AIR TESTING

FOR CONTAMINANTS IN MINES

TYPICAL AIR CONTAMINANTS IN MINING OPERATIONS

PARTICULATES

- Metal fumes from welding operations
- Respirable dust including crystalline silica in silica-containing rock and coal dust
- Asbestos in asbestos-containing ore
- Diesel particulate from engine exhaust

TYPICAL AIR CONTAMINANTS IN MINING OPERATIONS

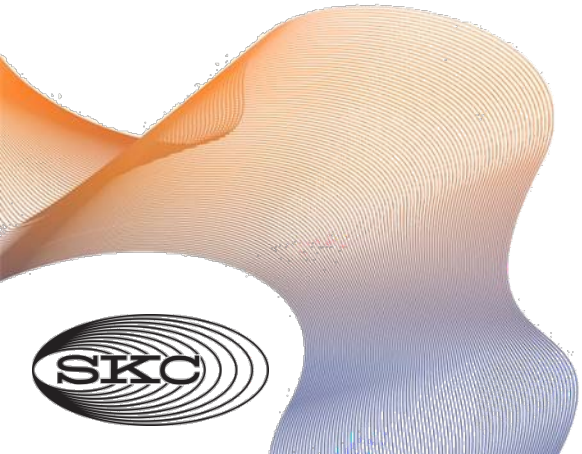
GASES AND VAPORS

- Naturally occurring methane and hydrogen sulfide
- Nitrogen oxides and carbon monoxide from engine exhaust and blasting operations
- Formaldehyde from urea-formaldehyde or isocyanates from polyurethane foams
- Organic solvents used in cleaning or other applications

AIR CONTAMINANTS IN URANIUM MINING OPERATIONS

- **Radon** - Naturally occurring radioactive *gas*
- **Radon Daughters** - Fine solid *particles* which result from the radioactive decay of radon gas; attach themselves to airborne dust and smokes and reach the gas exchange section of the lungs where alpha radiation is emitted

AIR TESTING EQUIPMENT:
SO MANY CHOICES



CHOOSE YOUR EQUIPMENT:
BASED ON YOUR OBJECTIVES

- **Survey Tool** - a direct-reading device that will provide immediate indications of chemical levels in the field. Immediacy of results overrides limitations in accuracy.
- **Validated Method** - air sample collection followed by laboratory analysis. Accuracy of results overrides delay in obtaining results.

CHOOSE YOUR EQUIPMENT:
BASED ON YOUR OBJECTIVES

- **Applications for Survey Tools** -
  Leak Detection, Confined Space Entry, Hazmat Response, Initial Screening, and Spot Checks of Personal Exposure Levels

- **Applications for Validated Methods** -
  Compliance with Government Regulations, Measurement of Highly Toxic Compounds, and Measurement of Compounds for which direct-reading survey tools do not exist

SURVEY TOOLS

OPTIONS AND APPLICATIONS

GENERAL CATEGORIES
OF SURVEY TOOLS

Colorimetric Technologies

- Detector Tubes
- Color Badges
- Colorimetric Wipes
- Colorimetric Swabs

Sensor Technologies

- Catalytic
- Photoionization
- Electrochemical
- Light-scattering

SURVEY TOOLS

COLORIMETRIC TECHNOLOGIES

DETECTOR TUBES
A FIRST LINE OF DEFENSE

- Classical measurement technique with first patent in 1919
- Glass tube containing a chemical media that reacts with the contaminant of interest by changing color
- Concentration is read directly from a printed scale on the tube
- Tubes now available for measurement of over 200 gases/vapors

TYPES OF DETECTOR TUBES

GRAB SAMPLE TUBES

- Used with a hand-operated pump to collect on-the-spot measurements
- Measurements typically take a few minutes to complete
- Pump and tube are calibrated by the manufacturer as a unit

LATEST DEVELOPMENT
OF DETECTOR TUBE TECHNOLOGY

CHIP MEASUREMENT SYSTEM (CMS)

- Chemical-specific capillary tubes using same technology as short-term tubes
- 10 tubes on a chip
- Used with an electronic analyzer with internal pump and data recorder

SKC 802-series

APPLICATIONS

GRAB SAMPLE TUBES AND CMS

Qualitative

- Leak Detection
- Chemical Migration
- Confined Space Entry (using extension hose)
- Unknown Identification (using hazmat kits)

Semi-quantitative

- Spot checks of area or breathing zone samples
- Maximum levels during various processes or worker activities
- Analysis of sample bags containing air emissions

TYPES OF DETECTOR TUBES

PASSIVE TUBES

- Break open one end and place in designated holder.
- Sample from 1 to 10 hours.
- Length of stain indicates air concentration in ppm-hr.
- Divide by hours sampled to obtain ppm concentrations in air.

