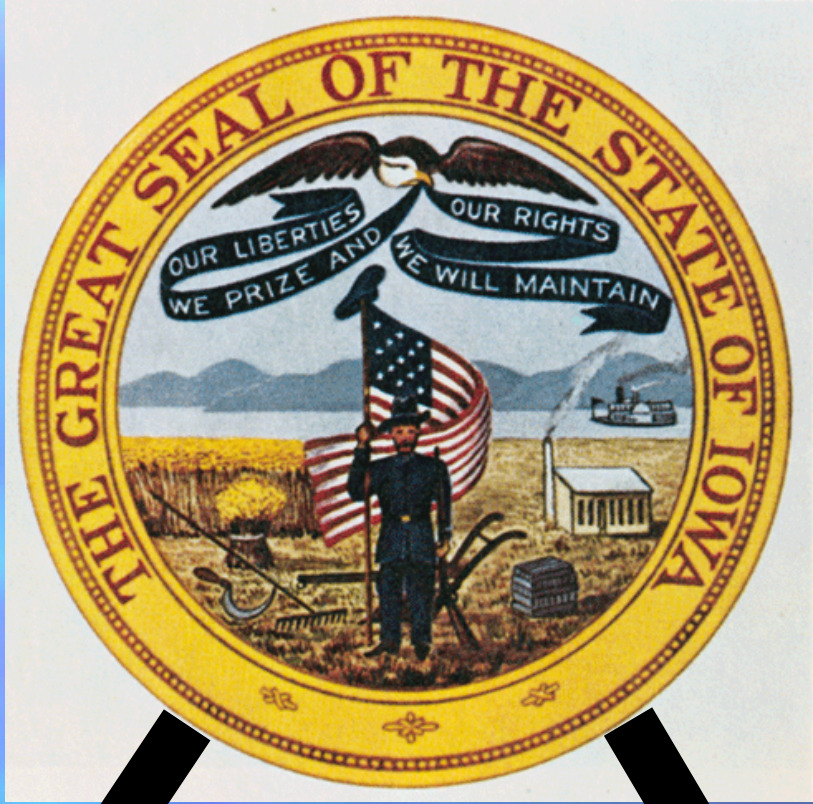
INDOOR AIR QUALITY

Iowa OSHA Consultation and Education

515-281-7629



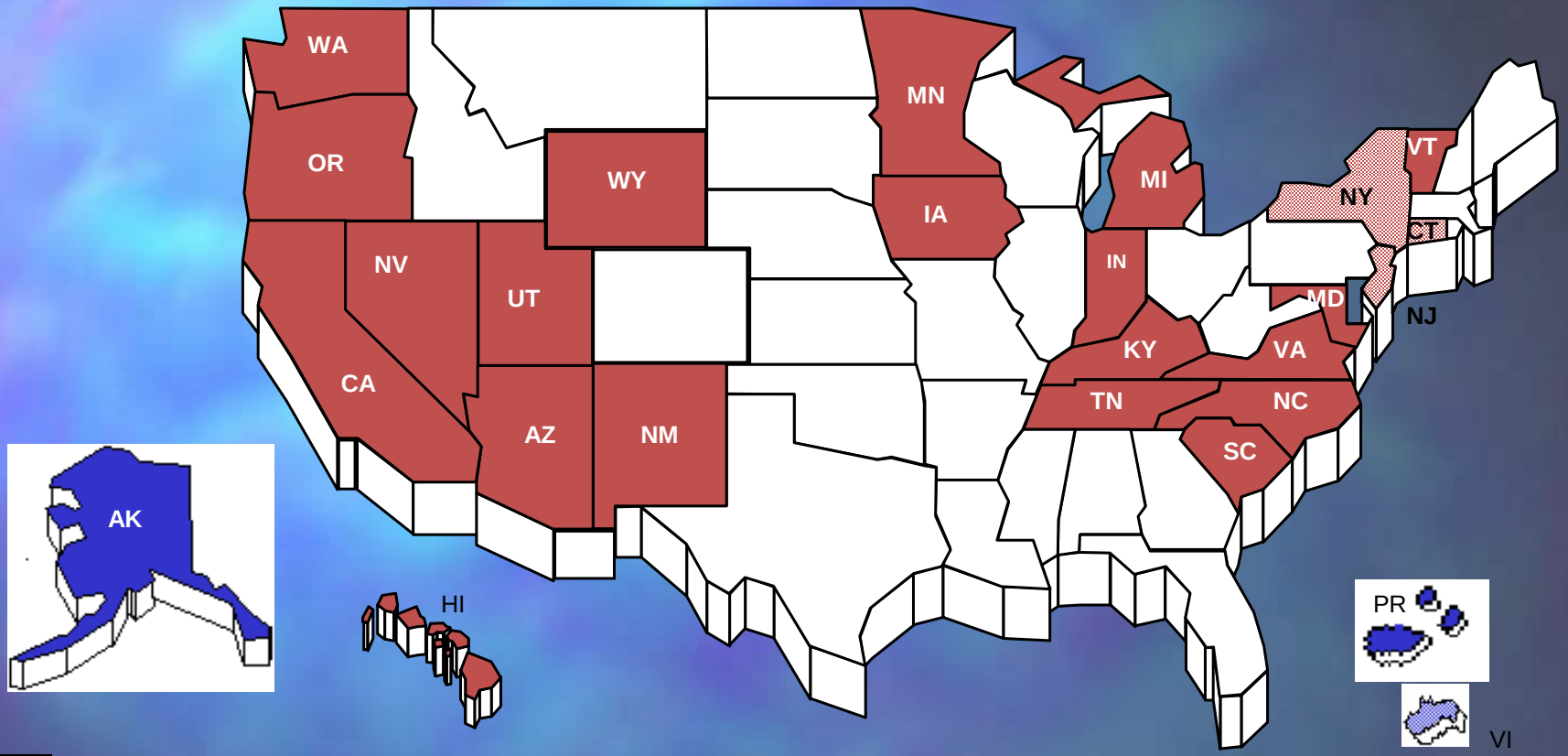
Enforcement

(Regulatory Compliance)

