Resource for Mine Management

HEALTH FOCUS

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INTRODUCTION TO THE MODULE

Mine managers/employers generally have a duty by law to provide their employees with a place of employment that is free from recognizable hazards that are causing or likely to cause death or serious harm to employees. In addition, management is required to identify hazards and thereafter eliminate, control and minimize the risks relating to safety and health at mines.

This toolkit focuses primarily on dust hazards associated with mining operations and specifically on respirable crystalline silica, which causes silicosis. Since silicosis is an incurable disease, prevention is the only answer. The keys to prevent silicosis are straightforward; identify employee exposure to respirable crystalline silica (commonly known as silica) dust and then eliminate or control employee exposure to silica dust. The term "respirable" is used as this relates to the very small particles of dust (less than 10 microns in diameter) which penetrate deep into the lungs.

There are additional obligations for management to prepare documents that describe the organisation of work; to establish policies concerning the protection of employees' safety and health at work; and arrangements for carrying out and reviewing such policies.

This module is a resource for mine managers and employers to understand what good practice looks like in terms of managing (assess, measure and control) occupational dust exposures.

BACKGROUND READING

The model on the next page depicts a comprehensive dust management and occupational hygiene health programme geared towards the elimination of occupational lung diseases in mining operations.

DUST GENERATION

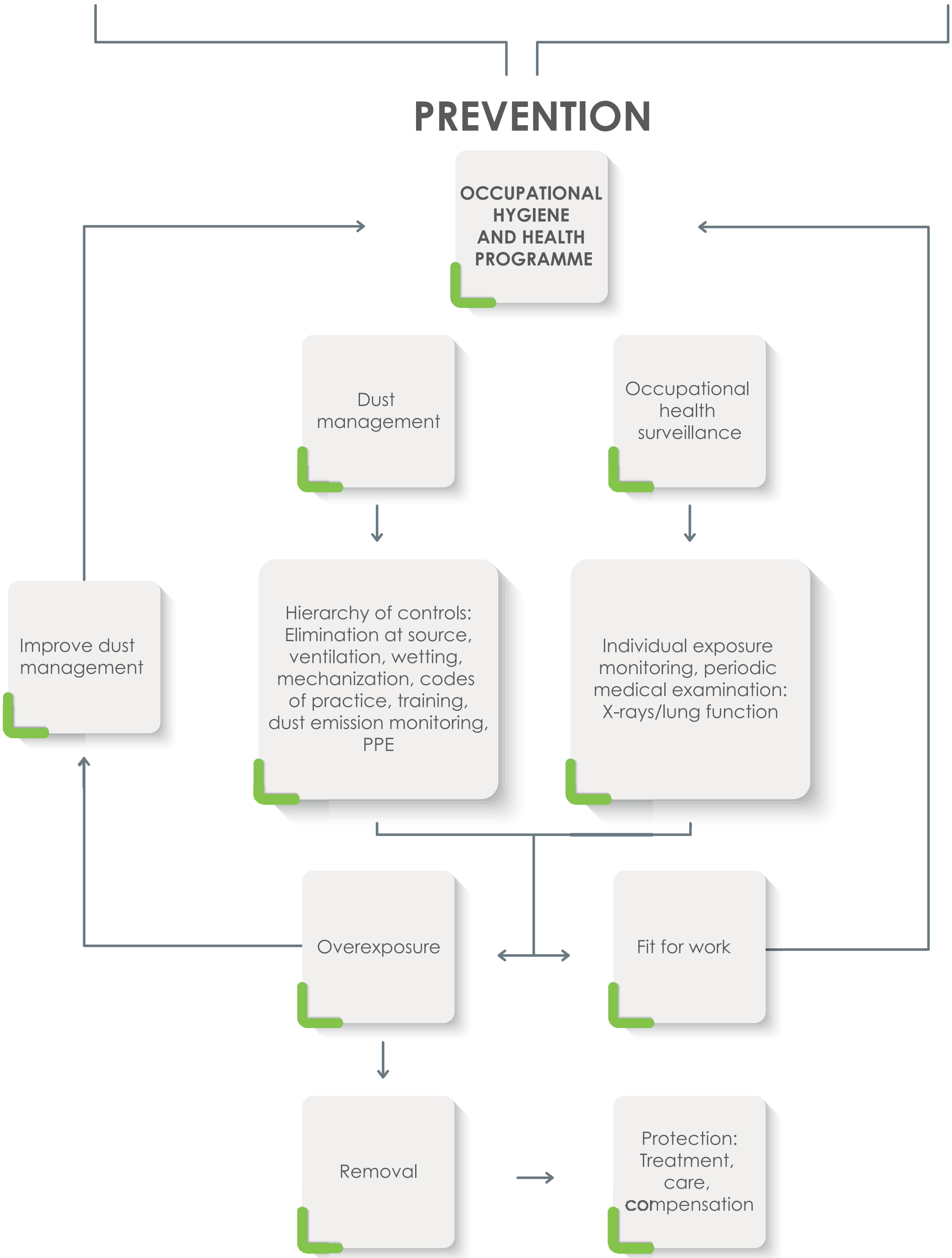

Blasting


Drilling


Loading


Cutting


Transporting



SOCIAL PROTECTION

Risk assessment

As part of managing the health and safety of your business, you must control the risks in your workplace. To do this you need to think about what might cause harm to people and decide whether you are taking reasonable steps to prevent that harm. This is known as risk assessment and it is something you are required by law to carry out.

You are probably already taking steps to protect your employees, but your risk assessment will help you decide whether you have covered all you need to. Think about how accidents and ill health could happen and concentrate on real risks – those that are most likely and which will cause the most harm.

Guidance on how to conduct the risk assessment is provided in the tools section of this module. Various risk assessment templates are provided (from basic to advanced risk assessment) to cater for the varying needs/complexity of the operation and/or end-users.

Quantification/measurement of dust levels

How much crystalline silica is hazardous, depends on how long and how often a worker is exposed, as well as the level of exposure. Because respirable silica dust particles which are the cause of silicosis cannot be seen with the naked eye and because the dust which can be seen is coarse and comparatively harmless, the human eye is not a reliable guide to any dangerous dust in the air. It is therefore necessary to make use of dust sampling instruments which can provide indications of the concentrations of respirable dust in air. Any respirable dust sampling instrument should be designed to capture only dust particles of a size considered to be dangerous to health – usually smaller than about 10 microns.

