Indoor Air Quality for Non-Industrial Settings

Student Manual

BWC Division of Safety and Hygiene
Ohio Center for Occupational Safety and Health
Revised July 2003
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BUILDING AIR QUALITY:
A Guide for Building Owners and Facility Managers (EPA)
 Basics
 Preventing IAQ Problems
 Resolving IAQ Problems
 Appendices
 Blank Forms

SEPARATOR SHEET
COURSE OBJECTIVE

Students will be able to understand how to anticipate, recognize, evaluate and control IAQ problems in non-industrial environments, including the use of various tools and reference materials which apply these concepts to the workplace.
AGENDA

DAY 1
8:30 COURSE INTRODUCTION
STUDENT INTRODUCTIONS
AWARENESS SURVEY
OVERVIEW OF IAQ
  1. Statement of Problem
  2. Cost benefit analysis
  3. Why is improving IAQ important?
STANDARDS & CODES

11:45 LUNCH
12:45 RESPIRATORY SYSTEM Anatomy & Physiology
INTRODUCTION TO HVAC
  1. Properties of Air
  2. Temperature/Humidity
  3. Impact on IAQ

4:30 ADJOURN

DAY 2
8:30 CONTROL HIERARCHY
CONTAMINANTS
A-REC MODEL
  1. Building & occupant issues
  2. Chemical
     a) CO
     b) Formaldehyde
     c) VOC (paints, coatings, adhesives, etc.)
     d) Particulates
AGENDA CONTINUED

DAY 2 continued

HVAC
1. Ventilation
2. Temperature/humidity control
3. Air distribution
4. HVAC system contamination
5. Air filtration

11:45 LUNCH
12:45 INVESTIGATION and EVALUATION of IAQ PROBLEMS
   1. Building Surveys
      a) Walk-through
      b) HVAC system inspection
   2. Employee Surveys

CASE STUDY EXERCISE

FIELD EXERCISE

SUMMARY

4:30 ADJOURN
INSTRUCTORS

Gary Chambers

Instructor for Indoor Air Quality, Occupational Respiratory Protection, and Violence in the Workplace

Gary Chambers has been involved with occupational safety since 1981. He has worked as a safety program manager for a multi-site public utility. Since 1986, he has been a staff industrial hygienist for the Division of Safety & Hygiene, State of Ohio Bureau of Workers’ Compensation. He performs industrial hygiene consultative services as well as gives training in a variety of industrial settings. A particular area of interest is confined space evaluation and training.

Gary has a B.A. in Economics from Heidelberg College and an M.S. in Preventive Medicine from The Ohio State University. He has given numerous presentations on a variety of topics at local, regional, and national conferences. Occasionally, he also teaches for the OSHA Training Institute.

Gary is a member of the American Industrial Hygiene Association (AIHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Academy of Industrial Hygiene. He is certified in the comprehensive practice of industrial hygiene (certificate #6120). He currently serves on the AIHA Confined Spaces technical committee.
Tim Fiorilli

*Instructor for Indoor Air Quality*

Tim Fiorilli has a Bachelor of Science degree in Environmental Health Science from Cleveland State University. Tim has over 19 years experience in safety and health including joining the Division of Safety & Hygiene in 1979 and over three years with the EPA. Tim is a member of AIHA and ACGIH. He has been actively involved in Indoor Air Quality (IAQ) and Indoor Air Quality studies since 1985.

Rich Patnode

*Instructor for Indoor Air Quality*

Rich Patnode did his graduate work at Central Missouri State University. He has been a practicing industrial hygienist since 1978 and has been a Certified Industrial Hygienist (CIH), since 1983. Rich began his hygiene career with the US Army as a civilian employee at Fort Leonard Wood, Missouri. He then joined the Health Hazard Evaluation (HHE) staff at the National Institute for Occupational Safety and Health, NIOSH, first in Cincinnati, and later with the Division of Respiratory Disease Studies in Morgantown, West Virginia.

After five (5) years with NIOSH, Rich joined the Division of Safety and Hygiene in 1984 where he performs a wide range of industrial hygiene services including serving as an instructor. Rich was actively involved with the development of three (3) courses when OCOSH was in its infancy. He participates in several OSHA 10-hour training modules conducted by the Warren Service Office and has recently joined the IAQ Team.
Gary Swinehart

Instructor for Indoor Air Quality

Gary Swinehart is an industrial hygienist with the Division of Safety and Hygiene. Gary has been a staff industrial hygienist for the Division of Safety and Hygiene, State of Ohio Bureau of Workers’ Compensation since 1986. He performs industrial hygiene consultative services in a wide range of industries and topics.

Gary has a B.A. in Biology from Wittenberg University and attended graduate classes at the University of Cincinnati Department of Environmental Health. Gary is a member of the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Academy of Industrial Hygiene. He is certified (since 1994) in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygienists (ABIH).
AWARENESS SURVEY

1. Which of the following are reasons for concern about indoor air today?
   a. people spend most of their time indoors
   b. the use of natural ventilation has decreased
   c. many buildings and furnishings are produced from synthetic chemicals
   d. all of the above

2. Which is most likely to be a potential source of formaldehyde?
   a. particleboard subflooring
   b. roofing felt
   c. paint
   d. solid hardwood floors

3. Volatile organic compounds (AKA VOCs) are most likely to be released from which of the following sources?
   a. asbestos insulation
   b. an area with newly installed carpet
   c. a recently poured concrete basement floor
   d. old, dirty carpet

4. If a house has a volume of 15,000 ft³ and air is replaced at a rate of 500 ft³ per minute, how many air changes are occurring each hour (expressed as “ach”)?
   a. 0.5 ach
   b. 1.0 ach
   c. 2.0 ach
   d. 0.25 ach

5. Which term correctly identifies the occurrence of eye, nose, and throat irritation experienced by a person who walks into a new home?
   a. acute effect
   b. chronic effect
   c. homeitis effect
   d. delayed effect

6. Which of the following determines whether or not health effects will result from exposure to indoor contaminants?
   a. physical properties of the contaminant
   b. age and body size
   c. humidity level
   d. all of the above

7. Internal nose hairs are useless evolutionary structures.
   a. true
   b. false
8. Which of the following is most likely to be associated with dry air?
   a. fatigue
   b. chest pain
   c. irritation of the eyes, nose, and throat
   d. profuse sweating

9. Which of the following contaminants could result from the use of a heat exchanger or evaporative cooler? (Note: mark all that apply.)
   a. carbon monoxide
   b. hydrogen sulfide
   c. nitrogen dioxide
   d. microorganisms

10. Which of the following statements about ASHRAE’s Standard 62-1989 (Indoor Air Quality Procedure) is correct?
    a. Acceptable indoor air quality is defined as air that does not have known harmful contaminants and 80 percent or more of the people exposed do not express dissatisfaction.
    b. Acceptable indoor air quality must be achieved by meeting acceptable concentrations of indoor air contaminants.
    c. The Standard recommends using a safety factor of 1/100 as a preliminary guideline for contaminants that are not specifically listed.
    d. The Standard is designed to provide protection to the entire population, including those who are especially sensitive to chemical exposures.

11. Which of the following are characteristics of VAV* systems?
    a. variable temperature
    b. variable volume
    c. control from one temperature sensor for each location
    d. provide both hot and cold air

12. Why may ventilation standards/guidelines be inadequate to protect indoor air quality in the U.S.?
    a. houses have been constructed at different times under different code or standard requirements
    b. some HVAC systems may be poorly maintained and not operated correctly
    c. although adequate openable window space may be available, it may not be used
    d. all of the above

*VAV = variable air volume
13. Which of the following statements about survey forms is not correct?

a. survey forms should collect data in a consistent manner  
b. form design is not difficult  
c. the confidentiality of collected information must be preserved  
d. survey forms can include questionnaires with both yes/no and open-ended questions

14. Which of the following is not important when obtaining data on health effects?

a. smoking history  
b. occupational history  
c. caffeine intake  
d. all are important

15. Which of the following explains why it is difficult to evaluate measurement results? (Mark all that apply.)

a. there are many different types of houses/structures  
b. the variability in human response to contaminants  
c. the lack of consensus on standards and guidelines  
d. the similarity of symptoms resulting from exposure to indoor air contaminants and stress

16. A given volume of humid air weighs __________ than the same volume of dry air

a. more  
b. less

17. Which can hold the greatest quantity of water vapor?

a. air at 100° F  
b. air at 98.6° F  
c. air at 55° F  
d. air at 30° F

18. ASHRAE Standard 62-1989 recommends that ____ CFM of outside air per person be supplied to non-smoking occupied office environments

a. 5  
b. 10  
c. 15  
d. 20  
e. 25

19. Energy-efficient buildings are the primary cause of IAQ problems today.

a. true  
b. false

20. Air sampling is a necessary step in performing a legitimate IAQ investigation.

a. true  
b. false
IAQ Overview

This course will cover:

- Standards and Codes
- Respiratory System
- HVAC
- Contaminants, Chemical and Biological
- How To Do An IAQ Investigation
- Planning to Prevent IAQ Problems
- Exercises and Case Studies

Typical complaints

- Upper respiratory irritation
  - Dry throat
  - Eye irritation
  - Coughing
- Headache, fatigue, inability to concentrate
- Congestion
- Dizziness and nausea
Cause of Symptoms

- Actual verifiable problem
  - Bacteria grow in HVAC system and distributed throughout building

- Nonverifiable, dissatisfied employees
  - Mass psychogenic disease - caused by suggestions that people should be feeling sick

Spectrum of causes

<table>
<thead>
<tr>
<th>Actual verifiable physical agent</th>
<th>Nonverifiable physical agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria throughout bldg</td>
<td>Mass psychogenic illness</td>
</tr>
</tbody>
</table>

IAQ Has Become An Issue

- Since 1973 tighter building construction
  - Energy conservation
  - Costs more to heat/cool outside air
  - Windows do not open
    - Less control over environment
    - Better individual adjustment
### IAQ Has Become An Issue
- New building and construction materials
- Large amount of time spent indoors
- Increased public awareness
- Increased % of population has asthma and allergies

### Importance of IAQ
- Productivity
- Desirability of rental properties
- Potential liability issues
- Good IAQ enhances occupant health, comfort, and morale

### Proactive Management
Building air quality should be managed like other aspects of the business.
Proactive Management

IAQ is influenced by a constantly changing interaction of employees and the building mechanical system.

COST BENEFIT ANALYSIS

IAQ Cost / Benefit Analysis

SECTION ONE

Ways to think about the economic impact of poor indoor air quality...
Costs of legal action:

“‘Sick Building’ workers get $1.5 Million”

*The Cincinnati Enquirer,*
August 16, 1997

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**Annual IAQ costs $60,000,000,000**

- this is the EPA’s estimate for costs to US businesses from IAQ problems
- most of the cost is the result of lost productivity
- the remainder: WC and health care

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**ENVIRONMENTAL PROTECTION AGENCY’S COST ESTIMATES**
Total Cost Estimate

Based on the following criteria:

- Material & Equipment Cost
- Direct Medical Cost
- Indirect Medical Cost
- Lost Production

Material & Equipment Damages
Bell Communication Research

$10,000 - $380,000 per event

Direct Medical Cost

Poor IAQ
Average 0.24 doctor visits/worker/year
Average cost per office visit = $40
Estimated work force = 64 million workers
64,000,000 x 0.24 visits x $40/visit = $614,400,000
Indirect costs
- loss in production
- investigation time
- cost of overtime or replacement worker
- employee morale
- cost to fix problem (possibly duplicates work that should have been done originally)

“Sick building” costs*
- assumption: 1% IAQ-related absenteeism rate
- $300 annual productivity losses per employee

*research from Healthy Buildings International

Lost Production
- Less effective because workers feel --
  fatigued,
  suffer from headaches
  eye irritation
- Accomplish less work per hour
- Spend more time away from the work location
Lost Production

EPA concluded --

- Average production loss of 3% due to poor IAQ
- Equivalent to 14 minutes/day in lost work time
- Average of 0.6 added sick days/worker

COST RECOVERY

Cost recovery

- **Labor Costs** - salary levels & occupancy load (150 square feet/person)
  - $100 to $300 per ft²/year
- **Energy Costs**
  - $1.00 to $2.00 per ft²/year
- **Total Environmental Control Costs**
  - $2.00 - $10.00 per ft²/year
Energy costs vs personnel costs

Energy costs are usually less than one percent of personnel costs.

Heating, ventilation, and air-conditioning (HVAC) & costs

- At 20 percent relative humidity, a room temperature of 86 degrees F is needed to match comfort of a 70 degree room at 50 percent relative humidity
- It is less expensive to add 30 percent humidity than to add 16 degrees!

Material & Equipment Damages

<table>
<thead>
<tr>
<th>Material</th>
<th>Damage</th>
<th>Air Pollutant</th>
<th>Other Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint &amp; organic coating</td>
<td>Surface erosion, discoloration, soiling</td>
<td>SO$_2$, H$_2$SO$_4$ Particulates</td>
<td>H$_2$O, sun, O$_3$, microbes</td>
</tr>
<tr>
<td>Textiles</td>
<td>Reduce tensile strength, soiling</td>
<td>SO$_2$, NO$_x$, particulates</td>
<td>H$_2$O, sun, O$_3$, physical wear</td>
</tr>
</tbody>
</table>
## Environmental Protection Agency
### Air Pollution Effects on Materials

<table>
<thead>
<tr>
<th>Materials</th>
<th>Types of Damage</th>
<th>Principal Air Pollutants</th>
<th>Other Environmental Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Corrosion, tarnishing</td>
<td>Sulfur oxides and other gases</td>
<td>Moisture, sea salts, microorganisms, particulate matter</td>
</tr>
<tr>
<td>Paint and organic coatings</td>
<td>Surface erosion, discoloration, soiling</td>
<td>Sulfur oxides, hydrogen sulfide, particulate matter</td>
<td>Moisture, sunlight, ozone, microorganisms</td>
</tr>
</tbody>
</table>

Source: EPA, 1987

### Environmental Protection Agency
### Air Pollution Effects on Materials, cont.

<table>
<thead>
<tr>
<th>Materials</th>
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<th>Other Environmental Factors</th>
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<tbody>
<tr>
<td>Textiles</td>
<td>Reduced tensile strength, soiling</td>
<td>Sulfur oxides, nitrogen oxides, particulate matter</td>
<td>Moisture, sunlight, ozone, physical wear</td>
</tr>
<tr>
<td>Textile dyes</td>
<td>Fading color, soiling</td>
<td>Nitrogen oxides, ozone</td>
<td>Sunlight</td>
</tr>
<tr>
<td>Rubber</td>
<td>Cracking</td>
<td>Ozone</td>
<td>Sunlight, physical wear</td>
</tr>
<tr>
<td>Ceramics</td>
<td>Changes surface appearance</td>
<td>Acid gases, HF</td>
<td>Moisture, microorganisms</td>
</tr>
</tbody>
</table>

Source: EPA, 1987

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**INDIRECT COSTS ARE 4 TO 10 TIMES THE DIRECT COST**

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BWC Division of Safety & Hygiene
Indoor Air Quality
Revised: July 2003
**Injury and Illness Costs**
- Medical
- Compensation costs (Insured costs)

**Ledger Costs of Property Damage**
- Building damage
- Tool & equipment damage
- Product & material damage
- Production delays and interruptions
- Legal expenses
- Expenditure of emergency supplies & equipment
- Interim equipment rentals
- Investigation time

**Uninsured Miscellaneous Costs**
- Wages paid for time lost
- Cost of hiring and/or training replacements
- Overtime
- Extra supervisory time
- Clerical time
- Decreased output of injured worker upon return
- Loss of business and good will
<table>
<thead>
<tr>
<th>CHOP: Main Elements of IAQ Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C</strong>ontaminants</td>
</tr>
<tr>
<td><strong>H</strong>VAC System Deficiencies</td>
</tr>
<tr>
<td><strong>O</strong>ccupant Behavior</td>
</tr>
<tr>
<td><strong>P</strong>athways</td>
</tr>
</tbody>
</table>
# Standards & Codes

## Standards or Recommendations?

What “standards”?

<table>
<thead>
<tr>
<th>OSHA</th>
<th>ASHRAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACGIH</td>
<td>OBBC</td>
</tr>
<tr>
<td>NIOSH</td>
<td>BOCA</td>
</tr>
<tr>
<td>EPA</td>
<td>HUD</td>
</tr>
</tbody>
</table>

## Risk Rankings

![Risk Rankings Chart](chart.png)
**OSHA & ACGIH (PELs & TLVs)**

Based on health effects to healthy adults of exposures for 8 hour days over a working lifetime

Issue: relevance to office setting where focus may be 1) comfort or 2) desire for absence of unusual sensory stimuli?

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**OSHA**

*Occupational Safety & Health Administration*

- IAQ standard on hold
- Nothing new
- Record-keeping is emphasized

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**NIOSH**

*National Institute for Occupational Safety & Health*

- Research arm for OSHA
- HHE* provide unique, valuable info on building related illnesses
- Provides useful specific guidance -- e.g., on CO₂ levels even though recommendations only

*Health Hazard Evaluations
NIOSH
National Institute for Occupational Safety & Health

Technical info: 1-800-356-4674

Publications: 1-513-533-8287
e.g., “Guidance For Indoor Air Quality Investigations” (1987)

EPA
Environmental Protection Agency

◆ National Ambient Air Quality Standards (six contaminants)
◆ Set in order to protect the public 24 hours a day
◆ Issue: relevance for office IAQ problems?