Consultation

(Voluntary Compliance)

The MAP



Federal Enforcement

Complete State Plans (Private, State and Local Government Employees)

State Plans for Public Employees (State and Local Government Employees Only)

INDOOR AIR QUALITY

- NOT REALLY A NEW CONCERN OR ISSUE
- PREHISTORIC CAVES WERE FOUND TO HAVE VENTILATION PROVISIONS
- 1ST "CODE" IN THE EARLY 1600'S
- YABBADABBADOO!

Importance of IAQ

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

Standards or Recommendations?

What "standards"?

OSHA
ACGIH
NIOSH
EPA

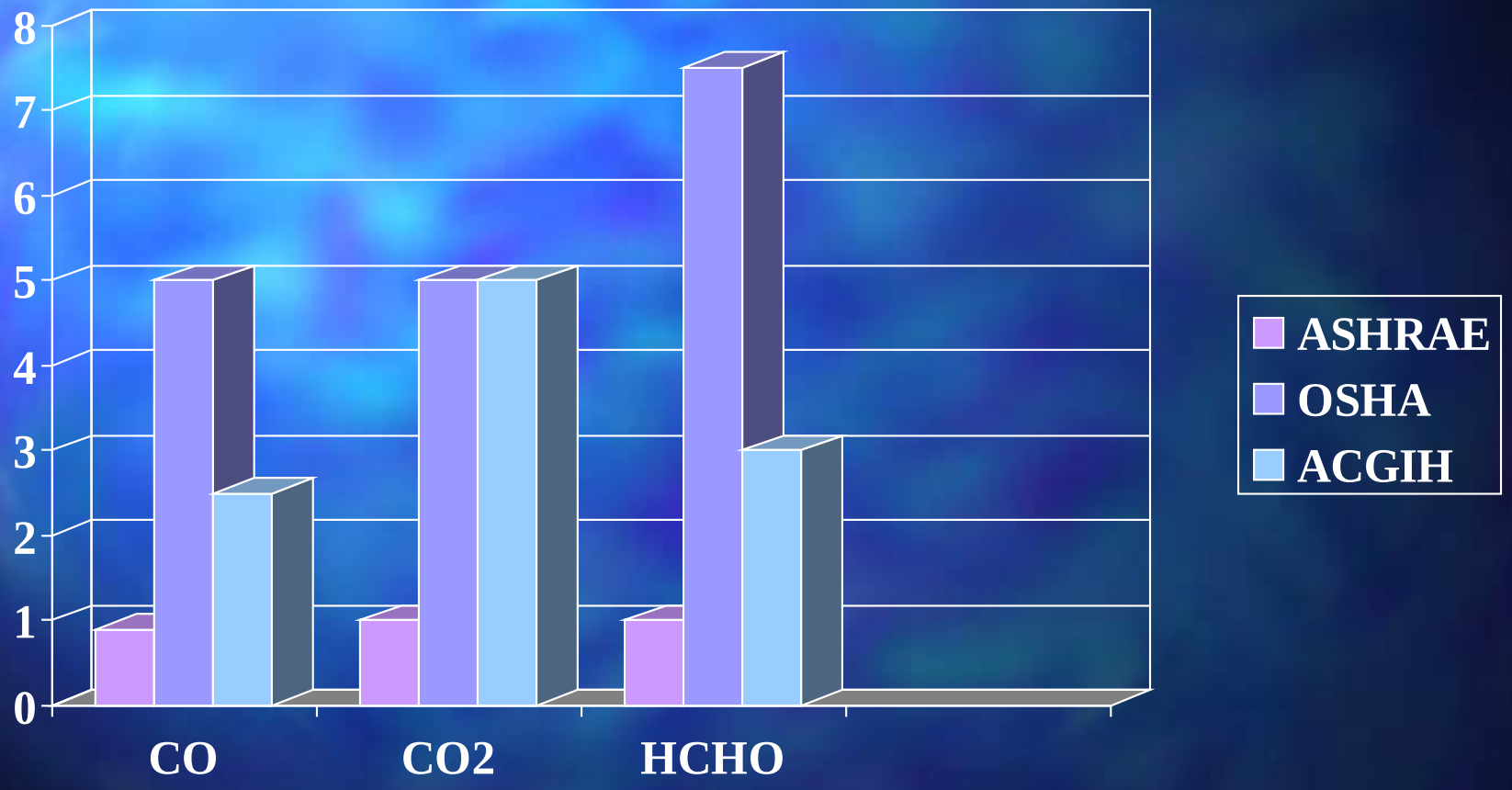
ASHRAE
OBBC
BOCA
HUD

National Ambient Air Quality Standard (EPA)

Contaminant	Long Term Concentration / Averaging	Short Term Concentration Averaging
Sulfur Dioxide	80 ug/m3 / 1 year	365 ug/m3 / 24 hours
Total Particulate	50 ug/m3 / 1 year	150 ug/m3 / 24 hours
Carbon Monoxide		35 ppm / 1 hour 9 ppm / 8 hours
Ozone		0.12 ppm / 1 hour
Nitrogen Dioxide	100 ug/m3 / 1 year	
Lead	1.5 ug/m3 / 3 months	

The **National Ambient Air Quality Standards** (NAAQS) are **standards** established by the United States Environmental Protection Agency under authority of the Clean **Air** Act (42 U.S.C. 7401 et seq.) that apply for outdoor **air** throughout the country.