TARGET COMPOUNDS
PASSIVE COLOR TUBES

- Acetic Acid
- Ammonia
- Butadiene
- Carbon Dioxide
- Carbon Monoxide
- Ethanol
- Hydrochloric Acid
- Hydrocyanic Acid
- Hydrogen Sulfide
- Nitrogen Dioxide
- Perchloroethylene
- Sulfur Dioxide
- Toluene
- Trichloroethylene

Additional passive color tubes available from Gastec.

SOURCES OF ERROR
DETECTOR TUBES

- Accuracy is limited.
- Interfering compounds cause similar reactions and readings on tube.
- Affected by temperature and humidity
- Subjective differences in “eyeballing” the color change to determine result

COLOR BADGES

IMMEDIATE VISUAL INDICATORS

- Badges contain a chemically coated filter paper or “indicator layer.”
- Target chemicals in air react with the chemical coating used in the badge and produce a color change.
- This change is a visual indicator to the worker that an exposure has occurred.
- Color comparison charts allow for exposure estimates.

APPLICATIONS
COLOR BADGES

- Visual indication to evacuate work area in presence of dangerous chemicals
- Semi-quantitative exposure level screening
- Leak Detection
- Warning for Escape

www.kandmenvironmental.com

APPLICATIONS
COLOR BADGES

- Ammonia
- Aniline
- Carbon Dioxide
- Carbon Monoxide
- Chlorine
- Dimethyl Amine
- Formaldehyde
- Hydrazine
- Hydrogen Chloride
- Hydrogen Sulfide
- MDI
- Mercury
- Nitrogen Dioxide
- Ozone
- Phosgene
- Sulfur Dioxide

SOURCES OF ERROR
COLOR BADGES

- Limited accuracy for quantitative measurements using “dose estimators”
- Cross-sensitivities with other chemicals
- Temperature and humidity effects
- UV light may discolor indicator

COLORIMETRIC WIPES
FOR CHEMICALS ON SKIN/SURFACES

- Chemicals in air will eventually deposit on skin and surfaces and may pose a risk to workers by skin absorption or ingestion.
- Chemical residue on shoes, lunch boxes, and other personal items may inadvertently become a take-home toxin for worker's family members.

FULL DISCLOSURE WIPES
FOR LEAD ON SKIN OR SURFACES

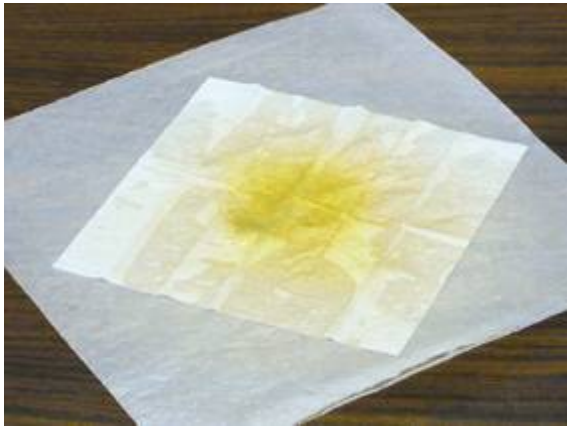
- Developed by U.S. NIOSH; NIOSH Method 9105
- Licensed for production by SKC
- Behavior modification tool - Allows workers to determine if their washing/decontamination has been effective
- Can identify down to 18 µg of lead

