A Review of Current Lab ACH Rate Standards & Guidelines Across the World

Garvan Cancer Center, Australia

Univ. of Pennsylvania

Masdar City, UAE: MIST 1A

Arizona State University

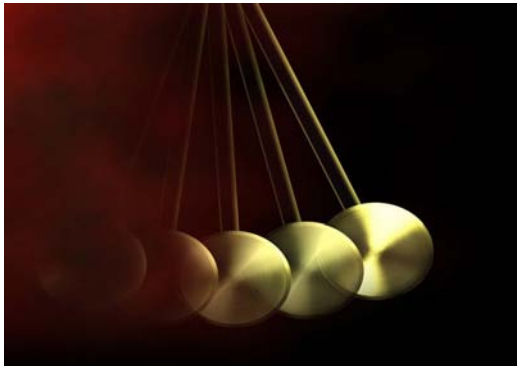
Sabanci University, Turkey

AIRCUITY

Why Discuss ACH Rate Standards & Guidelines?

- **In the last 5 years ACH rate guidance has changed**
- **History of Air Change/Hour (ACH) guidance:**
  - ✓ **In the 70's & 90's – Recommended rates often > 10 ACH**
    - *Prescriptive approach*
  - ✓ **In the early 2000's rates started to drop to 6 to 8 ACH**
    - *Lower unoccupied rates also began to be used*
  - ✓ **In the last 5 years pendulum is swinging back:**
    - *Research showing lower rates below 8 ACH not as effective*
    - *Need to adjust airflow based on actual conditions & hazards*

ACH guidance is becoming more performance based

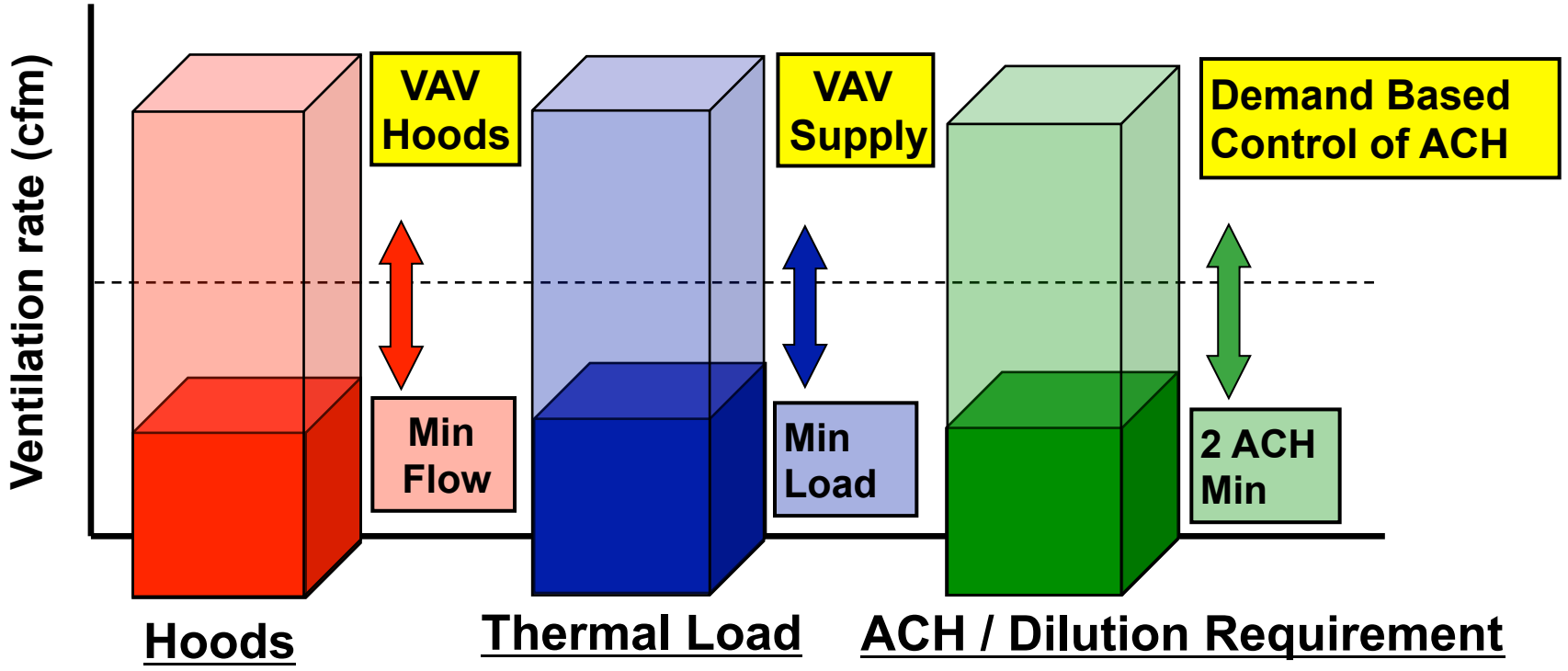


New Standards and Guidelines Agenda

- Fume hood minimum flow standards
- Air change rate (ACH) standards
  - ✓ General recommendations
  - ✓ Unoccupied rate guidance
  - ✓ Active sensing rate guidance
- Vivarium room ACH rate guidelines

Airflow Drivers in Laboratory & Vivaria

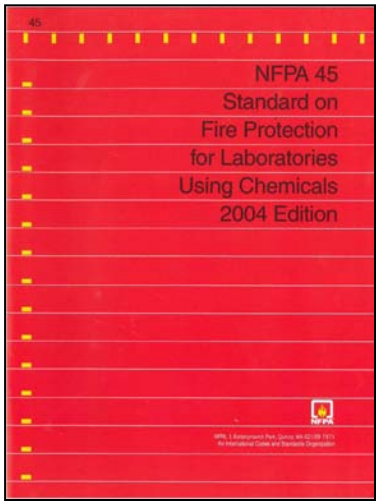
- **What are the drivers of lab airflow?**
  - ✓ **Hood flows, thermal loads & ACH rates**

