

Appendix 13.13-E Workplace Monitoring Procedures

WORKPLACE MONITORING PROCEDURES MANUAL

©Ministry of Energy and Mines, Mines Branch

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CHAPTER 1: INTRODUCTION

1-1 Background

Worker health and safety is a vital component of any occupation in British Columbia. Workers can potentially be exposed to conditions or contaminants that may cause both short and long term adverse health effects. Silicosis and black lung disease, long thought to be diseases of the bygone era are two of the health risks directly associated with the mining industry. Figure 1-1 graphically displays all mining related deaths, which have occurred in B.C from 1986-2000. Silicosis accounts for 55% of all deaths.

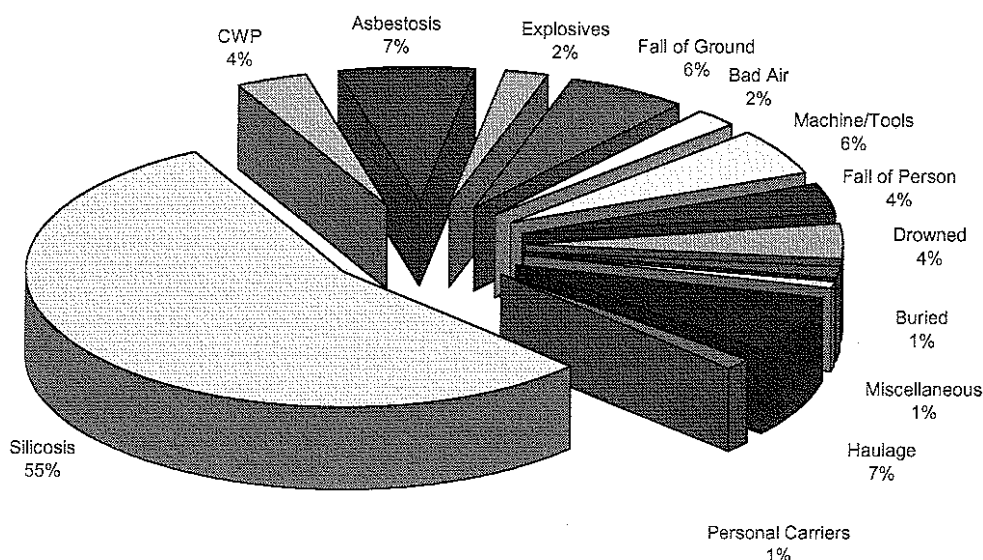


Figure 1-1: B.C. Mine Accident Fatalities and Occupational Disease Deaths Directly caused from Mining. Data compiled from 1986 to 2000 (BC Mines Branch and Vital Statistics data)

Diseases such as these and other occupational health hazards can be mitigated through worker recognition of harmful contaminants and potential workplace hazards.

Pursuant to section 2.2.3 of the *Health, Safety and Reclamation Code for Mines in British Columbia*, the occupational health and safety of mine workers is the direct responsibility of the mine manager. Development of an ongoing workplace contaminant monitoring program, as required by the Code, and recognition of potential on site health hazards, will greatly increase worker health and safety.

1-2 Legislation

Occupational health and safety at mines in British Columbia is regulated under the Mines Act, R.S.B.C. 1996, c.293. A Health, Safety and Reclamation Code for Mines in British Columbia has been developed in accordance with the Mines Act. Compliance with this Code is mandatory under section 35 (1) of the Mines Act.

1-3 Code Requirements

Part 2 of the *Health, Safety and Reclamation Code for Mines in British Columbia (the "Code")*, specifically addresses Occupational Health. Section 2.2.3 (1) states;

"The manager shall establish a written program, acceptable to the chief inspector, for a qualified person to monitor workplace contaminants as often as necessary to ensure compliance with section 2.2.1 (stated below). The program shall specify the substances and locations to be monitored and the frequency of monitoring. The results of the program shall be available for examination by an inspector."

Section 2.2.1

"Employees shall not be exposed to airborne concentrations of chemical or physical agents in excess of the concentrations specified in Tables 2.1, 2.2 and appendices or where not specified those listed in the 1994-1995 edition of the American Conference of Governmental Industrial Hygienists book entitled "Threshold Limit Values and Biological Exposure Indices".

1-4 Threshold Limit Values™ (TLVs™)

There are several widely used standards and guidelines in use today. Table 1 summarizes the most accepted standards and guidelines, which may be used for compliance monitoring depending upon your regulatory jurisdiction.

Table 1-1: Standards and Guidelines

ADMINISTRATIVE ORGANIZATION	STANDARD or GUIDELINE
BC Workers Compensation Board (WCB)	Permissible Exposure Limits (PEL's)
Occupational Health and Safety Administration (OSHA)	Permissible Exposure Limits (PEL's)
American Conference of Government Industrial Hygienists (ACGIH)	Threshold Limit Values (TLV's)
National Institute for Occupational Safety and Health (NIOSH)	Recommended Exposure limits (REL's)

Mines in British Columbia are required by the Code, to adhere to the ACGIH, TLVs™ outlined in the *1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* with exceptions noted in the Code.

TLVs™, are simply the concentrations of airborne substances that are believed to be the limit at which nearly all workers may be repeatedly exposed, day after day, without adverse health affects. However, it should be understood that some individuals have a unique susceptibility level for some chemical, physical and biological agents, and therefore a small number of workers may experience discomfort at threshold concentrations or slightly less than threshold concentrations. Although it is believed that serious injury is unlikely when within the TLVs™, a rule of thumb should be to always maintain concentrations of all airborne contaminants at the lowest feasible level.

Currently, three categories of TLVs™ have been defined;

Threshold Limit Value-Time-Weighted Average (TLV-TWA) - the timed-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

When shifts are longer than eight hours, the TWA concentration is based on a concentration equivalence (Ceq). The following formula allows for equivalent TLV™ concentrations to be determined if a workshift is longer than eight hours.

$$Ceq = \frac{(8\text{-hour TWA}) \times 8}{\text{shift length in hours}}$$

Threshold Limit Value-Short-Term Exposure Limit (TLV-STEL) - the concentration to which workers can be exposed continuously for a period of time, provided the daily TLV-TWA is not exceeded. Exposure must be no longer than 15 minutes, be separated by 60 minutes if repeated, and occur no more than 4 times per day; and

Threshold Limit Value-Ceiling (TLV-C) - the concentration that must never be exceeded.

1-5 Sampling Terminology

(a) Integrated vs. Grab Sampling

Integrated and grab sampling are sampling techniques used to determine the ambient concentration of airborne contaminants. Integrated sampling however, involves drawing a known volume of air through a sampling device for a given period of time. This specific sampling technique allows for the determination of the average exposure to airborne concentrations of contaminants during a specific period of time, usually a workshift. Grab sampling on the other hand, is a technique that involves the direct collection of an air sample by means of a bag, flask, or syringe. Grab samples are useful for determining the concentrations of a contaminant at a specific site and a specific point in time. While, this type of sampling technique is not useful in determining the average exposure of workers to airborne contaminants, it can be used as a preliminary evaluation of airborne concentrations that are the result of a specific process.

(b) Active vs. Passive Sampling

Integrated sampling can be done either actively or passively. During active sampling, forced air, by means of a sampling pump, is drawn through a sampling device. Flow rate is calibrated before sampling allowing for an accurate determination of the volume of air used during the sampling procedure. Passive sampling, on the other hand, does not rely on a forced air flow, but rather on physical processes such as diffusion or permeation.

(c) Personal vs. Area Sampling

Personal sampling is when a sampling device is worn by a worker, within the breathing region, to determine the average exposure throughout a workshift. Generally, the sampling device is attached to the workers collar. Area sampling involves sampling at a fixed location over a given period of time. This type of sampling allows for the determination of average ambient concentrations at a fixed location, usually in the vicinity of specific operation or process.

1-6 Objective of the Manual

This manual is intended as a guide with which to aid mines in complying with section 2.2.3 (1) of the Code. Acknowledging that every mine has unique characteristics, specific sections within this manual may not pertain to every mine. Mine managers should use the applicable chapters in this manual as a guide when developing a site specific workplace contaminant sampling program.

CHAPTER 2: SAMPLING

2-1 Developing a Sampling Strategy

One of the most important parts of any monitoring program is the preparation and sample selection. The objective in any monitoring program is to collect a sufficient number of samples to ensure statistical significance and reproducibility. Sufficient samples should be taken to accurately characterize the variability and central tendency for each occupation and/or process.

Equally important is that the quality assurance/quality control of any monitoring program is well thought out in order to ensure a specific degree of confidence in the sample result.

Every program is faced with the questions regarding where to monitor, who to monitor, when to monitor, how long to sample for, and how many samples to collect. Key in this selection is to choose samples representative of all the different occupations and processes, keeping in mind the variations which may result due to: differences in work techniques of individual employees, differences in exposure concentrations during the day, the differences in the average daily exposure between days and differences due to the random variations in sampling and analysis.

DEVELOP A SAMPLING PROGRAM

When developing a sampling program for workplace exposure monitoring, a number of elements must be taken into consideration including:

- where to sample
- when to sample
- how long to sample
- who to sample
- how many samples to collect,a
- how should the sample be obtained, and
- quality assurance and quality control

Remember any measurement of workers' exposures provides information only for that moment in time. For example, wet weather conditions may result in a low exposure to dust inside a loader or drill, whereas dry, hot weather conditions may attribute to higher than average dust exposure. Individual work habits, changes in process or changes in control measures can also cause significant differences in monitoring results. Especially for outdoor activities, readings should be taken preferably in all four seasons; on wet and dry days, windy and calm conditions. It's not sufficient to take one sample and apply that result to all situations.

(a) Where to Sample

Generally, there are three types of locations that could potentially be sampled.

- a specific process or operation
- a general workroom or general air sample
- a personal sample in a workers breathing zone

For the purposes of determining average worker exposure over an entire workshift, a personal sampler in the worker's breathing zone is necessary. However, when monitoring worker exposure to some physical agents such as vibration or heat and cold stress, specific process or a general air sample would be relevant.

(b) When to Sample

When developing a sampling schedule, specific sampling days, times, and shifts should be selected randomly, but should be done so that sampling is undertaken during every season of the year. As the seasons change, indoor and outdoor ambient conditions change and therefore, it is critical to obtain comprehensive sampling results throughout the year. Ambient conditions could also change between shifts, again making it important to select shifts randomly and to ensure all shifts have been covered in the sampling schedule.

(c) How Long to Sample

The length of each sample is directly dependant on both the agent being sampled and the specific analytical method being followed. Generally, exposures are a time weighted averaged over an entire workshift, but there are a number of exceptions including sampling for airborne asbestos or any area where the ambient dust concentrations will clog the filter. Each specific analytical method will include a sampling time or a specified volume of air for each sample.

(d) Who to Sample

When collecting a personal sample, the shift and worker must be chosen randomly. Once workers have been categorized into specific similar exposure groups (SEG), workers from that similar exposure group must all have an equal probability of selection (See Chapter 3 Monitoring Plan). This can be done by simply placing every worker from that SEG in a hat and drawing names from that hat. By choosing workers randomly, personal bias is eliminated and the results of the sampling program should provide representative exposure data for each specific SEG. However, in practice there are often restrictions as to the scheduling of shifts and workers affecting the randomness of the sample.

There are also workers who will refuse to wear the sampling devise. Experience has shown that only cooperative workers should be sampled.

(e) How Many Samples to Collect

There are no set rules to determine the number of samples that are necessary to evaluate a workers exposure. The number of samples taken depends on the purpose of sampling. However, Chapter 3 Developing a Monitoring Plan, suggests minimum levels for sampling.

(f) How Should the Sample be Obtained

Each agent to be sampled should have a specified NIOSH, WCB, or OSHA analytical method that must be followed during sampling (Table 1-1, Chapter 1). In addition, this manual describes many of the agents, their TLVs™, and the types of equipment that can potentially be used when sampling. Each chapter in this manual also includes a general step by step procedure for the collection of various types of samples.

(g) Quality Assurance/Quality control (QA/QC)

QA/QC is a systematic process, which ensures a specific degree of confidence in data collection. A quality assurance program involves a series of steps, procedures and practices, which must be followed to ensure integrity of a sample. Without this assurance there is no way of knowing whether or not the data you have collected is valid and more importantly, not misleading.

Quality assurance/quality control starts in the field. The quality of data generated in a laboratory depends to a large degree on the integrity of the samples that arrive at the laboratory. Consequently, when field sampling you must take the necessary precautions to protect samples from contamination.

Essential elements for any quality assurance program include:

- Sample collectors should keep their hands clean and workplace tidy and refrain from eating or smoking while working.
- All sampling apparatus and sampling media (i.e. filters) must be kept clean and contaminate free.
- Keep all sampling material in a clean environment, away from dust, fumes and grime.
- Use only recommended sample media (i.e. the proper use of filter types) .
- Ensure all instruments are in working order and are calibrated regularly with a record kept of results, and
- Establish a quality control program.

Quality control is an essential element of a field sampling process in addition to the standardized procedures outlined in your quality assurance program. Field quality control

involves the submission of blank and replicate samples to test for contamination due to contaminated sampling media or equipment, handling and transportation, and also to check for analytical errors and reproducibility.

The timing and the frequency of blanks and replicates should be established in your written procedures. A minimum level of effort would be to use blanks and replicates consisting of 10% of the samples.

Another aspect of quality control, for those that use in house lab facilities, is the use of certified or standard reference materials to assist the laboratory process.

What are field blanks?

In the case of filter cassettes, a blank would be a plugged cassette, which would be exposed to the same handling, transportation and sampling environment as the real sample. Consequently they provide information on contamination resulting from handling, transportation and other potential sources of contamination. They are processed in the same manner as the associate samples.

What are replicate samples?

Replicate samples are independent samples collected as close as possible using the same sampling technique at the same point in space and time and are intended to be identical samples. These samples are essential in documenting the precision of the entire sampling and analytical (laboratory) process and are particularly recommended for QC studies.

CHAPTER 3: DEVELOPING A WORKPLACE MONITORING PROGRAM

3-1 Workplace Monitoring Program

Why Do I Need a Workplace Monitoring Program?

People working in the mining industry including metal mines, coal mines, quarries and the processing of sand and gravel, are potentially exposed to levels of respirable dust containing quartz or silica and in some cases coal, which can cause serious lung disease if levels are not controlled. In addition to dust, there are other substances regularly used in industrial situations, which can cause serious side effects such as solvents, epoxies, paints and thinners. These contaminants may come in the form of a fume, mist, or vapour. To determine workers' exposure to dusts, fumes, mists, vapours, or even noise and other potentially harmful agents, actual measurements must be made.

The *Code* requires the mine manager to establish a written program acceptable to the Chief Inspector. While there is no specific format specified, the Workplace Monitoring Program (WMP) needs to address:

1. All work areas and occupations that are potentially exposed to "*airborne concentrations of chemical or physical agents in excess of the concentrations specified...*"
2. A detailed annual monitoring plan for those areas and occupations,
3. A summary of control measures now in use to prevent workers from excessive exposures to harmful conditions or substances, and
4. Details of the sampling methodology, type of analysis to be done, and personnel to perform the monitoring.

In order that you provide the necessary information requirements we suggest dividing the documented portion of your Workplace Monitoring Program into 2 sections – A Monitoring Schedule Section and a Sampling Methodology Section which will make it easier to provide and access the required information. Following are format suggestions for both.

3-2 Developing a Monitoring Schedule

The following step-by-step procedure has been developed to help design a workplace monitoring program acceptable to the Chief Inspector of Mines. A key feature of this process is the selection of a sampling frequency, which will ensure the results are statistically significant. Table 3-1 has been developed to ensure at least the minimum number samples are collected.

STEP 1: WORKPLACE HAZARD CHARACTERIZATION

Anticipation and recognition of potential and present hazards can be accomplished through a preliminary evaluation of the site and all of its components. This preliminary evaluation is basically a workplace hazard characterization that identifies on site processes, occupations, environmental agents and any controls currently in place.

(a) *Gather Information by:*

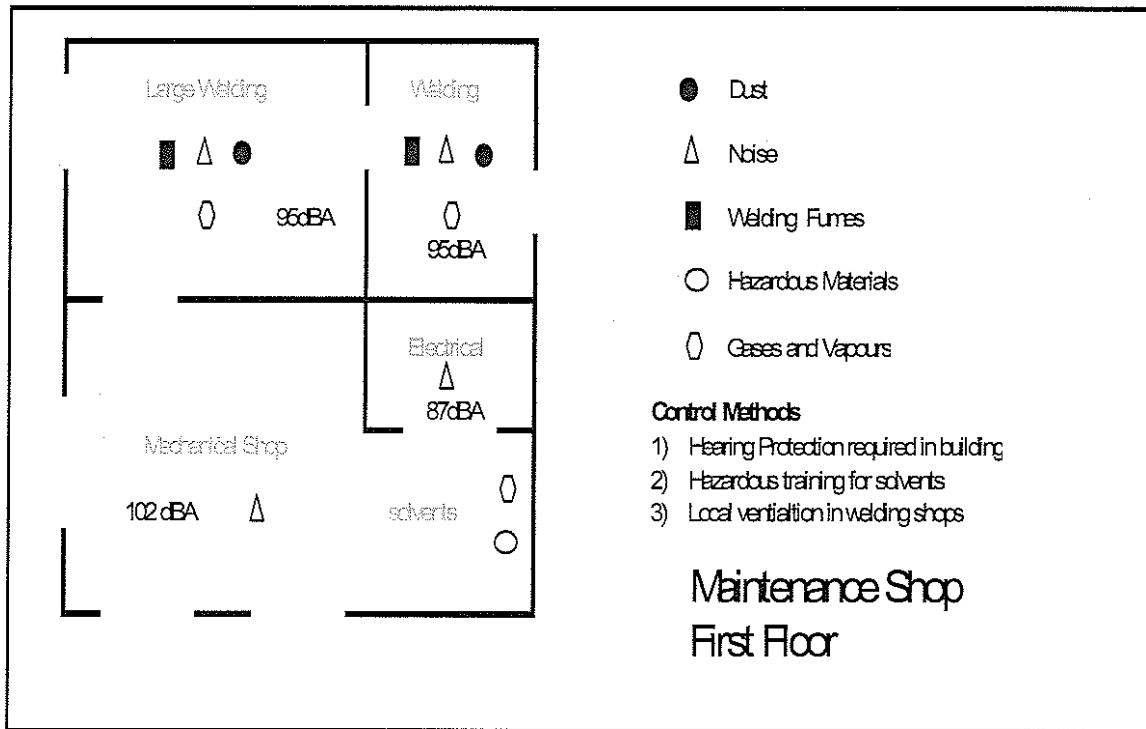
- Conducting a walk around survey,
- Interview workers, managers, engineers, medical and safety staff
- Review relevant company records including,
 - MSDS sheets for hazardous substances
 - standard operating procedures
 - production
 - medical surveillance
 - engineering plans and drawings
 - environmental reports
 - process flow diagrams
- Interview governmental and non governmental organizations for process information, and
- Do a literature research if required.

(b) *Documentation*

All observations should be clearly documented. Every building and area should be documented, with all processes, tasks, agents, and control methods recorded. The physical, chemical and biological agents present should be clearly noted.

Diagram and arrange this information in the following format:

AREA	PROCESS	OCCUPATION	AGENT
Maintenance Shop	Mechanical Repairs	Mechanic	Noise
	Maintenance	Electrician	Noise
		Apprentice	Noise
		Foreman	Noise
	Welding Shop	Welder	Noise, welding fumes, particulate



STEP 2: DETERMINE SIMILAR EXPOSURE GROUPS (SEGs)

Once the preliminary survey has been completed, worker tasks could be grouped into similar exposure groups (SEG) for ease of monitoring. SEGs are groups of workers of varying tasks that are exposed to similar concentrations of workplace contaminants. When sampling for exposures, this allows workers with closely related exposures to be sampled as a single specific group. This reduces the number of samples that are required as each exposure group must regularly be monitored. Grouping similar exposure groups can be done through observation or by conducting preliminary sampling, allowing for a baseline of exposure data to be established. In general, similar exposure groups are groups of workers that have the same general exposure profile in terms of frequency and length of exposure and rely on:

- process exposure
- task/ specific job
- agent(s) exposure (physical, chemical, or biological)

Add this information to your table.

