of the output signal (fan 1 failure = 10% of F.S., fan 2 failure = 20% of F.S., etc.)



Example

Items	Cost Add	Piezo Ring	EBTRON Fan Array
Ring	$50 per fan	$400.00	
Transducer	$200 per fan	$1600.00	
Current Donut	$50 per fan	$400.00	
ATC Alarms Points	$ 600 per fan	$ 4800.00	$1000.00
		$7,200.00	$3,512.00

Better Performance

No Yearly Calibration

-F Fan Inlet Specifications

Range: *0-10,000 fpm*

Airflow *Sensor* Acc'y: +/- 2% of the reading
+/- 0.25% repeatability

Temp Sensor Acc'y: +/- 0.15 °F

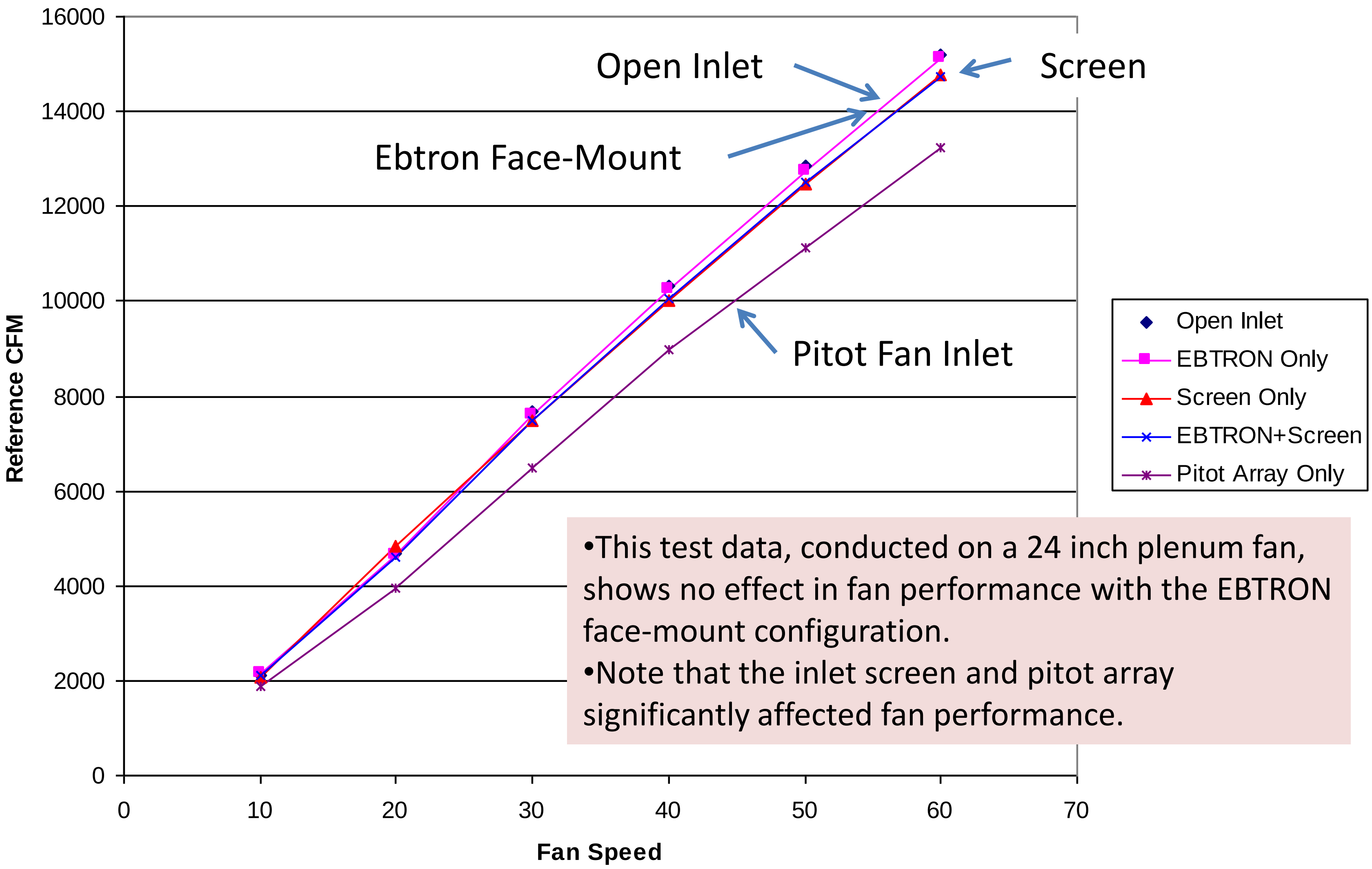
Environmental: -20 to 160 °F
0 to 99% RH, non-condensing

Size Ranges: 11 to 64 inches

Plug & Play: No matching of probe to transmitter
Calibration data stored in cable's memory chip

Cables: Plenum rated, PVC jacket
10 ft. standard, 50 ft. maximum

Face-Mount: No Fan Performance Effects



- This test data, conducted on a 24 inch plenum fan, shows no effect in fan performance with the EBTRON face-mount configuration.
- Note that the inlet screen and pitot array significantly affected fan performance.

A more cost effective Bleed Sensor!

- SB1 compatible
- Two analog output signals
- Contact closure alarm

Bi-Directional, Low-Flow Sensor Specifications

Range: -3,000 to 3,000 fpm
bi-directional

Airflow *Sensor* Acc'y: +/- 2% of the reading
+/- 0.25% repeatability

Temp Sensor Acc'y: +/- 0.15 °F

Environmental: -20 to 160 °F
0 to 99% RH, non-condensing

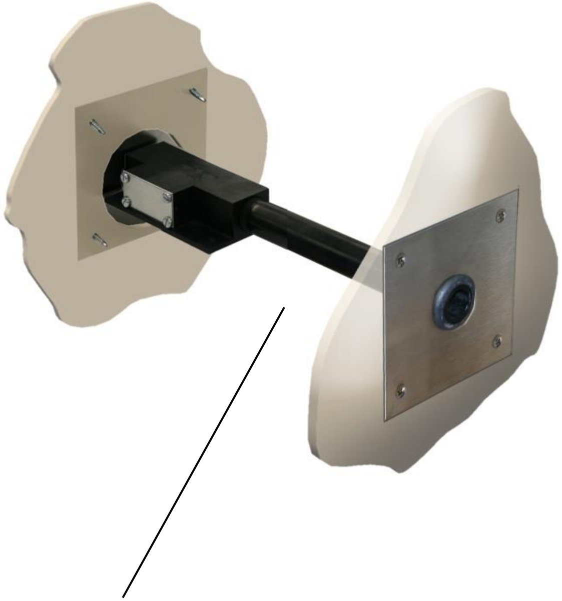
Outputs: Velocity (can convert to equivalent pressure)

Plug & Play: No matching of probe to transmitter
Calibration data stored in cable's memory chip

Cables: Plenum rated, PVC jacket
10 ft. standard, 50 ft. maximum

Measures Flow instead of Pressure to Ensure/Calculate Zone or Bldg. Pressurization

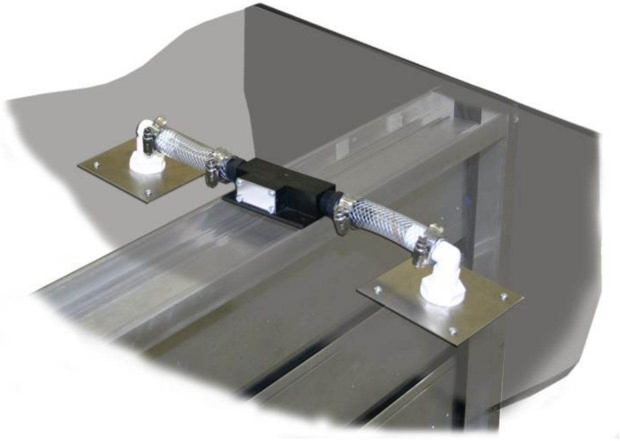
-B Bi-Directional, Low-Flow Airflow Sensors
For Measuring Differential Pressure Between ‘Zones’



MONITOR LOW PRESSURE

Use to verify pressure differentials by determining the pressurization flow between spaces or across the building envelope

EBTRON optional *Through-Wall* kit shown. Protect from rain or snow by providing a rain hood or louver (by others) on exposed outdoor walls.



CONTROL DAMPERS

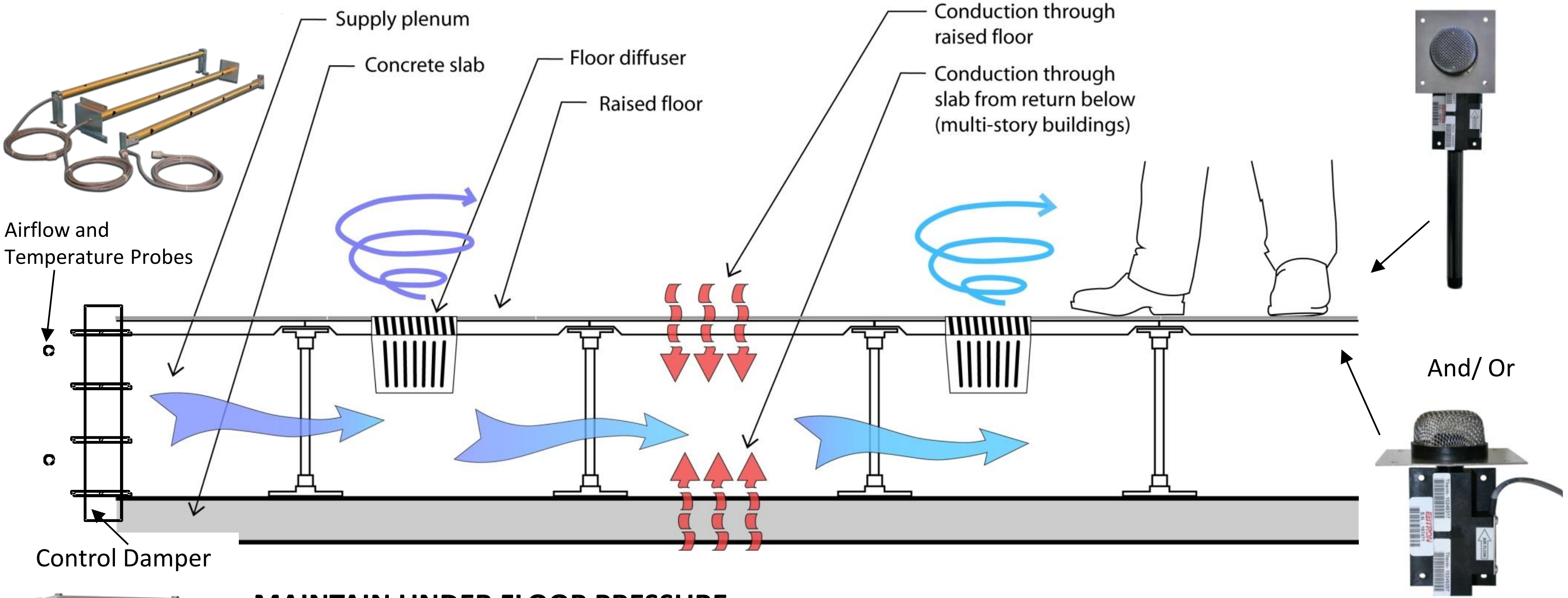
Assure proper airflow direction across relief dampers (supply/return fan system) or recirculation dampers (supply/exhaust fan systems)

Sensors can also be used to determine airflow across many intake louver configurations (consult *EBTRON* for flow rate requirements).

MAINTAIN UNDER FLOOR PRESSURE

Use bleed airflow to maintain stable pressurization with under floor systems

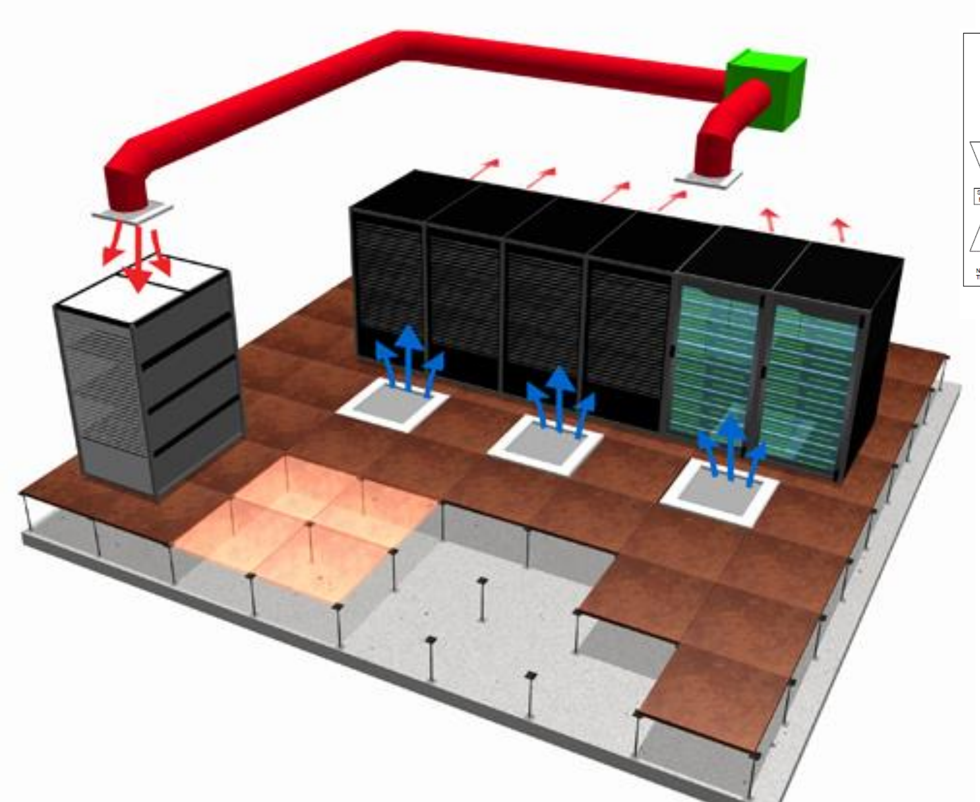
-B Bi-Directional, Low-Flow Sensor for Under Floor System Control



MAINTAIN UNDER FLOOR PRESSURE:

Use the bleed sensor to monitor the UFAD pressurization flow. Using a GTX-116 airflow (through the BAS) and a simple reset PID control loop, reset the flow <u>(800 to 1200 fpm nominal)</u> to incrementally increased and decreased the UFAD supply damper flow to meet the bleed sensor(s) nominal velocity for stable under floor control.

Original Data Center Designs



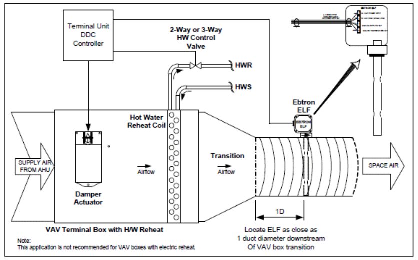
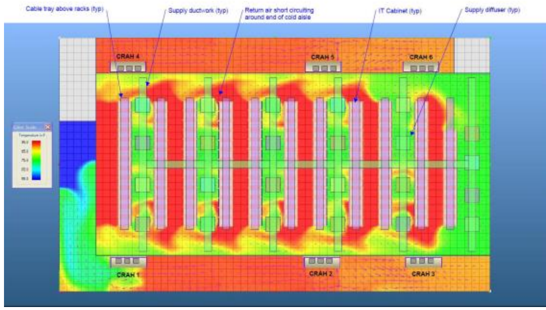
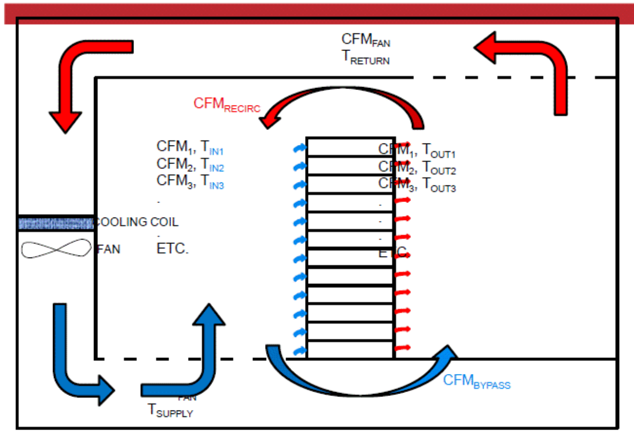


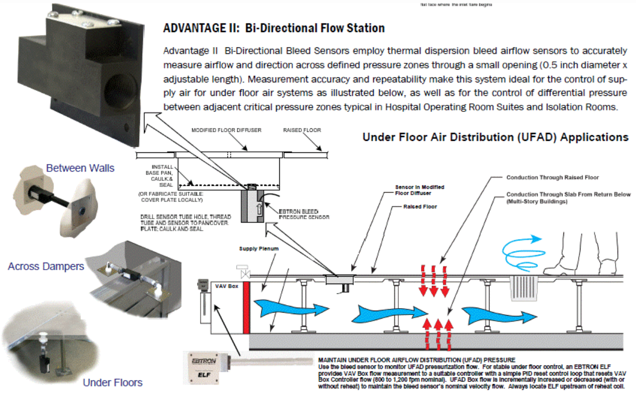
FIGURE 1.
ELF-D APPLICATION - VAV TERMINAL UNIT WITH HOT WATER REHEAT

Phase 1 - No Aisle Containment - 75 F Supply Air Temp





Representative Data Center Without Containment



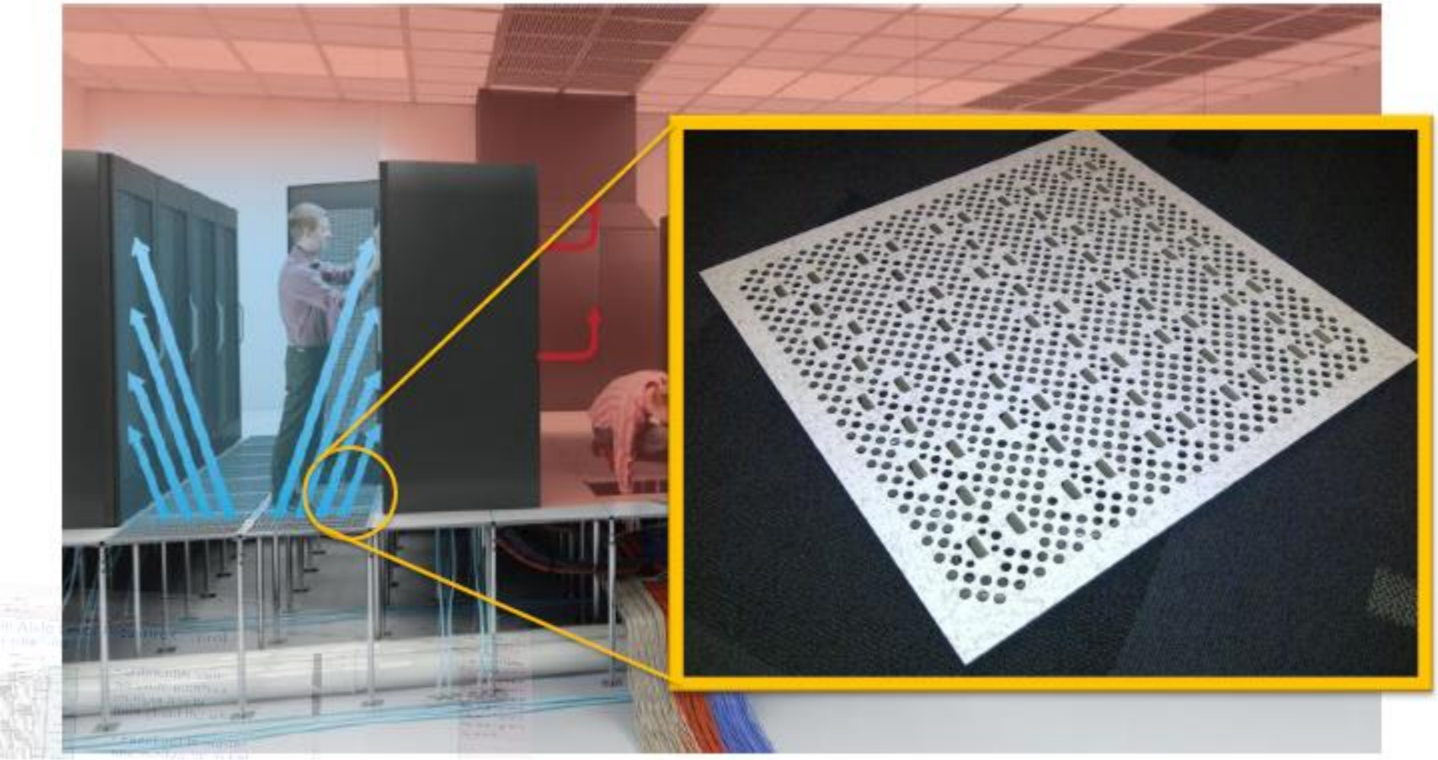
ADVANTAGE II: Bi-Directional Flow Station

Advantage II Bi-Directional Bleed Sensors employ thermal dispersion bleed airflow sensors to accurately measure airflow and direction across defined pressure zones through a small opening (0.5 inch diameter x adjustable length). Measurement accuracy and repeatability make this system ideal for the control of supply air for under floor air systems as illustrated below, as well as for the control of differential pressure between adjacent critical pressure zones typical in Hospital Operating Room Suites and Isolation Rooms.

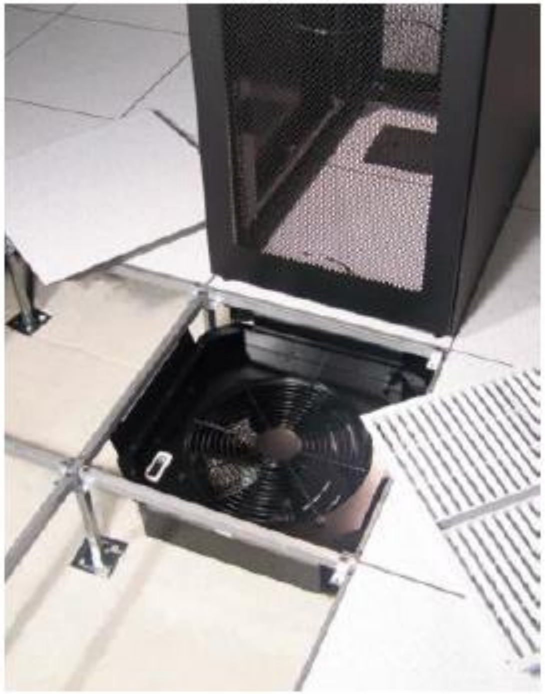
Under Floor Air Distribution (UFAD) Applications

MAINTAIN UNDER FLOOR AIRFLOW DISTRIBUTION (UFAD) PRESSURE
Use the bleed sensor to monitor UFAD pressurization flow. For stable under floor control, an EBTRON ELF provides VAV Box flow measurement to a suitable controller with a simple PID reset control loop that resets VAV Box Controller flow (800 to 1,200 fpm nominal). UFAD Box flow is incrementally increased or decreased (with or without reheat) to maintain the bleed sensor's nominal velocity flow. Always locate ELF upstream of reheat coil.