LEAD WIPE KIT FROM SKC

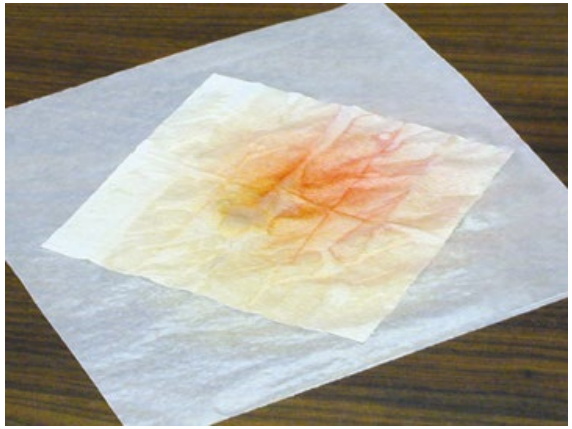
Step 1

Step 2

Step 3



SKC 550-001



COLORIMETRIC SWABS
FOR LEAD IN PAINT AND SURFACES

- Self-contained sampling swabs for rapid screening of lead in paint and on surfaces
- Squeeze the swab to release the test reagents and then wipe the surface with the swab
- Observe color change

SKC 225-2404

SOURCES OF ERROR
COLORIMETRIC WIPES AND SWABS

- Cross-sensitivities
- Extremely heavy soiling or other contaminants on the test surface may interfere with color development.
- Persons with color blindness may not be able to detect the color development.

SURVEY TOOLS

SENSOR TECHNOLOGIES

CATALYTIC SENSORS
COMBUSTIBLE GAS MONITORS

- Commonly used since 1959
- Test gas or vapor is heated to combustion (burned) and the instrument translates the resulting increase in temperature/resistance as a percentage of the lower explosive limit (LEL).
- Oxygen (> 10%) is required for the catalytic sensor to operate properly.

APPLICATIONS
CATALYTIC SENSORS

Non-specific measurement of high, explosive concentrations of gases/vapors in air:

- Confined space entry
- Emergency response

Handheld 5-Gas Monitor including catalytic LEL sensor

SKC 805-series

SOURCES OF ERROR
CATALYTIC SENSORS

- Poisoning or degraded performance can occur when sensor is exposed to certain compounds such as lead-containing compounds, silicones, sulfur-containing compounds, and halogenated hydrocarbons.
- Oxygen deficient environments will cause the instrument to produce erroneous readings.

PHOTOIONIZATION DETECTORS
BROAD SPECTRUM VOC MONITORS

- Based on the principle that some chemicals can be ionized when hit with high-energy UV light. The instrument measures the resulting current which is proportional to concentration of the gas/vapor in air.
- Instrument manufacturers publish technical documents with lists of chemicals that can be detected using UV lamps with various energy levels.

APPLICATIONS
PHOTOIONIZATION DETECTORS

Non-specific
measurement of ppm
concentrations
of gases/vapors in air:

- Leak Detection
- Personal Exposures
- Spill Delineation
- Hazmat Response

SKC 730-series

SOURCES OF ERROR
PHOTOIONIZATION DETECTORS

- Non-specific - cannot identify specific VOC
- Does not detect all VOCs or compounds such as carbon monoxide, hydrogen, methane, oxygen, and formaldehyde
- Humidity can cause lamp fogging resulting in lower readings
- Sensor drift

ELECTROCHEMICAL SENSORS
SPECIFIC TO TARGET COMPOUNDS

- Contain components designed to react with a specific gas or vapor. The reaction generates a current which is translated into concentration in air.
- Sensors available to measure about 20 compounds in the ppm range.
- Some cross-sensitivities can occur from other compounds.

APPLICATIONS
ELECTROCHEMICAL SENSORS

Measurement of ppm concentrations of target gases/vapors in air:

- Leak Detection
- Personal Exposures
- Confined Space Entry
- Spill Delineation
- Hazmat Response

5-gas monitor

Single-gas monitor

SOURCES OF ERROR
ELECTROCHEMICAL SENSORS

- Cross-sensitivities
- Sensor performance and lifetime can be affected by very dry or very humid environments or by brief exposures to high concentrations.

AEROSOL PHOTOMETERS

MEASURE AIRBORNE DUST LEVELS

- A light beam is shined through air containing particulate matter. The particulate matter scatters the light beam and the amount of light scattering is measured on a photocell and displayed as mg/m^3 concentrations.
- Commonly known as “light scattering” instruments

APPLICATIONS
AEROSOL PHOTOMETERS

- Screening tool evaluating personal dust levels
- Perimeter sampling
- Internal dataloggers allow for TWA or peak determinations.
- Internal pumps allow for concurrent sample collection using filters.

