Indoor Air Quality in HVAC Systems

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Agenda

- Purpose
- Quality Building Environments
- Need for Improved Indoor Air Quality (IAQ)
- Options for Improving IAQ

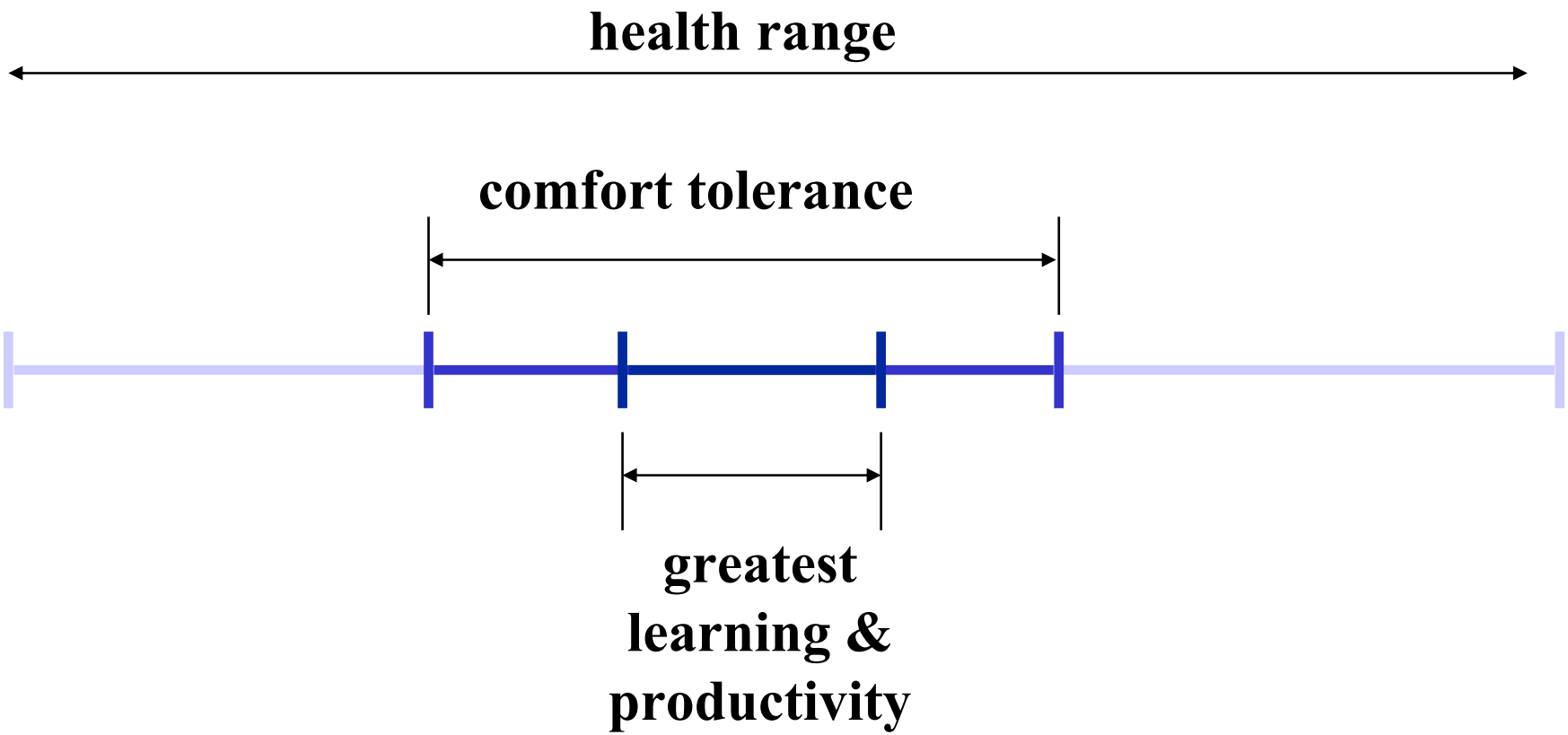
What is a Quality Building Environment?