Directional Perf (Directional Airflow Perforated Panel)



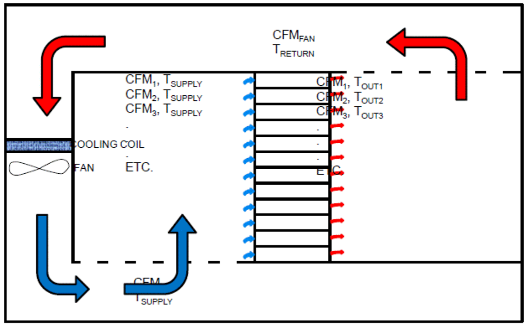
Fan Assisted Cooling



Future Data Center Designs

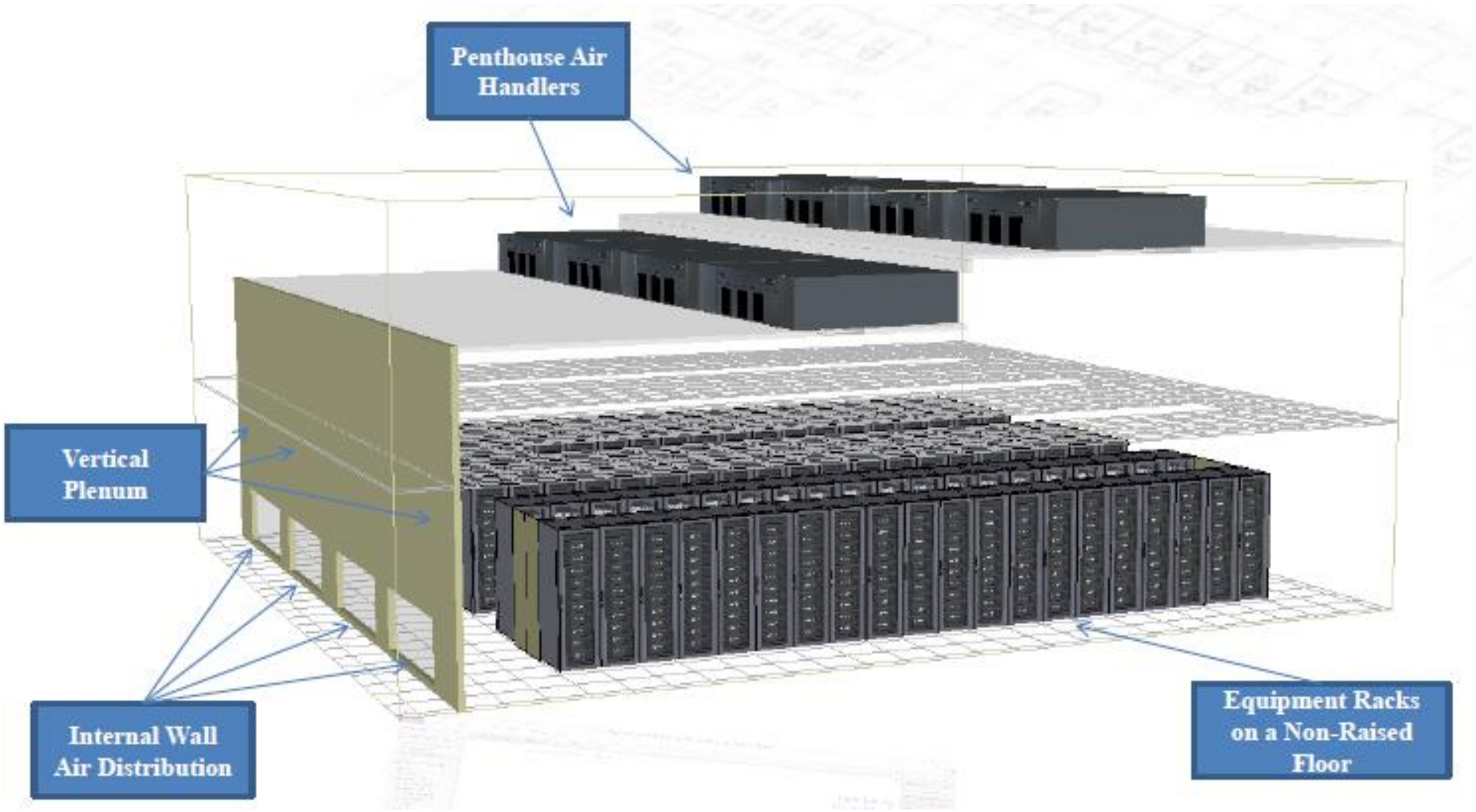
Phase 1 - Hot Aisle Containment - 75 F Supply Air Temp

Hot / Cold Containment



Representative Data Center With Containment

Central Air Handler System



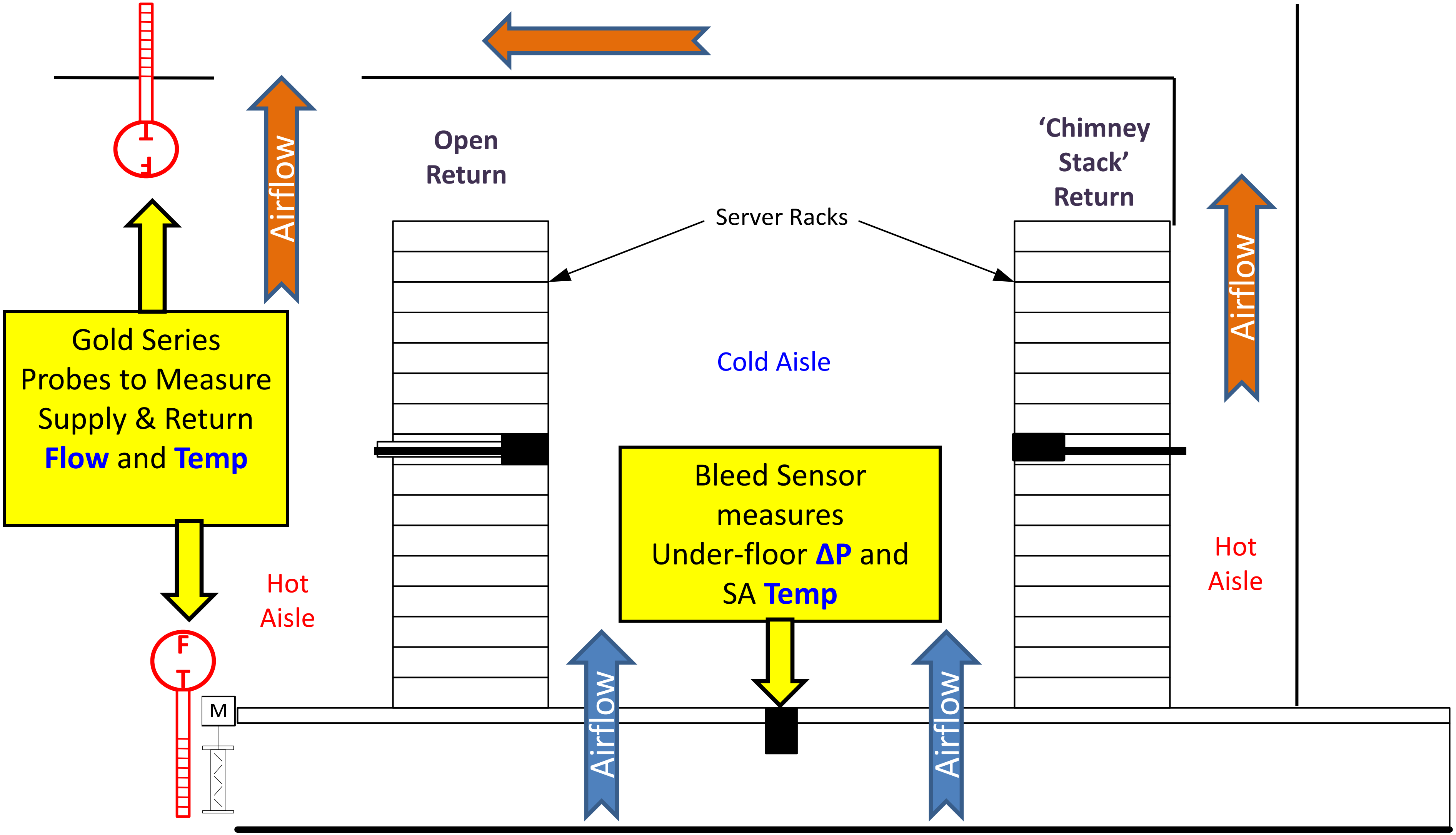
Penthouse Air Handlers

Vertical Plenum

Internal Wall Air Distribution

Equipment Racks on a Non-Raised Floor

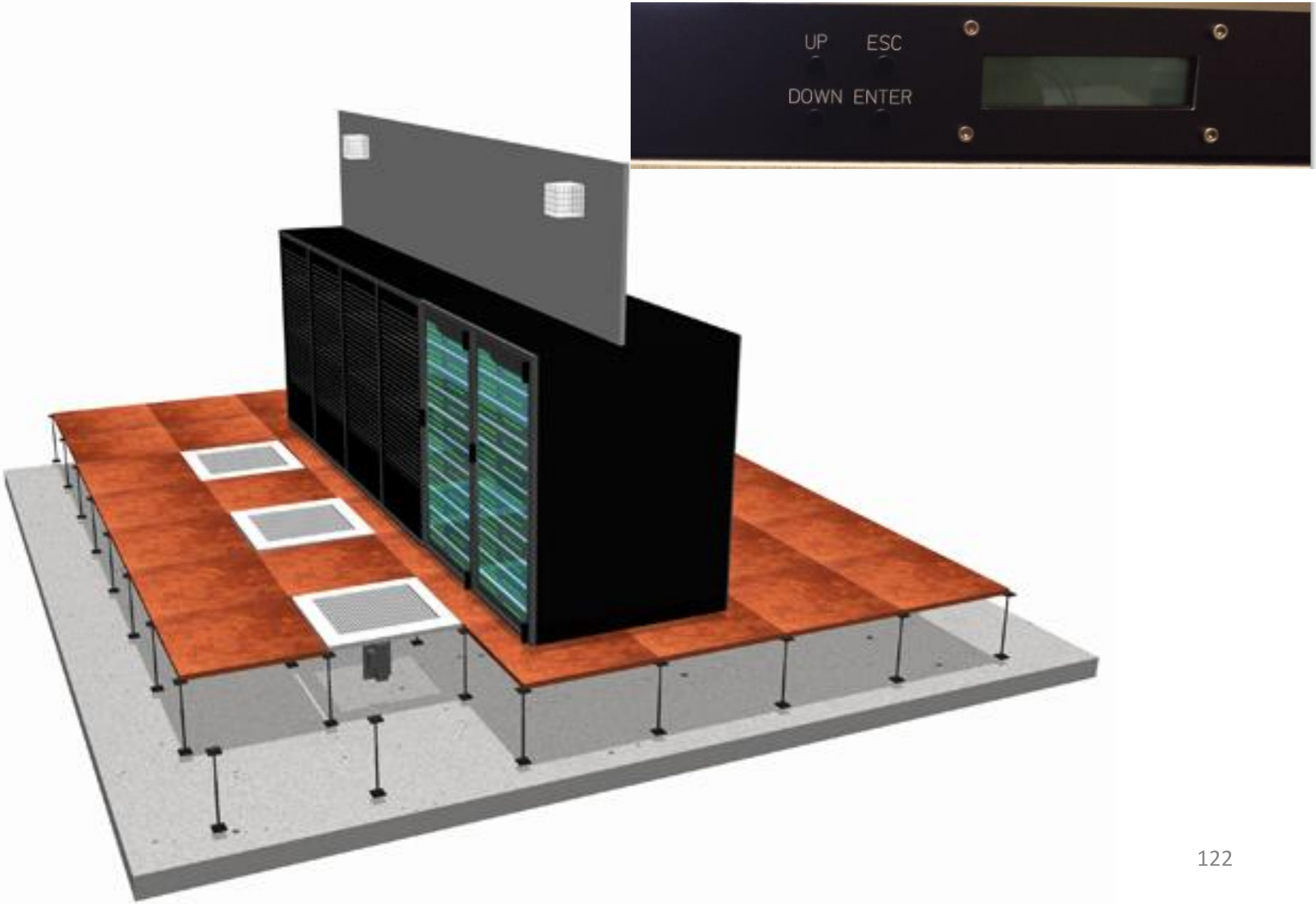
EBTRON Airflow Stations & 'Bleed'
Ensure Proper SA & RA Flow and Temperature



Gold Series Probes to Measure Supply & Return **Flow** and **Temp**

Bleed Sensor measures Under-floor **ΔP** and SA **Temp**

Future Data Center Designs



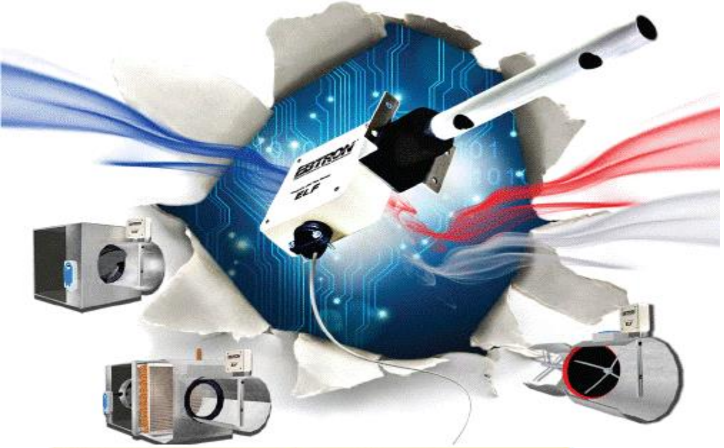
Data Center Action Plan

$$\text{PUE} = \frac{\text{Total data center power}}{\text{IT equipment power}} = \frac{1}{\text{Site infrastructure efficiency}}$$

- Understand their Language for Data Centers (Owner & Consulting Engineers)
- Ebtron sensors can be utilized as alarms for existing & smaller data center designs
- Ebtron sensors can be utilized as an alarm and control points for Hot/Cold Aisle Containment
- Ebtron’s Velocity Weighted Temperature Control point is unmatched and saves the client money
- Ebtron’s Bi Directional Flow Meters provide the client with the most reliable and stable system for underfloor applications.

Protect Your Equipment!
Compare the Ebtron Cost to Cost of the Servers

EBTRON ELF (Electronic Low Flow)



Factory-Mounted Controls

- Ebtron Electronic Air Flow Stations
- Customer Provided Controls
- Factory Controls

Airflow Ranges:	0-500 fpm 0-1,000 fpm 0-2,000 fpm 0-3,000 fpm
Accuracy:	+/-3% of the READING
Input:	24 VAC
Voltage Output:	0-10/2-10 VDC 0-5 /1-5 VDC
Outputs (units):	Airflow (fpm) Equivalent Velocity Pressure (for controllers designed to take a ΔP input)
Duct Sizes:	4 to 16 inches

Ideal for lab/operating/isolation room airflow tracking and accurate VAV box measurements

+/-% of Reading Error Comparison

Pressure Transducer *Drift* Effect vs. ***Ebtron ELF***

$p_{vel}=p_{total}-p_{static}$

$V= 2500 \times \sqrt{p_{vel}}$

	ΔP Devices			**EBTRON *ELF***
	@1,250 fpm	@750 fpm	@400 fpm	
Start-Up	**0%**	**0%**	**0%**	**3%**
Year 1	2.0%	5.7%	21.9%	**3%**
Year 2	4.1%	11.8%	53.2%	**3%**
Year 4	8.4%	25.5%	Error%*	**3%**
Year 6	12.8%	42.2%	Error%*	**3%**

ΔP Assumptions:

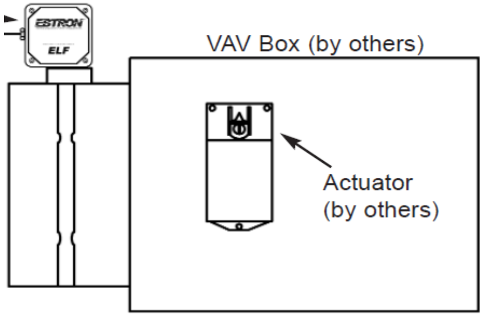
0 error at start-up

0.5% F.S./yr pressure transducer drift

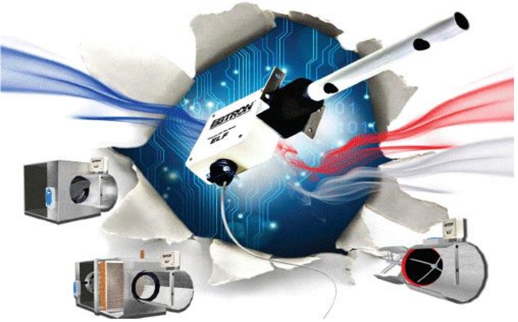
2" w.c. pressure range

k = 2,500 fpm ('amplifying' flow cross)

* >100% Error - Airflow cannot go negative

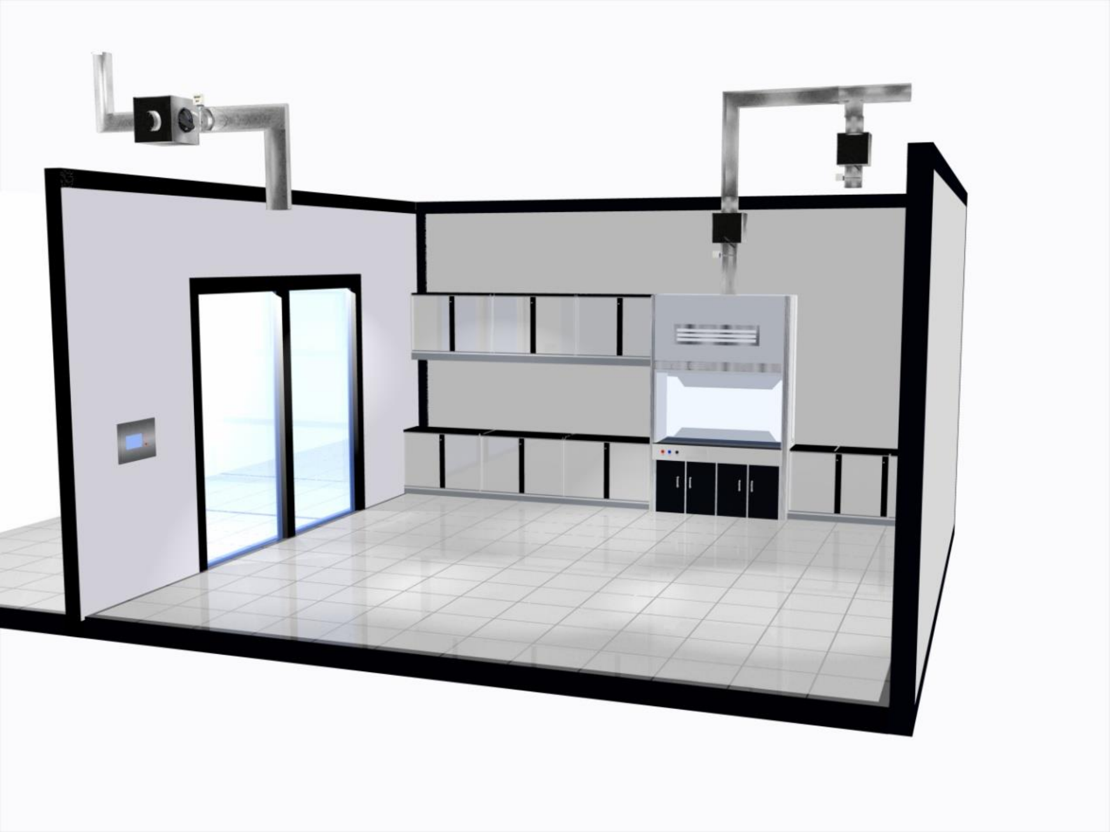


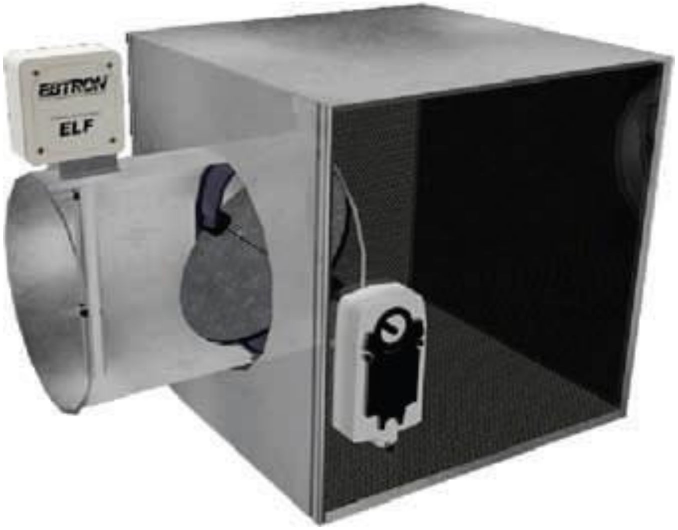
*Ebtron **ELF*** Outperforms Today's VAV Box Airflow Measurement

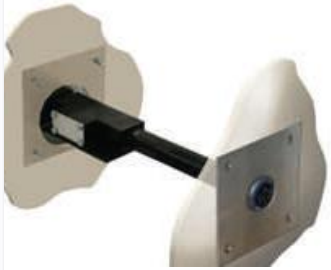


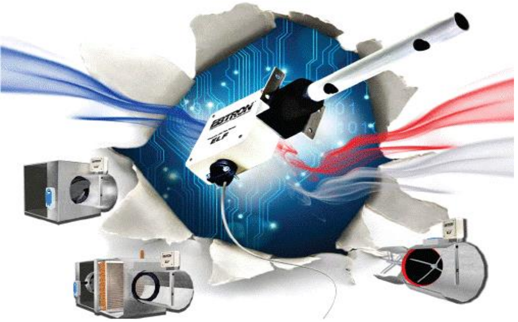
Ebtron ELF: Labs

Engineers take into effect all the factors that can contribute to leakage and specify a differential airflow based on an estimated leakage rate or target for which the airflow rates are adjusted



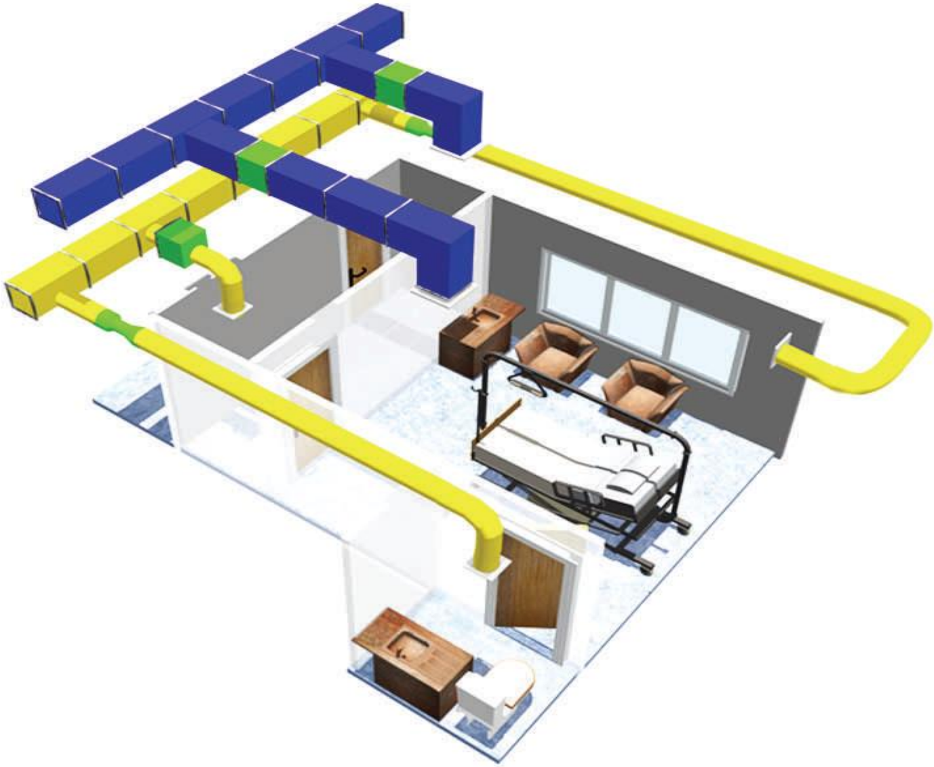






Ebtron ELF: Hospitals

Pressurization is a key factor in controlling room airflow patterns in a health care facility. Engineers take into effect all the factors that can contribute to leakage and
specify a differential airflow based on an estimated leakage rate or target for which the airflow rates are adjusted



Exciting New Alliance!

