WELCOME

EDISON ELECTRIC INSTITUTE

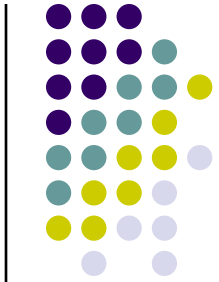
OCCUPATIONAL SAFETY & HEALTH COMMITTEE

TOOLS OF THE TRADE FOR EVALUATING INDOOR AIR QUALITY

Debbie Dietrich, CIH

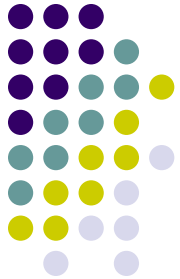
SKC Inc.

THE CHALLENGES UNIQUE TO IAQ EVALUATIONS



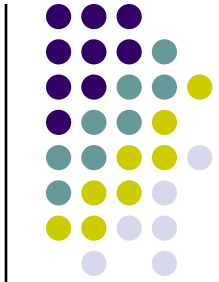
1. Building occupants may complain of health effects at contaminant levels far below the OSHA limits.
2. NIOSH/OSHA sampling methods may not be able to detect the lower levels found.
3. Once you get the sampling results, it is difficult to interpret the data.
4. Building comfort factors may confound the investigation of *air quality*.

OVERCOMING THE CHALLENGES:
RESPONDING TO COMPLAINTS



- In the overall costs of operating a commercial building, “people costs” are by far the highest.
- If the workforce is absent, sick, or unproductive, the OSHA limits will be irrelevant to management.
- So health and safety professionals will serve both the building occupants and the building owner/employer by seriously addressing the concerns.

OVERCOMING THE CHALLENGES: RESPONDING TO COMPLAINTS



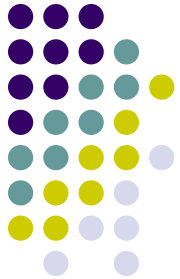
THE FIRST STEP

- Before embarking on a program of air measurements, survey both the area and the people involved in the complaint.
- Use this time for information gathering.
- Look around. Listen.

GATHER CRITICAL INFO

- Complaint vs non-complaint areas.
- Date when problem was first noted.
- Days or times when problem is noted more and less.
- Seek input so you can formulate a hypothesis on the root cause of the complaints.

OVERCOMING THE CHALLENGES: SAMPLING METHODS



- NIOSH/OSHA sampling and analytical methods are designed for industrial workplace applications.
- If you want to use these methods to measure lower levels, talk to your analytical laboratory for advice prior to sampling.
- For gases/vapors, NIOSH suggests you sample a LONGER TIME rather than a higher flow rate to collect more contaminant onto the media.

OVERCOMING THE CHALLENGES: SAMPLING METHODS

- In 1990, U.S. EPA published a compendium of methods for the collection of indoor air pollutants.
- These methods are designed to collect typical indoor contaminants at the lower levels found in this environment.
- These methods can be found on the California EPA website at www.arb.ca.gov/research/indoor/methods.htm

OVERCOMING THE CHALLENGES: DATA INTERPRETATION

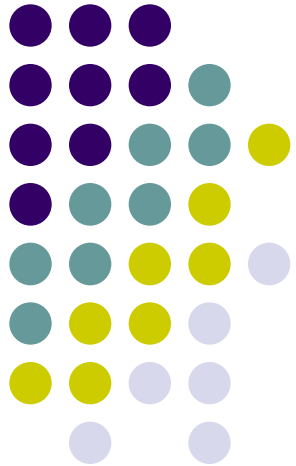
- OSHA PELs or ACGIH TLVs will not typically be useful in evaluating indoor air measurements.
- Data interpretation may involve *comparison* of results: complaint vs non-complaint areas; indoor vs outdoor; test area vs control area.
- Guidelines from professional associations or peer-reviewed journals are also useful and will be given in this presentation.

OVERCOMING THE CHALLENGES: CONFOUNDING FACTORS

- Even if the complaint seems at first to be related to air contaminants, also consider building comfort factors that may cause similar health effects.
- Building comfort factors include illumination levels, glare, temperature, relative humidity, and noise.

COMMON INDOOR AIR CONTAMINANTS

SOURCES, SAMPLING METHODS, AND GUIDELINES FOR DATA INTERPRETATION



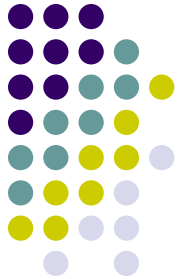
TARGET: MOLD

NOT SUCH A FUN-GI

MOLD: A MOISTURE PROBLEM

- Mold can grow on any substance including wood, paper, carpet, and foods providing moisture is present.
- Most microorganisms can thrive in the temperature range and on the nutrient sources in buildings.

INVESTIGATING MOLD:
MOISTURE INDICATORS



- Water marks on ceiling tiles and other surfaces
- Visual presence of mold
- Musty smell of microbial VOCs
- White, powdery or crystalline substance of the surface of concrete, plaster and masonry which are soluble salts dissolved from the building materials

INVESTIGATING MOLD:
MOISTURE METERS

- Used to survey moisture in any non-conductive porous material to which the probes can be applied.

