Ocena kemijske izpostavljenosti na delovnem mestu

Presented by: ETTA, OSH Division 919-807-2875

Prepoznava kemijske izpostavljenosti

- Prepoznava.
  - Podobne industrije.
  - Poznavanje procesa.
  - MSDS.
- Ocena tveganja.
- Kontrola.

Asbestos removal

Prepoznava kemijske izpostavljenosti

- Prepoznava.
- Ocena tveganja.
  - Kemijska oblika.
  - Način izpostave.
  - Št. izpostavljenih.
  - Stopnja izpostavljenosti.
  - Dovoljene mejne vrednosti (Permissible exposure limit (PEL))
- Kontrola.

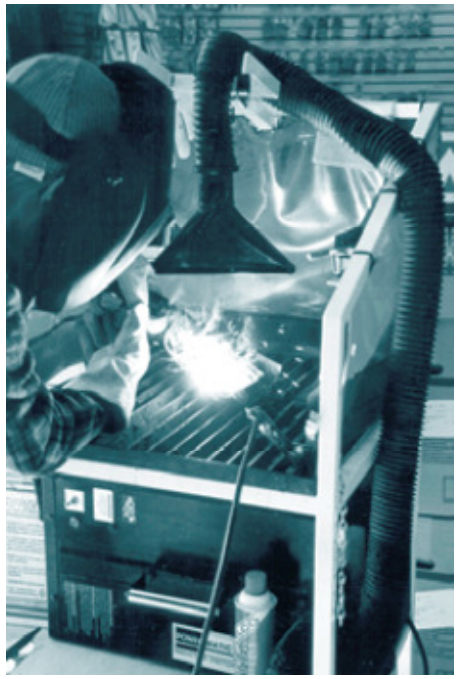
Lead abatement

Kemijske oblike (Agregatno stanje)

- Trdna onesnaževala.
  - dim.
  - megla.
  - Prah & vlakna.
- Plini in hlapi.

Trdna onesnaževala

- Dim.
  - Nastane s kondenzacijo izparjenih snovi v hladnem zraku.
  - Nastanejo pri varjenju, obločno rezanje, spajkanju, etc.
  - Ponavadi manj kot 1.0 µm premera.
  - V večini primerih reagirajo vroče pare z zrakom in nastanejo oksidi.



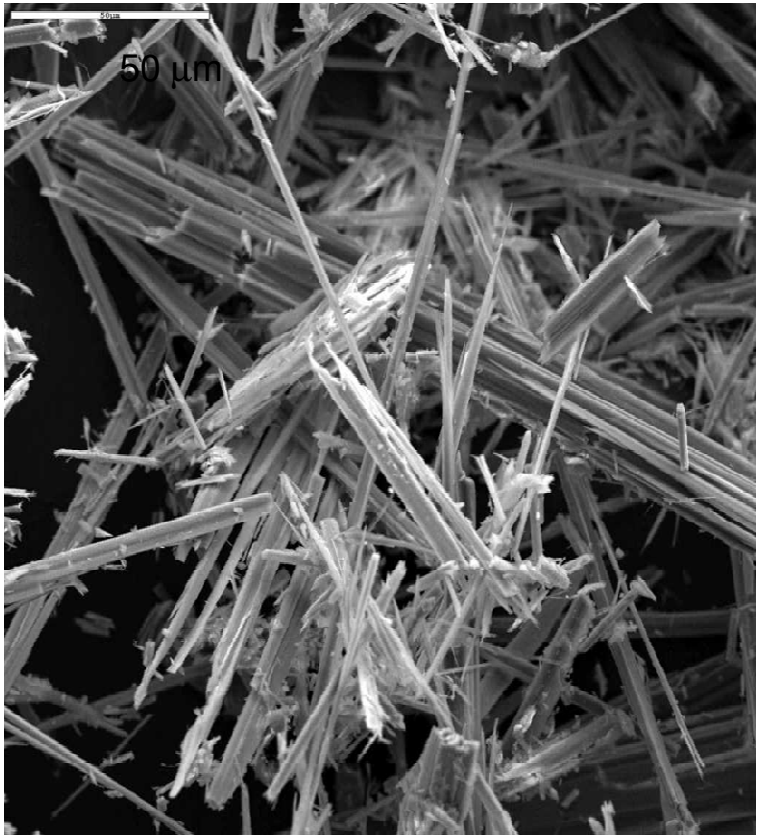
Trdna onesnaževala

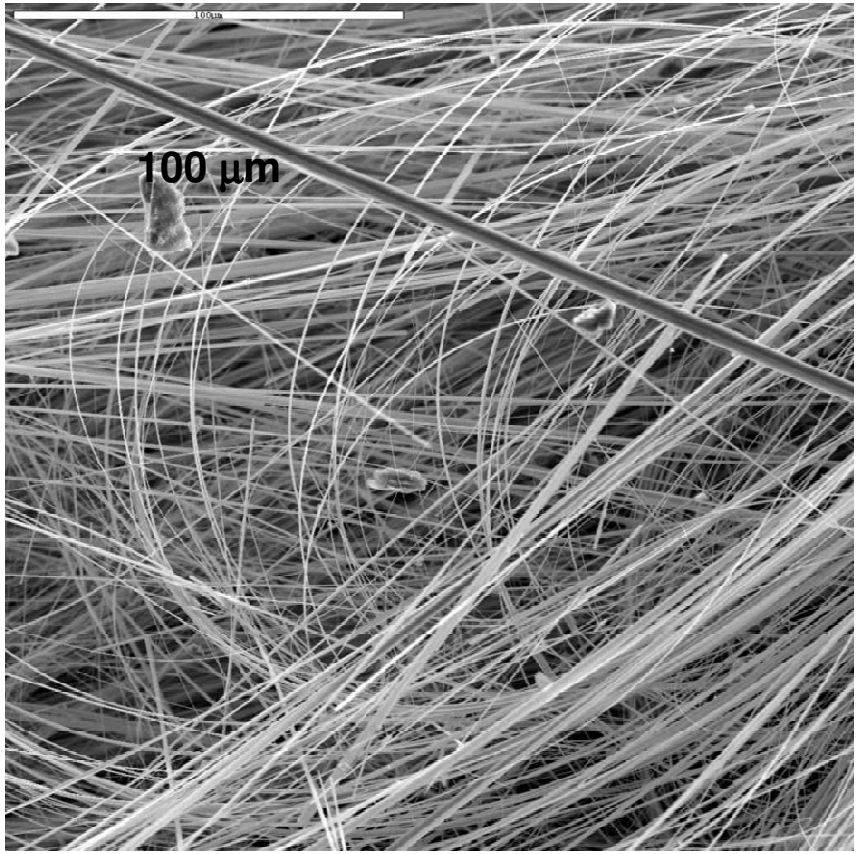
- Megla.
  - Suspendirane kapljice tekočine nastajajo zaradi:
    - » Kondenzacije tekočine iz hlapov ***ali***
    - » Razprševanja tekočine v drobne kapljice.
  - Term “mist” is applied to finely divided liquid suspended in atmosphere.