TWO PREMIERE MANUFACTURERS
ONE EXCEPTIONAL PRODUCT

ADVANCED THERMAL DISPERSION
AIRFLOW MEASUREMENT SYSTEM
AND DAMPER

TAMCO EBTRON

AIR-IQ AIR FLOW MEASUREMENT SOLUTION

TAMCO EBTRON

AIR-IQ AIR FLOW MEASUREMENT SOLUTION

AIR-IQ
SMART-SOLUTION

You provide us with the:

- Opening size
- Damper series
- Mounting application
- Access requirements for probes

We build your unit with the:

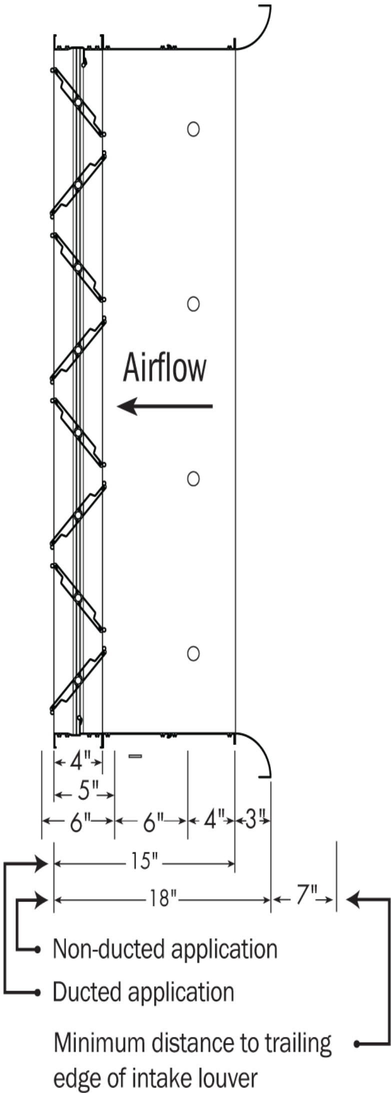
- ✓ Optimal probe sensor density
- ✓ Ideal probe placement
- ✓ Appropriate sleeve style

BENEFITS

- Satisfy ASHRAE 62.1, 189.1 & 90.1
- Obtain LEED points
- Improve indoor air quality
- Save energy
- Reduce maintenance costs

APPLICATION

- Outside air intakes
- Floor return airflow tracking
- AHU return & bypass flow measurement



TAMCO EBTRON

2000 SERIES DAMPERS

SERIES 2100

SERIES 2900

PERFECTLY ADJUSTED AND CALIBRATED

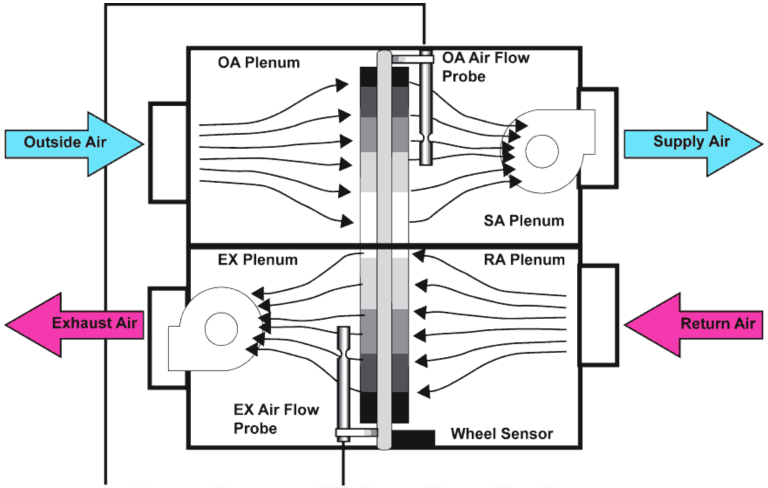
for use in conjunction with
EBTRON Airflow Measuring devices

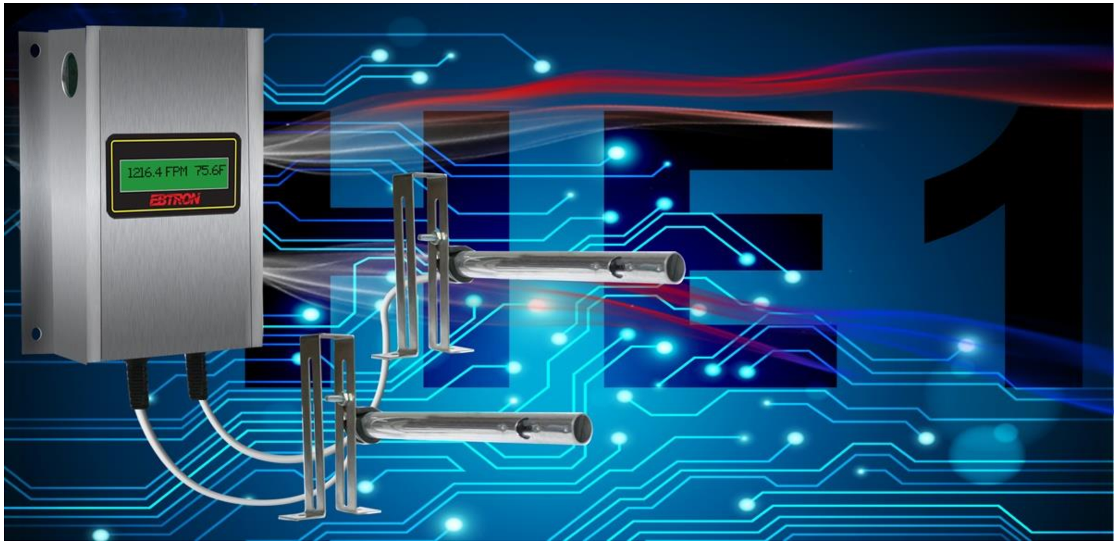
LONG-LASTING AND ACCURATE PERFORMANCE

for fresh air intake and exhaust applications

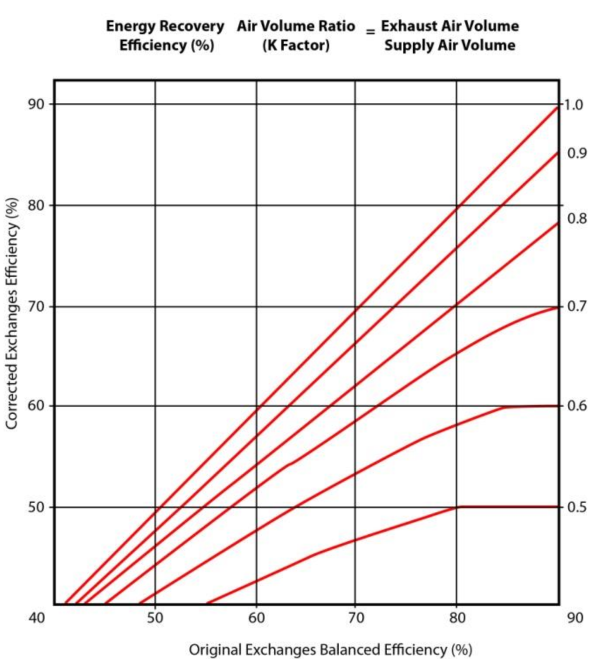
MAINTENANCE-FREE

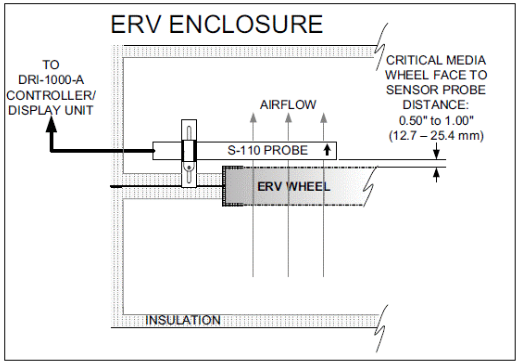
Energy Recovery Ventilation
Air Flow Solutions

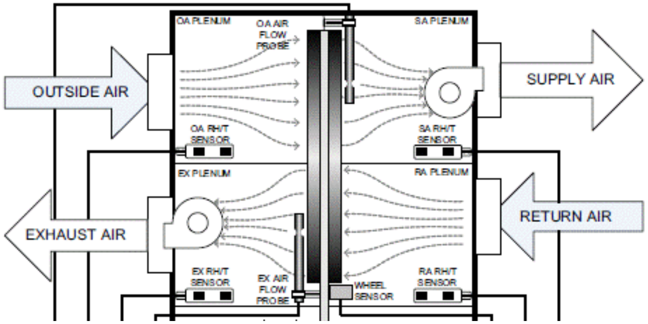




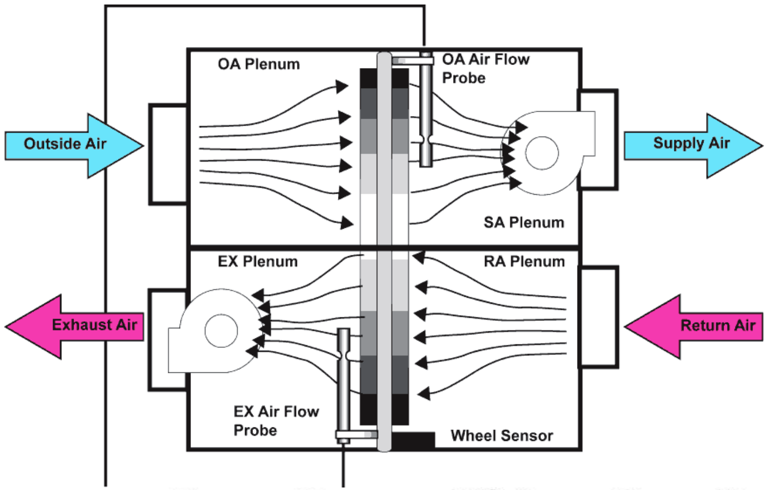
Energy Recovery Efficiency Correction Cure







Energy Recovery Ventilation
Air Flow Solutions



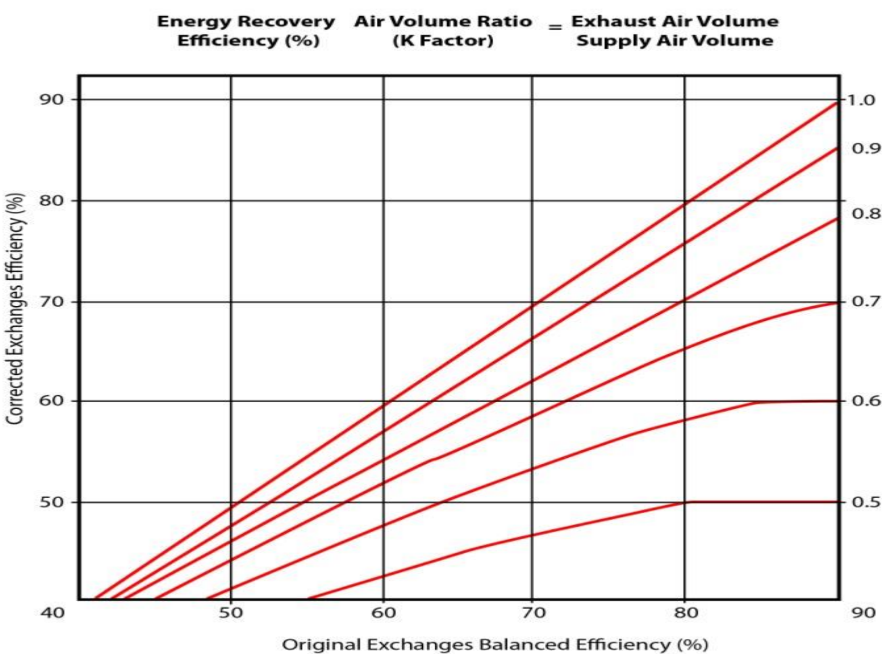
2 Analog Outputs

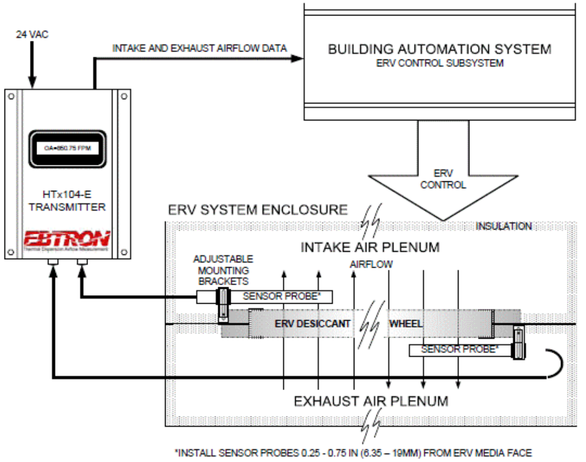
In ERV mode, place a flow probe on each side of the wheel (supply air and exhaust air streams)

Helps solve 2 main issues with HRV's/ERV's

- Setup the airflow balance on each side of the wheel airflow balance is key to wheel efficiency
- Helps to maintain the desired balance (or offset) during the HRV/ERV's life
  - Detects dirty filters
  - Detects clogged wheels

Energy Recovery Efficiency Correction Cure



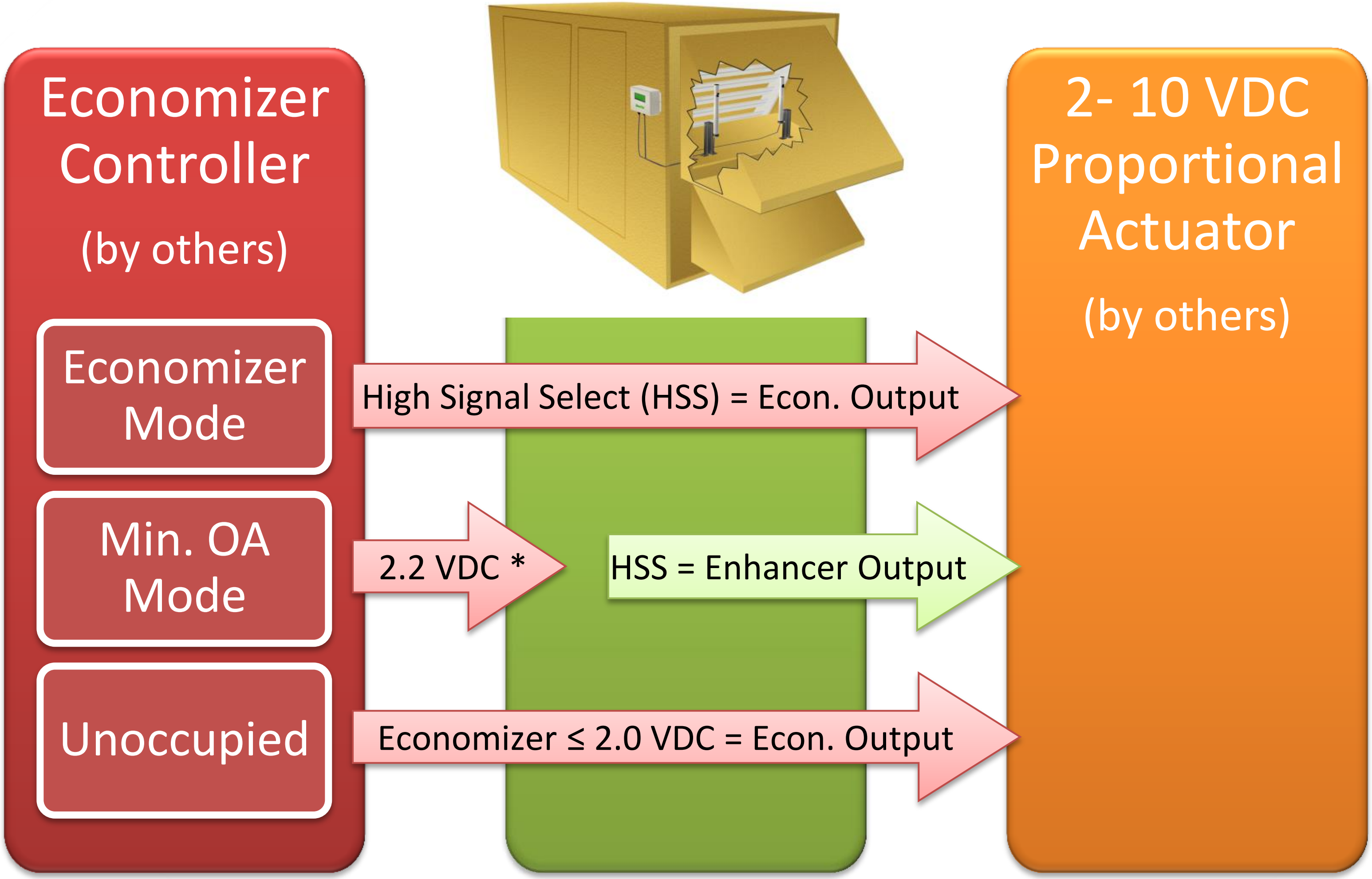


*INSTALL SENSOR PROBES 0.25 - 0.75 IN (6.35 – 19MM) FROM ERV MEDIA FACE

Economical Airflow Measurement

- Universal insertion and stand-off mount
- Ideal for small rooftop unit OA measurement (in hood or ducts)
- Perfect for ERVs
- Can be applied in most classroom unit ventilators
- T probe compatible (ELF with display)
- Two analog output signals
- Contact closure alarm


MAIN MENU
STATUS
Shows current operating conditions
DATA
HISTORY
IN/OUTPUTS
FACTORY
NETWORK
ADV. STATUS
RUNTIMES
SETUP
INSTALLATION
TEST & BALANCE
INTEGRATION
SERVICE
TEST
REPLACE
REPORT
S/W UPDATE
OFFLINE
SETTINGS
CONTROL
RTU OPTIONS
INSTALL
GENERAL
Use these features for maintenance, setup, and service
LENNOX
PRODIGY
Use solid green arrows to navigate menu
Press any button to start display
DATA SETUP SERVICE SETTINGS
HELP
MAIN MENU
MAIN MENU
SHOW STATUS
>DATA
SETUP
SCROLL
BACK
SAVE
SELECT
Adjust and set values
BACnet
LENNOX
S-BUS
THERMOSTAT
SENSOR
OUTPUTS
INPUTS
COM
24VAC



Economizer Controller

(by others)

Economizer Mode

Min. OA Mode

Unoccupied

High Signal Select (HSS) = Econ. Output

2.2 VDC *

HSS = Enhancer Output

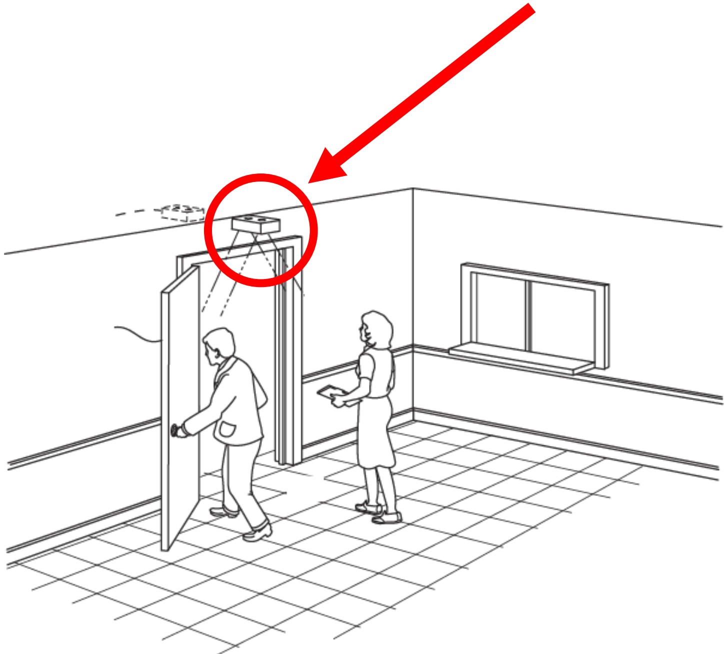
Economizer ≤ 2.0 VDC = Econ. Output

2- 10 VDC Proportional Actuator

(by others)

CENSus®

BACnet/Analog Room Occupancy (ie People) Counter



- IR-based device to count people as they enter & exit a room
- First release is for interior single zones (ie classroom or movie theater) with one or two doors
- Combine with the outdoor airflow measurement for real-time DCV
- Result: Energy Savings with DCV that meets the 'Spirit & Letter' of the building codes and standards

Now Available for Single Rooms

Looking for BETA Test Sites!

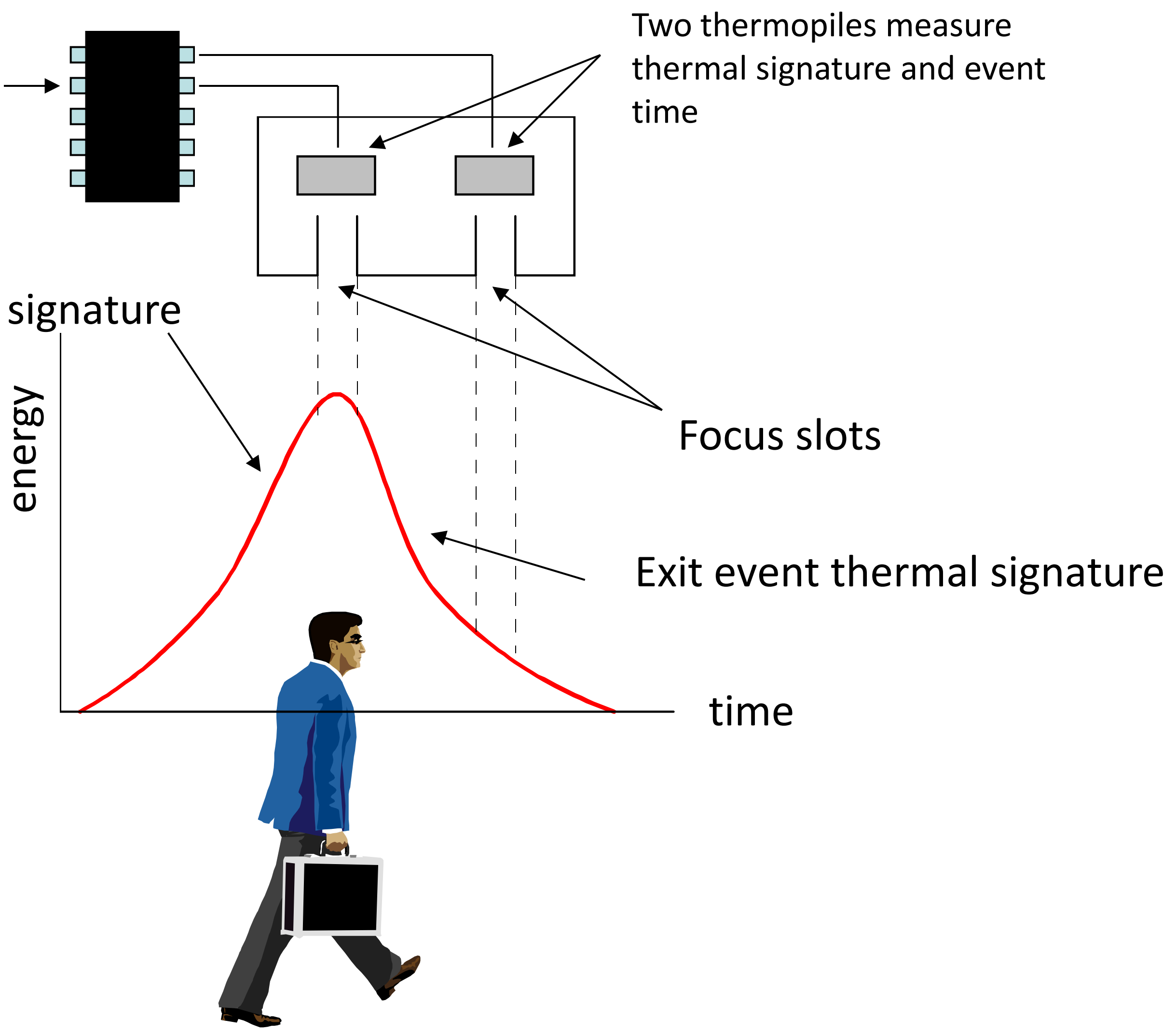
CENSus®

Application Criteria

- Designed for spaces with a design of 15 or more occupants.
- Doors/Openings must meet specific criteria (first version).
  - 36” width maximum
  - 7 ft. height maximum (other heights are being evaluated)
  - Door must open away from counter (limits applications if counter is in high traffic hallway).
  - Door closers must not cross the plane of the sensors.
- Requires door mounted sensor.
  - First release will be for single doors.
  - Not recommended to replace occupancy sensors for lighting control.

CENSus®

How it works



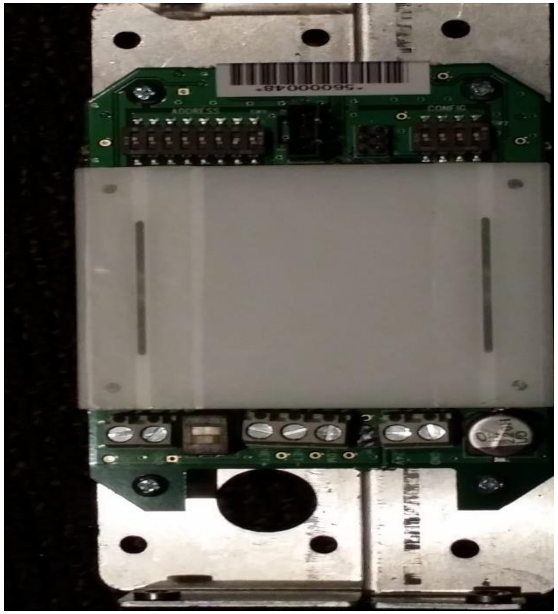
A high speed microprocessor with ADC processes signals in real-time

Two thermopiles measure thermal signature and event time

Entry event thermal signature

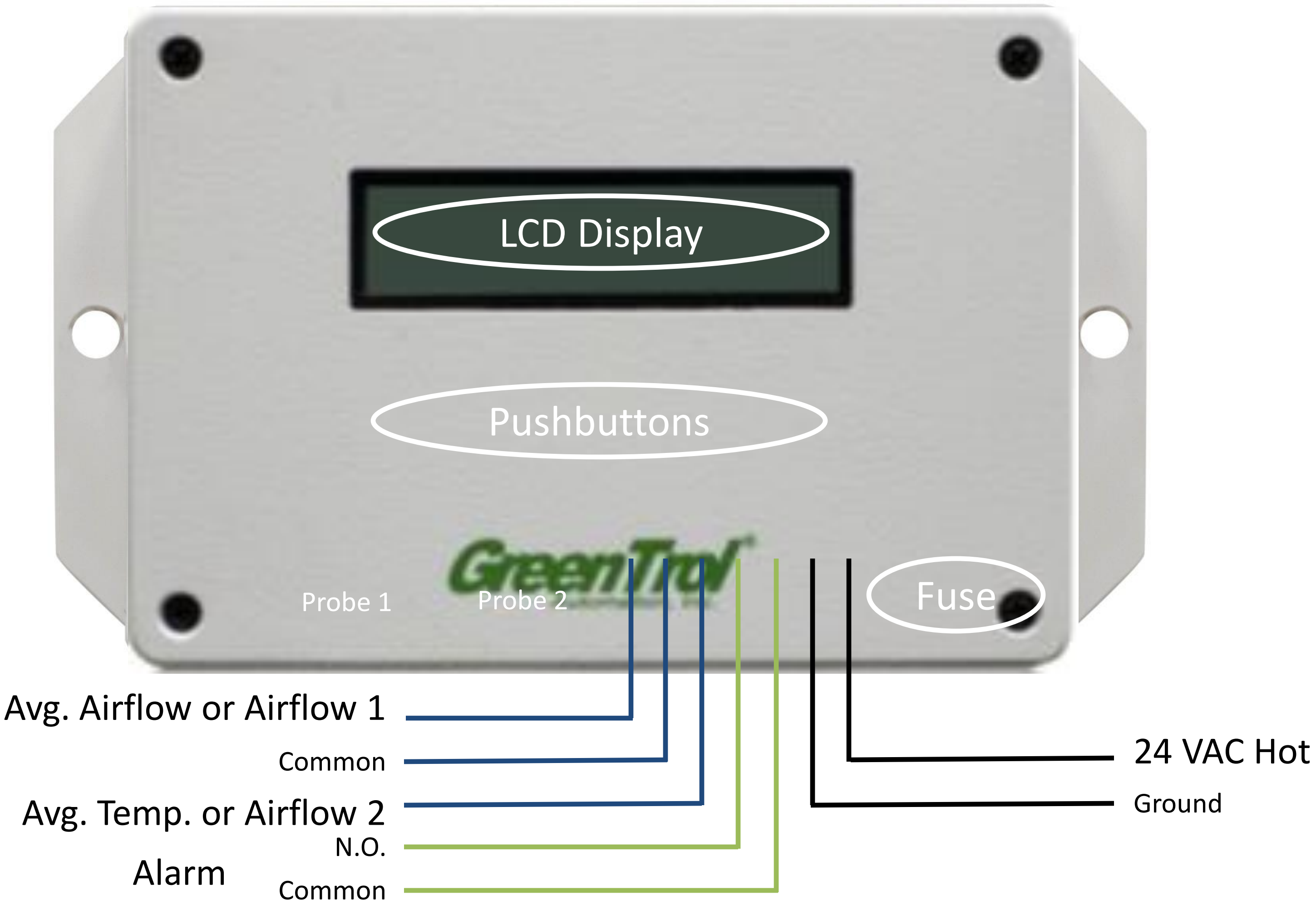
Focus slots

Exit event thermal signature



Airflow Transmitters

GF-A2000 (accepts up to 2 probes & 2 total sensors)