MONITORING SCHEDULE

AREA	PROCESS	OCCUPATION	AGENT	# of EMPLOYEES IN SEG	TOTAL # IN SEG
Maintenance Shop	Mechanical Repairs	Mechanic	Noise	4	9
	Maintenance	Electrician Apprentice Foreman		3 1 1	
	Welding Shop	Welder	Noise, welding fumes, particulate	4	4

■ Note that the mechanic, electrician, apprentice and foreman from the maintenance shop have all been lumped into a similar exposure group (SEG), with the total number of employees in that group equal to 9.

STEP 3: DETERMINE MINIMUM NUMBER OF SAMPLES REQUIRED

Using Table 3-1 below determine the minimum number of samples required per year / agent/ for each SEG identified.

TABLE 3-1: DETERMINATION OF SAMPLING FREQUENCY

AGENT \ NUMBER OF EMPLOYEES IN SEG	1 to 3	4 to 6	7 to 11	12 to 19	20 to 35	36 to 50	> 50
	Minimum Sample Requirements						
	2 x year	4 x year	8 x year	12 x year	16 x year	18 x year	24 x year
Dust	1 employee every 6 months	1 employee every 3 months	2 employees every 3 months	2 employees every 2 months	4 employees every 3 months	3 employees every 2 months	2 employees every month
Welding Fumes	1 employee every 6 months	1 employee every 3 months	2 employees every 3 months	2 employees every 2 months	4 employees every 3 months	3 employees every 2 months	2 employees every month
Gases, Vapours or mists	1 employee every 6 months	1 employee every 3 months	2 employees every 3 months	2 employees every 2 months	4 employees every 3 months	3 employees every 2 months	2 employees every month
Underground Diesel Fumes	1 employee every 6 months	1 employee every 3 months	2 employees every 3 months	2 employees every 2 months	4 employees every 3 months	3 employees every 2 months	2 employees every month
Noise	1 employee every 6 months	1 employee every 3 months	2 employees every 3 months	2 employees every 2 months	4 employees every 3 months	3 employees every 2 months	2 employees every month
Heat/Cold stress	AS REQUIRED (see manual)						
Lighting	AS REQUIRED (see manual)						
Asbestos	AS REQUIRED (see manual)						
Radon and Other Chemical Hazards	AS REQUIRED (see manual)						

Complete for each area and occupation identified in step 1. Add this information to your table. Complete by developing a yearly monitoring plan.

MONITORING SCHEDULE

AREA	PROCESS	OCCUPATION	AGENT	# of EMPLOYEES IN SEG	TOTAL # IN SEG	Samples required per year	Frequency
Maintenance Shop	Mechanical Repairs	Mechanic		4	9	8	2 employees every 3 months
	Maintenance	Electrician Apprentice Foreman	Noise	3 1 1			
	Welding Shop	Welder	Noise, Welding fumes, Dust	4	4	3	1 employee every 4 months noise, welding fumes and dust
Crushing area	Screening and crushing	Crusher operator	Dust Noise	4	4	3	1 employee every 4 months for noise and dust
	Clean up/ housekeeping	Helper	Noise Dust	2	2	2	1 employee every 6 months for noise and dust

YEARLY MONITORING PLAN

	Maintenance General	Maintenance Welding	Crusher operator	Crusher General
JAN	Noise X 2		Noise	Noise
FEB		Noise Welding fumes Dust		
MARCH				
APRIL	Noise X 2			
MAY				
JUNE			Noise Dust	
JULY	Noise X 2	Noise Welding fumes Dust	Dust	Noise Dust
AUGUST			Dust	Dust
SEPTEMBER				
OCTOBER	Noise X 2			
NOVEMBER		Noise Welding fumes Dust	Noise	Noise
DECEMBER				

3-2 Developing a Sampling Methodology Section

The following is a suggested format to describe your sampling methodology. This section should document:

- ☒ Type of sampling and calibration equipment used,
- ☒ Detailed sampling procedures,
- ☒ Quality assurance/ quality control (QA/QC) procedures (ie calibration procedures, using field blanks etc.),
- ☒ Analyses procedure,
- ☒ Engineering and/or administrative controls used.

A Table of Contents is attached as a suggested format.

TABLE OF CONTENTS

SECTION II - SAMPLING METHODOLOGY

1.0 Dust

Areas of concern
Sampling and calibration equipment used
Sampling and calibration procedure
QA/QC (Quality assurance/quality control) procedures
Analyses procedures
Engineering and administrative controls and personal protection use

2.0 Welding Fumes

Areas of concern
Sampling and calibration equipment used
Sampling and calibration procedure
QA/QC (Quality assurance/quality control) procedures
Analyses procedures
Engineering and administrative controls and personal protection use

3.0 Diesel Exhaust

Areas of concern
Sampling and calibration equipment used
Sampling and calibration procedure
QA/QC (Quality assurance/quality control) procedures
Analyses procedures
Engineering and administrative controls and personal protection use

4.0 Gases, Vapours of Mists

Areas of concern
 Sampling and calibration equipment used
 Sampling and calibration procedure
 QA/QC (Quality assurance/quality control) procedures
 Analyses procedures
 Engineering and administrative controls and personal protection use

5.0 Noise

Areas of concern
 Sampling and calibration equipment used
 Sampling and calibration procedure
 QA/QC (Quality assurance/quality control) procedures
 Analyses procedures
 Engineering and administrative controls and personal protection use

6.0 Other Monitoring parameters

Heat /Cold stress
 Asbestos
 Lighting
 Radon Gas

REFERENCES**APPENDICES**

Example for dust monitoring.

1.0 DUST

Areas of concern:	Crusher/screening room, Crusher /screening outside area, Load Out areas, Drills, Front End loaders, Haul trucks, Welding shop
Sampling and Calibration equipment	10 mm nylon cyclone with Airchek 2000 pumps Dry Cal DC Lite Calibrator
Sampling procedure:	Filter type: CANMET prepackaged silver membrane filter.

	Sampling procedure follows page 3-8 of the Workplace Monitoring Manual (BCMEM, 1999) for personal monitoring at frequencies outlined in Section II. Area sampling will be conducted as required. Flow rates used 1.7 l/min Calibration is conducted both pre and post sampling. Sample discarded if >5% discrepancy between readings (See attached diagrams for sampling train and calibration train).
Quality Assurance/Quality Control (QA/QC):	Calibration of Dry Cal DC Lite calibrator done every year (last calibration date June, 1999) 1 field blank is used for every 10 samples sent to the lab for analyses
Analyses Procedure:	Samples are sent to CANMET for analyses of total dust and quartz. NIOSH procedures 0600, 7500 are used.
Engineering and Administrative Controls:	For equipment all seals are checked periodically, cabs are pressurized and air conditioned. Crusher room is sealed and air conditioned. Road are watered during dry days Ventilation in the welding shop is checked for adequacy. Proper housekeeping is encouraged Respirator use is required on all drills.

CHAPTER 4: DUST

4-1 Background

Dusts are small, dry particulates suspended in air and range in size from less than 1 micron or one millionth of a metre (μm), to 1 millimetre (mm) in size. On a mine site, most dust particles of concern are airborne as a result of a grinding, drilling, or pulverising process. As the toxicity of airborne dust is dependant on size and chemical composition, monitoring respirable concentrations, is critical in determining the health effects of worker exposure.

When air containing dust particles is inhaled, the dust itself, dependant on size, will reach one of three regions of the respiratory tract. Generally, the larger particulates will be deposited in the nasopharyngeal (NP) region or the nose and mouth region. Particles penetrating the NP region will either be deposited in the tracheobronchial (TB) region or if small enough, the pulmonary (P) region (refer to Figure 4-1).

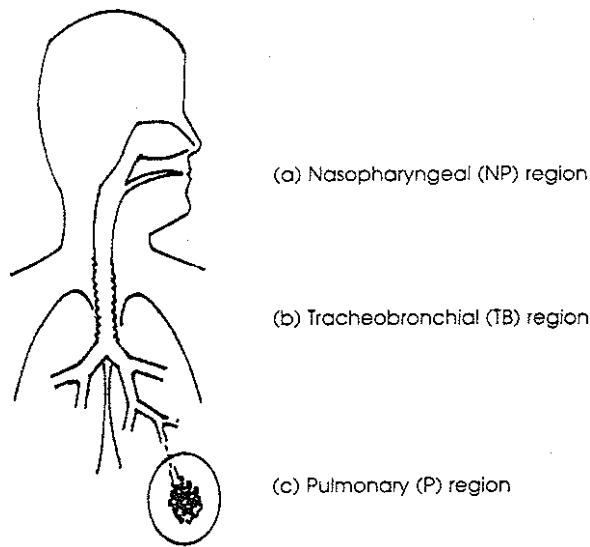


Figure 4-1: Regions of the Respiratory Tract (The Occupational Environment, AIHA Press, 1997)

Mass fraction is the dust a worker inhales with a breath. Inhalable or inspirable mass fraction, is basically any particulates in the air that a worker could potentially inhale via the nose or mouth (refer to Figure 4-2). Larger particles within this fraction, 10 - 100 μm , will generally be deposited on the nasal mucus in the NP region and expelled from the

body. Particles not trapped in the NP region enter the TB region of the respiratory tract. The particulate mass entering the TB region is called the thoracic mass fraction, and is generally less than $10\ \mu\text{m}$ in size. As the airways branch within the lungs, many of the particles are captured on mucus and most are eventually expelled.

The greatest threat to worker health comes from the particulates small enough to enter the P region or gas exchange region of the lungs. These particulates are referred to as the respirable mass fraction, and are generally less than $4\ \mu\text{m}$ in size and are not visible to the naked eye. When particulates are deposited in the gas exchange region, sedimentation within the lung or diffusion into the bloodstream occurs. Certain respirable dusts, such as coal or silica, are the direct cause of diseases such as silicosis and black lung disease.

Many of the ACGIH TLVs™, are now based upon the inhalable or respirable particulate mass fraction.

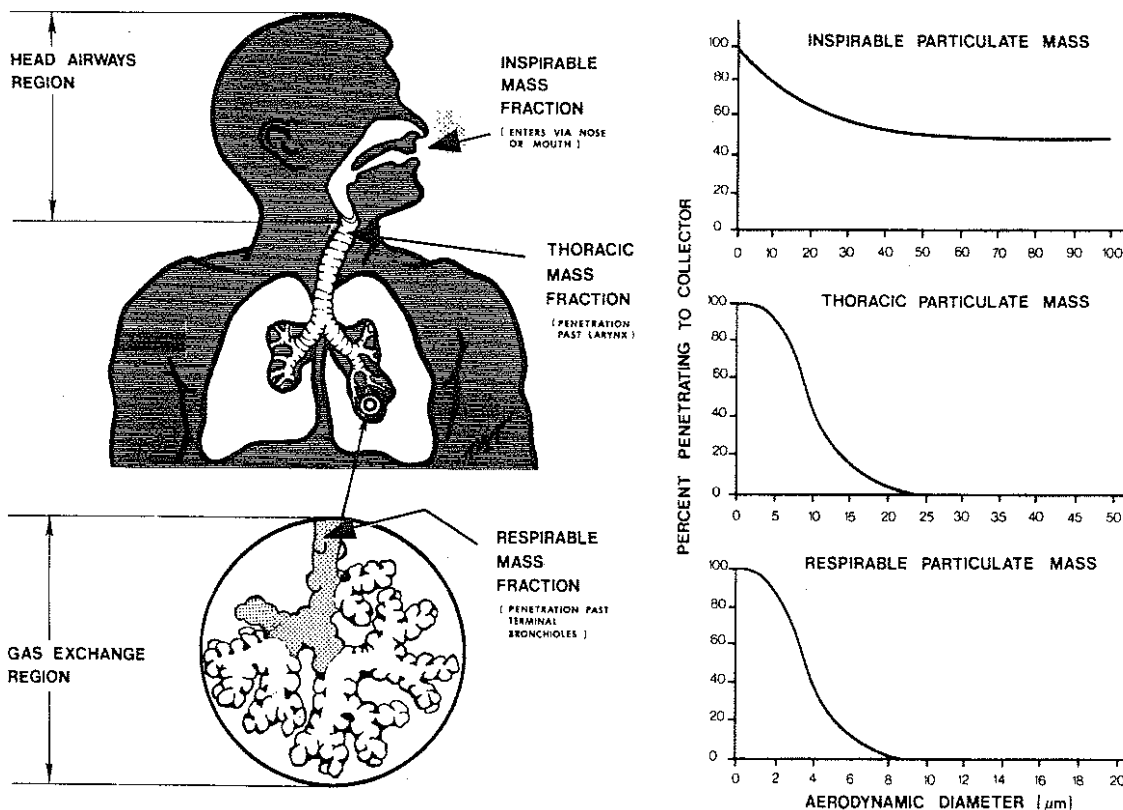


Figure 4-2: Breakdown of Mass Fractions of Dust Particulates (Air Sampling Instruments, ACGIH, 1989)

4-2 Health Effects

The impact of dust on human health is highly dependant on a number of factors. Composition, concentration, particle size, exposure time and individual susceptibility all

directly affect the consequences of dust exposure on human health. In the mining industry, prolonged exposures to dusts such as coal and silica dust, increase the risk of work related disease. Failure to monitor and protect workers from various dusts could eventually lead to the development of pneumoconiosis, a chronic disease of the lungs resulting from the inhalation of respirable dusts. In particular, the following two types of pneumoconiosis can be directly linked to mine dust exposures.

(a) Silicosis

Silicosis is a chronic disease of the lungs that is caused directly from a prolonged exposure to respirable dust containing free crystalline silica. Particles of crystalline silica, small enough to penetrate the lungs, cause a scarring of the lung tissue and eventually, promote the growth of nodules. As the nodules increase in size over time, lung capacity decreases, eventually leading to shortness of breath, fatigue, loss of appetite, severe cough and chest pain. Common minerals containing silica are quartz, cristobalite, tridymite, and tripoli.

(b) Coal Workers' Pneumoconiosis (CWP)

Coal workers' pneumoconiosis, historically referred to as black lung disease, is also a chronic disease of the lungs. However, CWP is caused from the inhalation of dusts containing carbon. Coal dust, in particular, contains carbon and has been the direct cause of the "black lung" since the early nineteenth century. As respirable coal dust becomes trapped in a worker's lungs, the lungs begin to form macules. Over time, the size of the macules increases, eventually leading to an enlargement of the air spaces adjacent to the macules. As the disease progresses, there is the loss of elastic fibres in the airways leading to an increase in rigidity of the alveolar walls. Nodules form as the walls of the macules become rigid and there is a gradual increase in shortness of breath and a cough producing black sputum.

Silicosis and CWP are both chronic lung diseases and are both fatal. These diseases have also both demonstrated a synergistic effect between smoking and the development of lung disease. Fortunately, these diseases to a large extent, are also preventable. Monitoring of worker exposure to dusts, in particular respirable dusts, can help determine unsafe worker environments and prevent environmental conditions that may lead to the development of such diseases.

4-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapters 2 and 3 of this manual describes how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.

2. A reliable laboratory should be contacted to determine:
 - (a) the specific analytical technique that the laboratory will use to analyse the samples (refer to examples in section 4-4); and
 - (b) the specific NIOSH, OSHA or WCB standardised analytical method recommended for the sampling procedure. **Currently, the accepted sampling method must be approved as a WCB, NIOSH or OSHA standardised analytical method.** The standardised sampling method will outline the necessary equipment required and will guide the sampler through a step by step sampling procedure. Appendix A lists the reference number for each related analytical method.
3. Finally, the results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Table 4-1).

4-4 Analytical Techniques

When a dust sample is sent to a laboratory for analysis, there are a number of methods that can be used to measure respirable dust. The most common analytical methods used are X-Ray Powder Diffraction, Infrared Absorption Spectrophotometry, and Gravimetric.

(a) X-Ray Powder Diffraction (XRD)

X-ray powder diffraction essentially scans a dust sample with an x-ray beam. The structure and concentrations of minerals is determined through diffraction of the x-ray beam onto a piece of film. Since each mineral has unique diffraction capabilities, based on its crystal structure, concentrations of specific substances can be analysed.

(b) Infrared Absorption Spectrophotometry (IR)

IR evaluates the structures in a sample rather than the basic concentrations. Basically, infrared light is passed through a prepared liquid sample and a liquid blank. The light energy that is transmitted at each wavelength is compared to reference wavelengths. Comparison to references allow for identification of the various mineral components in the sample.

(c) Gravimetric

Gravimetric sampling involves drawing a known volume of air through a filter, capturing any airborne particulates. Prior to sampling the filter is weighted. Once sampling has been completed, the filter is conditioned in the laboratory by a certified technician in accordance with the NIOSH standardised analytical method. The difference in the weight of the filter allows for the estimation of total respirable or inhalable dusts.

4-5 Sampling Equipment

When sampling for respirable dust exposure, a sampling head attached to a personal sampling pump can be used to determine worker exposure. The sampler should be fastened to a workers collar so that it is within the worker's breathing zone with the sampling pump attached to the workers belt.

(a) Cyclones

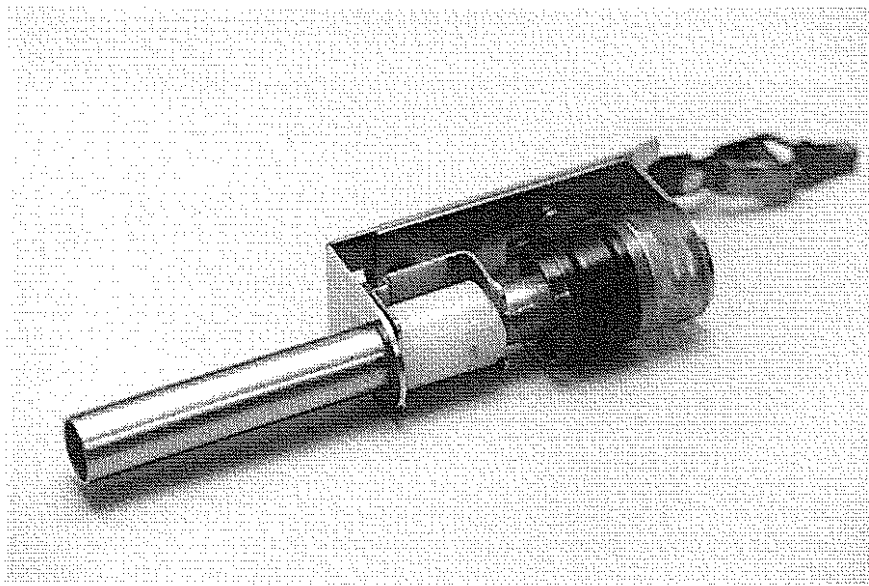


Figure 4-3a: MSA Holder, Nylon Cyclone and filter cassette assembly

Cyclones are gravimetric dust samplers (refer to Figure 4-3a,b). Respirable cyclones separate, and collect on a filter, the respirable dust fraction from within an air sample. With the use of a personal sampling pump, air is drawn into the cone segment of the cyclone. Centrifugal forces within the cyclone causes particulates within the captured air to spiral down the sides of the cone, gravimetrically separating the larger particles from the particles of a respirable size. Respirable particles, still suspended in the centrifugal airflow, spiral back up the centre of the cone and pass through a filter cassette and are captured onto a filter. The filter itself can then be analysed by one of a number of different types of analytical methods to determine the concentration of a specific airborne dust. Filters can be analysed for either total respirable dust concentrations or for concentrations of specific contaminants within the respirable dust. Low-ash polyvinyl chloride (PVC) filters are typically used for respirable dust sampling.