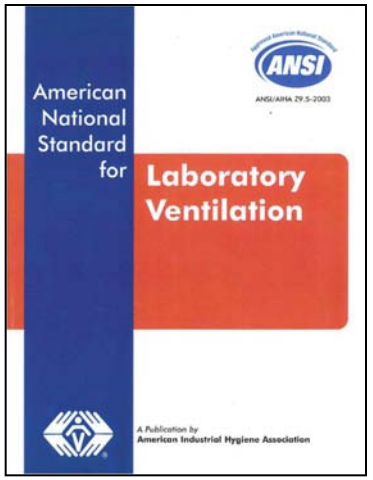


To achieve lab flows down to 2 ACH to reduce energy & 1st cost, *all* flow requirements need to be reduced

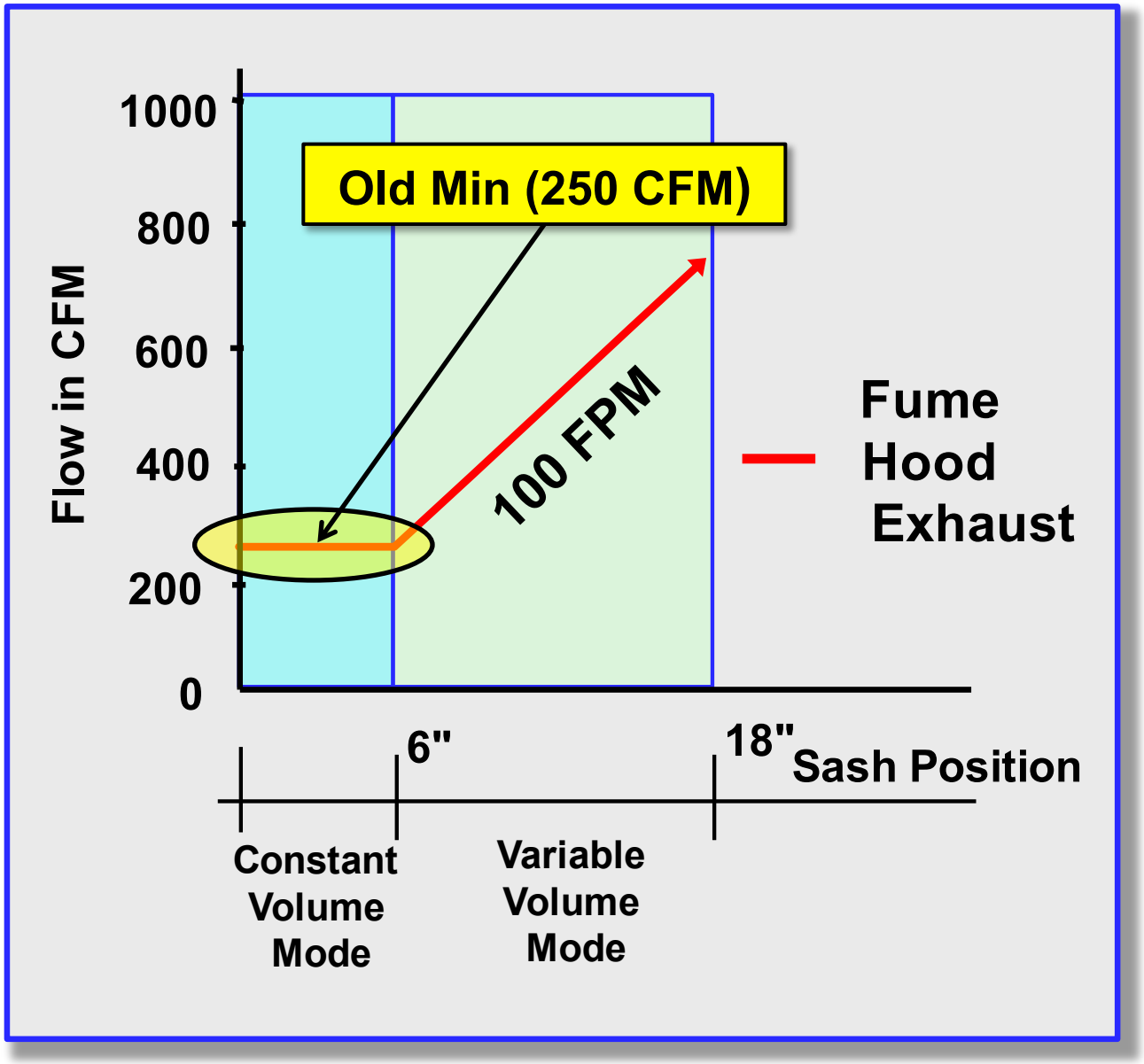
Major Change in Lab Standards: Fume Hood Min Flow

- **New NFPA 45 standard changed:**
  - ✓ **2004 version *recommended* 25 cfm/ ft²**
  - ✓ **2011 version now only refers to Z9.5**
    - *Z9.5 is their sole guideline on hood min flow*
- **New ANSI/AIHA Z9.5-2012 standard:**
  - ✓ **2003 version effectively recommends:**
    - *Larger of 50 cfm/ ft of hood width or 25 cfm/sq ft of bench area*
  - ✓ **2012 version changes:**
    - *Changed basis of flow to hood ACH (volume)*
    - *Changed minimum flow to a min/max range*
      - 25 cfm/ft² to become 150 to 375 hood ACH
    - *Need to consider several factors:*
      - Controls, corrosives, & heavy use of solvents