Alarms and Bridges

ALRT-200

ALRT-100

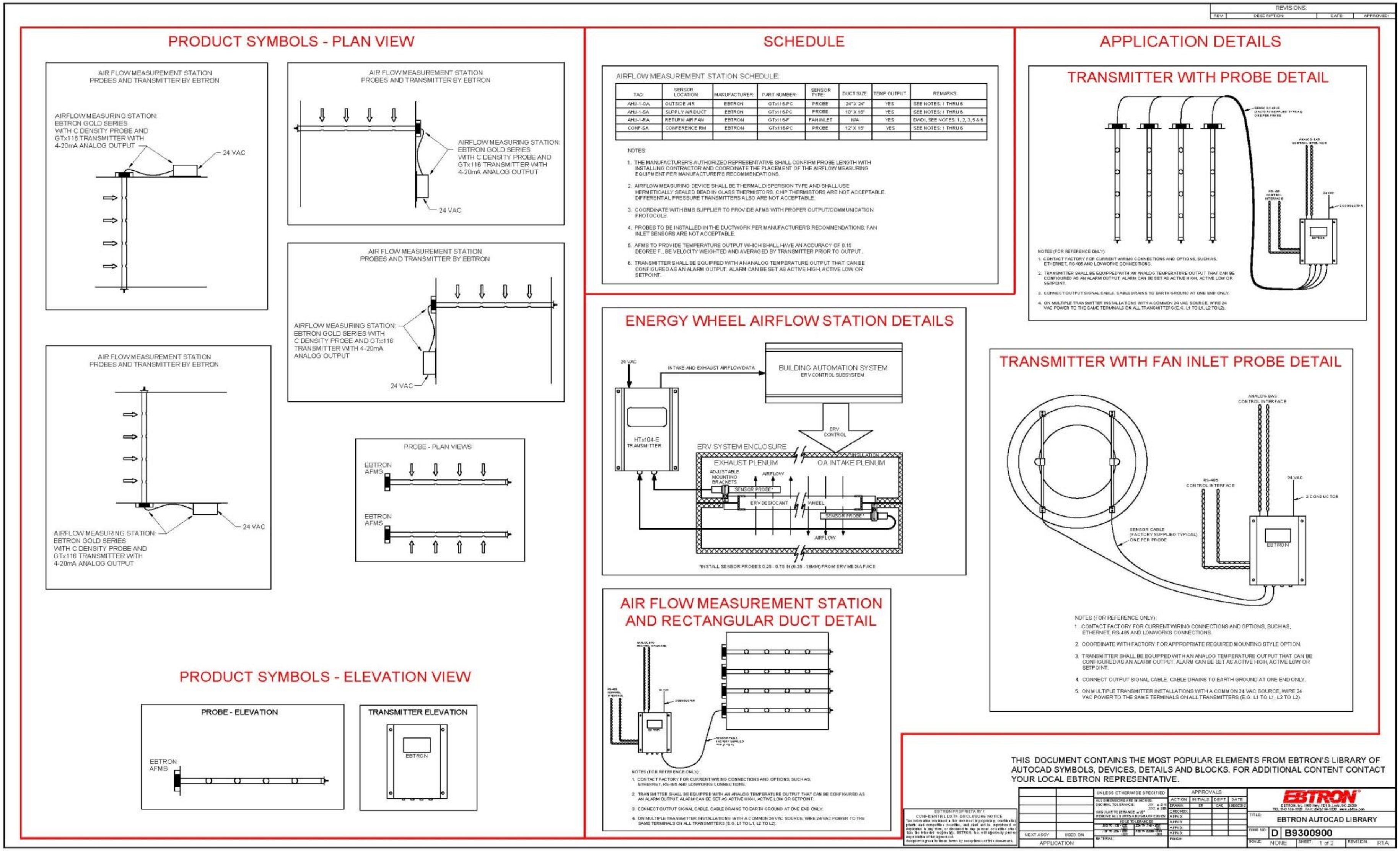
ALRT-200

- Programmable remote display
- Visible and contact closure alarm
- Analog to RS-485 bridge (BACnet and Modbus)

ALRT-100

- Visible (LED) and contact closure alarm accepts 0-10 or 4-20 mA signal

AutoCAD Library



PRODUCT SYMBOLS - PLAN VIEW

PRODUCT SYMBOLS - ELEVATION VIEW

SCHEDULE

AIRFLOW MEASUREMENT STATION SCHEDULE:

TAG:	SENSOR LOCATION:	MANUFACTURER:	PART NUMBER:	SENSOR TYPE:	DUCT SIZE:	TEMP OUTPUT:	REMARKS:
AHU-1-OA	OUTSIDE AIR	EBTRON	GTx116-PC	PROBE	24" X 24"	YES	SEE NOTES: 1 THRU 6
AHU-1-SA	SUPPLY AIR DUCT	EBTRON	GTx116-PC	PROBE	10" X 16"	YES	SEE NOTES: 1 THRU 6
AHU-1-RA	RETURN AIR FAN	EBTRON	GTx116-F	FAN INLET	N/A	YES	DWDI, SEE NOTES: 1, 2, 3, 5 & 6
CONF-SA	CONFERENCE RM	EBTRON	GTx116-PC	PROBE	12" X 16"	YES	SEE NOTES: 1 THRU 6

NOTES:

1. THE MANUFACTURER'S AUTHORIZED REPRESENTATIVE SHALL CONFIRM PROBE LENGTH WITH INSTALLING CONTRACTOR AND COORDINATE THE PLACEMENT OF THE AIRFLOW MEASURING EQUIPMENT PER MANUFACTURER'S RECOMMENDATIONS.
2. AIRFLOW MEASURING DEVICE SHALL BE THERMAL DISPERSION TYPE AND SHALL USE HERMETICALLY SEALED BEAD IN GLASS THERMISTORS. CHIP THERMISTORS ARE NOT ACCEPTABLE. DIFFERENTIAL PRESSURE TRANSMITTERS ALSO ARE NOT ACCEPTABLE.
3. COORDINATE WITH BMS SUPPLIER TO PROVIDE AFMS WITH PROPER OUTPUT/COMMUNICATION PROTOCOLS.
4. PROBES TO BE INSTALLED IN THE DUCTWORK PER MANUFACTURER'S RECOMMENDATIONS; FAN INLET SENSORS ARE NOT ACCEPTABLE.
5. AFMS TO PROVIDE TEMPERATURE OUTPUT WHICH SHALL HAVE AN ACCURACY OF 0.15 DEGREE F., BE VELOCITY WEIGHTED AND AVERAGED BY TRANSMITTER PRIOR TO OUTPUT.
6. TRANSMITTER SHALL BE EQUIPPED WITH AN ANALOG TEMPERATURE OUTPUT THAT CAN BE CONFIGURED AS AN ALARM OUTPUT. ALARM CAN BE SET AS ACTIVE HIGH, ACTIVE LOW OR SETPOINT.

ENERGY WHEEL AIRFLOW STATION DETAILS

*INSTALL SENSOR PROBES 0.25 - 0.75 IN (6.35 - 19MM) FROM ERV MEDIA FACE

AIR FLOW MEASUREMENT STATION AND RECTANGULAR DUCT DETAIL

NOTES (FOR REFERENCE ONLY):

1. CONTACT FACTORY FOR CURRENT WIRING CONNECTIONS AND OPTIONS, SUCH AS, ETHERNET, RS-485 AND LONWORKS CONNECTIONS.
2. TRANSMITTER SHALL BE EQUIPPED WITH AN ANALOG TEMPERATURE OUTPUT THAT CAN BE CONFIGURED AS AN ALARM OUTPUT. ALARM CAN BE SET AS ACTIVE HIGH, ACTIVE LOW OR SETPOINT.
3. CONNECT OUTPUT SIGNAL CABLE. CABLE DRAINS TO EARTH GROUND AT ONE END ONLY.
4. ON MULTIPLE TRANSMITTER INSTALLATIONS WITH A COMMON 24 VAC SOURCE, WIRE 24 VAC POWER TO THE SAME TERMINALS ON ALL TRANSMITTERS (E.G. L1 TO L1, L2 TO L2).

APPLICATION DETAILS

TRANSMITTER WITH PROBE DETAIL

NOTES (FOR REFERENCE ONLY):

1. CONTACT FACTORY FOR CURRENT WIRING CONNECTIONS AND OPTIONS, SUCH AS, ETHERNET, RS-485 AND LONWORKS CONNECTIONS.
2. TRANSMITTER SHALL BE EQUIPPED WITH AN ANALOG TEMPERATURE OUTPUT THAT CAN BE CONFIGURED AS AN ALARM OUTPUT. ALARM CAN BE SET AS ACTIVE HIGH, ACTIVE LOW OR SETPOINT.
3. CONNECT OUTPUT SIGNAL CABLE. CABLE DRAINS TO EARTH GROUND AT ONE END ONLY.
4. ON MULTIPLE TRANSMITTER INSTALLATIONS WITH A COMMON 24 VAC SOURCE, WIRE 24 VAC POWER TO THE SAME TERMINALS ON ALL TRANSMITTERS (E.G. L1 TO L1, L2 TO L2).

TRANSMITTER WITH FAN INLET PROBE DETAIL

NOTES (FOR REFERENCE ONLY):

1. CONTACT FACTORY FOR CURRENT WIRING CONNECTIONS AND OPTIONS, SUCH AS, ETHERNET, RS-485 AND LONWORKS CONNECTIONS.
2. COORDINATE WITH FACTORY FOR APPROPRIATE REQUIRED MOUNTING STYLE OPTION.
3. TRANSMITTER SHALL BE EQUIPPED WITH AN ANALOG TEMPERATURE OUTPUT THAT CAN BE CONFIGURED AS AN ALARM OUTPUT. ALARM CAN BE SET AS ACTIVE HIGH, ACTIVE LOW OR SETPOINT.
4. CONNECT OUTPUT SIGNAL CABLE. CABLE DRAINS TO EARTH GROUND AT ONE END ONLY.
5. ON MULTIPLE TRANSMITTER INSTALLATIONS WITH A COMMON 24 VAC SOURCE, WIRE 24 VAC POWER TO THE SAME TERMINALS ON ALL TRANSMITTERS (E.G. L1 TO L1, L2 TO L2).

THIS DOCUMENT CONTAINS THE MOST POPULAR ELEMENTS FROM EBTRON'S LIBRARY OF AUTOCAD SYMBOLS, DEVICES, DETAILS AND BLOCKS. FOR ADDITIONAL CONTENT CONTACT YOUR LOCAL EBTRON REPRESENTATIVE.

EBTRON PROPRIETARY / CONFIDENTIAL DATA DISCLOSURE NOTICE

NEXT ASSY
USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES.
DECIMAL TOLERANCE:
ANGULAR TOLERANCE ±1/2°
REMOVE ALL BURRS AND SHARP EDGES
HOLE TOLERANCES
MATERIAL:

APPROVALS

ACTION	INITIALS	DEPT	DATE
DRAWN:	ER	CAD	12/06/2012
CHECKED:			
APP'VD:			
APP'VD:			
APP'VD:			
APP'VD:			

FINISH:

EBTRON

TITLE: EBTRON AUTOCAD LIBRARY
DWG NO: D B9300900
SCALE: NONE
SHEET: 1 of 2
REVISION: R1A

EBTRON Presents...

BRING - A - GUEST 2015

The Myrtle Beach Seminar for IEQ

UP TO 9 PDH CREDITS

Expanded Format

Also qualifies for [illegible]

(for qualifying states)

2015 Seminar Dates:

- May 14th to 16th
- September 10th to 12th
- October 22nd to 24th

Arrive: Thursday afternoon
Depart: Saturday evening or Sunday

EBTRON®
a measurable difference!

Agenda

I. Why Measure & Control Outdoor Air Delivery?

II. Analyze Alternatives:
   A. Fixed Outdoor Air Damper Position ≠ Control
   B. Supply Air – Return Air ≠ Outdoor Air

III. Outdoor Airflow Control Improves CO2-based Ventilation Control Systems

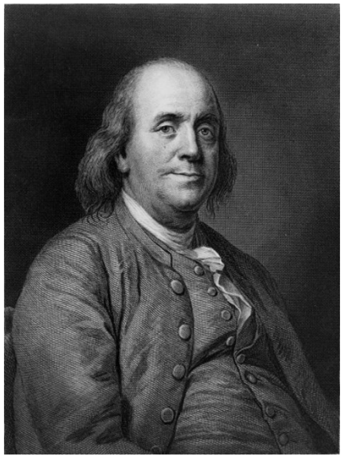
IV. Outdoor Air Delivery Design Guidelines

V. Selecting Outdoor Airflow Monitors

VI. Applying for LEED 2009 IEQ Credit 1, Outdoor Air Delivery Monitoring

Benefits of Measuring and Controlling Outdoor Air Intakes

Proper Ventilation Helps Ensure a Comfortable, Healthy, & Productive Indoor Environment



Benjamin Franklin

On Fresh Air, 1785

" I considered (fresh air) as an enemy and closed with extreme care every crevice in the rooms I inhabited.

Experience has convinced me of my error. I now look upon fresh air as a friend. I even sleep with an open window.

I am persuaded that no common air from without, is so unwholesome as the air within a close(d) room that has been often breathed and not changed."

Letter from Benjamin Franklin to Dr. Ingenhaus physician to the emperor in Vienna

Quote found in Real Estate Law (Thomson/Southwestern) Jennings, 2008 & 2005: pg 229, Chapter 10: Commercial Leases: Condition of the Premises – The Sick Building Syndrome

Ventilation Standards and Codes

- ASHRAE 62.1, Ventilation for Acceptable IAQ
  - Designers must choose compliance under one procedure from Section 6.
    - Ventilation Rate Procedure
      - A prescriptive, **ventilation rate based** procedure that specifies breathing zone outside airflow rates based on space type/application, population and floor area.
      - Typically selected by engineers and owners
    - Indoor Air Quality Procedure
      - A subjective procedure, often requiring expensive and sophisticated monitoring equipment.
      - Not all contaminants of concern may be recognized or monitored, thus exposing occupants to risk.
      - Not recognized by LEED 2009 for Mechanically Ventilated Systems!

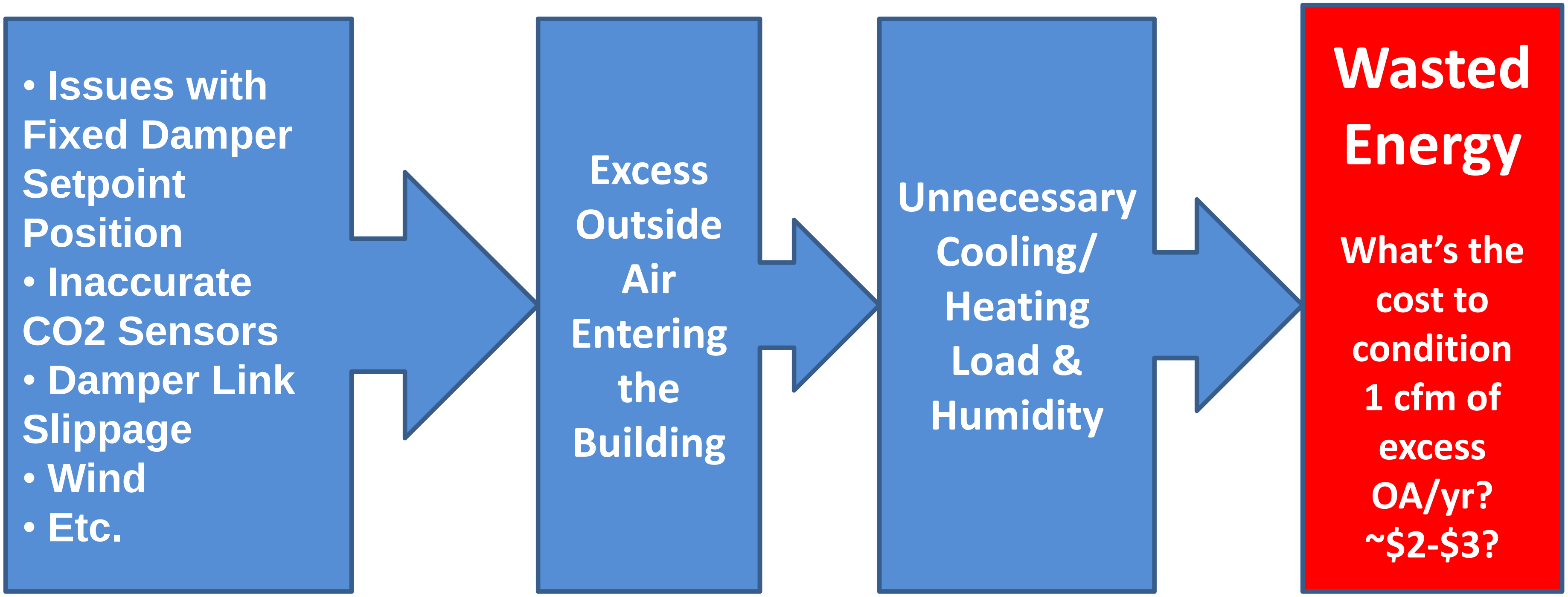
Ventilation Standards and Codes

- International Mechanical Code (IMC)
  - Strict compliance with the ventilation rate procedure (VRP) of ASHRAE 62.1
    - Current version has adopted 62.1
    - IMC does not recognize the 62.1’s IAQ Procedure
    - Most, if not all, jurisdictions reference older versions of IMC
      - Prior to 2004, IMC’s ventilation standard only included the per person ventilation portion and did not include the per ft^2 ventilation rate
      - Presents a conflict for designers since older versions reference the standard prior to 2004. Ventilation rates were calculated differently at that time.

Controlling Outdoor Air Intakes Ensures Compliance to Ventilation Codes and Standards

- Measurement & Verification provides documented proof of compliance
- Cannot control what is not measured
- Outdoor Air Delivery *Monitoring* is required or recommended by:
  - ASHRAE 62.1 in VAV Systems
  - LEED 2009
  - Local Statutes like Minnesota 123B.71 – Schools
  - ASHRAE 189.1

Controlling Outdoor Air Intakes Prevents Wasted Energy Caused by Over-Ventilation



- Issues with Fixed Damper Setpoint Position
- Inaccurate CO2 Sensors
- Damper Link Slippage
- Wind
- Etc.

Excess Outside Air Entering the Building

Unnecessary Cooling/ Heating Load & Humidity

Wasted Energy

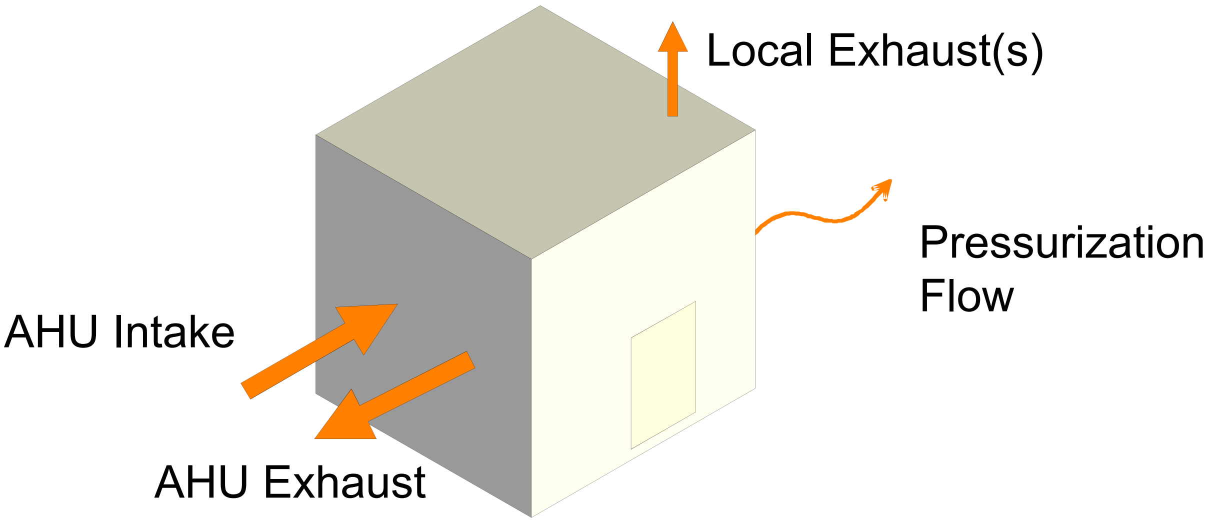
What's the cost to condition 1 cfm of excess OA/yr? ~$2-$3?

Bringing in more outside air than predicted costs $'s

300 cfm of extra outdoor air can cost $600-$900 or more per year!

Outdoor Air Delivery is the Key to Maintaining Building Pressurization

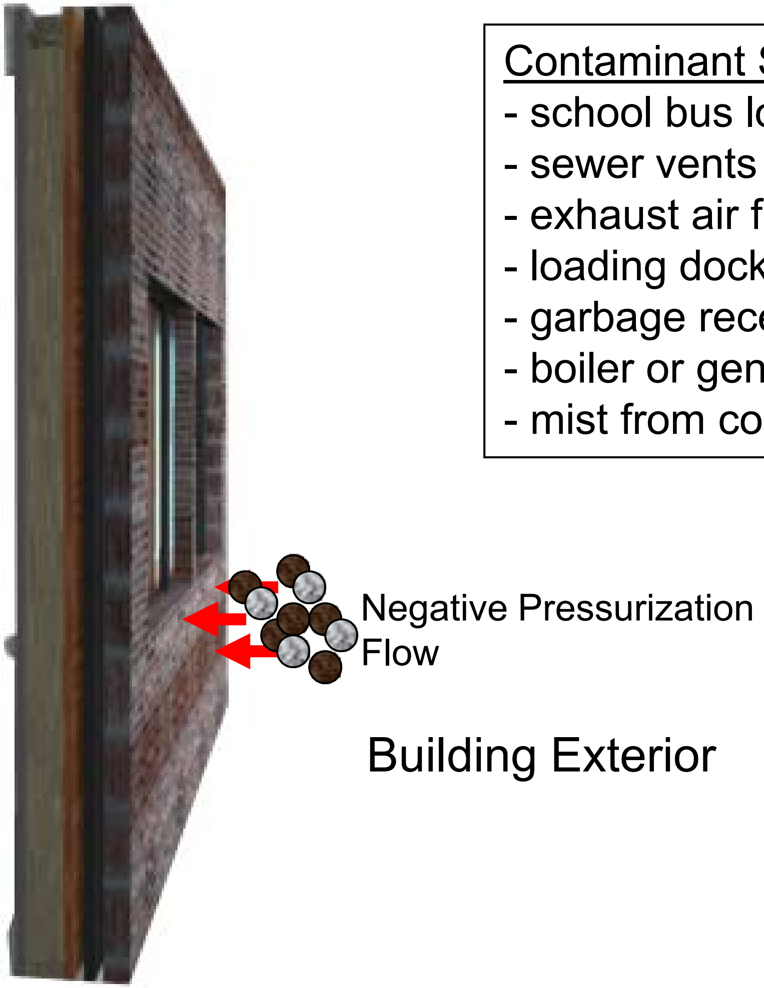
- Pressurization Flow – Delivering more outside air into the building than is being exhausted
- Only the mechanical ventilation system can pressurize your building



Net Building Pressure = Pressurization Flow = In - Out

Control Building Pressure to Reduce Contaminants

Negatively pressurized buildings use the building envelope as the first stage of filtration!



