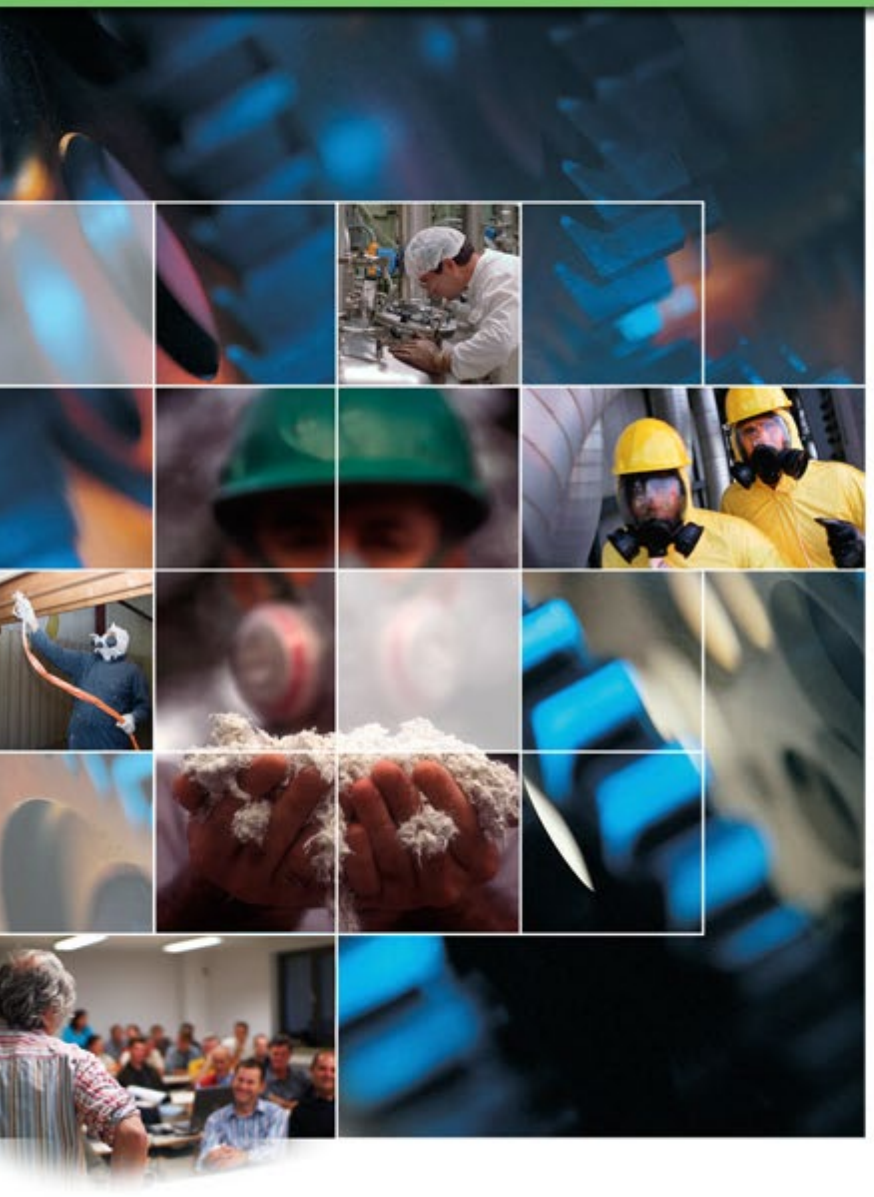


Focused and Efficient Industrial Hygiene Sampling

Tony Watson, MSPH, CIH, CSP
Dennis Forbis, CIH, CSP

Workplace HYGIENE

Objectives

- Review IH Concepts
- Review NEP Contaminants
- Help sharpen decision-making regarding compliance sampling to achieve maximum efficiency

History of Industrial Hygiene

- 1938 American Conference of Governmental Industrial Hygienists founded.
- 1939 American Industrial Hygiene Association (AIHA) formed.
- 1948 All states had compensation laws.
- 1970 Williams-Steiger Occupational Safety and Health Act (OSHA).

History of Industrial Hygiene

- 1700 Ramazzini wrote first comprehensive treatise on occupational disease.
  - De Morbis Artificum Diatriba (Discourse on the Disease of Workers)
  - Was a physician
  - Studied diseases of scholars, seafarers, soldiers, salt workers, lawyers, & others
- Described silicosis in pathological terms, as observed by autopsies of miners. Asked question: *"Of what trade are you?"*

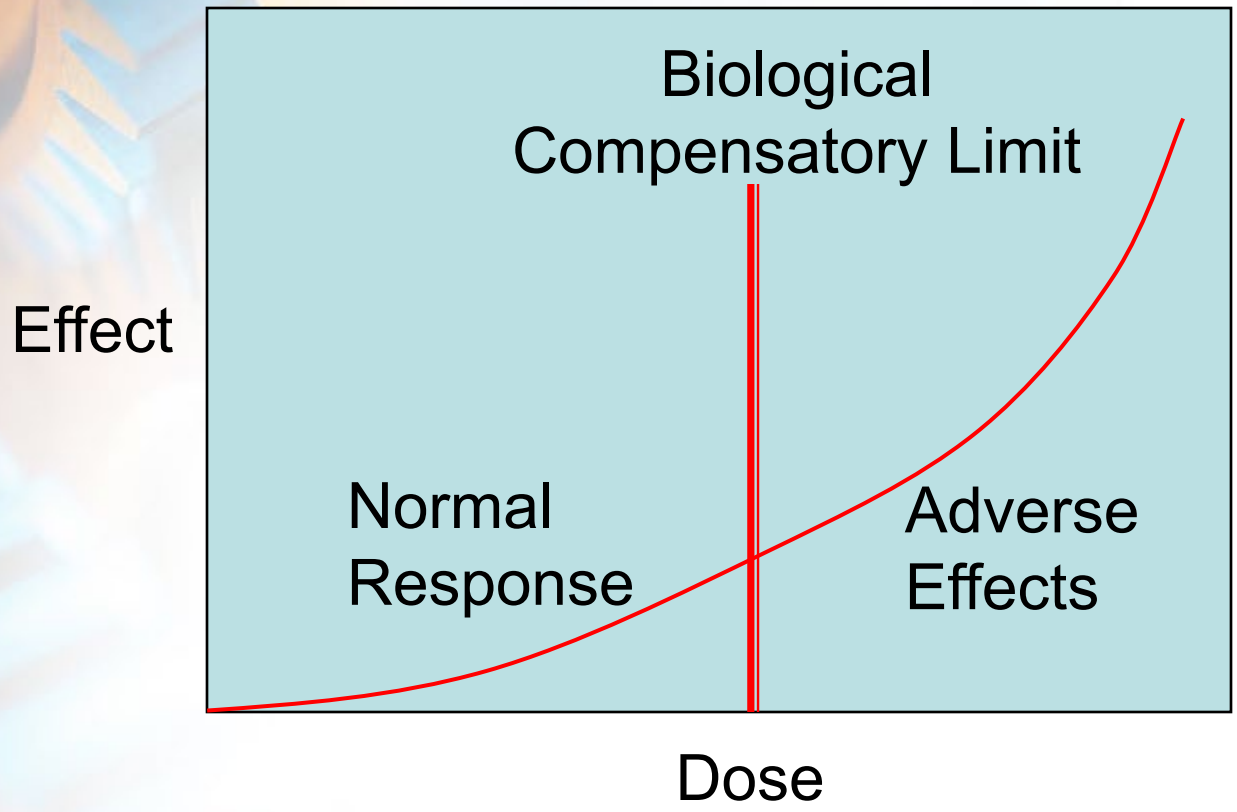
History of Industrial Hygiene

- 16th Century Paracelsus warned of toxicity of certain metals and described mercury poisoning; debunked medical practices such as bleeding and purging.
- Had no formal training

History of Industrial Hygiene

- *"What is it that is not a poison? It is the dose only that makes a thing not a poison."* Phrase has become *"the dose makes the poison."*
- Rephrased: "To call everything a poison is to call nothing a poison."