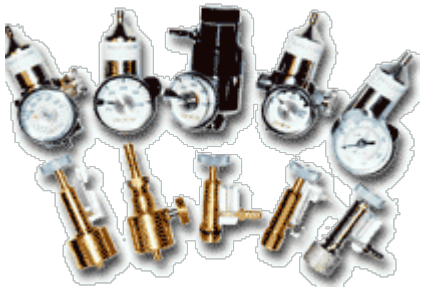
HazDust IV
SKC 770-4004

SOURCES OF ERROR
AEROSOL PHOTOMETERS

- Test dust does not produce the same results as the calibration dust; correction factor needs to be determined.
- Does not respond to fibrous dusts like asbestos or to small ultrafine dusts.
- Note: Most are not intrinsically safe.

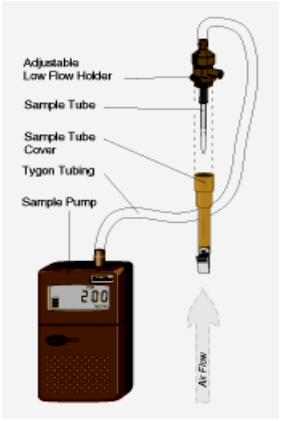
CALIBRATION IS CRITICAL
FOR SENSOR TECHNOLOGIES

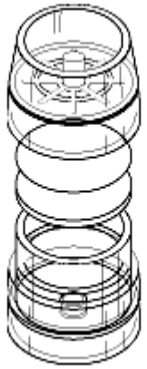
- All direct-reading instruments must be calibrated properly and regularly.
- Both factory and user calibrations are required.



VALIDATED METHODS WITH LABORATORY ANALYSIS

OPTIONS AND APPLICATIONS





VALIDATED SAMPLING METHODS
WITH LABORATORY ANALYSIS

- Published by government or other scientific agencies
- Define all the critical sampling parameters for accurately measuring exposures of specific chemicals
- Most reliable means of evaluating exposures, but lab analysis takes time

WEBSITES

FOR GOV'T AGENCY METHODS

NIOSH Methods:
http://www.cdc.gov/niosh/docs/2003-154/

OSHA Methods:
http://www.osha.gov/dts/sltc/methods/toc.html

HELP FROM SKC:
SAMPLING GUIDE IN SKC CATALOG

- Lists all regulated chemicals
- Includes:
  - Agency Method Number
  - Sampling Details such as Flow Rate, Time, Volume
  - Analytical method
  - Sample collection media and SKC catalog number

SKC SAMPLING GUIDE APP

- Free download of the SKC Sampling Guide App for Apple or Android devices
- Visit SKC homepage at www.skcinc.com, and look for link for mobile devices.

TYPES OF SAMPLES
USING VALIDATED METHODS

- **Active Samples** - Require the use of (3) key elements: Pump, Sample Collection Media, Pump Calibrator (Flowmeter)
- **Passive Samples** - Require the use of a passive sampler (badge) that has been thoroughly tested to ensure sampling reliability under various field conditions

DEFINING PASSIVE SAMPLING

- The collection of airborne gases and vapors at a rate controlled by the physical process of diffusion WITHOUT the use of a sample pump to actively pull air through the sample collection media.

DEFINING PASSIVE SAMPLING

- Chemicals diffuse from an area of high concentration in the air to an area of low concentration on the sampler. Based on their mode of sample collection, passive samplers are also referred to as *diffusive samplers*.

- The uptake or sampling rate for individual chemicals must be supplied by the manufacturer of the sampler or the agency that published the validated method.