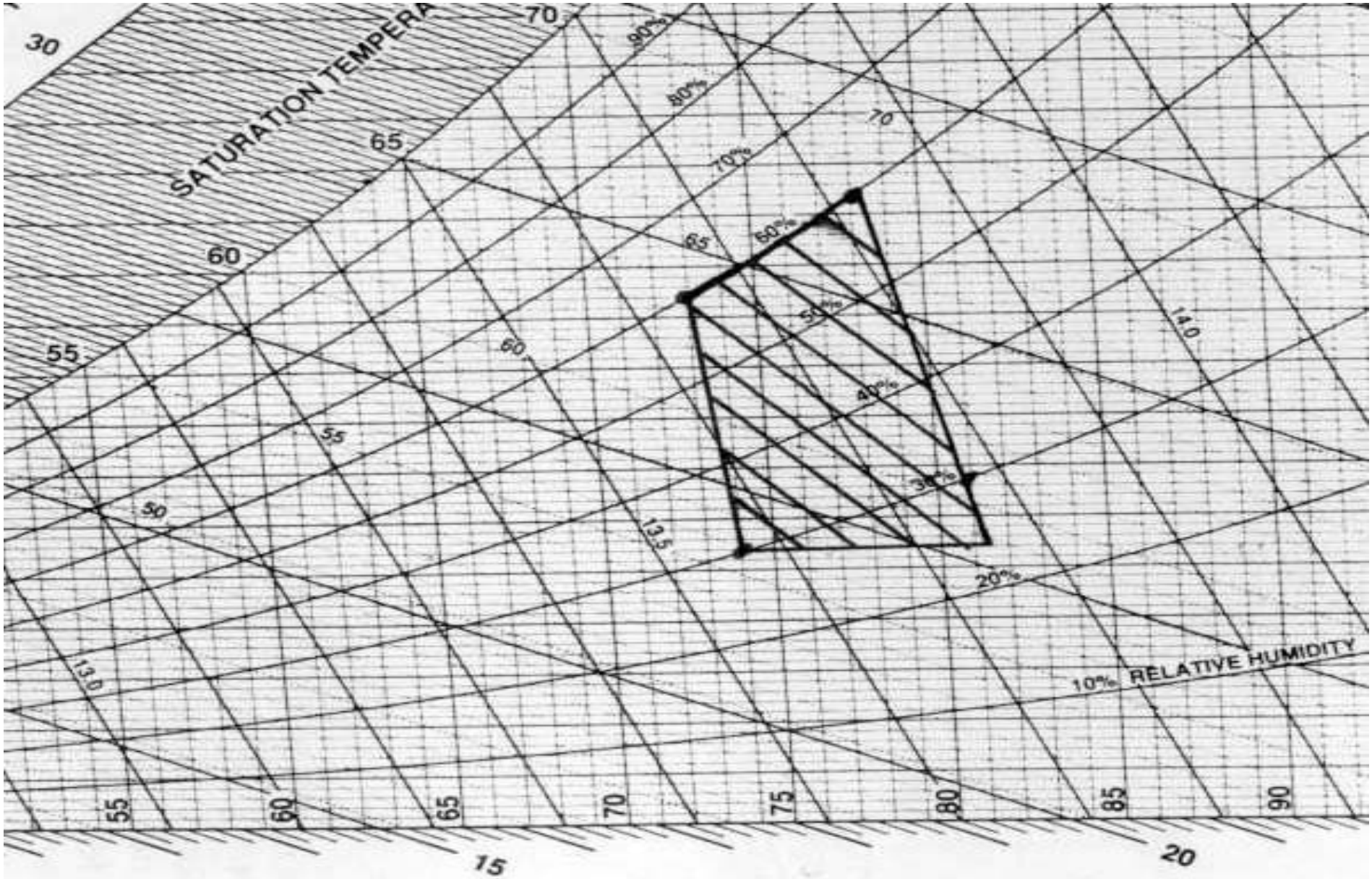
- ***"A Quality Building Environment is one that is healthy, comfortable, productive, secure and provided in a financially sound manner"***