Concept of Acceptable Dose



“The Dose Makes the Poison”

Workplace HYGIENE

Exposure vs. Dose

- Exposure
  - Potential contact with individual's exchange boundaries (e.g. respiratory system, skin) for chemical, physical, or biological agents

  (*Note: OSHA standards consider inhalation exposure to be that which would be experienced without respiratory protection*)
- Dose
  - Bodily uptake or flux available for biological activity
- Occupational Exposure Limits (OELs) are often based on Exposure/Effect relationship, rather than Dose/Effect relationship

Hazard vs. Risk

- Hazard: the inherent ability of a substance to cause harm
- Risk: the probability that harm will result (Risk = Hazard x Probability)
  - Example: Lead is inherently toxic (high severity) but the risk depends on whether it is introduced into body, and how much
- Hazard is fixed - control the risk

What is Industrial Hygiene?

That science and art devoted to the ***anticipation, recognition, evaluation, and control*** of those ***environmental factors and stresses*** arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among **workers** or among the **citizens of the community**.

Concepts of Industrial Hygiene

- **Anticipation**
- **Recognition**
- Evaluation
- Control

Anticipation

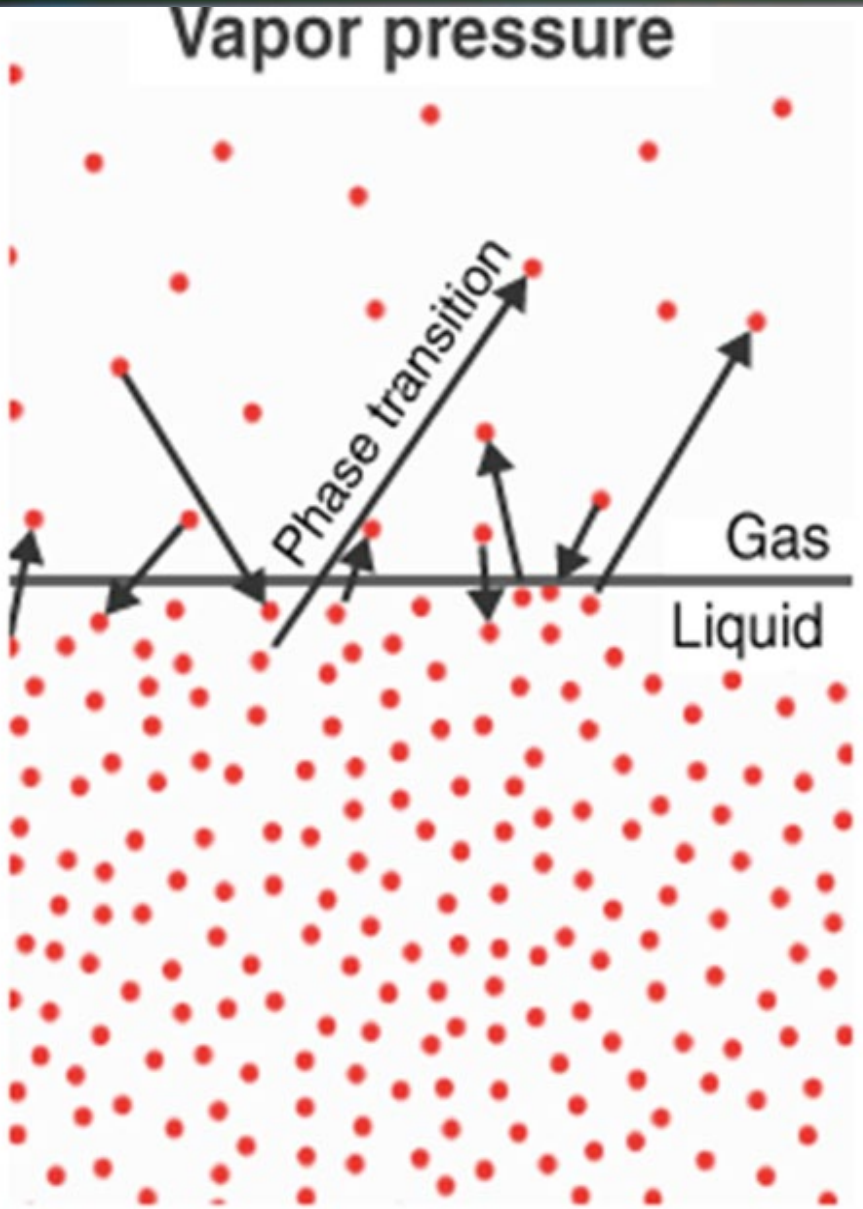
- Routine activities
- Non-routine activities
- Changes in process
- New processes

Exposure Recognition

- Toxicity (high, acute, etc.)
- Carcinogen, Sensitizer, or Reproductive Toxicity
- Quantity Used
- Frequency Used
- Powder, Liquid, Gas , Solid
- Energy Input (Heated, Sprayed, Mixed, Milled, Cut, etc.)
- Vapor Pressure
- Controls
- Open to workplace air (surface area)
- Degradation or Reaction By-products
- Other

Vapor Pressure

- The pressure exerted by a vapor that is in equilibrium with its solid or liquid form
- Increases with increasing temperature



Molecules have higher energy at higher temperature, increasing vapor pressure

Atmospheric Pressure

- 1 atm =
  - 14.7 psi
  - 760 mmHg
  - 29.92 in Hg
  - 33.93 ft water
  - 1013 mbar

Vapor Pressure Comparisons

Contaminant	Vapor Pressure (mmHg @68 F)
Acetone	180
Ammonia	6460 (8.5 atm)
Benzene	75
Chlorine	5168 (6.8 atm)
Chloroform	160
Formaldehyde	>760
MDI	0.000005 (@77F)
Toluene	21
Xylene	9

Airborne Contaminants

- Gas – Gaseous phase at ambient conditions
- Vapor – Liquid at ambient conditions but will evaporate as vapor; higher vapor pressure increases evaporation rate
- Aerosols

Airborne particulates are part of aerosols which includes...