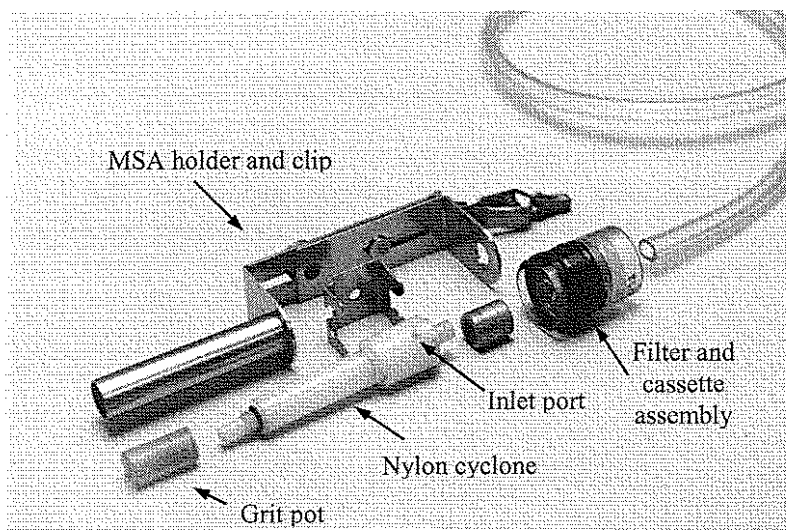


Figure 4-3b: Nylon Cyclone Assembly

Before sampling with a cyclone, double check the flow rate specific to that type of cyclone. American Conference of Governmental Industrial Hygienists (ACGIH) standards suggest a flow rate of 1.7 l/min for Nylon cyclones and a flow rate of 2.5 l/min for the SKC Inc., Aluminum cyclones.

(b) Inhalable Dust Samplers

Inhalable dust samplers are used to measure total inhalable dust. When attached to a personal air sampling pump, these devices draw air through a filter as a worker would inhale air via the mouth or nose (refer to Figure 4-4). The filter is weighed both before and after a sampling period allowing for the total mass of inhalable particulates to be determined. Inhalable dust samplers are useful for determining a worker's dust exposure during a shift.

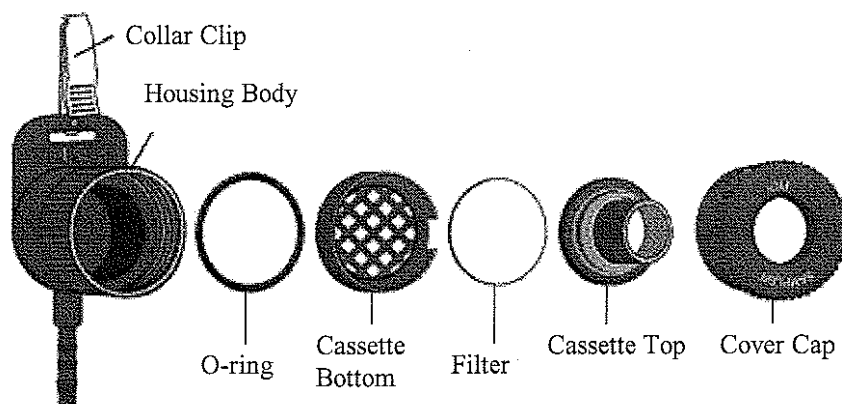


Figure 4-4: Inhalable Dust Sampler (Diagram provided by SKC Inc., reprinted with permission.)

(c) Inertia Impactors

Impactors separate dust particles based on particle size and inertia. An air sample is jetted through an impactor with a personal sampling pump, and particles are impinged onto collection plates specific to that particle's aerodynamic diameter and inertia (refer to figure 4-5).

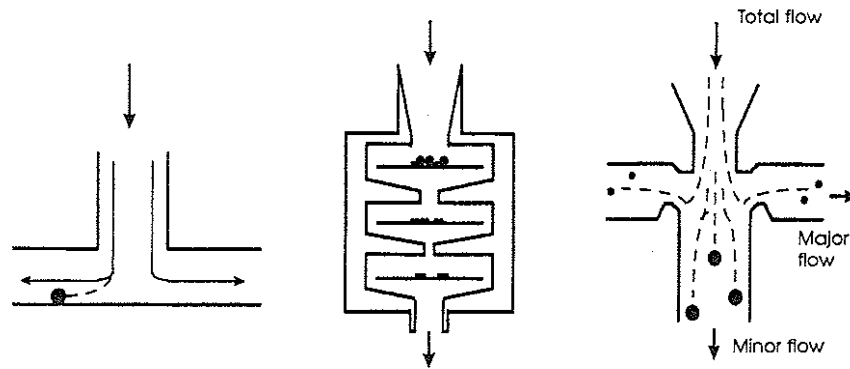


Figure 4-5: Inertial Impactors (*The Occupational Environment*, AIHA Press, 1997)

(d) Personal Particle Sampler

TSI® has recently developed the RespiCon™, a new type of impactor that has the ability to separate particles based on inhalable, thoracic and respirable mass fraction (refer to Figure 4-6). The RespiCon™ impactor captures particulates onto three individual collection filters that are each weighed before and after collection. The difference in filter weights allows for the determination of airborne concentrations of each mass fraction.



Figure 4-6: Personal Particle Sampler

(e) Micro-Orifice Uniform Deposit Impactor (MOUDI)

A MOUDI is a multi-stage cascade impactor used for area sampling of dusts. Generally, the lower impactor stages use chemically etched, micro-orifice impaction plates. Impactors are size selective samplers that separate dust particles based on particle size and inertia. An air sample is jetted through an impactor with a personal sampling pump, and particles are impinged onto collection plates specific to that particle's aerodynamic diameter and inertia.

4-6 General Sampling Procedure

1. *Calibrate* the personal sampling pump to the specified flow rate. Calibration must be done using a primary standard calibrator (refer to Appendix A). Appendix A outlines the step by step calibration procedure.
2. *Attach* the specified filter into a sampling cassette and support the filter with either a steel screen or cellulose backup pad. The cassette should be firmly closed sealed with plastic tape, **OR** purchase a pre-assembled cassette and filter from the laboratory.
3. *Inspect* the sampler and its components for dirt and wear. Clean sampler if needed.
4. *Remove* the cassette filter caps and attach the cassette to the sampler. Double check the alignment of the cassette.
5. *Connect* the outlet of the sampler to the personal sampling pump using flexible tubing.
6. *Clip* the cyclone assembly to the worker's collar so that it is within the worker's breathing zone.
7. *Prepare* filter blanks. At least two blanks should be prepared and shipped with every 10 samples sent to the laboratory. While sampling, field blanks should accompany the sampler into the environment and be stored with the other samples.
8. *Record* necessary information on a record keeping sheet and begin sampling. A sample record keeping sheet can be found in Appendix B of this manual.
9. *Check* the filter regularly during a sampling period for overloading or clogging. If overloading or clogging occurs, stop sampling immediately. Also check that the sampler is positioned properly at all times.
10. *Complete* sampling after specified time.

11. *Record* necessary information on a record keeping sheet.
12. *Cap* the inlet and outlet of the filter cassette after taking the sampling assembly apart.
13. *Recheck* the calibration of the sampling pump with the same calibration instrument. , record the current flow rate. If the difference in flow is greater than 5% the sample should be discarded.
14. *Label* the samples clearly and accurately.
15. *Ship* labelled samples and blanks to the laboratory.

4-7 TLVs™

When referring to the TLVs™ for dust, the limit is determined based on the percent silica found in the respirable portion of the dust. An initial bulk sample should be analyzed to determine first of all if silica is present. If silica is found within the bulk sample, the percent of respirable silica and the type of airborne dust determine which TLV-TWA to use.(Table 4-1).

Substance	Rationale	mg/m3
<i>For Particulates not otherwise classified(NOC)</i> <i>"Dust"</i>	If the respirable silica in the sample is > 1% the exposure limit is based on the TLV-TWA for quartz.	0.1
	If the respirable silica in the sample is < 1% the exposure limit is based on the TLV-TWA for particulates NOC (respirable)	3.0
<i>For Coal Dust</i>	If the respirable silica in the sample is > 5% the exposure limit is based on the TLV-TWA for quartz.	0.1
	If the respirable silica in the sample is < 5% the exposure limit is based on the TLV-TWA for coal dust.	2.0

From American conference of Governmental Industrial Hygienists, Inc., 1994-1995 Threshold Limit Values™ and Biological Exposure Indices™

Table 4-1: TLVs™ for Mine Site Dusts

NOTE: TLVs™ are subject to change with each revision of the *Health, Safety and Reclamation Code for Mines in British Columbia* therefore, it is important to consult and reference the most recent edition of the Code.

CHAPTER 5: WELDING FUMES

5-1 Background

Welding fumes are composed of a variety of chemical contaminants and vary in toxicity depending on the welding process and the alloy being welded. Fumes are not gases, but tiny particulates formed by the evaporation of solid or liquid materials. Generally, fume particle size is very small, usually 1 μm or smaller, but these particles tend to agglomerate together forming larger particulates. A number of occupational hazards are directly associated with exposure to the welding process including radiation exposure and toxic fume inhalation. Since welders are generally protected from UV radiation with protective clothing and equipment, welding fumes tend to pose the greatest occupational health risk to workers in the same work area who are not wearing protective equipment.

5-2 Health Effects

A number of potential long and short term health hazards result from the inhalation of welding fumes.

(a) Short Term Exposures

Short term health effects include metal fume fever, exposure to ozone and exposure to nitrogen oxides. Metal fume fever is most commonly the result of worker inhalation of zinc oxide fumes, but can occur after exposure to a number of other metals. With the onset of the fever, a worker may experience symptoms such as chills, fever, muscle aches, headache, metallic taste, nausea and vomiting. Short term exposure to ozone and nitrogen oxides can result in symptoms such as nausea, headaches, eye irritation and an inflammation of the respiratory tract.

(b) Long Term Exposures

Long term exposure to welding fumes can potentially cause adverse health effects that affect various systems within the body. The respiratory, nervous and cardiovascular systems are all at risk to damage if exposed for an extended period of time to concentrations exceeding the TLVsTM. As many of the agents found within welding fumes are known carcinogens, development of cancer after long term exposure may also pose a threat to workers.

5-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapters 2 and 3 of this manual describe how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. A reliable laboratory should be contacted to determine:
 - (a) the specific analytical technique that the laboratory will use to analyse the samples (refer to the example in section 5-4); and
 - (b) the specific NIOSH, OSHA or WCB standardised analytical method recommended for the sampling procedure. **Currently, the accepted sampling method must be approved as a WCB, NIOSH or OSHA standardised analytical method.** The standardised sampling method will outline the necessary equipment required and will guide the sampler through a step by step sampling procedure. Appendix B lists the reference number for each related analytical method.
3. Finally, the results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Table 5-1).

5-4 Analytical Techniques

(a) Inductively Coupled Plasma (ICP)

Due to the variable nature of welding fumes, an analytical method, capable of detecting numerous contaminants with a single analysis, is necessary. Currently, the most commonly used analytical method for determining contaminant concentrations in welding fumes is the Inductively Coupled Plasma (ICP), method. All the elements collected on the filter are first digested into a solution. A plasma is introduced into the solution which in turn excites the electrons of each of the various elements. When the electrons of a specific element are excited they produce photons, similar to bursts of light, unique to that of all the other elements. Analysis of the various photons allows for determination of the concentrations of the various elements.

5-5 Sampling Equipment

When sampling welding fumes, a filter cassette assembly attached to a personal sampling pump can be used to determine worker exposure. **The cassette holder should be fastened to a workers collar so that it is beneath the helmet when the helmet is down, and the sampling pump attached to the workers belt.**

(a) Filter Cassette

Pre-assembled filter cassettes, attached to a personal sampling pump (figure 5-1) is the simplest method of sampling for welding fumes. As welding fumes are of variable composition, filters that allow for the detection of multiple contaminants are recommended. Note there is NO cyclone used for welding fumes.

Collect total dust on a pre-weight low-ash polyvinyl chloride (PVC) filter and collect metal fumes on a 0.8 micron mixed cellulose ester (MCE) filter.

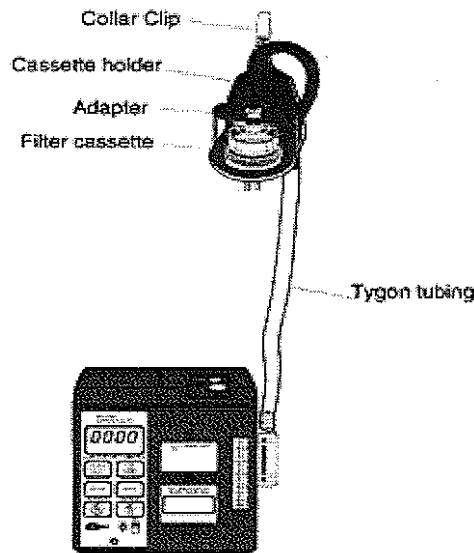


Figure 5-1: Welding Fume Sampling Assembly

5-6 General Sampling Procedure

1. *Calibrate* the personal sampling pump to the specified flow rate. Calibration must be done using a primary standard calibrator (refer to Appendix A). Appendix A outlines the step by step calibration procedure.
2. *Attach* the specified filter into a sampling cassette and support the filter with either a steel screen or cellulose backup pad. The cassette should be firmly closed sealed with plastic tape, **OR** purchase a pre-assembled cassette and filter from the laboratory.
3. *Remove* the cassette filter caps and attach the cassette to the cassette holder. A cyclone is **NOT** used when sampling welding fumes.
4. *Connect* the outlet of the cassette holder to the personal sampling pump using flexible tubing.

5. *Clip* the cassette holder to the worker's collar so that it is within the worker's breathing zone.
6. *Prepare* filter blanks. At least two blanks should be prepared and shipped with every 10 samples sent to the laboratory. While sampling, field blanks should accompany the sampler into the environment and be stored with the other samples.
7. *Record* necessary information on a record keeping sheet and begin sampling. A sample record keeping sheet can be found in Appendix B.
8. *Check* the filter regularly during a sampling period for overloading or clogging. If overloading or clogging occurs, stop sampling immediately. Also check that the sampler is positioned properly at all times.
9. *Complete* sampling after specified time.
10. *Record* necessary information on a record keeping sheet.
11. *Cap* the inlet and outlet of the filter cassette once apart from the sampling assembly.
12. *Recheck* the calibration of the sampling pump with the same calibration instrument. If the flow rate has changed, record the current flow rate.
13. *Label* the samples clearly and accurately.
14. *Ship* labelled samples and blanks to the laboratory.

5-7 TLVs™

As the toxicity of welding fumes is highly dependant on the alloy being welded, the welding rod, and the shielding gas, the safety personnel should also refer to the TLVs™ for specific metals and gases such as zinc, aluminum, iron, chromium, ozone, carbon monoxide, and oxides of nitrogen. WHMIS information should also be available for the welding rod materials.

TWA-TLV's		
Substance	ppm	mg/m3
Welding Fumes		5
Zinc (Zn)		
zinc chloride fume		1
zinc chromates		0.01
zinc oxide - fume		5
Aluminum (Al)		
welding fume		5
Iron (Fe)		
iron oxide - fume		5
Chromium (Cr)		
metal and CrIII		0.5
water soluble and CrIV		0.05
Ozone (O3)		
Carbon Monoxide (CO)	25	29
Oxides of Nitrogen (NOx)		
nitrogen dioxide	3	5.6
nitrous oxide	50	90

From American conference of Governmental Industrial Hygienists, Inc., 1994-1995 Threshold Limit Values™ and Biological Exposure Indices™ Reprinted with permission.

Table 5-1: TLVs™ for Welding Fumes

NOTE: TLVs™ are subject to change with each revision of the *Health, Safety and Reclamation Code for Mines in British Columbia* therefore, it is important to consult and reference the most recent edition of the Code.

CHAPTER 6: NOISE

6-1 Background

Worker exposure to physical agents needs to be addressed in the same manner as worker exposure to chemical contaminants. Noise is a physical agent within the workplace that has the potential to affect worker health and safety if not properly monitored and controlled.

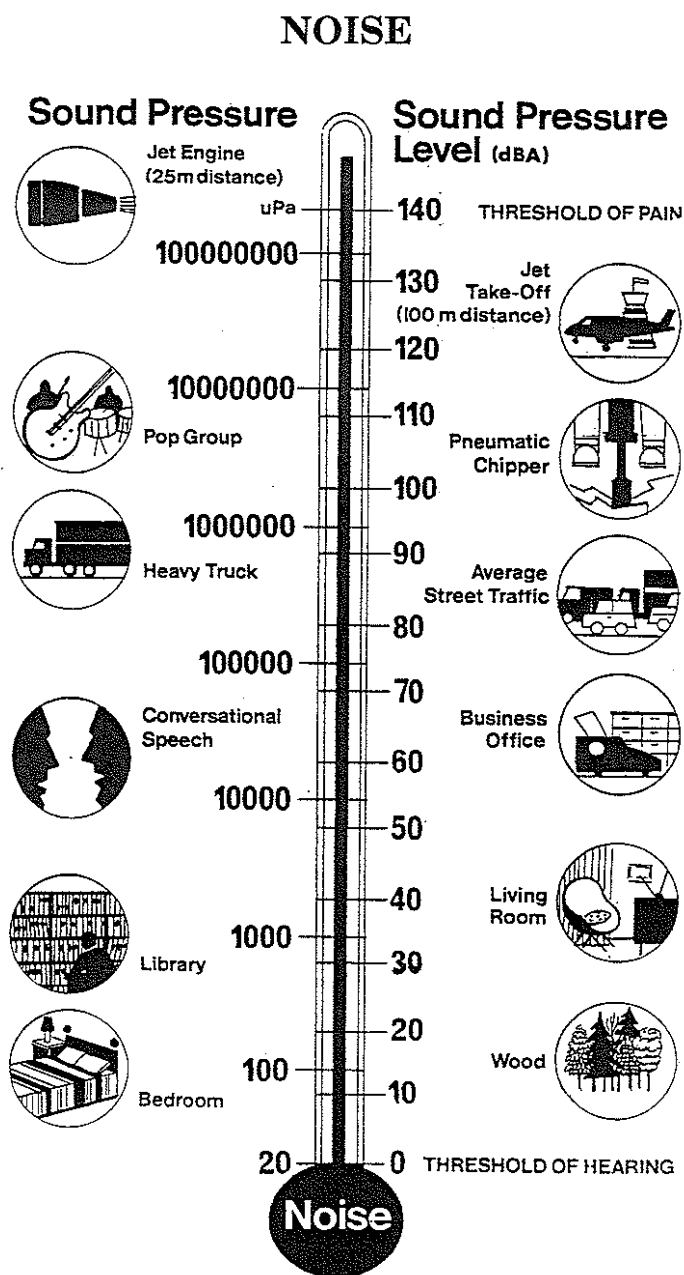


Figure 6-1 Sound Pressure Levels

When describing sound, pitches and tones may vary from worker to worker, therefore frequency is used to describe various sound levels. Frequency is the rate of vibration of a sound, or rather the number of sound waves that pass a given point over a 1 second time period, and is measured in cycles per second or hertz (Hz.). The average person has the ability to hear sounds ranging in frequency from 30 Hz. to nearly 15,000 Hz.

When describing the loudness or intensity of a sound, again, perception varies from worker to worker, therefore requiring a standardised unit of measurement. The decibel (dB), describes the loudness or intensity of a sound (refer to Figure 6-1). Measurement of decibels is important as exposure to increased intensities of sound could potentially lead to permanent hearing loss.