- Ceiling Tiles
- Gypsum Board
- Carpeting
- Wood
- Plaster
- Concrete

INVESTIGATING MOLD:
MOISTURE METERS

ECONOMY MODEL

- Operates by measuring the electrical conductance between two probes inserted into the material to be tested.
- Useful for construction or renovation projects or other situations when the test surface can be punctured by the probes.

SKC 751-6060

INVESTIGATING MOLD:
MOISTURE METERS

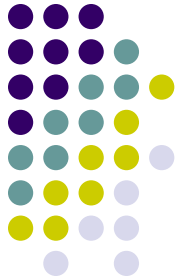
PINLESS MODEL

- Measures resistance between two low-frequency signals transmitted from conductive pads without the need for insertion into the test material.
- Specialty models available for testing concrete.

SKC 759-101/102

DATA INTERPRETATION

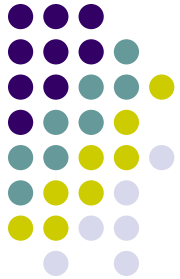
MOISTURE METERS



- Moisture levels can be compared from wall to wall to determine where moisture intrusion is occurring.
- Once the location of the moisture is found, an investigation can be made as to the cause and a control strategy can be developed.

DATA INTERPRETATION

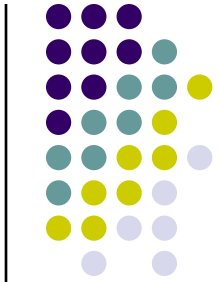
MOISTURE METERS



- The Western Wood Products Association (WWPA) has prepared a technical guide on preventing and controlling mold in **lumber**. See www.wwpa.org/moldff2.htm.
- WWPA recommends that the moisture content of the wood be kept below **20%.**

DATA INTERPRETATION

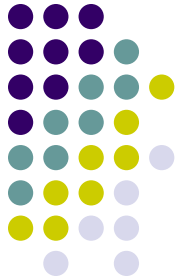
MOISTURE METERS



- Greenguard Environmental Institute (GEI) has received ANSI approval for a standard covering the management of moisture (and mold growth) during building construction.
- See www.greenguard.org

SAMPLING FOR MOLD

WHY AND HOW



Sampling is done:

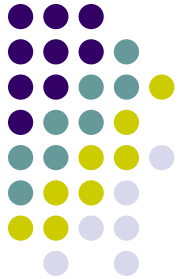
- To test your hypothesis on the cause of the problem
- To positively confirm the presence of mold
- To identify the type of mold (genus/species)
- To confirm the effectiveness of mold decontamination.

Sampling may include:

- Bulk samples
- Surface samples
- Air samples

Followed by analysis at a qualified environmental microbiology laboratory.

BULK SAMPLING FOR MOLD

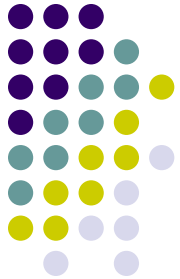


- Portions of materials in the building can be tested for mold or other biological contaminants.
- Typical test materials include sections of wallboard/wallpaper, carpet pieces, return-air filters, duct lining, and settled dust.
- These are very useful as air sampling may miss some mold contaminants due to temporal variations in spore release .

BULK SAMPLING FOR MOLD

- Portions of the test material are typically placed in a sealable plastic bag for transport to the lab.
- In some cases, sterile jars for dry items or sterile bottles for water samples may be required.
- Settled dust can be collected using conventional vacuum cleaners and a new vacuum cleaner bag for each sample.

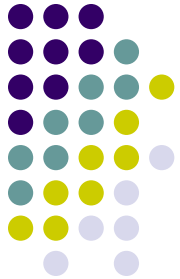
SURFACE SAMPLING FOR MOLD:
WHY AND HOW



SAMPLING IS DONE:

- To confirm the **presence** or absence of microbial growth on test surfaces.
- To determine whether microbial **levels** in test areas are greater than background levels.
- To identify the **types** of microorganisms present.
- To determine possible **sources** of microbial contaminants.