- Mist
- Fog
- Fume
- Dust
- Smoke
- Fiber

Aerosol Component Definitions

- Fumes – Fine solid particles condensed from vaporized material that is normally solid, can agglomerate

- Smoke – Mixtures of solid and liquid aerosol particles, gases, and vapors resulting from incomplete combustion of carbonaceous materials; fine but can agglomerate

Aerosol Component Definitions

- Mist – Spherical droplet aerosols produced from bulk liquid by mechanical processes such as splashing, bubbling, spraying – same composition as parent liquid
- Fog – Droplet aerosols produced by condensation from the vapor phase; typically smaller than mist droplets

Aerosol Component Definitions

- Dust – Dry particulate aerosol produced by mechanical processes such as breaking, grinding, pulverizing. Chemically same as parent material, with increased surface area per unit mass

- Fiber – Elongate particle, with length multiple of width – such as asbestos fiber defined as having length:diameter ratio of at least 3

Occupational Exposure Limits

- Typical units
  - ppm =parts per million parts of air
    (used for gases and vapors only)
  - mg/m^3 = milligrams per cubic meter of air
    (used for gases, vapors, and aerosols)
  - f/cc = fibers per cubic centimeter of air
  - mppcf = million particles per cubic foot of air (seldom used as an OEL expression)

Most Common Expression for Airborne Concentrations

- ppm – used for gases and vapors (see ppb, ppt also)
  - 1ppm = 1,000 ppb = 1,000,000 ppt
- mg/m^3 - used for gases and vapors , and particulates (aerosols) – see also ug/m^3, ng/m^3, etc.)
  - 1 mg/m^3 = 1,000 ug/m^3 = 1,000,000 ng/m^3

Occupational Exposure Limit Development & Use

- Hazard form
- Exposure route
- Toxicology data
- Chemical properties
- Acute toxicity
- Irritation data
- Sensitization studies
- Oncogencity
- Metabolism
- Genotoxicity
- Reproductive
- Neurotoxicity
- Subacute/subchronic
- Chronic
- Human experience
- Reference & rationale

Occupational Exposure Limits

- 8 - hour Time Weighted Average (TWA)

$$\frac{C_1T_1 + C_2T_2 + C_3T_3 + \ldots .C_nT_n}{\text{480-minutes or 8-hr}}$$

where C = concentration
T = exposure time (minutes or hrs.)

Mixtures

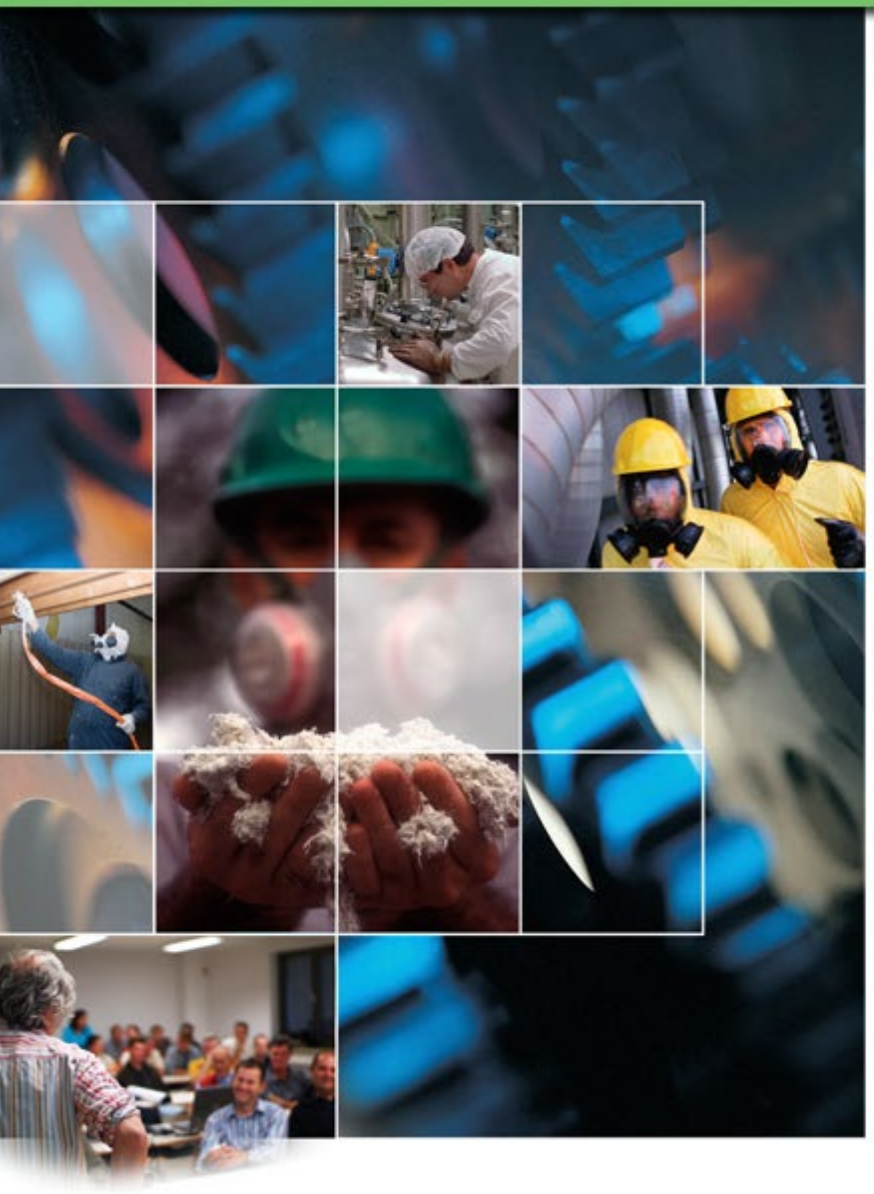
$$\text{Mixture Index} = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots \frac{C_n}{T_n}$$

Where:

C is the concentration of a particular contaminant.

T is the PEL or TLV for the contaminant.

A Mixture Index below 1.0 indicates that the TLV or PEL for that mixture was not exceeded.



Hexavalent Chromium

Workplace HYGIENE

Chromium

- Large deposits of chromite ore were found near Baltimore, MD. However, no mining has taken place since 1961.
- Cr(VI) can generally be attributed to industrial activity

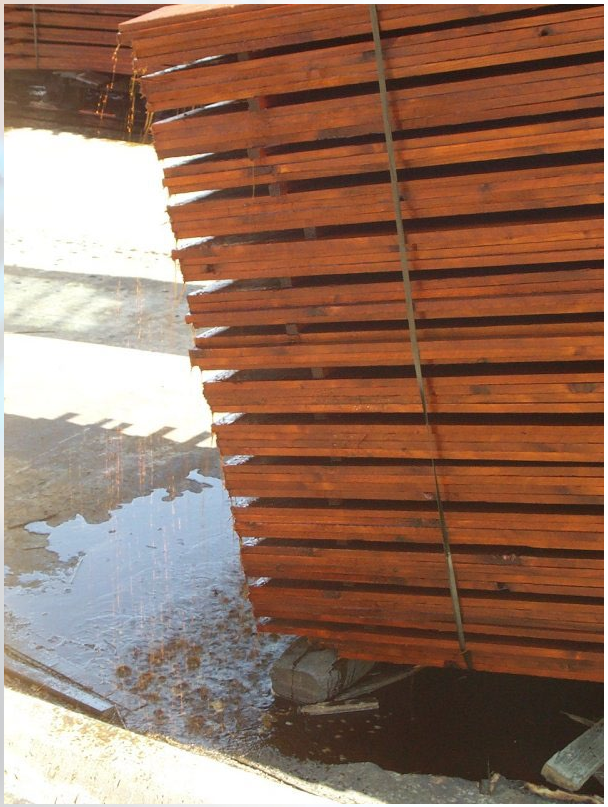
Chromate Use

- **Pigments**
  - Lead Chromate
  - Zinc Chromate
  - Barium Chromate
  - Calcium Chromate
  - Potassium Dichromate
  - Sodium Chromate

