Indoor Environmental Quality: Investigating the Problem

Charles S. McCammon, Ph.D., CIH

Tri-County Health Department

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Indoor Air Quality: How Clean Is Clean?

Investigating & Attacking Sick Building Syndrome

Also Inside

The Burgeoning Bioremediation Industry

PCBs & Transformer Technology

Introduction

- Politically Correct to say “Indoor Environmental Quality” – IEQ
- Refers to any number of Building Associated Problems Including:
  - Comfort Complaints
  - Odor Complaints
  - Sick Building Syndrome
  - Building Related Illness

How Big Is the Problem?

- In 1990, EPA Estimate $65 Billion in Lost productivity: Value > $100 B Now
- EPA still ranks IAQ as #2 Environmental Issue
- Why should you care about IAQ?
  - $$$$$$$$$$$$$$$$$$$$$$$$$
  - Civil lawsuits = $$$$$$$
  - Employee productivity.
  - Employee satisfaction.
  - Worker compensation claims = $$$$$
  - A Call from OSHA

Background

- Why did we not hear about IAQ until 70-80s?
- Arab Oil Embargo of 1973
  - ASHRAE Changed from 15 cfm to 5 cfm Outside Air per person- term “Tight Building Syndrome”
- Legionella Outbreak 1976
  - Realization that buildings can make you sick (even die!)
- Awareness of Problem


The Washington Post
A WEEKLY JOURNAL OF MEDICINE
HEALTH
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EATING RIGHT:
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HOW & WHY:
WH...WHAT'S WRONG WITH ME? COULD I BE GETTING SICK FROM THAT... BUILDING?...
nfronting America's
west Health Hazard

MARKETPLACE

Who's News: *PepsiCo taps O'Neal to head overseas-restaurants unit* **Page B9.**

Law: *Daiwa Bank reportedly hid losses from accountants, lawyers* **Page B10.**

Squabbles Delay Cure of 'Sick' Office Buildings

By Amal Kumar Naj
Staff Reporter of The Wall Street Journal

While workers sneeze, ache and cry from breathing indoor air, landlords, architects and engineers are at loggerheads over how to make buildings healthier.

For a dozen years, employers, workers, unions, health officials, landlords and builders have been agonizing and arguing over "sick-building syndrome"—a collection of cold-like symptoms that develop among people working in office buildings with sealed windows. Scientists have identified more than 1,500 bacterial and chemical indoor-air pollutants from such sources as carpets and office machines.

"Buildings aren't designed to vent out those products," says Sandra Eberle, the chief of the

ENVIRONMENT

implementation branch of the Environmental Protection Agency's indoor-air division. And aside from the continuing discomfort of workers, the sick-building syndrome is proving increasingly expensive for employers and landlords.

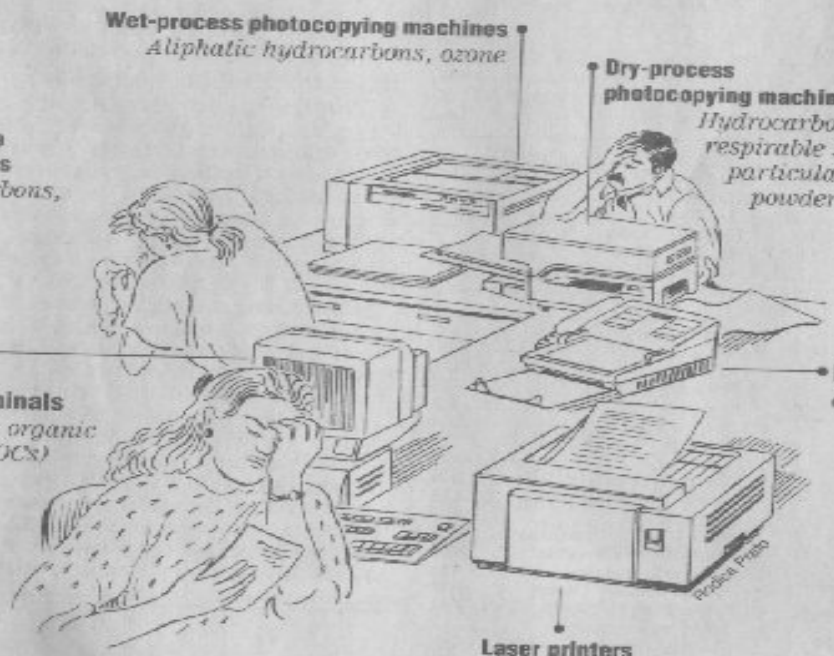
As a notable example, a buildup of bacteria in the indoor air of the county courthouse in Bartow, Fla., led to the evacuation of the building in 1992; the 10-story building, built at a cost of $30 million, was recently reconstructed, along with its air-conditioning and ventilation systems, at an additional expense of $37 million.

In Detroit, some 600 employees had to be evacuated on two occasions from Madison Center, which houses Michigan's 36th Circuit Court, before its air-circulation system was remodeled in 1992. John Paul, the court administrator, said employees complained of headache, nausea and high blood pressure. He said the owner of the building eventually settled several suits filed by employees.

Sealed-window buildings, designed to conserve ener-

OFFICE-EQUIPMENT EMISSIONS

Health complaints include increased perception of headache; mucous irritation; eye, nose and throat irritation; dry and tight facial skin



Source: Air and Energy Engineering Research, EPA

30% of the nation's 4.5 million office and public buildings have problems with their indoor air, estimates James Woods, professor of architecture at Virginia Polytechnic Institute in Falls Church, Va.

headquarters of **West Bend Mutual Insurance** Co. in West Bend, Wis., built in 1991 at a cost of $13.5 million. In its old headquarters, the company had logged many complaints of nausea and headaches from employees, says Ronald Lauret, executive vice president. The company decided to try a new air-filtration and circulation system developed by **Johnson Controls** Inc. of Milwaukee.

By means of the Johnson Controls system, the air in West Bend Mutual's new building is first cooled and filtered in a central unit and then goes through two more filters at each work site. The system has controls at each site that allow workers to customize flow, direction and temperature of the air.

The new system, which did away with the extensive duct work in the conventional system, increased construction costs by only $150,000. Mr. Lauret says the company has recovered that cost many times over. "The absenteeism has dropped, and productivity is up between 8% and 16%," he says. The system also has resulted in significant energy savings; it costs 11 cents per square foot compared with 18 cents in the company's old headquarters.