A specialist or trained, competent person in airborne dust measurements can determine whether a worker is overexposed by sampling the air a worker breathes and comparing the exposure measured with the relevant Occupational Exposure Limit (OEL). The OEL is a limit value set for an occupational exposure in the workplace and represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day for a working life without adverse health effects. In the case of crystalline silica, the OEL is the maximum amount of airborne respirable crystalline silica dust that one can be exposed to during a full work shift and is expressed in milligrams per cubic meter (abbreviated to mg/m3).

Various international and regulatory bodies that provide guidance on exposure to crystalline silica have recommended exposure to respirable quartz be kept as low as reasonably practicable, below the legislated OEL.

Dust sampling strategy

In any work environment, there are spatial and temporal variations in the concentration of airborne contaminants, so that exposure may differ with workers' movement as well as with time of the day, week, or even month. There are also sampling and analytical errors; some can be avoided by careful procedures, while others are inherent to a certain methodology and must be accounted for when deciding on the degree of reliability required for the estimation of the true value of the exposure parameter. Therefore, a sampling strategy, accounting for all factors that may lead to any variation in the results, must be designed and followed, so that the data obtained is representative of the workers' exposure, thus ensuring a reliable exposure assessment.

Important factors include:

- the day, week, or month sampling is performed,
- production rate,
- raw materials,
- work shift,
- task performed,
- individual performing task,
- dust control measures,
- technology used,
- number of workers,
- climate,
- other nearby processes,
- distance of worker from source, and
- errors in sampling and analytical procedures.

If the national authority responsible for the adopted OELs has laid down an accompanying assessment strategy, this should be followed. If not, the responsible professional should design and follow a suitable strategy. In any case, professional judgement during an assessment is indispensable.

The classic questions when designing a sampling strategy are:

- Where to sample?
- For how long to sample?
- When to sample?
- How many samples to collect?

This subject has been widely discussed in the specialized literature. However, although specific methodological principles have been well established, there are nuances in their application. Obviously, any sample must be representative of the worker's exposure, which usually determines where and when to sample. Also, for the same type of agent and the same type of collecting medium, the recommended duration of sampling will be of the same order. However, specific situations may dictate differences in the number of samples required for an evaluation, because this, together with the quality of the measuring system, will determine the accuracy and precision of the obtained results, and the degree of reliability required will depend on the objective of the hazard evaluation.