Chromate Use

Wood Preservation

Chromium Trioxide



Stainless Steel

Cr(VI) when:

- Cast
- Welded
- Torch Cut

Workplace HYGIENE

Stainless Steel Welding Exposures

- TIG Welding – Low
- MIG Welding – Higher (Likely > PEL)
- Stick Welding – Highest (Usually > PEL)
- Torch Cutting – Similar to stick welding
- MIG or Stick welding inside confined space (tanks) – (Usually > PEL)

Chromate Use

Textile Dyes

- Ammonium Dichromate
- Potassium Chromate
- Potassium Dichromate
- Sodium Chromate

Leather Tanning

- Ammonium Dichromate

Chromate Use

Anti-Corrosion Coatings

- Zinc Chromate
- Strontium Chromate
- Lead Chromate

Workplace HYGIENE

Chromate Use

Anti-Corrosion Plating

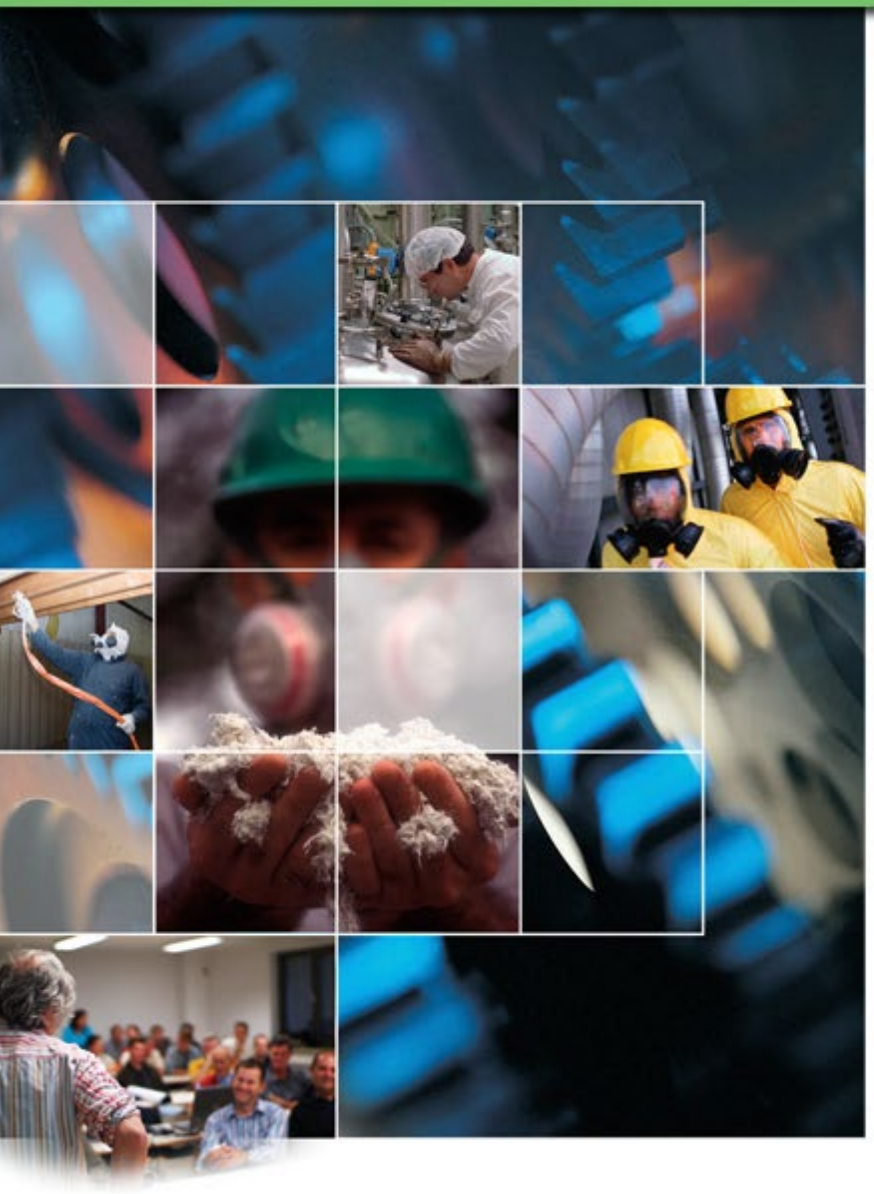
- Chromium Trioxide
- Barium Chromate
- Calcium Chromate
- Sodium Chromate

Health Effects

- Lung Cancer
- Nasal Septum Ulcerations & Perforations
- Asthma
- Skin Ulcerations
- Allergic & Irritant Contact Dermatitis
- Conjunctivitis

OSHA Standard – 29 CFR 1910.1026

- OSHA PEL = 5 µg/m^3
- OSHA Action Level = 2.5 µg/m^3
  - µg/m^3 = micrograms of contaminant per cubic meter of air
  - ACGIH TLV = 0.2 µg/m^3 TWA (inhalable)
    0.5 µg/m^3 STEL (inhalable)



Crystalline Silica

Workplace HYGIENE

Silica Exposure

Industries and operations in which exposure to crystalline silica can occur include, but are not limited to:

- Construction
- Glass products
- Pottery products
- Structural clay products
- Concrete products

- Foundries
- Dental laboratories
- Paintings and coatings
- Jewelry production
- Refractory products
- Ready-mix concrete
- Cut stone and stone products
- Refractory installation and repair
- Railroad track maintenance
- Hydraulic fracturing for gas and oil
- Abrasive blasting in
  - Maritime work
  - Construction
  - General industry

ACGIH TLVs for Silica

- Quartz 25 µg/m^3 (Respirable)
- Cristobalite 25 µg/m^3 (Respirable)

OSHA Exposure Limits

- Final Rule:
  - 8-hour PEL of 50 micrograms of respirable crystalline silica per cubic meter of air (50 $\mu g/m^3$).
  - Action Level of 25 $\mu g/m^3$.

Previous Silica OELs

- 29 CFR 1910.1000
  - Table Z-3

- Quartz (Respirable)

$$\frac{10\ mg/m^3}{\%SiO_2 + 2}$$

Silica and Its Hazards

- SiO_2 – Silicon Dioxide
- Crystalline
  - Quartz
  - Cristobalite
  - Tridymite
- Quartz – most common mineral in Earth's crust

Silica and Its Hazards

Workers who inhale crystalline silica are at increased risk of developing serious silica-related diseases, including:

- Silicosis, an incurable lung disease that can lead to disability and death;
- Lung cancer;
- Chronic obstructive pulmonary disease (COPD); and
- Kidney disease.