Still, cost fears continue to deter most landlords and engineers from trying new approaches. "I have had many clients who were truly interested in addressing the issue of indoor-air quality, but as the projects went along it didn't stay a high priority," says Hal Levin, an architect in Santa Cruz, Calif.

Kevork Derderian, president of Continental Offices Ltd., a real-estate development and management company in Chicago, says: "The simple fact of life is that if I put in the best technology and I want a dollar more per square foot, I wouldn't get it, not even close to it."

Even if there is a desire to try a new technology, it often fades over the question of who should bear the fi-

Building Associated Illnesses

- Complaint or Symptom Rates are Elevated
- Investigation Confirms Relationship to Occupancy in Building
- Occupants Feel Better Over Weekend, Start Getting Sick Early on Monday A.M.

Sick Building Syndrome - SBS

- Symptoms Abate Upon Leaving and Worsen Upon Reentry of Building
- Characterized by Absence of Routine Physical Signs and Clinical Abnormalities, i.e., Doctors can’t see what makes them sick
- Symptoms NOT Associated with Specific Environmental or Other Casual Agents

SBS Symptoms-WHO

- Eye, Nose, Throat Irritation
- Dry Mucous Membranes and Skin
- Mental Fatigue
- Headaches
- Lethargy
- Nausea and Dizziness
- Airways Infection and Cough

Comfort and Odor Complaints

- Most Common of Building Complaints
  - Too Hot
  - Too Cold
  - High/Low RH can trigger complaints
- Odors
  - Most Common Trigger for Perception of Poor Indoor Air Quality
  - Can result in nausea, headache, fatigue

Building Related Illness

- Real Deal, like Legionella Outbreak
- Have Known Causes
- Accompanied by Physical Signs and Laboratory Findings, Docs can diagnose
- Diseases Associated with Contamination Problems
  - Infectious Microorganisms
  - Allergenic compounds, e.g., molds
  - Chemicals

Possible Causes for Increased Complaints in IAQ

- Physical Factors – >50%
  - HVAC system, design, maintenance, etc.
- Chemical
- Biological
- Psychological

Common Chemical Sources in IAQ

- Tobacco smoke- slowly dissipating as problem area
- Volatile Organic Compounds (VOCs)
  - Formaldehyde-outgasses from many new products
- Gases, like CO from combustions and Ozone from copiers/printers
- Biocides, pesticides, etc.

Physical Factors

- Inadequate Ventilation is #1
  - Not enough outside air
  - Poor air distribution
  - Poor air filtration
  - Poor location of outside air intake
  - Modification of offices without HVAC mods
  - Poor location/type of air diffusers
  - No return air

How are IAQ Investigations Conducted?

IAQ Investigations

- Building Characterization
- Symptom Survey
- Ventilation System Evaluation
- Source Identification
- Sampling
- Remediation

Building Characterization

- Type and age of building
- Construction materials
- Primary uses
- Cleaning practices

Type and Age of Building

- Previous ventilation systems.
- What remodeling has taken place?
- What were the prior uses?
- Is asbestos a concern?
- Is mold a concern?

Construction Materials

- Wood Construction vrs Metal
- Fire proofing material
- Crawl spaces
- Carpeting and wall coverings

Primary Uses

- Is a manufacturing area included?
- What is the occupant density?
- Computer usage.
- Has the primary usage changed?

Cleaning Practices

- Who cleans the building?
- When is the building cleaned?
- Cleaning product storage.
- Cleaning product MSDS information?

Symptom Surveys

- Questionnaires vs. Interviews
- Risk: If problem not wide-spread, it will be after questionnaire
- The survey must:
  - Cover a majority of the staff (80-90%).
  - Be pre-tested.
  - Eliminate bias.
  - Not suggest answers.
  - Not be a group effort.

Questionnaire Topics

- Demographic Questions
- Comfort Questions
- Medication Questions
- Diagnosed Illness Questions
- Symptom Questions
- Air Quality Control Questions
- Job Satisfaction Questions

Comfort Factors

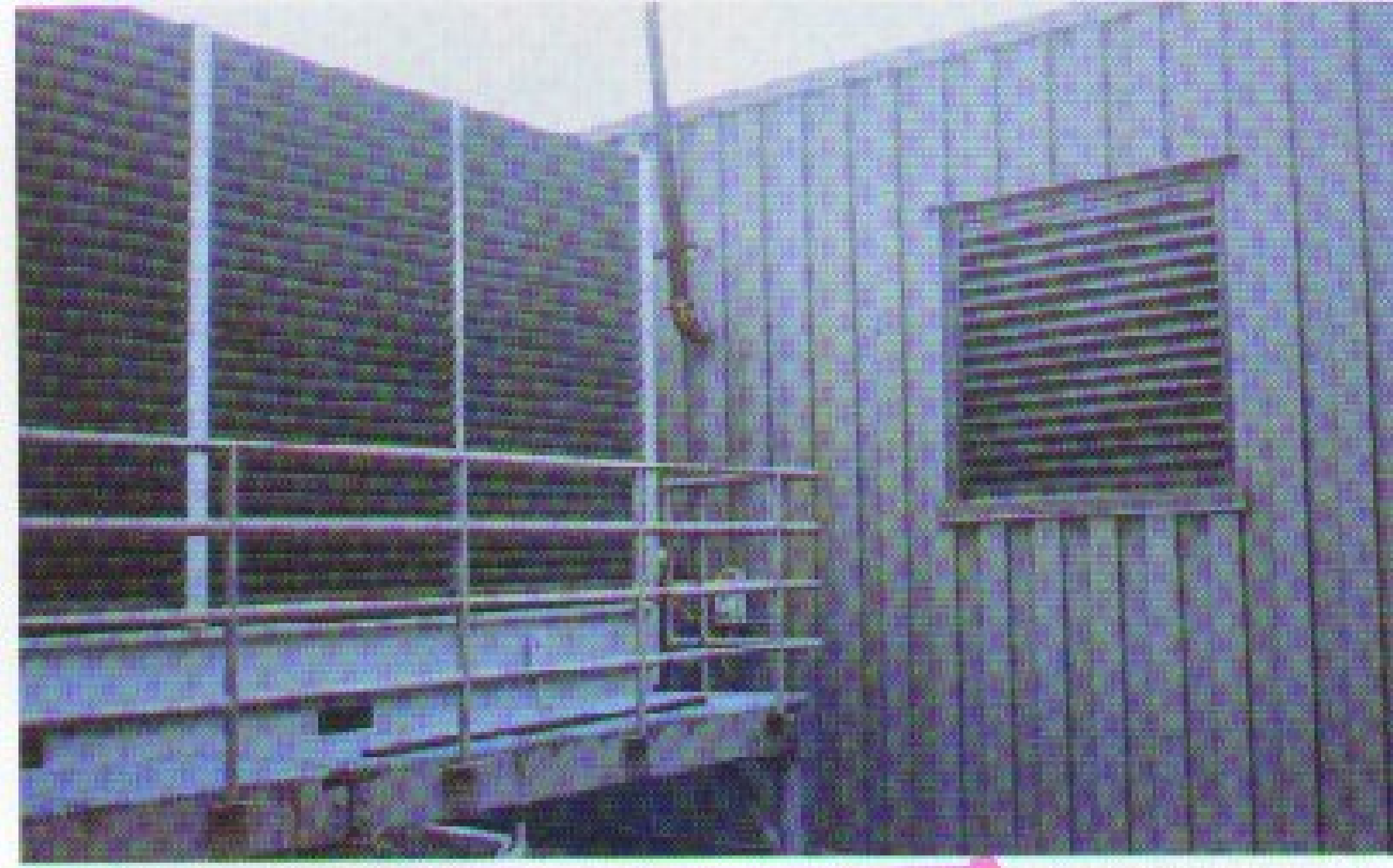
Complaint	Low School	High School
Cold	32%	73%
Hot	21%	50%
Stuffy	7%	52%
Moldy	14%	10%
Dusty	11%	23%
Noisy	0%	19%
Dry	11%	25%
Crowded	0%	17%