Trdna onesnaževala

- Prah.
  - Nastaja pri obdelavi, drobljenju, brušenju, razstreljevanju,...
  - Označujemo prašne delce v zraku z velikostjo od 0.1 - 25 µm.
- Vlakna.
  - Podobna velikost.
  - Bistveno večja dolžina od 6-12 mm.

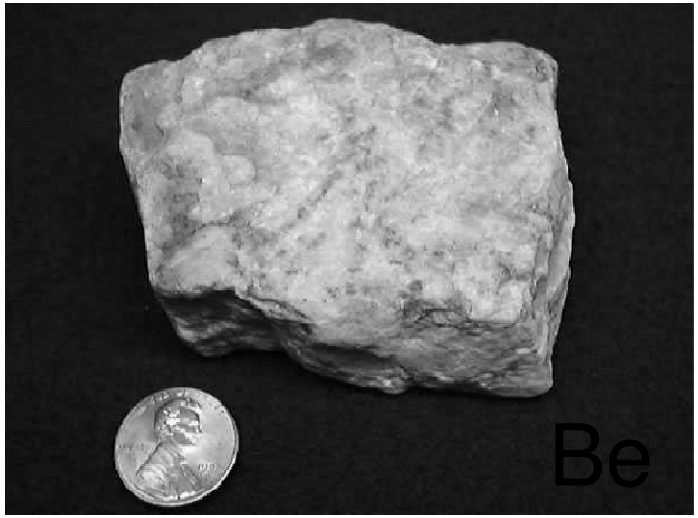
Nevarna trdna onesnaževala

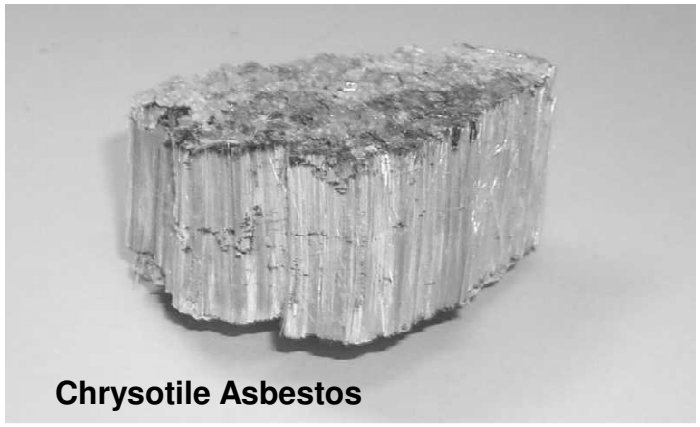




Selected Hazardous Particulates

- Asbestos.[20 μm]
  - Asbestosis, cancer.
- Beryllium.
  - Berylliosis, cancer.
- Bacteria.
  - Humidifier fever.
- Cotton dust.
  - Byssinosis.





Chrysotile Asbestos

Selected Hazardous Particulates

- Diesel exhaust.
  - Lung cancer.
- Lead & compounds.
  - CNS, PNS, blood.
- Nickel.
  - Nasal cancer, allergic contact dermatitis.
- Pesticides.
  - CNS, cancer.
- Cadmium, chromium, cobalt, manganese.
  - Cancer, CNS, pneumoconiosis.

Lead ore

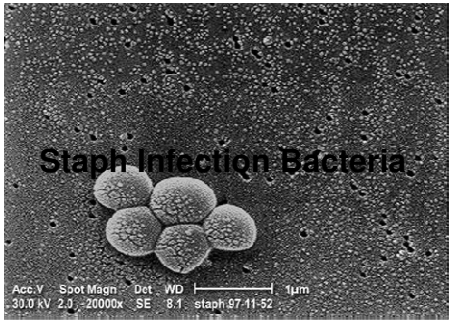
Gases and Vapors

- **Gas** is a fluid in the gaseous state having neither independent shape or volume.

- **Vapor** refers to a gas-phase material that that normally exists as a liquid or solid under a given set of conditions.