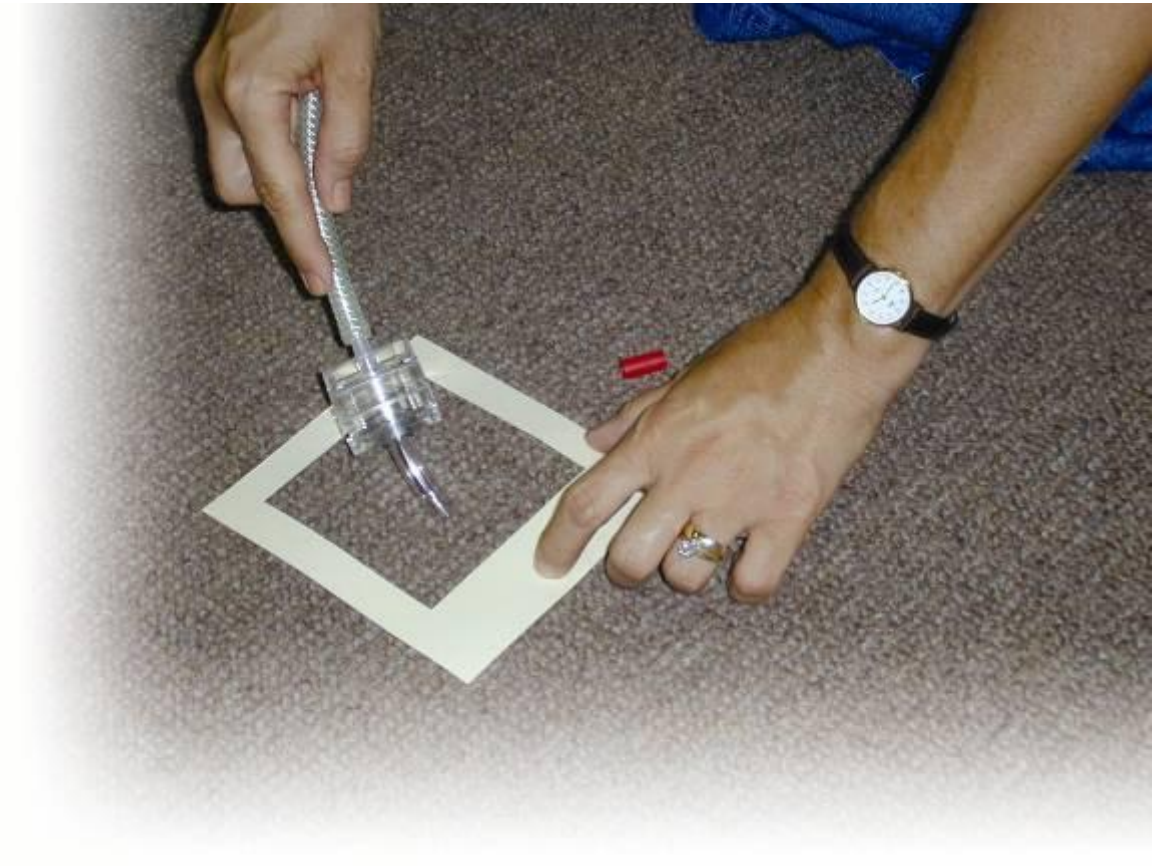
SURFACE SAMPLING FOR MOLD



MICROVACUUM CASSETTES

- Carpeting is an effective reservoir for fungal spores and sampling this surface can reveal the history of mold in the building.
- To sample fungal spores in carpeting, a vacuum-style cassette is available with a 0.45 um polycarbonate filter loaded into a 3-piece styrene cassette with 2-inch tubing nozzle. Sample at flows up to 16 L/min to vacuum a defined area.
- Work the inlet tube as deep as possible into the carpeting to collect a good sample of the dust.

CARPET SAMPLING KIT



SKC 225-9540

DATA INTERPRETATION

CARPET SAMPLES

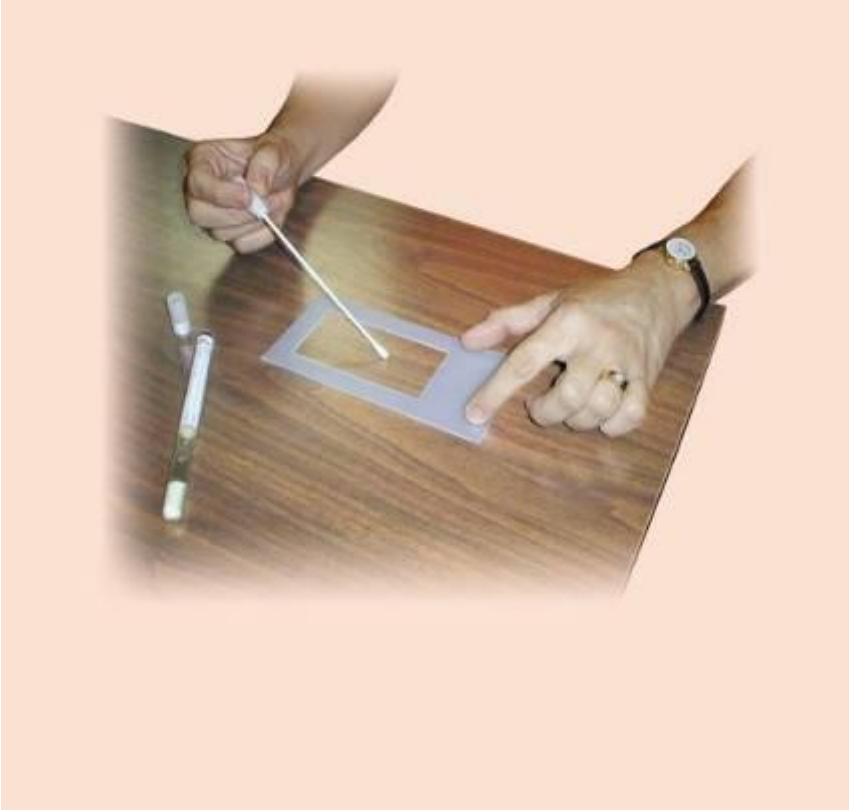
An 2003 AIHCE paper by MidWest Microbiology gave some numerical guidelines for **fungal spores** on surfaces like carpet using microvacuum cassettes:

- Normal- <5,000/1000 cm^2
- Borderline- 25,000/1000 cm^2
- Elevated- 75,000/1000 cm^2

SURFACE SAMPLING FOR MOLD

STERILE WIPES

- A swab or filter wetted with sterile water or wash solution is used to wipe a specified area.
- Typically, the swab is then used to inoculate an agar plate for growth culture.