National Ambient Air Quality Standard

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Long Term Concentration / Averaging</th>
<th>Short Term Concentration / Averaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur Dioxide</td>
<td>80 µg/m³ / 1 year</td>
<td>365 µg/m³ / 24 hours</td>
</tr>
<tr>
<td>Total Particulate</td>
<td>50 µg/m³ / 1 year</td>
<td>150 µg/m³ / 24 hours</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>9 ppm / 1 hour</td>
<td>8 ppm / 8 hours</td>
</tr>
<tr>
<td>Ozone</td>
<td>0.12 ppm / 1 hour</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>100 µg/m³ / 1 year</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>1.5 µg/m³ / 3 months</td>
<td></td>
</tr>
</tbody>
</table>
Comparing Industrial and IAQ limits

ASHRAE
American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Developed specifically for the indoors

- Thermal comfort guidelines (55-1992)
  See BAQ, p. 137-38

- Ventilation standard (62-1999)
  See BAQ, p. 137

ASHRAE 55 - 1992

- Temperature range:
  - 67 - 76 F in winter
  - 72 - 81 F in summer

- Relative humidity range:
  - above 20 - 30 % in winter
  - below 60 % in summer
ASHRAE
American Society of Heating, Refrigerating, and Air-Conditioning Engineers

★ Applies to residential & commercial
★ Guideline: “satisfy” 80% of occupants
★ CFM refers to OUTSIDE air supplied per person

ASHRAE
American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Defines acceptable indoor air quality as:

“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
American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Fresh Air Per Occupant

<table>
<thead>
<tr>
<th>Standard:</th>
<th>Non-smoking area:</th>
<th>Smoking area:</th>
</tr>
</thead>
<tbody>
<tr>
<td>62-1973</td>
<td>25 CFM</td>
<td>50 CFM</td>
</tr>
<tr>
<td>62-1981</td>
<td>5 CFM</td>
<td>20 CFM</td>
</tr>
<tr>
<td>62-1989/99</td>
<td>20 CFM</td>
<td>60 CFM</td>
</tr>
</tbody>
</table>
ASHRAE Outdoor Air Requirements (62-1999)

<table>
<thead>
<tr>
<th>Location</th>
<th>cfm/person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Space</td>
<td>20</td>
</tr>
<tr>
<td>Conference Rooms</td>
<td>20</td>
</tr>
<tr>
<td>Reception Area</td>
<td>15</td>
</tr>
</tbody>
</table>

ASHRAE Guidelines for Carbon Dioxide

- Instantaneous level
- Outdoor air = 300–450 parts per million (ppm)
- People exhale 2–3% CO₂
- 1% = 10,000 ppm
- 1000 ppm guidance level based on 300 ppm outdoor level

IAQ Indicators Table (Room#)

<table>
<thead>
<tr>
<th>TIME</th>
<th>PEOPLE IN ROOM</th>
<th>ROOM CO₂ LEVEL</th>
<th>TEMP</th>
<th>HUM</th>
<th>VENTILATION</th>
<th>CO₂ IN VENTILATOR</th>
<th>DOOR</th>
<th>WINDOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30</td>
<td>0</td>
<td>800</td>
<td>70</td>
<td>29</td>
<td>ON</td>
<td>800</td>
<td>OPEN</td>
<td>CLOSED</td>
</tr>
<tr>
<td>10:30</td>
<td>26</td>
<td>2200</td>
<td>71</td>
<td>27</td>
<td>ON</td>
<td>2000</td>
<td>OPEN</td>
<td>CLOSED</td>
</tr>
<tr>
<td>12:00</td>
<td>1</td>
<td>1500</td>
<td>71</td>
<td>38</td>
<td>ON</td>
<td>1400</td>
<td>OPEN</td>
<td>CLOSED</td>
</tr>
<tr>
<td>1:30</td>
<td>27</td>
<td>2200</td>
<td>70</td>
<td>30</td>
<td>ON</td>
<td>2000</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>2:30</td>
<td>12</td>
<td>2400</td>
<td>71</td>
<td>38</td>
<td>ON</td>
<td>2100</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>

- SPECIFIC AGENTS (CO, DUST, FORMALDEHYDE, VOC'S, OZONE)
- COMMENTS: (Return blocked; Musty odor; Stained tiles; Plants; Pets)
62-1999 (Continuous Maintenance)

- June 1997 instead of revision of entire std.
- 62-c: Std. Will no longer deal with thermal comfort issue.
- 62-d: Compliance does not assure relief for susceptible individuals.
- 62-e: Removes smoking reference since EPA carcinogen.
- 62-f: Changes 1000 ppm to difference between indoor and outdoor.

62 - 1989 R (Revised)

- System commissioning
- Satisfy accustomed occupants
- Minimum filtration efficiencies
- Continuous HVAC operation
- HVAC protection during renovation
- Balance ventilation every 5 years
- Monthly record of filter pressure drop
- CO level > 3 ppm above outdoor level

HUD US Dept. of Housing & Urban Development

Source emission standard
- Product standard limiting formaldehyde exposures from pressed wood products in mobile & manufactured homes
- <0.2 PPM plywood
- <0.3 PPM particleboard
- Goal: indoor HCHO exposures <0.4 PPM, but TLV is now 0.3 PPM!
HUD (continued)

Ventilation standard

Part of its mortgage insurance and low rent public housing program as well as construction requirements for manufactured housing

HUD (continued)

Ventilation standard

- Area at least 8% the size of floor area must be available for natural ventilation, or
- Mechanical system available to change room air every 30 minutes (2 ach)

Model Building Codes

- Purpose: identify design & construction specifications for buildings (housing)
- Updated to reflect new knowledge or incorporate standards
- State & local governments can use part or all of a code.
Model Building Codes

Primary codes in US:

- **BOCA**  Building Officials & Code Administrators International
- **SBCCI**  Southern Building Code Congress International
- **CABO**  Council of American Building Officials
- **APHA**  American Public Health Association

Model Building Codes

Ventilation specification areas (examples):
- Area of window space & amount openable
- Alternatives to openable windows
- Bathroom exhaust
- Crawl space ventilation openings
- Attic ventilation

Ohio Model Building Codes

**Ohio Basic Building Code (OBBC)**
Uses BOCA’s Nat’l Mechanical Code (Article 16, “Ventilation Air”)

**Article 16** [Ohio Admin. Code 4101:2-47]
“Ventilation Air (Mechanical)”
Ohio Model Building Codes

- Ventilation required depends on occupant load & use of the space; e.g., 35 CFM in conference rooms
- Specifies minimum outdoor air of 5 CFM per person

Ohio Model Building Codes

- Smoking areas not specifically addressed
- Recirculation rates specified (max.: 67 to 85 %)

Other resources:

- ACGIH Industrial Ventilation Manual
  “Ventilation Aspects of Indoor Air Quality”
- OSHA Technical Manual
  “Indoor Air Quality Investigations”
IAQ Tools for Schools Action Kit

- IAQ Coordinator’s Guide
- IAQ Coordinator’s Forms
- IAQ Backgrounder
- IAQ Problem Solving Wheel
- IAQ Checklists
  - Teachers
  - Administrative Staff
  - Health Officer
  - Building Maintenance
  - Food Services
  - Renovation and Repair

Additional Resources

- American Lung Association
  - 800 LUNGUSA
- ACGIH
  - 513-742-2020
- ASHRAE
  - 800-344-9000
- Bldg Air Quality Alliance
  - 800-768-2577
- Division of Safety & Hygiene
  - 800-438-5500
- EPA IAQ Division
  - 202-554-9782
- EPA Research & Info. Clearinghouse
  - 800-438-4318
- Tool for School Pub. 055-000-005-03-6
  - 202-512-1800
- National Air Duct Cleaning Association
  - 202-707-2024
- National Air Filtration Association
  - 202-228-5328
- National Pesticide Network
  - 800-686-7378
- NIOSH
  - 800-35NIOSH
- Ohio Dept. of Health Env. Health Div.
  - 614-666-5545
- Ohio State U. Extension Services
  - 800-799-8292
- OSHA / GPO Clev.
  - 216-512-8902
  - 419-259-7542
- Radon Information Hotline
  - 800-777-7723

Standards on the Web

- ansi.org - Amer. Nat. Standards Institute
- asme.org - Amer. Society of Civil Eng.
- astm.org - Am. Soc. For Testing and Materials
- bocai.org - Building Officials & Code Administrators International
- codes.org - U.S. Dept. of Energy Bldg. Stds. & Guidelines Program
- ichi.org - International Conference of Building Officials
- material.org - National Evaluation Services, Inc.
- nfpusa.org - The National Fire Protection Association
- nbs.org - National Institute of Building Sciences
- nist.gov - National Institute of Standards and Technologies
- nson.org - National Resource for Global Standards
The Respiratory System