For the assessment of inhalation exposure, it is necessary to characterize the air that workers are inhaling; therefore, the samples should be collected in the "breathing zone," which is usually defined as a hemispherical zone with a radius of approximately 30cm in front of the head. Some design considerations should include "worst case" exposure sampling or sampling a representative number of workers' indicative of all job categories. Sampling should be of full-shift duration or for the complete length of a process cycle, if the objective is to determine a time-weighted average concentration. Due to the variability in results and the probable lognormal distribution of dust exposures, sampling needs to be conducted over several shifts and during several days to best characterize the workplace exposures.

When assessing exposure to fast-acting substances (seldom the case with dusts) that can cause irreversible damage even on brief high exposures, sampling of very short duration (at the right time) is required, to detect concentration peaks, particularly if there are appreciable concentration fluctuations. High concentrations occurring for short periods can remain hidden, and undetected, if a sample is collected over a longer period during which very low concentrations also occur. Infrequently performed tasks also need to be characterized so that potential short duration but high concentration or peak exposures can be documented.

For the same exposure situation (including the expected environmental fluctuations), if the coefficient of variation of the measuring procedure is known and constant, it is possible, through the application of inductive statistical methods, to determine how reliable an estimate is, or what degree of uncertainty can be expected from a certain number of samples or measurements. This will guide the decision on how many samples to collect or how many measurements to make. The better the sensitivity, accuracy and precision of the measuring system and the greater the number of samples, the closer the estimate will be of the true concentration.

It is usually accepted that, if measurements are needed, they should be as accurate and precise, that is as reliable, as possible. However, there is the issue of the associated cost and, in practice, an acceptable and feasible degree of reliability must be established, per the purpose of the investigation and in view of the available resources. One approach is to look at the purpose of the results. For example, in determining control measures the results should be reliable enough to decide what control action is necessary. A different accuracy may be required if the measurements are part of an epidemiological investigation.

If it seems too costly and difficult to establish compliance (or non-compliance) with a standard, it may be better just to reduce the exposure. Considering that new knowledge on risk assessment often leads to a decrease in exposure, good practice should aim at controlling exposures to the lowest possible level. The required reliability depends largely on the consequences of making a wrong decision based on the collected data.

Size-selective sampling

Dust exposures can span a wide range of particle sizes with health effects dependent upon the region of deposition in the lung. For this reason, size selective dust sampling is performed. The American Association of Governmental Industrial Hygienists (ACGIH), the International Organisation for Standardisation (ISO) and the European Standardisation Committee (CEN) have reached agreement as to particle size-selective sampling criteria and defined three fractions for health-related measurement, namely inhalable, thoracic and respirable, as follows:

- Inhalable fraction for those materials that are hazardous when deposited anywhere in the respiratory tract (50% cut off at 100µm),
- Thoracic fraction for those materials that are hazardous when deposited anywhere within the lung airways including the gas-exchange region (50% cut off at 10µm); and,
- Respirable Fraction for those materials that are hazardous when deposited anywhere in the gas-exchange region of the lungs (50% cut off at 4µm).

There has been international agreement that OELs for particles should normally be specified as one of the above fractions. Modern exposure limits for dusts are usually expressed in terms of the inhalable or respirable fractions.

Measuring equipment

Measurements can be made by:

- the use of direct-reading instrumentation, to obtain results in (near) real time, and,
- collection of samples, for weighing and subsequent laboratory analysis.

Each has its advantages and disadvantages and has its recommended application, as will be described.

Sampling for airborne particles requires instruments that extract them from a measured volume of air and collect them in a manner that permits subsequent weighing and/or chemical analysis, or particle counting under a microscope. These instruments comprise a sampling head, an air mover (with a power source) and a flowmeter.

The sampling head must be designed to collect the fraction of airborne particles to which the OEL applies. The head will therefore consist of a collecting device (e.g. a filter in a filter holder), and a pre-collector such as a cyclone for the respirable dust fraction or a specially designed entry if the inhalable dust fraction applies.

It is essential that the air mover (sampling pump) functions at a measurable and practically constant flow rate and that the flow is always checked before and after sampling with a properly calibrated flowmeter. Analysis of air samples should be performed by a qualified laboratory which has an established quality assurance/quality control programme.

For exposure assessment, the best practice is to utilize personal samplers, which are portable sampling units carried by the workers as they move around. A common procedure is to attach the air mover to the belt, and the sampling head (which should be in the breathing zone) to the lapel of the worker's clothing. Care must be taken, however, when evaluating exposures to airborne particles, because it may happen that particles collected in the clothing [especially specialized personal protective equipment (PPE) like disposable coveralls] are re-entrained into the sampling unit when being removed, thus introducing a bias in the sampling [Cohen et al. (1984)].