On the noise “thermometer”, there are illustrations of typical sound levels for various activities (refer to Figure 6-1). The “threshold of pain” (140 dBA, or more than 100,000,000 μPa) at the top will vary with the individual. On the right at the bottom it shows “0” decibels, but as explained earlier this is, by definition, 0 dB SPL re: 20 μPa or the quietest sound the average person can hear at 1,000 Hz. That is why it coincides with 20 μPa on the left side. People with sensitive hearing often are able to detect sounds below this defined level of “0”.

When monitoring noise exposures with sound level meters, readings are usually frequency weighted and time weighted. Frequency weightings are readings based on how the ear hears sound and time weightings is averaging sound over a given period of time. The most commonly used frequency weighting is the A-weighted response, which also measures the sound intensity in dBA. This particular response simulates the sensitivity of a normally functioning ear, and is a good indicator of potentially harmful sound levels. The time weighting allows for the measurement of the average exposure of the frequency weighting.

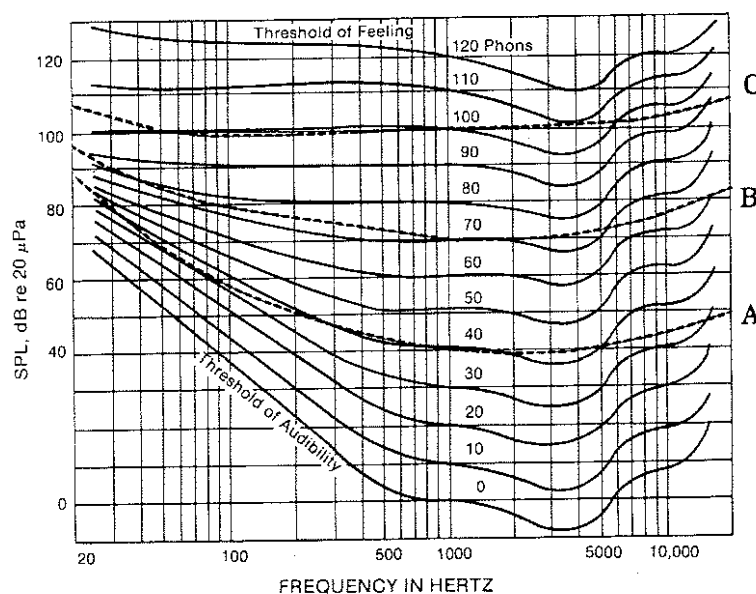


Figure 6-2: Equal Loudness Contours

Figure 6-2 shows the "equal loudness contours" of human hearing. The scale on the left is in decibels (SPL re: 20 micro Pascals of pressure - the definition of 0 dB at 1,000 Hz) and the bottom scale is in frequencies (20 to 20,000 Hertz). The lines across the grid show how loud (intense) sounds must be at the various frequencies before they are perceived by the ear as being equally loud ("equal loudness contours") for the very quiet sounds (bottom line - "Threshold of Audibility") up to very loud sounds (top line - "Threshold of Feeling" or sometimes, pain). As sound gets louder this curve flattens out indicating that at more intense levels the ear becomes more efficient in its ability to detect various frequencies. Each curved line which changes shape as the sound becomes louder, is called a "phon."

Note where the A, B and C scales' frequency weighting curves (the filters used in sound level meters to measure sound more closely to the way the ear perceives it) are located. At 40 phons the A scale, at 70 phons the B scale, and at 100 phons the C scale very closely mimic the ear's response. Although it may be more accurate to use the B or C weighting scales when measuring louder sounds, decades of noise measurements and how they affect hearing have all been taken using the A scale. Sound level readings were being made before transistors were invented, let alone the microchip. Technology at that time simply didn't allow those types of measurements.

6-2 Health Effects

NOISE

Hearing loss is the most common effect of workplace exposure to noise. In general, there are two distinct types of hearing loss; conductive and sensorineural. Conductive hearing loss is not a result of noise exposure, but rather the result of a trauma or infection within the ear. Sensorineural, or noise induced hearing loss (NIHL), is directly associated with noise exposure.

When assessing workplace exposure, two categories of noise pose concern to worker health; steady state (continuous) and impact (impulse). Steady state, or continuous noise, refers to noise that is relatively constant throughout worker exposure. Impact, or impulse noises are generally short term, high intensity noises.

Noise induced hearing loss (NIHL), results from a prolonged exposure to excessive noise or a short term exposure to an intense noise. Cilia, the tiny hairs within the inner ear, when exposed to excessive noise, are easily damaged. Once damaged, the inner ear cannot heal or be treated, ultimately inducing permanent hearing loss. Workers affected by NIHL will generally experience difficulty understanding speech in noisy conditions. NIHL is a condition that gradually progresses over time if exposure continues, and unfortunately, any damage sustained is irreversible.

6-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapters 2 and 3 of this manual describes how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. The results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Tables 6-1 and 6-2).

6-4 Sampling Equipment

Evaluation of worker exposure to noise can be undertaken with one of a number sound measuring devices. Personal exposures to noise, for example, should be monitored with a device that is able to detect A-weighted responses such as a sound meter or noise dosimeter.

NOISE

(a) Sound Level Meters

In general, sound level meters consist of a microphone, an amplifier, a preamplifier, frequency weighted filters, meter response circuits, and a digital readout mechanism (refer to Figure 6-3). Most sound levels meters used today can be set to monitor either A-weighted or C-weighted responses. For the purpose of evaluating noise, the sound level meter should be set for A-weighted responses.

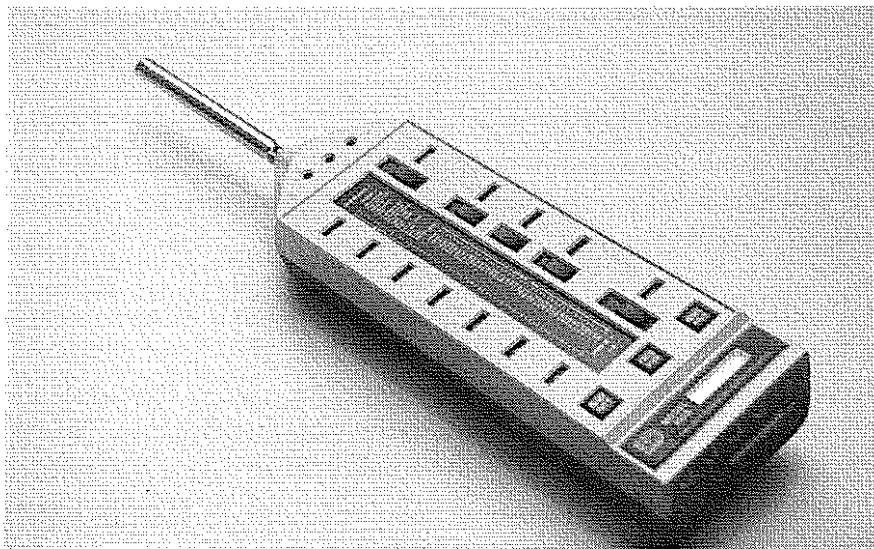


Figure 6-3: Sound Level Meter

Because our ears do not hear different sounds (frequencies) equally well, sound level meters have built-in circuits or filters to compensate for this phenomenon. The most commonly used filters are named A and C and readings taken with them are called A or C weighted, written dBA or dBC. It is intended to measure the loudness or intensity of sound more closely to the way our ears respond to it (refer to Figure 6-4). There are "B", "D" and "E" weighting filters as well, but they are used in specialized noise measurements.

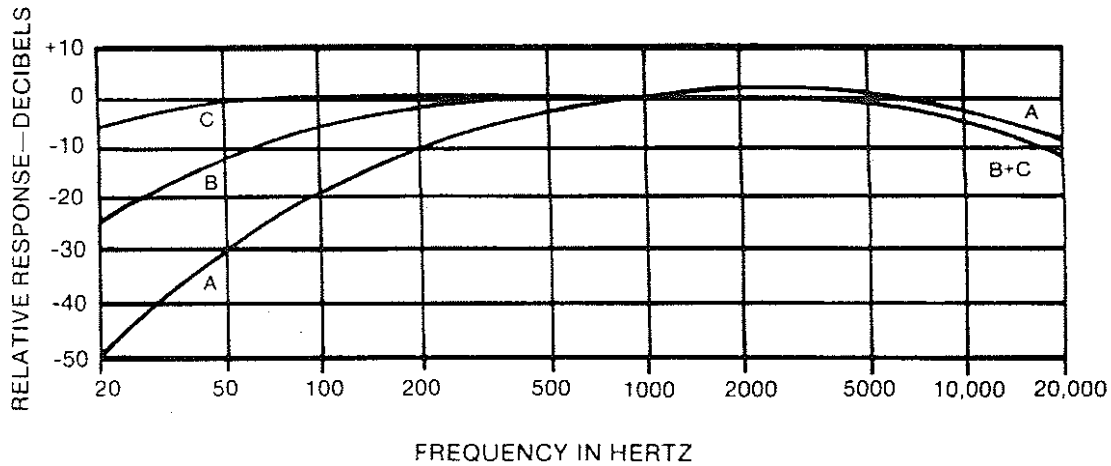


Figure 6-4: A, B, and C Weighting Networks

(b) Dosimeters

Personal noise dosimeters are the most effective method of monitoring a worker's average noise exposure throughout a workshift (refer to Figure 6-5). Noise dosimeters are a type of small electronic sound level meter that measures the noise dose to which a worker is exposed. Dosimeters can be used as sound level meters or as personal sampling devices attached to a worker's collar.



Figure 6-5: Personal Noise Dosimeter

Instrument specifications from section 2.7.2 and 2.7.3 of the Code are as follows:

2.7.2 Instruments used to measure noise levels shall meet the following standards, as updated from time to time

- (1) for sound level meters IEC Standard Publication 651 (1979), "Sound Level Meters", for type 2 sound level meters or better,
- (2) for integrating or averaging sound level meters IEC Standard Publication 804 (1985) "Integrating Averaging Sound Level Meters", for type 2 sound level meters or better, and
- (3) for personal noise dosimeters ANSI Standard S1.25-1991, "Specification for Personal Noise Dosimeter for type 2 tolerances or better

2.7.2 Personal noise dosimeter shall have the following measurement specifications

- (1) **a noise measurement exchange rate of 3dB*,**
- (2) a threshold level of 75 dBA or lower, and
- (3) if measurement is expressed as a percentage, a reading of 100% for an average exposure of noise equivalent to 85 dBA for 8 hours (Lex)

*Some caution is necessary when selecting noise measurement equipment. Mathematically (and the correct method of measuring sound) every 3 dB increase in sound level is actually double the previous level (70 dB + 70 dB = 73 dB). This is known

as the 3 decibel doubling principle, and is required by the Code when selecting monitoring equipment.

6-5 Code Requirements

NOISE

Maximum permissible noise exposure for unprotected ears on a daily basis:

Lex=85 dBA average for 8 hours, or equivalent, including peak impulse noise except

- (a) no exposure to steady state noise over 109 dBA, and
- (b) no exposure to peak impulse noise over 140 dBA

where

- (1) "**Lex**" is the equivalent of 85 dBA for 8 hours (see examples below).
- (2) "**steady state noise**" means noise in which variation of peak pressure levels are on second or less, and
- (3) "**peak impulse**" means noise in which variations of peak pressure levels are greater than one second apart,

Examples of equivalent levels to 85 dBA for 8 hours:

Length of Exposure Average Noise Level	
16 hours	82 dBA
12 hours	83 dBA
10 hours	84 dBA
8 hours	85 dBA
4 hours	88 dBA
2 hours	91 dBA
1 hours	94 dBA
½ hours	97 dBA
¼ hours	100 dBA

Table 6-1: Exposure Limits for Noise (Table 2-2 of the Health, Safety and Reclamation Code for Mines in British Columbia, 1997.)

CHAPTER 7: LIGHT

7-1 Background

Poorly lit working environments can potentially lead to occupational health concerns such as eye strain, eye fatigue, trips, falls, and similar types of injuries. In the mining industry, occupational health issues associated with light exposure arise from both the quantity (the actual amount of foot-candles or lumens), and quality (glare, reflectance, brightness, dark shadows and the type of light) of the light at a work site. Determination of the quality of light in a working environment is therefore, important when assessing worker exposure.

7-2 Sampling Equipment

Lightmeters can be used to assess areas of a work site that may either be poorly lit or excessively lit. Two of the most common types of light meters are the illuminance meters and the luminance meters.

(a) Illuminance Meters

Illuminance is the density of light striking a surface, measured in foot-candles, and can be directly monitored using illuminance meters. Illuminance meters can be used to assess poorly lit areas of a work site.

(b) Luminance Meters

Luminance is the photometric brightness, or measurable brightness of a surface, usually measured in footlamberts (fL) or candelas per square foot. Luminance meters can be used to assess work site areas where lighting conditions may be excessive.

7-3 Code Requirements

The code requires that lighting standards comply with the standards set out in the ANSI/IES Standard RP-7-1991: "American National Standard Practice for Industrial Lighting", unless otherwise authorised by the code. Table 7-1 outlines the currently recommended illuminance categories and illuminance ranges for interior industrial lighting design from the "American National Standard Practice for Industrial Lighting".

Type of Activity	Illuminance category	Ranges of Illuminance		Reference workplane
		lx	fc	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General Lighting Throughout
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on Task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary)
Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

Table 7-1: Currently recommended illuminance categories and illuminance ranges for interior industrial lighting design.

CHAPTER 8: HEAT & COLD STRESS

8-1 Background

Excessively warm or cool-working environments can cause a worker to undergo physiological stress or strain. Heat stress occurs when excessive temperatures and conditions cause the body's cooling system to fail so that the core body temperature rises to extreme levels. Heat stroke is the most serious effect of heat stress, and is often fatal. Susceptibility levels to excessive heat will vary from worker to worker and therefore, it is difficult to predict when the onset of heat stress will occur. Factors that make a worker more likely to develop heat stroke or other heat stress disorders include age, weight, physical fitness, degree of acclimatization, metabolism, decreased fluid intake, exertion, consumption of alcohol and drugs before or during work and various medical conditions, including high blood pressure.

Cold stress, on the other hand, occurs when the core body temperature drops excessively low. Cold stress cannot only cause conditions such as frostbite and hypothermia, but can reduce productivity in workers even under moderate conditions.

Acclimatization of a worker's body is one of the most critical factors in controlling the effects of extreme environments. Generally, acclimatization to a thermal environment can occur if a worker is exposed to the environment for **two hours a day over a period of eight days**. By following this general principle, the physiological strain to a worker will gradually decrease over time. Managers need to be aware of the importance of acclimatization, and ensure workers are properly acclimatized to their working environment.

Other factors including hydration, physical fitness, health, and age also play major roles in a worker's ability to acclimatize to extreme ambient conditions. Workers should consume a healthy diet and keep well hydrated before, during and after shifts. Beverages containing sugar and salt help the body to retain fluids whereas diuretic drinks such as coffee and alcohol should be avoided.

8-2 Health Effects

HEAT STRESS DISORDERS

(a) Heat Stroke

Heat stroke develops when workers are exposed to temperatures higher than the acclimatization capabilities of their bodies. Generally, heat stroke can be characterised by

pale blue or mottled skin and high internal body temperatures. As a result of increased body temperature, a worker may experience mental confusion or in extreme cases, unconsciousness. If not immediately attended to, heat stroke can become a life threatening condition.

(b) Heat Rash

Heat rash is most prevalent under warm, moist conditions. Basically, a heat rash is the result of an inflammation of the sweat glands and a swelling of the skin. The skin develops a rash which has the potential to greatly reduce a workers ability to cope with heat in the work environment.

(c) Heat Exhaustion and Cramps

Heat exhaustion and cramps again, result from working under adverse conditions. Heat exhaustion is not life threatening, but should be taken as a warning sign in preventing heat stroke.

COLD STRESS DISORDERS

(a) Hypothermia

Hypothermia is a condition in which the internal temperature of the body is low enough that a stress occurs on the body. Hypothermia is a very serious condition that could potentially be fatal. At the onset of hypothermia, a worker might experience shivering, extreme cold, falling blood pressure and an accelerated heart rate.

(b) Frostbite

Frostbite, a less serious cold strain than hypothermia, is basically a freezing of the extracellular fluid in the skin. Once frostbite has attacked an area of skin, there is usually permanent tissue damage.

8-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapters 2 and 3 of this manual describe how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. The results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Tables 8-1 and 8-2).

8-4 Monitoring Equipment

(a) Wet Bulb Globe Temperature (WBGT)

WBGT is currently, the only accepted method of measuring heat stress conditions. The WBGT measures the four primary environmental conditions that contribute to heat stress in workers; air temperature, humidity, air velocity and radiation.

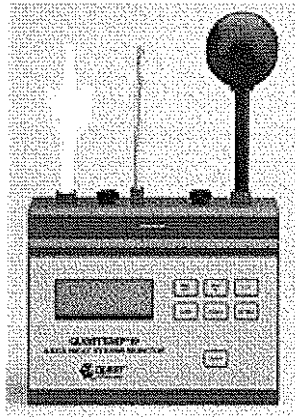


Figure 8-1: WBGT Heat Stress Monitor (Picture provided by Quest Technologies, reprinted with permission.)

There are a number of electronic monitoring devices on the market that can give a direct read out for WBGT. However, natural wet bulb temperature, radiant temperature and ambient air temperature can also be measured independently to determine WBGT.

The standard calculation for determining outdoor WBGT is:

$$\text{WBGT} = 0.7t_{\text{nw}} + 0.2t_{\text{g}} + 0.1t_{\text{a}}$$

Where

t_{nw} = natural wet bulb temperature

t_{g} = radiant (globe) temperature

t_{a} = ambient air temperature

The standard calculation for determining indoor WBGT is:

$$\text{WBGT} = 0.7t_{\text{nw}} + 0.3t_{\text{g}}$$

Where

t_{nwb} = natural wet bulb temperature

t_g = radiant (globe) temperature

Natural wet bulb temperature (t_{nwb}) can be measured using a standard mercury-in-glass thermometer. The thermometer bulb is wrapped in muslin and kept wet. As the water from the wetted muslin evaporates, a cooling effect occurs. The cooled temperature of the “wet bulb” can be compared to a thermometer with a “dry bulb” or no wetted muslin. The difference in the temperatures indicated by the two thermometers gives a measure of atmospheric humidity as the rate of evaporation from the wet-bulb thermometer depends on the humidity of the air.

Radiant heat (t_g), is the amount of solar and infrared radiation on the human body and can be measured with a black globe thermometer. A black globe thermometer, usually consists of a thermometer inserted into a hollow copper bulb that is coated with a black matte paint. Incoming solar and infrared radiation are absorbed onto the black bulb and the heat is absorbed into the centre of the bulb where it is measured by the inserted thermometer.

Ambient air temperature (t_a) is the easiest variable to measure. A simple mercury thermometer can be used to determine the surrounding air temperature.

(b) Wind Chill Index

Wind chill index is a common method of assessing cold. As wind plays a major role in how fast a body cools, assessing wind chill and temperature can allow for measurement to predict dangerous conditions. To determine wind-chill, measurements of dry bulb temperature and wind speed are necessary.

8-5 TLVs™

Work Load Categories

Light Work - sitting or standing to control machines, performing light hand or arm work.

Moderate Work - walking about with moderate lifting and pushing.

Heavy Work - pick and shovel work.

