SAFETY SERVICES MANITOBA

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Air Quality in the Workplace

Presented by: Léo Jr. Nicolas, CIH

Course Outline

- What is Occupational Hygiene?
- Why is air testing required?
- Difference between worker exposure air testing and indoor air quality testing
- Developing a Sampling Strategy
  - Why? What? When? How? Where? Who? ……to Sample
  - Quality Control Considerations

Course Outline

- Overview of Sampling Equipment
  - Industrial Hygiene
  - Indoor Air Quality (IAQ)

Occupational Hygiene

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

“Environmental Factors”

1. Chemical Agents
2. Biological Agents
3. Physical Agents

Occupational Hygiene

- Occupational hygiene has traditionally been interested in the longer-term (chronic) health effects of workplace hazards.
- Safety is generally more concerned with more short-term effects which result in injuries or death.

Why is air testing required?

- Manitoba Safety & Health Regulation (MR 217/2006)
  - Part 4.1, Air Quality & Ventilation
  - Part 36, Chemical & Biological Substances

Manitoba Regulation

Part 4.1, Air Quality & Ventilation

- "An employer must, as much as is reasonably practicable, ensure that

  (a) a workplace has appropriate air quality and is adequately ventilated; and

  (b) contaminants and impurities are prevented from accumulating in the air at a workplace".

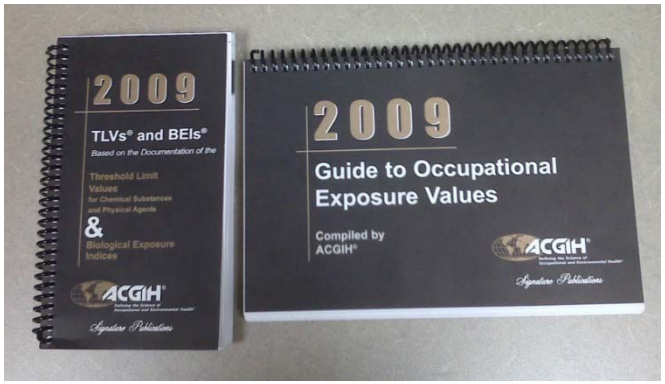
Manitoba Regulation

Part 36, Chemical and Biological Substances

- "This part applies to every workplace in which a chemical or biological substance is present.
- An employer must assess all information that is practicably available to the employer respecting a chemical or biological substance present in the workplace to determine if the substance creates or may create a risk to the safety or health of a worker in the workplace".

Part 36, Occupational Exposure Limits

- "If an assessment determines that the presence of an airborne chemical or biological substance in the workplace creates or may create a risk to the safety of the worker, an employer must
  - Establish an OEL for the substance that does not exceed the threshold limit value (TLV) established by the ACGIH (American Conference of Governmental Industrial Hygienists)".



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Part 36, Occupational Exposure Limits

- Listed in Improvement Orders…

Improvement Order(s)

Pursuant to **Section 26 of the Workplace Safety and Health Act (WSHA)**, the following improvement orders are issued:

Order Number	Explanation	Compliance Date
1	**Chemical and Biological Substances - Monitoring and Control Measures - Monitoring** **Workplace Safety and Health Regulation 36.6(1)** Observation: Workers - the painter and the welders, are, or may be, exposed to an airborne chemical or biological substances (powder coating and mild and stainless steel) in the workplace at a concentration in excess of the occupational exposure limit for the substance. Requirement: The employer must conduct personal air monitoring for the stainless and mild steel welders as well as for the painter on a regular basis to determine the airborne concentration of the substance; or implement control measures sufficient to ensure that no worker is exposed to the substance in excess of the occupational exposure limit for that substance. Reference: 'Guideline for Chemical and Biological Substances in the Workplace'	22 December 2018

Threshold Limit Values (TLVs)

- Published yearly by the ACGIH
- Adopted by many jurisdictions as standards
- TLVs are not consensus standards
- **N.B. Not all chemicals have TLVs**
- **Some chemicals have exposure limits established by other organizations**

- U.S. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs)
- National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs)
- American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Levels (WEELs)

- Books can be purchased from www.acgih.org

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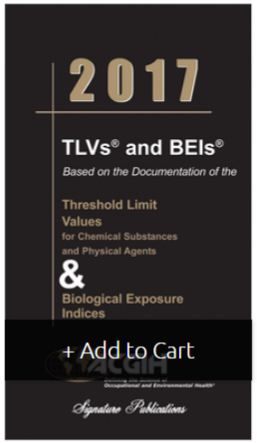

***2017 TLVs and BEIs**

The information in this user-friendly, pocket-sized publication is used worldwide as a guide for evaluation and control of workplace exposures to chemical substances and physical agents.