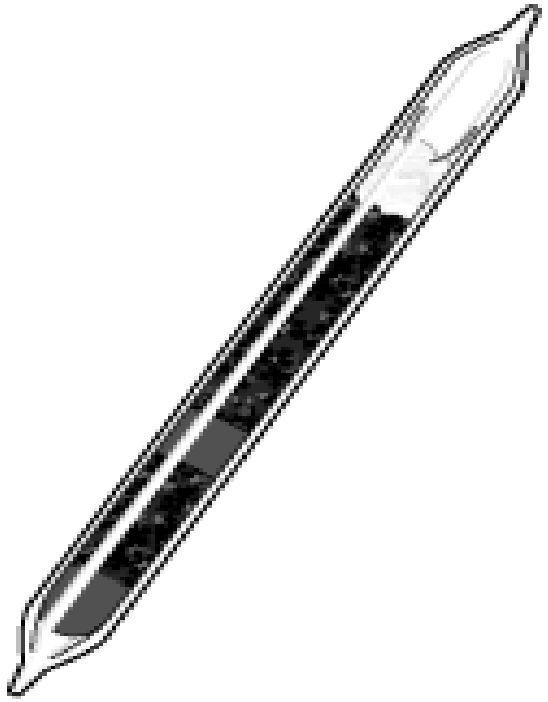
VALIDATED SAMPLING METHODS

GASES AND VAPORS

ACTIVE AIR SAMPLING:
USING SORBENT TUBES

- Glass tubes containing sorbent materials are used to trap designated compounds for lab analysis.

- Contaminants are ADsorbed onto the surface of the sorbent material and then DEsorbed for laboratory analysis.



Sorbent Tube

SORBENT TUBE SAMPLING:
FOR ORGANIC SOLVENTS

Sorbent: Activated Charcoal

- Specified in government methods for the collection of common organic compounds including benzene, toluene, and xylene
- High adsorptive capacity
- Derived from coconut shells

SORBENT TUBE SAMPLING:
FOR GASEOUS EMISSIONS

Sorbent: Chemically-coated adsorbent materials

- Specified in government methods for the collection gaseous emissions such as nitrogen oxides and formaldehyde
- Contaminants react with the chemical coating and produce a stabile compound for analysis.
- Example: Nitrogen dioxide is collected using a tube containing carbon molecular sieve sorbent that is chemically-coated with triethanolamine (TEA).

ACTIVE AIR SAMPLING
USING SAMPLE BAGS

- Used to collect *grab samples* of an air-contaminant mixture into a flexible container for subsequent analysis
- Mining applications include methane, carbon monoxide, and organic solvent vapors.

SAMPLING WITH BAGS
TYPES AND APPLICATIONS

TEDLAR® OR SKC FLEXFILM BAGS

- Typically used for the collection of organic vapors
- Designed for short-term storage of up to 1 to 2 days prior to analysis

ALUMINIZED OR SKC FLEXFOIL™ BAGS

- Typical mine applications include methane and carbon monoxide.
- Can store samples up to 5 days prior to analysis