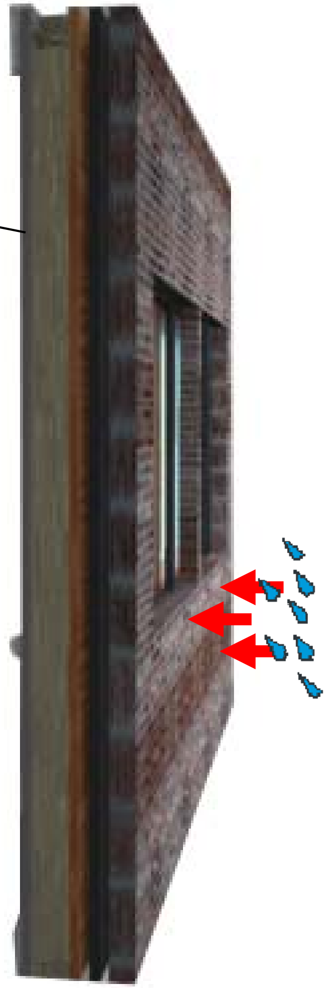
Building Interior

Building Exterior

Contaminant Sources:
- school bus loading areas
- sewer vents
- exhaust air from the school
- loading docks
- garbage receptacles
- boiler or generator exhausts
- mist from cooling towers

Control Building Pressure to Reduce Mold

Mold growth may occur in negatively pressurized buildings when the outside air dew point is greater than 65 ^{0}F



Elevated humidity levels approach saturation within the building envelope and promote mold growth

Negative Pressurization Flow

Building Interior

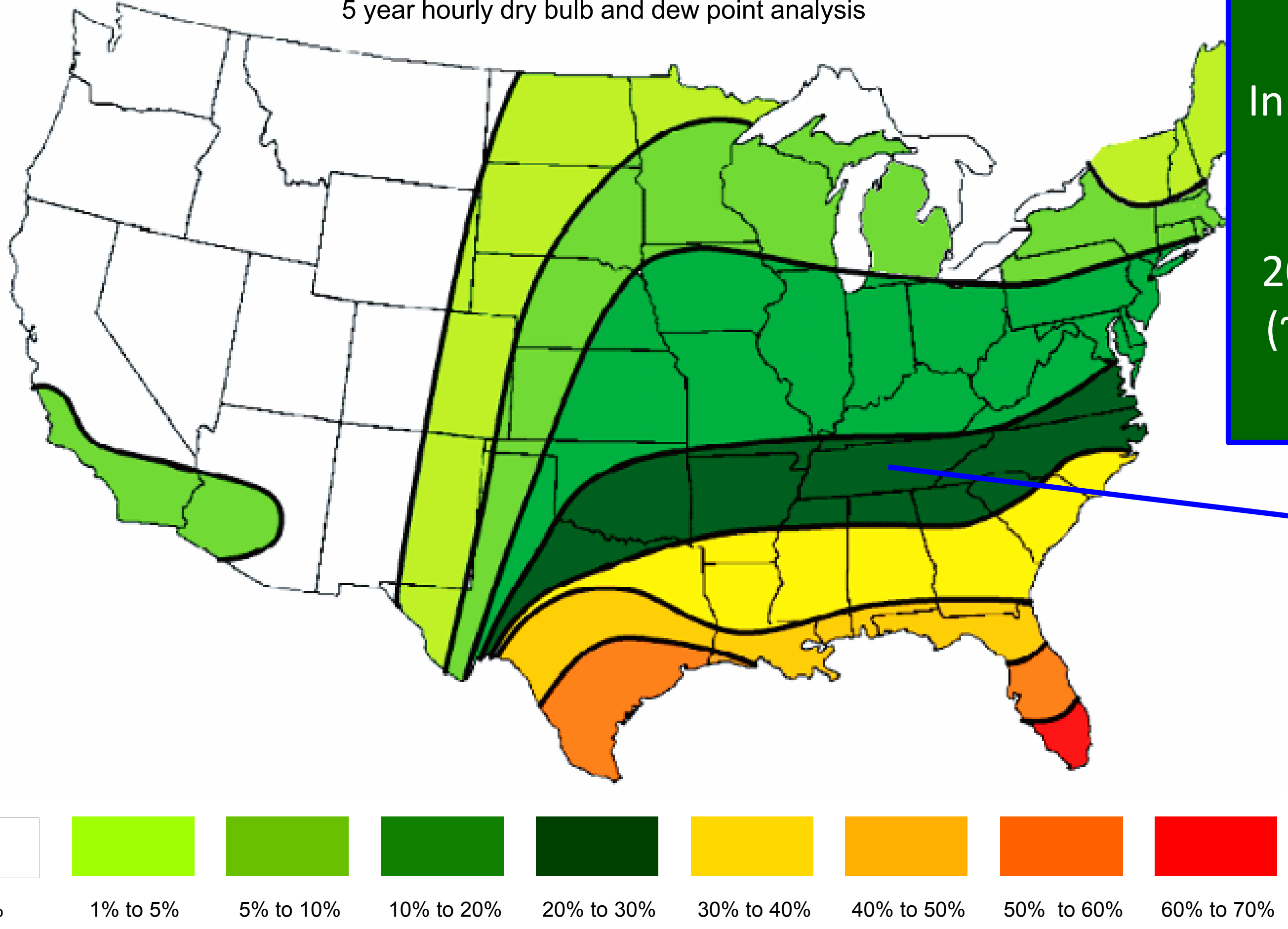
Building Exterior

Control Building Pressure to Reduce Mold

Mold Growth Potential

Percentage of time that the envelope humidity can exceed 70%*

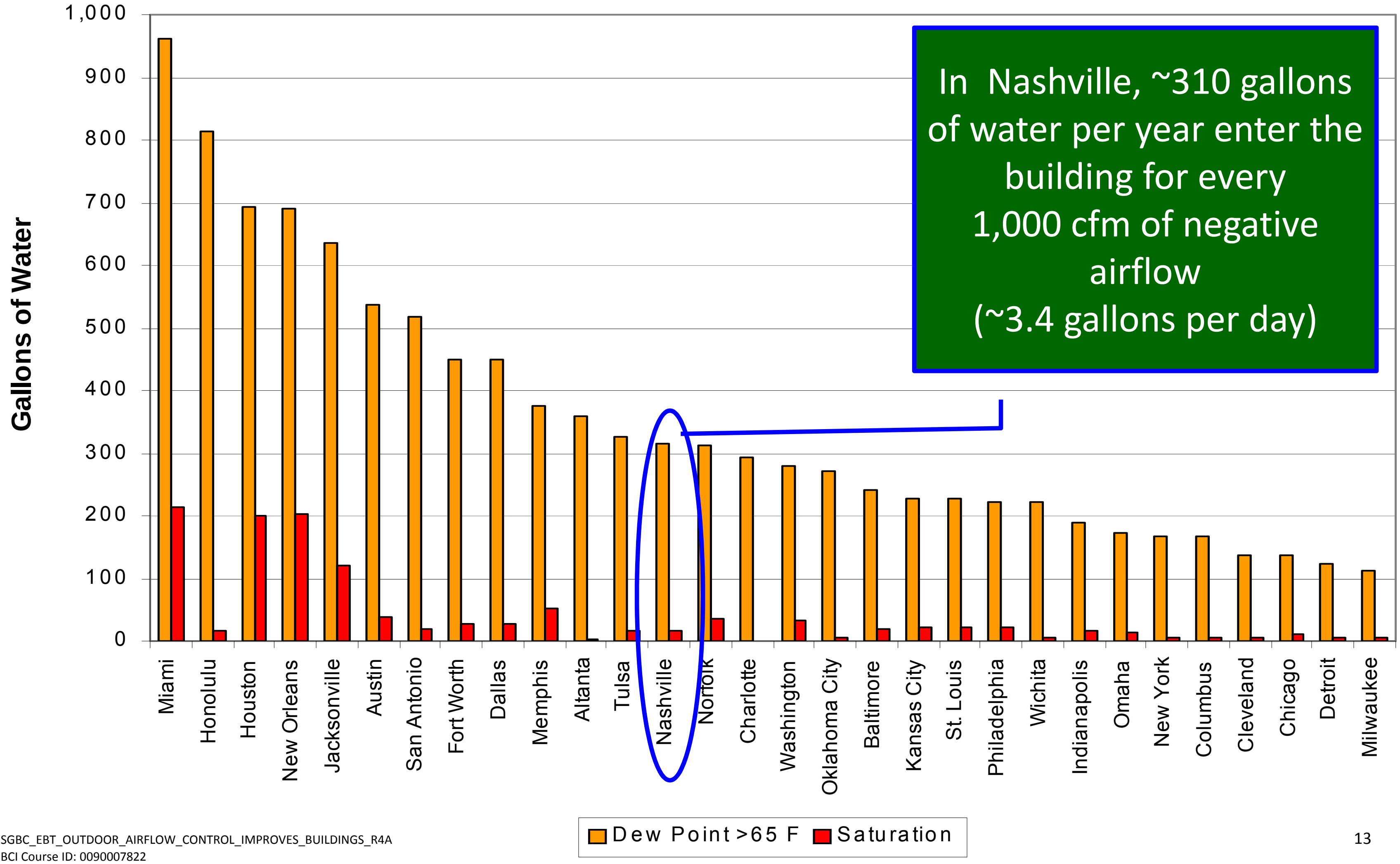
5 year hourly dry bulb and dew point analysis



In TN, Conditions are Favorable for Mold Growth 20-30% of the Time (~91 days per year)

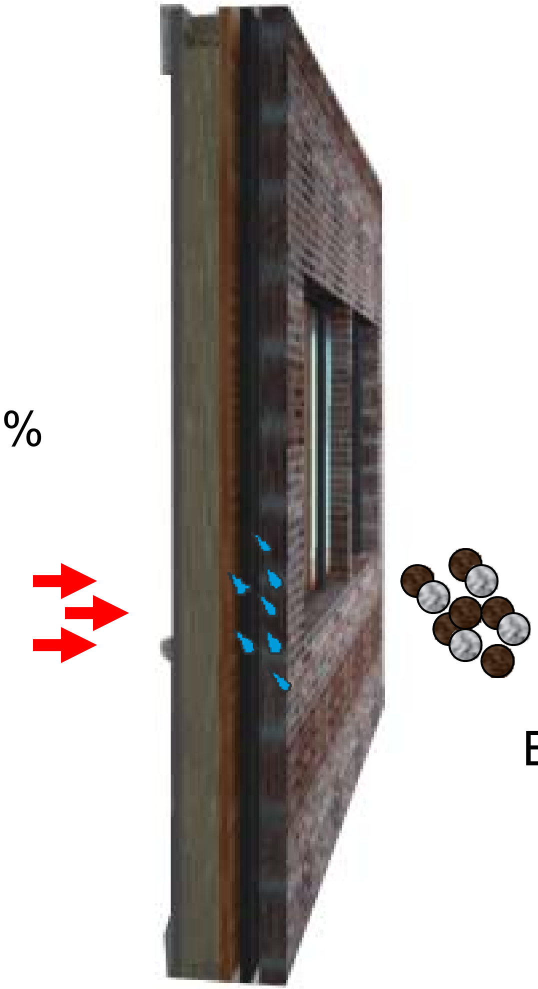
* Based on an indoor temperature of 74 F and an outdoor dew point >= 65 F
Data provided to EBTRON courtesy of the Forecast Institute, Inc.

Annual Gallons of Water Transported Across the Building Envelope for every 1,000 CFM of Negative Airflow
First 30 of top 50 US Cities by Population (2000 Census)



In Nashville, ~310 gallons of water per year enter the building for every 1,000 cfm of negative airflow (~3.4 gallons per day)

Building Pressure Is Key to Indoor Environment Quality



Net Positive Building Pressure
will result in a
Net Drying Effect
when outside dew points are elevated
& help prevent infiltration of OA contaminants

Relative Humidity << 60%

Building Interior

Building Exterior

Recommendation: Keep Building NET POSITIVE

Outdoor Air Control Helps Meet the Intent of LEED 2009: Better Performing Buildings

Prerequisite or Credit	Description	NC	SCHOOLS	CS
EA Prerequisite 1	Fundamental Commissioning	Required	Required	Required
EA Prerequisite 2	Minimum Energy Performance	Required	Required	Required
EA Credit 1	Optimize Energy Performance	1-19 points	1-19 points	3-21 points
EA Credit 3	Enhanced Commissioning	2 points	2 points	2 points
EA Credit 5	Measurement and Verification	3 points	2 points	NA
IEQ Prerequisite 1	Minimum IAQ Performance	Required	Required	Required
IEQ Prerequisite 2	ETS (tobacco smoke) Control	Required	Required	Required
IEQ Prerequisite 3	Minimum Acoustical Performance	NA	Required	NA
IEQ Credit 1	**Outdoor Air Delivery Monitoring**	**1 Point**	**1 Point**	**1 Point**
IEQ Credit 2	Increased Ventilation	1 Point	1 Point	1 Point
IEQ Credit 3/3.1	Construction Management Plan (constr.)	1 Point	1 Point	1 Point
IEQ Credit 3.2	Construction Management Plan (occup.)	1 Point	1 Point	NA
IEQ Credit 6.2	Controllability of Systems - Thermal	1 Point	1 Point	1 Point
IEQ Credit 7/7.1	Thermal Comfort - Design	1 Point	1 Point	1 Point
IEQ Credit 7.2	Thermal Comfort - Verification	1 Point	1 Point	NA
IEQ Credit 9	Enhanced Acoustical Performance	NA	1 Point	NA
IEQ Credit 10	Mold Prevention	NA	1 Point	NA
ID Credit 1	Innovation in Design	1-5 points	1-4 points	1-5 points

LEED 2009, IEQ Credit 1

Outdoor Air Delivery Monitoring

	NC	SCHOOLS	CS
Credit	IEQ Credit 1	IEQ Credit 1	IEQ Credit 1
Points	1 Point	1 Point	1 Point

Intent: To provide capability for ventilation system monitoring to help promote occupant health and well-being.

Requirement: Generate an alarm via either the BAS to the building operator or a visible or audible alert to the building occupants when values are more than +/-10% of design.

MECHANICALLY VENTILATED SYSTEMS

Low Occupant Density Spaces (under 25 people per 1,000 sq.ft.)

– When 20% of more of the design supply airflow serves non-densely occupied spaces, provide a ***direct*** outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow rate with an accuracy of +/-15% of reading.

High Occupant Density Spaces (> 25 people per 1,000 sq.ft.)

– Provide a CO_2 device within all high occupant density spaces.

Standard 189.1-2009

8.3.1.2 Outdoor Air Delivery Monitoring

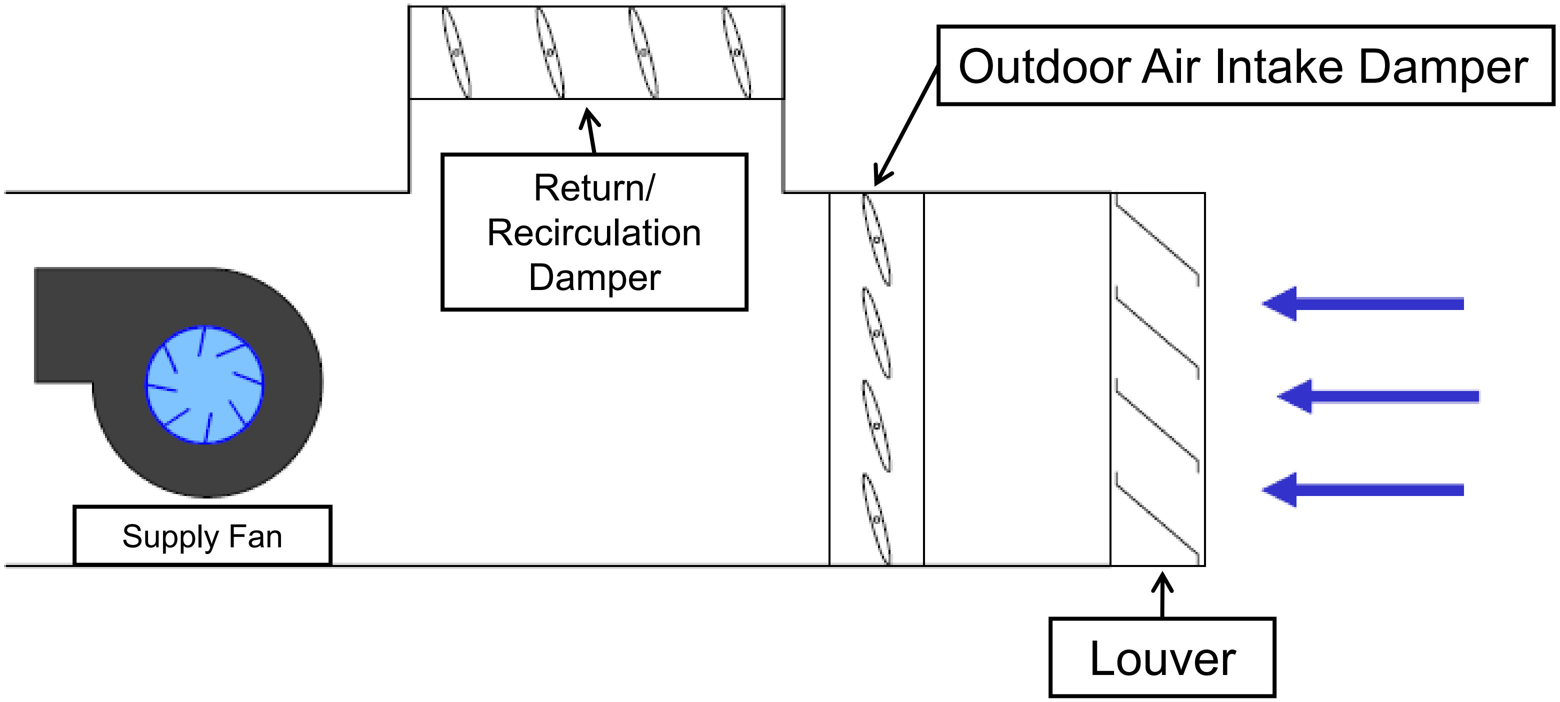
8.3.1.2.1 Spaces Ventilated by Mechanical Sys**tems.**
A permanently mounted, *direct total outdoor airflow measurement device* shall be provided that is capable of measuring the system *minimum outdoor airflow rate*. The device shall be capable of measuring flow within an accuracy of ±15% of the *minimum outdoor airflow rate*. The device shall also be capable of being used to alarm the building operator or for sending a signal to a building central monitoring system when flow rates are not in compliance.

Exception: Constant volume air supply systems that use a damper position feedback system are not required to have a direct total outdoor airflow measurement device.

Fixed
Outdoor Air
Damper Position
≠
Control

What is 'Fixed Outdoor Air Damper Position'?

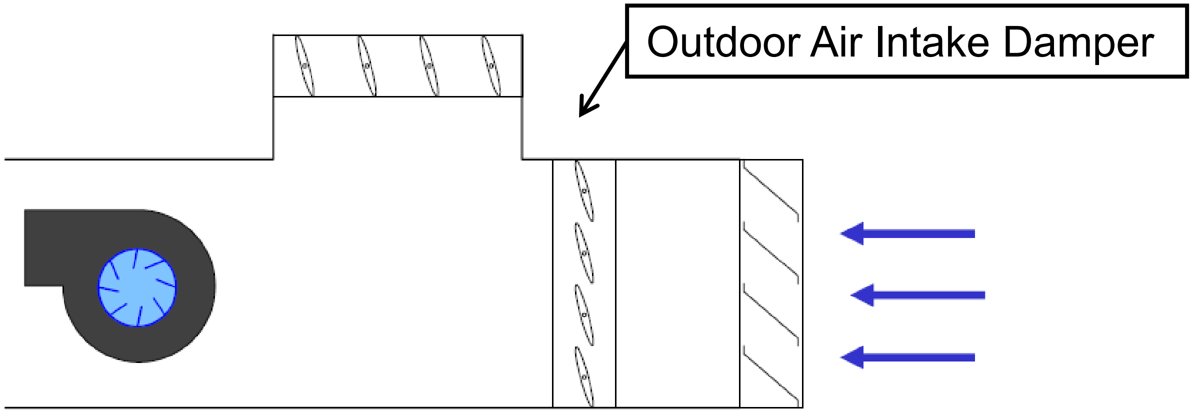
- During 'Occupied Mode', the Outdoor Air Intake Damper goes to a pre-determined '% Open'
- This method of 'control' is unfortunately used by an overwhelming majority of new and existing buildings



Fixed Damper Position ≠ Control

Fixed Damper Setpoint Position is:

- Determined by ‘Test And Balance’ during initial commissioning
- Based on the minimum design airflow (i.e. building codes or ASHRAE 62.1)
- ‘% Open’ kept throughout the building’s life
- Rarely ever re-checked (i.e. retro-commissioned)



Fixed Damper Position ≠ Control

Sources of Outdoor Air Intake Uncertainty with Fixed Damper Position

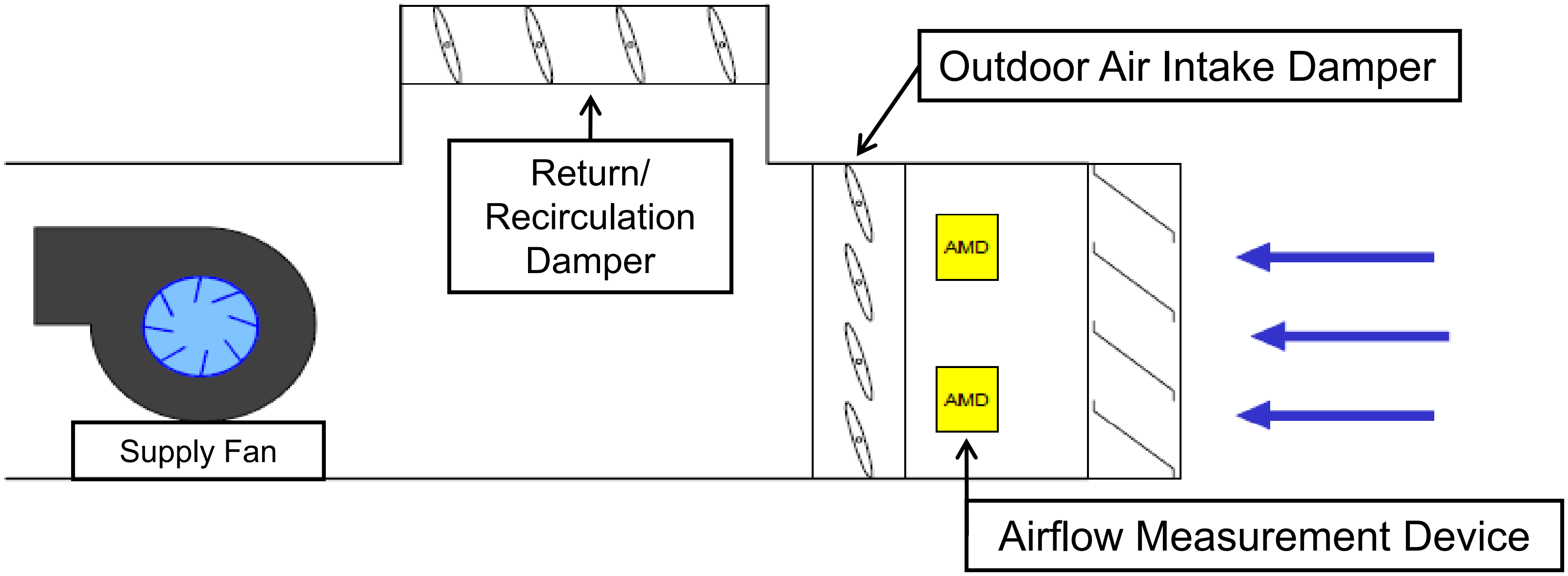
- Damper Hysteresis
  - Damper/Actuators don’t always go back to the exact same position
- Wind Effect
- Stack Pressure
- Conditions at Time of Commissioning

Damper Hysteresis Test:
Damper ‘Position’ ≠ Desired Airflow

Step 1: A ‘Fixed Damper Position’ (15% open) was selected and the resulting airflow was recorded. This airflow will be the target (shown as 100% on the chart)

Step 2: Damper was moved fully open, then back to the damper setpoint position (15%) and the airflow measurement was taken (shown in red on the next slide)

Step 3: Damper was closed. Then, moved back to the damper setpoint position (15%) and the airflow measurement was taken (shown in blue on the next slide)