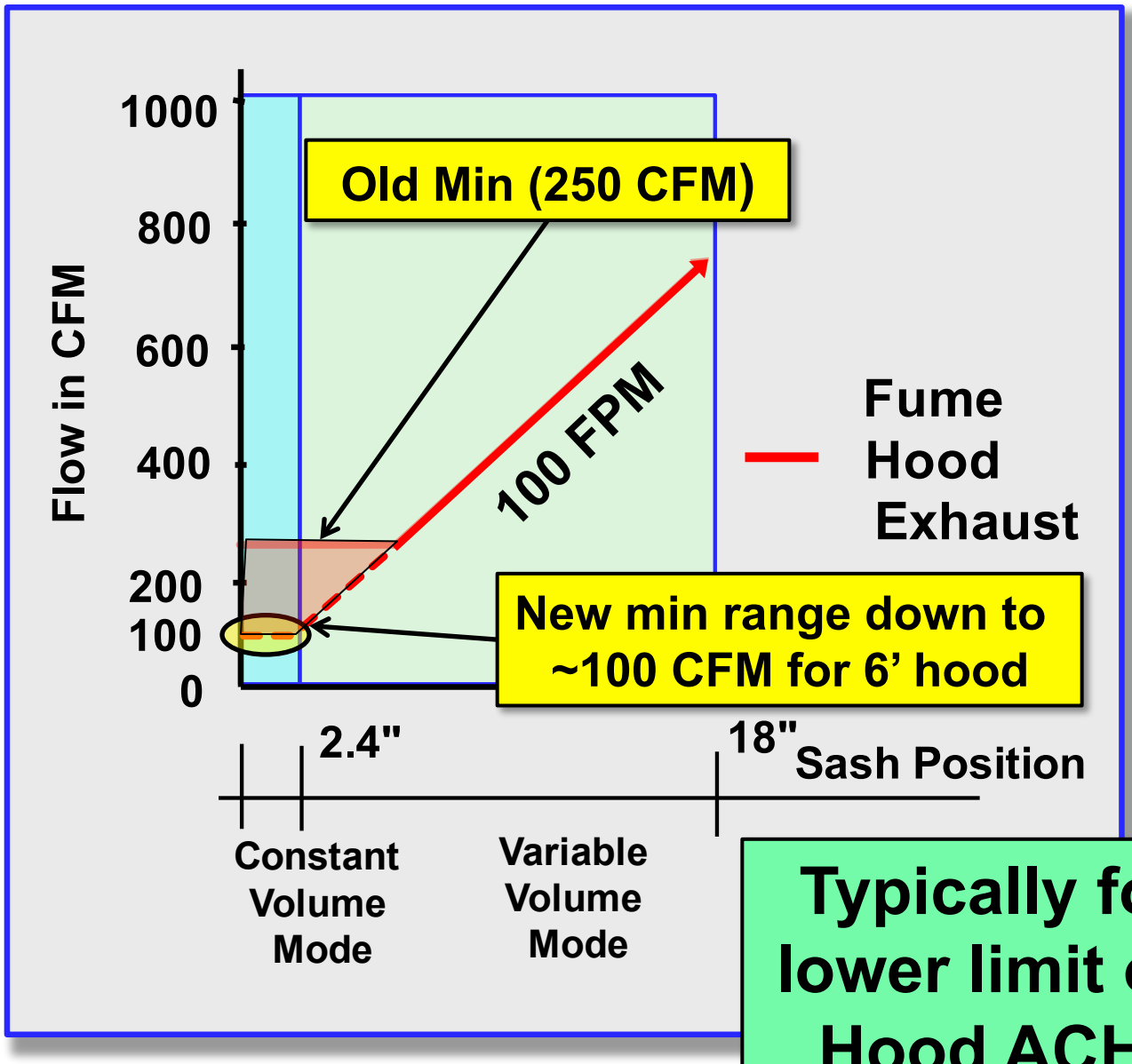


What is the Fume Hood Minimum Flow Rate?



- **Fume Hood Min:**
  - ✓ For VAV hoods
  - ✓ Only affects hood flow for small or closed sash positions
  - ✓ Independent of face velocity
  - ✓ Changing min will <u>not reduce</u> face velocity

What is the VAV Fume Hood Minimum Flow Rate?



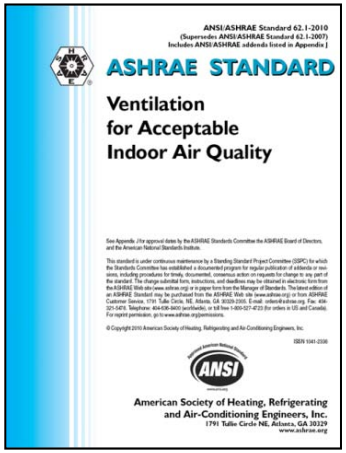
- **Fume Hood Min:**
  - ✓ For VAV hoods
  - ✓ Only affects hood flow for small or closed sash positions
  - ✓ Independent of face velocity
  - ✓ Changing min will <u>not reduce</u> face velocity

Typically for most labs a lower limit of near the 150 Hood ACH can be used.

Industry Recommendations on ACH Rates

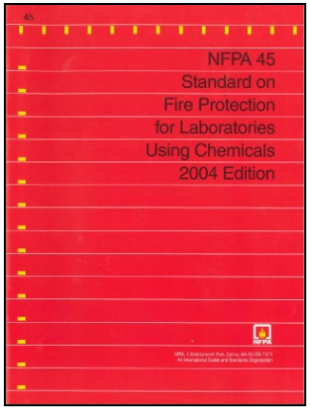
- **No codes other than ASHRAE 62.1**
  - ✓ **Univ/college labs & other similar research labs:**
    - *~1.2 ACH fresh air or .18 cfm/sq. ft. area ventilation requirement*
  - ✓ **Special exhaust requirement for school science labs**
    - *1 cfm/sq. ft. (~6 ACH) but only for high school chem labs*
  - ✓ **Does classify Fume hood exhaust as class 4 exhaust**
    - *Does not allow any recirculation or use of heat wheel type H.R.*
    - *Applies to even mixed Fume hood/ general exhaust flows*