SAMPLING WITH BAGS

SAMPLE COLLECTION OPTIONS

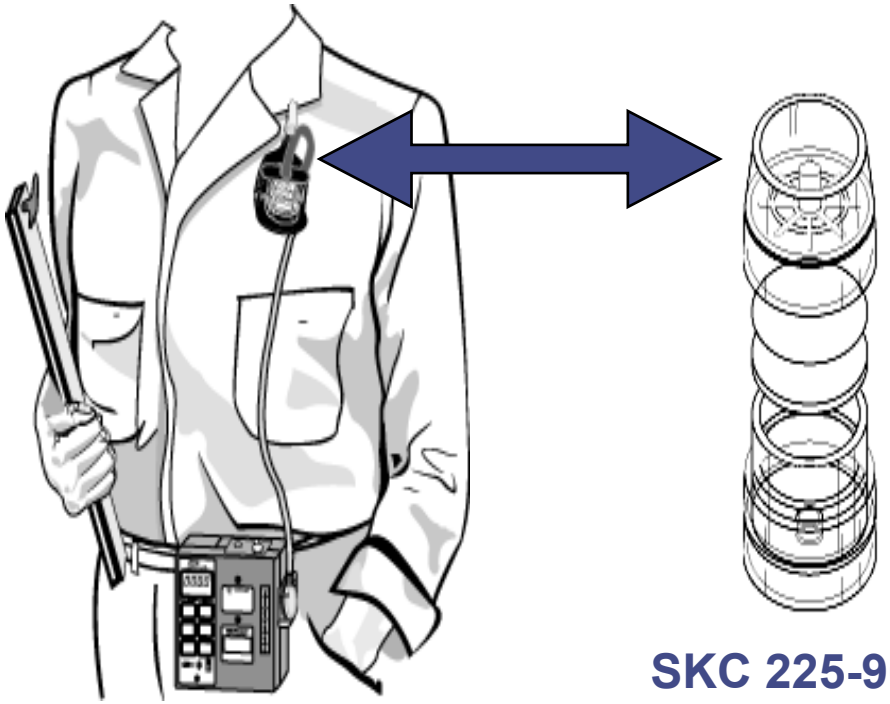
Positive Pressure

Negative Pressure

ACTIVE AIR SAMPLING
USING CHEMICALLY COATED FILTERS

- Filters are used as a substrate for liquid media that can trap contaminants.
- Liquid media will react with the contaminant of interest producing a stabile compound for storage and analysis.
- Mining applications include isocyanates such as TDI and MDI.

SAMPLING TRAIN
WITH COATED FILTERS



SKC 225-9002
for TDI or HDI

PASSIVE AIR SAMPLING:
FOR ORGANIC SOLVENTS

- Validated sampling methods for organic solvents specify the use of passive samplers containing charcoal sorbent.
- Methods allow the use of passive samplers for use in collecting 8-hour TWAs or 15-minute STELs.

SKC 575-series

OSHA PASSIVE SAMPLING METHODS:
FOR ORGANIC SOLVENTS

- Toluene by OSHA 111
- Tetrachloroethylene and trichloroethylene by OSHA 1001
- Xylenes and ethyl-benzene by OSHA 1002
- MEK and MIBK by OSHA 1004
- Benzene by OSHA 1005

PASSIVE AIR SAMPLING:
FOR FORMALDEHYDE

- Validated OSHA Method 1007 specifies a passive sampler that contains a chemically treated filter paper.
- Formaldehyde combines with chemical to form a stabile compound for lab analysis.

SKC 500-100

VALIDATED SAMPLING METHODS

PARTICULATES

DEFINING PARTICULATE CONTAMINANTS

TOTAL DUST

Particulate matter, both respirable and nonrespirable, that can be trapped onto the designated filter loaded into a cassette

RESPIRABLE DUST

Particulate matter small enough in size to penetrate deep into the lung down to the gas exchange (alveolar) region

TOTAL DUST VS RESPIRABLE DUST SAMPLERS

Total Dust Samplers

Respirable Dust Samplers

AIR SAMPLING FOR PARTICULATES IN MINING OPERATIONS

Air sampling is done using filters loaded into cassettes WITHOUT cyclones for:

- Metals
- Asbestos
- Radon Daughters

Air sampling is done using filters loaded into cassettes WITH cyclones for:

- Respirable Crystalline Silica and Coal Dust
- Diesel Particulate Matter (DPM)

TOTAL DUST SAMPLING TIP

- The filter cassette is clipped on the worker's lapel in the breathing zone with the inlet of the sampler pointing *downwards.*
- Remove the small plug only from the inlet.
- Watch for filter overloading.

AIR SAMPLING:
FOR ROUTINE METALS

- Most metals can be collected onto 37-mm, 0.8-µm pore size MCE filters.
- The Metal/Nonmetal Inspection Handbook recommends a pump flow rate of 1.7 L/min.
- Laboratory chemical analysis of the filter can determine the type of metals and amount present in air.

AIR SAMPLING:
FOR HEXAVALENT CHROMIUM

- Some metals such as hexavalent chromium (Cr^{+6}) will require alternative sampling media and special sample handling procedures.
- Cr^{+6} sampling requires the use of a 5-µm pore size PVC filter at a typical flow rate of 1.7 L/min.
- Filters should be removed from the cassette, placed into vial, and *rushed* to the laboratory.

AIR SAMPLING:
FOR HEXAVALENT CHROMIUM

- Samples are rushed by overnight shipment to the laboratory because interfering compounds in the test atmosphere can cause the collected Cr^{+6} to convert to Cr^{+3} upon storage.
- Interfering compounds include Fe^{+2} in welding applications.