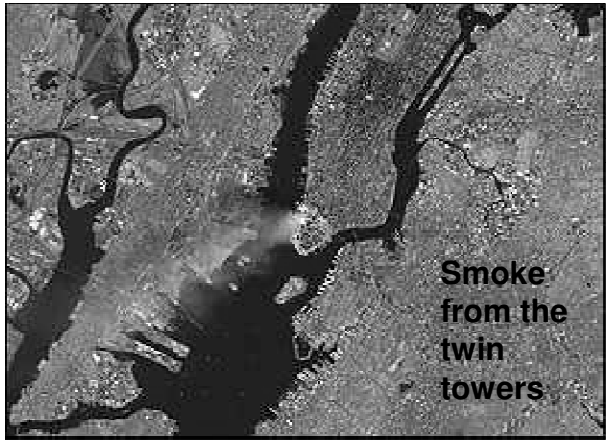
Critical Factors

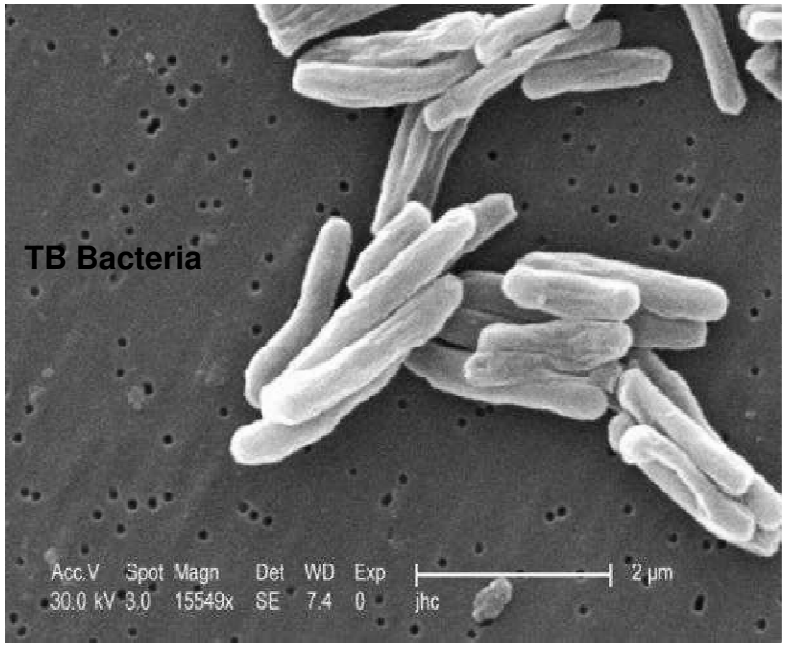
- Determining exposure.
  - Chemical composition.
  - Crystalline, structural, & isotopic forms of particles.
  - Shape of particles.
  - Size of particles.
  - Dose: concentration vs. duration.
  - Pre-existing health or genetic status.
  - Concurrent exposure to other toxic agents.



Chemical Composition

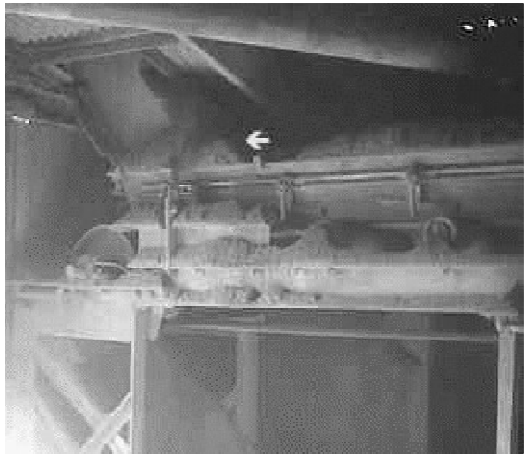
- Chemical composition can be primary concern.
  - Lead, cadmium, silica, smoke composition, radiological particles, etc.
- Biological organisms.
  - Type and numbers.

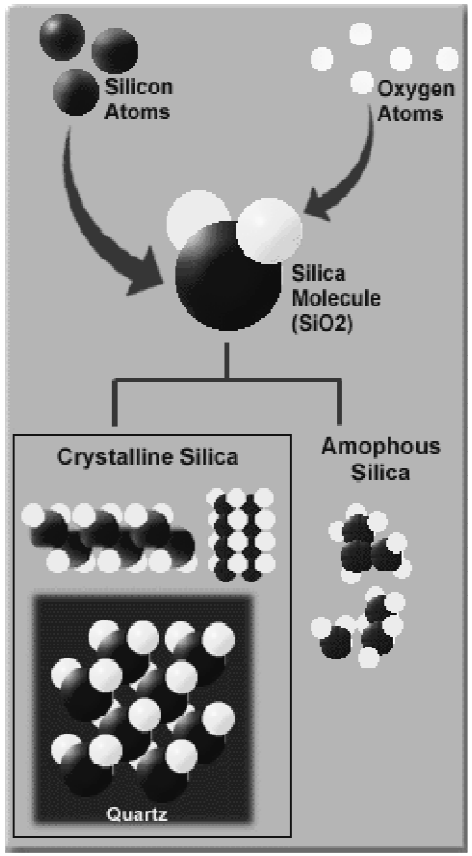




Crystalline, Structural, Isotopic Nature

- Silica dust.
  - "free crystalline silica".
    - Diatomaceous earth.
    - Fumed silica.
    - Silica gel.
- Smokes, soots, organic origin.
- Radioisotopes.





Particulate Size Determination

- Workers are not exposed to single particles but rather to large masses of particles suspended in air (particle clouds).
- Particle clouds may be:
  - Monodisperse.
    - » Composed of airborne particulates with a single size or a small range of sizes.
    - » e.g. fog from boiling acid; welding fumes.
  - Polydisperse.
    - » Composed of airborne particulates of many different sizes.
    - » e.g. sand blasting; paint spraying.

Particle Size Terminology

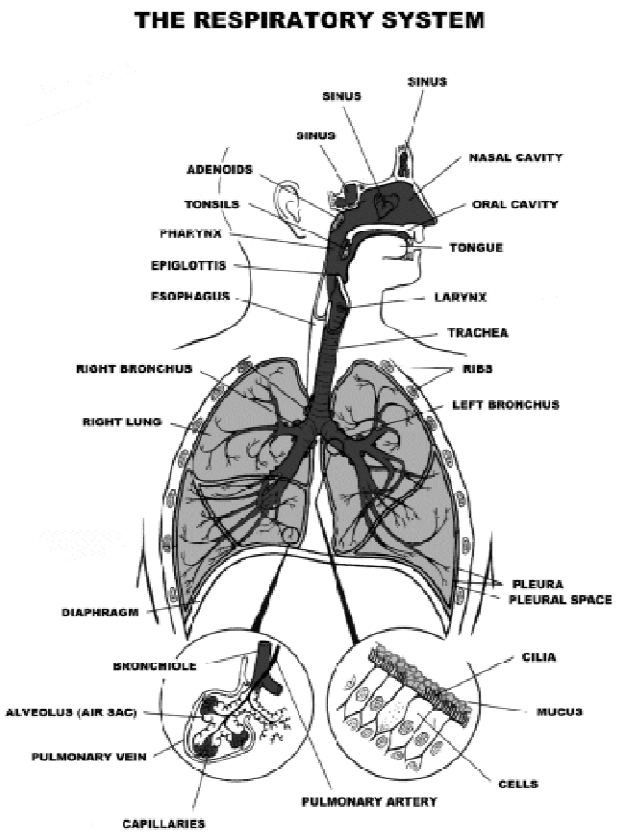
- Micrometer (µm). A unit of length equal to one millionth of a meter. Also known as "micron." Equal to 1/25, 400th of an inch.

- Non-respirable. Particles $\geq$ 10 µm in diameter. Deposited in respiratory system before reach alveolar sacs in lungs.

- Respirable. Particles < 10 µm in diameter. Likely to reach alveolar sacs in great quantities.

Routes of Exposure

- Inhalation.
  - Through the lungs.
- Ingestion.
  - Swallowed.
- Absorption
  - Through the skin or eyes.
- Injection.
  - Needle stick.