Outdoor Air Intake Damper

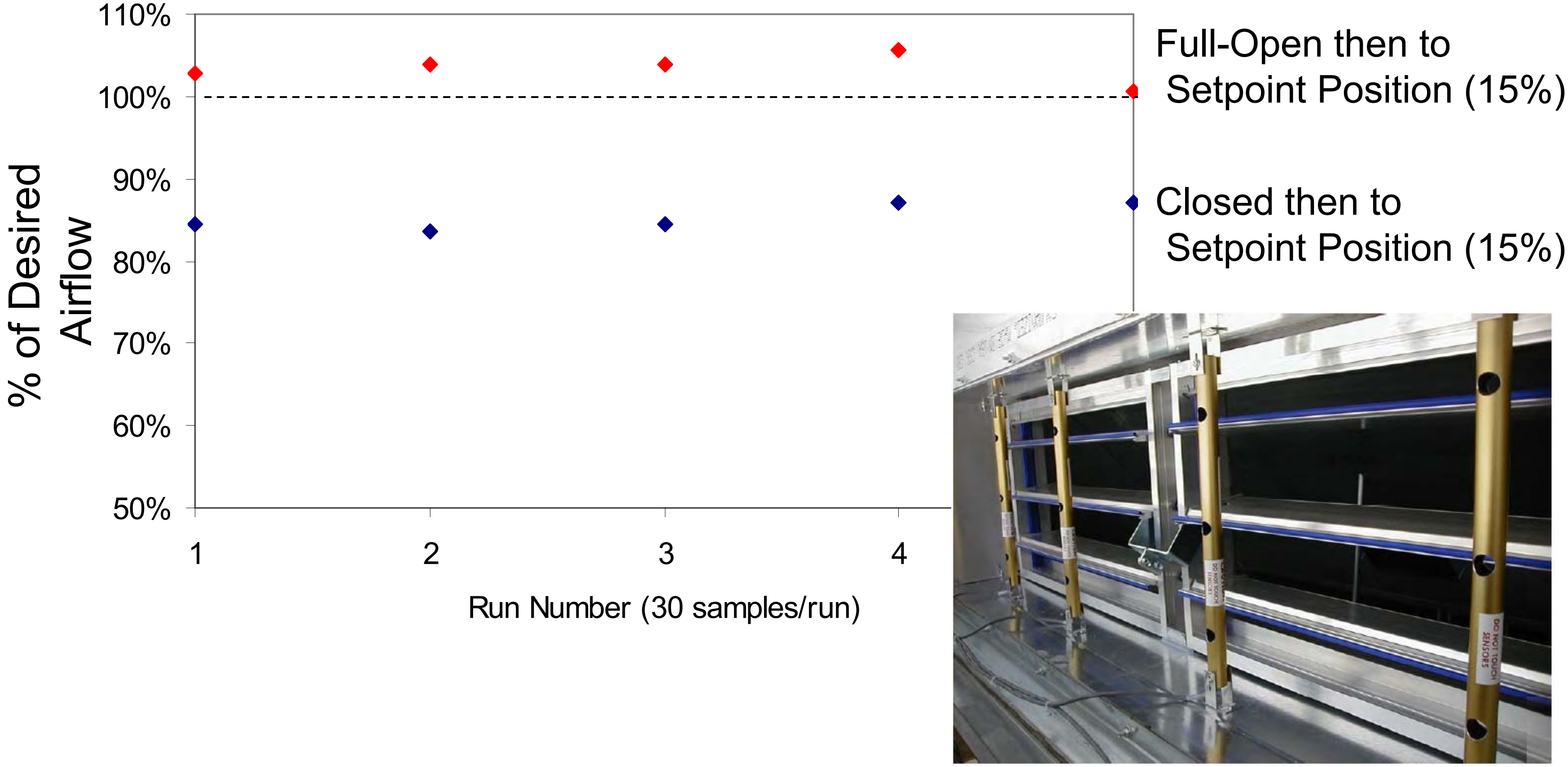
Return/
Recirculation
Damper

Supply Fan

Airflow Measurement Device

Damper Hysteresis Test Results: Position ≠ Desired Airflow

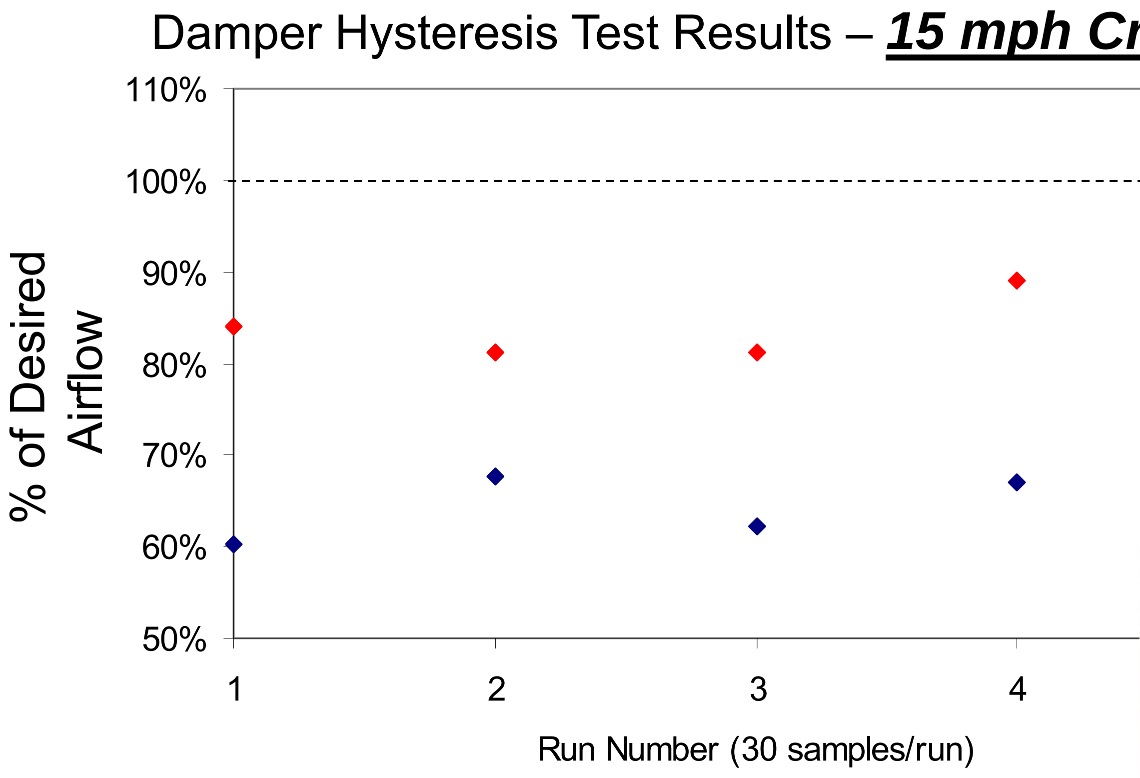
Damper Hysteresis Test Results – ***Still Air***



-Damper/Actuators don’t always return to the exact desired position

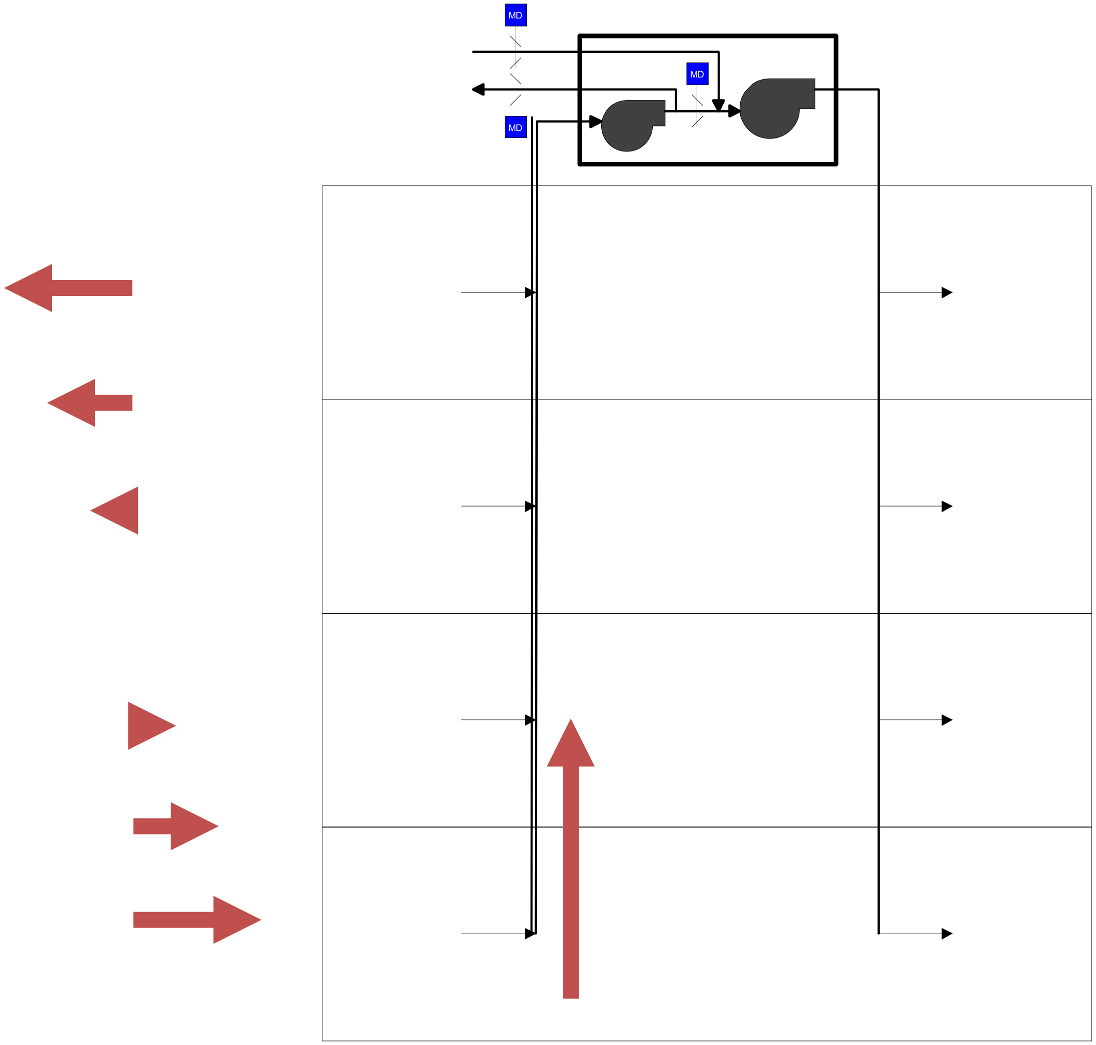
-What is the airflow on Day 2 of operation (ie after the damper is closed at night)?

Wind Effects Outdoor Air Intakes



What if the wind blows directly at the damper?

Stack Pressure Effects Outdoor Air Intakes



Stack Effect in Winter

Warm air in the building rises pushing out on the outdoor air damper

Question:

Will a damper setpoint position selected in the winter be valid in the summer?

Fixed Damper Position ≠ Control

Damper Setpoint Position Depends on Conditions at Time of Commissioning

What is wind speed?

What is the wind direction?

What is the indoor temperature?

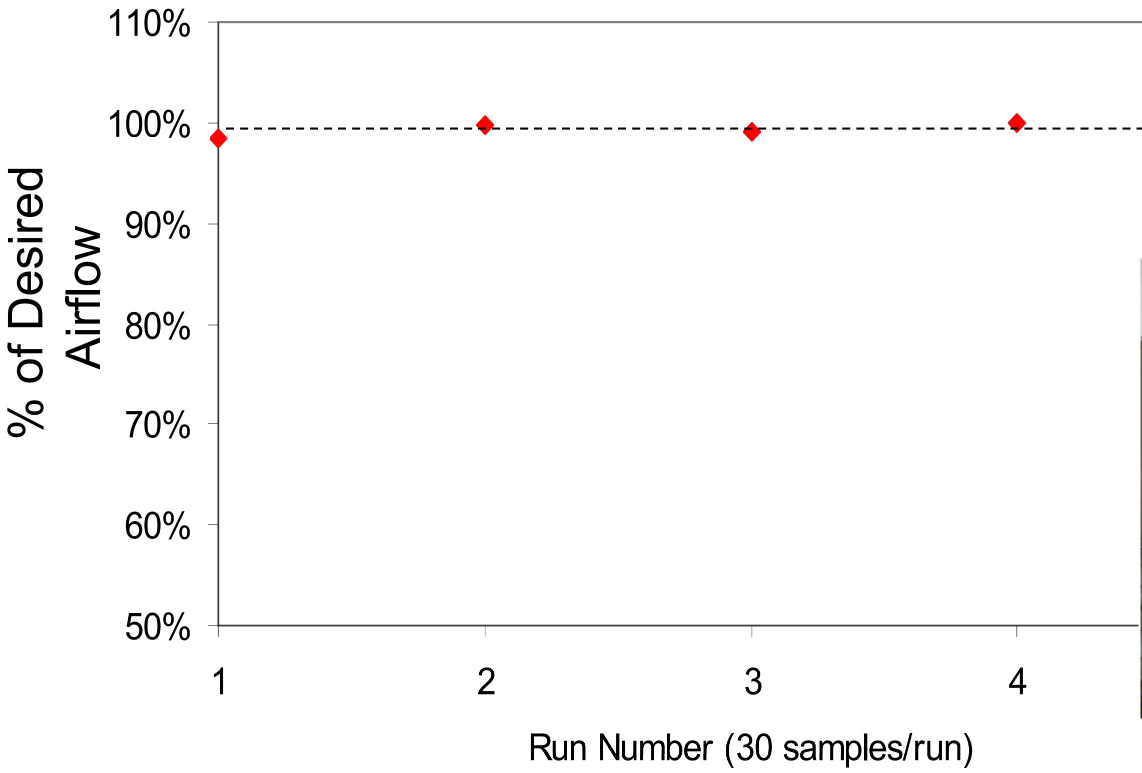
What is the outdoor temperature?

What is the damper hysteresis effect?

Solution:

Control Outdoor Intakes With Airflow Monitors

Damper Under Active Control - Light & Variable Wind



Requires Accurate & Stable Airflow Measurement

Why Measure OA
when
Measuring SA & RA?

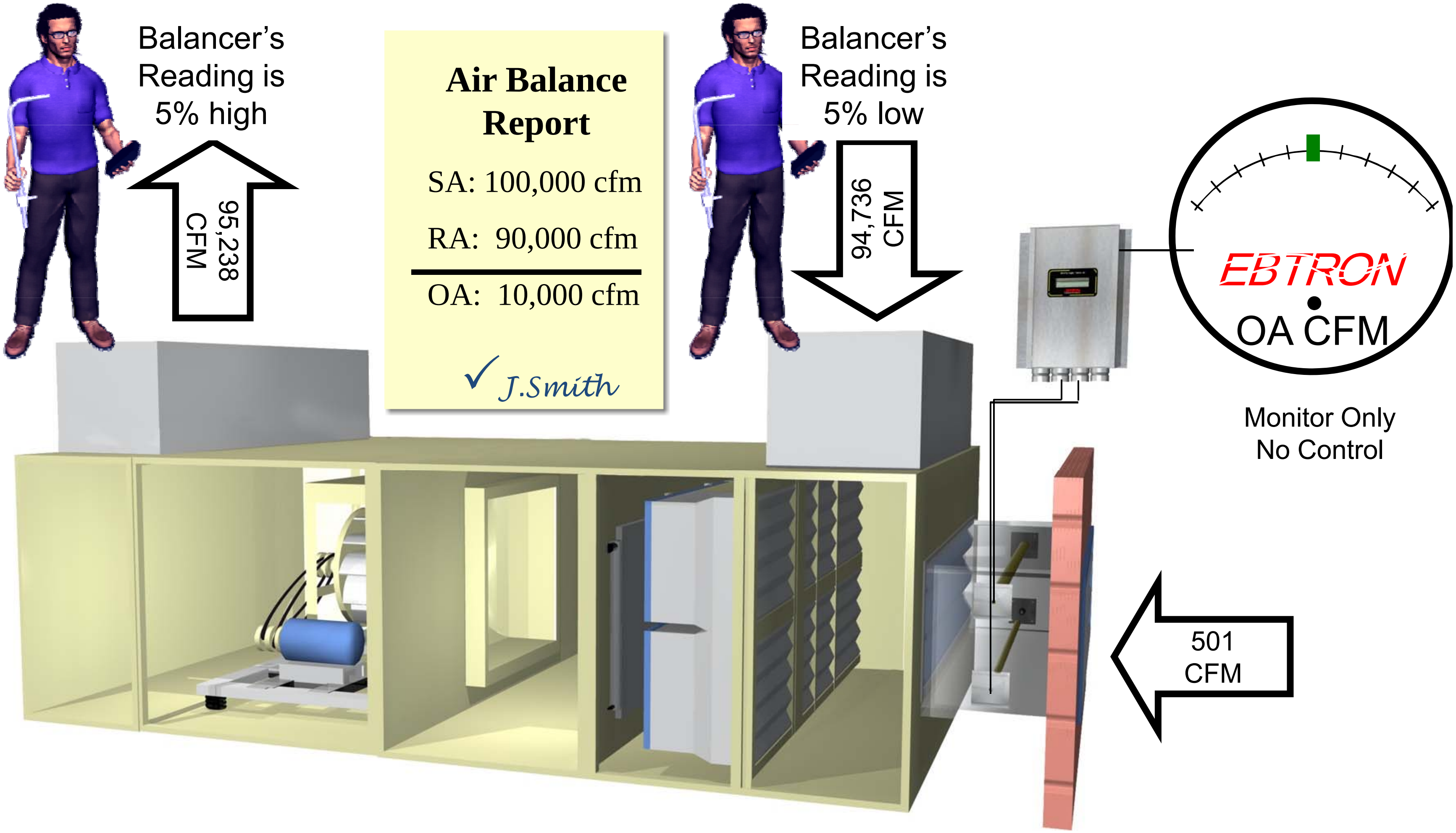
Supply Air – Return Air ≠ Outdoor Air

- LEED 2009 IEQ-1 and ASHRAE 189.1 say to:

*‘Provide a **Direct** Outdoor Airflow Measurement Device’*

- Numerous systems assume that SA-RA = OA, so OA is calculated, not measured
- Small errors in the SA or RA measurements result in large OA calculation error (see the following example)

Directly Measure Outdoor Air Even When Measuring Supply & Return Airflows



Balancer's
Reading is
5% high

95,238
CFM

Air Balance Report

SA: 100,000 cfm

RA: 90,000 cfm

OA: 10,000 cfm

✓ J.Smith

Balancer's
Reading is
5% low

94,736
CFM

EBTRON

OA CFM

Monitor Only
No Control

501
CFM

- SA – RA = OA uses the difference between two large airflows to calculate OA
- Small errors in measure SA & RA lead to large errors when calculating OA

Overcome Issues with CO2-based Ventilation Control Using Outdoor Air Delivery Monitoring & Control

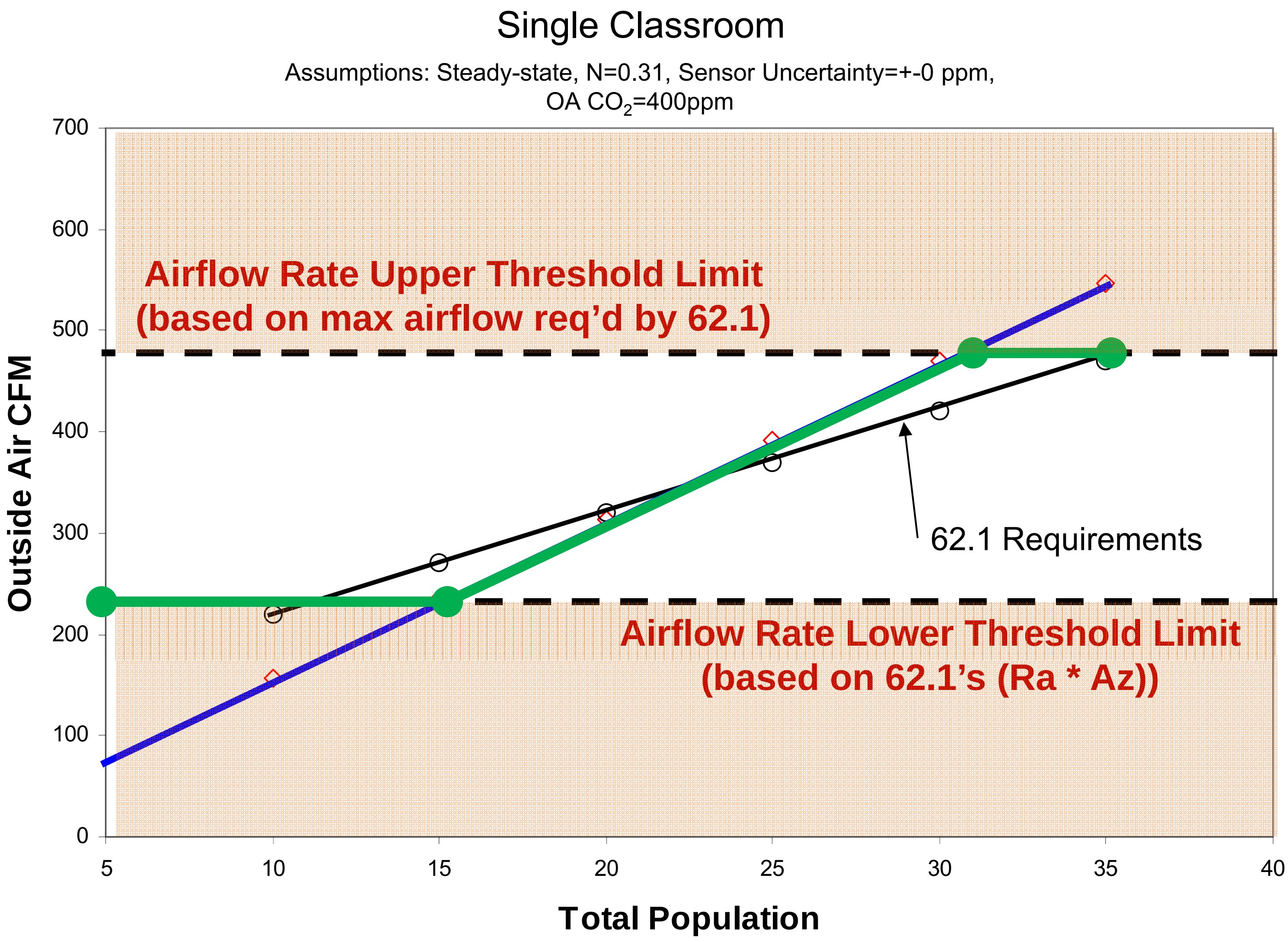
2 Issues with CO2-based Ventilation Control

- Always want enough outdoor air entering the building during occupied mode to maintain building pressurization
  - CO2 readings only indicate per person ventilation rates

$$V_{bz} = R_p \cdot P_z + \boxed{R_a \cdot A_z}$$

- Never want to bring in more outdoor air than desired
  - Inaccurate or ‘drifting’ CO2 sensors may ask for more than necessary outdoor air

Use Airflow Monitors to put 'Bounds' on CO2-based DCV's Airflow Adjustments



Outdoor Air Control Design Guidelines

Outside Air Intake Guidelines

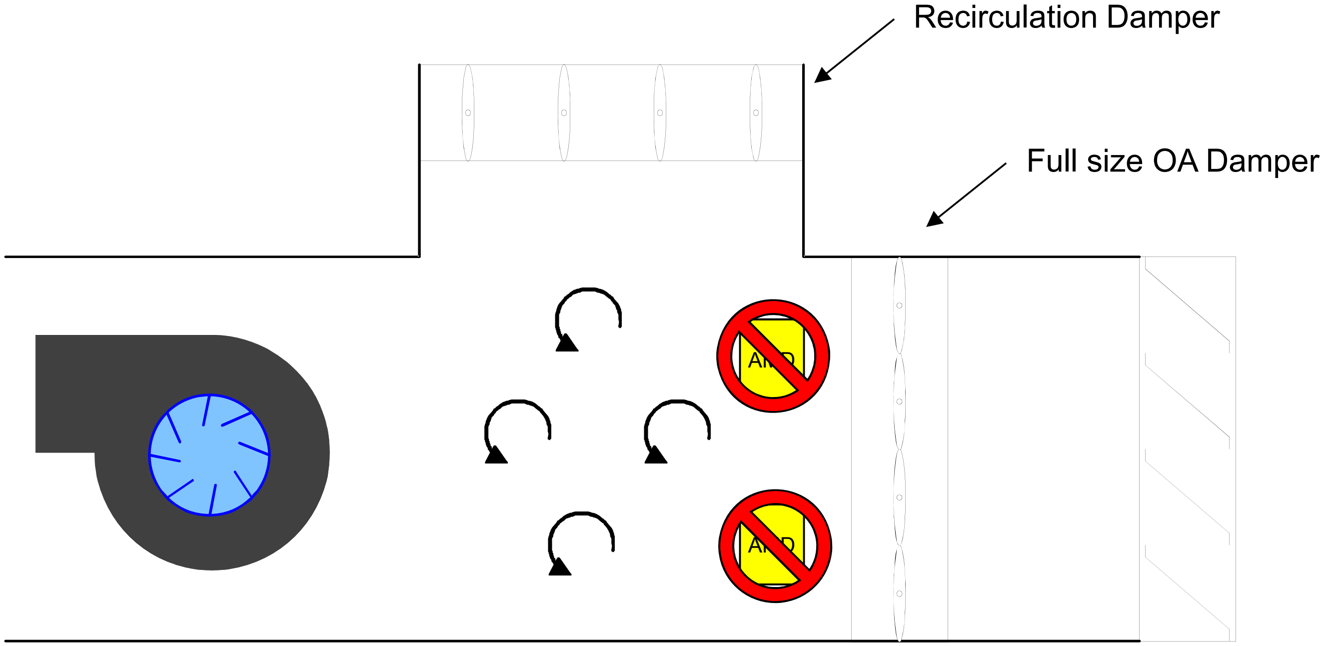
Follow these basic rules for success:

- Select and **apply** airflow measuring devices suited for the measurement of intake flow rates.
  - Make certain the flow meter can measure the outdoor air intake flow rates
  - **Make certain that the flow rates are high enough to control and are not affected by transient wind gusts (> 150 FPM at minimum [200 FPM preferred])**
- Select and size quality control dampers.
  - Use high quality, extruded aluminum blades, with long-lasting and non-binding linkage
- Implement a control strategy that optimizes the performance of the system
  - **Use the right sequences and slow it down!**

Outside Air Intake Guidelines

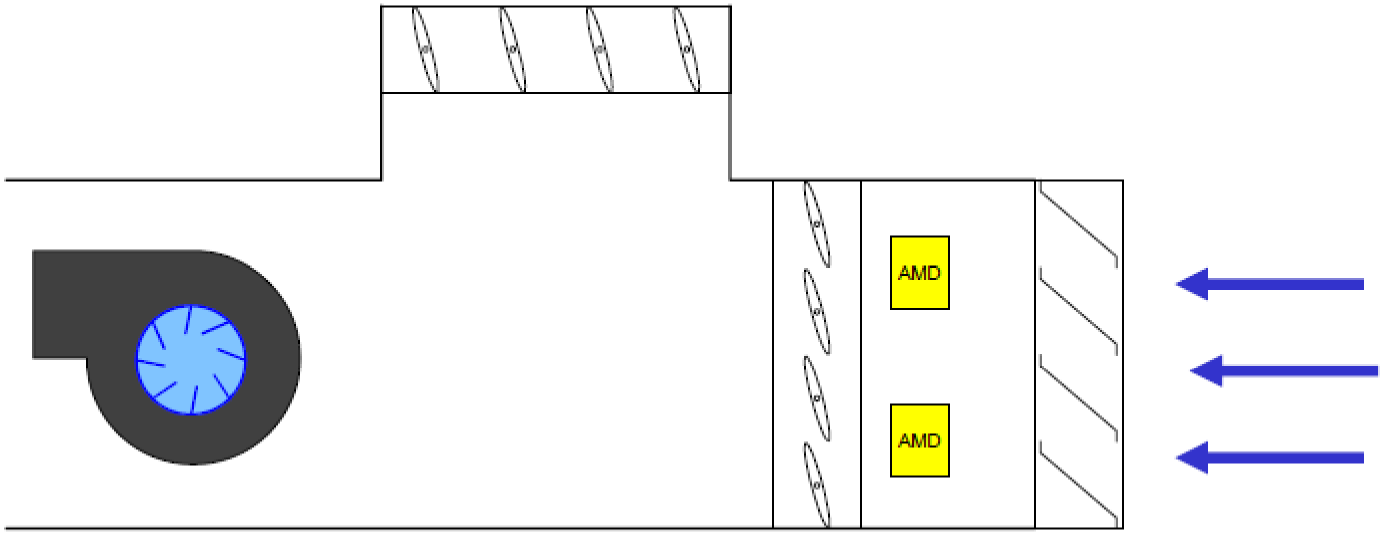
Turbulence in the mixed air plenum from fans and dampers can result in false airflow readings.