SKC 225-2402

DATA INTERPRETATION
SWAB SAMPLES

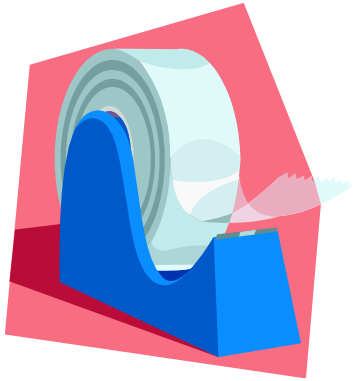
The November 2001 AIHA *Synergist* guidelines for fungal spores in swab samples:

- Normal: <10,000 cfu/in^2 or <1,500 cfu/cm^2
- Probable Contamination: >10,000 cfu/in^2 or >1,500 cfu/cm^2

SURFACE SAMPLING FOR MOLD

LIFT TAPE

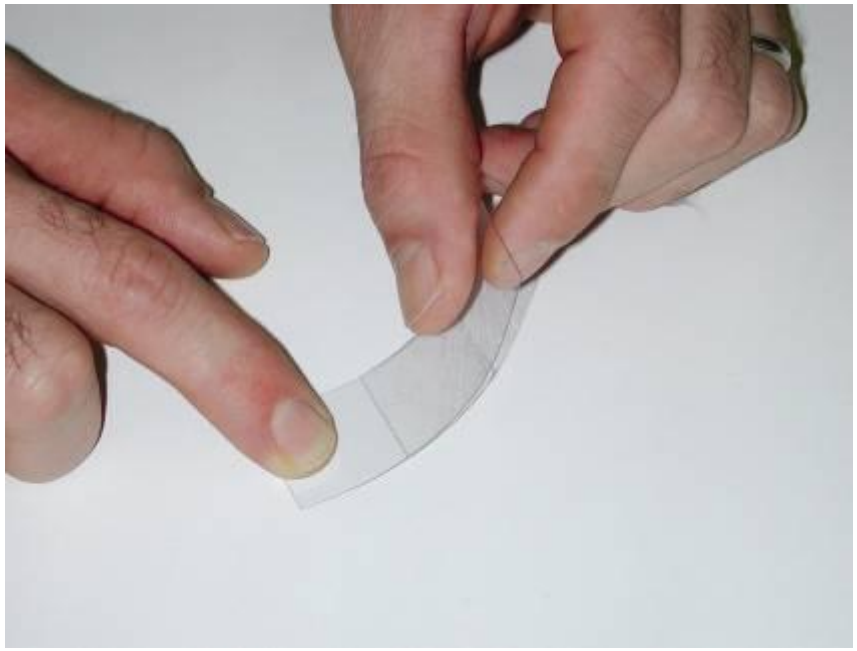
- Collected by placing clear adhesive or packing tape or commercially available sampling strips onto a surface and removing it with slow, steady force
- Following collection, the tape is attached to glass slides and examined using light microscopy.



SURFACE SAMPLING FOR MOLD

LIFT TAPE ON A SLIDE

- Flexible plastic microscopic slides with a sticky adhesive sample area can be used like lift tape.
- Press on the test surface, place the slide in the provided mailer and send to a qualified laboratory.



Stick-to-It Slides

SKC 225-9808/9

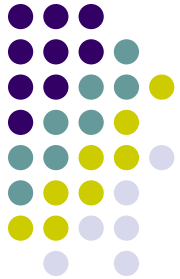
DATA INTERPRETATION

LIFT TAPE SAMPLES

The November 2001 AIHA *Synergist* guidelines for fungal spores in tape samples:

- Normal: No significant fungal material or biomass; 1-5% spores
- Probable Contamination: 25-100% spores

AIR SAMPLING FOR MOLD:
WHY AND HOW



Like with chemical sampling, air sampling for mold or other biological contaminants is done for the purpose of evaluating actual human exposures.