Inhalation

- Chemicals in the air are inhaled into the body through the mouth or nose.
  - In the workplace, airborne chemicals may occur in different forms such as gases, vapors, dusts or mists.

Ingestion

- Ingestion can occur through eating or smoking with contaminated hands or in contaminated work areas.

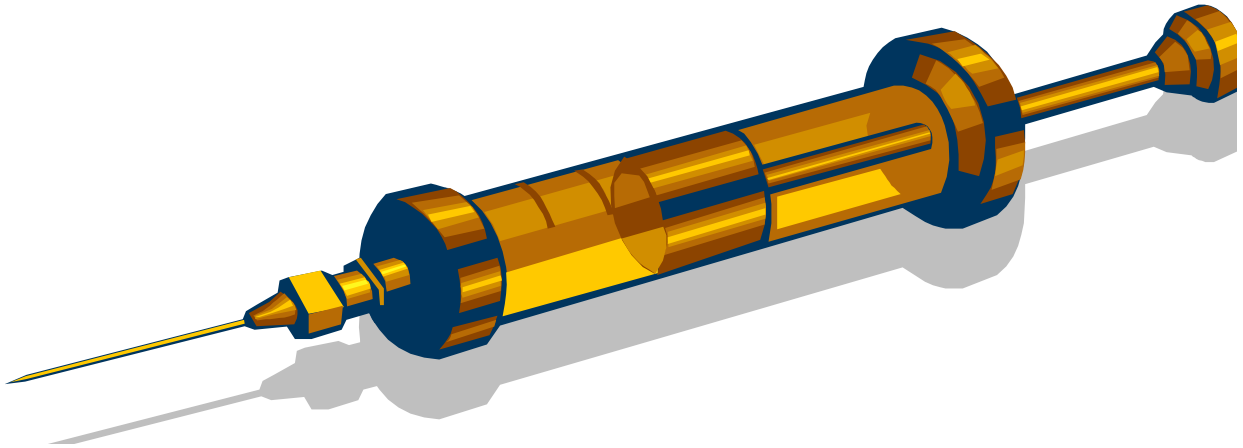
Absorption

- Skin contact with chemicals can result in irritation, allergic response, chemical burns, and allergic contact dermatitis.

- Physically damaged skin or skin damaged from chemical irritation or sensitization will generally absorb chemicals at a much greater rate than intact skin.

Injection

- Chemical substances can be injected into the body by accidentally puncturing the skin with a contaminated needle or other sharp device.



Exposure Terminology

- A **Permissible Exposure Limit (PEL)** is the maximum amount or concentration of a chemical that a worker may be exposed to under OSHA regulations.

- **8-hour Time Weighted Averages (TWA)** are an average value of exposure over the course of an 8 hour work shift.

Exposure Terminology

- **Threshold Limit Values (TLV)** are guidelines (**not** standards) prepared by the American Conference of Governmental Industrial Hygienists, Inc. (ACGIH) to assist industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace.

Exposure Terminology

- **Ceiling Values (C)** is an exposure limit for which at no time should it be exceeded.

- **"Skin"** designation serves as a warning that cutaneous absorption should be prevented in order to avoid exceeding the absorbed dose received by inhalation at the permissible exposure level.

Exposure Terminology

- **Short Term Exposure Limit (STEL)** is defined by ACGIH as the concentration to which workers can be exposed continuously for a **short** period of time without suffering from:
  - Irritation.
  - Chronic or irreversible tissue damage.
  - Narcosis of sufficient degree.

Exposure Terminology

- Acute.
  - Contact with a substance that occurs once or for only a short time.
- Chronic.
  - Occurring over a long time.
- Additive effect.
  - A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together.

PELs Are Dosages (D 🔔 C & t)

- **Concentration** (C).
  - ppm – parts per million.
  - mg/m^3 – milligrams per cubic meter.
  - mppcf – million particles per cubic foot.
  - µg/m^3 – micrograms per cubic meter.
  - f/cc – fibers per cubic centimeter.
- **Time period** (t).
  - 8-hour time-weighted average.
  - 15-minute short term exposure limits.
  - 30-minute excursion limits (EL).
  - Instantaneous or ceiling values.
  - Skin designation.

Pre-Existing or Genetic Status

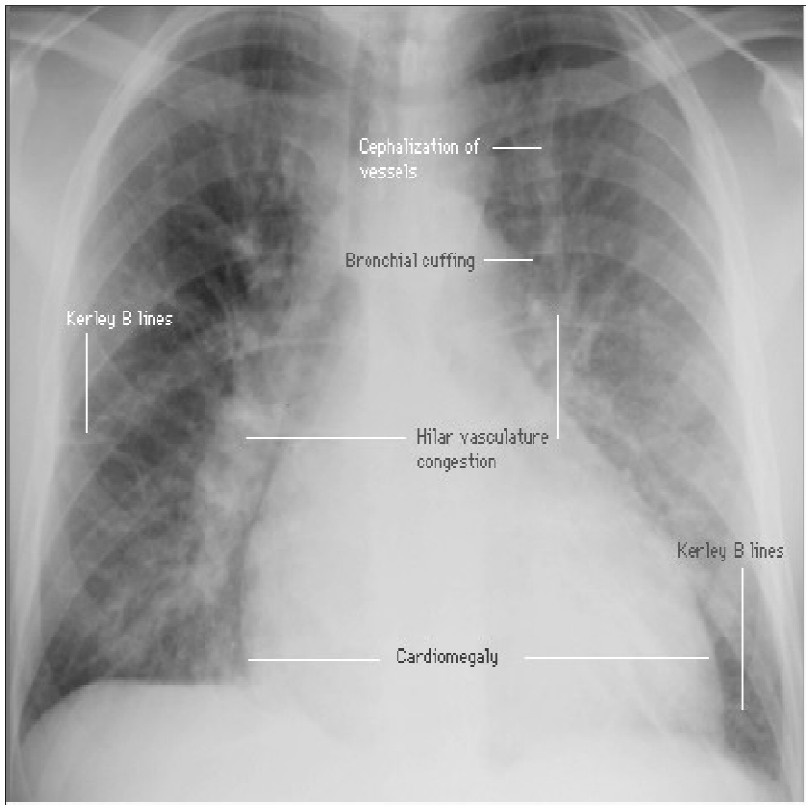
- Permissible exposure limits (PEL) and threshold limit values (TLV) are set for healthy workers.
- Susceptibility of individuals is not taken into account when setting these levels.
- Some medical evaluation is done as in pre-employment physicals and medical history.