Principles and types of size-selective samplers

An OEL which is expressed in terms of the inhalable or respirable fraction requires a sampling method which can collect particles of the desired size distribution. The objective of inhalable or respirable dust sampling is thus to separate out the larger particles from the dust stream, and to collect the remaining dust fraction on a filter or other media. The removal of the non-inhalable or non-respirable fraction by size-selective samplers such as elutriators, cyclones, and impactors is usually dependent on the greater mass and inertia of these larger particles (ACGIH, 1995; Vincent, 1995; Kenny et al., 1997). Because of their size and operating requirements, elutriators are used for area sampling. Cyclones and impactors are available for personal and for area sampling.

Brief details follow:

Elutriators

The dusty air is sucked along a vertical or horizontal channel, and the particles separated per their settling velocities. Elutriators must be used in their design orientation, so they cannot be used for personal sampling.

Cyclones

Cyclones use centrifugal force to remove dust. A particle in a rotating air stream is subjected to a centrifugal force that accelerates it towards a surface where it will impact and lose momentum, thus being removed from the air stream. These cyclones are usually of small sizes, from 10 mm to no more than 50 mm in diameter. They have been widely used since the 1960s to collect the respirable fraction of dust. In a typical cyclone pre-collector, the air enters tangentially at its side and swirls around inside. Particles above a certain size are thrown to the cyclone walls and collected at its base ("grit-pot"). The air containing the respirable dust leaves through the central exit in the top of the cyclone, and the air is filtered to collect the dust. Because of the complexity of fluid behaviour in cyclones, it is difficult to predict mathematically their collection characteristics and they are based on empirical design. To achieve the proper size selection, however, the air sampling pump must be calibrated to provide the appropriate flow throughout the cyclone opening, within a specified variability, and the flow must be smooth. If the pump is not calibrated correctly, the selection will be shifted, either to larger (for low flow) or smaller (for high flow) aerodynamic diameters.

Once calibrated, cyclones can be used for all particles, but are not generally used for fibres. The cyclones available on the market to be used as pre-collectors in two-stage samplers are usually made of nylon or aluminium. Different cyclone designs and manufacturers each have their own specific operational flow rates and filter cassette configuration (2-piece or 3-piece).