HEAT STRESS (Recommended Standards)

Examples of Permissible Heat Exposure Threshold Limit Values. [Values given in °C WBGT]

Work-Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% Work - 25% Rest, each hour	30.6	28.0	25.9
50% Work - 50% Rest, each hour	31.4	29.4	27.9
25% Work - 75% Rest, each hour	32.2	31.1	30.0

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Table 8-1: Heat Stress TLVs™

COLD STRESS (Recommended Standards)

Threshold Limit Values Work/Warm-up for Four-Hour Shift

Air Temp-sunny sky	No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C	Max Work Period	No.of Breaks	Max Work Period	No. of Breaks	Max Work Period	No. of Breaks	Max Work Period	No. of Breaks	Max Work Period	No. of Breaks
-26 ⁰ to -28 ⁰	Norm.	1	Norm.	1	75 min	2	55 min	3	40 min	4
-29 ⁰ to -31 ⁰	Norm.	1	75 min	2	55 min	3	40 min	4	30 min	5
-32 ⁰ to -34 ⁰	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35 ⁰ to -37 ⁰	55 min	3	40 min	4	30 min	5				
-38 ⁰ to -39 ⁰	40 min	4	30 min	5						
-40 ⁰ to -42 ⁰	30 min	5								
-43 ⁰ & below										

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Table 8-2: Cold Stress TLVs™

Notes for Above Table:

- Schedule applied to any 4-hour work period with moderate to heavy work activity, with warm-up periods of ten (10) minutes in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower.

For example, at -35°C with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 min with 4 breaks in a 4-hour period (Step 5).

2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/m^2 ; 2) all non-emergency work should have ceased at or before wind chill of 2250 W/m^2 . In general, the warm-up schedule provided above slightly under-compensated for the wind at the warmer temperature, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges because windy conditions rarely prevail at extremely low temperatures.
4. TLVs apply only for workers in dry clothing.

CHAPTER 9: ASBESTOS

9-1 Background

Asbestos is the term used to describe a group of natural, fibrous silicates. Generally, asbestos can be broken down into two main categories, the serpentines and the amphiboles. Chrysotile (white asbestos), is the most common type of serpentine mined. Amosite (brown asbestos) and crocidolite (blue asbestos) are the two amphibole asbestosis mined and pose concern with relation to occupational health.

In the mining industry, asbestos can be present as both fibres in the air or as a solid material found in the infrastructure of on site buildings. Generally, when mining asbestos, workers should be concerned with the concentrations of ambient airborne fibres. However, it is equally important to determine the presence of asbestos in the construction materials of on site buildings. Any buildings containing asbestos material may not pose as an immediate health risk to workers, but future damage to building walls etc., could introduce elevated concentrations of asbestos indoors.

In accordance with section 2.2.4 of the Code, the removal of asbestos from on site buildings must adhere to the procedures outlined in the manual "Safe Handling of Asbestos - A Manual of Standard Practices", produced by WCB.

9-2 Health Effects

Inhalation or ingestion of asbestos can potentially cause detrimental health effects to exposed workers. Long and short term exposures to elevated concentrations of airborne asbestos fibres can damage worker lungs and potentially lead to one of a number of fatal chronic diseases.

(a) Asbestosis

Asbestosis is a type of chronic fibrosis in which the lungs gradually become scarred from a prolonged exposure to asbestos fibres. As the soft tissue of the lungs stiffens, destruction of cellular and non-cellular elements within the lungs occurs. Over time the lungs become increasingly stiff and ultimately, breathing is impaired.

(b) Lung Cancer

Exposures, both short and long term, to asbestos has noticeably increased the incidence of lung cancer in workers, in particular, workers who smoke. Generally, lung cancer becomes prevalent 15 - 20 years after exposure. Development of cancer however, is

related to dose and length of exposure therefore, exposures limited to even a few weeks may be significant.

(c) Pleural and Peritoneal Mesothelioma

Mesothelioma is an incurable fatal cancer. In asbestos workers, malignant mesothelioma appears as a thick, diffuse mass which lines the lungs. Again, development of mesothelioma is dependant on dose and length of exposure. For this disease, asbestos exposures have ranged from 2 months to 50 years.

9-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapter 2 of this manual describes how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. A reliable laboratory should be contacted to determine:
 - (a) the specific analytical technique that the laboratory will use to analyse the samples (refer to examples in section 9-4); and
 - (b) the specific NIOSH, OSHA or WCB standardised analytical method recommended for the sampling procedure. **Currently, the accepted sampling method must be approved as a WCB, NIOSH or OSHA standardised analytical method.** The standardised sampling method will outline the necessary equipment required and will guide the sampler through a step by step sampling procedure. Appendix B lists the reference number for each related analytical method.
3. Finally, the results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Table 9-1).

When sampling for bulk asbestos, steps 1,2 and 3 from above should be followed as well as a number of precautionary steps.

- (a) Only persons sampling should be present and sampling should be undertaken in an area that is currently not in use.
- (b) Prior to sampling, the material should be sprayed with a light mist of water as to reduce the potential for creating airborne fibres.
- (c) The use of a protective respirator by the sampler will prevent inhalation of any fibres that do become airborne.

- (d) Any left over material disturbed during sampling must be properly cleaned up.

9-4 Analytical Techniques

(a) Polarised Light Microscopy (PLM)

PLM utilises an optical microscope to examine the various diffractive indices and crystallographic properties of asbestos. This procedure allows for the accurate identification of asbestos fibres from within a bulk sample.

(b) X-Ray Diffraction (XRD)

X-ray powder diffraction is essentially a process by which a sample is scanned with an x-ray beam, and the diffractive properties of the compounds within the sample are assessed. The structure and concentrations of minerals are identified when each diffracted x-ray beam is recorded onto a piece of film. Since each mineral has unique diffraction capabilities based on its crystal structure, concentrations of specific substances can be assessed.

(c) Phase Contrast Microscopy (PCM)

PCM is an analytical technique used to determine the concentration of fibres from an airborne sample. A sample is collected onto a filter and through chemical techniques the filter is made transparent without compromising the integrity of the fibres. Finally, fibres are counted using a phase contrast microscope and the total airborne concentration of fibres can be calculated using the following formula:

$$\text{Result fibres/cm}^3 = \frac{\text{total number of fibres on the filter}}{\text{total volume of air sampled (in cm}^3\text{)}}$$

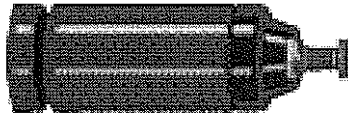
A formalized counting method to determine the number of fibres on a filter must be completed by a certified laboratory technician.

(d) Transmission Electron Microscopy (TEM)

In TEM methods, fibres on a sample filter are analysed using an electron microscope. Filters are prepared chemically, as in the PCM technique, but the microscopic analysis differs. TEM allows for the identification of all particles in the sample, based on the specific electron diffraction patterns.

9-5 Sampling Equipment

When sampling asbestos fibres, a filter cassette assembly attached to a personal sampling pump can be used to determine worker exposure to airborne fibres. The sampler cassette should be fastened to a workers collar so that it is within the worker's breathing zone with the sampling pump attached to the workers belt.



(a) Filter Cassette

Pre-assembled filter cassettes are the simplest method of sampling for airborne asbestos fibres (refer to Figure 9-1).

Figure 9-1: Filter Cassette (Diagram provided by SKC Inc., reprinted with permission)

9-6 General Sampling Procedure

AIR SAMPLE

1. *Calibrate* the personal sampling pump to the specified flow rate. Calibration must be done using a primary standard calibrator (refer to Appendix A). Appendix A outlines a step by step calibration procedure.
2. *Attach* the specified filter into a sampling cassette and support the filter with either a steel screen or cellulose backup pad. The cassette should be firmly closed sealed with plastic tape, **OR** purchase a pre-assembled cassette and filter from the laboratory.
3. *Remove* the cassette filter caps and attach the cassette to the cassette holder.
4. *Connect* the outlet of the cassette holder to the personal sampling pump using flexible tubing .
5. *Clip* the cassette holder to the worker's collar so that it is within the worker's breathing zone. **When sampling for asbestos, the sampler should be face down at all times.**
6. *Prepare* filter blanks. At least two blanks should be prepared and shipped with every 10 samples sent to the laboratory. While sampling, field blanks should accompany the sampler into the environment and be stored with the other samples.

7. *Record* necessary information on a record keeping sheet and begin sampling.

Sampling times can vary depending on the fibre loading in the cassette. Generally, a sampling rate of 1-4 l/min for 9 hours is appropriate when ambient concentrations of asbestos fibres are approximately 0.1 fibre/cc, and there is a low concentration of non asbestos dust. When atmospheric conditions are relatively dusty, smaller sample volumes are required, usually less than 400 l. A number of these samples can be taken consecutively, and the results averaged over the total sampling time. On the other hand, in atmospheres that contain a fibre concentration of much less than 0.1 fibre/cc, larger sample volumes need to be taken to gain viable loadings. Before sampling for asbestos, refer to the detailed sampling procedure outlined in the analytical method.

8. *Check* the filter regularly during a sampling period for overloading or clogging. If overloading or clogging occurs, stop sampling immediately. Also check that the sampler is positioned properly at all times.
9. *Complete* sampling after specified time.
10. *Record* necessary information on a record keeping sheet.
11. *Cap* the inlet and outlet of the filter cassette once apart from the assembly.
12. *Recheck* the calibration of the sampling pump with the same calibration instrument. If the flow rate has changed, record the current flow rate.
13. *Label* the samples clearly and accurately.
14. *Ship* labelled samples and blanks to the laboratory.

BULK SAMPLE

1. *Collect* 1-10 grams of the material to be analysed in a bulk sampling container. The sample should be as representative of the material as possible. This can be done when sampling by penetrating the entire depth of the material.
2. *Seal* the sampling container with tape to ensure no leakage will occur during shipping. If using a plastic container, the sample shall be double bagged.
3. *Ship* the samples in a rigid packing material as to prevent damage during transportation.

9-7 TLVs™

Substance	TWA mg/m3
<i>Asbestos</i>	
<i>Amosite</i>	0.5 fibre/cc
<i>Chrysotile</i>	1 fibre/cc
<i>Crocidolite</i>	0.2 fibre/cc
<i>Other Forms</i>	1 fibre/cc

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Table 9-1: TLVs™ for Asbestos

NOTE: TLVs™ are subject to change with each revision of the *Health, Safety and Reclamation Code for Mines in British Columbia* therefore, it is important to consult and reference the most recent edition of the Code.

CHAPTER 10: DIESEL EXHAUST

10-1 Background

Diesel exhaust is a compound of variable composition containing thousands of chemicals, many of which have proven to be carcinogenic or mutagenic in nature. Dieselized engines, particularly in underground mines, can deteriorate environmental conditions such that levels of exhaust gases and diesel particulates can become excessively high.

When broken down, diesel exhaust is a mixture of particulates and gases and is primarily comprised of carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxide (NO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrocarbons and carbonaceous particles. Although many of the gases in the mixture cause adverse health effects, the respirable particulate mass poses the greatest threat to worker health.

Airborne particulates, that result from the combustion of diesel fuel, are extremely small in size and are composed primarily of organic and elemental carbon. Many gases, including hydrocarbons and sulphates tend to adsorb to the surface of the carbon particulates, resulting in small agglomerations (refer to figure 10-1). As a result of the adsorption of hydrocarbons onto the solid carbon spheres, the toxic effects of worker exposure dramatically increases. Polynuclear aromatic hydrocarbons (PAH's), in particular benzo (a) pyrene, readily adsorb to carbonaceous particulates and are known gaseous carcinogens produced from the incomplete combustion of diesel fuel. Workers can potentially inhale these particulate masses, allowing for deposition of the carcinogenic substances deep within the lungs. Prolonged exposure to such carcinogenic particulates can potentially lead to chronic lung diseases or cancer.

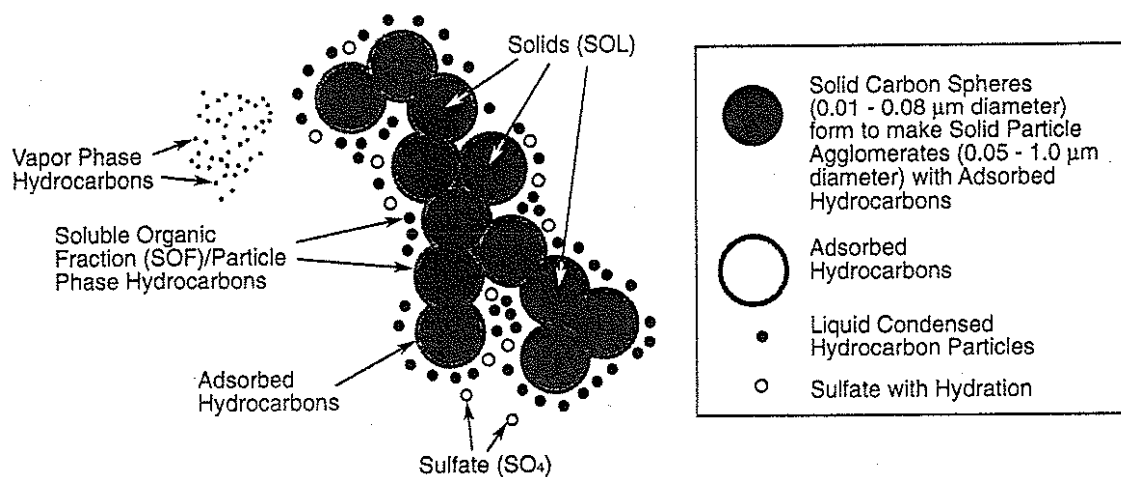


Figure 10-1: Diesel Particulate Mass (Appl. Occup. Environ. Hyg. 12(12) December 1997.)

10-2 Health Effects

As with many contaminant exposures, diesel exhaust has the potential to cause both acute and chronic health effects in workers. Acute effects include symptoms such as headaches, nausea, throat and eye irritation, impaired vision, and a noticeable impairment of pulmonary function.

Chronic effects of a prolonged exposure to diesel exhaust can range from a chronic cough to lung cancer. As diesel particulates are of submicrometer size, they, and any toxins adsorbed to their surface, are deposited deep within the lungs. Once deposition of the contaminants occurs, a very small percentage of the toxins are able to be expelled by a worker's lungs. Continued exposure to carcinogens adsorbed to the surface of these particulates, therefore, leads to the development of respiratory symptoms. Chronic diesel exposure may induce chronic cough, chronic phlegm, breathlessness, and ultimately, the development of lung cancer.

10-3 Sampling Methodology

1. A sampling strategy must be formulated. Chapters 2 and 3 of this manual describe how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. Secondly, a reliable laboratory should be contacted to determine:
 - (a) the specific analytical technique that the laboratory will use to analyse the samples (refer to examples in section 10-4); and
 - (b) the specific NIOSH, OSHA or WCB standardised analytical method recommended for the sampling procedure. **Currently, the accepted sampling method must be approved as a WCB, NIOSH or OSHA standardised analytical method.** The standardised sampling method will outline the necessary equipment required and will guide the sampler through a step by step sampling procedure. Appendix B lists the reference number for each related analytical method.
3. Finally, the results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Table 10-1).

10-4 Analytical Techniques

(a) Elemental Carbon (EC)

The EC method separates and measures the three fractions of respirable aerosols through thermo-optical analysis. A size selective sampler, attached to a personal sampling pump, separates the elemental carbon (EC), organic carbon (OC) and total carbon (TC) from within an air sample. As the respirable EC is almost strictly from diesel exhaust, concentrations of diesel particulates within a sample can be estimated. As coal mines generally have increased coal dust concentrations, an impactor with submicrometer cutpoint must be used to minimise collection of coal dust. It should be noted however, if submicrometer aerosols are present such as tobacco smoke, they will interfere with the size selective sampling of elemental carbon.

(b) Respirable Combustible Dust (RCD)

The RCD method differs from the EC method in that the RCD determines the concentration of combustible aerosols within an air sample rather than strictly diesel particulates. An air sample of respirable fraction is collected onto a quartz fibre filter and the filter is accurately weighed. The combustible fraction of particulates is removed from the sample through combustion during the in laboratory heating process. However, other combustible substances such as oil mist, cannot be differentiated from diesel particulates during analysis therefore, restricting the accuracy of determining diesel concentrations within the air sample.

10-5 Sampling Equipment

When monitoring diesel particulates, respirable combustible dust (RCD), and elemental carbon (EC) are the two most common methods utilised by the mining industry. Monitoring exhaust gases can be done by means of a direct monitoring instruments or integrated samplers. This section of the manual will strictly focus of the monitoring of diesel particulate matter, as monitoring and sampling of gases is discussed in Chapter 11: Gases and Vapours.

(a) Filter Cassette

A filter cassette assembly, attached to a personal sampling pump can be used to determine worker exposure to diesel particulates (example figure 10-2). The sampler should be fastened to a workers collar so that it is within the worker's breathing zone with the sampling pump attached to the workers belt. After sampling, filters can be sent to a laboratory to undergo EC or RCD analysis.

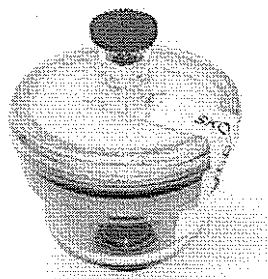


Figure 10-2: SKC Diesel Particulate matter cassette with impactor.

(b) Micro-Orifice Uniform Deposit Impactor (MOUDI)

A MOUDI is a multi-stage cascade impactor used for area sampling of diesel exhaust. Generally, the lower impactor stages use chemically etched, micro-orifice impaction plates. Impactors are size selective samplers that separate dust particles based on particle size and inertia. An air sample is jetted through an impactor with a personal sampling pump, and particles are impinged onto a collection plates specific to that particle's size and inertia (refer to figure 10-3).

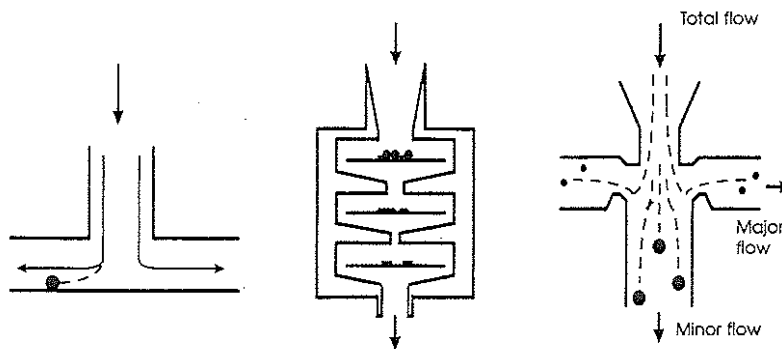


Figure 10-3: Inertial Impactors (*The Occupational Environment*, AIHA Press, 1997)

10-6 General Sampling Procedure

1. *Calibrate* the personal sampling pump to the specified flow rate. Calibration must be done using a primary standard calibrator (refer to Appendix A). Appendix A outlines a step by step calibration procedure.
2. *Attach* the specified filter into a sampling cassette and support the filter with either a steel screen or cellulose backup pad. The cassette should be firmly closed sealed with plastic tape, **OR** purchase a pre-assembled cassette and filter from the laboratory.

3. *Remove* the cassette filter caps and attach the cassette to the cassette holder.
4. *Connect* the outlet of the cassette holder to the personal sampling pump using flexible tubing.
5. *Clip* the cassette holder to the worker's collar so that it is within the worker's breathing zone.
6. *Prepare* filter blanks. At least two blanks should be prepared and shipped with every 10 samples sent to the laboratory. While sampling, field blanks should accompany the sampler into the environment and be stored with the other samples.
7. *Record* necessary information on a record keeping sheet and begin sampling. A sample record keeping sheet can be found in Appendix B.
8. *Check* the filter regularly during a sampling period for overloading or clogging. If overloading or clogging occurs, stop sampling immediately. Also check that the sampler is positioned properly at all times.
9. *Complete* sampling after specified time.
10. *Record* necessary information on a record keeping sheet.
11. *Cap* the inlet and outlet of the filter cassette once apart from the assembly.
12. *Recheck* the calibration of the sampling pump with the same calibration instrument. If the flow rate has changed, record the current flow rate.
13. *Label* the samples clearly and accurately.
14. *Ship* labelled samples and blanks to the laboratory.