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Threshold Limit Values (TLVs)

- Consensus standards are standards developed through the cooperation of all parties who have an interest in participating in the development and/or use of the standards.
- Consensus requires that all views and objections be considered, and that an effort be made toward their resolution

Threshold Limit Values (TLVs)

- "TLV's refer to airborne concentrations of substances and represent conditions under which <u>it is believed</u> that <u>nearly all workers</u> may be repeatedly exposed day after day <u>without adverse effects</u>"

- Three types of exposure limits have been set

TLV-TWA

- Time-weighted average (TWA) concentration for a conventional 8-hour workday and a 40-hour workweek to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effects

TLV-STEL

- 15-minute Short Term Exposure Limit (STEL) which should not be exceeded at any time
- Exposures up to the STEL should not exceed 15 minutes, should not occur more than 4 times per day, and successive exposures should be separated by at least 60 minutes
- Not a separate, independent exposure limit (i.e. the 8-hour TWA must also not be exceeded)

TLV-Ceiling (TLV-C)

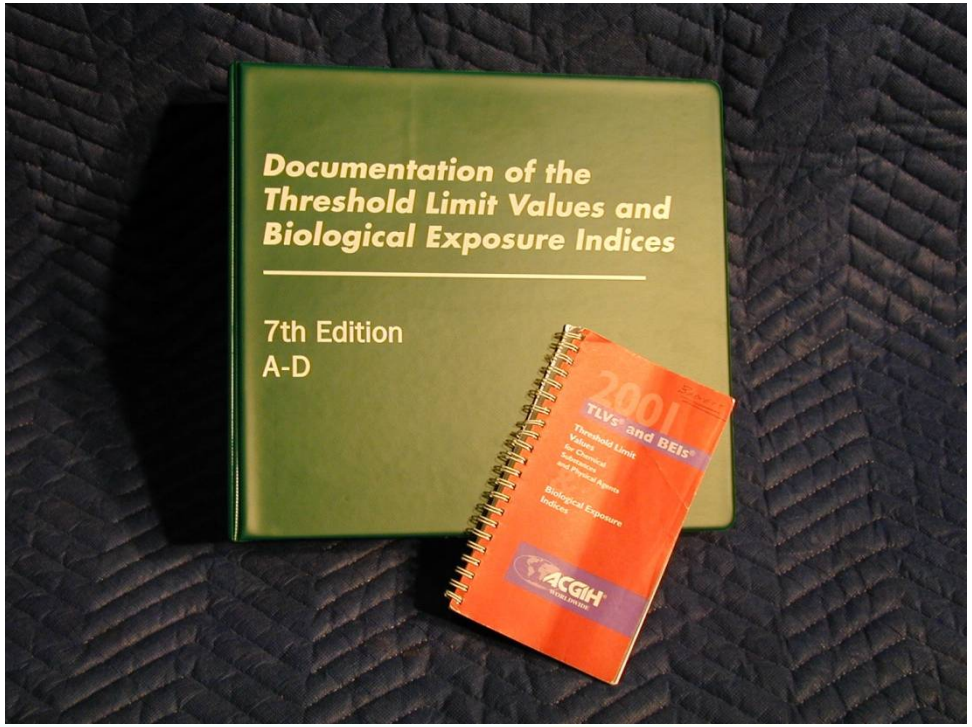
- The concentration that should not be exceeded during any part of the working exposure

Basis of the TLVs

- TLV's based on best information from:
  - industrial experience
  - experimental human studies
  - experimental animal studies
  - and when possible, from a combination of the three
- Basis on which TLV's are established may differ from substance to substance

TLV Documentation

- Information on specific substances available from the "TLV Documentation"



TLV Documentation can also be purchased online, www.acgih.org

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https://www.acgih.org/tlv-bei-guidelines

Uses of TLVs

Uses:

- Intended for use in the practice of industrial hygiene as guidelines or recommendations to assist in the control of potential workplace health hazards and for no other use.

