Ventilation, IAQ and Money

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The youniversal Facility Management Experience

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Goals of Ventilation Study

- Determine Ventilation levels needed to Optimize Indoor Air Quality
- Meet requirements of applicable Building Codes, Regulations and Standards
- Minimize risk of liability from IAQ claims
- Optimize energy use

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Building Code Requirements

- Florida Building Code
- ANSI/ASHRAE 62.1 – 2007 with amendments

ANSI/ASHRAE Standard 62.1-2007
(Supersedes ANSI/ASHRAE Standard 62.1-2004)
Includes ANSI/ASHRAE Addenda listed in Appendix I

ASHRAE STANDARD

Ventilation for Acceptable Indoor Air Quality

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Acceptable Indoor Air Quality

- Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more of the people exposed) do not express dissatisfaction.
    - ASHRAE 62.1

Acceptable Indoor Air Quality

- Contaminants maintained at or below acceptable levels
- High quality educational / work environment
- Prevent microbiological contamination

Contaminants of Concern

- Carbon Monoxide
- Total Volatile Organic Compounds (TVOCs)
- Particulate (Respirable)
  - < 10 micrometer (PM_{10})
- Microbiological growth
- Carbon Dioxide
  - Surrogate for Bioeffluents (odors)

Controlling Contaminants

- Reduce sources
  - EPA Tools for Schools
  - American Lung Association – Asthma Friendly School
  - Low VOC cleaning and supplies
  - Low VOC construction materials
- Remove unavoidable contaminants at their source
  - Exhaust ventilation
- Good housekeeping and mechanical filtration
  - Removes particulate
- Prohibit Smoking

Ventilate

- Bring clean air into space
  - Filtered and conditioned outside air
  - Filtered and processed return air
- Filter out contaminants of concern
  - Particulate filter (MERV 8-13)
  - VOC filter
  - CO_2 scrubber

Case Study

South Florida School District

Study Specific to South Florida Schools

- Schools built to District standards
- Operated and maintained to District standards
- Located in the hot humid environment of South Florida

MZA IAQ Ventilation Study

- Determine if building in IAQ program met ASHRAE 62.1 requirements under the IAQ Procedure
- Study based on measurements of actual contaminant levels in 42 schools

	Schools	Rooms
Elementary	31	76
Middle	7	42
High	4	26

Methods of Compliance

- Florida Building Code
  - 15 CFM per student
- ASHRAE 62.1-Ventilation Rate Procedure
  - 10 CFM per student + 0.12 CFM/SF
- ASHRAE 62.1-IAQ Procedure
  - As required to maintain acceptable IAQ in a specific building in a specific climate

Ventilation Rate Procedure

6.1.1 Ventilation Rate Procedure. This is a prescriptive procedure in which outdoor air intake rates are determined based on space type/application, occupancy level, and floor area. **Note:** The Ventilation Rate Procedure minimum rates are based on contaminant sources and source strengths that are typical for the listed space types.

ASHRAE 62.1

Ventilation Rate Procedure

- 10 CFM / student + 0.12 / SF
  - Prescriptive
  - Ventilation rates set forth in tables
  - Based on typical buildings and national averages – mainly office buildings
  - Based on national average weather conditions
  - Easy to implement – pick numbers off a chart
  - No knowledge of building required
  - No credit for good IAQ practices
  - No credit given for good O&M

TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 or #/100 m^2	cfm/person	L/s•person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Day room	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Classrooms (ages 5-8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9	E	25	17	8.6	-
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3		35	12	5.9	1
Multi-use assembly	7.5	3.8	0.06	0.3		100	8	4.1	1

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IAQ Procedure

6.1.2 IAQ Procedure. This is a design procedure in which outdoor air intake rates and other system design parameters are based on an analysis of contaminant sources, contaminant concentration targets, and perceived acceptability targets. The IAQ Procedure allows credit to be taken for controls that remove contaminants (for example, air cleaning devices) or for other design techniques (for example, selection of materials with lower source strengths) that can be reliably demonstrated to result in indoor contaminant concentrations equal to or lower than those achieved using the Ventilation Rate Procedure. The IAQ Procedure may also be used where the design is intended to attain specific target contaminant concentrations or levels of acceptability of perceived indoor air quality.