Typical HVAC System Problems

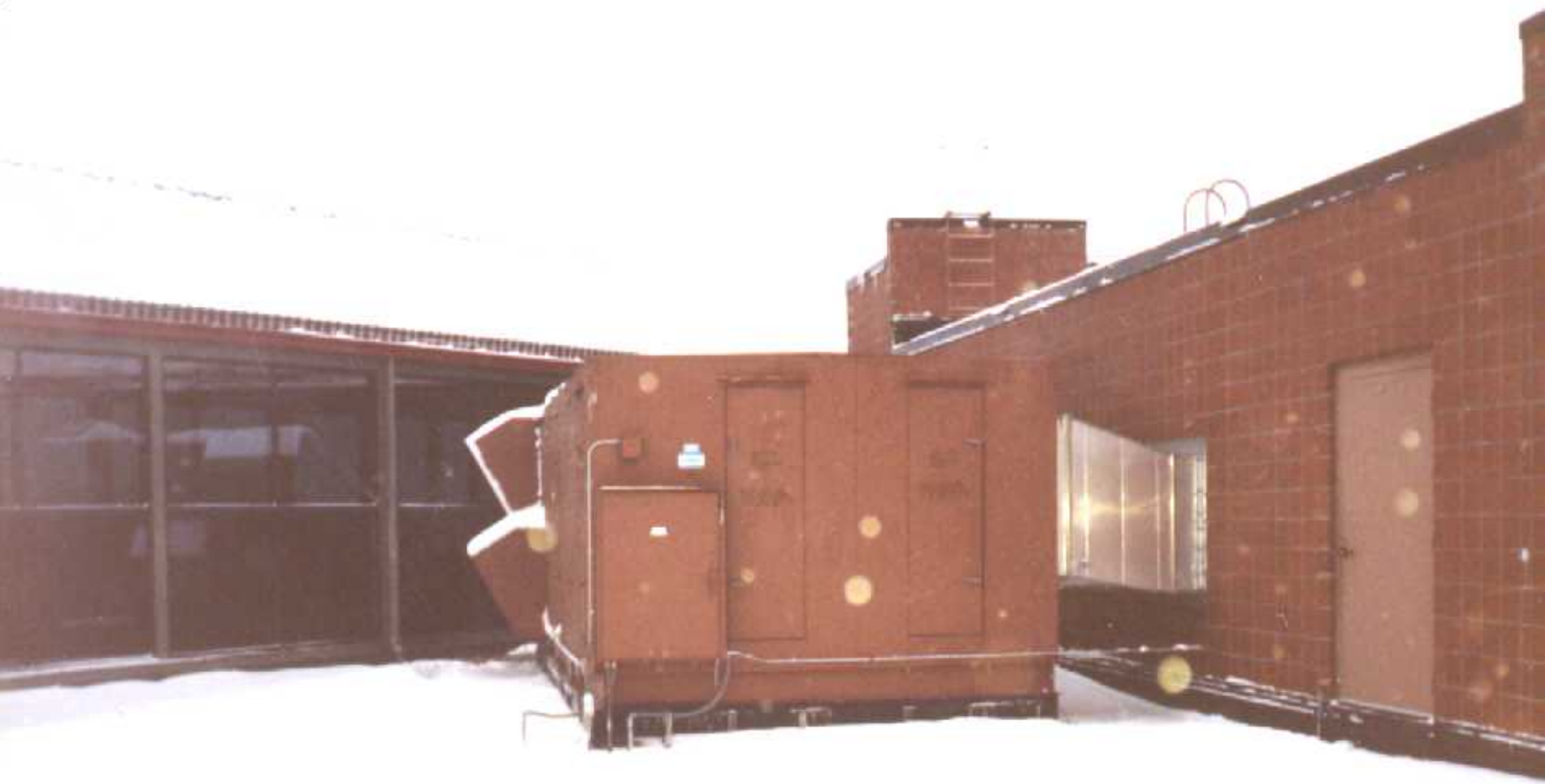
- Design Problems
- Construction Problems
- Operator Problems
- Renovation Problems
- Occupant Problems