Silica and Its Hazards

- Crystalline silica
  - pulmonary fibrosis
    - silicosis
  - cancer
    - IARC Group 1 carcinogen
    - ACGIH A2 carcinogen

Silica and Its Hazards

- Chronic silicosis – 10 years of exposure to low concentration
- Accelerated silicosis – develops 5-10 years after short exposure to high concentration
- Acute silicosis – develops weeks to years after short exposure to high concentration
- Gauley Bridge Disaster 1931: ~764 workers
- It's Just Dirt!!

Silica and Its Hazards

- Symptoms
  - initially asymptomatic
  - chest symptoms – cough, difficulty breathing
  - abnormal chest x-ray – fibrotic nodules and scarring
  - infections – fever, night sweats, weight loss
- Persons with silicosis are at high risk of active tuberculosis

Potential Exposures

chipping
hammering
drilling
crushing
loading
hauling
dumping of rock or coal

Potential Exposures

blasting with silica abrasive

blasting of concrete (regardless of abrasive)

Potential Exposures

sawing
hammering
drilling
grinding
chipping
of concrete or masonry

***(use of sharp tools helps reduce exposure intensity and duration)**

Workplace HYGIENE

Potential Exposures

Demolition of concrete and masonry structures

Dry sweeping or pressurized air blowing of concrete, rock, or sand dust

Potential Exposures

- Manufacture of
  - glass
  - bricks
  - abrasives (sand paper)
  - shingles
  - metal casts (shakeout, knockout)
- Furnace maintenance
- Mixing textured paints

Potential Exposures

- Filter maintenance
- Tilling or moving soil
- Gravel or dirt road traffic

Potential Exposures

- Construction
  - site preparation
  - foundations
  - highway construction
  - finishing
  - renovation

Potential Exposures

- General Industry
  - foundries
  - glass manufacture
  - hydraulic fracturing
  - abrasive manufacture

Engineering Controls

- Substitution
  - aluminum shot
  - apricot pits
  - glass beads
  - polycarbonate
  - stainless shot
  - cut wire
  - steel grit
  - walnut shells
  - wheat grain
  - zircon

Coal-Fired Boiler Slag
<0.1% Crystalline Silica

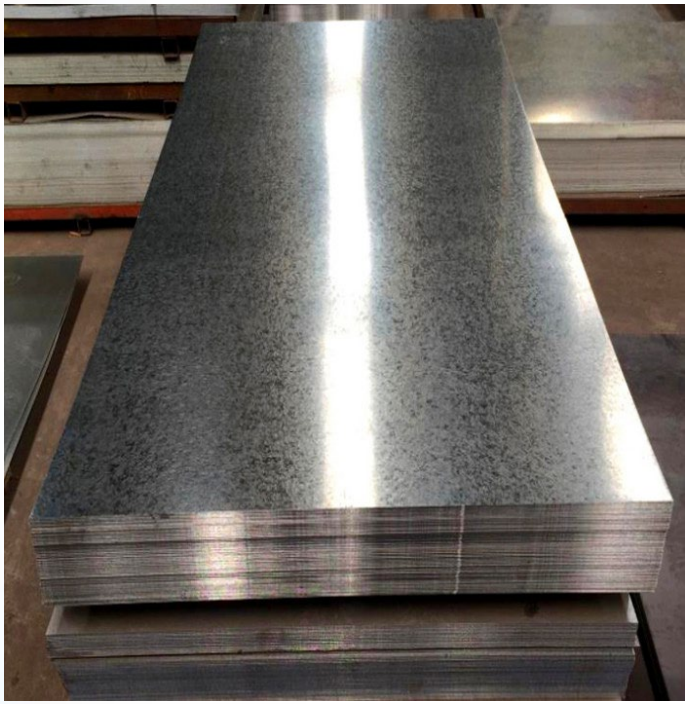
GREEN DIAMOND SAND PRODUCTS

Contains no-free silica, eliminating risk of silicosis

Workplace HYGIENE

Zinc Oxide

- Most Exposures are from welding galvanized steel
  - May not always be obvious that the steel is galvanized (e.g. bar stock)



Zinc Oxide

- Metal Fume Fever (flu-like)
  - chills,
  - fever,
  - muscular pain
  - Nausea
  - Vomiting

  - Typically takes 4 days to recover

Zinc Oxide Exposure Limits

- OSHA PEL = 15 mg/m^3 (total)
  5 mg/m^3 (respirable)

- ACGIH TLV = 2 mg/m^3 TWA (respirable)
  5 mg/m^3 STEL (respirable)

Isocyanates

Applications

- Monoisocyanates
  (as an intermediate product)
  - Methyl isocyanate - Agricultural chemicals
  - n-Butyl isocyanate - Agricultural chemicals
    - Biocides
  - Phenyl isocyanate - Herbicides
    - Printing ink
    - Decorative coating

Isocyanates

Applications

- Diisocyanates and Polyisocyanates
  - Polyurethane Foams (Flexible and Rigid)
  - Polyurethane Coatings, Adhesives and Sealants
  - Polyurethane Binders
  - Polyurethane Elastomers

Isocyanates

HDI and IPDI: polyurethane coatings

- Use in automobile body repair shops, although there are others, is the most representative process.
- > 200,000 workers in the US
- Painting is aliphatic isocyanates main application:
  - Aliphatic = UV light resistant (cars exposed to sun light !)
  - Aromatic isocyanate (TDI): in undercoats only
- Isocyanate composition in coatings
  - Monomer: 0.1 – 1 %
  - Oligomers: 50 – 75 %
- 2 main processes for paint application
  - Spraying
  - Brushing & rolling

Isocyanates

MDI: rigid polyurethane foam

- **Spraying**:

Building insulation

Underground mine wall consolidation

- **Molding / injection**

concrete lifting

Seat molding

packaging

Isocyanates

General principle

Because isocyanates are highly reactive molecules, the method used to assess either *inhalation and cutaneous exposures* will almost always be a variation on the following sampling and analysis principle:

The isocyanate is captured on a substrate and immediately (or within a very short time) placed in contact with a chemical reactant, which will convert the isocyanate into a more stable molecule that will be easier to analyze. This process is called ***derivatization****.*

Isocyanates

Collection efficiency of vapor and particles

Remember isocyanates are fast reactive, and therefore require **derivitization**.

Type of sampler		Vapor	Aerosol	remarks
Filter	Non-impregnated	-	+ (for short-period sampling only, field desorption)	Not efficient for aerosols from fast-curing process
	Reagent impregnated	+	+ (field desorption)	
Impinger (reagent in liquid media)		+	+ (particles > 2 µm only)	
Denuder		+	-	

Isocyanates

Reagent acronyms

1,2 PP	1-(2-pyridyl)piperazine
1,2 MP (aka MOPP or MOPIP)	1-(2-methoxyphenyl)piperazine
MAP	1-(9-anthracenylmethyl)piperazine
DBA	dibutylamine
MAMA	9-(N-methylaminomethyl)anthracene
1,8 DAN	1,8 diaminonaphthalene

Isocyanates

OSHA 42/47 (ISO 14382)

Isocyanate	Monomer	HDI, TDI, MDI, IPDI(PV2034), HMDI(PV2092)
	Oligomer	none
Sampler		37-mm CFC, glass fiber impregnated filter (1,2-PP)
Sampling rate		1 L/min
Sampling duration		15 min (> if vapor only*)
Sampling type		personal
Vapor		Yes
Particles		Yes
Laboratory technique		HPLC-UV/FI
LOQ typical range		0.1 µg

Advantages: Easy to use, easy access to laboratory service.