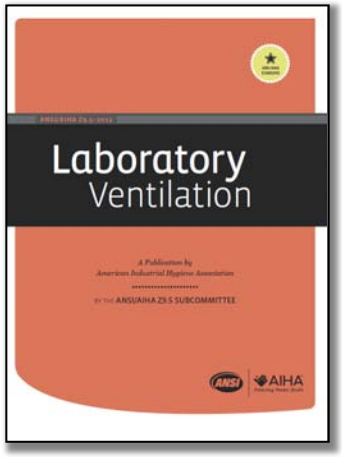
ASHRAE 62.1 doesn't cover lab room chemical dilution ventilation rates, it is more focused on people related ventilation rates

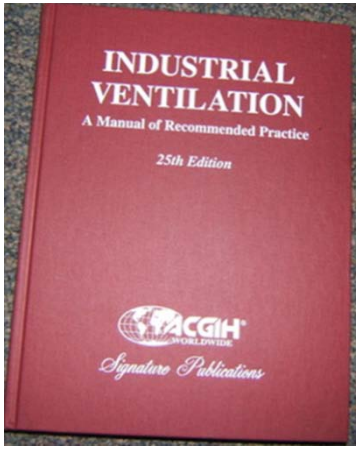


Other Recommendations on ACH Rates

- **Most fixed ACH values are being dropped:**
  - ✓ **NFPA 45 - 2011: 8 Occ / 4 Unocc rates were removed**
    - *Committee was challenged & had no basis for these rates*
  - ✓ **ANSI Z9.5-2012 Doesn't advocate for a fixed rate:**
    - *"An air exchange rate (air changes per hour) cannot be specified that will meet all conditions."*
  - ✓ **ACGIH Industrial Ventilation Manual**
    - *The required ventilation depends on the problem, not on the size of the room in which it occurs."*





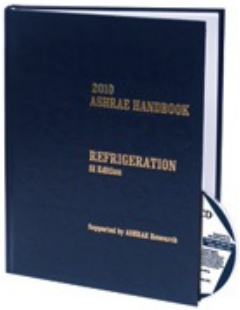


What about the European Experience & DIN?

- **No specific European guidance other than DIN**
  - ✓ **German DIN std. typically followed by central Europe**
- **DIN 1946-7 *Ventilation & air conditioning, Part 7***
  - ✓ **A minimum exhaust volume of *25 m3/hr. per m^2***
    - *Works out to slightly over 8 ACH minimum requirement*
  - ✓ ***Does however allow a lower minimum to be used***
    - *Based on a risk assessment of planed lab activities*

German DIN provides a performance based approach/assessment to allow a lower ACH

Industry Recommendations on ACH Rates & DBC

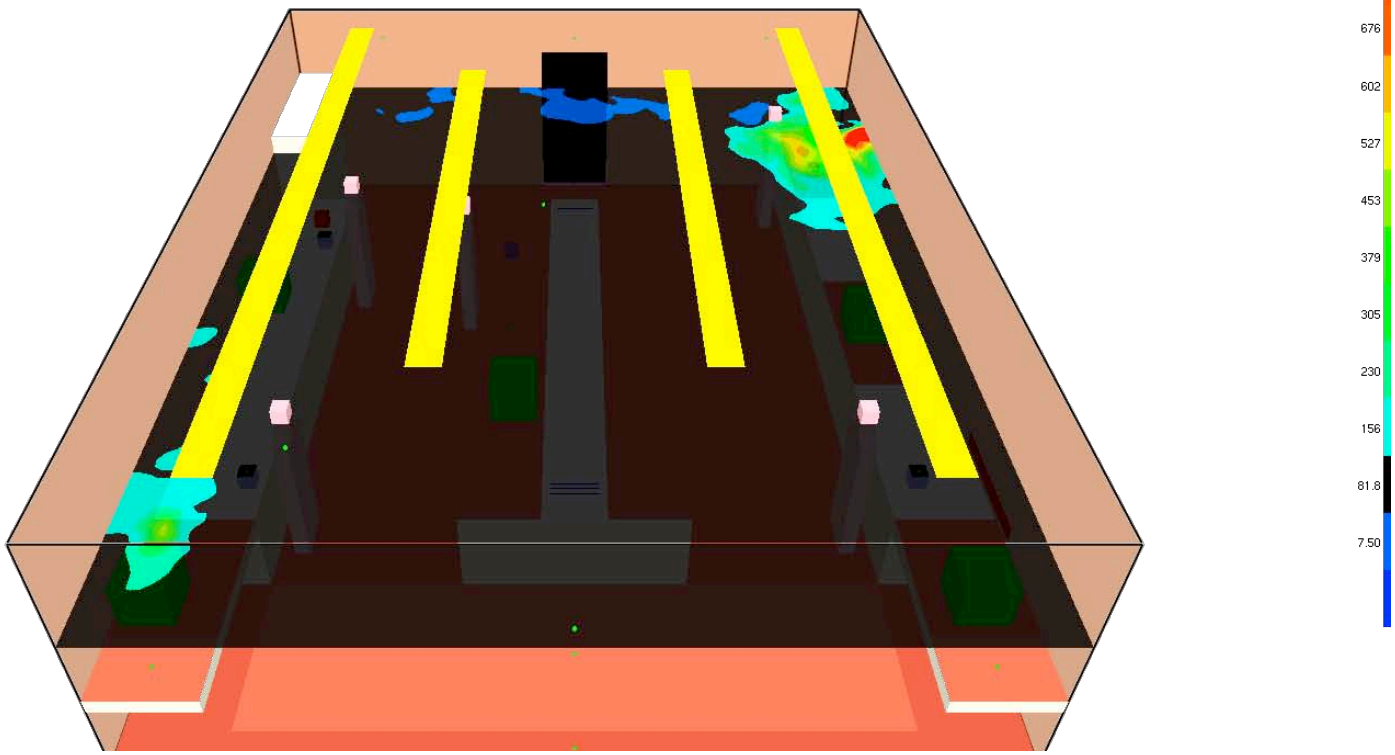


- **2011 ASHRAE Handbook, Lab chapter 16:**
  - ✓ **…recent university research (Klein et al. 2009) showed a significant increase in dilution and clearing performance by increasing the air change rate from 6 to 8 ach with diminishing returns above 12 ach.**
  - ✓ **…This information indicates that minimum ventilation rates at the lower end of the 6 to 12 air change per hour range may not be appropriate for all laboratories.**
  - ✓ **…As the operation, materials, and level of hazard of a room change, an increase or decrease in the minimum ventilation rate should be evaluated.**
  - ✓ **…Active sensing of the air quality in individual laboratories is an alternative approach for dealing with the variability of appropriate ventilation rates, particularly when energy efficiency is important or when less may be known about the hazard level.**

Using a single ACH rate such as 6 ACH is not appropriate. Yale research shows a significant difference from 6 to 8 ACH.