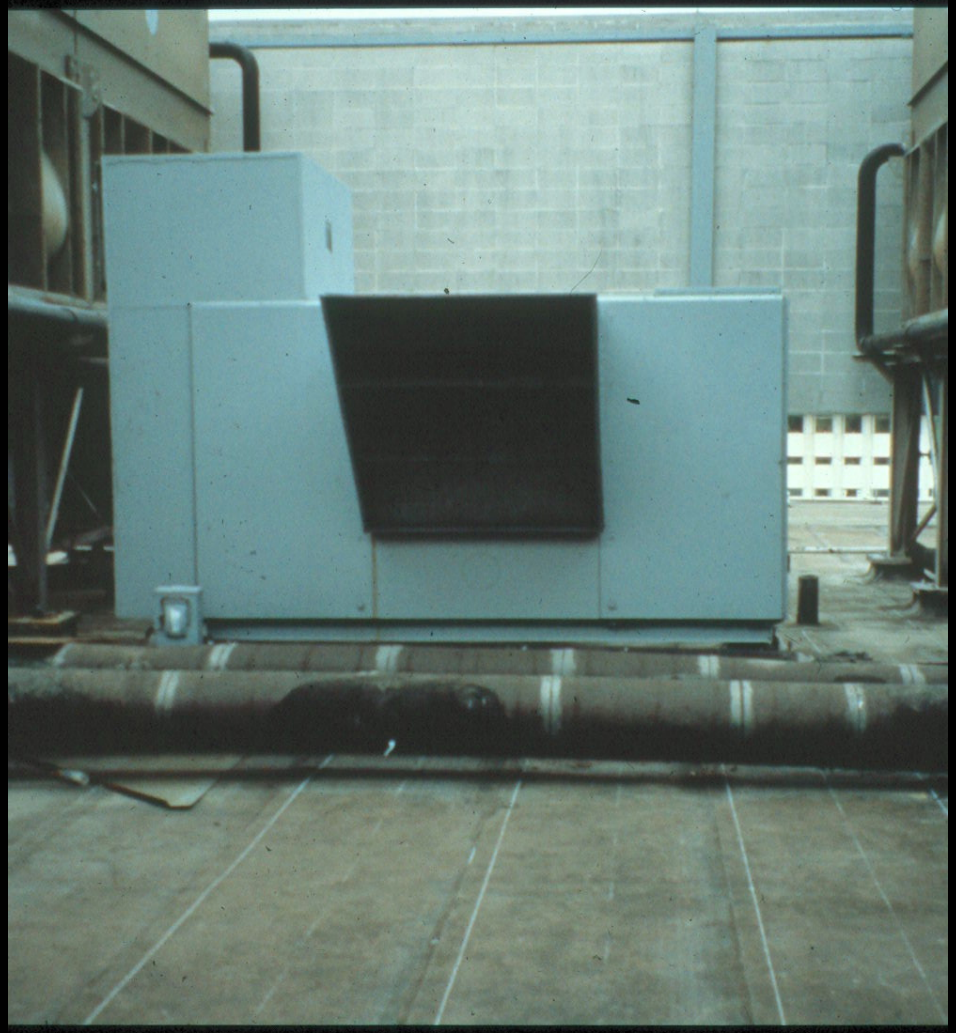
Ventilation System Evaluation

- Visual inspection of System.
- Carbon dioxide (tracer gas) measurements.
- Look for the following:
  - Water infiltration
  - Maintenance history
  - General condition
  - Use of local exhaust
  - Placement of exhausts and intakes

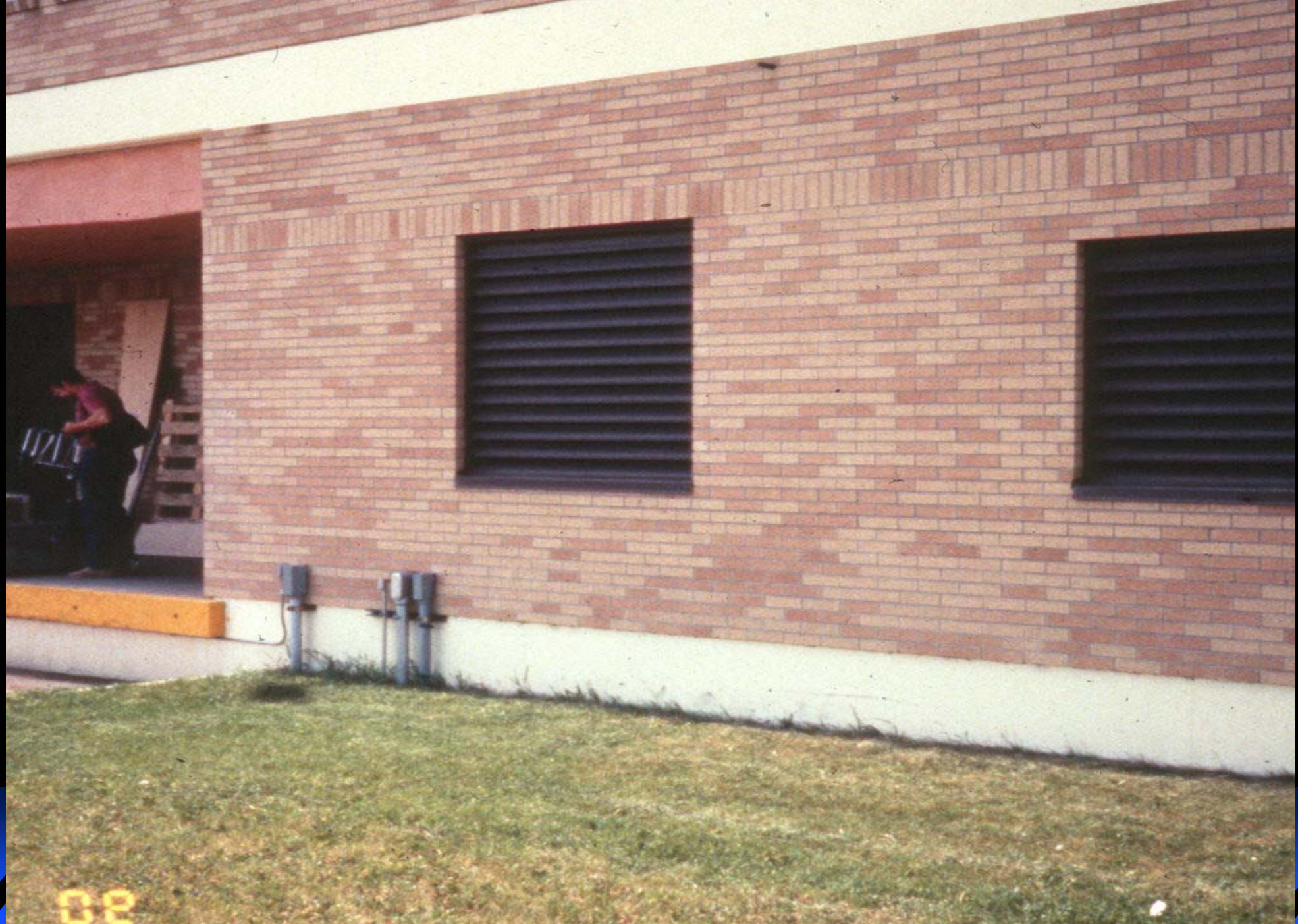


An outside air intake positioned too close to a cooling tower . . .