Concurrent Exposures

- Exposures do not normally occur in isolation.
- Some exposures follow the same route but have very different effects on body.
- Some materials may also be additive, synergistic or potentiators.
  - Lead & thallium can be additive as they have similar toxic effects.
    - » When the exposures are measured together, the TWA fractions of the exposure limits are added, if total is >1.0 than overexposure has occurred.
  - Asbestos & smoking are synergistic (multiplier effect).

Biological Reactions

- Pulmonary irritants.
- Pulmonary edema.
- Acute or chronic bronchitis.
- Allergic sensitization.
- Fibrosis.
- Emphysema.
- Systemic toxicity.
- Lymphatic toxicity.
- Infection.
- Oncogenesis.
- Metal fume fever.



Meritve v delovnem okolju

- Meritve v delovnem okolju glede na mesto odvzema vzorcev delimo na:
  - meritve v širšem območju,
  - meritve osebne izpostavljenosti in
  - meritve vira onesnaženja.

Meritve v širšem območju

Meritve v širšem območju služijo za oceno imisijskih vrednosti merjenih spojin. Z meritvami želimo pokriti čim širše območje. Tak tip meritev ponavadi uporabljamo za meritve onesnaženja v okolju.

Če ni možno izvesti drugačnih meritev lahko takšne meritve uporabljamo tudi za oceno osebne izpostavljenosti v delovnem okolju (npr. meritve na večih mestih v proizvodnji hali lahko služi za oceno izpostavljenosti delavcev, ki se nahajajo v tem delovnem okolju).

Meritve osebne izpostavljenosti

- Če želimo, da so meritve osebne izpostavljenosti opravljene v skladu z OSHA standardi, moramo izvesti odvzem vzorca v dihalnem območju razen, če je to prepovedano zaradi specifik merilne tehnike ali delovnega okolja.

- Dihalno območje je definirano z namišljenim pravokotnikom, ki je omejen s širino ramen, sredino prsi in višino glave.

Meritve v vira onesnaženja

- Z meritvami vira onesnaženja določamo emisijske vrednosti merjenih spojin.

- V delovnem okolju s takimi meritvami predvsem kontroliramo znane vire onesnaženja delovnega procesa.

- Služijo lahko tudi za procesno kontrolo proizvodnje (npr. ob zaznavanju povišanih emisij strupenih spojin se lahko proizvodnja omeji/modificira ali celo ustavi).

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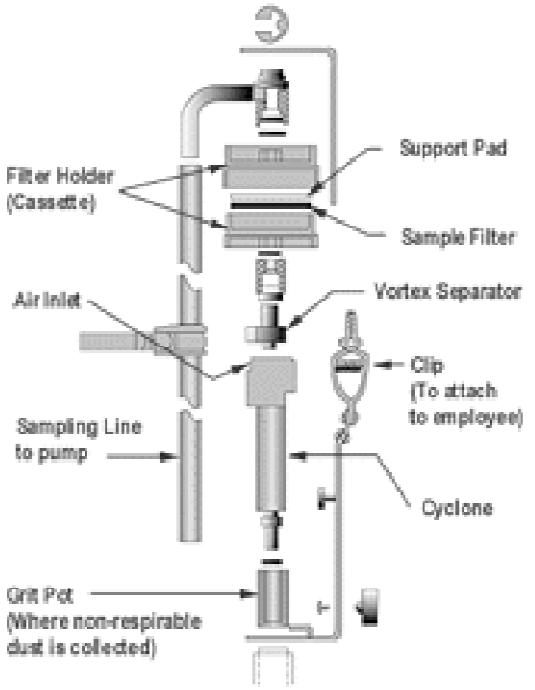
Air Sampling & Analysis

- Area sampling.
  - Area where workers are located.
    - » Sampling pump and cassette placed in area.
    - » New instantaneous instruments to measure total, **PM10 and PM2.5.**

- Microbiological sampling is generally area sampling using plates or impingers.

Air Sampling

- Size selective particle sampling on filters for either gravimetric or microscope counting of fibers.
  - Respirable dust is collected on a filter (37mm) using a cyclone set up.
    - » Gravimetric analysis.
- Asbestos is collected on smaller filter.
  - 25 mm.



Cyclone filter

Gases and Vapors

Why Am I Making the Measurements?

- Personal protection.
- Personal compliance monitoring.
- TWA.
- STEL or ceiling.
- Area monitoring.
- Confined space entry.
- Hazardous spill.
  - May influence choice of range, battery life, etc. . .

What Gases/Vapors Do I Want to Measure?

- Gases or vapors measured limit the sensing technology used.

- Range will also limit sensing technology used.

Magellan ammonia pipeline rupture in Kingman Co., Kansas on Oct. 27, 2004.

Integrirne tehnike

- Odvzem vzorca in meritev sta krajevno ločena (analiza poteka v laboratoriju).

- Meritve so enostavnejše (za izvedbo ne potrebujemo visoko usposobljenega osebja).

- Dobimo informacijo o povprečnih koncentracijah. Z njimi ponavadi ne zaznamo kratkotrajnih ekstremov.

- Integrirne tehnike so lahko aktivne ali pasivne.

Čas izpostavljenosti (jemanja vzorcev)

- Lahko sovpada s časom podanim v predpisu za omejevanje mejnih vrednosti (8 urna izpostavljenost).

- Čas jemanja vzorcev lahko skrajšamo, da dobimo informacijo o gibanju koncentracij tekom delovnega procesa (možna je zaznava tudi ekstremov).

- S krajšim časom jemanja vzorcev se v primeru kratkotrajnega izpada izognemo popolni izgubi informacije.

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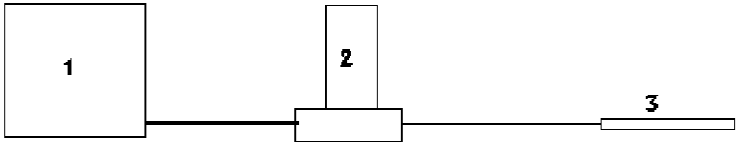
Aktivne tehnike

- Za aktivne tehnike je značilna uporaba energije (črpalke). Za določitev koncentracije merjene spojine potrebujemo poznati volumen prečrpanega zraka.