Impact of Higher Air Changes

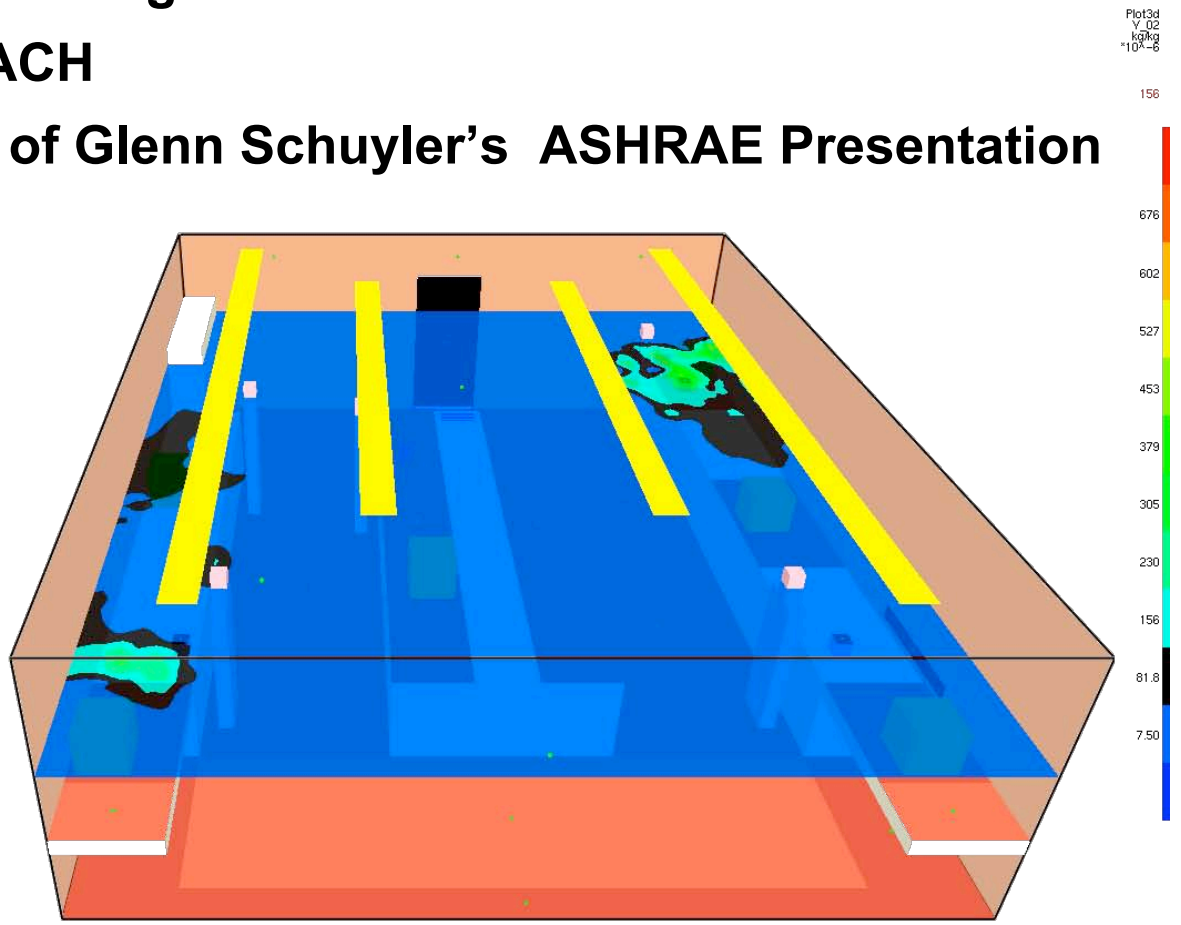
- Test Case– Teaching Lab
- Acetone at 4 ACH
- CFD courtesy of Glenn Schuyler's ASHRAE Presentation



Relative contaminant level: 27 PPM (black)