Content covered

- Overview of respiratory system function
- How chemicals can interact with the respiratory system

Chemistry versus Physics

Chemistry:
- 130,000 toxic chemicals - NIOSH
- 650,000 hazardous chemicals - OSHA

Physics - only 3 physical states:
- Solid
- Liquid
- Gas
Physical states of matter --

**GAS**

- a state of matter having very low density & viscosity compared with solids & liquids (expands to fill its container)
- at NTP (Normal Temperature and Pressure) is in the gaseous state

Physical states of matter --

**LIQUID**

- **Vapor**: gaseous phase of a substance whose normal state is as a liquid (mimics a gas)
- **Mist**: tiny liquid droplets suspended in air (mimics a particle)
  synonyms - fog, spray

Physical states of matter

- **Solids** - become airborne as dusts, fumes or fibers
- **Aerosol** - general term including both airborne liquids and solids
### Physical states of matter -- SOLID

**Dust:**
- finely divided solid particles
- typically generated by mechanical processes
- Examples: sawing, grinding, sanding

**Fume:**
- a solid which has been heated to a vapor and cooled quickly, condensing as extremely small particles
- Examples: welding, soldering

**Fiber:**
- an airborne solid whose length is at least three times its width.
- Examples: asbestos, fiber glass, man-made mineral fibers, refractive ceramic fibers
Deposition in the Respiratory System

**Gases and Vapors** - solubility in water.
(Fat-soluble chemicals tend to affect other organs)

**Aerosols (airborne liquids and solids)** - particle size

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**Water-Soluble Chemicals**

**Highly water-soluble:**

- Formaldehyde
- Ammonia
- Acids

They tend to act rapidly mainly on the eyes, skin, mouth & throat.

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**Water-Soluble Chemicals**

**Less water-soluble:**

- Chlorine
- Sulfur dioxide

These tend to affect the upper respiratory tract.
Water-Soluble Chemicals

Low in water-solubility:

- Phosgene
- Oxides of nitrogen

Site of injury: delayed onset of symptoms affecting lower respiratory tract (at alveoli).

Fat-Soluble Chemicals

- More likely to end up beyond the respiratory system -- for example, in the blood and major organ systems
- Examples: some pesticides, amines, & alcohols

Micron

- One millionth of a meter
- About 1 thousandth the size of a hair
- µ or um
Particle deposition mechanics

- Impaction - inertia
- Interception - contact especially fibers
- Sedimentation - gravity
- Diffusion - movement due to kinetic energy of the particle

The Lungs

Very large surface area
70 m² in healthy male (or, about 40 times greater than surface area of external skin)

Very thin membrane required at gas exchange area
(only 1/2 to 1 micron thick in healthy persons, thickness of a soap bubble)

Respiratory System

Function:
- Gas exchange between atmosphere & blood

Parts:
- Upper respiratory system:
  - Mouth, nose, pharynx, larynx
- Lower respiratory system:
  - Trachea, bronchi, bronchioles, lungs
### Respiratory System - Anatomy

Anatomy (parts continued)

In addition to upper and lower respiratory system, we can think of the respiratory system in terms of airways and gas exchange region. Actual gas exchange takes place very deep within the lungs at the respiratory bronchioles and alveoli.

### Upper Respiratory System

**Actions:**
- Filters/traps large particles (8-10 microns)
  - Nose filters
  - Mucous traps
  - Impaction at sharp bends
- Humidifies & heats air taken in
- Reacts with water-soluble chemicals

### Lower Respiratory System

**Actions:**
- Traps & expels particles in mucous
  - (muco-ciliary escalator)
- Provides less abrupt directional changes; particles 1 to 5 microns deposited
### Lower Respiratory System

**Actions (continued):**
- In lungs, gas exchange actually occurs at clusters of 300 million air sacs (alveoli) 2 cells thick
- Particles smaller than 1 micron can reach the alveoli

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### Gas Exchange

- Oxygen in (and quite a bit out)
- Carbon dioxide out
- Thin-walled (2 cells thick normally)
- But: chemicals (and disease) can cause thickening

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### Gas Exchange (continued)

- Thickening can interfere with gas exchange; example: pneumonia, pulmonary fibrosis (scarring)
- Lack of elasticity in lungs also a problem; example: emphysema

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Respiratory System Disorders

- Now that we know how the respiratory system functions, we can better understand what can go wrong in terms of disease.

Emphysema

- Occurs when adjacent walls in alveoli break through, causing a reduction in the number of air sacs
- This decreases the total gas exchange surface that is available
- Over time, the lung becomes less elastic, and the outflow of air is obstructed

Chronic bronchitis

- Inhaled irritants cause excessive production of mucous in lower respiratory passages
- They also cause inflammation & fibrosis (hardening) of the skin surface (mucosa)
**Chronic bronchitis (continued)**

- The result: airway obstruction, poor ventilation of lungs, & interference with the gas exchange process
- Bacteria thrive in the mucous & so pulmonary infections often occur

**ETS* -- Respiratory effects**

- Irritates mucous membranes
- Interferes with system which mechanically expels contaminants
- Causes a decrease in respiratory performance (e.g., emphysema)
- Can worsen effects of a respiratory disease as well as delay healing
*Environmental Tobacco Smoke

**ETS**

Causes both:
- emphysema, and
- chronic bronchitis
Protective Measures

- Nasal hairs filter larger particles
- Sharp directional changes in pathway cause particles to be caught
- Air is heated before entering lungs
- Moist surfaces react with water-soluble substances before they get further into the system

Protective Measures (continued)

- Organisms may kill or neutralize inhaled particles (& even inhaled micro-organisms)
- Cough and sneeze reflexes expel some foreign substances
- Allergic reactions can restrict entry of air

Protective Measures (continued)

Many of these defense mechanisms can deteriorate with age, or be compromised as a result of illness, tobacco smoking, or exposure to chemical irritants.
Allergic Reactions

- Muscles in bronchioles (smaller branches) contract
- Mucous membranes swell
- Effect: reduction of airflow
  - Note: not necessarily bad

Allergic Reactions

- Common toxicological concepts such as “dose” and “particle size,” etc. are overpowered by the immune system.
# Introduction to HVAC

### Heating, Ventilation, & Air Conditioning

## Content covered:
- Terminology, principles & properties of air relevant to IAQ.
- Primary HVAC system functions and their impact on IAQ.
- Major HVAC system components & configurations used to perform these functions.

## Part I - Air
- Terminology
- Principles
- Properties
**Dry Air**

Approximate Composition (by volume):

- 78.0 % Nitrogen
- 20.9 % Oxygen
- 1.0 % Argon
- 0.1 % Other Gases

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**Wet Air**

Wet Air = Dry Air + Water Vapor

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**Wet Air Composition**

Approximate Composition:

- 78.0 % Nitrogen
- 20.9 % Oxygen
- 1 - 2 % Water Vapor
- 1 % Argon
- 0.1 % Other Gases
**Answer: “Billions and Billions...”**

Question: How many molecules of air are in this room?

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**Answer: Really fast!**

Question: How fast do air molecules typically move?

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**Pressure**

\[ Pressure = \frac{Force}{Area} \]

- The total force exerted upon a given surface at any instant divided by the area of that surface
- Expressed in “pounds per square inch” (psi)
**Barometric Pressure**
- The total force of all air molecules impacting a given surface at a given instant in time divided by the area
- AKA: “Atmospheric Pressure”
- Measured using a *barometer* and stated in “inches of mercury”

**Trick Question #1**
- Which weighs more:
  - 1 cubic ft. of *dry* air
  - 1 cubic ft. of *humid* air?

**Air Density**
- Mass of air per unit volume
- At 70 °F., the density of *dry* air is
  
  75 lbs. per 1000 cubic ft.
Why Does Warm Air Rise?

As the temperature increases, 

AIR EXPANDS

Causing its density to DECREASE

Vapor

A gas which may condense to a liquid at normal temperatures

Water Vapor is actually H₂O gas occurring in a mixture with dry air.

Relative Humidity (RH)

Ratio of the amount of moisture present in the air to the maximum amount which it can hold at saturation at a given temperature
**Human Thermal Comfort**

- Defined in terms of both temperature *AND* relative humidity
- ASHRAE Standard 55-1992 contains a chart for determining human thermal comfort

**Trick Question #2**
- Which can hold more water vapor:
  - WARM air
  - or
  - COOL air?

**Sensible Heat**

The amount of heat which when added to air causes a change in temperature with NO CHANGE in the amount of water vapor present
### Latent Heat

The heat content of the water vapor present in the air.