Comparing indoor IAQ limits



HCHO ???

- Remember Organic Chemistry?
- HCHO is the same as CH_2O
- ...
- **Formaldehyde** is a naturally-occurring organic compound with the formula CH_2O

CH2O

MAKING WATER WORK FOR YOU

CH_2O manufactures water treatment products that "make water work for you!" Our treatment programs are designed to reduce the operating and maintenance expenses associated with the boiler and cooling systems.

H- CH – O… CH_2O = Formaldehyde

- OSHA standard 1910.1048
- TWA time-weighted average 8-hours = 0.75 ppm
- STEL short term exposure limit 15 minutes = 2.00 ppm

CO = carbon monoxide

- OSHA standard 1910. 1000
- TWA = 50 ppm

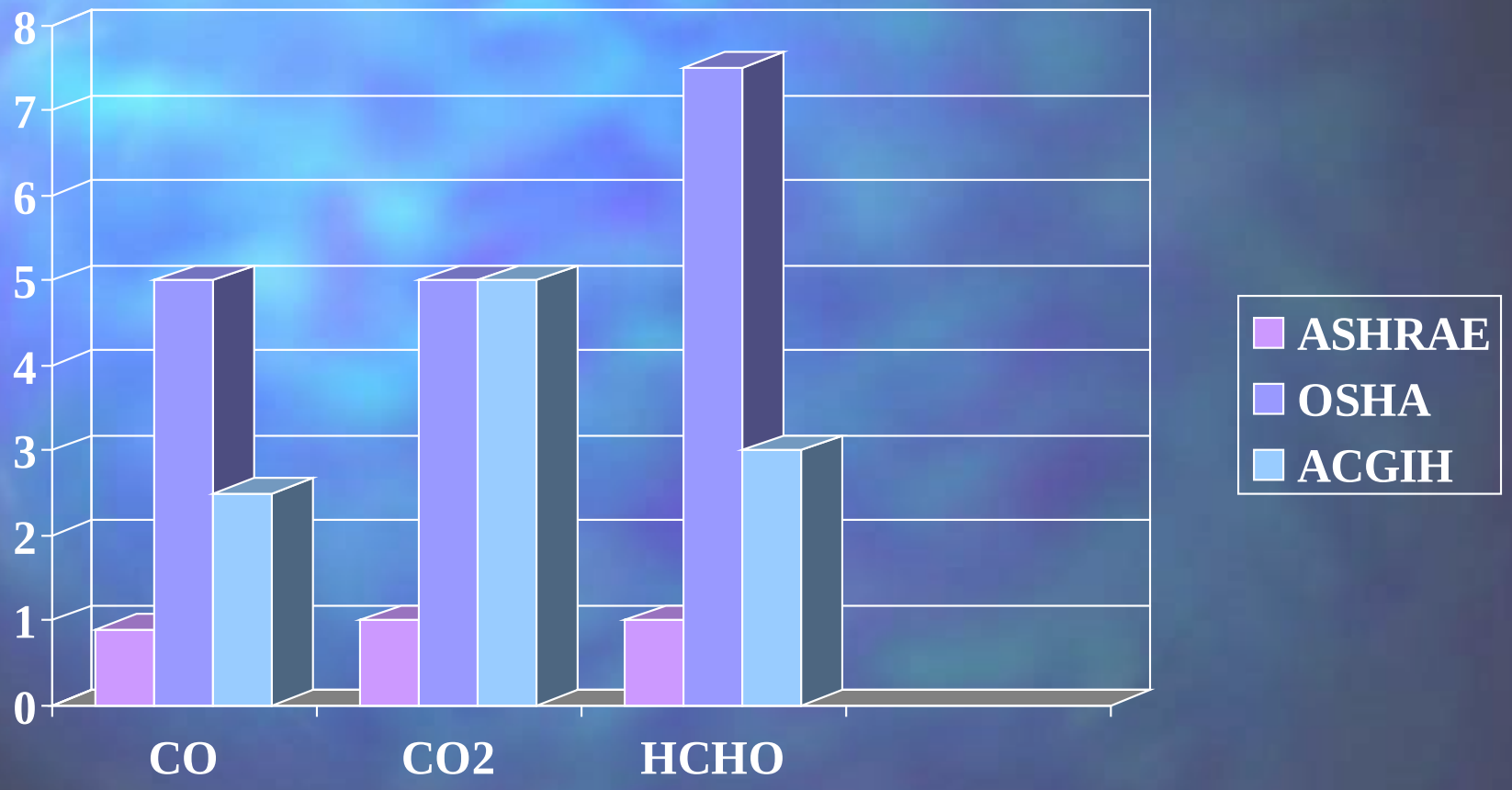
CO2 = carbon dioxide

- OSHA standard 1910.1000
- TWA = 5,000 ppm

OSHA

- Carbon Monoxide (CO) 1910.1000 50 ppm TWA
- Carbon Dioxide (CO2) 1910.1000 5,000 ppm TWA
- Formaldehyde 1910.1048 0.75 ppm as TWA
- Formaldehyde (CH_2O) 2.00 ppm as STEL
- Can you smell it? Does it burn the skin/eyes? Does it cause respiratory tract irritation? Can you test for it?