Getty
Premium
Unleaded




20X25
FAP 30
Flanders
FAP 30
Flanders
16 x 25 x 2
Series 300

HVAC Systems
Air Filters

- Low Efficiency: 10-20%
  - Used to keep lint from clogging coils
- Medium: 30-60%
  - Used to remove bacteria, pollens, insects, soot, dust & dirt (often in combination with Low Eff.)
- High: 85-95%
  - Exceptionally clean – not usual for most buildings

An example of low quality, poorly maintained and improperly fitted filters

HVAC Systems
Air Filter Considerations

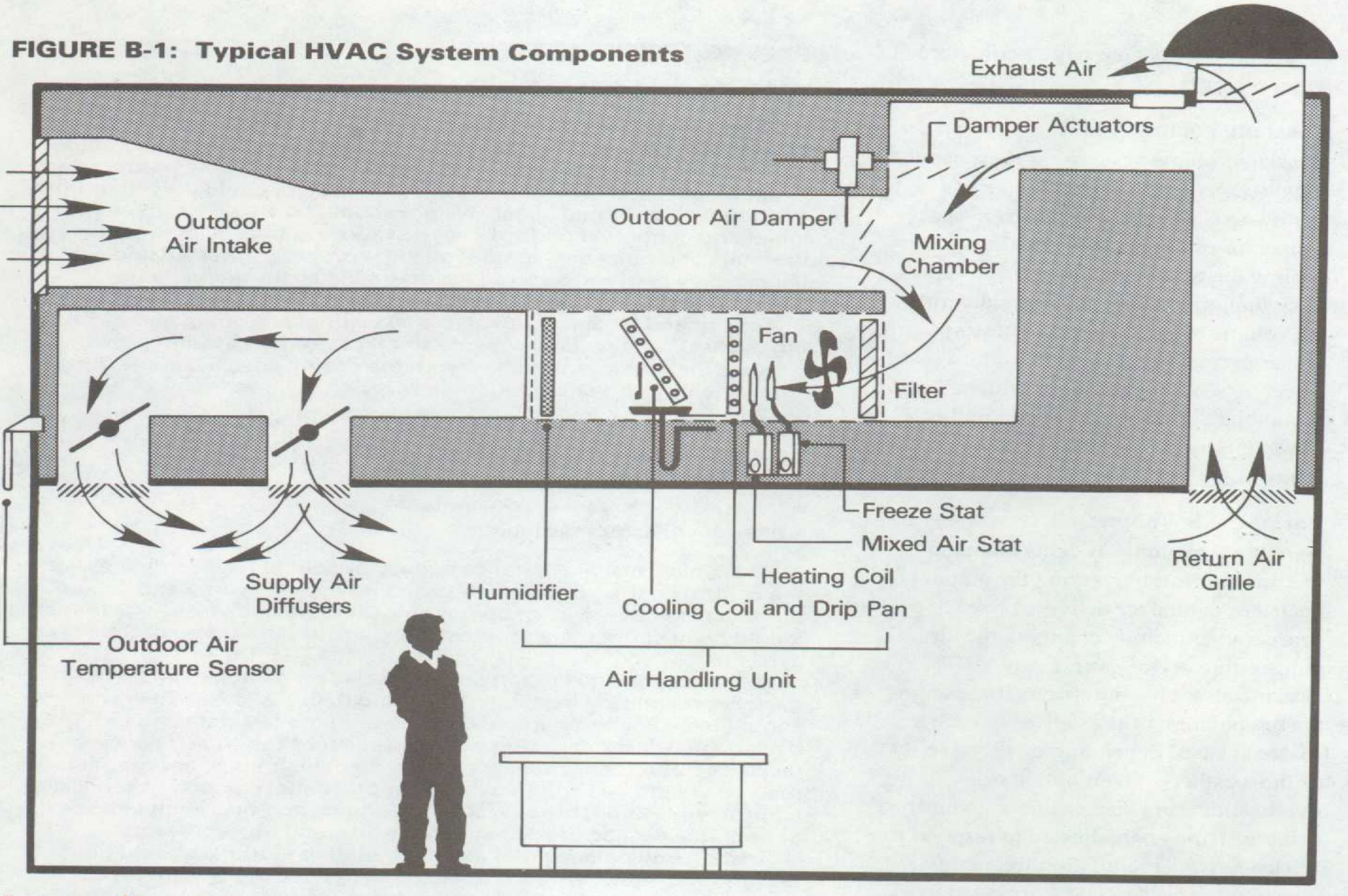
- Always use maximum system can handle (pleated type low Pressure Drop)
- Keep log, replace regularly
  - Inspect often for tears
- Never, Ever Wet Filters
- Make filters easy to access
  - Not often case for fan coil, reheat units


2 58

Ventilation System Characterization

- System Type
  - Constant Volume
  - Variable Air Volume
  - Unit Ventilators
- Zones
  - Single Zone
  - Multi-Zone
- Reheat or No Reheat
- Ducts - Lined or Unlined

FIGURE B-1: Typical HVAC System Components

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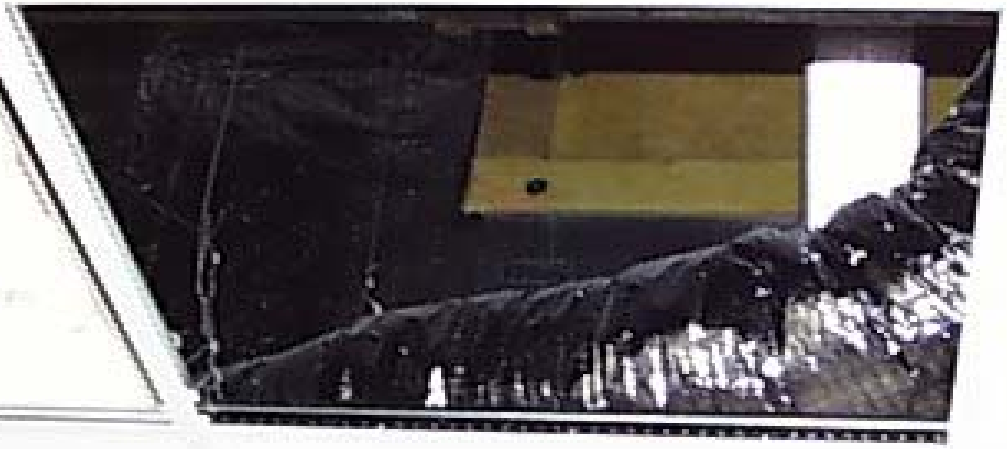