QBE & Human Response

- 20-30 year old Americans spend 90-95% of their time in artificial environments
- Brain, 2% of body weight, 20-25% of energy consumed
- Brain under stress, redirects all energy to cellular survival
- Body can overcome 1 environmental stress, but 2 begin to diminish productivity
- HVAC systems control contaminants, and provide thermal comfort

QBE Effects on Learning and Productivity





ASHRAE COMFORT RANGE :

Common Indoor Contaminants, Symptoms and Sources

- **Molds, bacteria, virus and other microbes**
  - Allergic reactions
  - Respiratory problems
  - Odors
  - Sinus problems
  - Legionnaire's Disease

  → Mold, mildew, leaks and water damaged surfaces, HVAC system coils and drip pans, people, cooling towers, outdoor air

- **Formaldehyde**
  - Eye and skin irritation
  - Suspected carcinogen

  → Particleboard, plywood, furniture, cleaners, glues/resins

- **Volatile Organic Compounds**
  - Odor
  - Headache
  - Eye and respiratory irritation

  → Solvents, paints, adhesives, building materials, waxes/polishes, pesticides, binders, copiers & printers

Common Indoor Contaminants, Symptoms and Sources

Sources

- **Particulates**
  - Eye and Skin Irritation
  - Respiratory Problems
  - Sinus Problems

  → Foot Traffic, Carpet, Copiers, Printers, Infiltration Air, Inadequate Filtration

- **Thermal Conditions**
  - Discomfort
  - Sleepiness and Fatigue

  → Improper Temp. or RH, Drafts, Direct Solar Heat

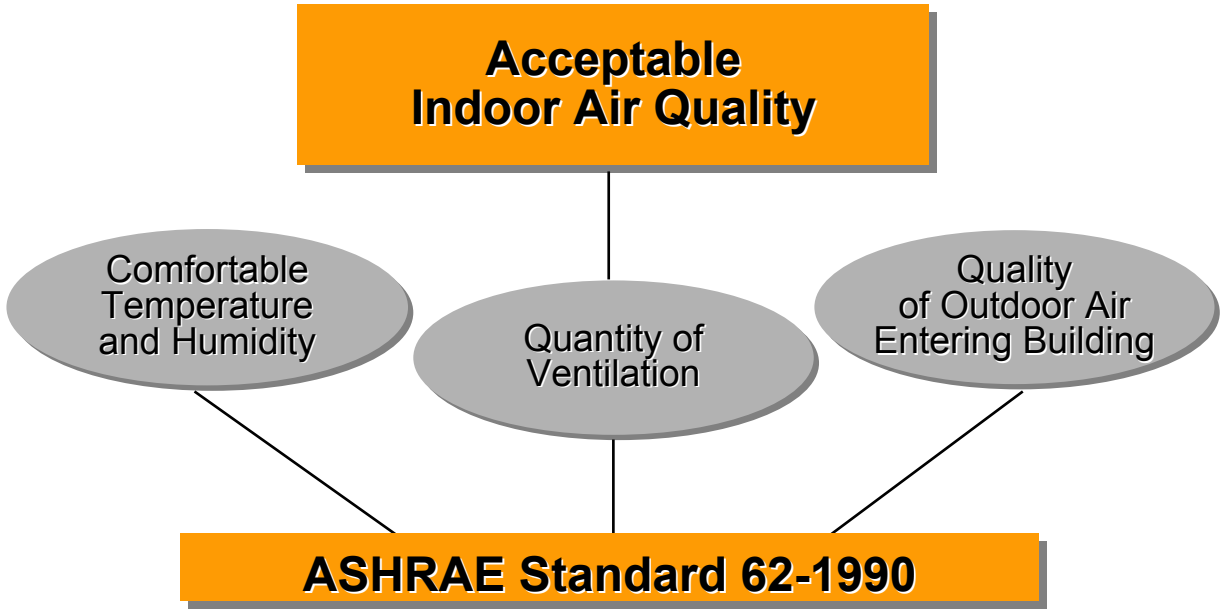
Traditional Methods……..