### Total Heat

\[
Total \ Heat = Sensible \ Heat + Latent \ Heat
\]

### Part II

- HVAC System Functions
- Impact on Indoor Air Quality
The Basics

**H**eating

**V**entilation

**A**ir

**C**onditioning

**HVAC System Functions**

- Heating
- Cooling
- Ventilation
- Filtration
- Dehumidification
- Humidification
- Distribution

**Impact on IAQ**

*Over 50% of all IAQ problems are due to Inadequate Ventilation!*

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BWC Division of Safety & Hygiene
Indoor Air Quality
Revised: July 2003
Control Hierarchy

- Engineering controls
- Administrative controls
- Personal Protective Equipment

Contaminants

IAQ is relevant because --

✦ 90 percent of your time is spent indoors!
IAQ is relevant because --

- Change in complexity of chemicals used
- Increase in number/types of chemicals
- New methods to disperse chemicals
- New processes/equipment

Is the problem new?

“No common air from without is so unwholesome as the air within a closed room that has been often breathed and not changed.”

*Ben Franklin*

Historical examples

- Physicians in the 1700s linked the deaths of English sailors to their unventilated cabins.
- In World War I, high levels of carbon monoxide accumulated in Renault tanks from long-term weapons firing.
The Office Setting Today

Pollutant sources:
- Building material emissions
- Furnishings
- Office equipment
- Human metabolism
- Outside contaminants brought inside

Building-related illness

- Where 1 or more workers develop a well-defined illness,
- A specific cause (airborne agent & pathway) is found, and
- The cause is clearly related to the building.

Building-related illness

Causative agent:
- Chemical, or
- Pathogen, or
- Biological allergen
### Building-related illness --

**Examples**

- Infectious syndromes:
  - Legionnaires’ disease
  - Pontiac fever
  - Q fever
  - Humidifier fever
  - Hypersensitivity pneumonitis
  - Building-related asthma

### Sick-building syndrome*

- Significant number of workers develop non-specific complaints or illness
- Few physical signs; absence of clinical abnormalities
- Specific causative agent rarely found, and assumed to be multi-factorial
- Highest risk: new or recently remodeled structures with tight envelopes

*AKA SBS, tight building syndrome, TBS

### Common SBS symptoms:

- Irritation of eyes, nose, and throat
- Dry mucous membranes and skin
- Erythema (reddenened skin)
- Headache, dizziness, or mental fatigue
- Respiratory infections or cough
- Hoarseness or wheezing
- Nausea
- Hypersensitivity reactions (note: if unproved)
Tight-building syndrome

Alternative definitions:

- Applied where engineering or architectural flaws result in either a building-related illness or a sick-building syndrome, or
- Applied where symptoms occur due to a tightly sealed building -- that is, where conditions permit the build-up of contaminants.

Sensitization

- Sensitivity to individual chemical *
- May occur after brief or long-term exposures
- Assumed to be permanent
- Prevention:
  - Proactive: limit exposures
  - Reactive: remove from workplace
- Examples: isocyanates, formaldehyde

*Antigen produces immune response

Mass Psychogenic Illness

- “Symptoms that develop in a group that is under stress (physical or emotional)”
- Suggested by 1) symptoms that have no organic basis or are inconsistent with exposure & 2) illness occurring only after learning of others being ill
Mass Psychogenic Illness (continued)

- At risk: those in low-paying, stressful jobs that are boring or unrealistically paced, or within physically stressful or rigid authoritarian organizations

Multiple Chemical Sensitivity

- Particular sensitivity to a broad range of low chemical levels
- Does it exist?
- Theories
  - Sensitization spreads from chemical to chemical
  - Stressor overload
  - Psychiatric in origin

Indoor Contaminants
“All substances are poisons! There is none which is not a poison. The right dose differentiates a poison and a remedy.”

Paracelsus

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**Major IAQ Contaminants**

- Carbon monoxide
- Formaldehyde
- VOCs (volatile organic compounds)
- Particulates

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**AREC Evaluation Model**

- **Anticipation**  Sources
- **Recognition**  Symptoms, signs
- **Evaluation**  Testing
- **Control**  Prevention

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Carbon Monoxide (CO)

Anticipation (sources)
- Cracked heat exchangers
- Combustion engines
- Poorly located air intakes
- Gas burners, gas ovens, wood stoves, or kerosene heaters
- Even from weapons firing!

Recognition
- Possibly complaints of headache
- Extreme: collapse

The problem: prevents blood from carrying normal oxygen level -- and puts those with heart problems at special risk.

Evaluation
Note: can't be smelled, tasted, or seen.

Use direct-reading instruments
- Passive, electronic and draw samplers

TLV(ACGIH): 25 PPM
PEL (OSHA): 50 PPM
### Carbon Monoxide

**Control**

- Preventive maintenance  
  - e.g., forklift tune-ups
- Proper ventilation design/layout  
  - Structure & location

### Carbon Monoxide (continued)

- Appropriate policies/rules  
  - Where and when motor vehicles can idle
- Equipment choice  
  - Airtight wood stoves, reduced fuel consumption  
    - Kero heaters

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### Formaldehyde

**Anticipation (sources)**

- Insulation (UFFI)
- Composition boards  
  - Medium density fiberboard, hardwood plywood, pressed wood, particle board
- Carpet & carpet adhesives

**AREC**
Formaldehyde

Anticipation (sources continued)
- Fabrics
- Gas burners, gas ovens
- Embalming fluids
- Many other sources

A R E C

Formaldehyde

Recognition
- Burning eyes (0.1 to 0.3 PPM)
- Respiratory tract irritation (2 or 3 PPM)
- Dermal sensitization

A R E C

Formaldehyde

Evaluation
- Odor threshold below 1 PPM
- Direct reading instruments, and long-term sampling
- TLV: 0.3 PPM PEL: 0.75 PPM

A R E C
Formaldehyde

Control
- Product choice or application method
- Scheduling of work (exposure)
- Proper isolation design
- Local exhaust ventilation
- Dilution ventilation
- Building commissioning procedures
- PPE

Volatile Organic Compounds (VOC)

Classes:
- Aliphatic hydrocarbons
  - e.g., n-hexane, kerosene
- Aromatic hydrocarbons
  - Benzene, xylene, toluene

VOC -- classes (continued)
- Halogenated hydrocarbons
  - Perchloroethylene, methylene chloride, diazinon
- Oxygenated hydrocarbons
  - Aldehydes, alcohols, and ketones
Vocality

The tendency of a material to pass into the vapor state at a given temperature; that is, the tendency to evaporate into the surrounding space

VOCs

Anticipation
- Maintenance products
- Building materials
- Combustion processes (including tobacco smoking)
- Industrial / laboratory chemicals
- Many potential sources

A R E C

Recognition

Examples:
- Mucous membrane irritation
- Ocular (eye) irritation
- Skin irritation

A R E C
### VOCs

**Evaluation**
- Direct reading, and
- Long-term sampling

**Examples:**
- N-hexane: TLV: 50 PPM; PEL 500 PPM
- Methyl alcohol: TLV & PEL: 200 PPM

### VOCs

**Control**
- Product choice or application method
- Scheduling of work (exposure)
- Proper isolation design
- Local exhaust ventilation
- Dilution ventilation
- PPE

### Particulates

**Anticipation**
- Grinding
- Welding
- Cutting
- Sawing, etc.
Particulates

Recognition
- Visible contamination
- Irritation of mucous membranes
- Lung illness

A R E C

Particulates

Evaluation
- Long-term methods primarily
- Direct reading (increased use)
- Direct observation of gross contamination

A R E C

Particulates

Control
- Local exhaust ventilation
- Dilution ventilation
- Material or process selection
- Work area isolation
- PPE

A R E C
Bioaerosols

Biologically derived airborne contaminants include:

- Microorganisms
- Fragments
- Toxins
- Particulate waste from all varieties of living organisms

BWC Division of Safety & Hygiene
Indoor Air Quality
Revised: July 2003
Microorganisms

Bacteria
- Pathogenic or Natural Flora
- Unicellular prokaryotic (no nucleus)
- Multiplies by cell division
- Typically contained within a cell wall

Legionella pneumophila

Anticipation
- Water-cooled systems

Recognition
- Stagnant water

Evaluation
- Bulk samples
- Proper diagnosis

Control
- Regular maintenance
- Temperature setting
  - Below 40 degree F
- Avoid standing waters
**Tuberculosis**

**Anticipation**
- Hospitals
- Nursing Homes
- Public Health

**Recognition**
- Occupants are sources, not building structure

**Tuberculosis**

**Evaluation**
- Physician diagnosis of patient

**Control**
- OSHA / CDC has guidelines for prevention of spread of TB bacillus in affected industries

**Microorganisms**

**Virus**
- Group of minute infectious agents
- Can’t be seen by a light microscope
- Characterized by a lack of independent metabolism
- Ability to replicate only within living host cells
**Microorganisms**