Comparing Industrial and IAQ limits



Is it lighter than air (will it rise)?

Molecular Weight: C = 12, O = 16, H = 1, N = 14

Air O_2 ? No no no. Air is about 20.9% oxygen. Mostly Nitrogen

Molecular weight of “air” is around 29.

Air = 29
CO = 28 carbon monoxide
CO_2 = 44 carbon dioxide
CH_2O = 30 formaldehyde

VOC’s (volatile organic compounds) – heavier molecular weight than air?

What Type of VOC's?

Halogenated hydrocarbons

- perchloroethylene, methylene chloride

Oxygenated hydrocarbons

- aldehydes, alcohols, ketones

Aliphatic hydrocarbons

- n-hexane, kerosene

Aromatic hydrocarbons

- benzene, xylene, toluene

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

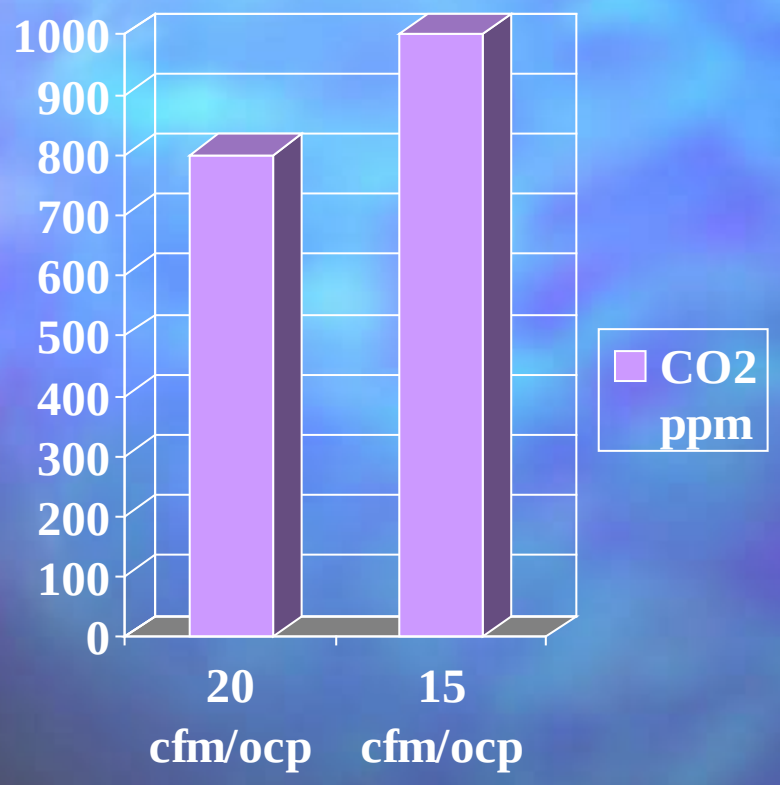
Defines acceptable indoor air quality as:

"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."

- Cog-ni-zant:

  - Fully informed; conscious. Aware.

ASHRAE Guidelines for Carbon Dioxide



- Instantaneous level
- Outdoor air = 300-450 parts per million (ppm)
- People exhale 2-3% CO_2
- 1% = 10,000 ppm
- 1000 ppm guidance level based on 300 ppm outdoor level

What about OSHA?

- OSHA Field Operations Manual used by OSHA compliance officers.

DIRECTIVE NUMBER: **CPL 02-00-159**
EFFECTIVE DATE: **October 1, 2015**
SUBJECT: Field Operations Manual (FOM)

Disclaimer

This manual is intended to provide instruction regarding some of the internal operations of the Occupational Safety and Health Administration (OSHA), and is solely for the benefit of the Government. No duties, rights, or benefits, substantive or procedural, are created or implied by this manual. The contents of this manual are not enforceable by any person or entity against the Department of Labor or the United States. Statements which reflect current Occupational Safety and Health Review Commission or court precedents do not necessarily indicate acquiescence to those precedents.

- Occupational Safety and Health Administration (**OSHA**) is a federal organization (part of the Department of Labor) that ensures safe and healthy working conditions for Americans by enforcing standards.

- The Occupational Safety and Health Act of 1970 created *OSHA*, which sets and enforces protective workplace safety and health standards.

On December 17, 2001 OSHA withdrew its Indoor Air Quality proposal and terminated the rulemaking proceedings, see Federal Register 66:64946

- OSHA does NOT have an Indoor Air Quality standard!

- 29 CRF 1910 (In Iowa – IAC 875 Chapter 10) general industry

- Subpart Z – Toxic and Hazardous Substances
- 1910.1000 – Air Contaminants

- Table Z-1 – Limits for Air Contaminants
- Table Z-2
- Table Z-3 – Mineral Dusts (silica)

- EXPANDED STANDARDS > 1910.1001 – 1052.