1 - črpalka
2 - masni regulator pretoka
3 - absorpcijska cevka

Med aktivne tehnike spadajo:

- črpanje na absorpcijske cevke,
- črpanje preko filtrov,
- izpiralke (impinger),
- črpanje v vreče ali cilindre, itd.

Pasivne tehnike

●Pri pasivnih tehnika ne potrebujemo vira energije. Za določitev koncentracije merjene spojine potrebujemo poznati čas izpostavljenosti vzorčevalnikov.

Med pasivne tehnike spadajo:

- difuzijske absorpcijske cevke,
- “badge” vzorčevalniki
- cilindri iz nerjavnega jekla itd.

Kot vidimo lahko določene tehnike uporabimo v aktivnem kot tudi v pasnim načinu jemanja vzorcev.

Območje delovanja

- Odvzem vzorca mora biti prilagojen uporabljeni metodi končne določitve množine/mase merjene spojine ter specifikam vzorčevalnika.

- Sposobni moramo biti določiti merjeno spojino v območju od 0.1 do 2 MV.

- Glede na te omejitve moramo poznati minimalno in maksimalno količino prečrpanega zraka oz. časa izpostavljenosti.

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Območje delovanja 2 (aktivno vzorčevanje)

- Minimalno količino prečrpanega zraka (MinPZ) določa meja detekcije instrumentalne metode. Izračunamo jo iz spodnje meje merilnega območja.

$$MinPZ(l) = \frac{MD(\mu g)}{0.1 * MV(\mu g / l)}$$

Maksimalno količino prečrpanega zraka (MaxPZ) določa kapaciteta absorbentov (KA). Izračunamo jo iz zgornje meje merilnega območja.

$$MaxPZ(l) = \frac{KA(\mu g)}{2 * MV(\mu g / l)}$$

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Območje delovanja 3 (pasivni vzorčevalniki)

- Minimalen čas izpostave (t_{min}) določa meja detekcije instrumentalne metode. Izračunamo jo iz spodnje meje merilnega območja in hitrosti vzorčevanja (hV), ki podaja hitrost nalaganja merjene spojine na vzorčevalnik.

$$t_{\min}(\min) = \frac{MD(\mu g)}{0.1 * hV(l/\min) * MV(\mu g/l)}$$

Maksimalni čas izpostave (t_{max}) določa kapaciteta absorbentov (KA) in hitrost vzorčevanja. Izračunamo jo iz zgornje meje merilnega območja.

$$t_{\min}(\max) = \frac{KA(\mu g)}{2 * hV(l/\min) * MV(\mu g/l)}$$

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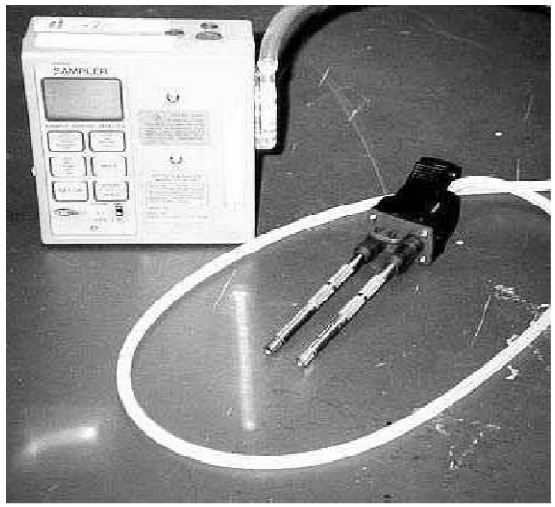
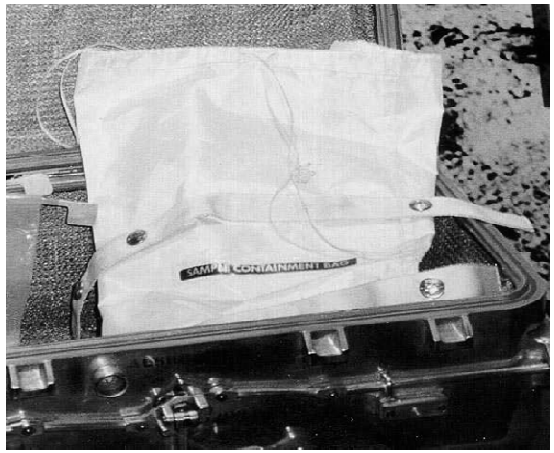
Gases and Vapors: Sampling Methods

- **Grab sampling.**
  - **Detector tubes.**
  - **Gas bags.**
- Passive dosimetry.
  - “Film badges”.
- Active sampling.
  - Sorbent tubes & personal sampling pump.
- Direct reading instruments.

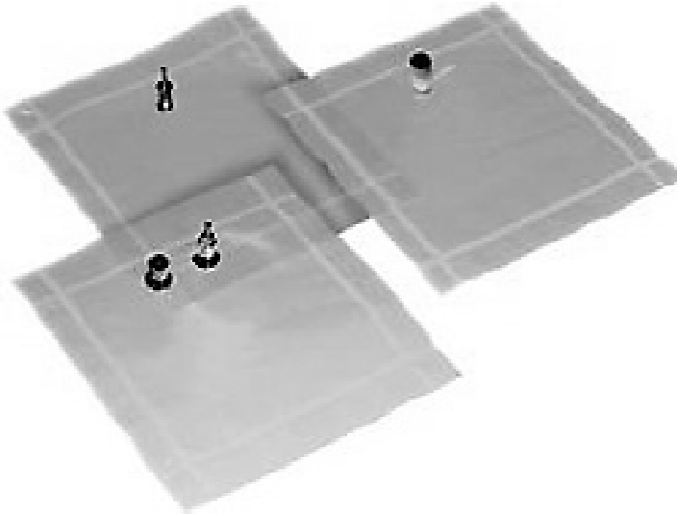
Gas Bags (Grab bags)

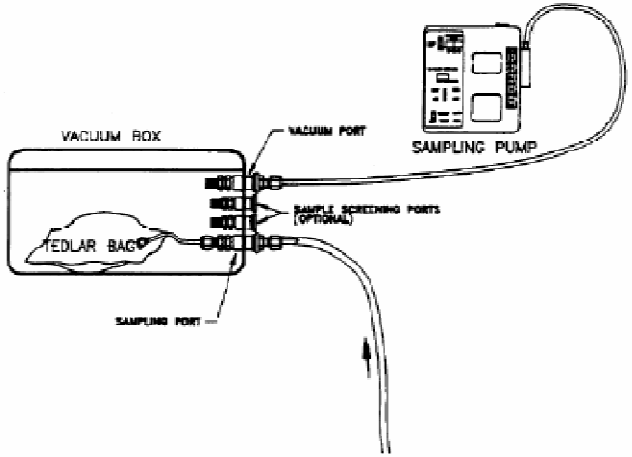
- Theory – samples are collected via a slow-flow sample pump and stored in a plastic or foil bag.
- A wide variety of gases can be measured.
- Advantages – Easy sample storage. A variety of bag materials adds to the unit's versatility.