IAQ Procedure Based on

- Analysis of contaminant sources
- Contaminant concentration targets
- Perceived acceptability targets
- Allows credit for controls that remove contaminants

IAQ Procedure

- As Required to maintain acceptable IAQ
  - Determined by measurement of contaminants during actual operation of building
  - Based on specific building
  - Based on a specific climate
  - Requires sophisticated synergy of Engineering and Industrial Hygiene
  - Specific to a building
  - Credits good building hygiene

Measured Air Flow

Measured and Logged Contaminant Levels

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Found the Good, Bad and Ugly

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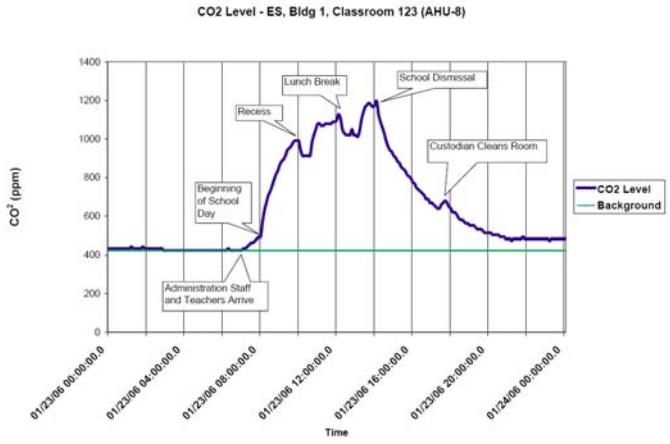
MZA Study Findings

- Contaminants of Concern below required levels at even low ventilation rates
- Required Ventilation rate governed by:
  - CO_2
  - Humidity

Carbon Dioxide

- "Maintaining a steady-state CO_2 concentration in a space no greater than 700 ppm above outdoor air levels will indicate that a substantial majority of visitors entering a space will be satisfied with respect to human bioeffluents (body odor)"
  - ASHRAE 62.1 Appendix C

Typical CO_2 Trend



Carbon Dioxide

- Student occupied time of typical South Florida Schools too short for CO_2 to reach equilibrium – "steady-state"
- CO_2 can be used as a surrogate for other exposures

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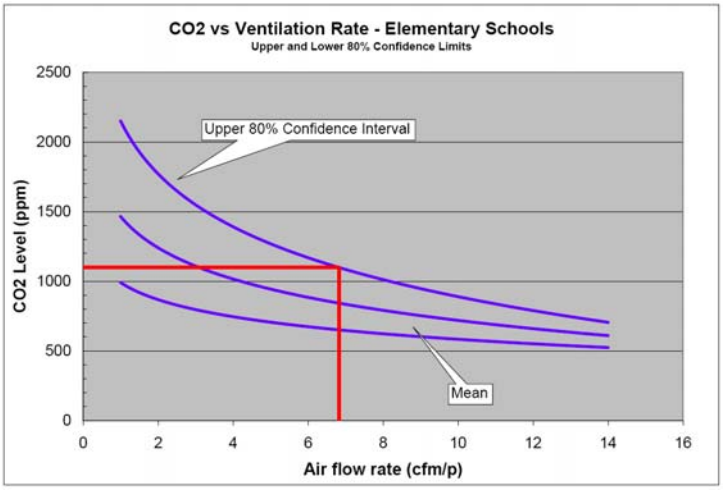
Acceptable CO_2

- 80% of occupants satisfied
- Measured by upper 80% confidence limit
- Criterion of 700 parts per million (ppm) above outside levels (1,100 – 1,200 ppm) used as surrogate for bioeffluents

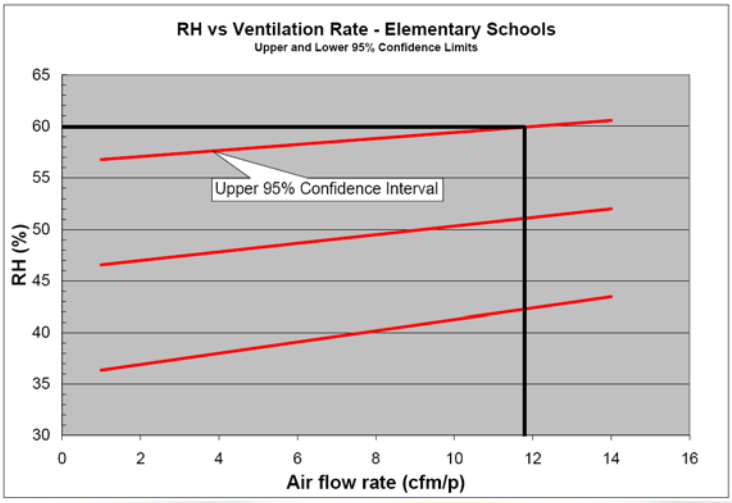
CO_2 vs Ventilation Rate



Acceptable Risk of RH

- 60% RH criterion
- Environmental issue
- Measure by upper 95% confidence limit

RH vs Ventilation



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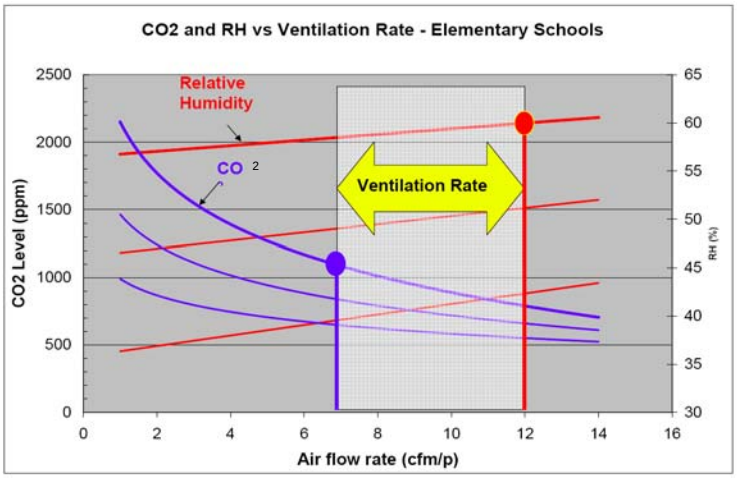
CO_2 & RH vs Ventilation Rate