Impactors

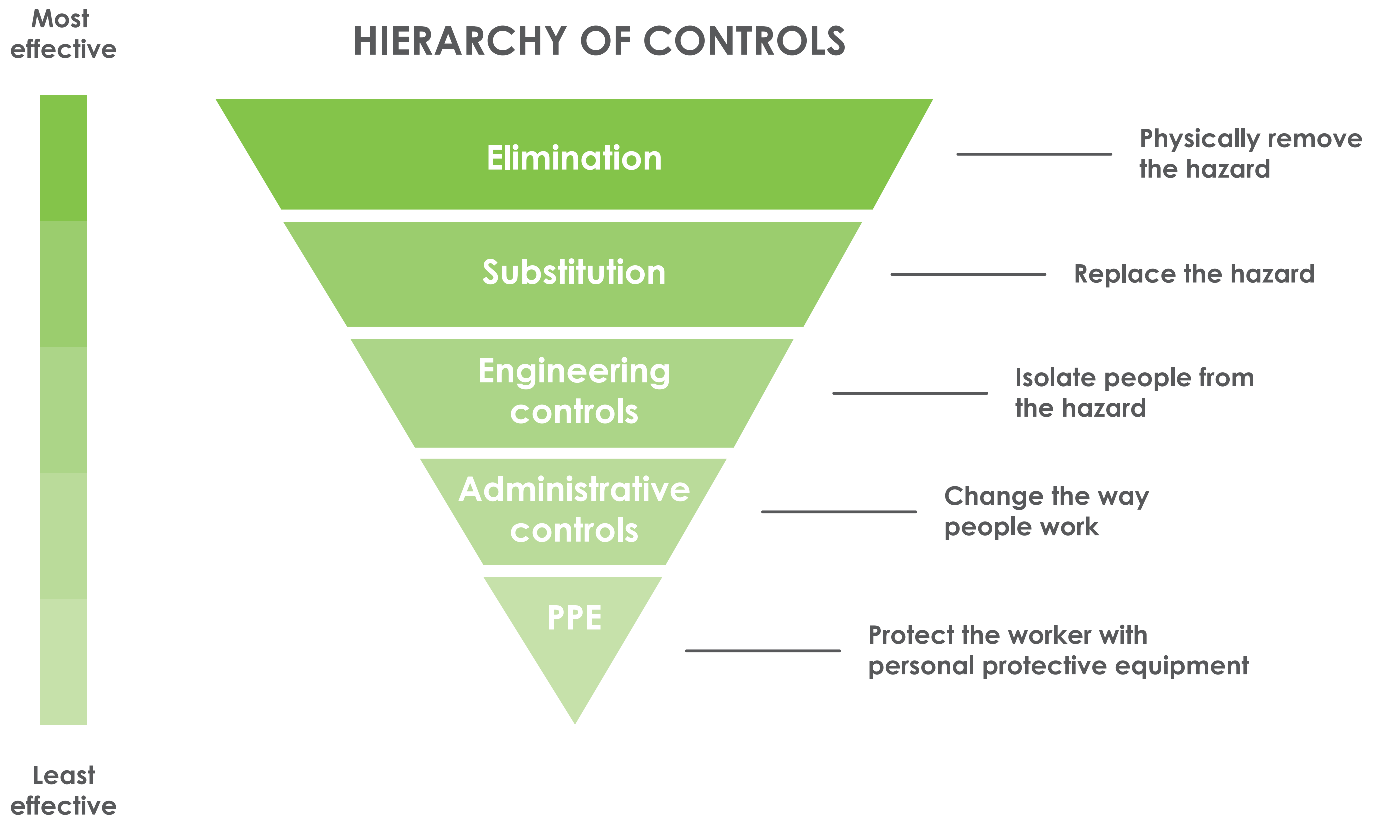
When a dust-laden airstream is forced to make a sudden change in direction, as when it flows directly and at high velocity against a flat surface, the momentum of the larger dust particles causes them to hit the surface. The particles may be collected on a liquid or gel surface for further analysis. The collection efficiency of an impactor, which relies on this principle, depends on the aerodynamic diameter of the particles and the velocity of the air stream. The multistage jet impactor, e.g. the Andersen sampler for viable particles, is used to separate fractions of different particle sizes.

Filters

Filtration is in fact a combination of principles as it involves direct interception, inertial collection, diffusion, electrical forces, adhesion and re-entrainment. Filtration efficiencies vary depending on parameters which include particle shape, density, surface characteristics, amount, humidity and collection velocity, but the filters used with dust samplers are close to 100% efficient. A great variety of filters are commercially available, for example: silver membrane, nucleopore, cellulose ester membrane, glass fibre, plastic fibre, etc., and the choice is usually determined by the analytical method to be used. If the filter is to be weighed, it is necessary to ensure that it is not significantly affected by changes in relative humidity. Polyvinyl chloride (PVC) or Teflon (PTFE) filters are most commonly used to reduce mass gain or loss from humidity. Information provided by filter and sampling equipment manufacturers will usually aid filter selection.

Prevention and risk mitigation

Inspectors are responsible for ensuring the mine managers apply the following hierarchy of controls to eliminate dust hazard exposures in the mining work place. There are brief descriptions for each of the controls below.



Elimination

The mine management should have records of their dust exposure levels and have systems in places to reduce the levels if above the national OEL.

Substitution

The mine management is responsible for replacing a dust generating process with a process generating less dust (e.g. use of wet process instead of dry process, or an automated process instead of manual process).

Engineering controls

Use of engineering controls are very effective towards reducing employee exposures, examples of such controls include:

Good ventilation

Good ventilation systems are used to dilute dust from the working environment and when combined with good filtration systems, dust can be effectively removed from the atmosphere and exposure to humans. Generally, a sound exhaust system is used whereby dust is removed and disposed of remotely from the working face but instances of a force exhaust overlap system may also be required.

Wet drilling and water sprays are most effective at allaying dust at its source thus preventing it from being released into the general air. Drilling is one of the primary sources of dust creation in any mine.

Machinery operated from a closed cabin

Conveyor wetting system

Mechanization

The use of machinery is advantageous as it aids productivity. It does however create large volumes of dust because of the energy levels being applied. Operators are offered protection by way of being housed in closed cabins in order not to be exposed to the dust created by those machines. Employers will be well advised to fit such cabins with air conditioning units to prevent persons from opening doors and windows because of a hot environment and to supply filters to the intake ventilation systems of these units.

Where possible machines should be able to be operated from stations remote from the source of dust being created by these machines.