Limitations of TLVs

Limitations:

1. Not to be used in the evaluation or control of community air pollution
2. Not to be used in estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods
3. Not to be used for proving or disproving an existing disease or physical condition in an individual
4. TLV's are not fine lines between safe and dangerous exposures
5. Not a relative index of toxicity
6. Should not be used by anyone untrained in the discipline of industrial hygiene

Important Considerations

- SKIN Notations
  - Refers to the potential significant contribution to overall exposure by skin absorption from dermal application studies
- SEN Notations
  - Refers to the potential for an agent to produce sensitization, as confirmed by human & animal data

Important Considerations

- Carcinogens (A1-A5)
  - A1: Confirmed Human Carcinogen
  - A2: Suspected Human Carcinogen
  - A3: Confirmed Animal Carcinogen with Unknown Relevance to Humans
  - A4: Not Classifiable as a Human Carcinogen
  - A5: Not Suspected as a Human Carcinogen
- Mixtures
- Unusual Work Schedules (>8 hours)

Biological Exposure Indices (BEIs)

- The measurement of the concentration of a chemical determinant in the biological media of those exposed and is an indicator or the uptake of the substance in the body
- BEIs are guidance values for assessing the biological monitoring results
- BEIs represent the levels of determinants that are most likely to be observed in specimens collected from healthy workers who have been exposed to chemicals to the same extent as workers with inhalation exposure at the TLV

Example of Page from ACGIH Book

Substance [CAS No.] (*Documentation date*)	ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis
Methyl chloroform [71-55-6] (1992)	350 ppm	450 ppm	A4; BEI	133.42	CNS impair; liver dam
Methylcyclohexane [108-87-2] (1962)	400 ppm	—	—	98.19	URT irr; CNS impair; liver & kidney dam
Methylcyclohexanol [25639-42-3] (2005)	50 ppm	—	—	114.19	URT & eye irr
o-Methylcyclohexanone [583-60-8] (1970)	50 ppm	75 ppm	Skin	112.17	URT & eye irr; CNS impair
2-Methylcyclopentadienyl manganese tricarbonyl [12108-13-3], as Mn (1970)	0.2 mg/m^3	—	Skin	218.10	CNS impair; lung, liver, & kidney dam
Methyl demeton [8022-00-2] (2006)	0.05 mg/m^3 (IFV)	—	Skin; BEI$_C$	230.30	Cholinesterase inhib
Methylene bisphenyl isocyanate [101-68-8] (1985)	0.005 ppm	—	—	250.26	Resp sens
‡ 4,4'-Methylene bis(2-chloroaniline) [101-14-4] (1991)	(0.01 ppm)	—	Skin; A2; BEI	267.17	Bladder cancer; MeHb-emia
Methylene bis(4-cyclohexylisocyanate) [5124-30-1] (1985)	0.005 ppm	—	—	262.35	Resp sens; LRT irr
4,4'-Methylenedianiline [101-77-9] (1992)	0.1 ppm	—	Skin; A3	198.26	Liver dam
Methyl ethyl ketone [78-93-3] (1992)	200 ppm	300 ppm	BEI	72.10	URT irr; CNS & PNS impair
Methyl ethyl ketone peroxide [1338-23-4] (1992)	—	C 0.2 ppm	—	176.24	Eye & skin irr; liver & kidney dam
Methyl formate [107-31-3] (2014)	50 ppm	100 ppm	Skin	60.05	CNS impair; URT irr; eye dam

What is CAS Number (CAS No.)?

- Unique numerical identifier assigned by the Chemical Abstracts Service to every chemical substance described in the open scientific literature
- Some chemicals can have several names, but only one CAS No.
- It can be easier to find chemical information by searching by CAS No.

SECTION 1. IDENTIFICATION

Product name : BENZENE

Synonyms : Benzol; aromatic hydrocarbons (C6H6); cyclohexatriene.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Mixture

Hazardous components

Chemical name	CAS-No.	Concentration
benzene	71-43-2	99.9 %
toluene	108-88-3	0.05 %

Difference between worker exposure air testing and indoor air quality (IAQ) testing

- Worker exposure air testing:
  - Personal air testing completed to determine the worker's exposure to chemical(s)
  - Testing performed over representative 8-hour workday to determine time weighted average or 15-min if chemical has TLV-STEL
  - Results compared to ACGIH values or values from other organizations

Difference between worker exposure air testing and indoor air quality (IAQ) testing

- IAQ testing:
  - Refers to air quality within buildings (commercial offices, schools, homes), i.e. non-industrial
  - Relates to the health and comfort of the building occupants
- Definition (Health Canada)
  - The physical, chemical, and biological characteristics of indoor air in non-residential workplaces with no internal industrial processes or operations that can affect the comfort or health of the occupant.