Conclusions

- If ventilation rates are below 7.5 CFM / student there is an 80% chance that CO_2 levels will exceed 1,100 ppm
- If ventilation rates exceed 12 cfm there is a 95% certainty that humidity in the school will exceed 60% with the attendant risk of mold growth

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Optimal Ventilation Rate

- 7.5 CFM/Student is the optimal ventilation rate for existing facilities in this South Florida school district
  - Increased rates carry a risk of high humidity leading to mold growth
  - Reduced rates lead to an increased risk of elevated levels of CO_2
- Reduces Energy Use
  - Estimated potential $3,000,000 in savings per year
- Reduces Construction Costs
  - Estimated at $25,000,000 for IAQ Program schools alone

Minimizing Risk

- IAQ Procedure reduces District risk
  - Ventilation rate based on actual measurements in District schools rather than national averages from all climates
  - Following the prescriptive "Ventilation Rate Procedure" carries substantial risk of liability due to mold and other moisture related issues

End of Case Study

Risk Assessment

- Risk of claim assertions can be minimized by a formal Risk Assessment
- Role of competing risks – mold vs CO_2 can be more accurately determined
- Risk of health consequence due to mold, bacteria, asthma, etc. from high humidity can be more exactly assessed and compared to potential health consequences of increased CO_2
- Provides a scientifically supported health basis for ventilation rates

Implementation of IAQ Procedure

- Identify Contaminant Sources
- Determine Contaminant Concentrations
- Specify Criteria for Perceived Indoor Air Quality
- Describe Design Approach
- Document Compliance with requirements of ASHRAE 62.1 IAQ Procedure

Documentation

- Contaminants of Concern Considered
- Sources and Strengths of Contaminants
- Target Concentration Limits, Exposure Periods and References for limits
- Design approach to control contaminants
- Justification for Design Approach
- Contaminant Monitoring and Occupant Evaluation to Demonstrate Compliance

Steps to implement IAQ procedure

- Industrial Hygiene – IAQ study of building
- Mechanical Engineering - Mechanical evaluation of HVAC equipment
- Engineering design of ventilation solution
- Post construction testing and validation of results
  - Test and Balance
  - Industrial Hygiene – contaminant measurement

Setting up a program

- Perform formal risk analysis
- Test newly constructed facilities
- Prioritize facilities for implementation
  - Areas with high ventilation rates
  - Areas with existing IAQ problems
  - Areas with mold and moisture issues
  - Areas with manual fans
- Fund program through energy savings

New Construction

- Tested buildings were “mature buildings” with construction materials that have completely out-gassed years ago
  - Test program in a new building required before adapting ventilation standard for new construction
  - Required ventilation rate for new construction may be higher during first several years of occupancy during out-gassing of materials – temporary ventilation may be an option.
  - Commissioning including purge and bake-in cycles may be beneficial to speed off-gassing of construction materials
  - Temporary dehumidification may be needed during “drying in” of building.
  - Additional data needs to be collected for contaminant sources related to new building materials. i.e. Formaldehyde

Energy Savings

- 7.5 cfm fresh air / student as opposed to 15 cfm / student estimated to save $3,000,000 per year in energy costs
- Further energy savings possible from
  - Controls optimization
  - Retro Commissioning
  - Optimizing air flow and controls

Energy Savings in IAQ Program

- Occupancy sensors - lighting control
- DDC controls
- Demand control on ventilation – CO_2 control
- 3:00 PM ventilation shut down

Additional Opportunities for Savings

- Areas with Manual Fans
  - Toilet exhausts
    - Install occupancy sensors
  - Kitchen vents
    - CO_2 controls
- Control Fresh Air Dampers
- Reduce Ventilation in under occupied areas

Fast Payback Energy Savings

- Initiate a controlled summer shut down
- Seal vented ceiling spaces
- Control toilet room exhaust
- Control outside air
- Daylighting - Lighting Controls
- DDC controls / CO2 Controls
- Electric Demand Savings – load shedding
  - Duty cycle
- Chiller optimization
  - Optimize start
  - Optimize shut down

Other Savings

- Non energy related cost savings
  - Asset inventory – cost optimization of maintenance
  - Cost optimization of HVAC and building envelope retrofit
  - Construction cost optimization
    - Control of project uncertainty
    - Control of change orders
    - Bulk purchase

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