Jemanje vzorcev v vreče ali kanistre





V primeru uporabe Tedlerjevih vreč uporabimo poseben način odvzema vzorca. Tedlerjevo vrečo priključimo na posebno vakuumsko komoro, ki omogoči napolnitev vreče z zunanjim zrakom brez kontaminacije.

Volumen odvzetega zraka je omejen z volumnom vreče. Kupimo jih lahko različnih dimenzij.

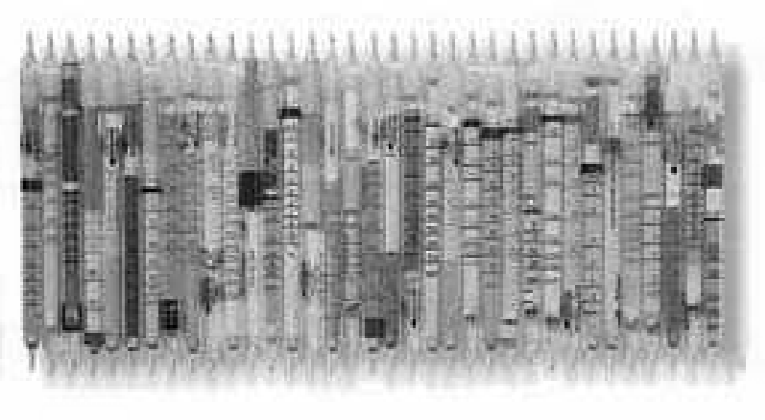
Jemanje vzorcev v vreče ali kanistre

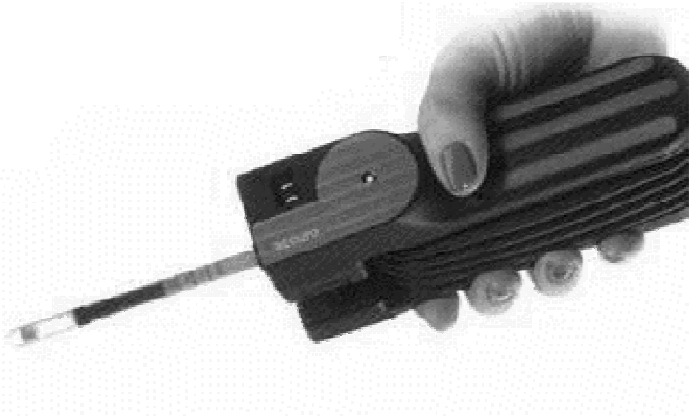
Kanistre pred vzorčevanjem evakuiramo in očistimo. Na terenu jih nato le odpremo in počakamo, da se tlak izenači z zunanjim tlakom.

Uporabljamo jih lahko za jemanje trenutnega vzorca ali kot integrirno tehniko.

Detector Tubes

- Theory - glass tubes filled with reagent that changes color in reaction to certain chemicals.
- Gases measured - Wide variety of gases can be measured.
- Advantages - Can measure many gases that cannot be measured by direct-reading instruments.





Detector Tubes

- Disadvantages –
  - Accuracy of ±25% under ideal conditions.
  - Must use hand pump (or electronic pump - RAE) and wait for reaction to take place.
  - Can't do continuous monitoring or sampling.
  - Temperature – pressure - time (TPT) dependence.

- Examples of Tube Vendors: Dräger Safety, Kitegawa (Matheson), Sensidyne.

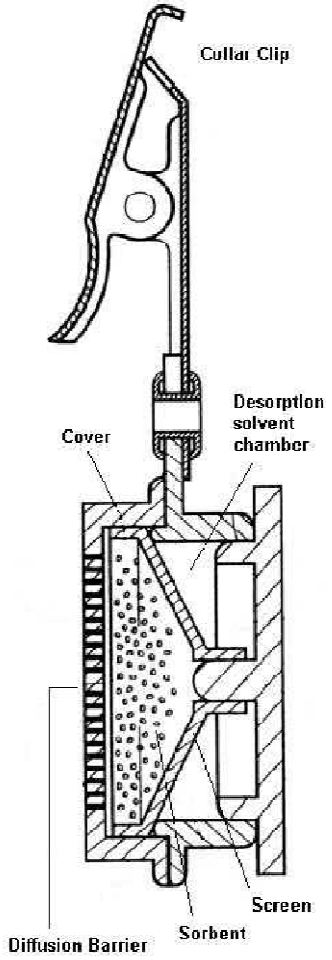
Gases and Vapors: Sampling Methods

- Grab sampling.
  - Detector tubes.
  - Gas bags.
- **Passive Dosimetry.**
  - **"Film badges".**
- Active sampling.
  - Sorbent tubes & persona
- Direct reading instrumer

Passive Sampling

- **Definition:** the collection of airborne gases and vapors at a rate controlled by a physical process such as diffusion through a static air layer or permeation through a membrane without the active movement of air through an air sampler.

- Diffusion of contaminated molecules from an area of high concentration to an area of low concentration on the sampler



Passive Dosimeters

- Partial list of substances for which badges are available:
  - Mercury (Hg).
  - Nitrous oxide (N_2O).
  - Ethylene oxide (C_2H_4O).
  - Formaldehyde (CH_2O).
  - Other organic substances.

Passive Dosimeters

- Advantages.
  - Easy to use.
  - Requires minimal training.
  - Economical — no costly pumps or sampling equipment is required.
  - Less burdensome to worker — only a lightweight badge or tube is worn.
  - Samplers are available that can be used for both short- and long-term sampling.