Air sampling for mold involves the use of:

- Impactors
- Filters or
- Liquid-based (impinger-type) devices

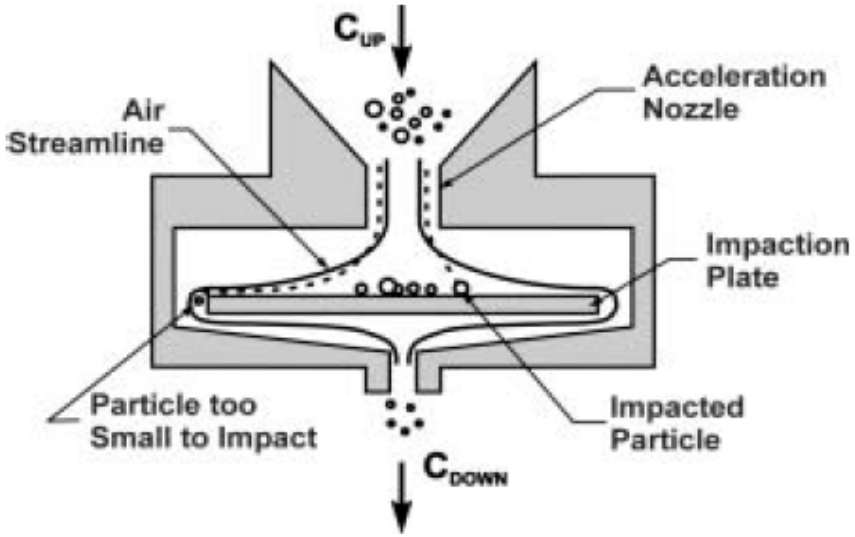
AIR SAMPLING FOR MOLD

SPORETRAP CASSETTES

- Easy, inexpensive screening device.
- Use with a pump at **15-30 L/min** for up to 10 minutes.
- Spores impact onto a microscopic slide with a sticky surface.
- Slide is stained and analyzed microscopically.

VERSATRAP CASSETTES

SKC 225-9820/1



AIR SAMPLING PUMPS

FOR USE WITH SPORETRAPS

- Constant flows from 10-30 L/min
- User selectable sampling times
- Lithium-ion battery powered up to 4 hrs
- Indefinite run time from AC adapter
- Optional sampling wand

SKC 228-9530

DATA INTERPRETATION

SPORE TRAPS

- Spore trap analysis will provide the **total number** of spores and the **genus** of the spores found.
- This information can be used to compare the complaint area to non-complaint areas of the building and to the outdoors.
- The genus of the spores should be similar inside and out.
- The numbers should be lower inside.

DATA INTERPRETATION

SPORE TRAPS

November 2001 AIHA *Synergist* guidelines for air samples:

Residential Buildings:

Normal: <5,000 spores/m^3

Probable Contamination: >10,000 spores/m^3

Commercial Buildings:

Normal: <2,500 spores/m^3

Probable Contamination: >10,000 spores/m^3

AIR SAMPLING FOR MOLD

VIABLE CASCADE IMPACTOR

- Specified in **NIOSH Methods 0800 and 0801**
- Used with a pump at 28.3 L/min for typical sample times of 2-5 minutes
- Mold impacts onto growth medium (agar).
- Agar plates are shipped to a microbiological laboratory for growth and culture.

VIABLE CASCADE IMPACTOR

SKC BIOSTAGE®

SKC 225-9610/11

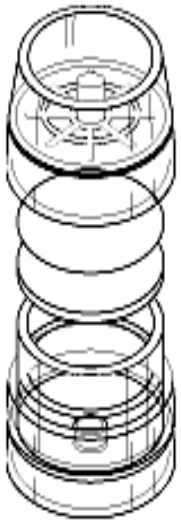
STANDARD MODEL @ 28.3 L/MIN
BIOSTAGE 200 MODEL @ 14.15 L/MIN

BIOSTAGE
SAMPLER PREPARATION

BIOSTAGE

WITH QUICKTAKE 30 PUMP

AIR SAMPLING FOR MOLD



FILTERS

- Collection of microorganisms is achieved by passage of air through a porous medium, typically a membrane filter.
- Polycarbonate, mixed cellulose ester, or polyvinyl chloride filters may be used depending upon the application.
- **Gelatin** filters will help to maintain viability by minimizing dehydration of the spores.

AIR SAMPLING FOR VIABLE MOLD

USING FILTERS

- Filters, support pads and cassettes should be **sterile.**
- Samples are collected with a portable pump at 1-4 L/min for **5-30 minutes.**
- After sampling, the material collected on the filters is inoculated onto agar plates.

AIR SAMPLING FOR MOLD

COLLECTION INTO LIQUID

- Pumps are used to pull mold spores into glass impingers filled with a liquid collection medium, typically a dilute buffer solution or mineral oil.
- Portions of the collection liquid can be placed onto nutrient agar and incubated or analyzed using other methods.