- *Calculate expected occupancy*
- *Calculate outdoor air flow rates at 5 CFM per person.*
- *Set the outdoor air dampers to a mechanically fixed minimum position, based on those design conditions.*

Why is there a need for accurate ventilation control?

- Risks of Under-ventilating
  - Poor IAQ and complaints
  - Inadequate make-up air and negative pressurization
  - Potential regulatory non-compliance and increased liability
- Risks of Over-ventilating
  - Increased heating and cooling requirements
  - Warm climates--increased need for dehumidification
  - Cold climates--too much dry air
  - Generally, more energy consumption

ASHRAE Standard 62-2001



Indoor Air Quality Procedure

(Demand Controlled Ventilation: based on all contaminants)

Infrequently used due to cost and unreasonableness.

Ventilation Rate Procedure

(Prescriptive OA Ventilation Rate per person or per sq ft of space)

Predominant method of compliance.

ASHRAE 62-2001

Acceptable Outdoor Air Standards

Area	CFM/Person	Persons/1000 ft2
• Classroom	15	50
• Auditorium	15	150
• Office	20	7
• Hospital PR.	25	10
• Hospital OR.	30	20
• Bars	30	100
• Retail	20	20

ASHRAE Standard 62-2001

Indoor Air Quality Procedure (IAQP): Not realistic given current technology

- "*Measure and control*" method
- Limited contaminant standards
- Limited monitoring technology for cost-effectively "...*restricting concentration of all known contaminants of concern*..."
- Human response to contaminant mixtures is not well understood

ASHRAE Standard 62-2001

Ventilation Rate Procedure (VRP)

- Prescriptive ventilation based on occupancy type and level (min. 15 CFM/person, 20 CFM/person for offices)
- Based on dilution of contaminants and ventilation flow measurement; contains provision to maintain air flow as VAV supply air flow decreases
- Designs require documentation of assumptions made and procedures used; thermal conditions must be in accordance with ASHRAE Std. 55-1992
- "*When mechanical ventilation is used, provision for air flow measurement should be included.*"

What about the costs of conditioning the additional outdoor air ?

- Lawrence Berkley Lab study...
- *Increased Outdoor Air flow from 5 CFM to 20 CFM per person.*
- *Less than 5% increase in utilities costs.*
- *Typical utilities costs approximately $2 per square foot.*
- *Typical rent approximately $20 per square foot*
- *Occupant salaries approximately $200 per square foot annually.*

Some Requirements and Methods for Providing a QBE

- Green Building Design Standards
- Manual Air Testing and Balancing
- Proper System Maintenance
- CO2 Monitoring
- Outdoor Air Flow Stations
- CO2 Mass balance equation

CO_2 Demand Controlled Ventilation

- Directly measure and control CO_2
- CO_2 concentration controlled via OA damper
- Not based on outdoor air measurements but rather just CO2
- Will not meet requirements of ASHRAE Standard 62-2001
  - IAQP considers *"...all known contaminants of concern..."; control of CO_2 alone is insufficient*

Outdoor Air Flow Stations

- Outdoor Air flow measuring stations' cost rises as the size of the AHU increases
- Need for costly mechanical retrofit to accommodate ductwork or other mechanical configuration requirements.
- Will not detect re-entrainment of exhaust air.

Mass Balance Equation

$$Flow_{oa} = \frac{CO_{2ra} - CO_{2sa}}{CO_{2ra} - CO_{2oa}} * Flow_{sa}$$

Mass balance equation where

- $Flow_{oa}$ = Outdoor air flow rate
- $Flow_{sa}$ = Supply air flow rate
- CO_{2ra}, CO_{2sa} and CO_{2oa} = CO_2 concentrations of return, supply and outdoor air respectively

Summary

- When designing or retrofitting, consider TOTAL QBE
- Meet all ASHRAE standards for Temperature, humidity *and* ventilation.
- Value of implementing QBE far exceeds costs