**Fungus - Plant**
- Eukaryotic - true nucleus
- Multiplies by mitosis
- No chlorophyll
- Rigid cell wall
- Simple morphology

**Fungus**
- Mushrooms
- Yeast
- Rusts
- Molds

**Mold**

**Anticipation**
- Temperature range above 40 and below 100 degree F.
- Mold spores present
- Nutrient base (most surfaces)
- Moisture
Mold

Recognition
- Exterior corners
- Poor circulation
- Wind washing
- Low insulation levels
- Greater surface area heat loss
- Set Back Thermostats - heating season
  - Mold growth during unoccupied periods

Mold

Recognition (continued)
- Air conditioned spaces
  - Conditioned air blows against the interior surface of an exterior wall.
- Thermal bridges
  - Causes localized cooling of surfaces
  - Dust accumulation
- Windows
- Concealed condensation

Mold

Evaluation
- Visible mold growth
- Air sampling
  - Anderson impactor
  - Wipe samples
  - Bulk samples
Mold

Evaluation (continued)

◆ HVAC evaluation
  ◆ Relative humidity
  ◆ Temperature control
  ◆ Air circulation

Free Water in/on bldg. Materials

[Aw = Water Activity]

◆ Aw Low = Primary colonizers (first to grow in dust/dirt on wall/ceiling cavities, carpet, furniture)
  Aspergillus and Penicillium fungi
◆ Aw Moderate = Secondary colonizers (common outdoors and infiltrate through air inlets & cloths)
  Cladosporium fungi
◆ Aw High = Tertiary colonizers (hydrophilic; grow on wet or recently wet bldg. materials; in cooling towers, humidifiers, cooling coils, and condensate pans)
  Fusarium/Stachybotrys fungi; Pseudomonas/
  Bacillus/Streptomyces/Actinomyces G- bacteria

Interpretation of Results (Air)

◆ Pathogenic fungi such as aspergillus, cryptococcus, histoplasma
◆ Toxogenic fungi such as stachybotrys atra, toxic aspergillus, fusarium
◆ Presence of 1 or more species (e.g., 2X) greater than outdoor
◆ > 50 cfu/m³ of 1 or more species except cladosporium, alternaria
◆ Different profile of species indoor than outdoor
◆ Mixture up to 150 cfu/m³ OK if similar to outdoor
◆ Higher levels OK in summer if primarily tree fungi like cladosporium
◆ Even low levels of stachybotrys and aspergillus a concern
### Mold

**Control**
- Maintain relative humidity near surfaces below dew point. Reduce moisture content of the air by...
  - Control of the source
  - Dilution of moisture laden air with outdoor air when humidity levels are low
  - Dehumidification

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### Mold

**Control (continued)**
- Increase air movement at surface
- Increase air temperature
  (general space or building)
  - Near room surfaces by raising the thermostat setting
  - Improve air circulation
  - Decrease heat loss: Add insulation; Close cracks in exterior walls

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### Biocontamination Prevention

- Upgrade filter efficiency
- *Regular cleaning and maintenance of cooling coil & drain pans*
- Maintain ductwork insulation to minimize application
- *Clean HVAC if there are obvious signs of contamination*
- Design HVAC without porous materials inside ductwork
- *Maintain and inspect humidifiers and cooling towers regularly*
- Placement of outdoor air intakes away from street level, loading docks, and cooling towers. Inspect and keep clean.
### ASHRAE 52.2 MERV

<table>
<thead>
<tr>
<th>MERV</th>
<th>%Eff</th>
<th>Final Resist</th>
<th>Controls</th>
<th>Type</th>
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<tbody>
<tr>
<td>1-4</td>
<td>&lt;20</td>
<td>0.3 in. w.g.</td>
<td>Pollen/mites/fiber Disp./Wash./ES</td>
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<tr>
<td>5-8</td>
<td>20-70</td>
<td>0.6 in. w.g.</td>
<td>Dust/mist/spores ES/Pleated</td>
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<td>9-12</td>
<td>70-90</td>
<td>1.0 in. w.g.</td>
<td>Fume/Legionella Box/Bag</td>
<td></td>
</tr>
<tr>
<td>13-16</td>
<td>90-99</td>
<td>1.4 in. w.g.</td>
<td>Tob.Sm./Bacteria Box/Ind. ES</td>
<td></td>
</tr>
</tbody>
</table>

- Minimum Efficiency Reporting Value (MERV)
- Highly controlled laboratory testing, instead of dust spot
- Minimum efficiency instead of average
- Filter ability to remove particles of specific size

### Histoplasma capsulatum

#### Histoplasmosis

#### Anticipation
- Animal access to buildings

#### Recognition
- Bird droppings

#### Evaluation
- Soil/site evaluation
- Proper diagnosis

#### Control
- Control access to attic
- Reduce airborne dust
Hypersensitivity Pneumonitis

Most prevalent and most difficult to determine

A group of allergic lung diseases resulting from sensitization and recurrent exposure to inhaled organic dust.

Aspergillus Fumigatus

- Causative agent associated with Aspergillosis
- Also known as Farmers Lung

Aspergillus Fumigatus

Anticipation
- Ubiquitous
  - Soil
  - Potted plants
  - Refrigerated foods
### Aspergillus Fumigatus

#### Recognition
- Thermophilic - thrives in high temperatures
- Composting sites in vicinity of HVAC fresh air intake
- Farmers and construction workers - higher risk

#### Evaluation
- Same as histoplasmosis
- Soil/site evaluation
- Air sampling
- Proper diagnosis

#### Control
- Control animal access to attics and building structures
- Reduce dust disturbance
Allergens

- A substance that causes allergic reaction in sensitized populations
- Chemical or biological in nature

Allergens

**Nonviable (not living)**
- House dust mite fecal pellets
- Cockroach feces
- Insect and spider remains
- Nonviable remains of molds and their spores

Allergens -- Nonviable continued

- Dried reentrained animal excretions
- Pollens
- Biogenic VOC (volatile organic compounds)
Allergens

Illnesses associated with these agents

- Allergic Rhinitis
  - Commonly known as hay fever
- Bronchial Asthma

Allergens - Other examples

- *Thermoactinomyces candidus*
  - Contaminated forced air systems
- Humidifier water
  - Altered or contaminated humidifier water
- Various Saprophytic fungus
  - Contaminated environments

Nonviable Allergens

Recognition

- Presence of debris
- Accumulation of debris in air handling units
- Improper cleanup from a fungus/mold growth episode
- Poor housekeeping
- After extermination of infestation
### Nonviable Allergens (continued)

#### Evaluation
- Walk-through inspection
- Antigen testing
- Physical examination

#### Control
- Improved housekeeping practices
- Proper cleaning after pest extermination
- Maintain rodent/bird guards at fresh air intake
HVAC SYSTEMS

Objective

- Provide an overview of the components which make up a typical heating, ventilating, and air conditioning (HVAC) system

Overview

- What is an HVAC system?
- HVAC system components
  - Heating equipment
  - Cooling equipment
  - Air handling
  - Controls
### Heating Equipment

- Steam and Hot Water Boilers
- Heat Exchangers

### Cooling Equipment

- Refrigerator Cycle
- Evaporators and Coils
- Compressors
- Heat rejection equipment
BASIC AIR CONDITIONING CYCLE

COMPRESSOR

HOT GAS (HIGH PRESSURE) → WARM GAS (LOW PRESSURE)

HEAT

WARM LIQUID (HIGH PRESSURE) → COLD GAS/LIQUID (LOW PRESSURE)

CONDENSER

EXPANSION VALVE

EVAPORATOR

HEAT
BASIC AIR CONDITIONING CYCLE
WITH WATER COOLED CONDENSER
Controls

- Proper operation critical
- Uncalibrated controls waste energy
- Good documentation, standard layout, accessible

Air Handling Equipment

- Fan
- Coils
- Outside Air Intake
- Filters
- Humidifier
TYPICAL AIR HANDLING UNIT
Unitary Systems

- Residential unit
- Rooftop unit
- Computer room unit
- Window unit

Types of All Air Systems

- Single Zone system
- Variable Air Volume (VAV) system
- Dual Duct system
- Multi Zone system
Single Zone System Characteristics

- Constant Volume of Air
- Variable Temperature of Air
- Control from one temperature sensor in space
- Effective for uniform load
- Simple
- Inexpensive

VAV System Characteristics

- Variable Volume of Air
- Constant Temperature of Air
- Control at each location
- Effective for Variable Loads
Separate Coil Air-Water System Characteristics