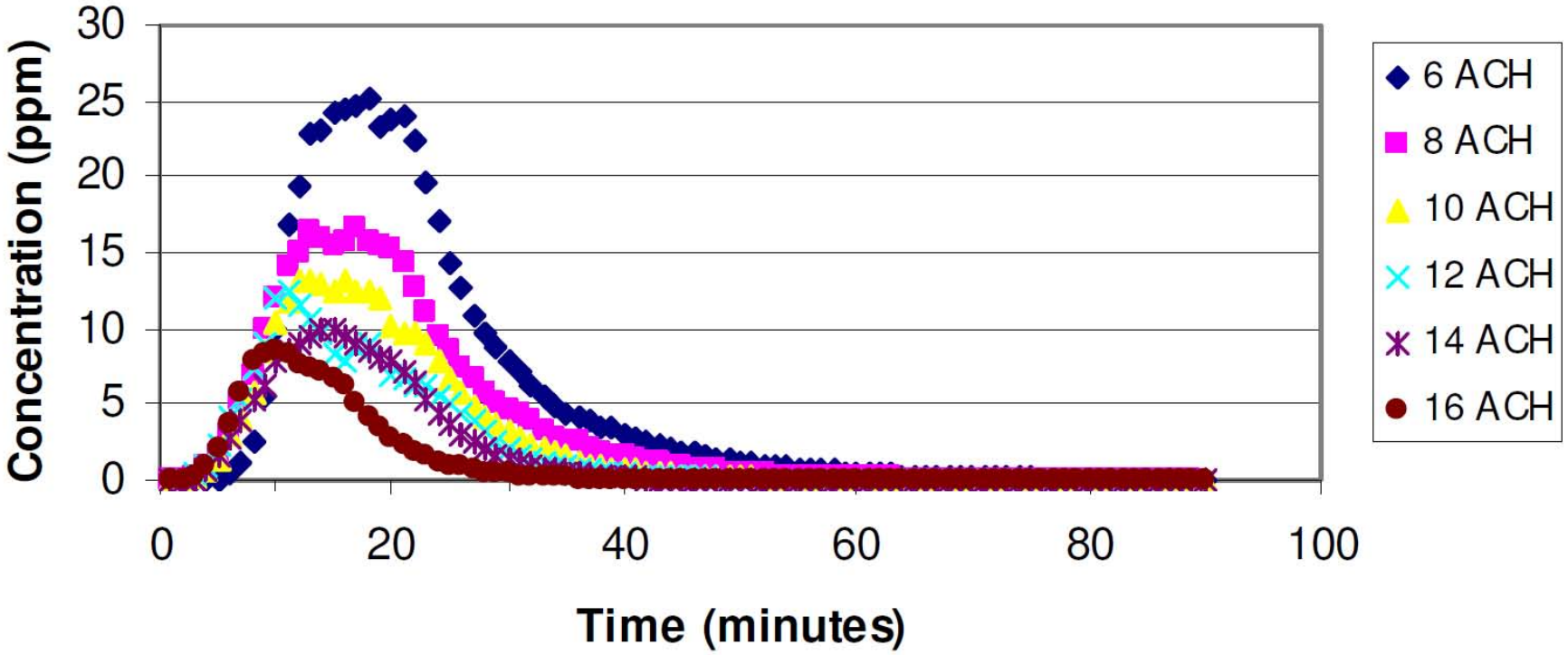
Impact of Higher Air Changes

- Test Case– Teaching Lab
- Acetone at 8 ACH
- CFD courtesy of Glenn Schuyler's ASHRAE Presentation



Relative contaminant level: 2.5 PPM (light blue):
Factor of 10 improvement!

Impact of Air Velocity on Actual Yale Spill Results



Significantly greater peak value at 6 ACH than at 8 ACH and above (almost twice as high)

Yale Research Results at 6 ACH vs 8 ACH

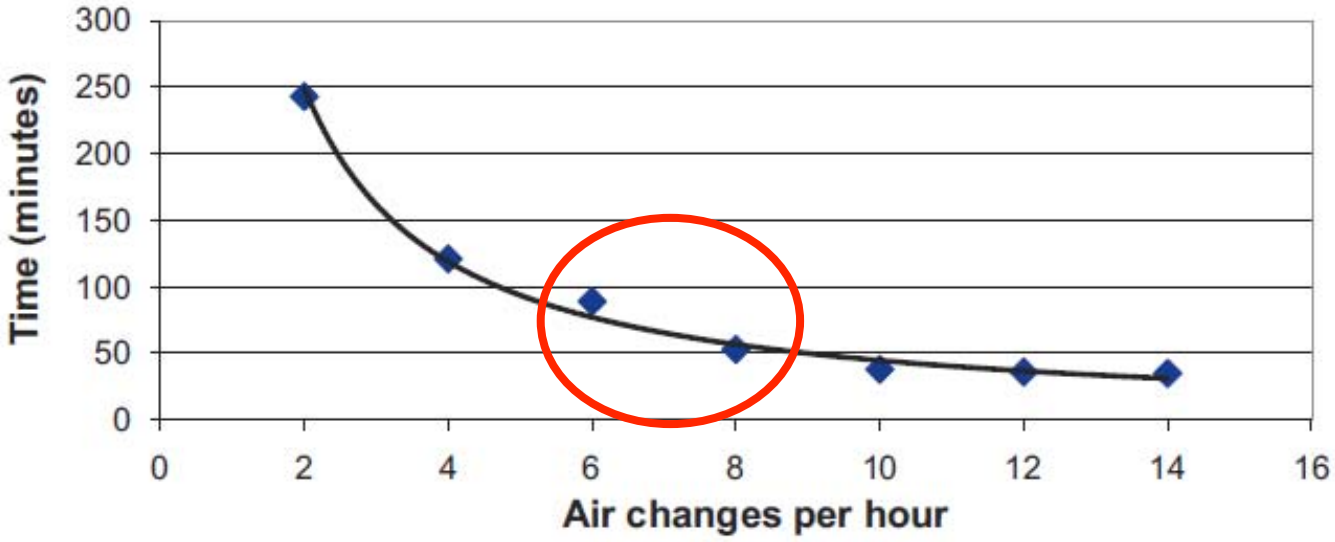


Figure 6. Clearance time to background levels after open bench-top releases of diethyl ether, by ACH rate, as measured by photoionization detection from the combined room exhaust duct centerline.