- 1910.1001 - Asbestos
- 1910.1002 - Coal tar pitch volatiles
- 1910.1003 - 13 Carcinogens (4-Nitrobiphenyl, etc.)
- 1910.1004 - alpha-Naphthylamine
- 1910.1006 - Methyl chloromethyl ether
- 1910.1007 - 3,'-Dichlorobenzidine (and its salts)
- 1910.1008 - bis-Chloromethyl ether
- 1910.1009 - beta-Naphthylamine
- 1910.1010 - Benzidine
- 1910.1011 - 4-Aminodiphenyl
- 1910.1012 - Ethyleneimine
- 1910.1013 - beta-Propiolactone
- 1910.1014 - 2-Acetylaminofluorene
- 1910.1015 - 4-Dimethylaminoazobenzene
- 1910.1016 - N-Nitrosodimethylamine
- 1910.1017 - Vinyl chloride
- 1910.1018 - Inorganic arsenic
- 1910.1025 - Lead
- 1910.1026 - Chromium (VI)
- 1910.1027 - Cadmium
- 1910.1029 - Coke oven emissions
- 1910.1044 - 1,2-dibromo-3-chloropropane
- 1910.1045 - Acrylonitrile
- 1910.1047 - Ethylene oxide
- 1910.1048 - Formaldehyde
- 1910.1050 - Methylenedianiline
- 1910.1051 - 1,3-Butadiene
- 1910.1052 - Methylene Chloride

Investigation Resources

- ACGIH Industrial Ventilation Manual
  "Ventilation Aspects of Indoor Air Quality"
- OSHA Technical Manual
  "Indoor Air Quality Investigations"

Additional Resources

- American Lung Association
  - **800 LUNGUSA**
- ACGIH
  - **513-742-2020**
- ASHRAE
  - **404-636-8400**
- Bldg.Air Quality Alliance
  - **888-704-2577**
- Division of Safety & Hygiene
  - **800 OHIOBWC**
- EPA IAQ Division
  - **202-233-9030**
- EPA Research & Inform. Clearinghouse
  - **800-438-4318**
- Tool for School Pub.# 055-000-00503-6
  - **202-512-1800**
- National Air Duct Cleaning Association
  - **202-737-2926**
- National Air Filtration Association
  - **202-628-5328**
- National Pesticide Network
  - **800-858-7378**
- NIOSH
  - **800-35NIOSH**
- Ohio Dept. of Health Env. Health Div.
  - **614-466-3543**
- Ohio State Un. Extension Services
  - **800-589-8292**
- OSHA / GPO Clev- **216-522-4922**

  Col- **614-469-5582** Tol- **419-259-7542**
- Radon Information Hotline

Standards on the Web

- ansi.org -Amer. Nat. Standards Institute
- asce.org -Amer. Society of Civil Eng.
- ashrae.org -Am. Society of Heating Refrig. & Air-conditioning Eng.
- astm.org -Am. Soc. For Testing and Materials
- bocai.org -Building Officials & Code Administrators International
- energycodes.org-U.S.Dept. of Energy Bldg. Stds. & Guidelines Program
- icbo.org -International Conference of Building Officials
- nateval.org -National Evaluation Services, Inc.
- ncsbcs.org -Nat. Conf. Of States on Bldg. Codes and Standards, Inc.
- nfpa.org -The National Fire Protection Association
- nibs.org -National Institute of Building Sciences
- nist.gov -National Institute of Standards and Technologies
- nssn.org -National Resource for Global Standards

Indoor Air Quality Issues

- Too many people at home?

- What about at work?

Chemistry versus Physics

Chemistry:

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

Physics - only 3 physical states:

- Solid
- Liquid
- Gas

Biological – Environmental?

- Bioaerosols (toxins)
- Microorganisms
  - Legionella pneumophila (stagnant water)
  - Tuberculosis
  - Fungus/molds
  - Histoplasma capsulatum (bird droppings)
  - Viruses (cold/flu)

Radon

Dust particles

Smoke/pollution

Drinking water

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

Cause of Symptoms

- Actual verifiable problem
- Nonverifiable

Allergic Reactions

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

Total Cost Estimate

Based on the following criteria:

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

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)