10-7 TLVs™

Substance	TWA		STEL	
	ppm	mg/m3	ppm	mg/m3
<i>Respirable combustible dust (RCD)</i>		1.5**		
<i>Carbon Monoxide (CO)</i>	25	29		
<i>Carbon Dioxide (CO₂)</i>	5000	9000	30000	54000
<i>Nitric Oxide (NO)</i>	25	30		
<i>Nitrogen Dioxide (NO₂)</i>	3	6	5	10
<i>Sulphur Dioxide (SO₂)</i>	2	5	5	10
<i>Polynucleic Aromatic Hydrocarbons (PAHs)</i>		0.2		

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**Not ACGIH

Table 10-1: TLV™ Exposure Limits for Diesel Exhaust

NOTE: TLVs™ are subject to change with each revision of the *Health, Safety and Reclamation Code for Mines in British Columbia* therefore, it is important to consult and reference the most recent edition of the Code.

CHAPTER 11: GASES & VAPOURS

11-1 Background

Gases and vapours are non particulate airborne substances that readily mix with the ambient air. Contaminant gases and vapours at mine sites are those substances that are not found in normal ambient concentrations. As gases and vapours become concentrated in the air, the potential threat to worker health and safety increases. On the other hand, gases such as oxygen can threaten worker health if found in excessively low concentrations.

Gases are materials that remain in a gaseous state at standard temperature and pressure (25⁰C and 760mmHg). Vapours, however, are solids or liquids at standard temperature and pressure, but due to ambient conditions, have evaporated into a gaseous phase. A substance begins to evaporate into vapours when it reaches its boiling point, just like water evaporates into steam when it reaches 100⁰C. Many materials however, have a much lower boiling point than water, readily volatilizing in what might not appear to be adverse ambient conditions.

In the mining industry, the gases that pose the greatest concern to worker health and safety are oxygen, carbon dioxide, methane, carbon monoxide, hydrogen sulphide, sulphur dioxide, oxides of nitrogen, hydrogen and finally, radon. However, there are many other gases and vapours that could pose as potential health risks, some of which were discussed in earlier chapters of this manual.

(a) Oxygen (O₂)

Oxygen is the only major gas that needs to be maintained in high concentrations therefore, occupational health concerns are centred around oxygen depleted environments. Most oxygen poor environments, less than 19.5% oxygen, are the result of the depletion or displacement of oxygen by various gases. When such conditions are present, an air supply such as a SCBA or and air supplied respirator must be supplied.

(b) Carbon Dioxide (CO₂)

Carbon dioxide is a non-combustible, colourless, odourless gas. When concentrations of CO₂ reach elevated levels, workers may develop an acidic taste and begin to experience an increased ventilation of the lungs. Carbon dioxide can occur naturally underground or by means of a mechanical or chemical process. Generally, sources include blasting, fire, and worker respiratory systems.

(c) Methane (CH₄)

Methane is a colourless, odourless, non toxic gas found most commonly in underground coal mines. Although not physiologically harmful to worker health, methane is an extremely explosive gas with an explosive range of 5% to 15%, and must be closely monitored at all times.

(d) Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. CO acts as a chemical asphyxiant, highly toxic to workers subjected to elevated concentrations. Although highly flammable, the asphyxiant properties of this gas poses the greatest threat to worker health. Sources include internal combustion engines, fires, and blasting.

(e) Hydrogen Sulphide (H₂S)

Hydrogen sulphide is a highly toxic, colourless gas that is easily distinguishable by its rotten egg odour. This gas is considered highly toxic and highly explosive, and is most often found in mines as a result of its solubility in water. Low concentrations are usually found in the seepage areas of a mine and high concentrations are generally located near an exposed ground water source. Although H₂S has a very distinguishable odour, the odour threshold is extremely low, in the range of parts per billion (ppb). In other words, the odour dissipates after one or two inhalations as a result of the olfactory nerves becoming paralyzed. Worker exposure to elevated concentrations will result in death within minutes.

(f) Sulphur Dioxide (SO₂)

Sulphur dioxide is one of the few non flammable gases found in mines. Usually formed as a result of the combustion of sulphur containing compounds, elevated concentrations can pose a health risk to workers. As ambient concentrations increase, worker exposure will result in eye nose and throat irritation eventually reaching life threatening levels.

(g) Oxides of Nitrogen (NO_x)

Nitrogen is a naturally occurring gas that is chemically inert under normal atmospheric conditions. However, various compounds containing nitrogen such as nitric oxide and nitrogen dioxide can be extremely toxic to workers. These gases have the potential to react with moisture in the ambient air and with the moisture in a worker's lungs. Generally, underground mine sources are internal combustion engines and blasting processes. High concentrations of oxides of nitrogen could rapidly lead to worker death. Once exposed, the effects of exposure may not occur until several hours later, ultimately resulting in edema.

(h) Hydrogen (H₂)

Hydrogen can be described as a colourless, odourless, tasteless, non-toxic gas and is produced in underground mines by a number of activities. Process such as battery charging, the use of acid on metals or the use of steam/water on hot objects, all increase the levels of hydrogen in enclosed spaces. Although, hydrogen is physiologically non toxic to worker health, it is considered an extremely explosive gas.

(g) Radon

Radon is a radioactive gas primarily found in uranium mines, but can be found in trace amounts in other mines. The gas itself diffuses into the mine through ground water and the rock strata. Once radon is released into the environment, a decay process continues, forming radon products (radon daughters). During this decay process, alpha or beta particles are emitted, increasing the radioactivity of the ambient environment. High exposures to radon generally occur as a result of poor ventilation in the basements of buildings or underground mines. Exposure to radon has been linked with a high incidence of lung cancer in exposed workers.

11-2 Health Effects

Gases and vapours pose a health risk to workers as they have the ability to pass from the lungs directly into the bloodstream and therefore, can directly affect various regions of the body. Toxicity of various gases and vapours is highly dependant on the solubility of the substance, the concentration being inhaled, and the exposure time of the worker. Highly soluble substances tend to react with the moisture in the nasal region upon inhalation. Acute effects include symptoms such as irritation, nausea, congestion, and headaches. However, depending on concentration and toxicity of the inhaled substance, exposure could potentially be life threatening. As substances become less soluble they are able to penetrate deeper into the respiratory tract. Moderately soluble substances tend to cause acute reactions such as spasms in the bronchio region. As gases and vapours penetrate deep into the respiratory tract, adverse health effects such as pneumonitis and pulmonary edema can occur.

Asphyxiants are gases and vapours that use up or interrupt the supply of oxygen to a workers lungs. Asphyxiants such as methane and nitrogen do not affect a worker directly, but rather, displaces the oxygen in the ambient air reducing the amount of oxygen available for inhalation. Chemical asphyxiants such as carbon monoxide, affect the cells in the body directly, interfering with oxygen transport cells within the blood.

11-3 Sampling Methodology

1. A sampling strategy must be formulated. A chapter 2 and 3 of this manual describe how to formulate a sampling strategy and is intended to be used as a guide. A sampling strategy is necessary to determine the number and frequency of samples required to obtain conclusive results.
2. A reliable laboratory should be contacted to determine:
 - (a) the specific analytical technique that the laboratory will use to analyse the samples (refer to examples in section 11-4); and
 - (b) the specific NIOSH, OSHA or WCB standardised analytical method recommended for the sampling procedure. **Currently, the accepted sampling method must be approved as a WCB, NIOSH or OSHA standardised analytical method.** The standardised sampling method will outline the necessary equipment required and will guide the sampler through a step by step sampling procedure. Appendix B lists the reference number for each related analytical method.
3. Finally, the results of the sampling must be assessed to determine any on site exposures exceeding the specified exposure limits (refer to Table 11-1).

11-4 Analytical Methods

(a) Gas Chromatography (GC)

Gas chromatography analysis allow for the detection of minute quantities of various gases from within an air sample. Air samples are generally collected in sorbent tubes. The contaminants adsorbed to the sorbent material within the tubes are then desorbed into a liquid media. Samples are injected into a specialised GC column and are forced through the column by means of a pressurised gas. The various contaminant gasses and vapours from within the sample adsorb to the sorbent material within the GC column. Depending on the affinity of each contaminant to adsorb to the sorbent within the column, a separation of the various substances occurs. Once separation has occurred, a detector analyses and records even minute quantities of the various gases and vapours present. GC is most commonly used for detecting carbon dioxide and hydrocarbons.

(b) Ion Chromatography (IC)

Ion chromatography is a form of ion exchange chromatography that analyses the anions of various contaminant compounds. IC separates ions using an ion-exchange column, a suppresser column, and a detector. Ions are separated in the ion-exchange column, with

any unwanted analytes being removed by the suppresser column. The detector is able to detect concentrations of certain contaminants based on the ion separation capabilities of the of the various substances. IC can be used to analyse substances such as hydrogen sulphide and sulphur dioxide.

(c) Visible Absorption Spectrophotometry

Many gases and vapours, including nitrogen dioxide, can be detected from within an air sample by means of visible absorption spectrophotometry. Each contaminant has unique physical and chemical properties, including the ability to absorb a specific spectra of visible light. A light source is passed through a sample and focused through a dispersion device. The visible light that has not been absorbed by the contaminants within the sample is collected and analysed. Determination of the contaminants present within the sample will be done by analysing the visible light spectrum not absorbed and comparing it that of a know contaminant.

(d) Infrared Absorption Spectrophotometry

IR evaluates the structure of various contaminants in a sample rather than the basic concentrations. Basically, infrared light is passed through a prepared liquid sample and a liquid blank. The light energy that is transmitted at each wavelength is compared to reference wavelengths. Comparison to references allow for identification of the various mineral components in the sample.

(e) High Performance Liquid Chromatography (HPLC)

Airborne contaminants with high boiling points or are unstable at high temperatures, cannot be readily analysed using GC methods. HPLC is a similar analytical method to GC, but allows for the separation of contaminants with such characteristics. Instead of using gas to move contaminants through a column, a liquid media is used. Under high pressure, the liquid solvent forces contaminants though a tiny sorbent column, allowing for the separation of different substances based on specific adsorption properties. A detector is then used to analysed the concentrations of specific contaminants. HPLC is particularly useful in the detection of PAH's.

11-5 Sampling Equipment

INTEGRATED SAMPLERS

(a) Sorbent Tubes

Sorbent tubes are generally small glass tubes packed with one or more layers of sorbent material (refer to Figure 11-1). Sorbent materials are solid materials such as activated charcoal or silica gel that allow for the adsorption of specific gases and vapours on their

surfaces. When an air sample is passed through a sorbent tube, contaminants will adsorb to the surface of the sorbent material for which they have an affinity. Sorbent tubes are generally attached to a personal sampling pump as part of a sampling train, and can be used as a personal sampler for detecting worker exposure to various gases and vapours.

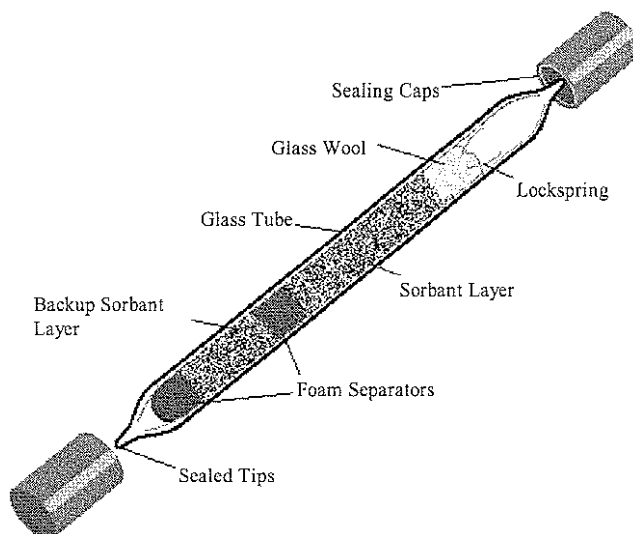


Figure 11-1: Sorbent Tube (Diagram provided by SKC Inc., reprinted with permission.)

(b) Impingers

Impingers are glass tubes designed to collect airborne contaminants onto a liquid media. By means of a personal sampling pump, impingers draw air through an apparatus at a known velocity and project an air sample against a wetted surface. The particles from the air sample lose their velocity and become trapped in the liquid media. The liquid media can then be analysed to determine the airborne concentration of various gases and vapours. Impingers are generally used as a personal sampling devices, worn on a worker's collar to determine exposure throughout an entire shift.

(c) Passive Dosimeters

Passive dosimeters allow for the detection of exposures to various gases and vapours over a workshift. Dosimeters, used for the collection of gases and vapours, contain a sorbent material and a diffusion barrier (refer to Figure 11-2). Passive samplers do not rely on a sampling pump to obtain a sample, but rather rely on the diffusive properties of the various airborne contaminants. These devices are exceptionally easy to use and are relatively inexpensive.

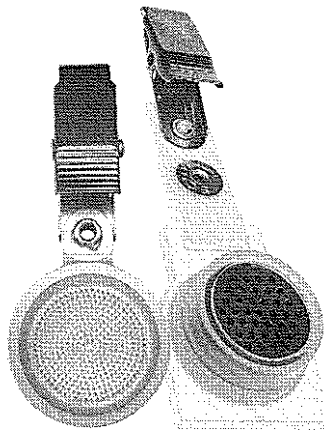


Figure 11-2: Passive Dosimeter (Picture provided by SKC Inc., reprinted with permission.)

GRAB SAMPLERS

(d) Sampling Bags

Sampling bags are a type of grab sampler that allows for the collection of an air sample at a specific site, at a given point in time (refer to Figure 11-3). Other devices such as plastic jars and syringes can also be used to collect instantaneous samples. Grab samples are useful in detecting unknown contaminants or to measure contaminant levels from specific onsite processes.

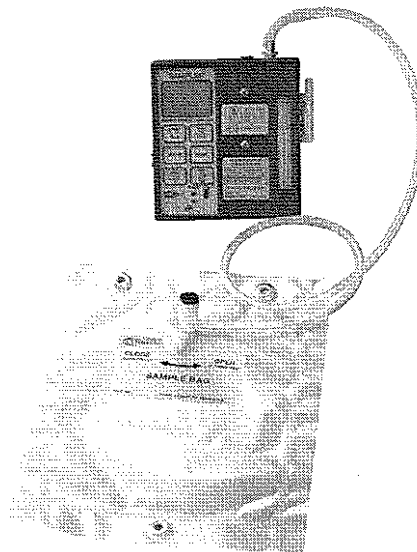


Figure 11-3: Sampling Bag Train (Picture provided by SKC Inc., reprinted with permission.)

DIRECT-READING MONITORS

(d) Detector Tubes

Detector tubes are colourimetric indicator tubes used to analyse the presence of various gases and vapours. A series of glass tubes are packed with an inert sorbent solid or granular material. The various sorbents are lined with reagents that change colour when they react with a specific contaminant or class of contaminants. Air is drawn through the tubes, and a visible colour change will occur with the presence of specific chemical contaminants. Detector tubes are generally part of a hand held direct reading instrument, and therefore are relatively easy to use.

(e) Electrochemical Sensors

Electrochemical sensors are gas and vapour specific sensors within a direct-reading instrument. Specific gas and vapour sensors can be worn to detect elevated levels of various contaminant gases and vapours. Approximately 50 different gases can be monitored, including all of the major gases mentioned. These sensors can be designed as compact personal samplers and can be worn by workers throughout a shift with little interference.

11-6 General Sampling Procedure

1. *Calibrate* the personal sampling pump to the specified flow rate. Calibration must be done using a primary standard calibrator (refer to Appendix A). Appendix A outlines a step by step calibration procedure.
2. *Connect* the outlet of the sampler to the personal sampling pump using flexible tubing (refer to Figure 11-4).
3. *Clip* the sampler to the worker's collar so that it is within the worker's breathing zone.
5. *Prepare* filter blanks. At least two blanks should be prepared and shipped with every 10 samples sent to the laboratory. While sampling, field blanks should accompany the sampler into the environment and be stored with the other samples.
4. *Record* necessary information on a record keeping sheet and begin sampling. A sample record keeping sheet can be found in Appendix B.
5. *Check* the sampler regularly during a sampling period for overloading or clogging. If overloading or clogging occurs, stop sampling immediately. Also check that the sampler is positioned properly at all times.

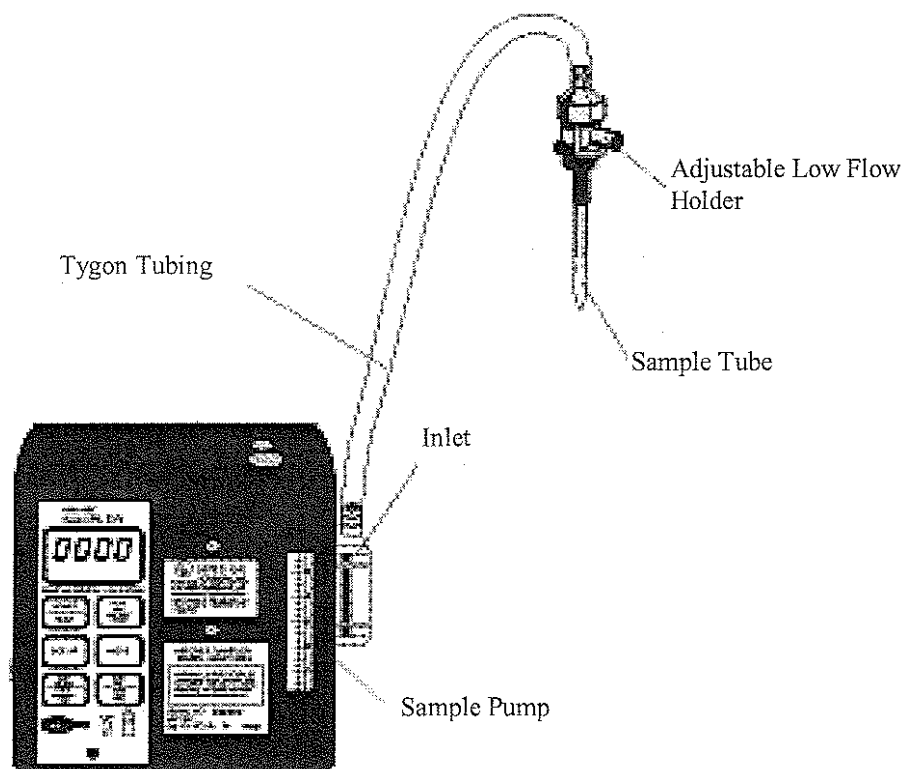


Figure 11-4: Pump-Sample Head Assembly (Diagram provided by SKC Inc., reprinted with permission.)

7. *Complete* sampling after specified time.
8. *Record* necessary information on a record keeping sheet.
9. *Cap* the inlet and outlet of the sampler if necessary once apart from the assembly.
10. *Recheck* the calibration of the sampling pump with the same calibration instrument.
If the flow rate has changed, record the current flow rate.
11. *Label* the samples clearly and accurately.
12. *Ship* labelled samples and blanks to the laboratory.

11-7 TLVs™

Substance	TWA		STEL	
	ppm	mg/m3	ppm	mg/m3
Acetone	750	1780	1000	2380
Ammonia	25	17	35	24
Carbon Dioxide	5000	9000	30000	54000
Carbon Monoxide	25 Asphyxiant	29		
Chlorine	0.5	1.5	1	3
Formaldehyde	1	1.5	2	3
Hydrogen	Asphyxiant			
Hydrogen Chloride			5 (TLV-C)	7.5 (TLV-C)
Hydrogen Sulphide	10	14	15	21
Methane	Asphyxiant			
Methylene Disphenyl Isocyanate (MDI)	0.005	0.005		
Nitric Acid	2	5	4	10
Nitric Oxide	25	30		
Nitrogen	Asphyxiant			
Nitrogen Dioxide	3	6	5	10
Nitrous Oxide	50	90		
Oxygen				
Ozone	0.1 (TLV-C)	0.2 (TLV-C)		
Radon				
Sulphur Dioxide	2	5	5	10
Sulphuric Acid		1		3
Toluene	100	375	150	560

From American conference of Governmental Industrial Hygienists, Inc., 1994-1995 Threshold Limit Values™ and Biological Exposure Indices™ Reprinted with permission.