Unit Ventilators or Fan Coil Units

- Not actually an air handling system.
- Mount on outside wall.
- Provide some filtration, conditioning, and movement.
- May have independent or centralized heating & cooling
- Induction units may provide outside air, others typically do not


97 4 30


94 4 14

Constant Volume Systems

- Provides a constant supply airflow rate to zones with similar thermal loads.
- Air temperature is controlled at the air handler or with reheat coils.
- Outside air is determined by:
  - Outside air temp.
  - Damper settings
  - Temperature demand

Variable Air Volume Systems

- Provides a constant temperature air to the duct system.
- Air from the duct system is supplied to the zone to manage thermal load by the use of VAV boxes – common in multiple zone systems, like schools.
- Under ventilation due to no minimum stop or max supple too low for loads in zone
- Outside air is determined by:
  - Thermal demand of zone.
  - Outside air temperature.
  - VAV box and damper minimum settings.

Results of CO_2 and ACH Sampling

	CV	VAV	UV
Mean of CO_2	715 ppm	666 ppm	573 ppm
CO_2 Range (ppm)	390 - 957	318 – 1,763	295 – 1,450
% of Time > 1000 ppm	0%	11%	9%
Mean ACH	4.6	2.8	2.7
Range ACH	1.9 – 7.5	0.8 – 4.6	0.4 – 4.6

Complaints by System Type

Type of Complaint	More than Expected	Less than Expected
Too cold	VAV	CV
Individuals w/ complaints		VAV
Eye Symptoms	CV	VAV
Headache Symptoms	UV	VAV
Nasal Symptoms	UV	VAV, CV
Throat Symptoms	UV	
Dustiness Complaints	UV	CV

HVAC Systems
Other Problem Areas

- Heating & Cooling Coils
  - Make sure condensation drains away
  - If hot water not hot enough, causes OA to be reduced and cannot heat spaces well
- Humidification Systems
  - Avoid use when possible
  - Keep % RH <60%
  - If needed, use only clean steam injection type
- Evaporative Coolers- also avoid

HVAC Systems
Other Problem Areas

- System balancing a must
  - ASHRAE 111-1988, every 3-5 yrs
- Use unlined ductwork whenever possible
- Check location, operation of diffusers
- Check return air plenums for contamination
- Insure sufficient makeup air for exhausted areas: toilets, cooking areas, parking garages

Source Identification

- Look for the following:
  - Manufacturing areas
  - Print shops
  - Construction
  - Cleaning agents
  - Combustion products
  - Other: pesticide treatment,
    - Chemical storage

Sampling

- Initial Site Assessment
- Secondary Sampling

Initial Site Assessment

- HVAC system measurements:
  - Carbon dioxide, air flow.
- Ambient air measurements
  - Carbon monoxide, carbon dioxide, temperature, relative humidity.


EXIT

Secondary Sampling

- Should only be conducted when:
  - Specific information is to be collected
  - Knowledgeable personnel are present
- HVAC measurements
  - Tracer gas, duct velocities
- Ambient Air
  - Chemicals - VOC's, aldehydes, MVOC's, odors, particulates, etc.
- Bioaerosol Sampling
- Medical monitoring

Why conduct tracer gas testing?

- To determine air exchange rate for a building or area of a building.
- To determine fresh air distribution for a building or area of a building.
- To determine ventilation infiltration.
- To determine exhaust system effectiveness.
- To determine contaminant pathways

Tracer Gas Testing Methods

- Tracer gas characteristics.
- Tracer gas introduction methods:
  - Injection
  - Constant Flow
  - Duct injection
  - Hood Testing
- Concentration measurement methods
  - GC
  - Infrared

Tracer Gas Testing Methods (Cont)

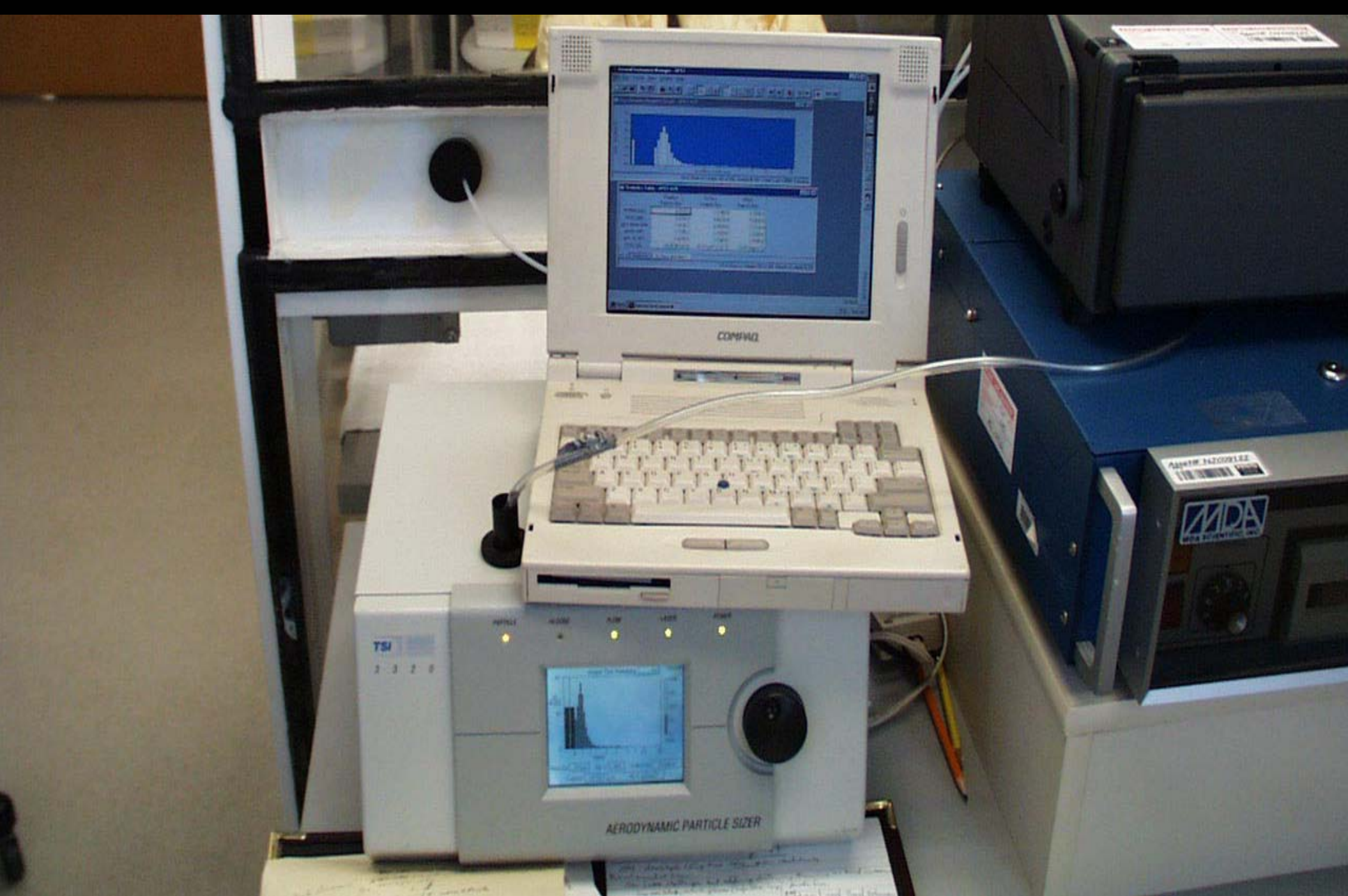
- Tracer gas introduction:
  - Air Change Studies
  - Contamination Studies
  - Hood Studies