Do NOT measure airflow rates downstream of the intake damper or near the mixed air plenum!



Outside Air Intake Guidelines

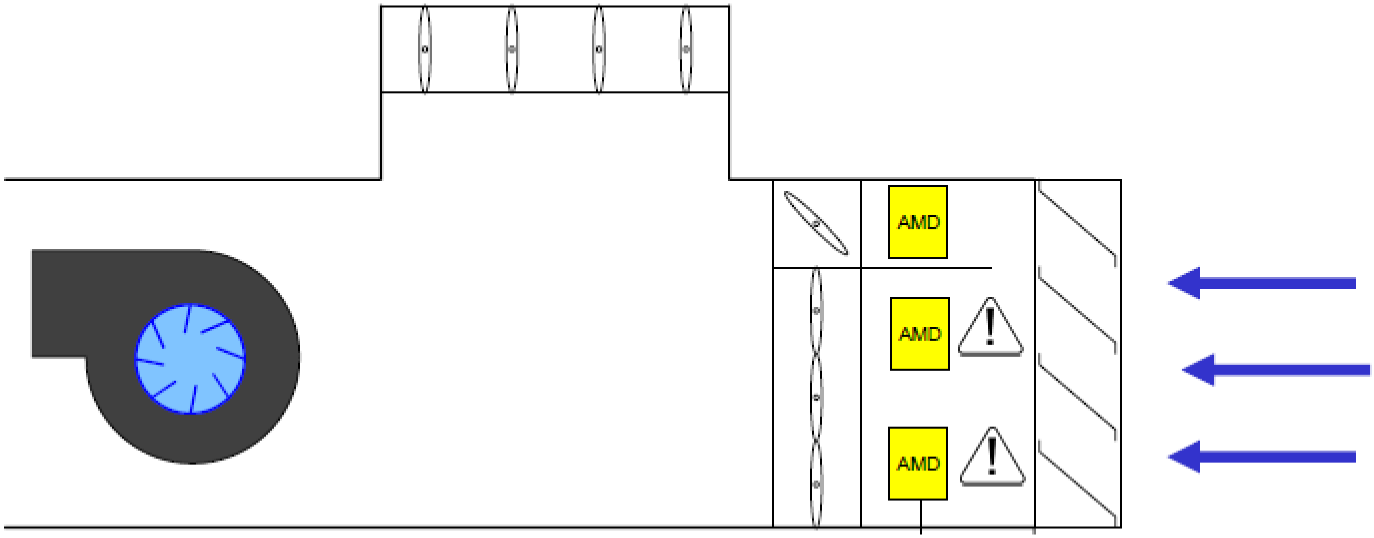
Always place the airflow measuring station UPSTREAM of the intake damper.



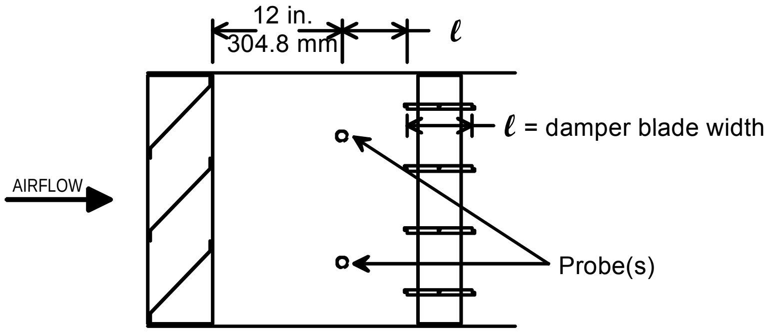
Outside Air Intake Guidelines

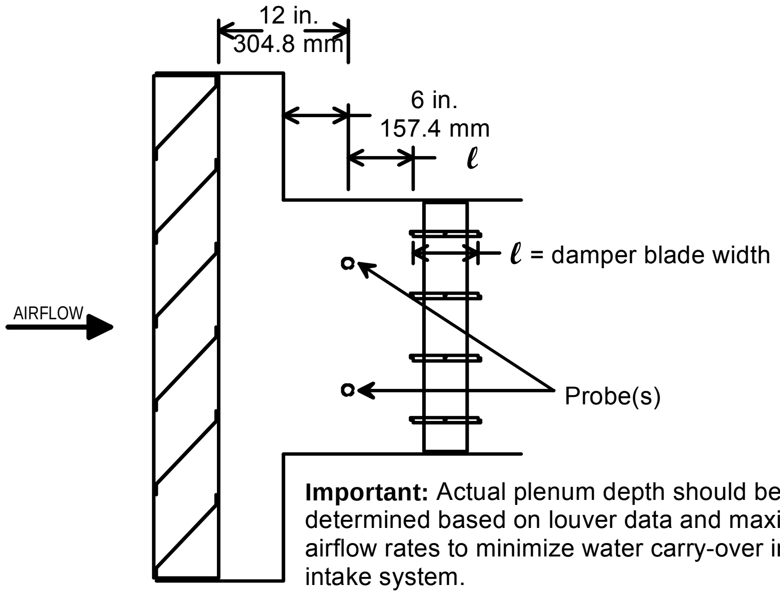
Consider using Min/Max dampers to improve measurement and control of OA intake

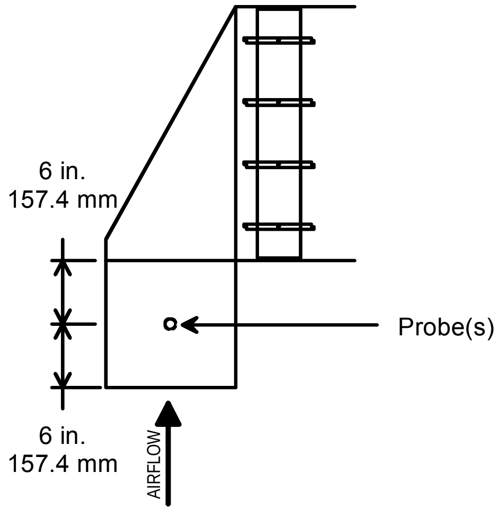
⚠ OA intake flow rates may not be accurately determined on max. damper as max. damper flow rate approaches 0 FPM as a result of wind effect on AMD!

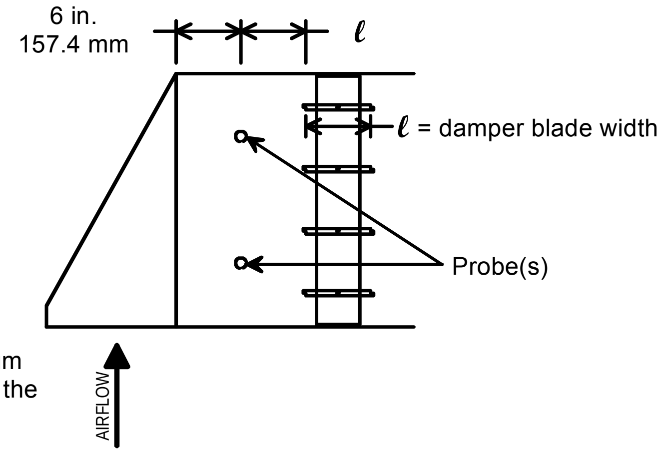


Outside Air Intake Placement Guidelines









Important: Actual plenum depth should be determined based on louver data and maximum airflow rates to minimize water carry-over into the intake system.

Guidelines shown are for one manufacturer
Not typical for all airflow monitors

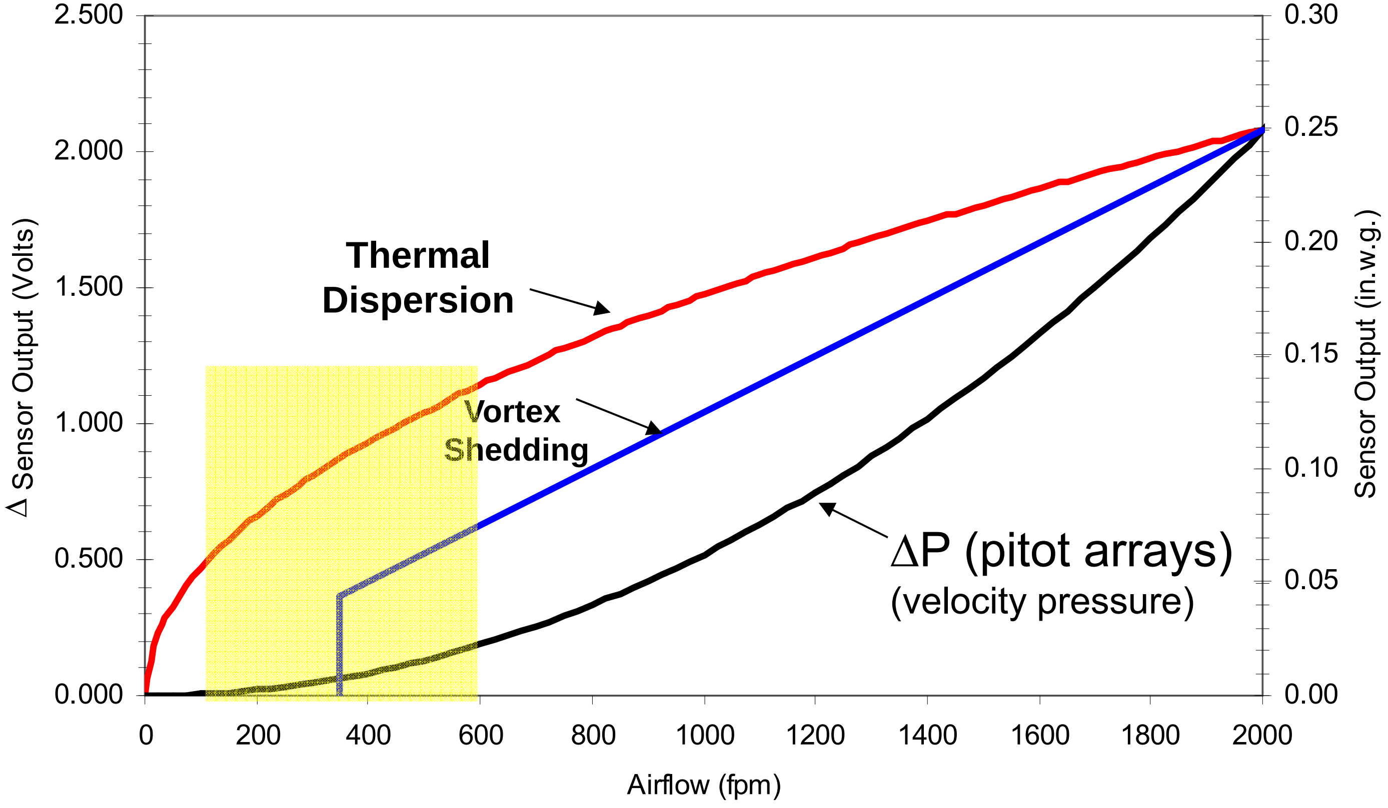
Selecting & Specifying Outdoor Airflow Monitors

What’s important?

1. Suitability for Application
    a) Desired Airflow
    b) Minimum Placement Guidelines
2. Total Installed Accuracy
3. Repeatability (i.e. Long-Term Stability)
    a) Long-Term Drift
    b) Recommended Calibration Interval
4. Application Support
5. Cost
6. Reliability
7. Ease of Installation
8. Service and Support

Technology Comparison

Thermal Dispersion vs. ΔP vs. Vortex Shedding



Thermal Dispersion has the Best Sensitivity at Low Airflows

Outdoor Air Intakes typically 150 to 600 fpm velocity

Applying for LEED 2009
IEQ Credit 1: Outdoor Air Delivery Monitoring
Example: Office Building

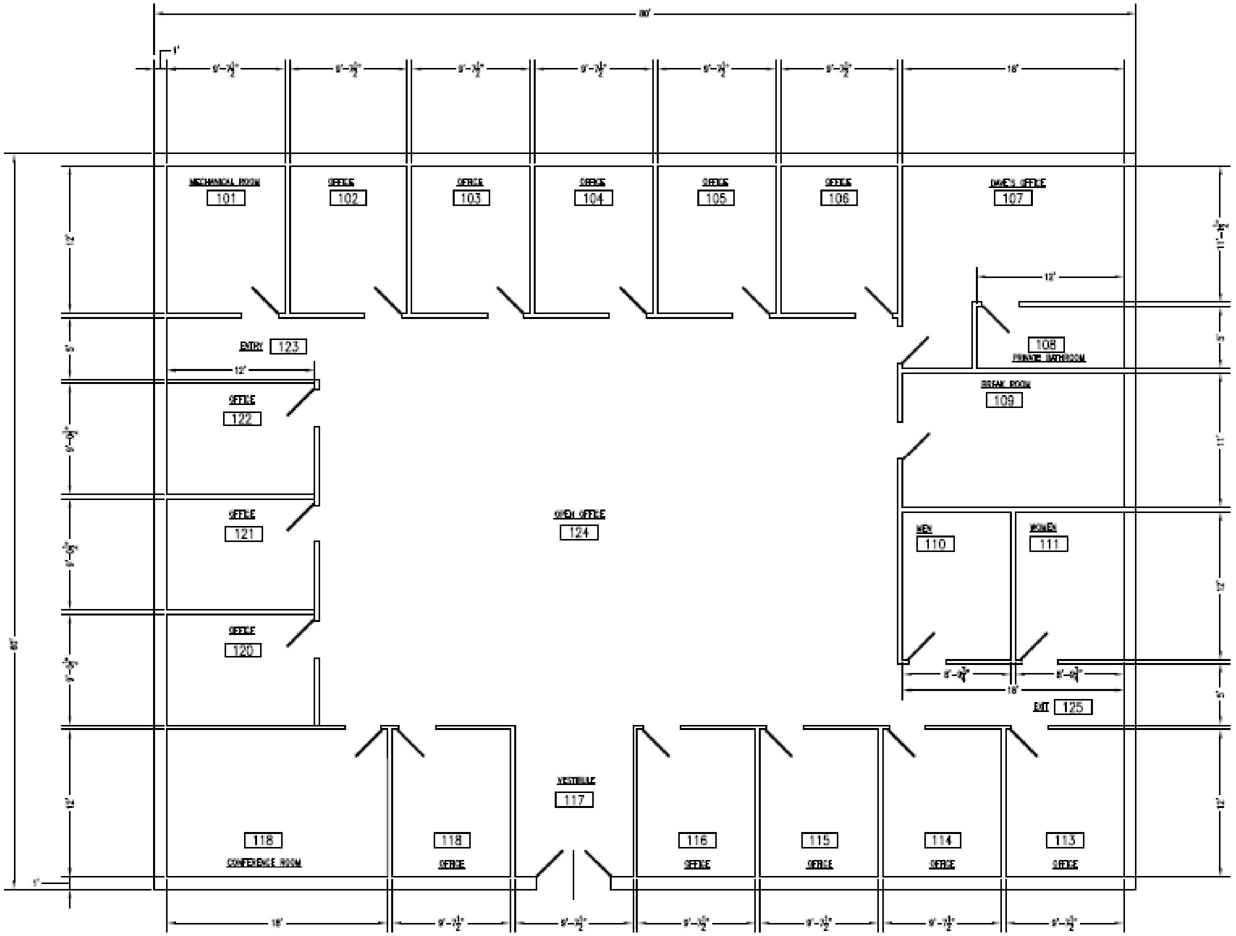
Example: Applying for LEED 2009 IEQ 1

Office Building

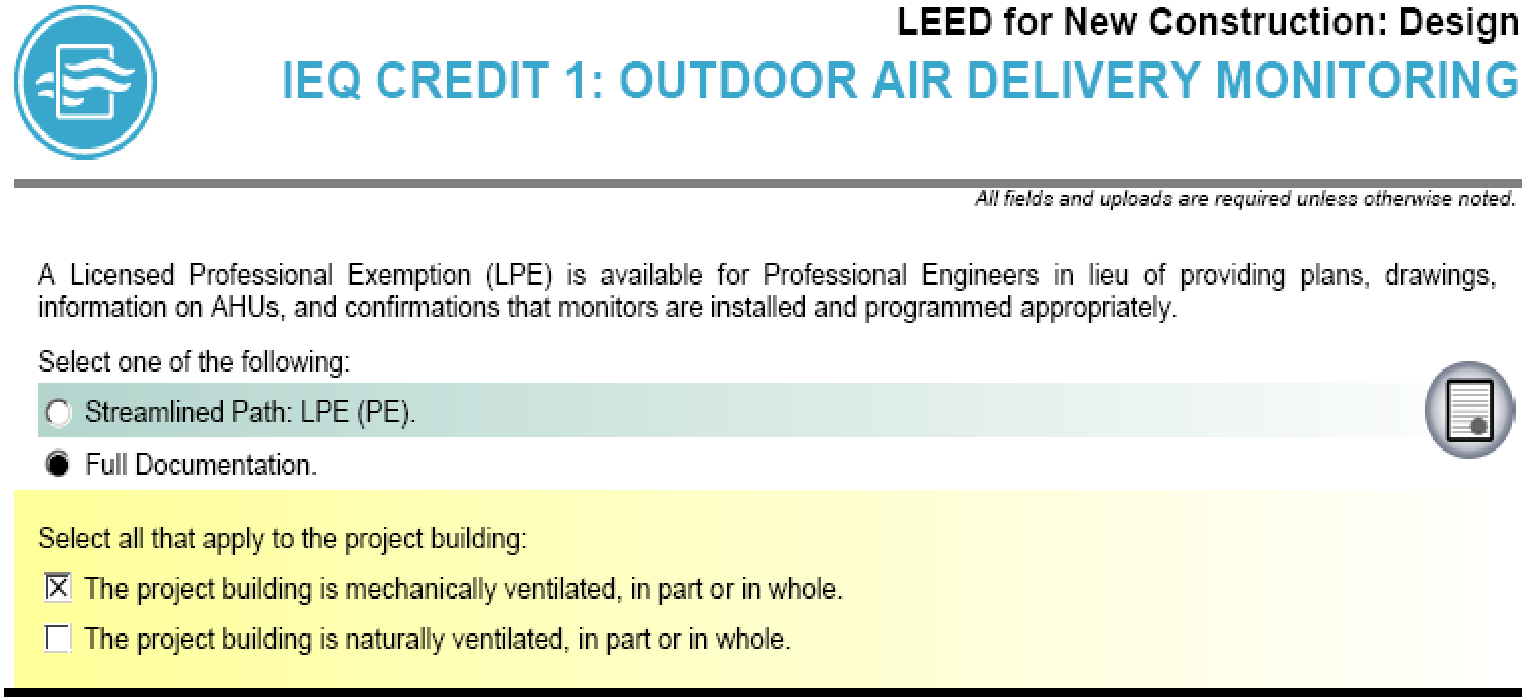
Single-Zone

4,800 SF

22 People



LEED 2009 IEQ Credit 1 Template



LEED for New Construction: Design

IEQ CREDIT 1: OUTDOOR AIR DELIVERY MONITORING

All fields and uploads are required unless otherwise noted.

A Licensed Professional Exemption (LPE) is available for Professional Engineers in lieu of providing plans, drawings, information on AHUs, and confirmations that monitors are installed and programmed appropriately.

Select one of the following:

○ Streamlined Path: LPE (PE).

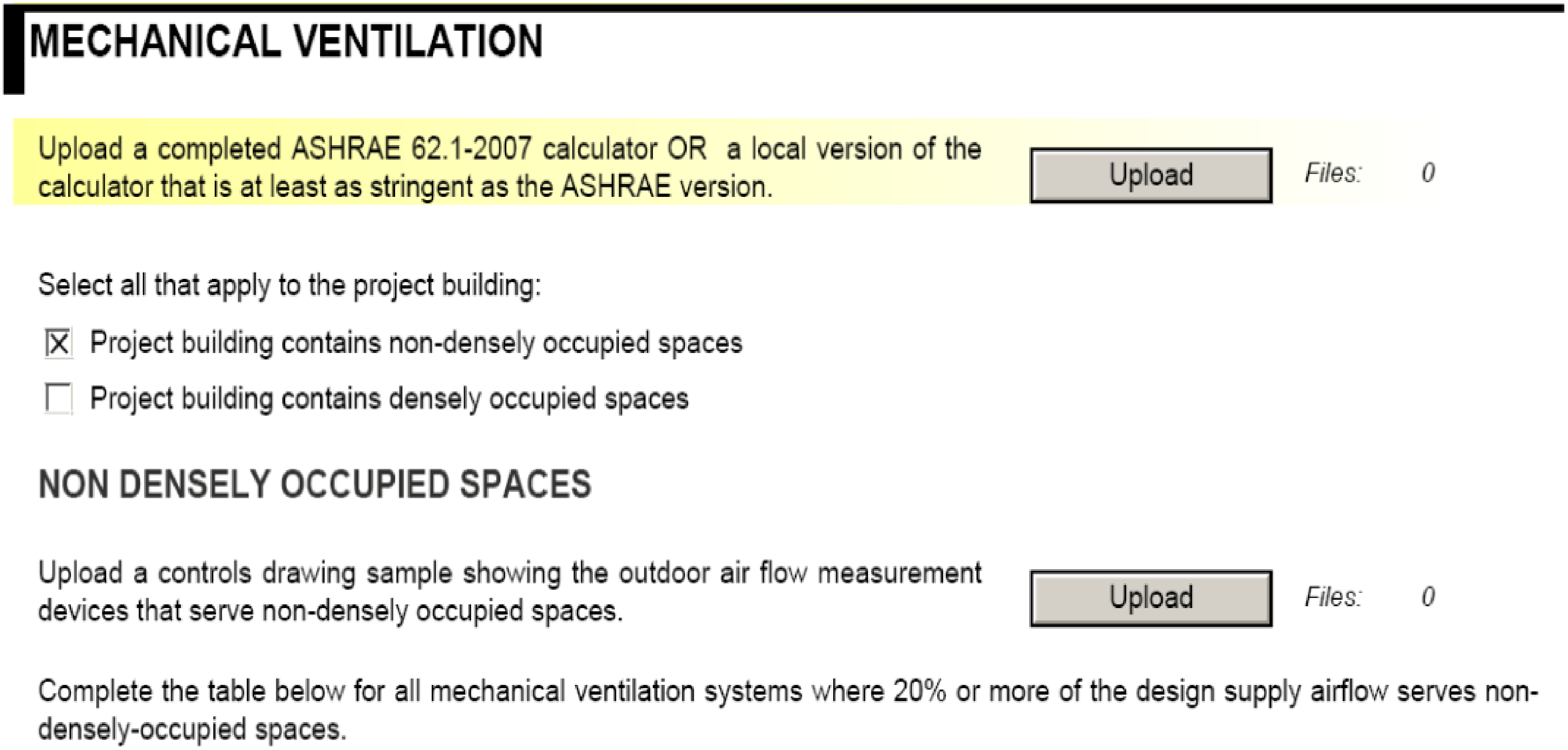
● Full Documentation.

Select all that apply to the project building:

☒ The project building is mechanically ventilated, in part or in whole.

☐ The project building is naturally ventilated, in part or in whole.

LEED 2009 IEQ Credit 1 Template



MECHANICAL VENTILATION

Upload a completed ASHRAE 62.1-2007 calculator OR a local version of the calculator that is at least as stringent as the ASHRAE version.