Indirect 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

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

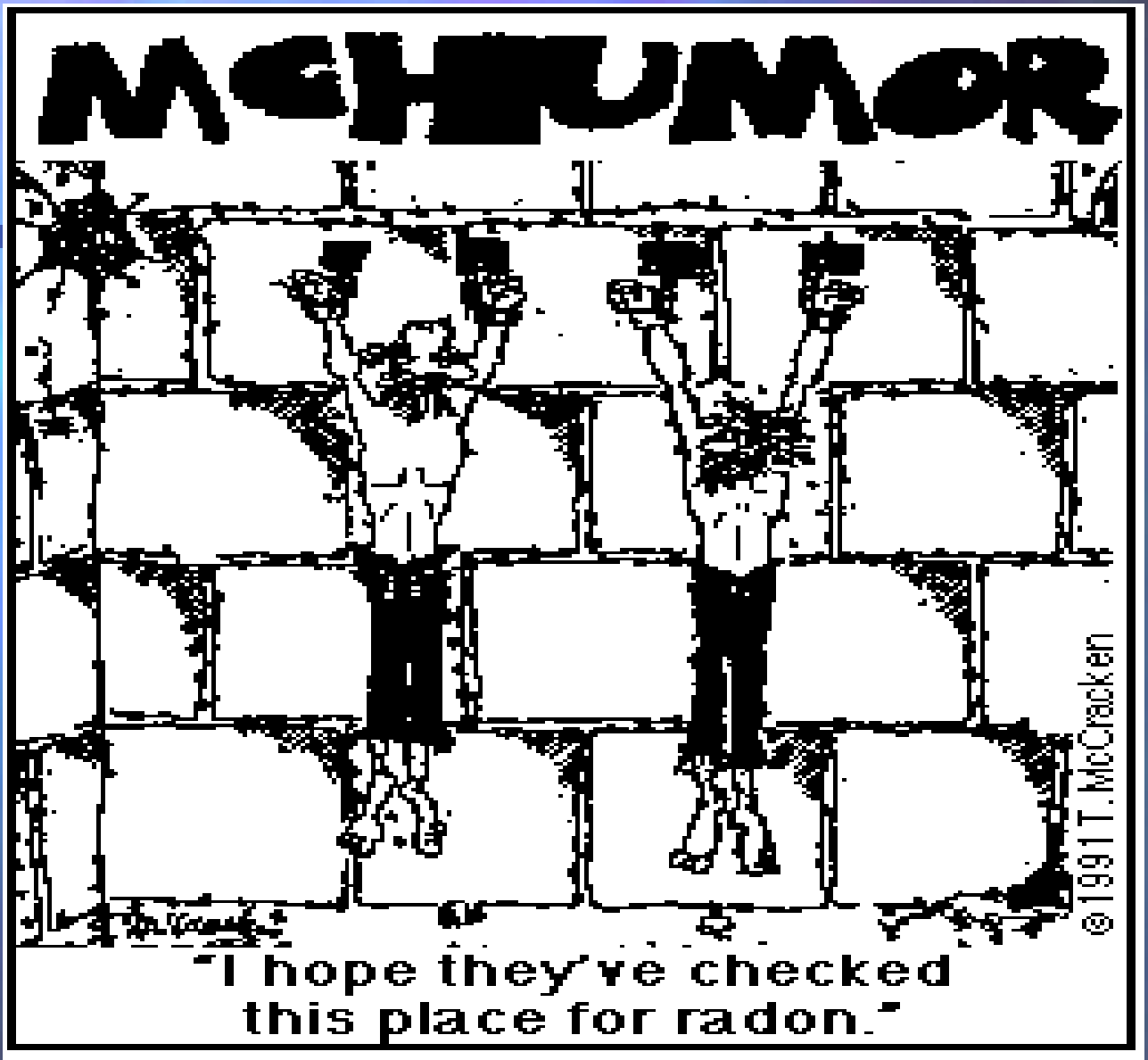
Energy costs vs personnel costs

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

- What is a comfortable humidity level?
- If the air temperature is 75 degrees Fahrenheit (24 C) and the relative **humidity** is 100 percent, we feel like it's 80 degrees (27 C) out. People tend to feel most **comfortable** at a relative **humidity** of about 45 percent. Humidifiers and dehumidifiers help to keep indoor **humidity** at a **comfortable** level.

What about environmental factors affecting indoor air quality?

- (Kansas City, Kan., Feb. 3, 2009) - EPA Region 7 has reached a legal settlement that paves the way for environmental cleanup work to be completed at a contaminated landfill and lagoon facility on the grounds of the 2,445-acre former Des Moines Ordnance Plant in Ankeny, Iowa.


MCHUMOR
©1991 T. McCracken
"I hope they've checked
this place for radon."

Physical states of matter -- GAS

- **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

Physical states of matter -- SOLID

Fume :

- a solid which has been heated to a vapor and cooled quickly, condensing as extremely small particles

- Examples: welding, soldering

Physical states of matter -- SOLID

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

Water-Soluble Chemicals

Highly water-soluble:

- Formaldehyde
- Ammonia
- Acids

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

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 (Phosgene is the chemical compound, formula $COCl_2$. This colorless gas became well known as a chemical weapon during World War I where it was responsible for about 85% of the 100,000 deaths caused by chemical weapons.) ALSO: is a major industrial chemical used to make plastics and pesticides.
- 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

Understanding “what the” potential IAQ contaminants are is necessary!

- Before You Start paying $$$ for testing that may or may not be necessary.