- Conditioned air delivered through independent system to meet ventilation load
- Terminal unit in space provides heating/cooling
TYPICAL MULTIZONE SYSTEM (ONE ZONE)
TYPICAL MULTIZONE AIR HANDLING UNIT
(THREE ZONE)
Investigation and Evaluation of IAQ Problems

Recognition and Evaluation

- Source
- HVAC system
- Occupant
- Pathway

Source

- Outside building
- Mechanical Equipment and office machines in building
- Human activities
- Building components and furnishings
HVAC system

- Unable to control air contaminants
- Unable to control thermal climate

Occupants

- Sensitive
- TLV’s and PEL’s for average white male
- Overcrowding

Pathways

- Airflow patterns
- HVAC system predominant path
- Windows, doors
- Wind
Pathways

HVAC system

occupant

source

pathway

Wind

Pathways

HVAC system

air intake

pathway

Diagnosing IAQ Complaints

- Meet with building owner/manager
- Initial walkthrough
- Interviews or questionnaires
- Review information
- More detailed investigation for specific contaminants (air sampling)
- Report, recommendations
- Apply control measures, reassess
Tools for initial walk-through

- CO₂ meter or tubes
- CO meter or tubes
- Temperature, Relative humidity
- Flashlight, step ladder, tool kit
- Tape measure, camera

Approach to IAQ Problems

- Problem surfaces
- Hypothesis
- Controls
- Tentative conclusions
- Walk-through
- Gather additional info or In-depth sampling

Contact building management

- Area where complaints originate
- Type and frequency
- Get building layout
- Recent renovations?
- Any suspected causes?
**Initial walk-through**

- Look for sources
- Water damage
- Presence of hazardous substances
- Obvious signs of occupant discomfort
- Look above dropped ceiling

BAQ p. 23

**Initial walk-through (continued)**

- Air intakes of HVAC system
- Blocked pathways of HVAC system

**Detailed Investigation**

- Sampling for specific contaminant if identified
- Bioaerosol monitoring
  - Limited guidelines
  - Expensive
Employee Surveys and Interviews

Data collection

Questionnaires / survey forms:
- Interviews
  - In person
  - Over phone
  - Mailed

See BAQ, pp. 185-86

Data collection

Activity logs:
- “Diary” type of data
- Tracking
  - activities
  - processes
  - symptom occurrences

See BAQ, pp. 183, 187, 189
Data collection

“Proactive”
Complaint form
See BAQ, p. 181

Reactive
Surveys, activity logs, etc.

Data collection (continued)

- Ensure confidentiality
- Don’t bias process
  - Be consistent
  - Be accurate
  - Be complete
- Get expert advice on question design
  (if writing own survey instrument)

Data collection (continued)

Compare:

“Have you been sick during the past three weeks?” (yes/no)

With --

“Describe any unusual symptoms you’ve had recently.” (open-ended)
Data collection (continued)

Compare:
“I haven’t felt well for three weeks.”

With --
“I’ve had itchy eyes and a dry throat for three weeks.”

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EPA Building Air Quality Action Plan

◆ Plan for comprehensive IAQ program
◆ 1998

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Designate an IAQ Manager

◆ Employee of building owner or manager
◆ Coordinates all IAQ in building
◆ Familiar with building structure and function
◆ Has authority to make changes
**Develop IAQ Profile**

- Comprehensive look at present situation
- Document existing practices
- Look at structure, function, occupancy
- Look at design of HVAC system and any changes
- Make changes to layout of building

**Address Existing Problems**

- IAQ Profile highlights potential problems
- Identify resources for emergency situations
- Use flowchart in EPA BAQ book (page 45)
- Same steps as investigating problems

**Educate Building Personnel**

- Give them perspective of thinking in terms of IAQ
- IAQ Profile helps determine who is trained
### Implement Plan for Facility Operations

- HVAC preventive maintenance and standard operating procedures
- Housekeeping
- Preventive maintenance
- Unscheduled maintenance

### Manage Potential Sources

- Remodel and renovation
- Painting, low VOC
- Pest control
- Shipping/receiving, loading dock
- Environmental Tobacco Smoke

### Communicate with Occupants

- To prevent IAQ problems
- To get cooperation once a problem occurs
Establish IAQ Complaint Procedure

- Always take complaints seriously
- Checklist to verify implementation
- Follow-up on complaints
CASE STUDY #1

For 15 years a company has used the same rust-inhibiting solution in which manufactured parts are dipped. For quality control reasons a decision is made to spray on the rust-inhibitor and this requires another chemical to be substituted for the one used long-term. In response to information on the new chemical’s MSDS, employees are instructed to wear disposable latex gloves; this is the first time any have done so. Shortly thereafter, several employees start to complain of skin irritation on their hands.

Meanwhile, office workers begin to complain of a smell which they had never before noticed. One day a person even becomes nauseous at work; that had never happened. The office employees complain to their supervisor, who says she couldn’t possibly bring up the problem now to the plant manager while the more serious production floor issues are going on -- and anyway, once those problems get fixed the office problem will, too.

Comment:

• Use the AREC model (anticipation, recognition, evaluation, control).
• What potentially incorrect assumptions are being made in this scenario?
• Based on what has been covered in this course, as well as your own insights/experience, what recommendations would you make to this company?
CASE STUDY #2

Personnel in a fourth floor hospital laboratory start complaining of strong diesel-like odors occurring periodically in their work areas. No one can remember this having happened before. The hospital has just had a major addition completed, which includes a (re-located) loading dock. The maintenance personnel have heard many complaints in the past from lab personnel about other air quality problems, and relations are strained between the lab’s director and the maintenance section head.

Comment:

- Use the AREC model.
- How would you investigate this situation?
- What are some likely causes?
- What steps might correct the lab’s problem?
CASE STUDY #3

You are the owner of a cash-poor printing firm located in the basement of a building which was flooded with several inches of water. The office’s carpet -- laid over floor tile -- was cleaned by a company which assured you that their steam clean process would make it almost like new. It is now a month later and again there are odors (both musty and organic solvent-like) in the office as well as the print department. Several office and print workers complain of stuffy noses and eye irritations. The carpet cleaners say another $150 cleaning should take care of the problem.

Comment:

• Use the AREC model.
• What are your various options and what do you do?
• Is the carpet the only possible culprit?
CASE STUDY #4

You are the owner of an up-and-coming nail salon that is located with several other tenants in a thirty-year-old office building located in an area with lots of empty rental spaces. You also own another business which has been in the building for five years. In addition, for two years you have acted as the Florida-residing, absentee landlord’s representative to the other tenants. Ever since your nail salon opened you have been barraged with odor complaints from three tenants -- including a dentist, whose patients periodically complain of strong odors, and from personnel in the office of a small construction firm. The landlord has heard rumors of at least two tenants threatening to move out.

The dentist calls in the Division of Safety & Hygiene; their investigator, granted access by you, finds 2,000 ppm carbon dioxide in all areas of the building but no solvent levels in your nail shop in excess of what OSHA allows. Also, she finds no evidence of a fresh air supply in the building’s HVAC system. She recommends that an HVAC maintenance vendor be called in to see what options are available. She does mention that a local exhaust system at all five of the salon nail benches might be appropriate to control the smells. You are afraid to think how much that might cost. The landlord and you are relieved that no OSHA chemical exposure violations were found.

Meanwhile, the HVAC vendor brings in a company rep who says he can sell, for only $1,200, an ozone generator which will, by producing small amounts of ozone, essentially neutralize all the solvent vapors created by your nail technicians. Its cost turns out to be about 20 to 30 percent of what you’d be charged for a local exhaust capture system. He has product literature which backs his claims. The State’s industrial hygienist must be restrained when she hears of this device.

Comment:

• Use the AREC model.
• What do you do?
• And what’s with that hygienist, anyway?
The Division of Safety & Hygiene wants Ohio workplaces to be safer and healthier by reducing occupational injuries and illnesses. To accomplish this goal, the Training Center emphasizes the importance of applying what you learn in class to your workplace.

Effective July 1, 2003, class participants will have a list of follow-up activities to review as possible steps to take when they return to work. During or at the end of a class, you may choose from among these follow-up activities or customize your own activity as appropriate for your workplace.

When you complete a follow-up activity in your workplace, notify the Training Center. Following notification, a certificate with continuing education credits for the class will be sent to you. You must complete this notification process from your first class in order to be eligible to enroll in a second class.

(Please see details on reverse side.)
Examples of follow-up activities
• Develop or improve a training program on the class topic;
• Organize a new or improve an existing safety team;
• Conduct a safety audit on one or more machines at work;
• Analyze illness/injury trends;
• Find and document hazardous chemicals to add to Hazard Communication program.

Notification process
Provide the following information when notifying the Training Center of your completed activity:
1. Please describe the activity you completed at your workplace as a result of taking the class;
2. Who at your company was involved in this activity;
3. The impact of this activity on your company;
4. What barriers, if any, you encountered;
5. How you would like your certificate sent to you (e-mail, fax, or no certificate needed);
6. Please estimate the amount of time you spent on this activity.