SKC 225-9595

DATA INTERPRETATION

VIABLE AIR SAMPLES

November 2001 AIHA *Synergist* guidelines:

Residential Buildings:

Normal: <500 cfu/m^3

Probable Contamination: >1,000 cfu/m^3

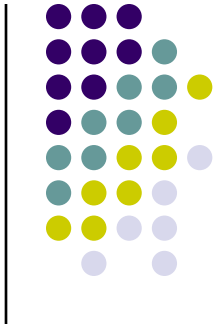
Commercial Buildings:

Normal: <250 cfu/m^3

Probable Contamination: >1,000 cfu/m^3

TARGET: FORMALDEHYDE

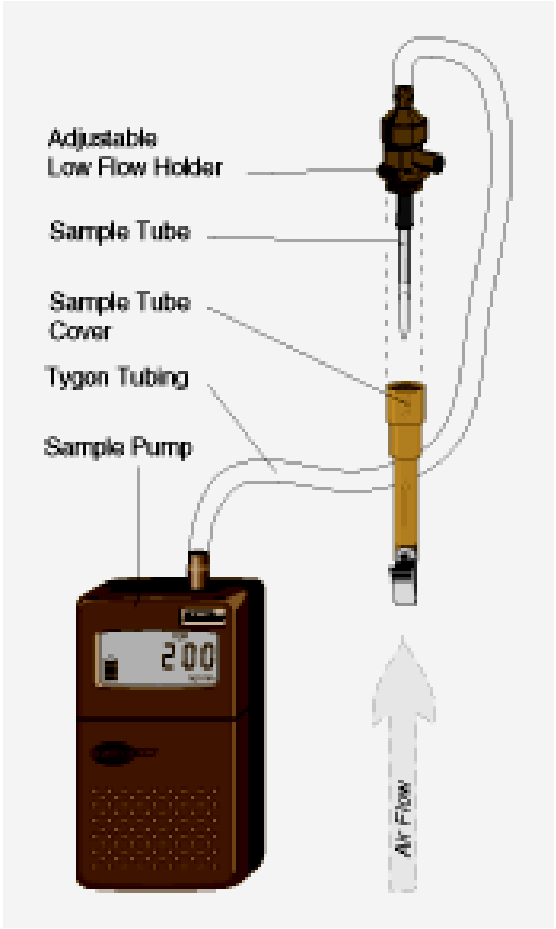
INDOOR SOURCES OF FORMALDEHYDE



- Formaldehyde is frequently used as a preservative and adhesive.
- Formaldehyde gas can be released indoors from particle board, veneered or laminated furniture and cabinets, paneling, permanent press fabrics, and drapes.
- Formaldehyde is a strong irritant that can cause burning in the eyes, nose, and throat.
- **As of 2004, the IARC classified formaldehyde as a carcinogen.**

AIR SAMPLING FOR FORMALDEHYDE

USING SORBENT TUBES



SKC 226-119/120

- **2,4- DNPH-treated silica gel tube** following EPA Method IP-6A, EPA TO-11A, or NIOSH 2016.
- This sorbent tube can detect lower levels than the OSHA workplace method.

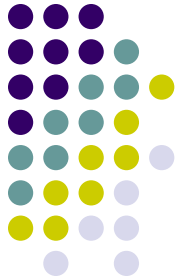
AIR SAMPLING FOR FORMALDEHYDE
USING PASSIVE SAMPLERS

SKC 500-100

UMEX 100

- Uses **2,4-DNPH chemistry** following OSHA Method 1007 and EPA Method IP-6C.
- Can detect down to 2 ppb
- Validated sampling rates for 24-hours or 7-day sampling for IAQ applications.

DATA INTERPRETATION
FORMALDEHYDE

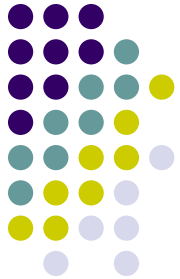


Indoor Air Quality Association Inc. (IAQA) recommends an indoor air limit of 50 ppb.

U.S. Green Building Council recommends an indoor air limit of 27 ppb in their LEED 2009 rating system for new construction and major renovations.

TARGET: PESTICIDES

SOURCES OF PESTICIDES INDOORS



- Indoor pesticide exposures may result from pesticides applied indoors or from pesticides inadvertently brought in from the outdoors on shoes.
- Pesticides may accumulate on carpeting and other flooring materials and become an exposure source.

AIR SAMPLING FOR PESTICIDES

OSHA VERSATILE SAMPLER (OVS)

- Sorbent tubes with an internal pre-filter and 2 layers of XAD-2 sorbent.
- Simultaneously collect pesticide vapors and aerosols following various OSHA/NIOSH methods.

SKC 226-30-16/226-58

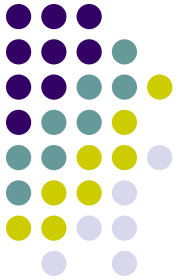
AIR SAMPLING FOR PESTICIDES

PUF TUBES

- Tubes containing specially prepared polyurethane foam are used at flows from 1-5 L/min for 4-24 hours for pesticide measurements following EPA Methods IP-8 and TO-10A.

SKC 226-92

DATA INTERPRETATION
PESTICIDES



The Agency for Toxic Substances and Disease Registry has published **Minimal Risk Levels** (MRLs) for various compounds including pesticides.

See the complete list of MRLs at http://www.atsdr.cdc.gov/mrls/index.html

TARGET: VOLATILE ORGANIC COMPOUNDS (VOCs)

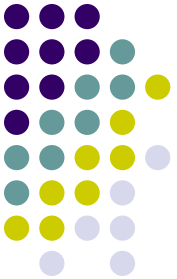
SOURCES OF VOCs

- Many common cleaning and household products contain solvents that can result in airborne concentration of a variety of VOCs that can cause problems for some people.