Passive Dosimeters

- Disadvantages.
  - No means to measure the air flow.
  - Theoretical uptake rate may not be valid for conditions of use.
  - Few analytical methods published by governmental agencies.
  - No indication of breakthrough or reverse diffusion.
  - Affected by wind velocity, temperature and humidity.
  - Sampling is either not accurate enough or not approved for compliance sampling.

Gases and Vapors: Sampling Methods

- Grab sampling
  - Detector tubes
  - Gas bags
- Passive Dosimetry
  - “Film badges”
- **Active sampling.**
  - **Sorbent tubes & personal sampling pump.**
- Direct reading instruments

Active Sampling

- Collection of airborne hazards by means of forced movement of air using an air-sampling pump through the appropriate sampling media.

- The pump is used to collect and/or concentrate the chemical of interest onto the sampling media.

Sorbent Tubes

- Common sorbent materials are:
  - Activated charcoal.
  - Silica gel.
  - Tenax.
  - XAD-2.
  - Chromosorbs.
- Sorbent used to collect specific chemicals will be specified in the sampling method.

Gases and Vapors: Sampling Methods

- Grab sampling.
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- Active sampling.
  - Sorbent tubes & personal sampling pump.
- **Direct reading instruments.**

Delitev merilnih tehnik glede na uporabljeno merilno opremo

- Meritve v realnem času
  - spektroskopske metode (enostavni spektrometri)
  - elektrokemijske metode (senzorji)

- Integrirne merilne tehnike
  - uporaba absorpcijskih cevk
  - filtri (prah)
  - izpiralke
  - zbiranje celotnega vzorca v vreče ali cilindre

NCDOL
N.C. Department of Labor

Meritve v realnem času

Take meritve so ponavadi povezane z višjimi stroški meritev.

Meritve so zahtevnejše z instrumentalnega stališča (problem izvedljivosti).

Odvzem vzorca in instrumentalna meritev poteka na istem prostoru.

Njihova prednost je predvsem podajanje rezultatov v realnem času v primeru alarmiranja in meritve v kratkih intervalih (možnost zaznavanja kratkih povišanih koncentracij merjenih spojin).

Flame Ionization Detector (FID)

- Examples of instruments:
  - Foxboro TVA 1000 Dual PID/FID.
  - Foxboro OVA 108 & 128 FIDs.
  - Fugitive Emissions LeakTracker Systems.
  - Heath DETECTO-PAK FID.
  - Photovac MicroFID.
  - Thermo Environmental 680.

Photo Ionization Detector

- Measures volatile organic compounds and other gases in concentrations from 1 parts per billion (ppb) to 10 000 parts per million (ppm).
- Efficient and inexpensive type of gas detector.
- capable of giving instantaneous readings and continuous monitoring.
- Widely used in military, industrial, and confined working facilities for safety.

Photo Ionization Detector

- Disadvantages.
  - Nonselective among organic vapors below ionization potential of lamp.
  - Affected by high humidity.
  - Higher potential lamps (11.7 eV) needed to measure CH_2Cl_2 have short life (~ 1 month).
  - UV lamps are expensive.

- Examples of instruments: Photovac 2020, MSA Passport PID II, RAE Systems MiniRAE PLUS.

Infrared Spectrophotometry

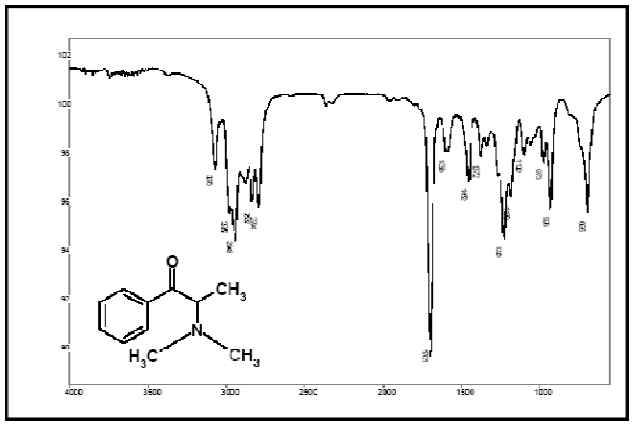
- An infrared spectrometer directs infrared radiation through a sample and records the relative amount of energy absorbed by the sample as a function of the wavelength or frequency of the infrared radiation.

- the infrared radiation is selectively absorbed by the material to produce an absorption spectrum.

- The spectrum produced is compared with correlation spectra from known substances.

Infrared Spectrophotometry

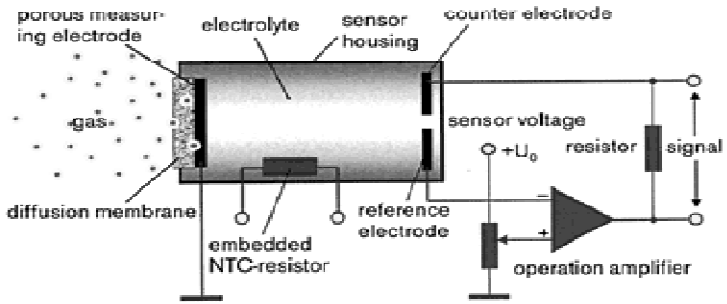
- Advantages – can detect and measure some compounds that can't be measured by other methods.
- Disadvantages – expensive, complicated.
- Examples of instruments: Foxboro MIRAN SapphIRe.



Electrochemical Sensors

- Theory – Gas diffusing into sensor reacts at sensing electrode to cause current to flow.

- Gases measured - O_2, CO, NO_2, NO, H_2S, SO_2, NH_3, HCl, HCN, Cl_2 and organic vapors such as alcohols, aldehydes, or ketones.



Electochemical sensor measuring principle

Electrochemical Sensors

- Disadvantages.
  - Not specific to single gas without use of filters or other methods.
  - HCl – zero drift due to bias voltage, zero drift at high temperatures, affected by rapid changes in %RH.
  - NH3 – not entirely catalytic – electrolyte is used up, zero drift at high temperatures.

- Examples of instruments: Dräger PAC III, Dräger Model 190, Quest SafeLog 100, Biosystems Toxi Ultra.

Zaključek

- Izbira ustrezne merilne tehnike je odvisna od podatkov, ki jih želimo pridobiti za oceno tveganja.
- Vse metode imajo svoje prednosti in slabosti, ki se jih upošteva pri izbiri optimalne merilne tehnike.
- Sledi se pravilu, da se uporablja najenostavnejšo tehniko, ki še zagotavlja ustrezne rezultate.