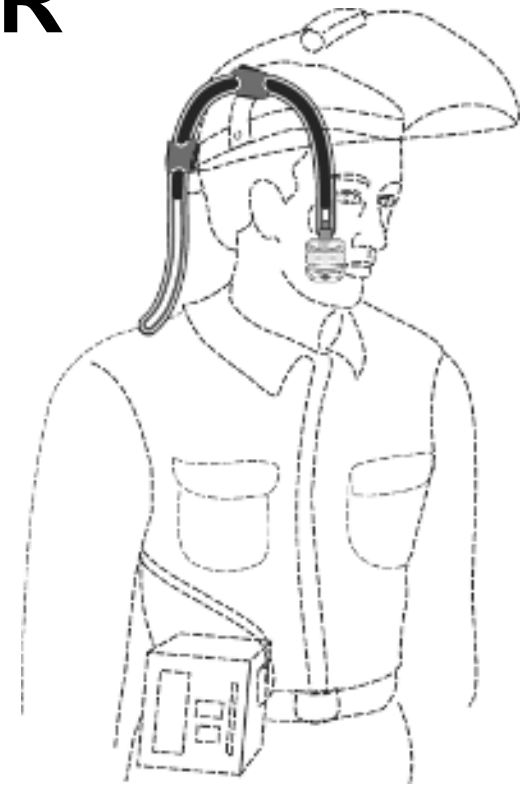
AIR SAMPLING:
FOR OTHER SPECIALTY METALS

- Other specialty metals such as silver, calcium, and mercury use the standard MCE filter for sampling, but require the use of a separate filter/cassette due to special handling in analysis.
- It is imperative that you communicate with your analytical laboratory PRIOR to sampling to ensure proper procedures are followed.

AIR SAMPLING:
FOR METALS IN WELDING

- MSHA advises that the filter-cassette sampler should be positioned *beneath* the welder's helmet when the helmet is placed down.
- A convenient welding helmet adapter has been developed by a Canadian agency for this application. Leather straps and flexible metal in the tubing allow for easy cassette placement.

WELDING HELMET ADAPTER



SKC 225-600

REGULATORY NEWS:
ASBESTOS

- Effective April 2008, MSHA issued a new PEL for asbestos of 0.1 fiber/ml of air, reduced from 2 fibers/ml.
- A new excursion limit of 1 fiber/ml for 30 minutes was also issued.
- The MSHA exposure limits for asbestos are now consistent with those issued by OSHA.

AIR SAMPLING:
FOR ASBESTOS

- Asbestos samples are collected using 25-mm, 0.8-µm pore size filters loaded into black, conductive cassettes.
- The filter cassettes have a cylinder cowl as the middle section that protects the filter and ensures a uniform fiber deposition.
- The cowl should point downwards when sampling, and the cassette inlet piece should be removed to allow for open-face sampling.

AIR SAMPLING:
FOR ASBESTOS

- After sampling, filters are analyzed microscopically so filter loading is critical.
- For full-shift sampling, the Metal/Nonmetal Inspection handbook recommends a flow rate of 1.7 L/min for air volumes of 300 to 2400 L.
- For short-term sampling of 15 to 30 minutes, flow rates of 1.7 L/min to 2.5 L/min or higher are recommended for optimal filter loading.

AIR SAMPLING:
FOR RADON DAUGHTERS

- Pump and filter sampling is done at a flow rate of 2 L/min using 25-mm glass fiber filters loaded into a cassette holder as shown.
- The filter is placed in the holder with the semi-smooth “waffled” pattern facing the pump and the rough side exposed to the air.
- Collect a 5-minute sample and count the sample using a radiation counter within 90 minutes.

WHY USE A RESPIRABLE DUST SAMPLER?

- Some air contaminants such as silica are regulated as respirable dust. Collecting larger, non-respirable particulates would inflate the results overestimating exposure.

CYCLONES:
TRADITIONAL RESPIRABLE DUST SAMPLERS

- Cyclones are named for the rotation of air within a chamber.
- Function on the same principle as a centrifuge
- Use centrifugal force to separate particles according to their aerodynamic diameter

CYCLONE OPERATION

- Air enters through a slit on the side of the sampler which creates cyclonic action.
- Large particles fall into red “grit pot” and are discarded.
- Small particles are thrown onto the filter for analysis.