Disadvantages: underestimation of aerosol isocyanates in fast-curing process. No oligomer quantification. Sampling duration (*due to 1,2-PP evaporation). Samples require field desorption for all isocyanate species.

Isocyanates

Iso-Chek® (ISO 17736)

Isocyanate	Monomer	HDI, TDI, MDI, IPDI, HMDI
	Oligomers	HDI, TDI, MDI, IPDI, HMDI
Sampler		CFC 37 mm, PTFE filter (field desorpt. 1,2 MP) and glass fiber impregnated filter (MAMA)
Sampling rate		1 L/min
Sampling duration		15 min (> if vapor only)
Sampling type		personal
Vapor		Yes
Particles		Yes
Laboratory technique		HPLC-UV
LOQ typical range		0.04 µg

Advantages: Easy to use, partition of vapor and aerosol isocyanates.

Disadvantages: Sampling duration. Underestimation of aerosol isocyanates in fast-curing process. *First* filter requires field desorption. 1,2 MP ban ?

Isocyanates

MDI: binder / glue

All-usage glue:

Binder in oriented-strand board (OSB):

Isocyanates

Physical Data of Selected Isocyanates

Name of isocyanate (abbreviation)	CAS	Vapour pressure (mm Hg @ 20°C)	Saturation concentration in air (ppm)
Methyl isocyanate (MIC) **Bhopal**	624-83-9	390	510,000
Butyl isocyanate (nBI)	111-36-4	16	21,000
Phenyl isocyanate (PHI)	103-71-9	2	2,600
Hexamethylene diisocyanate (HDI)	822-06-0	0.025	33
2,4-toluene diisocyanate (2,4-TDI)	584-84-9	0.02	33
Toluene diisocyanate (80:20 mix of isomers) (TDI)	26471-62-5	0.02	33
Isophorone diisocyanate (IPDI)	4098-71-9	5×10^{-4}	0.66
Poly Hexamethylene diisocyanate (pHDI)	28679-16-5	7.5×10^{-5}	0.099
Dicyclohexylmethane diisocyanate-4,4' (HMDI)	5124-30-1	1×10^{-5}	0.013
Diphenylmethane diisocyanate-4,4' (MDI)	101-68-8	$< 1 \times 10^{-5}$	< 0.013
Poly diphenylmethane diisocyanate (pMDI)	9016-87-9	$< 1 \times 10^{-5}$	< 0.013

Isocyanates

Physical Data of Selected Isocyanates

Name of isocyanate (abbreviation)	M.W.	State at room temp.	Boiling point °C
Methyl isocyanate (MIC)	57	liquid	38
Butyl isocyanate (nBI)	99	liquid	115
Phenyl isocyanate (PHI)	119	liquid	165
Hexamethylene diisocyanate (HDI)	168	liquid	213
2,4-toluene diisocyanate (2,4-TDI)	174	Solid. MP 22°C	*Decomp. > 170
Toluene diisocyanate (80:20 mix of isomers) (TDI)	174	liquid	Decomp. > 170
Isophorone diisocyanate (IPDI)	222	liquid	316
Poly Hexamethylene diisocyanate (pHDI)	~500	liquid	194
Dicyclohexylmethane diisocyanate-4,4' (HMDI)	258	liquid	Decomp. > 200
Diphenylmethane diisocyanate-4,4' (MDI)	250	Solid. MP 38°C	Decomp. > 200
Poly diphenylmethane diisocyanate (pMDI)	~300	liquid	Decomp. > 200

* Temperature of decomposition

Isocyanates

Data comparison: volatility

Isocyanate	Relative volatility
pHDI (isocyanurate trimer)	0.00052
pHDI (biuret)	0.93
MDI	1
pMDI	1
HMDI	1
IPDI	48
HDI	1,100
TDI	2,500
Water	1,800,000
Methyl ethyl ketone	9,100,000
Methyl isocyanate	34,800,000

Isocyanates

Common Properties of Isocyanates

- Little warning from odors
  - High odor threshold
- Highly reactive with:
  - Amines
  - Alcohols
  - Carboxylic acids
- Water reactive
  - CO_2 + ↑ Heat + polyurea

Isocyanates

Absorption

- Inhalation is the main route of absorption.
- Odor threshold does not protect.
- Another important route, to a lesser extent than inhalation, is through skin.
- Skin absorption would then be the main route of exposure for non-sprayed application of non-volatile isocyanates.

Isocyanates

Irritants and sensitizers

Due to high reactivity.

- respiratory tract
  - Mild cases : slight irritation of nose and throat
  - Severe cases: acute bronchial irritation, chest tightness, difficulty breathing
- Skin
  - Contact dermatitis
- Eyes.
  - Burning sensation, tears, conjunctivitis

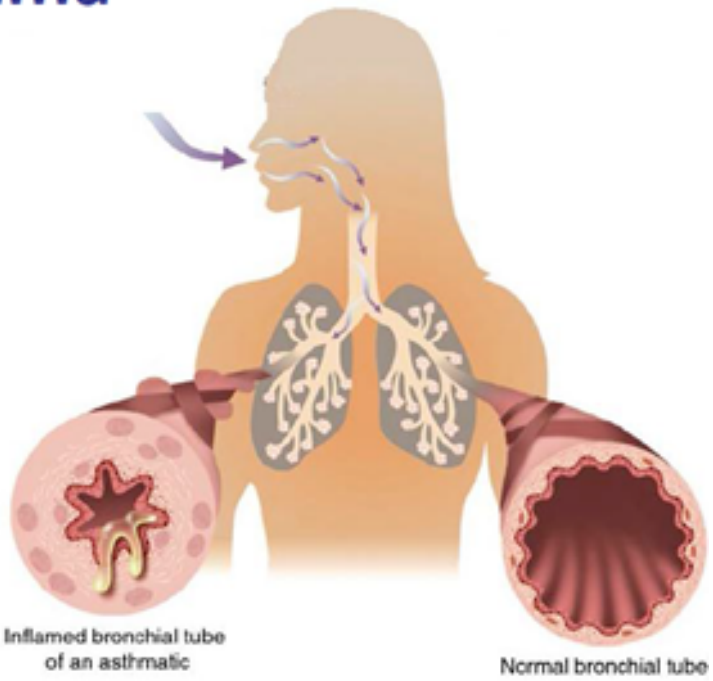
Isocyanates

- Rhinitis
- Reactive Airway Dysfunction Syndrome (RADS)
- Hypersensitivity Pneumonitis
- Asthma

Isocyanates

Asthma

- Chronic, main concern with isocyanate exposure;
- Isocyanate reacts with proteins and trigger an allergic response;
- Once sensitized ("allergic"):
  - Symptoms immediate or hours after exposure
  - Very low levels triggers asthma



- Symptoms lessening on the weekend or during vacations suggests that they are of occupational origin.