- Mold $$
- Chemicals $$$
- Asbestos $
- Lead $

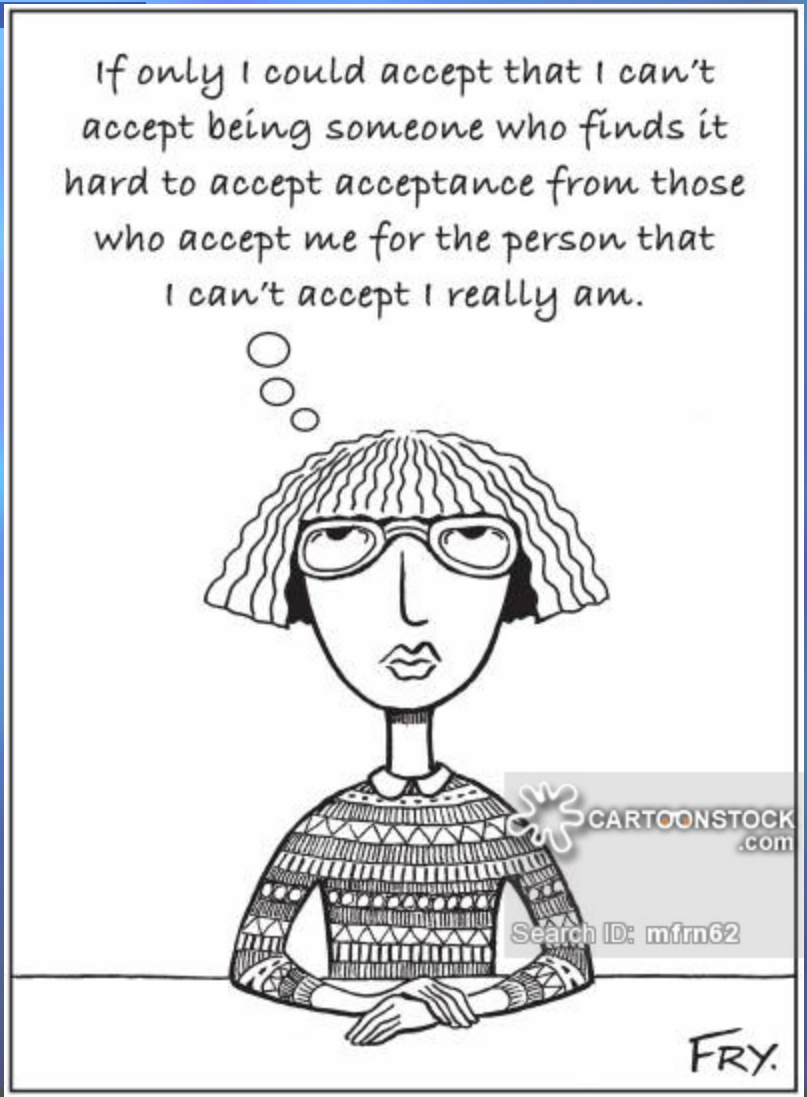
The UNKNOWN

- Molds
- Allergens
- Sensitivities
- Psychogenic
- Human Activities

- OSHA Consultation Visit – Mold labratory results; subjective?

Tape Aspergillus/Penicillium species	Moderate
Hyphae	Few
Cladosporium species	Few
Miscellaneous unidentified	Trace
Chaetomium species	Trace

IAQ Survey Results – tough to accept



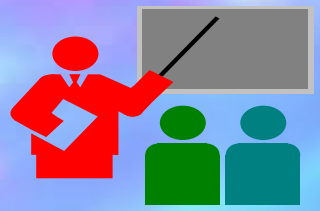
Evaluate the site

- Location
- History
- Upset conditions
- Occupant feedback
- Visual inspection
- Parameters $

CO_2 good indicator of air flow

TIME	# PEOPLE IN ROOM	ROOM CO2 LEVEL	TEMP.	R.H.	VENTI - LATION	CO2 ON VENTI- LATOR	DOOR	WINDOW
9:30	0	800	70	29	ON	800	OPEN	CLOSED
10:30	26	2200	71	27	ON	2000	OPEN	CLOSED
12:00	1	1500	71	28	ON	1400	OPEN	CLOSED
1:30	27	2200	70	30	ON	2000	CLOSED	CLOSED
2:30	12	2400	71	28	ON	2100	CLOSED	CLOSED

- **SPECIFIC AGENTS** (CO, DUST, FORMALDEHYDE, VOC'S, OZONE)
- **COMMENTS** (Return blocked; Musty odor; Stained tiles; Plants; Pets)



Investigation and Evaluation of IAQ Problems

Recognition and Evaluation

- Source
- HVAC system
- Occupant
- Pathway

Source

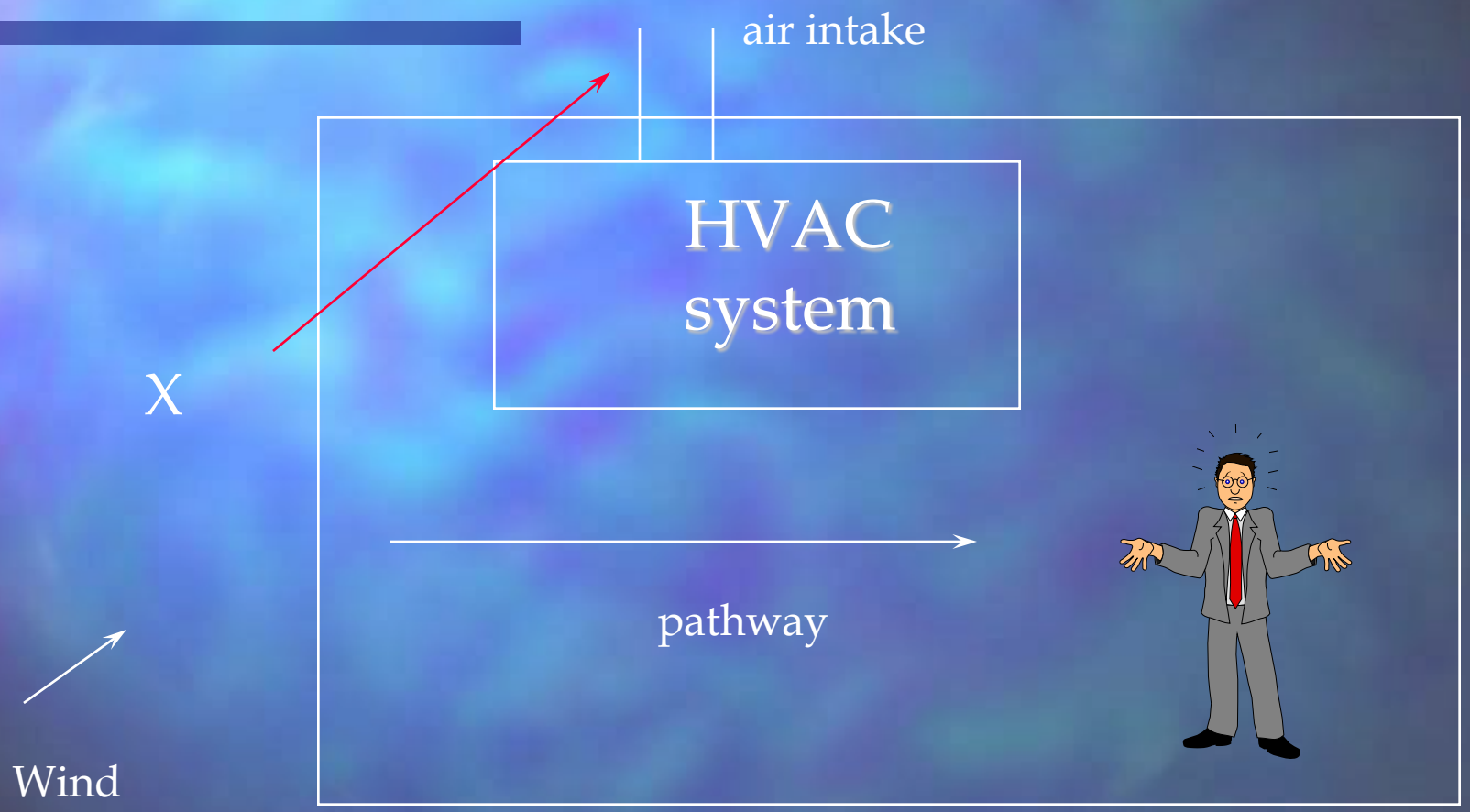
- Outside building
- Mechanical Equipment and office machines in building
- Human activities
- Building components and furnishings