- Furniture cleaners
- Wood preservatives
- Carpet shampoos
- Disinfectants
- Cleansers
- Paint/Paint strippers
- Moth repellants
- Hobby supplies

TOP 10 VOCs

MEASURED IN OFFICE BUILDINGS



- Toluene
- Acetone
- n-Hexane
- 1,1,1-Trichloroethane
- Chloromethane
- Benzene
- Ethanol
- 2-Propanol
- Dichlorodifluoro-methane
- m- and p-Xylenes

SCREENING DEVICES FOR VOCs

PHOTOIONIZATION DETECTORS (PIDs)

The new **ppbRAE 3000** can detect VOCs down to 1 ppb. These are good survey tools that can be used like a geiger counter to ID vapor sources.

SKC 730-C110-000

AIR SAMPLING FOR VOCs
USING CANISTERS

- The canister vacuum pulls the air sample without the use of batteries or AC power.
- Flow restrictors maintain flow stability over the desired time period from <1 minute to 12 hours.
- Some labs will supply canisters with their analysis service following EPA Methods

  IP-1A and TO-15.

AIR SAMPLING FOR VOCs
USING SORBENT TUBES

- Specialty tubes designed for thermal desorption are required to measure the low levels found in indoor air.
- These tubes are purged with heat by the laboratory and must be used within 30 days.
- After sample collection, the tubes are analyzed following EPA Methods IP-1B or TO-17.

Thermal desorption tubes are stainless steel or glass open-ended tubes to allow for thermal purging before/after sampling.

AIR SAMPLING FOR VOCs
USING PASSIVE SAMPLERS

- Standard IH organic vapor badges may be suitable to collect 24-hour samples of *some* VOCs at ppb levels in indoor air.
- Specialty passive samplers that utilize thermal desorption methods are better options for sub-ppb level measurements of VOCs.

SKC 575-Series Samplers

SKC 590-Series Ultra Samplers

DATA INTERPRETATION

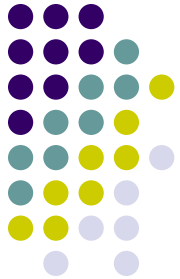
VOCs

Indoor Air Quality Association Inc. (IAQA) recommends an indoor air limit of 3 **mg**/m^3.

U.S. Green Building Council recommends an indoor air limit of 500 **µg**/m^3 in their LEED 2009 rating system for new construction and major renovations.

TARGET: COMBUSTION POLLUTANTS

SOURCES OF COMBUSTION POLLUTANTS



- Any device that burns fuel can introduce a combustion pollutant into the indoor environment if not properly vented. Common sources include gas stoves and ovens, space heaters, automobiles in adjacent garages, and burning, welding, and soldering activities.
- Combustion pollutants include **carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide, and particulates.**

AIR MONITORING

FOR GASEOUS COMBUSTION POLLUTANTS

AIR SAMPLING FOR GASEOUS COMBUSTION POLLUTANTS

SORBENT TUBES

Sorbent sample tubes containing specially treated sorbents are available for:

Sulfur Dioxide by OSHA Method ID 200

Nitrogen Dioxide by NIOSH Method 6014 or OSHA ID 182

PASSIVE SAMPLERS

A new passive sampler utilizing a chemically treated filter paper technology is now available for measurements of SO_2 and NO_2. It can detect 0.05 ppm NO_2 with 24-hr sample time.

DATA INTERPRETATION
CARBON MONOXIDE

Indoor Air Quality Association Inc. (IAQA) recommends an indoor air limit of 9 ppm.

U.S. Green Building Council recommends an indoor air limit of 9 ppm and no greater than 2 ppm above outdoor levels in their LEED 2009 rating system for new construction and major renovations.

DATA INTERPRETATION

Nitrogen Dioxide

WHO Indoor Air Guideline

0.08 ppm for 24 hours

0.21 ppm for 1 hour

Health Canada Indoor Air Guideline

0.25 ppm for 1 hour

AIR MONITORING
FOR PARTICULATES

EPAM-5000

- Measures particulates as PM10, PM2.5, or PM1 using light scattering technology with various sampling heads.
- Has internal sampling pump for concurrent gravimetric samples using a 47-mm filter.

SKC Cat. No. 770-201/3

AIR SAMPLING
FOR PARTICULATES

- EPA Method IP-10A specifies the use of size-specific Impactors and filters for **PM10/PM2.5** followed by gravimetric analysis.
- The Personal Modular Impactor (PMI) meets the requirements this method using flows of 3 L/min.