Clearance time at 6 ACH is significantly longer (almost twice as long) than at 8 ACH and above

Yale Research Results on 4 ACH vs. 6 ACH

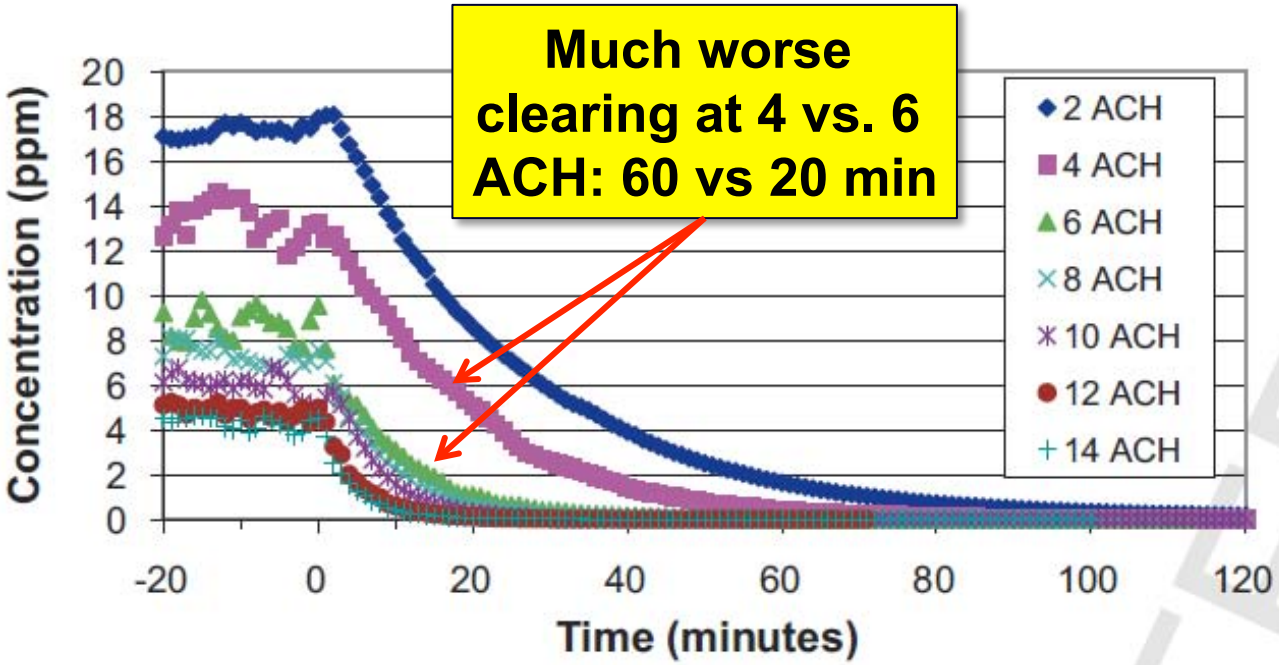
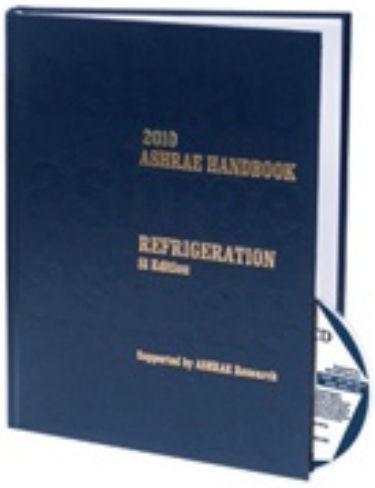


Figure 5. Chemical concentrations generated from open bench-top releases of diethyl ether under varying ACH rates, as measured by photoionization detection from the combined room exhaust duct centerline. Containers were left open for approximately one hour to achieve stable concentrations, and then recapped to observe differences in the speed of chemical removal from room air. The graph shows the last 20 minutes of open container evaporation, recapping of all containers at "0" time, and then the first 120 minutes of subsequent clearance time. Although not shown on the graph due to scaling, clearance time to background took nearly 250 minutes at the 2 ACH rate.

ASHRAE Provides Performance Based Guidance

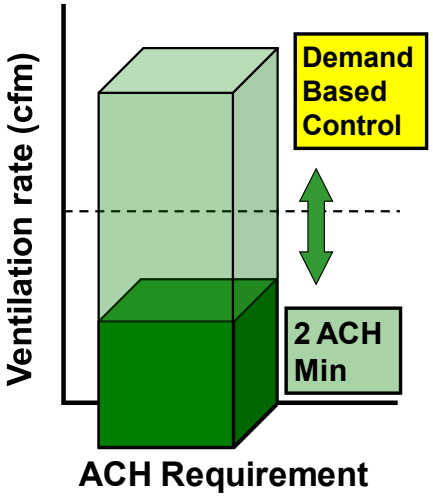
- **New 2011 ASHRAE Handbook, Lab chapter 16:**
  - ✓ **Active/Demand Based Control is recommended:**
    - *"Reducing ventilation requirements in laboratories and vivariums based on real time sensing of contaminants in the room environment offers opportunities for energy conservation."*
    - *"This approach can potentially reduce lab air change rates down safely to as low as 2 air changes per hour when the lab air is 'clean'..."*

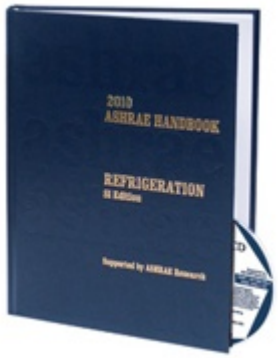


Potential for significant energy saving to reduce ACH rates down to 2 ACH when a system is used to sense contaminants

