Outside Air Intakes
Airflow Measurement Challenges

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Challenges

- Intake systems are dynamic, not static.
- Airflow rates are typically very low.
- There is little distance between the louver and damper to measure.
Outside Air Intakes:
DYNAMICS

Damper Issues

Linkage and Actuator Hysteresis will result in airflow variations
Minimum Outside Air - Fixed Minimum Damper set @ 900 CFM (90 FPM)
position set from open position with wind <5 mph
Operation: wind <5 mph
Mixed Air Plenum Pressure Variations
Supply Fan Speed Changes (VAV and multi-speed)
Outside Air Intakes:
DYNAMICS
Wind Pressure Variations

Delta P @ Louver (in. WC)

Stagnation Wind (0.7)

Slipstream/Cross Wind (-0.6)

Wind Velocity (mph)
Outside Air Intakes: DYNAMICS

Wind Effect

Direct Wind

Cross Wind

No Wind
Minimum Outside Air - Fixed Minimum Damper set @ 900 CFM (90 FPM)
position set from open position with wind <5 mph
Operation: cross wind 15 mph
Stack Pressure Variations

50 Ft.–Intake Louver from Neutral Plane.
No Stack Effect
Winter Stack Effect
Outside Air Intakes:
DYNAMICS

Summer Stack Effect
Outside Air Intakes: DYNAMICS

CO₂ DCV
**CO₂ – Contaminant or Surrogate for Ventilation?**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>Outside air CO₂ level (scfm CO₂/scfm Air)</td>
</tr>
<tr>
<td>Ci</td>
<td>Inside CO₂ level (scfm CO₂/scfm Air)</td>
</tr>
<tr>
<td>Vo</td>
<td>Outside air flow rate (scfm Air)</td>
</tr>
<tr>
<td>N</td>
<td>CO₂ production rate (scfm CO₂/person)</td>
</tr>
<tr>
<td>P</td>
<td>Number of people</td>
</tr>
<tr>
<td>R</td>
<td>Rate (scfm OA/person)</td>
</tr>
</tbody>
</table>

**Mass Balance Equation**

\[
\text{In} = \text{Out} \\
\text{Co} \cdot \text{Vo} + N \cdot P = \text{Ci} \cdot \text{Vo}
\]

Simplifies to:

\[
\frac{N}{(\text{Ci} - \text{Co})} = \frac{\text{Vo}}{P} = R
\]

\[
\frac{N}{(\text{Ci} - \text{Co})} = \frac{\text{Vo}}{P} = \text{scfm/person}
\]
Outside Air Intakes: DYNAMICS

ASHRAE 62.1-2010 CO₂ DCV

OA CFM provided at using fixed 1,000 ppm CO₂ setpoint

![Graph showing the relationship between the number of adult students and outside air (CFM) provided, illustrating the Single Setpoint CO₂ DCV Response compared to the ASHRAE 62.1-2010 Required Ventilation.]

- **Graph**
  - **Y-axis**: Outside Air (CFM)
  - **X-axis**: Number of Adult Students
  - **Single Setpoint CO₂ DCV Response**
  - **ASHRAE 62.1-2010 Required Ventilation**
Outside Air Intakes:

ASHRAE 62.1-2010 CO₂ DCV

OA CFM provided at using fixed 1,000 ppm CO₂ setpoint

If metabolic activity > assumed

ASHRAE 62.1-2010 Required Ventilation

Single Setpoint CO₂ DCV Response

Number of Adult Students

Outside Air (CFM)
Outside Air Intakes: DYNAMICS

ASHRAE 62.1-2010 CO₂ DCV
OA CFM provided at using fixed 1,000 ppm CO₂ setpoint

If metabolic activity < assumed
Outside Air Intakes:

ASHRAE 62.1-2010 CO₂ DCV

OA CFM provided at using fixed 1,000 ppm CO₂ setpoint

\[ V_{bz} = R_p \cdot P_z + R_a \cdot A_z \]

\[ V_{bz} = R_a \cdot A_z \]

(greater if local exhaust exceeds \( R_a \cdot A_z \))

Minimum OA airflow rate cutoff

Maximum OA airflow rate cutoff (when economizer is not active)

Single Setpoint CO₂ DCV Response

ASHRAE 62.1-2010 Required Ventilation

Number of Adult Students

Outside Air (CFM)
ASHRAE 62.1-2010 CO₂ DCV

OA CFM using CO₂ and OA airflow to estimate the population

Maximum OA airflow rate cutoff (when economizer is not active)

OA Response Using CO₂ and OA Airflow Rate to Calculate Vbz

ASHRAE 62.1-2010 Required Ventilation (left axis)

Minimum OA airflow rate cutoff

Number of Adult Students

Outside Air (CFM)
**Outside Air Intakes: DYNAMICS**

**CA Title 24 CO₂ DCV**

OA CFM provided at using fixed 1,000 ppm CO₂ setpoint and 0.15 CFM/sq.ft. minimum

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### Graph:

- **Single Setpoint CO₂ DCV Response**
- **Title 24 Required Ventilation**
- **Maximum OA airflow rate cutoff (when economizer is not active)**
- **Minimum OA airflow rate cutoff**
- **15 CFM x max population**

### Axes:
- **Y-axis**: Outside Air (CFM)
- **X-axis**: Number of Adult Students

### Labels:
- 0.15 CFM/sq.ft.
Outside Air Intakes:
LOW AIRFLOW RATES

- Thermal Dispersion Probes
- Vortex Shedding
- Pitot Tubes and Arrays
- Piezo Rings

Outside Air Intakes
Duct Tracking
Fan Inlets
Outside Air Intakes:
SOLUTIONS
Solutions

- Install permanently mounted airflow measuring devices for control or, at a minimum, alarm.
  - Flow rates?
  - Placement?
  - Other considerations?
  - Verification of performance?
  - Field adjustment?
OA Measurement & Control Guidelines

- Follow these basic rules and you will be successful:
  - Select and apply airflow measuring devices suited for the measurement of intake flow rates.
    - Make certain the flow meter can measure the flow rates you are trying to control.
    - 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])
  - Choose the best measurement location.
  - 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 your system.
    - Use the right sequences and slow it down!
OA Intake Placement

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

Downstream Louver with Parallel Blade Damper (5% error)

- Damper at 100%
- Damper at 80%
- Damper at 60%
- Damper at 40%
- Damper at 20%
Damper Interaction

Downstream Louver with Opposed Blade Damper (5% error)

- Damper at 100%
- Damper at 80%
- Damper at 60%
- Damper at 40%
- Damper at 20%