What is "Acceptable Air Quality"?

- Air in which there are no known contaminants at harmful concentrations, as determined by cognizant authorities and with which a substantial majority (i.e. 80% or more) of the people exposed do not express dissatisfaction.

From Canadian Standards Association (CSA) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has a similar definition.

Methods for Control of IAQ

Ventilation Rate Procedure

- Provide adequate ventilation to occupants to dilute contaminants in the air.
- ASHRAE provides ventilation rates.

Indoor Air Quality Procedure

- Manage indoor contaminants to ensure airborne concentrations do not exceed harmful concentrations.

Acceptable IAQ Airborne Contaminant Concentrations

- Office occupants exposed to concentrations much lower than the TLVs may report discomfort.
- Therefore acceptable airborne contaminant concentrations for IAQ are usually a fraction of the TLV.

Comparison of Acceptable Airborne Contaminant Concentrations

Agent	ACGIH TLV (Industrial)	IAQ
Carbon Dioxide	5,000 ppm	700 ppm above outdoor (usually <1,200 ppm) - ASHRAE
Carbon Monoxide	25 ppm	11 ppm – Health Canada

Terms Buildings with Poor IAQ are Referred to:

Sick Building Syndrome

- A set of symptoms affecting a sizable % of building occupants for which no causation can be identified. Symptoms include eye, nose & throat irritation and headache, lethargy and concentration difficulties.
- Symptoms are relieved after leaving the building.

Building Related Illness

- A distinguishable set of symptoms, often accompanied by physical and clinical abnormalities. Can be confirmed by a physicians diagnosis of a specific illness resulting from exposure to specific contaminants identified in a building (i.e. allergic rhinitis, Legionnaires disease, HP, etc.)

Several Factors Combine to Influence the Perception of IAQ

- Indoor climate
- Lighting
- Sensitivity of the occupants
- Changes in work location and crowding
- Attitudes about the job and working conditions

The Main Problems Associated with Poor IAQ include:

- Outdoor contaminants including vehicle exhaust, dust, pollen, smoke, etc.
- Indoor contaminants including chemical and microbiological contaminants.
- Inadequate ventilation and heating, ventilation and air conditioning (HVAC) deficiencies.
- Thermal comfort.

Developing the Sampling Strategy

- The “Walk-Through” or “Preliminary” Survey
  - Identify potential hazards
  - Set priorities
  - Plan the sampling strategy
  - Make recommendations that do not require supporting quantitative data

Why Sample?

To determine:

1. Compliance/Health hazard potential
2. Investigate employee complaints
3. Contaminant sources
4. Control system effectiveness (i.e. ventilation)
5. Maintain a history of worker exposure

Know your objective before developing your strategy and carrying out your survey!

What to Sample?

- Based on the information collected during your walk-through survey
- SDS Review:
  - Parent Products?
  - Thermal decomposition products?
  - Combustion products?
  - Do we need to sample for all the agents in a product?

SDS Review

- Identify parent products:

3. Composition/information on ingredients

Mixtures

Chemical name	Common name and synonyms	CAS number	%
Furfuryl Alcohol		98-00-0	90 - 100
"4,4'-Isopropylidenediphenol"		80-05-7	5 - < 10
Other components below reportable levels			< 0.2

*Designates that a specific chemical identity and/or percentage of composition has been withheld as a trade secret.

SDS Review

- Identify if parent products have TLVs:

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
Furfuryl Alcohol (CAS 98-00-0)	PEL	200 mg/m3
		50 ppm

US. ACGIH Threshold Limit Values

Components	Type	Value
Furfuryl Alcohol (CAS 98-00-0)	STEL	15 ppm
	TWA	10 ppm

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value
Furfuryl Alcohol (CAS 98-00-0)	STEL	60 mg/m3
		15 ppm
	TWA	40 mg/m3
		10 ppm

Biological limit values No biological exposure limits noted for the ingredient(s).