Isocyanates

Asthma

- Delayed response (e.g. at night) sometimes makes difficult link to isocyanate exposure;
- Some sensitized subjects removed from any exposure will recover, partially or completely;
- Sensitized worker remaining exposed to isocyanates: aggravation of symptoms, asthma attacks following exposure to very low doses of the causative agent, permanent lung damage, even death has been reported.
- Exacerbated (or aggravated) asthma: occurrence when a worker with isocyanate-associated asthma experience symptoms following exposure to any other lung irritant

Isocyanates

Prevalence estimation for sensitization / asthma:

- 1 to 20% of the exposed workforce

  (Literature covering 1993-2002)

Xylene (Dimethyl Benzene)

- Colorless, sweet-smelling aromatic hydrocarbon solvent
  - Used widely in industry
    - Printing, Rubber, Paint, & Leather
  - Used in histopathology labs extensively

Xylene Exposure Limits

- OSHA PEL = 100 ppm
- ACGIH TLV = 20 ppm
- Primarily a CNS depressant, but can also be irritating to eyes, nose, throat, and lungs (can lead to edema in extreme cases)
- Long-term exposure may lead to headaches, irritability, depression, insomnia, agitation, extreme tiredness, tremors, impaired concentration and short-term memory – aka “organic solvent syndrome”

CNS Effects of Xylene

100–200 ppm	Nausea, headache
200–500 ppm	Feeling “high,” dizziness, weakness, irritability, vomiting, slowed reaction time
800–10,000 ppm	Giddiness, confusion, clumsiness, slurred speech, loss of balance, ringing in the ears
>10,000 ppm	Sleepiness, loss of consciousness, death

Toluene (Methyl Benzene)

- Colorless liquid with a distinctive sweet smell that is widely used in industrial settings as a solvent.

- Toluene also is an ingredient in some consumer products such as paints, glues and nail polish removers.

Toluene

- OSHA PEL = 100 ppm
  300 ppm (Ceiling)
  500 ppm (10-min. peak)
- ACGIH TLV = 20 ppm
- Primarily a CNS depressant, but can also have excitatory effects – Most abused industrial chemical – Glue Sniffing
- Ototoxic

Health Effects of Toluene

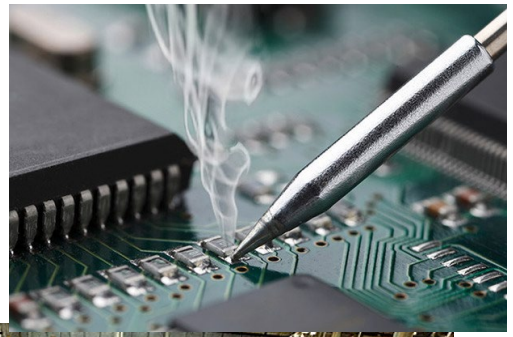
Acute effects	Chronic effects
– Irritation of eyes and respiratory pathways – Initial euphoria; excitation – Emotional liability: sudden mood changes – Dizziness – Slurred speech – Blurred vision – Lack of motor coordination – Illusions; hallucinations – Muscle spasticity	– Cognitive impairments (e.g., memory loss, difficulty in concentrating, and attention deficit) – Diffuse cerebellar atrophy – White matter abnormalities, particularly around brain ventricles – Ventricular enlargement – Loss of muscle strength – Cerebellar ataxia which leads to impaired motor coordination – Hearing loss; sight impairment; nystagmus

Lead

- Naturally occurring malleable, blue-gray, heavy metal
- One of the first metals used by humans
  - The cause of the first recorded occupational disease (Lead Colic in a 4th Century BC metal worker).

Lead

- Primary use in the U.S. is for lead-acid storage batteries, but lead-formed alloys are also found in:
  - Ammunition
  - Piping
  - Electrical Cable Coverings
  - Many Building Materials
  - Solder
  - Radiation shielding
  - Ceramic glazes
  - Stabilizer in Plastics



Health Effects of Lead

- Blood Lead Levels (BLLs) as low as 10 µg/dL
  - Impaired kidney function
  - High blood pressure
  - Nervous system and neurobehavioral effects
  - Cognitive dysfunction later in life
  - Pregnant women with high BLLs can have serious impact on the developing fetus.

Health Effects of Lead

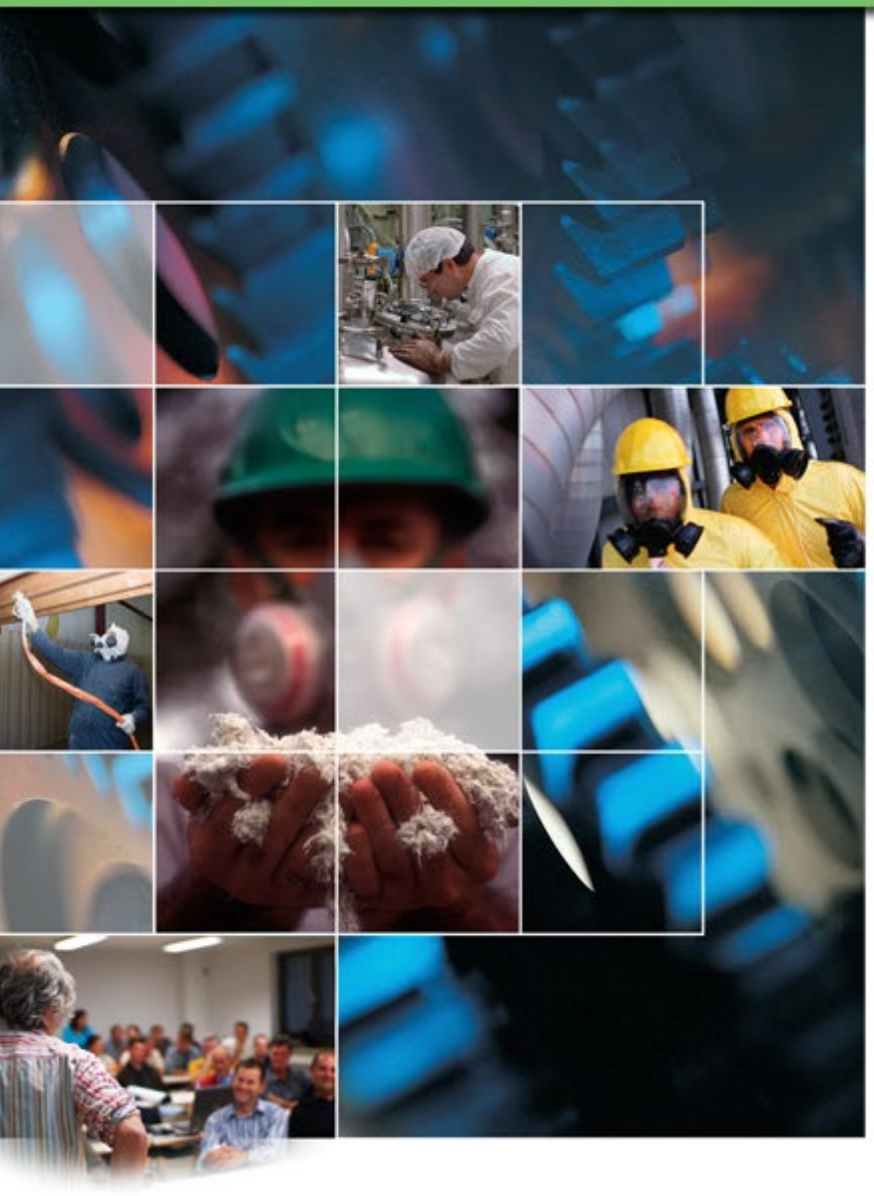
- BLLs > 20 µg/dL
  - Subclinical effects on cognitive function
  - Adverse effects on sperm/semen quality and delayed conception
- BLLs 20 – 40 µg/dL
  - Cognitive aging
  - Visuomotor dexterity deficits, slowed reaction times and attention deficit

