How to Test
Air Change Effectiveness

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13th June 2012

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Presentation Agenda

- What is Air-Change Effectiveness (ACE)?
- Why is it important?
- Green Star - IEQ-2
- ASHRAE Standard 129-1997 – Measuring ACE
- Which Tracer Gas & Why?
- The ACE Test Kit
- The Test Procedure
- Test Results
- Lessons Learnt

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What is Air-Change Effectiveness (ACE)?

- The actual age of the air within the occupied zone compared to the age of the air under perfect mixing conditions
- The age of the air is the time elapsed since the molecules of air entered the building from outside
- This air is effectively mixed and distributed into, across and out of the occupied space

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Why is it Important?

- ACE test results identify how effective the outside air will be delivered to the occupied space (effective mixing)
- An ACE result of 1 determines that the actual system performance matches perfect mixing conditions
- Faster “rates of decay” can deliver better than unity results(>1)
- Low ACE results indicate poor supply air mixing, insufficient supply quantities and supply to return / exhaust short cycling
- A low ACE can result in lower productivity, as outside air does not adequately mix with the occupied zone (Sick Building Syndrome)

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Green Star – IEQ-2

- Nominates ASHRAE F25-1997 - Ventilation & Infiltration
- Current revision is ASHRAE F16-2009 - Ventilation & Infiltration
- ASHRAE Standard 129-1997 (RA 2002) Measuring Air-Change Effectiveness

ASHRAE Standard 129-1997 – Measuring ACE

Building Requirements

- The test space must be representative of the building
- The test space can be separate, partially or entirely surrounded by other indoor spaces
- Systems that supply air to or remove air from a test space must not supply or return air form any other space
- Air infiltration and exfiltration between seperated spaces and ambient must be no more than the accepted level (Building Leakage Test)

ASHRAE Standard 129-1997 – Measuring ACE

System Performance Requirements

- The following parameters must not vary more than 10% during the test:
  - Supply, Exhaust and Outside Air Quantities
  - Internal Heat Loads
  - The number of occupants
  - Locally Mounted Fans (Air Flow)
- The test space temperature must not vary by more than 1.1 Degrees C for the duration of the test.

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Which Tracer Gas and Why?

- Two Commonly Used Gasses
  - Sulphur Hexafluoride
  - GWP 22800
  - The most potent known Greenhouse Gas
  - Relatively low quantity required for testing
  - Expensive Detection Equipment
  - Carbon Dioxide
  - GWP 1
  - Relatively high quantity required for testing
  - Inexpensive Detection Equipment

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The ACE Test Kit

Air Quantity Measurement Equipment (CO2)

- TSI Q-Trak Plus Indoor Air Quality Monitor and Logger
- Alnor Micromanometer, Pitot Tube and Airflow Hood

Injection / Tracer Gas Equipment

- Carbon Dioxide Cylinders
- Cylinder Regulator
- CO2 Flowmeter
- Connection Lines

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Injection / Tracer Gas Equipment

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The Test Procedure (Pre-Injection Setup)

- Install the CO2 tracer gas delivery system
- Setup CO2 loggers
- Read all system airflow rates
- Record the baseline CO2 measurements at each of the test point to establish the baseline CO2 levels being delivered **without** the tracer gas system operating.

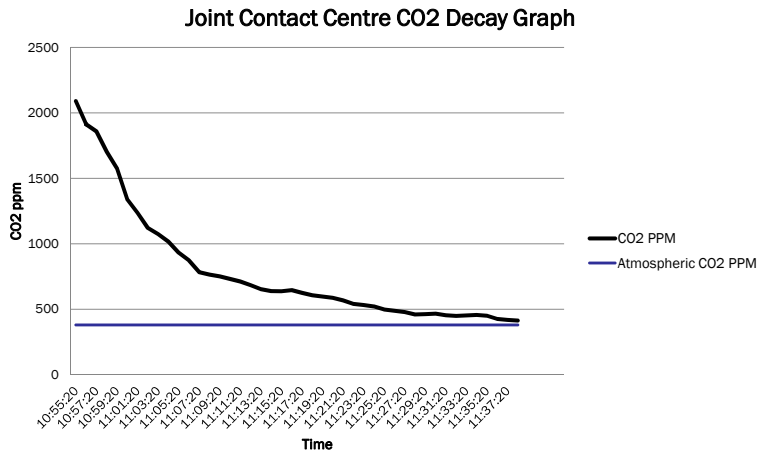
The Test Procedure (Injection Mode)

- Start the CO2 injection system
- Make adjustments as required to achieve tracer gas ppm
- Once tracer gas ppm has been achieved, measure and record in 6 locations across the width of the main supply air duct
- Tracer gas measurements are to be within 15%
- System is to operate under injection mode for a one hour period

The Test Procedure (Decay Mode)

- After one hour, stop the injection equipment
- Note the start time of the decay test
- Purge the space until the CO2 reading approaches ambient CO2

Tracer Gas Decay Graph



AIR CHANGE EFFECTIVENESS CALCULATION SHEET

Age of Air from a Tracer Gas Decay Method

Ai	the age of air at location i
t stop	the time when the final gas concentration is measured at location i
t start	the time when tracer gas injection starts at the beginning of the tracer gas step up
Ci,ave	the time-averaged tracer gas concentration at location i between t start and t end
Ci (t start)	the tracer concentration at location i and time t start

Equation Ai = (t stop - t start)(Ci,ave / Ci(t start))

Workstation age of air		
t stop	11:38:20	Test time in seconds
t start	10:55:20	2640.00
Ci,ave	408	
Ci (t start)	2090	
Ai	515.3684211	

723 is the CO2 PPM Average between the start and stop time

Ci,ave = Test Average CO2 - Atmosphere CO2 788-380 = 408

Nominal Time Constant	
Zone volume	
Length	12.6
Width	7.4
Height	3.7
Zone volume	344.988
AHU-G.4 air flow rate	626
Airflow rate m3/hr	2253.6
Air change rate/hr	6.532401127
Nominal Time Constant (tn)	551.0990415

Air-Change Effectiveness

Equation E = tn / Aavg

E	the air-change effectiveness
Aavg	age of air measured at breathing level within the test space
tn	nominal time constant

Aavg	515.3684211
tn	551.0990415
E	**1.069330248**

This figure should be 0.95 and greater to pass requirements for ACE

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Lessons Learnt

- Read adjacent spaces before during and after to determine if tracer gas is bleeding into these spaces
- Minimise people entering and leaving the space, test can be effected by adjacent pressurised spaces (opening of doors)
- Keep spare gas on site as test may go longer than planned
- Fix all plant and equipment airflow (including adjacent spaces)
- Do a dry run to iron out the bugs

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References

- Green Star IEQ-2 Air Change Effectiveness (Office As-Built V2)
- ANSI/ASHRAE1997. ASHRAE Standard 129-1997 (RA 2002), Measuring Air-Change Effectiveness, to be published by American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta, GA.

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THANK YOU

13th June 2012

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