Cap must be in place.

DIFFERENT CYCLONE OPTIONS

- All cyclones are not created equal!
- Each cyclone has different operating specifications and performance criteria.
- Be sure you know the flow rate specified to achieve the desired cut-point before using a cyclone.

A NEW RESPIRABLE DUST SAMPLER FROM SKC

- SKC has developed an impactor based sampler for respirable dust called the Parallel Particle Impactor or PPI.
- Single-use, disposable PPI models are available for use at either 2, 4, or 8 L/min.

SKC RESPIRABLE PPI:
FUNCTIONALITY

- The disposable models of the PPI look and function very much like a traditional 37-mm cassette.
- But the inlet comes pre-loaded with size-selective impactor plates that scrub out the non-respirable portion.
- PPI samplers are smaller than traditional cyclones and can fit under a welder's helmet or other PPE.

50% CUT-POINT:
A PERFORMANCE SPECIFICATION

- The 50% cut-point is often used to describe the performance of respirable dust samplers including cyclones.
- It is the particle size that the device can collect with 50% efficiency.
- Particles smaller than the 50% cut-point of the cyclone are collected with an efficiency greater than 50%.
- Larger particles are collected with an efficiency less than 50%.

RESPIRABLE DUST SAMPLERS: CURRENT U.S. CRITERIA

- Existing U.S. MSHA and OSHA regulations specify the use of respirable dust samplers with a 50% cut-point of 3.5 µm.
- But in 2013, OSHA issued a proposed rulemaking for respirable crystalline silica specifying the use of samplers with a 50% cut-point of 4.0 µm. This is consistent with NIOSH, ACGIH, and other organizations.

CYCLONE CALIBRATION TIP

SKC 225-111

- Cyclones can be placed inside calibration jars to measure the flow rate through the inlet.
- Take care when using calibration jars with piston-style calibrators such as the DC-Lite or Defender.

CYCLONE CALIBRATION TIP:
PISTON STYLE FLOWMETERS

SKC 717-510

The “dead” volume in the jar can affect the rise/fall of the piston causing the readings to be erroneously low.

Options:

- Use calibration adapters if available.
- Attach cyclone to calibrator pressure port and pump to suction port.
- Use smallest calibration jar possible.

CYCLONE SAMPLING TIP:
SAMPLER CLEANING

Failure to clean the cyclone after sampling can affect size-selection on future samples:

- After sampling, clean all parts of the cyclone with mild soapy water.
- Don’t forget to clean the grit pot.
- Dry the cyclone. (Air-dry or blow-dry)
- Wipe with a dust-free tissue or wipe with an isopropyl alcohol moistened pad.
- Caution: Do not use strong solvents to clean plastic cyclones.

DIESEL PARTICULATE MATTER (DPM)

- MSHA issued a final rule on DPM for underground metal/non-metal miners effective May 2008.
- PEL is 160 µg/m^3 as Total Carbon: Elemental Carbon plus Organic Carbon (EC + OC).

AIR SAMPLING:
FOR DPM

- MSHA requires that DPM samples be collected using a specialty filter cassette. (SKC 225-317).
- This filter cassette contains an internal impactor plate that separates DPM from other respirable particulate based on size.
- Larger respirable particles impact and are removed while DPM particles collect onto the heat-treated quartz filter.

DPM filter cassette -
SKC Cat. No. 225-317

DPM SAMPLING TRAIN

- **Cyclone**
  Removes non-respirable particles that may overload the filter
- **Internal Impactor Plate in Cassette**
  Removes respirable particles greater than 1.0 µm in diameter
- **After-filter assembly**
  Collects DPM particles less than 1.0 µm in diameter for analysis of EC and/or OC.

AIR SAMPLING:
FOR DPM

- Samples are collected at 1.7 L/min or 2.0 L/min for the full-shift.
- Again, it is important not to invert the sampler during the sampling period.
- After sampling, the filters are sent to the laboratory for analysis following NIOSH Method 5040.

AIR SAMPLING METHODS

So many contaminants, so many choices…

SKC CAN HELP

www.skcinc.com

1-800-752-8472

skctech@skcinc.com