Table 11-1: TLVs™ for Gases and Vapours

NOTE: TLVs™ are subject to change with each revision of the *Health, Safety and Reclamation Code for Mines in British Columbia* therefore, it is important to consult and reference the most recent edition of the Code.

CHAPTER 12: ERGONOMICS

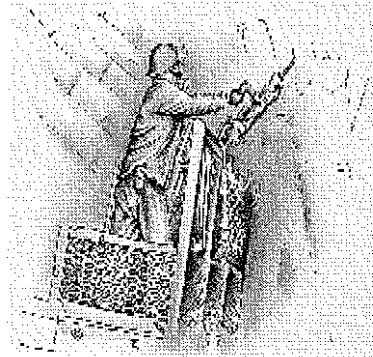
12-1 Background

Ergonomics is a field of applied science concerned with the design of work and how the stresses of work and the workplace affect people, productivity and quality of work. It is often defined as "fitting the job to the person" and involves identifying the physical and mental demands required to perform a job safely. Despite how we choose to define "ergonomics", the application of ergonomic principles in the workplace is necessary in the prevention of the development of work-related musculoskeletal disorders.

Work-Related Musculoskeletal Disorders (MSDs) is defined by the Workers Compensation Board of British Columbia (WCB) as an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including sprain, strain and inflammation that may be caused or aggravated by work. Some typical work-related musculoskeletal disorders are tendonitis, hand-arm vibration syndrome and back strains and sprains.

12-2 Ergonomics in Mining

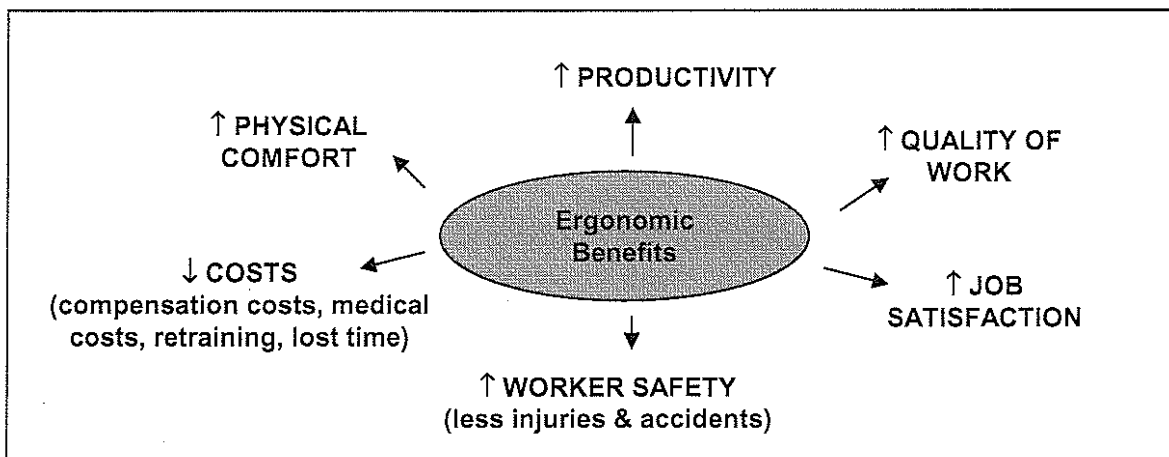
The mining industry employs a diverse group of workers who perform a variety of job tasks. The physical diversity of people in mining involves differences in height, weight, strength, and the general ability to withstand the mental and skillful stresses of a particular job whether it is in an office setting or in the field as a mechanic. This is why the application of ergonomics in the mining industry, fitting the job to the worker, whenever practical rather than the worker fitting the job, is essential. Ergonomics benefits both the employer and the worker by maximizing productivity and quality of work, increasing physical comfort and job satisfaction, and decreasing work related injuries and injury costs.



The ultimate goal of implementing ergonomics and musculoskeletal disorder prevention is to eliminate and reduce workplace risk factors for musculoskeletal disorders by recognizing, evaluating and controlling them.

12-3 Benefits of Ergonomics and Musculoskeletal Disorder Prevention in Mining

Implementing ergonomic principles does not have to be elaborate or expensive and has several benefits for both the employer and employee. The principles of ergonomics recognize the physical diversity of people in the mining workforce and once we acknowledge these differences we can begin to use ergonomics as a tool to tailor the job to the worker and decrease the risk of injury.



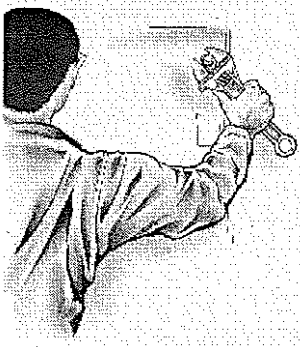
12-4 Ergonomic Risk Factors

A risk factor is a negative effect that can increase the risk of injury. The degree or amount of risk can be determined by the magnitude (how much) of exposure to the risk factor(s), frequency (how often) of exposure to the risk factor(s), and the duration (how long) of exposure to the risk factor(s).

Ergonomic risk factors are conditions of the job, process or equipment that contribute to the risk of developing a musculoskeletal disorder. Several risk factors can interact and produce an overall effect greater than their individual effects and thus further increase injury risk. For example a worker using an impact wrench is exposed to vibration from the tool and is required to apply a great amount of grip force to operate the tool. In this situation the worker is exposed to the two major risk factors of vibration and force which may interact and increase the workers injury risk more than if he was only exposed to one of the risk factors such as force.

There are several risk factors associated with the development of work-related musculoskeletal disorders. They are the following:

1) Repetition



Repetition refers to the number of times a certain task, action or similar motions is performed each shift, day, hour or minute. The amount of repetition a joint or muscle group can accommodate is limited and once the limitations are exceeded the risk for injury is probable. Repetition on its own is not risk factor but rather the risk is associated with the number and speed of movements, the amount of force exerted with each repetitive movement and the postures adopted to perform the repetitive task.

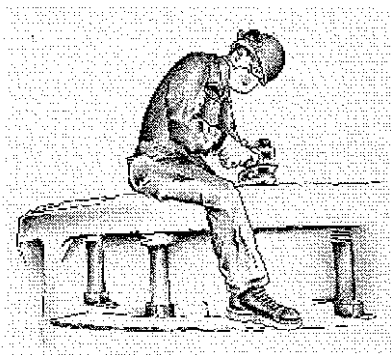
2) Duration

Duration refers to the length of time a task is performed and/or a worker is exposed to a risk factor without a break. Muscles, ligaments and tendons require an appropriate amount of rest to recover sufficiently from exertions. If sufficient rest is not provided, fatigue will develop and the probability of a musculoskeletal disorder developing increases. Recovery time depends on the level of muscular effort required to perform the task and how long the task is performed. The longer and harder the muscles are worked, the longer the recovery time required.

3) Force

Force refers to the amount of effort required to perform a task or hold a posture. People generate force by using muscles to push, pull, lift, grip, turn, move and throw. When muscles generate force, ligaments and tendons are stressed. The greater the force produced the greater the stress and risk for injury. The amount of force generated by the muscles is different depending on the task, the person performing the task and the presence of other risk factors.

4) Posture



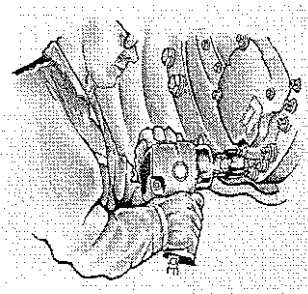
The "neutral" posture for a part of the body (shoulders, forearms, back, neck) is the posture it assumes when relaxed and/ or the posture at which it is least stressed. Neutral postures place the least amount of stress on the body and is considered "optimal" because muscles can generate the most amount of force and tendon, ligaments and nerves are not stressed.

Awkward postures are those positions in which a part of the body is moved to, or held in that is far from the "neutral" position. As a joint moves further away from

neutral, more stress is placed on the muscles, tendons and nerves and there is a higher injury risk. For example awkward postures for the back are bending forward (flexion), side to side(lateral flexion) or backward (extension).

5) Vibration

Vibration refers to the mechanical oscillations produced by either regular or irregular periodic movements and is characterized by frequency, amplitude, acceleration and direction. Vibration is quite complex to measure and is usually transmitted from the vibrating source through the hands, buttocks and feet. Various parts of the human body are affected by vibration frequency differently.

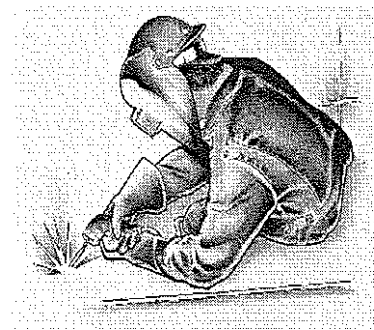


Vibration from vibrating hand tools, for example an impact wrench, can cause damage to the blood vessels and nerves of the hands and lead to a condition called Hand-Arm Vibration Syndrome (HAVS).

Whole body vibration (WBV) tends to affect heavy equipment operators who are exposed to shocks, bumps and rough terrain. The vibration is transmitted to the operator through the seat and backrest. Over the long term WBV can lead to serious damage of the lower spine and contribute to chronic back discomfort and other disorders.

6) Contact Stress

Contact stress refers to localized pressure or force applied to a body part. Contact stress can cause soft tissue damage and can compress tendons and nerves. Exposing the body to contact stress such as a mechanic kneeling on hard cement surfaces or a heavy equipment operator sitting for long periods of time (buttocks) can cause discomfort and which increases the risk of developing a musculoskeletal disorder.



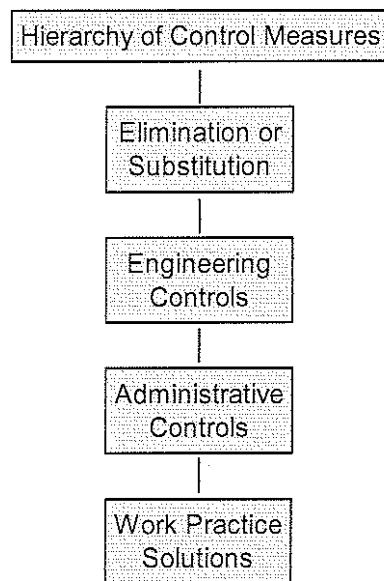
7) Work Organization

Many organizational factors can affect a worker's ability to perform his or her job task and can play a major role in the development of work related musculoskeletal disorders. Examples of organizational factors are work pacing, job pressure, shift work, work load, lack of appropriate feedback, wage incentives, time pressures, psycho-social stresses and new technology. Work organization factors can affect stress levels, work technique, muscle tension and ability to adapt to change.

12-5 Identifying, Evaluating, and Controlling Musculoskeletal Risk Factors in the Workplace

The process of identifying and evaluating workplace risk factors for musculoskeletal disorders does not have to be complex. There are several tools available which can be used to determine the potential “risk” of a particular job or job task. For example, mechanics are at a “high risk” for the development of Hand-Arm Vibration Syndrome (HAVS) because of their exposure to vibrating hand tools. However, they also may be at risk for the development of a musculoskeletal disorder of the back because of the awkward postures and heavy objects they manipulate to complete their job tasks. The identification and evaluation tools include checklists, lifting and carrying indexes, and measurements of heights, weights, distances and vibration. These tools help to prioritise job tasks are considered “high risk” in comparison to other jobs and which job tasks should be tackled/ controlled first.

Once the risk factor(s) is/are identified, solutions and controls must be developed in order to eliminate or reduce the worker’s exposure to the risk. The Hierarchy of Control Measures is used as a guideline when developing solutions to control workplace risk factors.



- ***Elimination or Substitution***

This stage refers to the elimination or substitution of work equipment or processes that expose a worker to the musculoskeletal disorder risk factor. Solutions are best implemented at this stage of controls since the worker exposure to the high risk factor is completely eliminated. An example is using a forklift to lift heavy objects rather than

manually lifting the objects. In this case, the worker exposure to lifting is completely eliminated by the forklift performing the lift.

- ***Engineering Controls***

This stage is the second stage of implementation for solutions/ controls. Engineering controls involve making physical changes to the workstation or equipment to control worker exposure to the risk factor (s). Engineering controls act on the hazard and control employee exposure to that hazard without relying on the worker to take self-protective action or intervention. An example of an engineering control is an adjustable workbench for welders so that they can reduce awkward postures in their neck and back by increasing the work height and bringing the work closer to the worker. In this case the awkward postures in the neck and back are minimized because the worker no longer has to bend over as much to complete the job task. Engineering controls can be applied to hand tools, equipment, workstations and manual materials handling.

- ***Administrative Controls***

Administrative controls are often a last resort after substitution/elimination and engineering controls have been considered without success. Administrative controls only limit the workers exposure to the risk factors, it does not eliminate the worker's exposure. These controls can be applied to job rotation, job enlargement, work schedule arrangement, increasing number of workers performing the job task and ensuring proper equipment maintenance. These options reduce the duration that a worker is exposed to a risk factor. For example, a labourer may rotate from a shovelling task to an equipment operating task to take a break from the shovelling task and perform a job task that does not require the same postures, motions and muscle groups as shovelling thus decreasing injury risk due to over exertion.

- ***Work Practice Solutions***

Implementing controls at this level will reduce the workers exposure to musculoskeletal disorder risk factors by altering the way in which a job task is performed and is frequently incorporated with the above stages. Work practice solutions and controls involve:

- Ensuring the worker is following proper work procedures.
- Ensuring new and reassigned employees are physical fit to perform new job tasks by creating a conditioning program.
- Providing workers with ergonomic and musculoskeletal disorder prevention training to decrease injury rates and worker exposure to risk factors.
- Ensuring workers are wearing adequate personal protective equipment.

It is important to note that it is a last resort to provide workers with additional personal protective equipment (PPE). Implementing engineering and administrative controls is preferred since additional PPE places a higher demand on the worker and usually makes the worker less comfortable.

12-6 Summary

Ergonomic and musculoskeletal disorder prevention should be a key component of all safety programs at any mine. It provides worker awareness regarding risk factors that can

lead to musculoskeletal disorders that prevent workers from being productive and physically comfortable at work. Ergonomic intervention decreases compensation costs, medicals costs, retraining costs, and increase job satisfaction and quality of life. Whenever changes to equipment or controls are going to be implemented it is important to have team, involving workers who perform the job task, union representatives and management assess the risk factors and to ensure that the new equipment or controls are being used properly and that new risk factors have not developed. It may take several attempts before a solution to eliminate a risk factor is found, however, don't get frustrated, and give ergonomics a chance because the process works.

CHAPTER 13: GLOSSARY

A

absorbing medium: A collection medium onto which contaminants will either dissolve or chemically react.

absorbtion: When a substance is uptaken through an exchange boundary such as the skin.

acclimatisation: Adaptation to a changed environment.

ACGIH: American Conference of Government Industrial Hygienists.

activated charcoal: A collection medium commonly used for gas adsorption.

active sampling: The collection of airborne contaminants by means of forced air through a sampling pump-sampler train.

acute exposure: Exposure to a high dose over a short period of time.

adsorbing medium: A collection medium that attracts airborne contaminants onto the surface of the collection material.

adsorption: Condensation of gases, liquids or dissolved substances onto the surface of a solid particle.

aerosol: Microscopic solid or liquid particles suspended in air.

aerodynamic diameter: Diameter of a sphere that would have the same settling velocity as a specified particulate.

agent: A chemical, physical or biological substance or process that has a deleterious effect on exposed workers.

air bag: A plastic bag used for area grab sampling.

airborne contaminant: An airborne substance found in unusual ambient concentrations.

air sampling: Collection and analysis of samples of air to determine concentrations of airborne pollutants.

alveoli: Small air sacs at the end of the bronchiole that make up gas exchange region of the lungs.

ambient: The surrounding environment.

ambient monitoring: Monitoring of the surrounding environment.

amorphous: A non-crystalline arrangement of atoms.

analytical method: The laboratory procedure specifying how to measure concentrations of contaminants within a sample media.

area sample: Collection of airborne contaminants at a fixed position on a work site.

asbestos: A fibrous magnesium silicate.

asbestosis: Pneumoconiosis as a direct result of inhalation of airborne asbestos.

asphyxiant: A vapour of gas that reduces oxygen concentrations in the ambient air to dangerous levels.

attenuation: The reduction of sound intensity expressed in decibels.

audible sound: The range of frequencies that can be normally heard.

B

blank sample: A sample media, not used for contaminant collection, but is subject to the analytical procedure to establish a zero baseline.

breathing zone: The area around a worker's head from which the worker can readily inhale air.

bronchioles: Branches of the trachea that allow for airflow in and out of the lungs.

bubble flow meter: A primary standard calibrator for calibrating the flow rates of personal sampling pumps.

C

calibrate: Adjust the measuring capabilities of a sampling instrument with a known primary standard.

carcinogen: A substance capable of potentially causing cancer in mammals.

cascade impactors: A size selective sampling device that separates particles onto a series of collection plates based on a particles size and inertia.

cellulose back up pad: The component of a filter cassette assembly that supports the filter.

chronic exposure: Exposure to a small dose over an extended period of time.

cochlea: A structure in the inner ear used for auditory functions. Damage results in restrictive hearing or hearing loss.

cold stress: Physiological stress incurred on the body as a result of adversely low temperatures.

combustible: A substance that is able to burn or ignite.

contaminant: A substance found in concentrations higher than normal and have a deleterious effect.

D

decibel (dB): A unit commonly used to measure levels of sound intensity and power.

desorbtion: Removal of a substance from the matrix onto which it has absorbed.

detection tube: A glass tube used for sampling of gases or vapors that contains sorbant material onto which contaminants will absorb.

diffusion: The movement of particles across a concentration gradient.

dilute: Reduce the concetraion of a substance through the addition of another substance.

direct reading instruments: Devices used to sample gases and vapours.

dose: The amount of substance per unit volume.

dosimeter: Detection instrument used to measure an accumulated dose.

dry bulb thermometer: A thermometer that directly measures temperature without taking relative humidity into consideration.

dust: Solid particulates that are able to temporarily remain airborne.

E

edema: A malfunction of the fluid exchange mechanism within the body such that cells, tissues or cavities accumulate an excessive amount of fluid.

element: Solid, liquid or gaseous particles that cannot be broken down further.

emission: A discharge of material into the air by means of a photochemical reaction or series of reactions.

environmental conditions: State of the air and radient energy surrounding a person or object.

ergonomics: Field of applied science concerned with the design of work and how stresses at work and the workplace affect people, productivity and quality of work.

evaporation rate: The amount of time required to evaporated a specified amount of liquid.

exposure: The subjection of a person to potentially harmful physical, cheimical or biological agents.

exposure assessment: Estimation of the magnitude, frequency and duration of an exposure.

F

fiber: An elongated particulate with a length to width ratio.

fibrosis: A physiological condition in which an organ develops an excess amount of connective tissue.

filter: A fibrous or membrane media used to collect dust, fume or mist from an air sample.

flow rate: The rate at which air is forced through a sampling device, usually by means of a sampling pump.

foot candle: A unit of illumination.

frequency: The rate of vibration of sound measured in hertz (Hz).

frostbite: A freezing of the extracellular fluid in the skin as a result of exposure to extreme cold.

fume: Airborne particulate formed by the evaporation of solid or liquid materials.

G

gas: A substance that is in its gaseous phase at standard temperature and pressure (25°C, 760mmHg).

gas chromatography: A separation technique that passes a gas sample through a packed column allowing for the separation and identification of the various components from within the sample.

globe thermometer: A measurement device for monitoring radiant heat, usually consisting of a black sphere with an internal thermometer.

grab sample: A short term sampling procedure that allows for determination of contaminant concentrations at a given point in time.

gravimetric: Measurement by weight.

gravimetric analysis: Procedure where filter weight is used to determine the concentration of airborne particulates from within an air sample.