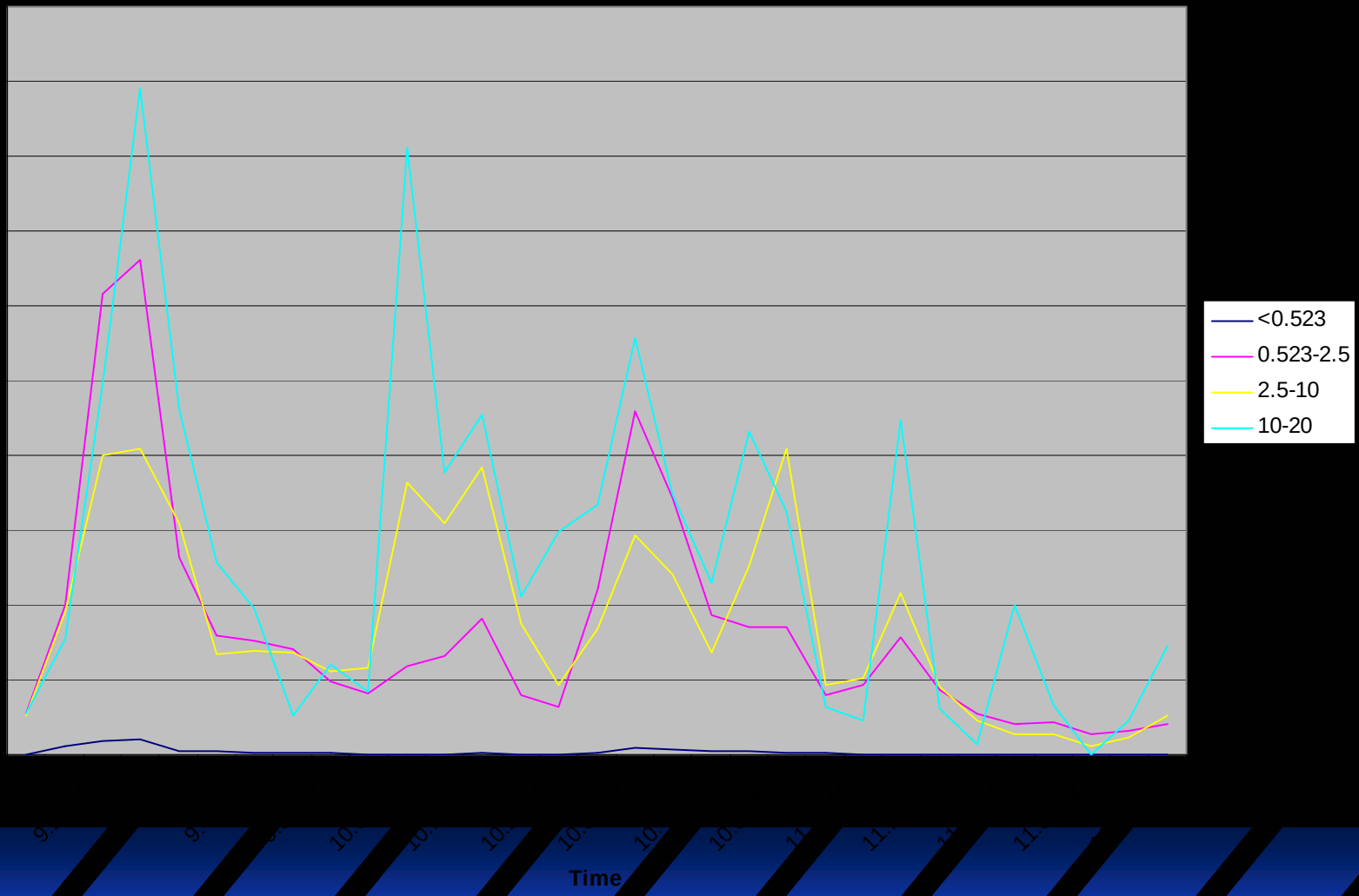
Results

- What do results indicate?
- Limitations!
- Comparisons with carbon dioxide methods for ventilation.