Methods of notifying the Training Center will be provided when you attend the class.

Summary
1. Enroll in one class at a time;
2. Attend class;
3. Select a follow-up activity that is reasonable and manageable at your workplace;
4. Complete the activity;
5. Notify the Training Center;
6. Receive certificate with continuing education credits;
7. Enroll in another class.

Exceptions
• Safety Works for You, Modules 1-7 (See Division Services catalog for course description)
• Safety Works for Kids (See Division Services catalog for course description)
• Students who are unemployed
Indoor Air Quality for Non-Industrial Environments

Follow up activities:
• Identified indoor air quality problems and provided solutions.
## Notification of Completed Activity

**Your name (please print) ___________________________**  
**Locator number of class ___________________________**  
**Date of class ___________________________**

**PIN* ___________________________**  
**Class title ___________________________**  
**Location of class ___________________________**

* PIN: First letter of your last name, four digits representing your day & month of birth, the last four digits of your SSN. Example: G03059784

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| 1. Please describe the activity you completed at your workplace as a result of taking the class. |
| 1a. What category fits your activity most accurately? Check more than one, if it applies. |
| - Personal protective equipment |
| - Policies, procedures |
| - Management directive |
| - Training |
| - Housekeeping |
| - Inspections/audits/assessments |
| - Tools & equipment |
| - Recordkeeping |
| - Written program |
| - Injury/illness trends |
| - Safety team |
| - Safety culture |
| - Other ________________________________ |

| 2. Who at your company was involved in this activity? |
| 3. What impact did this activity have on your company? |
| 4. What barriers, if any, did you encounter? |

| 5. How would you like your certificate to be sent to you? |
| - E-mail (If so, please print on line below.) |
| - Fax (If so, please list on line below.) |
| - No thanks. I don't need one. |

| 6. Please estimate the amount of time you spent on this activity. |
| - Less than 1 hour |
| - 1-3 hours |
| - 3-5 hours |
| - Over 5 hours |

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*See reverse side for methods of notifying the Training Center of your completed activity.*
Methods of notifying the Training Center of your completed activity

Internet: www.ohiobwc.com
   Safety Services
      Training Services
      Training Center, scroll down to:
         Reporting follow-up activity
         Notification form
   You can enter your information directly on the electronic Notification form.

E-mail: safety@bwc.state.oh.us

Fax: 614-365-4974

Call: 1-800-OHIOBWC (1-800-644-6292), follow the prompts for employer services, then safety services.

Mail: Ohio BWC Division of Safety & Hygiene Training Center
   Attention: Contact Center
   13430 Yarmouth Drive
   Pickerington OH 43147
Statement of Attendance

(Student name)__________________________________ attended the
(Class title)_______________________________________ class on
(Date)__________________________ at (Location) _______________.

Instructor’s signature

Note to student:
Please enter the class information above prior to asking the instructor to sign it.

After you notify the Training Center of your completed follow-up activity, a
certificate with continuing education credits will be sent to you.
Question: Several of us from our company attended this class. May we work on one follow-up activity together back at our workplace?
Answer: Yes, but each person needs to individually notify the Training Center of the completed activity.

Question: If I am not sure what activity I will do back at the workplace, what should I write on the sign-in sheet?
Answer: Please write your most likely activity. It is OK to change your mind or modify the activity when you return to the workplace.

Question: Do I have to do an activity on the list?
Answer: No, you can customize an activity that will benefit your workplace.

Question: May I enroll in a second class if the follow-up activity from the first class is not complete?
Answer: Sorry, no.

Question: Why are you restricting us to enrollment in one class at a time?
Answer: The DSH mission is to prevent injuries & illnesses. DSH is willing to invest resources in those students who contribute to that mission by improving the workplace through meaningful activities.

Question: When I am limited to enrollment in one class at a time, how can I plan out my year of classes? Won’t all the classes be full?
Answer: Plan out your classes with at least 4-6 weeks between them, pencil them on your calendar. Promptly after completing a class, begin your follow-up activity back at the workplace. When you notify the Training Center of your completed activity, send in your registration for your next class. Starting July 1, everyone will be “in the same boat;” that is, no one can sign up for more than one class at a time.

Question: Do web-based classes have follow-up activities?
Answer: Yes, but you may enroll in a web-based class and a regular class simultaneously.

Question: Can I be on a wait list for one class and be enrolled in another class?
Answer: No, you will have to choose whether to be on a wait list or to be enrolled in another class.

Question: Is “one class at a time” by individual or by company?
Answer: By individual.
Question: Some activities may take longer than others, so it may take months to complete an activity.
Answer: Here's a suggestion: break down the activity into smaller, but nonetheless significant, steps. Report to the Training Center the first completed step.

Question: What about PDP companies? All PDP requires them to do is attend a class to meet their Step 6 requirement.
Answer: For Step 6 credit, BWC will accept the "Statement of Attendance" signed by your instructor.

Question: What is the fastest method to report my completed activity and get my updated status, so I may enroll in a future class?
Answer: All methods of reporting will take 1-2 days for updating your status, but you may send in your registration form for the future class along with your notification form. Within two weeks, you should receive a confirmation notice of your enrollment in the future class.

Question: Why do I have to write the intended follow-up activity on the sign-in sheet?
Answer: What you have written on the sign-in sheet will be reviewed by BWC staff members who are responsible for assuring high-quality classes.

Question: What is the purpose behind the new direction?
Answer: It is a way of measuring the effectiveness of the Training Center in reducing occupational injuries and illnesses.
Resources Available from the Division of Safety & Hygiene (DSH) Libraries
(800) 644-6292      (614) 466-7388
library@bwc.state.oh.us
www.ohiobwc.com

Safety training:
- Safety talks, outlines and scripts - DSH Safety leader’s discussion guide, Training Center’s One-hour safety presentations, reference books, web resources
- Videos – hundreds of safety and health topics
- Books and articles on training techniques

Machine and equipment safety:
- Safety standards (ANSI, NFPA, CGA)
- Books and articles on power presses, material handling equipment, lockout/tagout, etc.

Sample written programs:
- DSH program profiles and sample written programs
- Reference books
- Internet resources

Illness and injury statistics:
- Statistics from the U.S. Bureau of Labor Statistics
- National Safety Council’s Injury Facts
- National Institute of Occupational Safety & Health (NIOSH) studies

Hazard communication and chemical safety:
- Chemical safety information
- Material safety data sheets (MSDSs)
- Sample written programs
- Videos
- Internet resources

Safety standards
- American National Standards Institute (ANSI) standards (including standards for construction, machinery and equipment, personal protective equipment)
- National Fire Protection Association (NFPA) fire codes (including the Life Safety Code and the National Electrical Code)
- Compressed Gas Association (CGA) standards

Other topics of interest (books, articles, magazines, videos and standards):
- Confined spaces
- Electrical safety
- Job safety analysis
- New employee orientation
- Powered industrial trucks
- Respiratory protection
- Scaffolds
- Spill response

Directories and lists of vendors of safety equipment

Occupational Safety & Health Administration (OSHA) regulations

Manual of Uniform Traffic Control Devices (MUTCD)

Recommendations of useful Internet sites

BWC publications
Saving You Time and Research

Requests for copies of OSHA standards, information on starting a safety committee, a video on accident investigation techniques -- these are some of the thousands of inquiries BWC’s Division of Safety & Hygiene (DSH) libraries receive each year.

DSH has two libraries to serve you:
- The central library in the William Green Building in downtown Columbus;
- The resource center and video library located at the Ohio Center for Occupational Safety and Health (OCOSH) in Pickerington.

Both libraries are open 8 a.m. to 4:45 p.m., Monday through Friday. Your need for information does not require a visit to the library. You can phone, fax, or e-mail your requests and receive a quick response.

The central library provides free information services on the topics of occupational safety and health, workers’ compensation and rehabilitation.

The OCOSH resource center provides similar services for those who visit OCOSH for meetings and training center classes.

Students from the DSH training center can use the services and collections of the libraries to assist with the completion of their course follow-up activities. The librarians have recommended a variety of resources for the follow-up activities and are available to answer questions and provide assistance.

The video library offers an extensive collection of videotapes to supplement your organization’s safety and health training program. It is a convenient and popular source for Ohio employers to borrow quality occupational safety- and health-related training aids.


Central library
30 W. Spring St., Third Floor
Columbus OH 43215-2256
1-800-OHIOBWC
(614) 466-7388
(614) 644-9634 (fax)
library@bwc.state.oh.us

OCOSH resource center
13430 Yarmouth Drive
Pickerington OH 43147
1-800-OHIOBWC
Resource center (614) 728-6464
Video library (614) 644-0018