Drill stations

Drill stations should be provided with skirts to prevent the ejection of air into the atmosphere, in addition to suction tubes to collect the dust and deposit it at another place remote from the operator by way of a cyclone and skirt.

Hand held drills must be supplied with clean water which is disposed of through the axial holes of the drill stems and the front head release ports of the machines.

Where dry drilling needs to take place use needs to be made of good ventilations systems, the limitations of persons in the vicinity of that activity and good PPE (Respiratory protective dust masks of a make and specification commensurate with the type of dust being created and the risk attached thereto).

Wet and damp surfaces

All surfaces in the vicinity and intake airways to workings of a mine should be kept wet and damp, this will assist in allaying dust particles and the disturbance of residual dust on foot walls and other surfaces.

Administrative controls

Training and education

Training and education of workers and supervisors alike is an important step towards the limitation of exposure to dust by persons working in the mine. This training should also include the identification and rectification of hazardous conditions; especially as far as hazardous airborne particulate matter is concerned.

Workplace sampling

Work places need to be sampled regularly to not only determine the dust loads to which persons may be exposed but also to determine the efficiency of the engineering controls that have been introduced. Here one would be able to pick up issues such as poor ventilation, recirculating air currents, break down in ventilation arrangements, insufficient water usage, clogged filtration units etc.

Well documented practice
A good documented practice for the prevention of and protection from silicosis (or other types of pneumoconiosis) for persons is essential in that it lays down the rules and activities required for maintaining a health and safe working environment. It should also contain the maximum allowable exposure limit of dust that people may be exposed to during their working shift and should be common knowledge among employees and supervisors alike.

Programmes aimed at the prevention of occupational lung diseases need to be audited regularly to ensure they function optimally and that certain areas are not neglected. This will ensure also that a role player ensures their part is taken care of and that the system is maintained in a healthy functioning state.

Personal dust sampling equipment including calibrator

Correct use of personal dust sampler

Personal protective equipment
The provision of respiratory Personal Protective Equipment (PPE) is an absolute last resort but may be used in conjunction with the other measure as above. Dust mask issued to employees must be of a type commensurate with the type of risk being faced, must be comfortable to wear and must be accompanied by training in the use and proper care of such units. Employees must be free to have access to such PPE Units on a regular basis (preferably daily) and should be permitted to exchange such units without prejudice from their employer or supervisor. Disposable N95 or FFP3 filtering face piece and reusable half face respirators can be used only if silica dust levels are less than 10 times the dust limit. More information about PPE fit testing can be found using this link: *https://www.cdc.gov/niosh/npptl/stps/respirator_testing.html*

Provision of hygiene facilities, such as change-house and ablution (washing) facilities must be provided on site to ensure that contaminated clothing and equipment is not taken off-site where it may endanger the lives of other persons.

The N95 dust mask

Social protection

Mineworkers have a right to compensation of occupational injuries and occupational diseases and should be informed about these rights. The labour or mine safety and health legislation clearly specifies which occupational lung diseases are compensable. Tuberculosis (TB) should be recognized as a compensable disease where there has been significant exposure to silica dust at work, such that this exposure would be sufficient to cause silicosis, as evidenced by radiography or histology. This dose (a function of time and exposure level) needs to be defined properly in the legislation. However, many countries do not yet recognize TB without pneumoconiosis as a compensable disease.

Regular benefit medical examinations (BMEs) should be offered to mineworkers and ex-mineworkers. Countries determine the frequency of BMEs by how long the mineworker was employed and the level of exposure. Mineworkers should have easy access to an accredited occupational health facility or public health facility (if appropriate) where x-rays and lung function tests can be taken and suitably qualified staff are able to diagnose silicosis and make submissions to the social security/worker compensation systems in that country.

Mine management should work with the competent authorities to develop a shared narrative around the harmfulness of dust and should commit to work together to reduce the levels of dust in the work environment.

Engineering controls in specific types of mines

Engineering controls in gold mines

All efforts must be made toward the prevention of liberation and or generation of dust at the source.

Work stations and dust creation
Footwalls, sidewalls and hanging walls must be regularly cleaned of dust and mud accumulations, ideally by watering down and by applying chemical dust suppression or binding agent.

Drilling must always be done wet, by way of water injection down the axial hole of the drill stem and by water sprayed from the front head release ports of the rock drill.

Blasting procedures must be put in place to prevent any person from being directly exposed to fumes and dust or to prevent persons from travelling or waiting in areas with dust or fumes. Adequate re-entry periods must also be enforced and areas need to be well wetted down before any access is allowed or any work is allowed to commence.