SDS Review

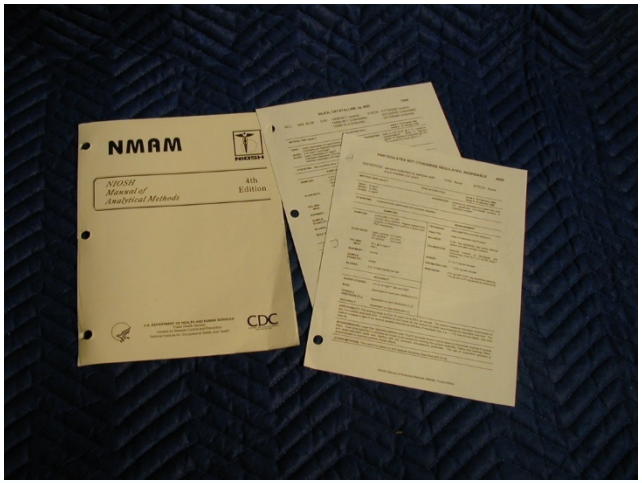
- Identify Hazardous decomposition products:

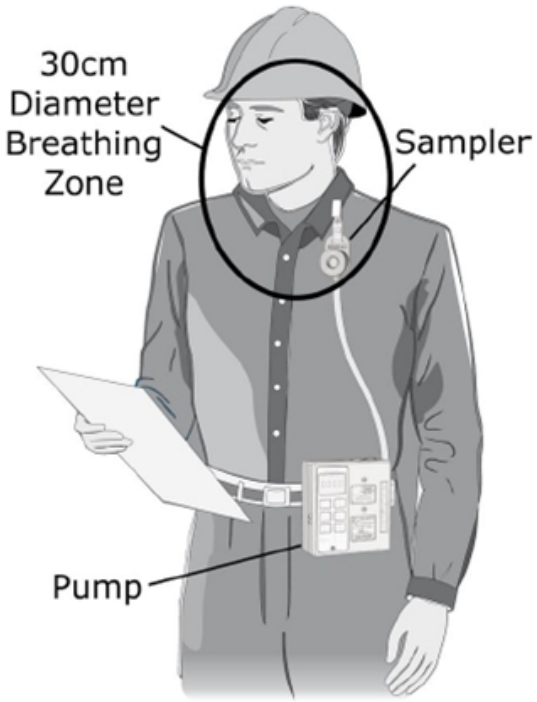
10. Stability and reactivity

Reactivity	This product is reactive and may cause an explosion if accidentally mixed with the corresponding binder component of this resin system without sufficient sand to absorb the heat of reaction.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Avoid heat, sparks, open flames and other ignition sources. Avoid temperatures exceeding the flash point. Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents, Alkaline metals.
Hazardous decomposition products	Hazardous emissions are normally generated when cores or molds are exposed to molten metal during pouring, cooling and shakeout operations through the partial combustion and/or pyrolysis of the binder system and other components of the mold package. These emissions may potentially include but are not limited to carbon monoxide, carbon dioxide, benzene, aldehydes including formaldehyde, phenol, hydrogen cyanide, ammonia, and a wide variety of organic compounds including benzo(a) pyrene. Oxygen may be deficient in pouring, cooling and shakeout areas. Hazardous particulate matter is also normally generated in pouring, cooling and shakeout operations including, but not limited to smoke, soot, polycyclic organic compounds, particulates, nitrogen oxides and crystalline silica.

How to Sample?

- Sampling and Analytical Methods (NIOSH, OSHA)
- Personal vs. Area Samples
- Breathing Zone