Select all that apply to the project building:

☒ Project building contains non-densely occupied spaces

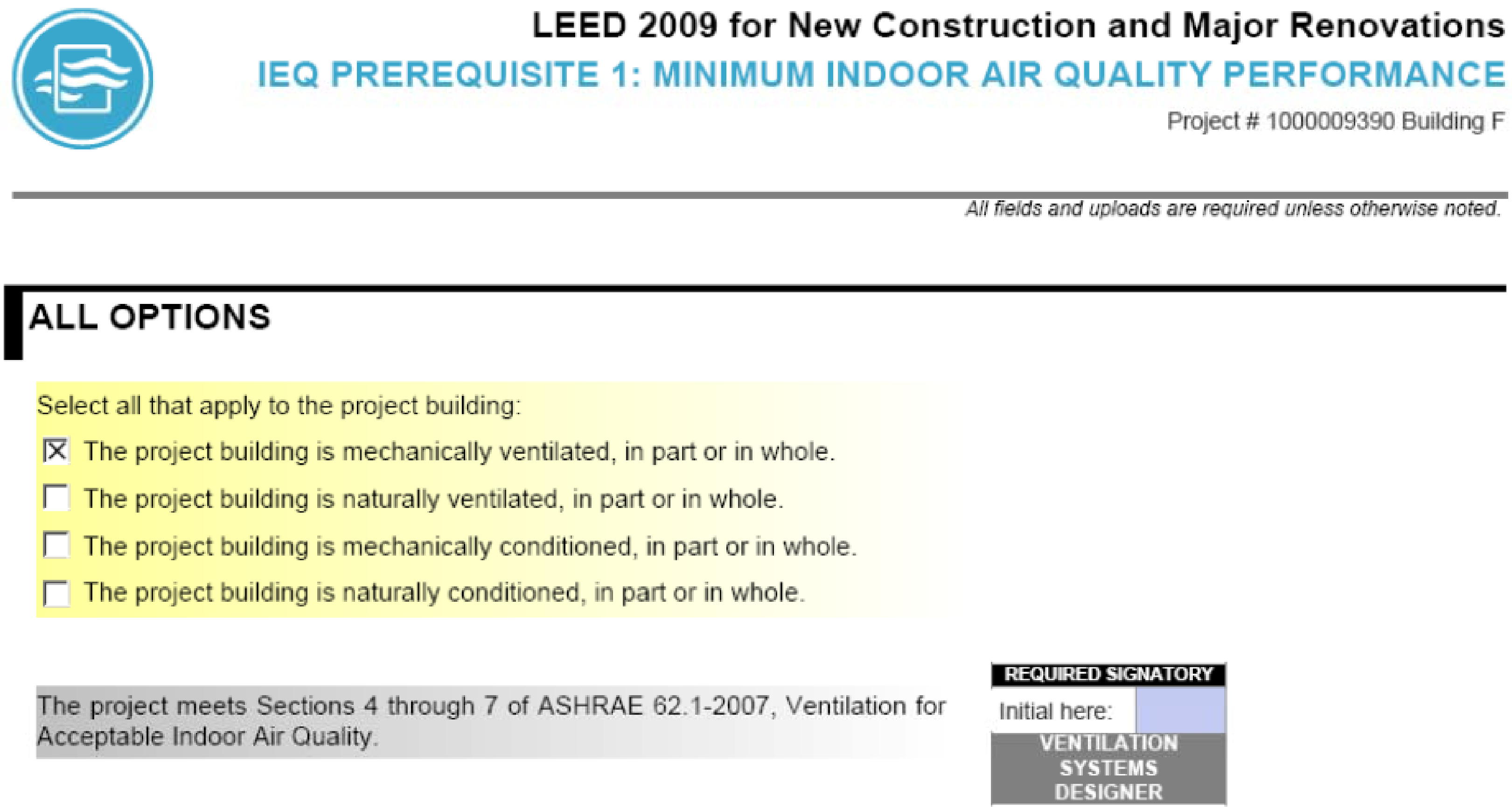
☐ Project building contains densely occupied spaces

NON DENSELY OCCUPIED SPACES

Upload a controls drawing sample showing the outdoor air flow measurement devices that serve non-densely occupied spaces.

Complete the table below for all mechanical ventilation systems where 20% or more of the design supply airflow serves non-densely-occupied spaces.

LEED 2009 IEQ Prerequisite 1 Template



LEED 2009 for New Construction and Major Renovations

IEQ PREREQUISITE 1: MINIMUM INDOOR AIR QUALITY PERFORMANCE

Project # 1000009390 Building F

All fields and uploads are required unless otherwise noted.

ALL OPTIONS

Select all that apply to the project building:

☒ The project building is mechanically ventilated, in part or in whole.

☐ The project building is naturally ventilated, in part or in whole.

☐ The project building is mechanically conditioned, in part or in whole.

☐ The project building is naturally conditioned, in part or in whole.

The project meets Sections 4 through 7 of ASHRAE 62.1-2007, Ventilation for Acceptable Indoor Air Quality.

REQUIRED SIGNATORY

Initial here:

VENTILATION SYSTEMS DESIGNER

ASHRAE 62.1-2007 Outdoor Air Calculation

Step 1: Determine Calculation Variables

System =	Single-Zone Constant Volume
Function =	Office Space
Per Person Vent Rate (R_p) =	5 cfm/person
Per SF Vent. Rate (R_a) =	0.06 cfm/ft^2
Floor Area (A_z) =	4,800 ft^2
Zone Population (P_z) =	22 people

Step 2: Determine Breathing Zone Outdoor Air Requirement (V_{bz})

$V_{bz} = R_p * P_z + R_z * A_z$

$V_{bz} = (5 * 22) + (0.06 * 4,800)$

$V_{bz} = 398$ cfm

Step 3: Determine Zone Ventilation Effectiveness (E_z)

$E_z = 1.0$ per Table 6-2 in Standard 62.1-2007

ASHRAE 62.1-2007 Outdoor Air Calculation

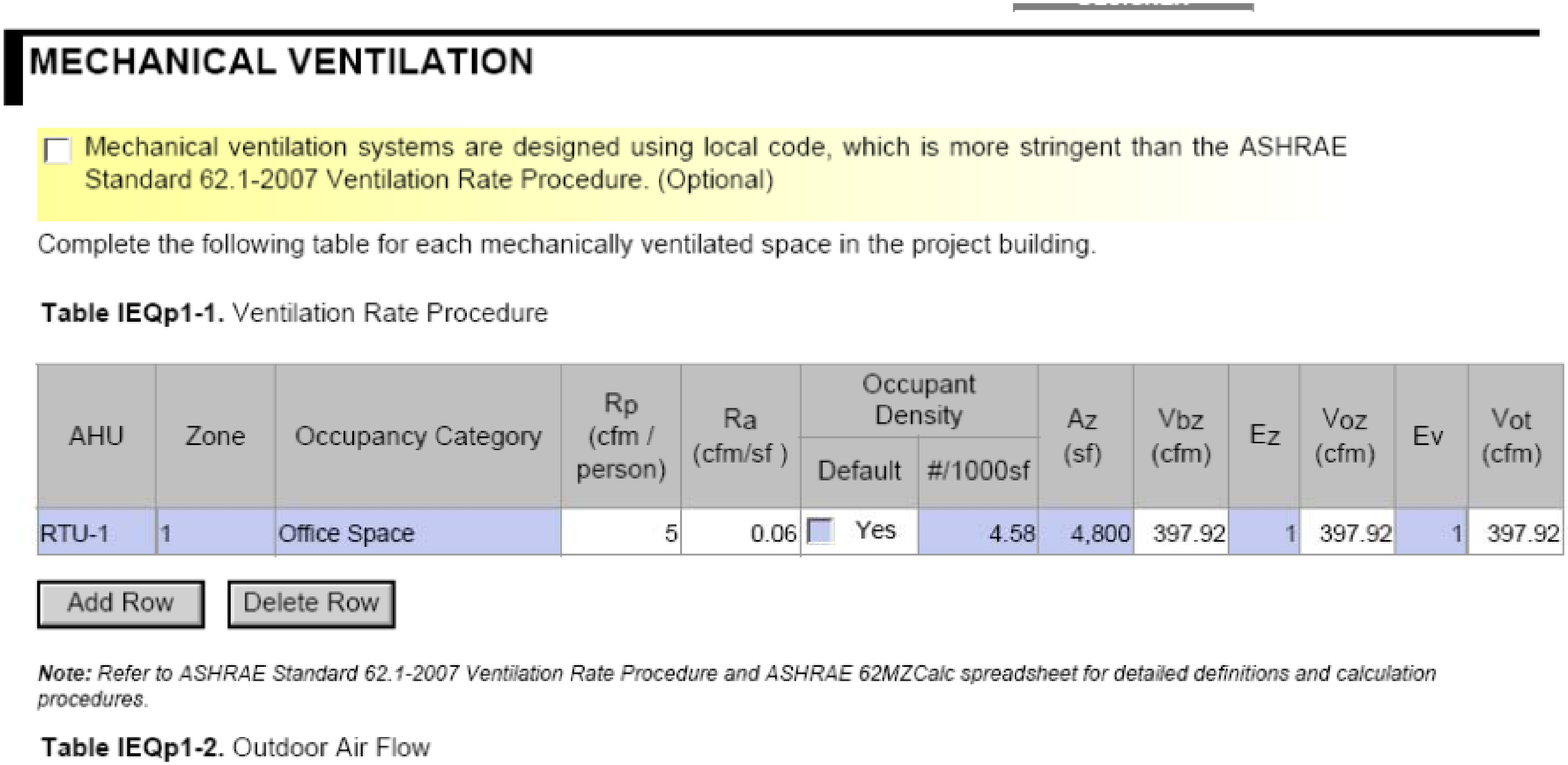
Step 4: Calculate the Zone Outdoor Airflow (Voz)

$V_{oz} = V_{bz} / E_z$
$V_{oz} = 398 / 1.0$
$V_{oz} = 398$ cfm

Step 5: For single zone systems, Calculate the Outdoor Air Intake Flow (Vot)

$V_{ot} = V_{oz}$
$V_{ot} = 398$ cfm

LEED 2009 IEQ Prerequisite 1 Template



MECHANICAL VENTILATION

☐ Mechanical ventilation systems are designed using local code, which is more stringent than the ASHRAE Standard 62.1-2007 Ventilation Rate Procedure. (Optional)

Complete the following table for each mechanically ventilated space in the project building.

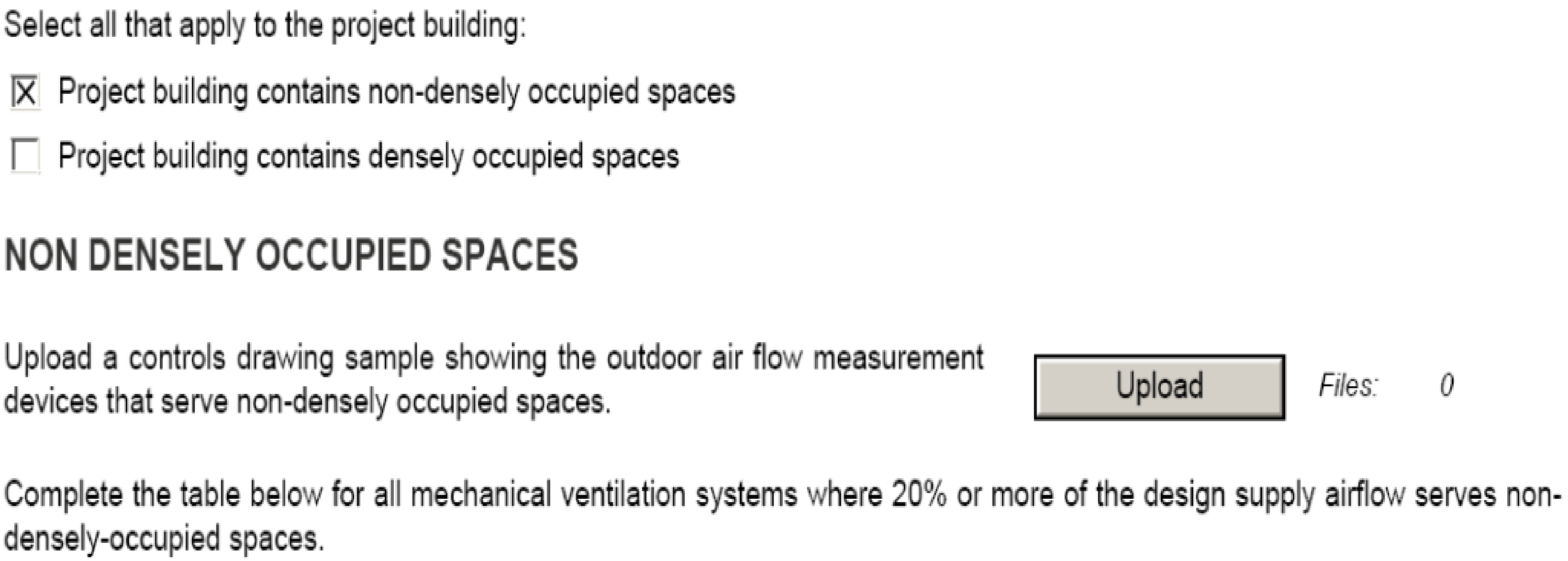
Table IEQp1-1. Ventilation Rate Procedure

AHU	Zone	Occupancy Category	Rp (cfm / person)	Ra (cfm/sf)	Occupant Density		Az (sf)	Vbz (cfm)	Ez	Voz (cfm)	Ev	Vot (cfm)
					Default	#/1000sf						
RTU-1	1	Office Space	5	0.06	☐ Yes	4.58	4,800	397.92	1	397.92	1	397.92

***Note:** Refer to ASHRAE Standard 62.1-2007 Ventilation Rate Procedure and ASHRAE 62MZCalc spreadsheet for detailed definitions and calculation procedures.*

Table IEQp1-2. Outdoor Air Flow

LEED 2009 IEQ Credit 1 Template



Select all that apply to the project building:

☒ Project building contains non-densely occupied spaces

☐ Project building contains densely occupied spaces

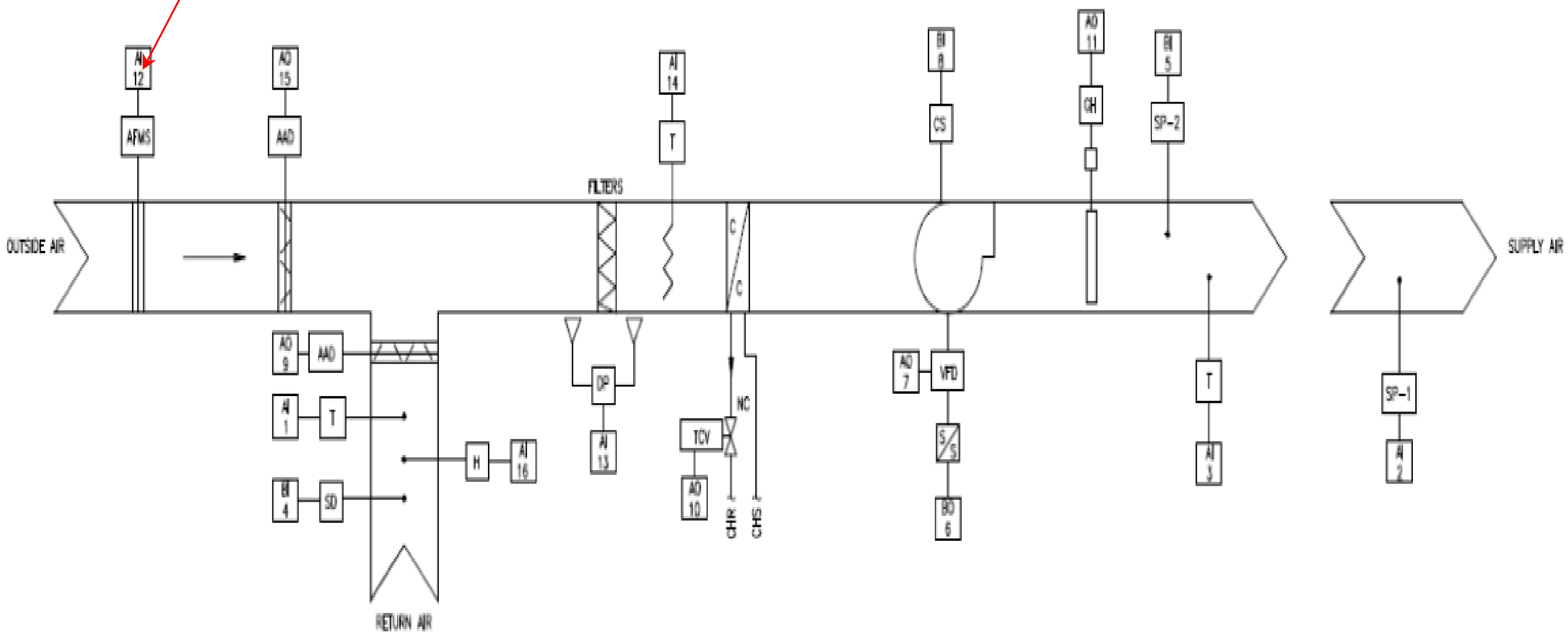
NON DENSELY OCCUPIED SPACES

Upload a controls drawing sample showing the outdoor air flow measurement devices that serve non-densely occupied spaces.

Files: 0

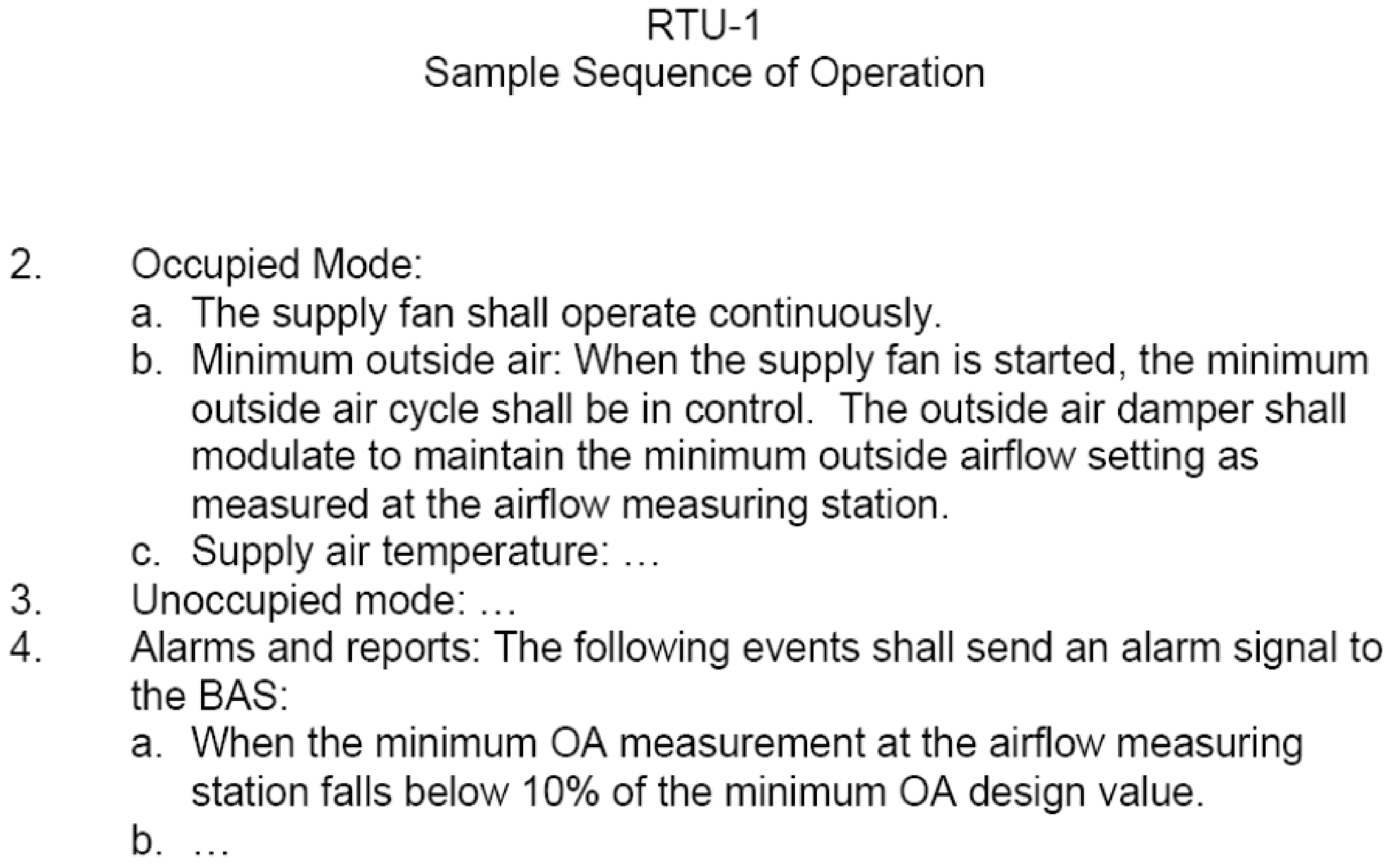
Complete the table below for all mechanical ventilation systems where 20% or more of the design supply airflow serves non-densely-occupied spaces.

Template – Sample Schematic – OA AFMS



OA AFMS

Template – Sample Control Sequence - OA



RTU-1
Sample Sequence of Operation

2. Occupied Mode:
   a. The supply fan shall operate continuously.
   b. Minimum outside air: When the supply fan is started, the minimum outside air cycle shall be in control. The outside air damper shall modulate to maintain the minimum outside airflow setting as measured at the airflow measuring station.
   c. Supply air temperature: …
3. Unoccupied mode: …
4. Alarms and reports: The following events shall send an alarm signal to the BAS:
   a. When the minimum OA measurement at the airflow measuring station falls below 10% of the minimum OA design value.
   b. …

LEED 2009 IEQ Credit 1 Template

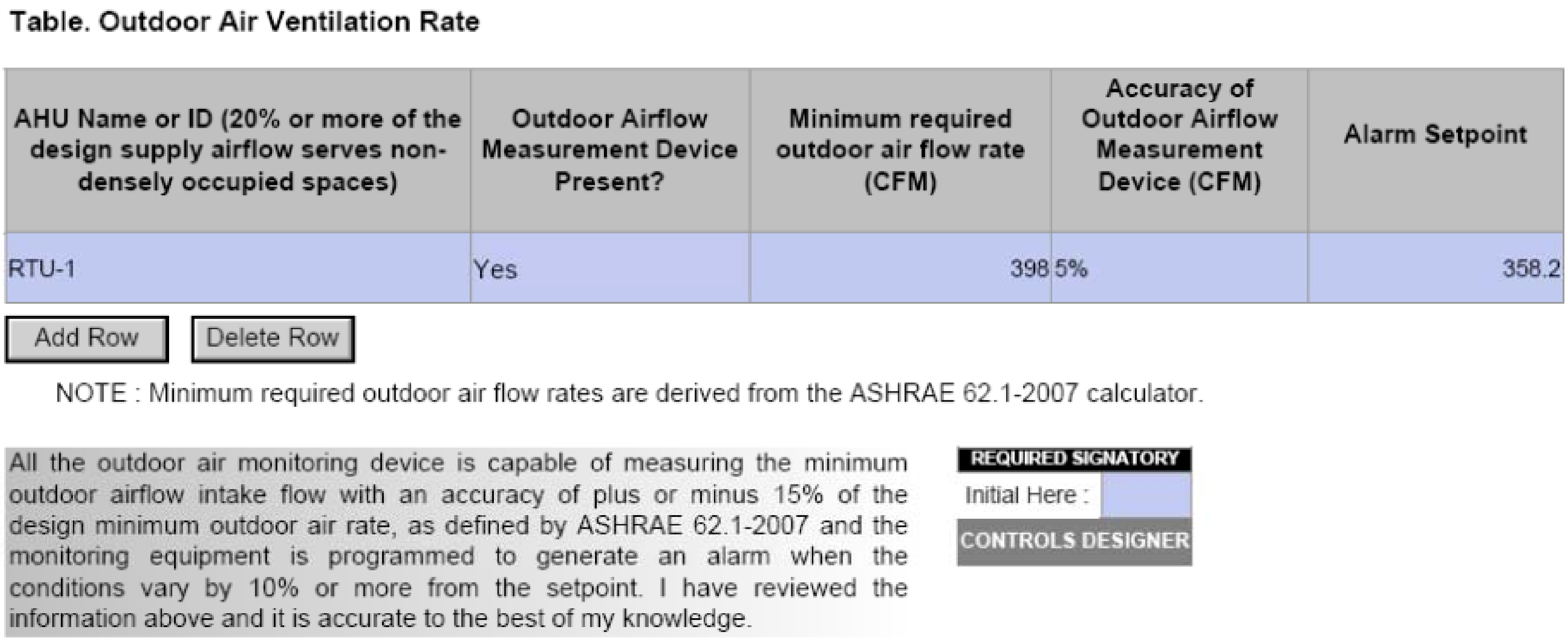


Table. Outdoor Air Ventilation Rate

AHU Name or ID (20% or more of the design supply airflow serves non-densely occupied spaces)	Outdoor Airflow Measurement Device Present?	Minimum required outdoor air flow rate (CFM)	Accuracy of Outdoor Airflow Measurement Device (CFM)	Alarm Setpoint
RTU-1	Yes	398	5%	358.2

NOTE : Minimum required outdoor air flow rates are derived from the ASHRAE 62.1-2007 calculator.

All the outdoor air monitoring device is capable of measuring the minimum outdoor airflow intake flow with an accuracy of plus or minus 15% of the design minimum outdoor air rate, as defined by ASHRAE 62.1-2007 and the monitoring equipment is programmed to generate an alarm when the conditions vary by 10% or more from the setpoint. I have reviewed the information above and it is accurate to the best of my knowledge.

REQUIRED SIGNATORY

Initial Here :

CONTROLS DESIGNER

LEED 2009 IEQ Credit 1

LEED 2009 IEQ Credit 1:
Outdoor Air Delivery Monitoring
is one of the easiest points to get !

Summary

- Airflow Measurement & Control = Comfortable, Healthy, Efficient, Compliant Indoor Environment
- Directly Measuring & Controlling Airflow is the Best Method for Outdoor Air Delivery & Building Pressurization Control
- Airflow Monitors Must Be Suitable, Accurate, Stable, & Reliable

Questions?

Jim Riendeau

843 877 4049