Pathways

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

Pathways

Pathways



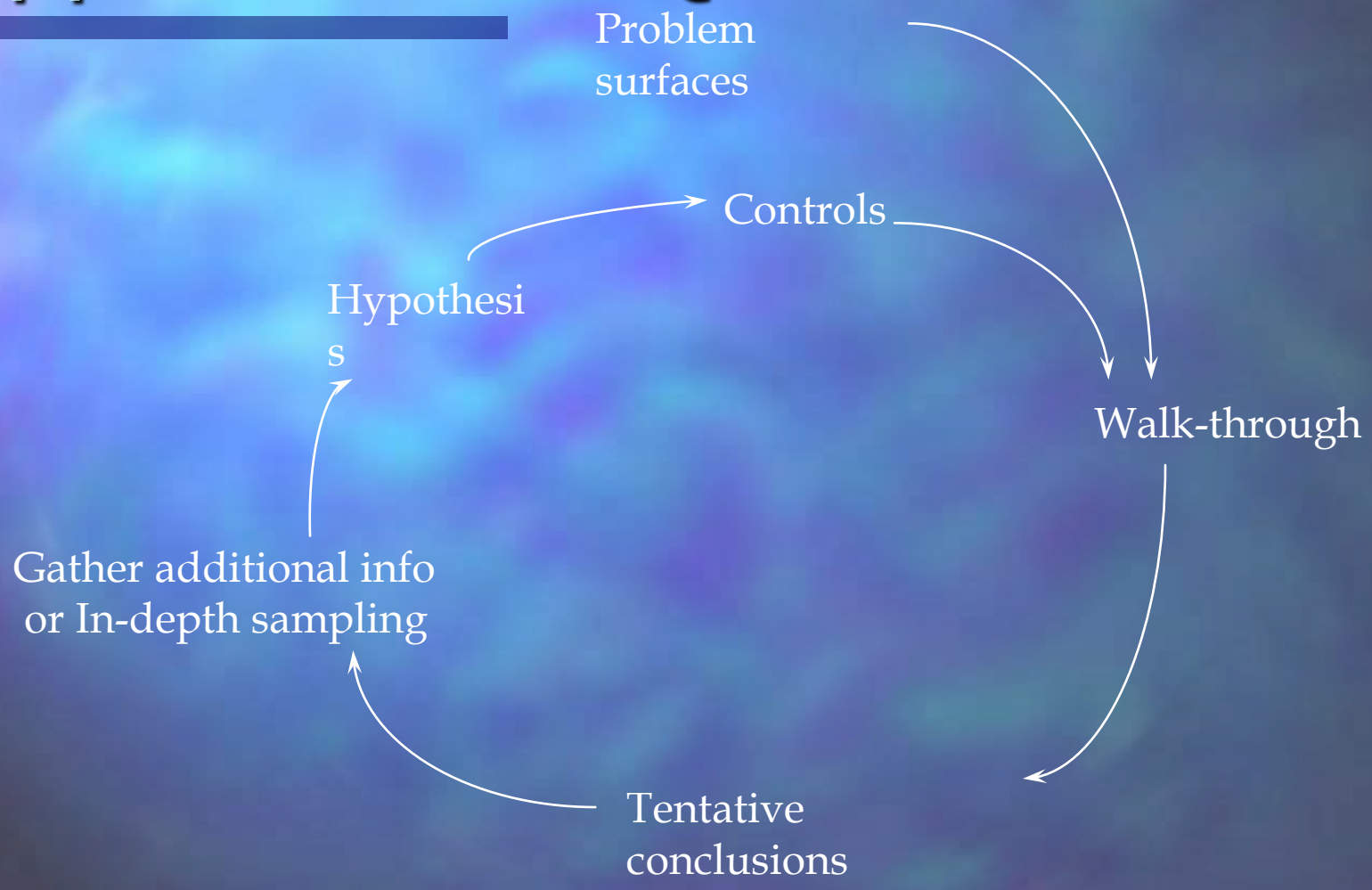
Diagnosing IAQ Complaints

- 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

- CO_2 meter or tubes
- CO meter or tubes
- Temperature, Relative humidity
- Flashlight, step ladder, tool kit
- Tape measure, camera
- Velometer

Approach to IAQ Problems



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

Detailed Investigation

- Sampling for specific contaminant if identified or suspect
- Bioaerosol monitoring
  - Limited guidelines
  - Expensive $

Data collection

Questionnaires / survey forms:

Interviews

- In person
- Over phone
- Mailed

- Tracking
  - activities
  - processes
  - symptom occurrences

Data collection (continued)

- Ensure confidentiality
- Don’t bias process
  - Be consistent
  - Be accurate
  - Be complete

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."

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

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