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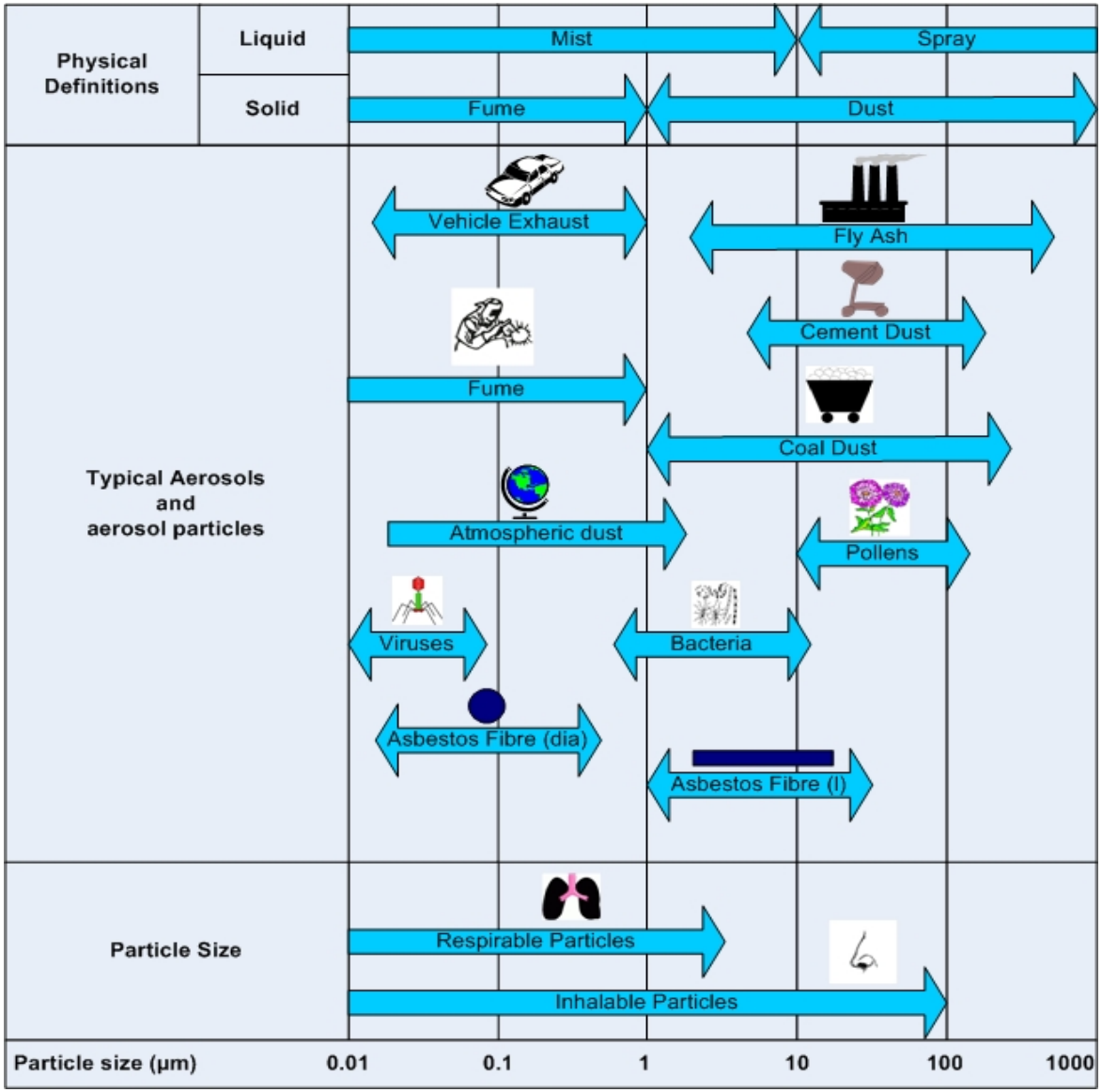
How to Sample?

- In order to fulfill requirements of an Improvement Order…
  - Personal worker testing must be completed (i.e. breathing zone sampling)
- Area testing can be completed in conjunction to determine potential migration to other areas of the work area

How to Sample?

- Dust, Fume, Mist, Gas or Vapour?
- Direct Reading Instrument
- Detector Tubes
- Sample Collection Media
- Particulate
  - Respirable (i.e. silica) vs. inhalable

Particle Sizes



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Crystalline Silica

- Composed of
  - α-quartz (CAS #1317-95-9; 14808-60-7); and,
  - cristobalite (CAS #14464-46-1)
- most widely occurring of all minerals and it is found in most rocks.
- Inhalation can give rise to silicosis = Pulmonary fibrosis
  - Dust concentration in the atmosphere;
  - Percentage of free silica in the dust, and the
  - Duration of exposure.

Crystalline Silica

- Silica is encountered during many processes which use minerals e.g. quarrying and mining, brick, tile and refractory manufacture, pottery and ceramic, sandblasting, glass manufacture.

Crystalline Silica – NIOSH method

Edition?

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Selenium (Se)	7302	ELEMENTS by ICP (Microwave Digestion) Now available in NMAM 5th edition
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Selenium (Se)	7306	ELEMENTS by Cellulosic Internal Capsule Sampler Now available in NMAM 5th edition
Selenium	9102	ELEMENTS on WIPES
Silica, amorphous	7501	SILICA, AMORPHOUS
Silica, crystalline	7500	SILICA, CRYSTALLINE, by XRD.
Silica, crystalline	7601	SILICA, CRYSTALLINE by VIS
Silica, crystalline	7602	SILICA, CRYSTALLINE (IR)
Silicon dioxide	7500	SILICA, CRYSTALLINE, by XRD.
Silica in coal mine dust	7603	SILICA in coal mine dust
Silver	7300	ELEMENTS by ICP
Silver	7301	ELEMENTS by ICP (aqua regia ashing)
Silver (Ag)	7302	ELEMENTS by ICP (Microwave Digestion) Now available in NMAM 5th edition
Silver (Ag)	7306	ELEMENTS by Cellulosic Internal Capsule Sampler Now available in NMAM 5th

Crystalline Silica

- ACGIH TLV-TWA = 0.025 mg/m^3 (R)
- (R) = respirable sized particle

Cyclone
Respirable Dust

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Welding Fume

- Mixture of airborne gases and fine metal particles
- The degree of risk will depend on: the composition of the fume, the quantity of fume in the air which is breathed, the duration of exposure.