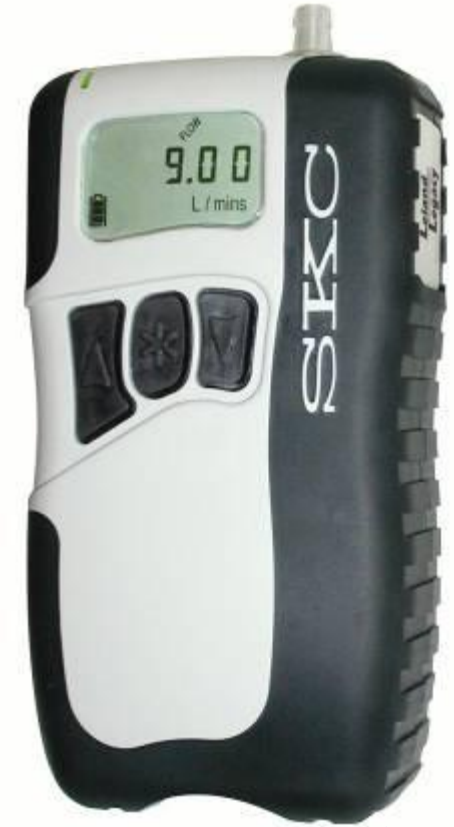
SKC 225-350/352

SAMPLING PUMPS:
NOW WITH LI-ION POWER

AirChek® XR5000

Up to 5 L/min

for 20+ hours



Leland Legacy ®

Up to 10+ L/min

for 20+ hours

DATA INTERPRETATION

Particulates

Both the IAQA and the USGBC have an indoor air guideline for particulates of 50 ug/m^3.

TARGET: COMFORT CONTROL AND BUILDING PARMETERS

ILLUMINATION LEVELS

- The amount of lighting in the workplace affects quality and quantity of output and can affect overall well-being of occupants .
- Improper illumination levels can result in poor performance and health effects including headache and eyestrain.

ILLUMINATION MEASUREMENTS

LIGHT METERS

- Light meters use a photo diode that converts incident light into an electrical signal.
- Readings are displayed on the meter in either lux or footcandles.

SKC 753-003

DATA INTERPRETATION

ILLUMINATION LEVELS

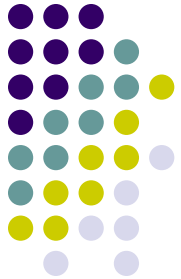
The Illuminating Engineering Society of North America publishes guidelines for office and industrial lighting as the ANSI Secretariat.

Their publications are available from SKC:

Office (SKC 877-612)

Industrial (SKC 877-611)

BUILDING COMFORT PARAMETERS



Improper control of physical parameters can result in adverse health effects that mimic chemical exposures. Physical parameters include:

- Temperature
- Relative Humidity
- Air Movement
- Ventilation (Carbon Dioxide)

INDIVIDUAL PARAMETERS
USING ELECTRONIC MONITORS

CARBON DIOXIDE

- Direct-reading monitors with non-dispersive infrared (NDIR) sensors can typically measure CO_2 levels up to several thousand ppm without the need for frequent calibration.

SKC Cat. No. 751-535

MULTIPLE PARAMETERS

USING ELECTRONIC MONITORS

QUEST

EVM-7

MEASUREMENT

OPTIONS:

- VOCs using PID
- Toxic gases
- CO_2
- Relative humidity and temperature
- Air velocity (with probe)
- Particulates

SKC 755-EVM-7

DATA INTERPRETATION
BUILDING COMFORT PARAMETERS

IAQA INDOOR AIR GUIDELINES

Temperature in Summer: 73-79 F

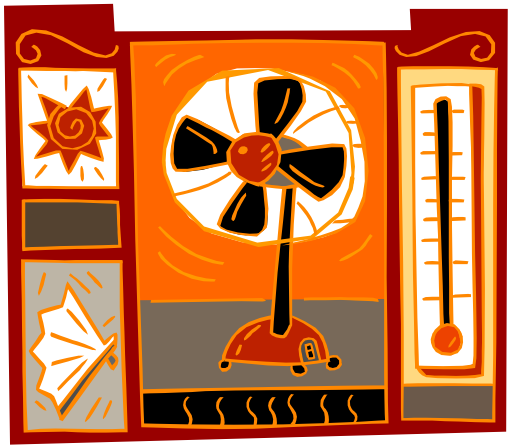
Temperature in Winter: 68-74.5 F

Relative Humidity: 30-65%

Air Movement: 0.8 ft/s or 0.25 m/s

DATA INTERPRETATION

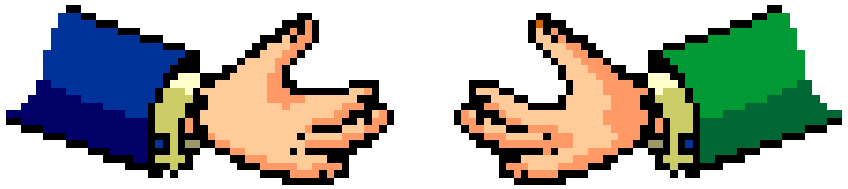
BUILDING COMFORT PARAMETERS



IAQA INDOOR AIR GUIDELINES

Ventilation (as Carbon Dioxide)-650 ppm over ambient

THANK YOU FOR YOUR ATTENTION!



www.skcinc.com

- If you have additional questions, please Email

  skctech@skcinc.com

- I will be the first responder to these Emails.