Rock transfer and rock handling
Scraping, handling or transport of rock can only be done when the rock is well watered down and the product is wet. If rock is to be transported by road tipper truck or similar method, it is necessary to ensure that the damp rock is covered by tarpaulin to prevent drying out and dispersing of dust.

Tipping and transfer points generate copious amounts of dust and these points need to be equipped either with water sprays and/or extraction ventilation systems to remove the dust from the air.

Ore passes and ore pass systems need to be so designed as to prevent "up casting" of air into the ore passes and up to the next level. They need to have ventilation extraction and filtration systems fitted to prevent dust from being expelled into the general ventilation streams.

Filtration systems and sprays
Filtration systems need to cleaned and maintained on a regular basis and their efficiency needs to be tested routinely. Filtration systems need to be designed so as to cater for the maximum load of application and ease of maintenance. Essentially, filtration systems must discharge into return airways and never into intake airways.
Crushers, screens, mills and filtration units need to have sufficient water supplies during operation.

Spillages and dust deposits
Backfill spillages and exposed backfill in the working areas may quite easily dry out and release dust into the general atmosphere. Such spillages and exposures need to cleared, repaired and cleaned as soon as practicable.

Muddy water pump columns may also rupture from time to time and also need quick repair and cleaning afterwards. Empty ore and material transport equipment must be cleaned regularly as resident dust may dry out and be liberated into the atmosphere.

Resident dust accumulations or mud must not be allowed to dry out; it should either be kept wet or be removed.

Engineering controls in coal mines

Respirable dust, flammable/explosive concentrations of coal dust and flammable gas controls in coal mines require special provisions and ventilation requirements.

Continuous miners (CMs) and drilling
Continuous miners (CMs) need to be fitted with on board scrubbers, water sprays, water powered air movers with additional auxiliary ventilation systems such as jet fans and effective ventilation supplies. Remote operation of CMs would be an advantage. The operation of these units must be interlinked with the water supply – should the water supply fail, the machine must automatically trip.

Should drilling be required for support or blast holes, similarly this should only be done when adequate water is present through the drill stems and the front-end release ports of the drilling machines and should also be linked to the water supply for fail safe operation.

Blasting
Blasting is done from time to time in some coal mines. This process must be accompanied by a procedure that limits access to the blasting site for persons, that allows for a sufficient re-entry period and for adequate watering down at re-entry.

Coal transport
Conveyer belts in all forms must only convey wet coal and must have sufficient water sprays and dust extraction and filtration points at all transfer points. Overland conveyors should be covered to prevent dispersion of dust by winds.
Transporting of coal by overland trucks and trains must only be done when coal is moist or wet and then also when covered by tarpaulin to prevent the release of dust into the atmosphere.

Mine footwalls (floors) need to be continually wetted down to ensure that dust is not liberated into the air by persons travelling or by moving machinery. Chemical additives may be used to bind the dust.

Ventilation systems
Ventilation systems in coal mines are particularly critical as not only is the threat of lung disease ever present but the buildup of flammable or explosive gases as well as the threat of coal dust explosions must be prevented.

Engineering controls in surface (open cast) mines (strip mining and quarrying)

Drilling and blasting

Ensure all drilling and all handling of all rock is done wet, where possible. Where drilling must be done dry, ensure that the drill operator stands remote from the source of the dust (coming from the drill hole), or that the drill operator is housed in an enclosed cabin, that the drill has a collection skirt for collecting the dust and depositing it remotely from the operator through a cyclone.

Blasting practices should dictate that no persons are exposed to any blasting fumes or dust and that the prerequisite re-entry periods and wetting down procedures are adhered to.

Watering down dust during ore transport on conveyor belt

Moving and transport of rock

Where rock needs to be loaded, it must be wet at all times, but if done so by mechanical means it would be preferable for the operator to be housed in an enclosed cabin.

Removal and placement of overburden would need to have water sprays operating at both the removal and the placement sites.

Transporting of rock by overland trucks and trains must only be done when the rock is moist or wet and then also when covered by tarpaulin to prevent the release of dust into the atmosphere if long distances are to be covered.

Haul roads are a major source of dust and need to be maintained regularly, wetted down by water tanker spray car and the addition of dust surfactant chemicals will assist in ensuring a stable and dust free road surface.

Tipping points, crushers and screens need to be supplied with sprays and extraction ventilation systems (and filters) where needed.