Welding Fume

- Main health effects are:
  - Irritation of the respiratory tract
  - Metal fume fever
  - Systemic poisoning
  - Long term or chronic effects

Welding Fume

- NIOSH method depends on individual metals

Manganese	7300	ELEMENTS by ICP
Manganese	7301	ELEMENTS by ICP (aqua regia ashing)
Manganese	7303	ELEMENTS by ICP (hot block/HCl/HNO_3 digestion)
Manganese (Mn)	7302	ELEMENTS by ICP (Microwave Digestion) Now available in NMAM 5th edition
Manganese (Mn)	7304	ELEMENTS by ICP (Microwave Digestion) Now available in NMAM 5th edition
Manganese (Mn)	7306	ELEMENTS by Cellulosic Internal Capsule Sampler Now available in NMAM 5th edition
Manganese	9102	ELEMENTS ON WIPES

Welding Fume

- Which metals to test for?
  - Most labs offer a welding metal fume profile
    - Results of approx. 15 various metals commonly identified in welding fume
  - Manganese (Mn) commonly found to be the highest contributor to worker exposure (i.e. greater than 90%)
    - Option to only test for manganese
    - ACGIH TLV-TWA = 0.02 mg/m^3 (R) & 0.1 mg/m^3 (I)

Welding Fume

Analyte	Health Effect	Analytical LOD (µg)	Result (µg)	TWA (mg/m3)	2018 TLV (mg/m3)	Exposure (% of TLV)
Aluminum	lung, irritation, neurotoxicity	<1.00	10.30	0.016	1	1.6
Antimony	skin and respiratory irritation	<0.40	0.63	0.001	0.5	0.2
Cadmium	kidney damage	<0.40	0.63	0.001	0.01	9.8
Chromium (III)	irritation	<1.00	1.57	0.002	0.003	81.8
Cobalt	asthma, lung, CVS	<0.40	0.63	0.001	0.02	4.9
Copper-Fume	irritation, GI, fume fever	<1.00	6.30	0.010	0.2	4.9
Iron Oxide	pneumoconiosis	<1.00	325.00	0.725	5	14.5
Lead	CNS, blood, kidney, reproductive	<0.40	0.63	0.001	0.05	2.0
Manganese	CNS impairement	<0.40	38.00	0.059	0.02	296.9
Molybdenum	respiratory tract irritation	<0.40	3.00	0.005	10	0.0
Nickel (elemental)	lung, irritation, dermatitis	<0.40	2.78	0.004	1.5	0.3
Titanium Dioxide	lung	<0.40	10.70	0.009	10	0.1
Vanadium Pentox	irritation, lung	<0.40	0.63	0.003	0.05	5.0
Zinc Oxide - Fume	metal fume fever	<1.00	10.40	0.020	2	1.0

Dominant Health Effect: CNS

Combined Exposure (as % of permissible) 300%

Welding Fume

- As welding fume particle size fall within respirable-size range, sample can be collected without the use of a cyclone
- Manganese testing performed on non-welding workers (grinding), use 0.1 mg/m^3 (Inhalable)

Welding Fume

- Trivalent chromium (Cr^{3+})
  - TLV-TWA recently lowered from 0.5 mg/m^3 to 0.003 mg/m^3
- Stainless steel welding
  - Test for hexavalent chromium (Cr^{6+})
  - TLV-TWA recently lowered from 0.01 mg/m^3 to 0.0002 mg/m^3
  - Also has TLV-STEL = 0.0005 mg/m^3

Direct Reading Instruments

Detector Tubes

- Typically colourimetric, change in colour to airborne concentration
- Each tube is chemical specific

Active Sampling

- …is the collection of airborne hazards by means of a forced movement of air by 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

Three Key Elements to Active Sampling

- A sampling pump
  - Something to pull or push air
- The sampling media
  - Something to pull or push air through
- A calibrator
  - Something to indicate how much air has been pulled or pushed

Passive Sampling

- Is defined as the collection of airborne gases and vapours 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 sampling pump

Passive Samplers

How to Sample?