Health Effects of Lead

- BLLs > 40 µg/dL
  - Headaches
  - Fatigue
  - Sleep disturbance
  - Joint pain
  - Myalgia
  - Anorexia
  - Constipation
- BLLs > 60 µg/dL
  - Anemia
  - Peripheral neuropathy
  - Interstitial kidney fibrosis
  - Convulsions
  - Coma
  - Death

Lead

- OSHA PEL = 50 µg/m^3*
  *Max. PEL = 400 divided by hours worked per day
- Action Level = 30 µg/m^3
- Medical Removal Protection
  - ≥ Action Level & BLL ≥ 60 µg/dL
  - ≥ Action Level & average 3 BLLs ≥ 50 µg/dL
  - ≥ Action Level & average previous 6 months' BLLs ≥ 50 µg/dL
- ACGIH TLV = 50 µg/m^3



Mold

Workplace HYGIENE

Mold - Key Points to Remember

- It has only been around for 550 million years or so
  - Estimates of fungi species range from 100,000 to 10 million
- There are real, documented health effects and there are not-so-real health effects
- Let common sense prevail
- Treat as an allergen – not as a toxic

Mold Growth Indoors

- Normally mold present indoors from outdoor sources: air, and deposition on surfaces
- **Growth** of mold **in buildings** is when occupants may have problems
- General consensus that mold growth in building should be removed
- Governmental Exposure Standards not established (OSHA, EPA)

Mold Growth Requires Moisture

- Moisture Sources can be:
  - External
  - Internal

Uncontrollable Sources of Moisture

Natural Disasters:

- **Floods**
- **Hurricanes**
- **Tornadoes**

Water leaks from outside

- Roofs, flashing, foundation, walls, windows, joints

Expansion Joint Failure

Water leaks from inside

- Pipes/Appliances
  - Piping, HVAC units, washers, water heaters, etc.
- HVAC Units
  - Malfunction (not cooling)
  - Oversized cooling capacity
    - (short cycling)

Envelope Leaks

Plumbing Leaks

Workplace HYGIENE

Health Effects of Mold

- Most people not affected
- Allergic response/irritation most common (similar to pollen or animal allergies)
  - Most commonly runny nose, eye irritation, cough, congestion
  - flu-like symptoms, skin rash may occur
  - Hypersensitivity pnuemonitis (rare)
- May aggravate asthma but not proven to cause asthma
- Most symptoms temporary and eliminated by correcting the mold problem

Health Effects of Mold –cont'd

- Human Pathogens
  - ✓ very limited number of pathogenic fungi such as *Blastomyces, Coccidioides, Cryptococcus*, and *Histoplasma* that can infect healthy individuals (ACOEM, 2002).
  - ✓ Few other rare infections for severely immunocompromised, or individuals with lung abscess, asthma or cystic fibrosis

Opportunistic Infections

- Issue for persons with severely impaired immune function, such as
  - cancer patients receiving chemotherapy,
  - organ transplant patients receiving immunosuppressive drugs,
  - AIDS patients,
  - patients with uncontrolled diabetes at significant risk for more severe opportunistic fungal infection

(ACOEM, 2002)

“Toxic” Mold

- Some molds produce mycotoxins as part of metabolism – dependent on food source, environment
- Toxicity known because of history of ingested moldy foods (humans, livestock); also some industrial or agricultural type exposures (silage, etc. where large amounts of fungi and other microbial entities also present)
- Based on health effects sometimes experienced in moldy environments, some surmise that inhalation of mycotoxins responsible for number of health effects

“Black Mold” or “Toxic Mold”

- Usually refers to *Stachybotrys chartarum,* greenish black in appearance
- Not all molds that appear black are *Stachybotrys*
- Not scientific terms (while only a few molds are truly black, many appear black)

Mycotoxins

- Chemicals produced by fungi which serve as defense mechanisms against insects, microorganisms, animals
- Overwhelming majority of toxic exposure is by ingestion, e.g. Food poisoning

Mycotoxins

- Aflatoxins – *Aspergillus Flavus*, in peanuts, soybeans, grains; carcinogenic in the lab, liver cancer as a promoter; acute toxicity rare
- Ergot alkaloids – *Claviceps Purura*, historical, ergotism, St. Anthony's Fire outbreaks in the middle ages; contaminated breads and cereals
- Fumonisins – *Fusarium* species, equine encephalomalacia, food contaminant with possible link to esophageal cancer

Mycotoxins

- Trichothecenes – *Fusarium* and *Stachybotrys* species; Toxic aleukia in Russians , 100K deaths , 1942-8, contaminated wheat and corn stored under snow; Necrotic ulcers in the mouth and GI tract
  - Dermatitis in those using handling infected straw for fuel, sleeping on infected straw
  - Acute toxic inhalation in some soviet scientists in lab characterized by sore throat, bloody discharge, cough, shortness of breath, low grade fever

Mycotoxins

- Vomitoxin: another trichothecene from *fusarium* sp; Wheat and corn contaminant characterized by nausea and vomiting
- Satratoxin: another trichothecene; Produced by *Stachybotrys charcharum (atra);* implicated in 10 infants with acute pulmonary hemorrhage in Cleveland. CDC review found no conclusive evidence

What Removes Moisture from Building ?

- Usually Air Conditioning

HVAC Interior Coils/Condensate

Removal of Mold Growth

- Non-porous materials can generally be cleaned
  - Masonry, Wood surfaces, Metal, Glass
  - *Note: Wood must have approximately 20% moisture to support mold growth*
- Porous materials with visible growth are generally discarded
  - Drywall, Clothing, Carpet, Curtains, Insulation
- Biocidal treatments are recommended only when the contaminant is one of the few fungi that are known to cause human infection (AIHA 2003)
  - More applicable to bacteria (sewage sources, cooling towers, etc.)

See IICRC S520 for Guidance

BASICS for Control of Mold

- Clean and Dry = GOOD !
- Deal with water events and high humidity immediately
- Remove identified mold growth
- Correct moisture problem or mold most likely will return
- Do Not Neglect HVAC systems