What about Occupied/Unoccupied Control

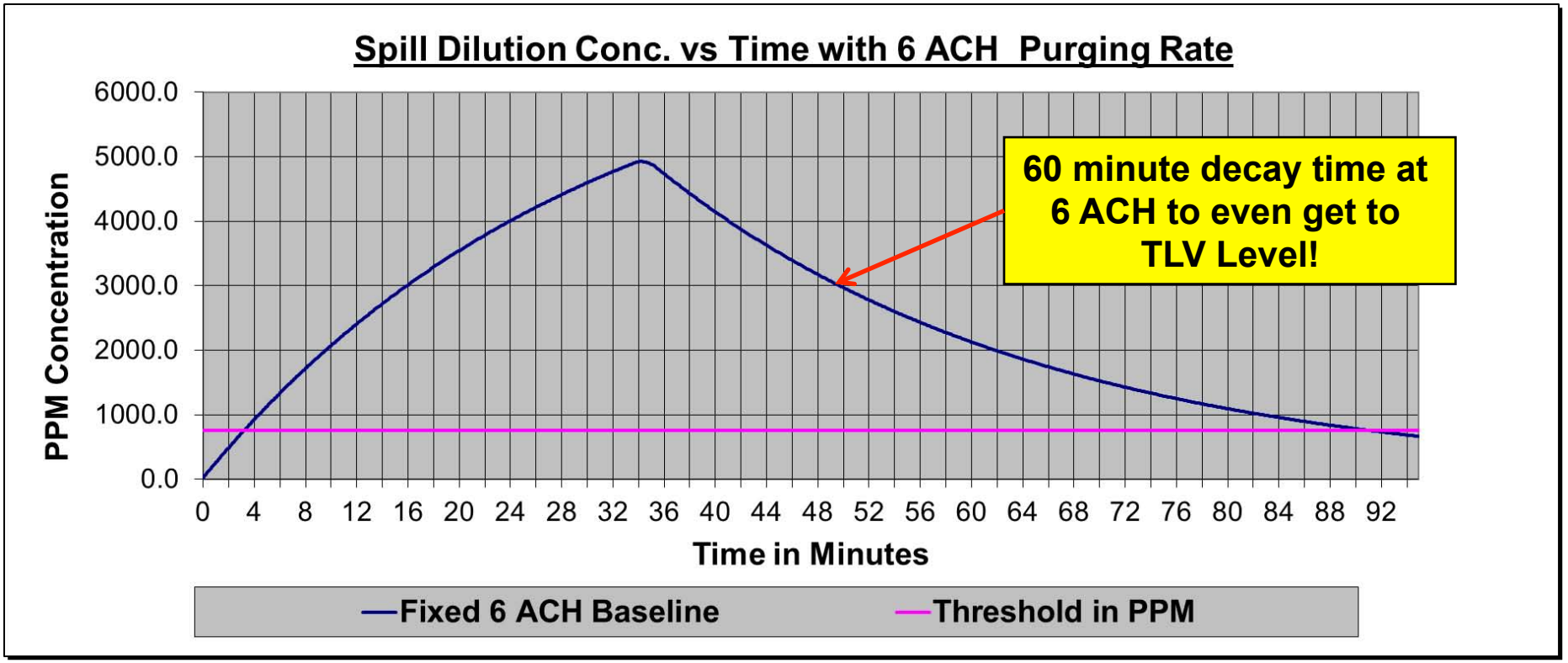
- One approach to reduce airflow:
  - ✓ Reduce airflow slightly during unocc periods
  - ✓ For example 8 ACH occ. and 6 ACH unocc.
- This has been used, but is it really safe?
- 2011 ASHRAE Handbook, Lab chapter 16:
  - ✓ Occ/Unocc Control scope is being limited:
  - ✓ "There should be no entry into the laboratory during unoccupied setback times"
  - ✓ "…Occupied ventilation rates should be engaged possibly one hour or more in advance of occupancy to properly dilute any contaminants."





Occ/Unocc control best used *only* when lab room access can be controlled

The Slow Response of Dilution Ventilation



- 1.5 L spill of acetone in 20 sq. m lab room, 1 sq. m spill
- After vaporized, 6 ACH still takes 60 minutes to even hit TLV
- After 2 hours 6 ACH Dilution ventilation is still at 302 PPM!

Dilution ventilation is slow & needs time to clear fugitive buildup

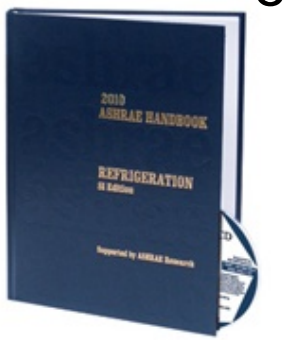
What about Vivarium Standard & Guidelines?

- **Vivarium ventilation requirements have been changing rapidly in the last few years**
  - ✓ **Moving to more performance based and use of VAV**

Further ASHRAE Handbook Vivarium Guidance

Performance Based Recommendations on ACH

- ✓ "The guideline of 10-15 fresh-air changes per hour has been used for secondary enclosures (the room) for many years and is considered an acceptable general standard. Although it is effective in many animal-housing settings, the guideline does not take into account the range of possible heat loads; the species, size, and number of animals involved; ….."
- ✓ "Active sensing of contaminants in the secondary enclosure and varying the air change rates based on the room environmental conditions is one approach that can be considered to meet these requirements in a more energy efficient manner."



DBC Favorable Language from the 2010 ILAR Guide:

Chapter 3: page 46 (Chapter 5: page 139)

- **VAV systems**

  "These systems offer considerable advantages with respect to flexibility and energy conservation, but should always provide a minimum amount of air exchange, as recommended for general use laboratories"

  "…but variable-volume (VAV) systems may offer design and operational advantages, such as allowing ventilation rates to be set in accordance with heat load and other variables."

aaalac INTERNATIONAL

AAALAC's Belief in Performance Based Criteria

Chapter 3: page 46 (Chapter 5: page 139)

VAV systems

Council interpretation:

- May allow for an air exchange rate below the previous guideline of 10-15 ach.
- Council will asses **overall air quality and air exchange rate using performance based criteria** that will take into account a variety of circumstances such as: cage type (ventilated cages vs static), whether IVC racks have supply and discharge air from the room (or directly to the building exhaust system), filtration of animal cage exhaust air (if any), animal density, husbandry practices and the overall needs of the animals and the science.
- Assessments will be made via the HVAC reports and on-site evaluations

Standards & Guidelines Presentation Summary

- Move to performance based versus prescriptive
- Ventilation rate requirements increasing
  - ✓ 8 ACH versus 6 ACH for effective purging
- Lower unocc control may not be advisable
  - ✓ Takes too long to dilute overnight pollutant buildup
- Demand based approaches now recommended

Questions?

For a copy of the presentation, contact:
Gordon Sharp, gsharp@Aircuity.com