H

hand-arm vibration syndrome

(HAVS): A physiological condition that results from prolonged exposure to vibrations that directly affect the hand-arm region of a worker.

hazard: A source of risk.

heat stress: Physiological condition resulting from excessive heat exposure.

hertz (Hz): Unit of measurement for frequency.

high flow personal sampling pumps:

Pumps that maintain an air flow rate between 0.5 to 4.5 L/min.

high performance liquid

chromatography (HPLC): Analytical method used to separate organic molecule using a liquid phase.

humidity: The degree of moisture in the ambient air.

hydrocarbons: Molecules composed only of hydrogen and carbon and are basic building blocks of all organic chemicals.

hypoxia: Physiological condition in which there is a lack of oxygen being delivered to the tissues within the body.

I

impaction plate: A collision surface on which a substrate is placed that allows for the separation of particles based on size.

impinge: To impact, strike, collide or push against.

impinger: A glass tube air sampling device that impinges an air sample into a liquid media.

inert: A substance that will not react chemically with any other substances.

inorganic: Substances that generally do not contain carbon.

inspirable mass fraction: The particulate fraction of air that could potentially be inhaled.

integrated sampling: A type of air sampling that involves passing a known volume of air through a collection media over a given period of time.

integrating sound level meters: Noise sampling devices that measure average sound over a given period of time.

L

liquid: A substance that is in a liquid state at standard temperature and pressure (25°C, 760mmHg).

low flow personal sampling pumps: Sampling pumps that maintain a flow rate between 0.5 and 500 mL/min.

luminance: The visible wavelengths of light.

M

mass: The physical quantity of matter.

mist: A dispersion of suspended liquid particles.

mixture: A physical combination of two or more substances that can be separated by mechanical processes.

molecule: A chemical unit composed of one or more atoms.

MSDS: Materials safety data sheets.

MSDs: musculoskeletal disorders, defined as an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including sprains, strains, inflammation that may be caused or aggravated by work.

MSHA: Mine Safety and Health Administration.

mutagen: A contaminant capable of altering the genetic material within a living cell.

N

natural wet bulb: A wet bulb measurement that is dependant on ambient air motion.

NIOSH: National Institute for Occupational Safety and Health.

noise: An unwanted sound.

noise induced hearing loss (NIHL): Loss of hearing as a direct result of excessive exposure to noise.

O

organic: Any carbon containing chemicals.

OSHA: Occupational Safety and Health Administration.

oxygen deficiency: An ambient environment that contains less than 21% oxygen, the normal concentration of oxygen in the atmosphere.

P

particle: A small discrete mass in the liquid or solid state.

passive dosimeter: Personal air sampling device that relies on the diffusive capabilities of a chemical to adsorb onto a collection media rather than utilizing a sampling pump.

passive sampling: The collection of a gas or a vapour onto a sampling media by means of physical processes such as diffusion.

personal sampler: A sampling device used to measure individual exposure over a given period of time (usually a workshift).

personal sampling pump: Pumps that create and maintain a constant flow of air and are used as part of a sampling train for personal air sampling.

pitch: See frequency.

ppb: The number of parts per billion.

ppm: The number of parts per million.

primary standards: Devices that base their calibration on direct and measurable parameters.

pulmonary: Directly associated with the lungs.

R

radiant heat: Heat transmitted by radiation from a hot object.

respirable dust: Particles, usually less than 5µm, that are capable of being inhaled.

respirable mass fraction: Particulates that are small enough to penetrate the pulmonary region of the lungs.

respiratory system: The system of the body associated with breathing.

S

sampling train: The total assembly of equipment necessary for sampling.

similar exposure groups (SEG): A group of workers that have a similar exposure profile for chemical, physical, and biological agents.

sorbent tube: A small glass gas and vapour sampling tube filled with one or more layers of sorbent material.

sound level meters: A noise and sound level measuring device.

stressors: Some form of stimuli that affects the normal homeostasis of a body.

T

temperature: The degree of hotness or coldness of a substance.

tinnitus: A ringing sound in the ears usually as a result of excessive noise exposure.

thoracic mass fraction: The particulate mass from inhaled air that is able to penetrate past the larynx.

TLV- C: Threshold limit value-ceiling limit.

TLV - STEL: Threshold limit value-short term exposure limit.

TLV-TWA: Threshold limit value-time weighted average.

threshold limit value (TLV): A time-weighted average concentration under which most people can work consistently for eight hours a day, day after day, with no harmful effects.

toxicity: The harmful effect of a chemical agent on a biological organism.

V

vapour: A substance in its gaseous phase that is a solid or liquid at standard temperature and pressure (25°C, 760mmHg).

volatilize: To convert from the solid or liquid state to a gaseous state.

W

WCB: Workers' Compensation Board.

wet bulb globe temperature (WBGT): The temperature that results from the combined effects of air temperature, humidity, air velocity, and radiation.

whole body vibration: When the entire body is exposed to a continuous workplace vibration.

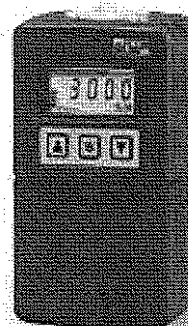
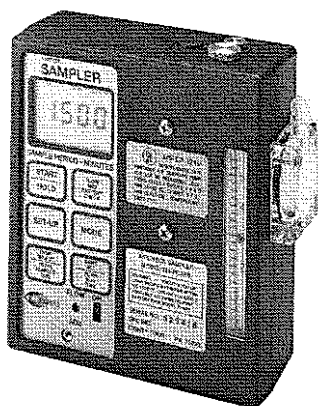
APPENDIX A

PERSONAL SAMPLING PUMP AND PRIMARY FLOW RATE CALIBRATORS

Personal Sampling Pump

Personal sampling pumps create and maintain a constant flow of air and are used in conjunction with a number of air sampling devices to accurately measure concentrations of airborne contaminants. A pump is calibrated to a specified flow rate and connected to a sampler. Air is drawn through a sampling device and average contaminant concentration can be estimated over a specified period of time.

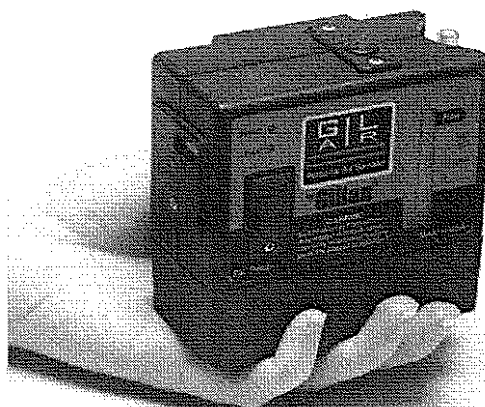
Pumps can be classified into two general categories, high and low flow pumps. Low flow pumps maintain flow rates between 0.5 and 500 ml/min. High flow pumps maintain flow rate around 500-4500 ml/min, or 0.5 to 4.5 L/min. When sampling for particulates, gases or vapours, a high flow pump can be used under most circumstances. The following pictures demonstrate several sampling pumps currently available.



SKC Inc., Personal Sampling Pumps and SKC Airchek 2000 Pump



MSA, EscortElf™ Personal Sampling Pump



Gilian, GilAir Personal Sampling Pump

To operate a pump follow the step by step instructions included in the manufacturers operations manual. In addition, it is critical with any personal sampling pump to always double check the following steps in order to maintain accurate results.

- 1) Charge the unit for a minimum of 14 hours by connecting charger plug to sampler charging jack.
- 2) Test the battery pack for full charge (follow manufacturers instructions).
- 3) Calibrate the flow pump to the required flow rate using a **primary standard** flow rate calibrator. Warm up the pump by running it for 5 minutes prior to calibration.
- 4) Double check the flow rate both before and after a sampling period to ensure the pump was functioning properly throughout the entire duration of the sampling period.

Primary Flow Rate Calibrators

Bubble Flow Calibrator

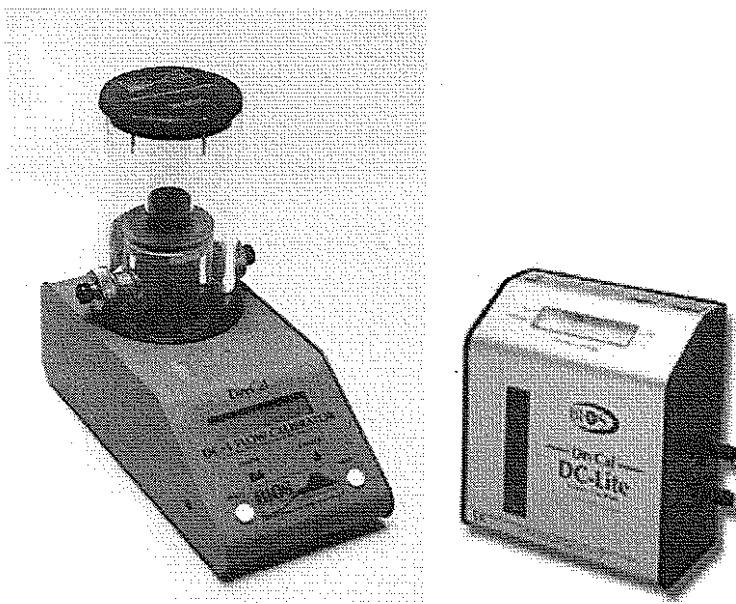
When attached to an air sampling pump, a thin soap film is drawn up a small flow cell within the calibration devise. Two infrared sensors accurately measure the time it takes for the soap film bubble to travel between two specified points within the flow cell. The flow rate of the pump is displayed on a digital screen on the calibration device, allowing for accurate adjustment of the flow rate on the sampling pump.



The Gilibrator by Gilian

Mass Flow Calibrator

Mass flow calibrators give the true primary volume flow readings. Instruments, such as the DryCal®, use a near frictionless piston and photo optic sensing technology to calibrate air pump flow rates.



The DryCal and DC-Lite by BIOS

Calibration Procedure:

- (1) Connect personal sampling pump to the outlet of the calibration instrument using rubber tubing and a blank filter cassette assembly. A blank filter cassette assembly is necessary during calibration to ensure a pump flow properties similar to that of the sampling train.
- (2) Take 10 readings per pump and average them to acquire a flow rate (see calculation below). If there is greater than a 5% difference between any two consecutive numbers, restart calibration for that particular pump. If a flow pump needs adjustment, adjust according to the equipment manual and begin the 10 readings over again. Do not adjust the sampling pump during or after 10 consecutive readings.

$$\text{Average Flow Rate} = \frac{\text{Reading \#1} + \text{Reading \#2} + \text{Reading \#3} \dots \text{Reading \#10}}{10}$$

- (3) Record the average flow rate and repeat procedure after sampling is completed. Ensure that the average flow rate both before and after sampling is clearly recorded. If the difference between the pre and post flow rates is greater than 5%, discard the sample.

STANDARDISED ANALYTICAL METHODS

	NIOSH	WCB	OSHA
CHAPTER 3: DUST			
Coal Dust	7603	5100	ID - 142
Chrystalline Silica	7602		
Chrystobalite			ID - 142
Quartz		1251	ID - 142
Fused Silica			ID - 142
Tridymite			ID - 142
Tipoli			ID - 142
Total Respirable Fraction	7500	1150	
Nucience Dusts	0600		
CHAPTER 4: WELDING FUMES			
Welding Fumes - Total Particulates			ID - 125
Aluminum	7300		ID - 121/ID - 125
Chromium	7300	1050	ID - 121/ID - 103
Iron	7300	1050	ID - 121/ID - 125
Zinc	7300	1050	ID - 121/ID - 125
Carbon Monoxide	6604	0260	ID - 210
Nitrogen Dioxide	6014	1077	ID - 182
Nitrous Oxide	6600	1101	ID - 190
Ozone		1160	
CHAPTER 8: ASBESTOS			
Asbestos	7400 / 7402	0201	ID - 160
Chrysotile	9000		
Bulk	9002	0205	
CHAPTER 9: DIESEL			
Diesel Particulates - Elemental Carbon	5040		
Sulphur Dioxide	6004		
PAH's	5506	2102	OSHA 58
CHAPTER 10: GASES AND VAPOURS			
Acetone	1300		
Ammonia	6015	0050	ID - 188
Carbon Dioxide	6603	4100	ID - 172
Carbon Monoxide	6604	0260	ID - 210
Chlorine	6011	0240	ID - 101
Formaldehyde	2541 / 3500 / 5700		ID - 205
Hydrogen Chloride	7903	0650	
Hydrogen Sulphide	6013	0800	ID - 141
Methane		4700	
Nitric Acid	7903	1060	
Nitric Oxide	6014		ID - 190
Nitrogen Dioxide	6014/6700	1077	ID - 182
Nitrous Oxide	6600	1101	ID - 166
Organic Vapours		5190	
Oxygen	6601	4600	
Ozone		1160	
Sulphur Dioxide	6004	1350	ID - 104/ID - 200
Sulphuric Acid	7903	1401	
Toluene	4000 / 1501		

USEFUL WEBSITES

Workers Compensation Board of BC – www.worksafebc.com

Mines and Aggregate Safety and Health – MASHA- www.masha.on.ca

American Conferences of Governmental Industrial Hygienists – ACGIH-
www.acgih.org

National Institute for Occupational Safety and Health – NIOSH –
www.cdc.gov/niosh/homepage.html

Occupational Safety and Health Administration (US Dept of Labour) – OSHA
www.osha-slc.gov

Canadian Centre for Occupational Health and Safety – CCOHS- www.ccohs.ca

Canadian National Occupational Health and Safety – CANOSH – www.canoshweb.org

APPENDIX B

PAGE OF

WEATHER CONDITIONS: _____ TEMPERATURE: _____ DATE _____
(SUNNY, WINDY, RAINY ETC.)

WORK AREA/JOB DESCRIPTION _____

EMPLOYEE NAME _____ OCCUPATION _____

EQUIPMENT CONDITIONS _____

☐ N/A
CHECK: ☐ WINDOWS/DOORS OPEN/CLOSED ☐ SEALS ☐ PRESSURIZATION OR AC ☐ RADIOS

AGENT BEING SAMPLED ☐ SILICA ☐ RCD ☐ METALS ☐ GASES ☐ OTHER _____

TYPE OF SAMPLE: ☐ TOTAL OR ☐ RESPIRABLE (<10UM)

☐ PERSONAL ☐ AREA

FILTER NO. _____ FILTER TYPE: ☐ PVC ☐ QUARTZ ☐ CELLULOSE ☐ AG MEMBRANE

PUMP NO. _____ FLOW RATE _____ (LPM) PRE-CALIBRATION _____ (LPM)

POST CALIBRATION _____ (LPM)

START TIME: _____ AM PM STOP TIME _____ AM PM TOTAL _____ (MIN)

(SPECIFY PARAMETER, RESULT AND UNIT OF MEASUREMENT)

REQUIRES FOLLOW-UP

TOTAL DUST	_____	mg/m3	_____	%	☐ YES	☐ NO
QUARTZ	_____	mg/m3	_____	%	☐ YES	☐ NO
RCD	_____	mg/m3	_____	%	☐ YES	☐ NO
METALS	_____	mg/m3	_____	%	☐ YES	☐ NO

RESPIRABLE (NOC) DUST:

IF RESPIRABLE SILICA IN SAMPLE IS > 1% THE TLV-TWA LIMIT TO USE IS:	0.1 mg/m ³ FOR RESPIRABLE QUARTZ
IF RESPIRABLE SILICA IN SAMPLE IS < 1% THE TLV-TWA LIMIT TO USE IS:	3.0 mg/m ³ FOR PARTICULATES NOT OTHERWISE CLASSIFIED
RCD (RESPIRABLE COMBUSTIBLE DUST):	1.5 mg/m ³

RESPIRABLE (COAL) DUST:

IF RESPIRABLE SILICA IN SAMPLE IS > 5% THE TLV-TWA LIMIT TO USE IS:	0.1 mg/m ³ FOR RESPIRABLE QUARTZ
IF RESPIRABLE SILICA IN SAMPLE IS < 5% THE TLV-TWA LIMIT TO USE IS:	2.0 mg/m ³ FOR COAL DUST

RCD 1.5 mg/m³

FOR METALS AND GASES REFER TO ACGIH TLV (1994-1995) OR MINES HEALTH, SAFETY AND RECLAMATION CODE

PAGE OF

TYPE OF WELDING _____ ELECTRODE/ROD COMPOSITION _____
 DESCRIBE VENTILATION _____
 RESPIRATORY PROTECTION USED _____

☐ MSDS REVIEWED

FILTER NO. _____ FILTER TYPE: ☐ PVC ☐ CELLULOSE

PUMP NO. _____ FLOW RATE _____ (LPM) PRE-CALIBRATION _____ (LPM)

POST CALIBRATION _____ (LPM)

START TIME: _____ AM PM STOP TIME _____ AM PM TOTAL _____ (MIN)

(SPECIFY PARAMETER, RESULT AND UNIT OF MEASUREMENT)

REQUIRES FOLLOW-UP

TOTAL DUST	_____	mg/m3	_____	YES	NO
QUARTZ	_____	mg/m3	_____ %		
METALS	_____		_____		

HOW MONITORED ☐ DIRECT READ ☐ DETECTION TUBES ☐ _____

PUMP NO. _____ FLOW RATE _____ (LPM) PRE-CALIBRATION _____ (LPM)

☐ N/A POST CALIBRATION _____ (LPM)

START TIME: _____ AM _____ PM STOP TIME _____ AM _____ PM TOTAL _____ (MIN)

(SPECIFY PARAMETER, RESULT AND UNIT OF MEASUREMENT)

REQUIRES FOLLOW-UP

_____ ☐ YES ☐ NO

MONITORING DATA SHEET (NOISE)

PAGE ____ OF ____

WEATHER CONDITIONS: _____ TEMPERATURE: _____ DATE _____
(SUNNY, WINDY, RAINY ETC.)

1

TYPE OF SAMPLE: ☐ PERSONAL ☐ AREA (TOTAL NUMBER OF SAMPLES TAKEN _____)

WORK AREA/JOB DESCRIPTION _____

EMPLOYEE NAME _____ OCCUPATION _____

EQUIPMENT CONDITIONS _____

☐ N/A

CHECK: ☐ WINDOWS/DOORS OPEN/CLOSED ☐ SEALS ☐ PRESSURIZATION OR AC ☐ RADIOS

DOSIMETER NUMBER _____ START TIME: _____ AM PM

LAST CALIBRATION DATE _____ (DAY/MO/YEAR) STOP TIME _____ AM PM

NOISE LEVEL Leq _____ dB _____ TIME _____ (MIN)

Max _____ dB _____

Peak _____ dB _____

2

TYPE OF SAMPLE: ☐ PERSONAL ☐ AREA (TOTAL NUMBER OF SAMPLES TAKEN _____)

WORK AREA/JOB DESCRIPTION _____

EMPLOYEE NAME _____ OCCUPATION _____

EQUIPMENT CONDITIONS _____

☐ N/A

CHECK: ☐ WINDOWS/DOORS OPEN/CLOSED ☐ SEALS ☐ PRESSURIZATION OR AC ☐ RADIOS

DOSIMETER NUMBER _____ START TIME: _____ AM PM

LAST CALIBRATION DATE _____ (DAY/MO/YEAR) STOP TIME _____ AM PM

NOISE LEVEL Leq _____ dB _____ TIME _____ (MIN)

Max _____ dB _____

Peak _____ dB _____

MAXIMUM PERMISSIBLE NOISE EXPOSURE

8 HRS 85 dBA
10 HRS 84 dBA
12 HRS 83 dBA

NO STEADY STATE NOISE >109 Dba
NO PEAK NOISE >140 Dba