- Examples of approved sampling methodologies
  - NIOSH Analytical methods
    - www.cdc.gov/niosh/docs/2003-154
  - OSHA Sampling & Analytical methods
    - www.osha.gov/dts/sltc/methods/index.html

How to Sample?

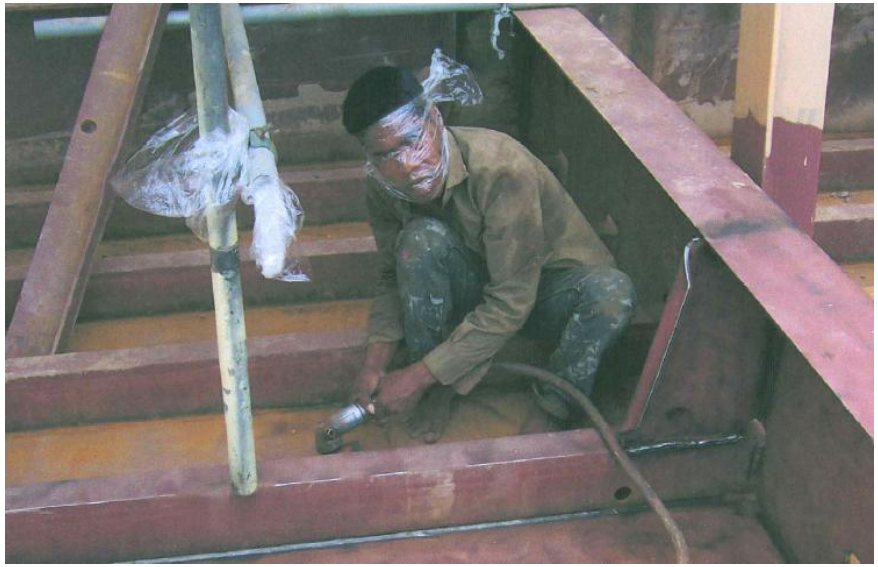
- Depends on:
  - Objectives (task vs. compliance testing)
  - Exposure Limit
  - Sequential Samples
  - Analytical Method
  - Desired Detection Limit (calculation of minimum sampling time)
- Samples must be “representative”!

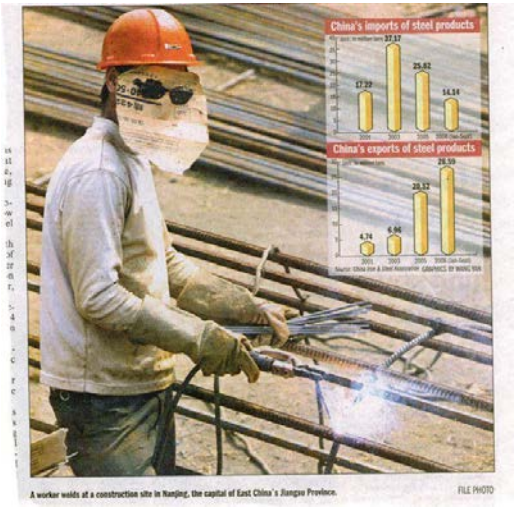
How to Sample?

- Review of:
  - Full-shift, single sample
  - Partial shift, single sample
  - Full shift sequential samples
  - Partial shift sequential samples
  - Grab samples

Who to Sample?

- Identify those workers with the highest exposure potential
- Similar Exposure Groups (SEG)





SEG

- “groups of workers having the same general exposure profile because of the similarity and frequency of the tasks they perform, the materials and processes with which they work, and the similarity of the way they perform the tasks.” (Mulhausen and Damiano, 1998)

How Many Samples?

- Ideal: “each worker’s exposure each day”!!!!$$$
- Professional judgement (and budget) often dictates
- At least 6 random measurements should be taken for each SEG monitored (Mulhausen and Damiano, 1998)

When to Sample?

- Normal vs. Worst-Case Conditions
- Day vs. Night Shift
- Summer vs. Winter
- Quantify Production Conditions!
- Know the Exposure Profile!

Quality Control

- Use of Validated Methods
- Pre and Post Survey Calibrations
- Blank Samples
- Sample Storage and Shipping
- Use of AIHA Accredited Labs
- Communication with Lab
- Equipment Maintenance Programs

Questions?