Particulate Sampling

- Methodology
  - Mass collection
  - Particle counters
  - Condensation nuclei counters
- Results - What do they mean????
  - Mass
  - Mass/particle size
  - Particle numbers
  - Ratios


COMPAQ
TSI
AERODYNAMIC PARTICLE SIZER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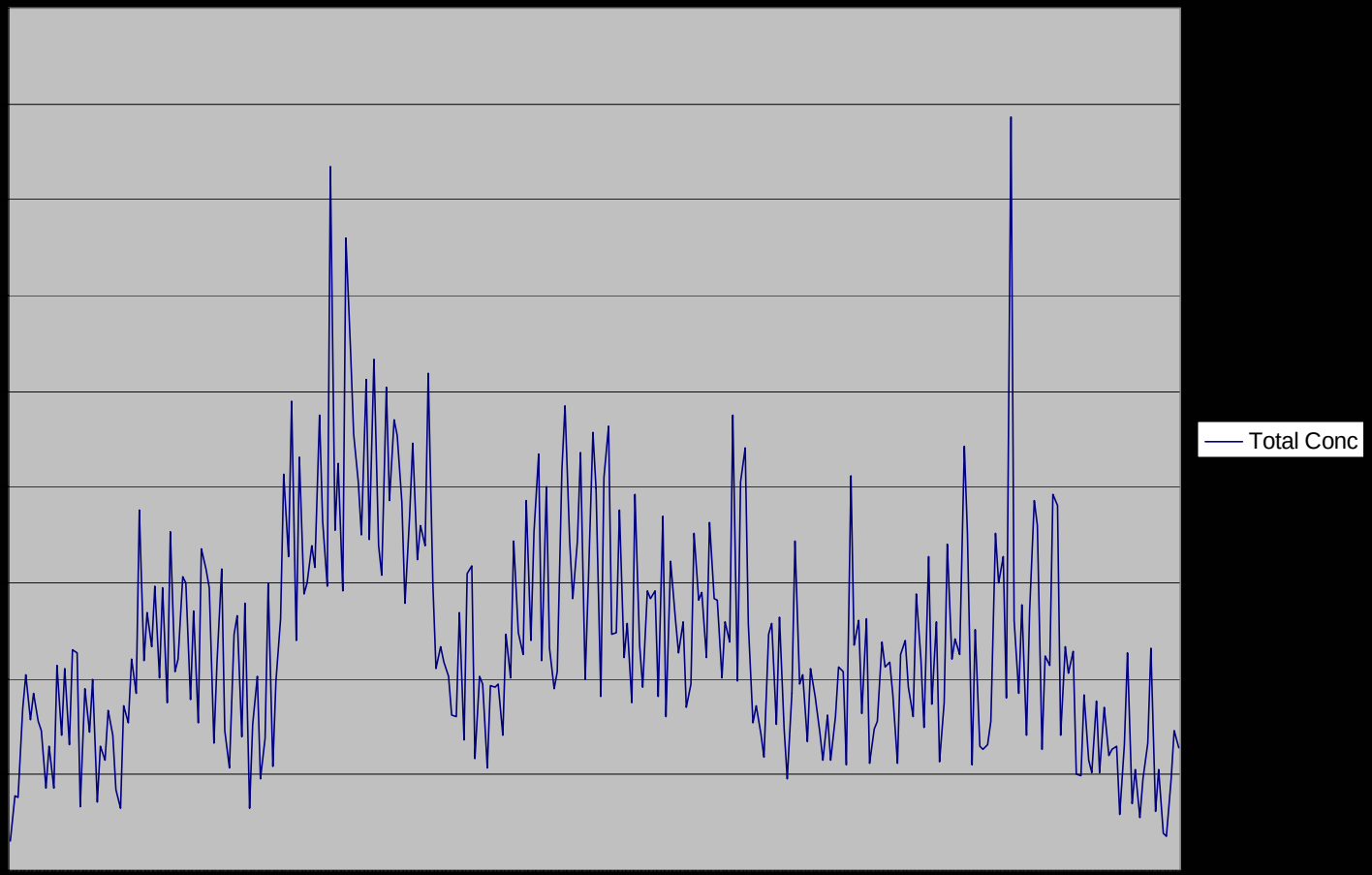
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Sampling complications

- Interpretation of results is difficult.
- Generally low probability of identifying a problem.
- High cost
- Grab samples may give non-typical results.
- Source identification may not be possible
- Source reduction will still need to be done.

Remediation

- Increase outside air
- Decrease outside air
- Control sources
  - Local exhaust ventilation
  - Elimination
  - Control devices
- Contain construction or remodeling
- Isolate manufacturing areas

WHEN GERMS ATTACK!

Dust, mold and microscopic germs maybe attacking you from the air ducts!

Indoor air pollution is often worse than the air outside. Your home's air ducts contain dirt, dust mites, mold, dead animals and microscopic germs. These pollutants can make your family sick with colds and allergies! Dirty air ducts can affect your family's health and make your furnace run inefficiently. Call now and ask for a FREE estimate! Monster Vac can improve your Indoor Air Quality. Take advantage of our superior power and get Monster Vac'd today!

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Factors confounding IAQ investigations

IAQ Problems are the Sum of all stressors, other sources include:

- Ergonomic problems
- Lighting
- Smoking policies
- Comfort Complaints
- Psychosocial issues
- Other job stressors

Job Stressors Leading to Job Strains

- Interpersonal Factors
  - Social density too high/low
  - Abrasive personalities
  - Group pressure to conform
- Physical Demands: noise, light, temp/RH
- Individual factors
  - Behavior pattern, e.g., Type A
  - Hardy personality styles
  - Self esteem
- Non-Work Factors: families, money, child rearing

Psychosocial Factor Studies

- Cornell University
- 3-1\2 yr of 27 office buildings
- 40% of bldg occupants reported at least 1 SBS symptom
- No complaint correlation with extensive environmental measurements
- High correlation of Symptoms with:
  - Job Stress
  - Job Satisfaction
  - Perception of Indoor Air Quality

Psychosocial Factor Studies

- Large Study by Bauer and Ryan
- Correlation of SBS Symptoms with:
  - Job Stress & Job Satisfaction
  - Belief that health is adversely effected by building
  - Perception of poor Indoor Air Quality
  - Off the job strains and conflicts
- Solution to Problem: Form IAQ Committee with
  - Employees
  - Management
  - Building Maintenance Personnel

How to Deal with Other Factors in IAQ

- Many factors exist which are out of the hands of maintenance personnel alone-solve what you can
- Problem must be addressed as a multifactorial one, not just looking for the smoking gun
- Need for lots of communications at all levels, from first-line HVAC Tech, through building occupants to Building Manager
- Get employees involved with the IAQ problems
- As a last resort, find other work environments for few problem employees