TOOLS FOR MINE MANAGEMENT

Various tools are provided to assist the user in executing the requirements as indicated in this module and can be found on the CD Tools for Module 3. The following good practice examples are provided with a brief description of their intended use:

Good practice: Risk assessment process

Two risk assessments processes have been described (basic and advanced) and provided to cater to the needs of the end-user or the complexity of the operations, resource availability and skills. Risk assessment templates (basic) and worksheets (advanced) have been supplied for recording the assessments.

Good practice: Dust sampling procedure

Provides a detailed method /guidance on how to setup and conduct respirable dust sampling; including equipment, instrumentation and consumable item requirements, sampling pump calibration procedures and the mounting of sampling equipment on workers when collecting samples.

Good practice: Field sampling record – chemicals and dust

(Available on the CD)

A field sheet used to record and collect the sampling data information. This will be used as a record of the sampling activity.

Good practice: Monitoring and results forms

(Excel file on CD)

These are Excel-based spreadsheets use for sampling data input, i.e. the results from the sampling programme. This will be used to capture all the pertinent sampling records for each of the Homogenous Exposure Groups. The spreadsheet also comes with an imbedded statistical analysis tool from the American Industrial Hygiene Association (AIHA) to manage the sampling data.

Good practice: Sampling and analytical methods

(Available on the CD)

Two approved, international sampling and analytical methods National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OHSA) used for measuring airborne levels of respirable crystalline silica have also been included for reference. These methods describe all the necessary equipment, sampling methodologies, and analytical techniques that need to be followed to ensure reliability and credibility of sampling results. The use of un-approved sampling methods would invalidate all sampling results collected.

Good practice: Basic risk assessment process

1. Identify the hazards

One of the most important aspects of your risk assessment is accurately identifying the potential hazards in your workplace. A good starting point is to walk around your workplace and think about any hazards. In other words, what is it about the activities, processes or substances used that could injure your employees or harm their health?

When you work in a place every day it is easy to overlook some hazards, so here are some tips to help you identify the ones that matter:

- Check manufacturers' instructions or data sheets for chemicals and equipment as they can be very helpful in explaining the hazards and putting them in their true perspective.
- Look back at your accident and ill-health records – these often help to identify the less obvious hazards.
- Take account of non-routine operations (e.g. maintenance, cleaning operations or changes in production cycles).
- Remember to think about long-term hazards to health (e.g. high levels of noise or exposure to harmful substances).

There are some hazards with a recognized risk of harm, for example working at height, working with chemicals, machinery, and asbestos. Depending on the type of work you do, there may be other risks.

2. Who might be harmed?

Think how employees (or others who may be present, such as contractors or visitors) might be harmed. Ask your employees what they think the hazards are, as they may notice things that are not obvious to you and may have some good ideas on how to control the risks.

For each hazard, you need to be clear about who might be harmed – it will help you identify the best way of controlling the risk. That doesn't mean listing everyone by name, but rather identifying groups of people (e.g. people working in the storeroom or passers-by). Remember:

- Some workers may have specific/unique requirements, e.g. new and young workers, migrant workers, new or expectant mothers, people with disabilities, temporary workers, contractors, homeworkers and lone workers.
- Think about people who might not be in the workplace all the time, such as visitors, contractors and maintenance workers.
- Take members of the public into account if they could be harmed by your work activities.
- If you share a workplace with another business, consider how your work affects others and how their work affects you and your workers. Talk to each other and make sure controls are in place.
- Ask your workers if there is anyone you may have missed.

3. Evaluate the risks

Having identified the hazards, you then must decide how likely it is that harm will occur, i.e. the level of risk and what to do about it. Risk is a part of everyday life and you are not expected to eliminate all risks. What you must do is make sure you know about the main risks and what you need to do to manage them responsibly.

Generally, you need to do everything 'reasonably practicable' to protect people from harm. This means balancing the level of risk against the measures needed to control the real risk in terms of money, time or trouble. However, you do not need to act if it would be grossly disproportionate to the level of risk.

Your risk assessment should only include what you could reasonably be expected to know – you are not expected to anticipate unforeseeable risks.

Look at what you are already doing and the control measures you already have in place. Ask yourself:

- Can I get rid of the hazard altogether?
- If not, how can I control the risks so that harm is unlikely?

Some practical steps you could take include:

- trying a less risky option;
- preventing access to the hazards;
- organising your work to reduce exposure to the hazard;
- issuing protective equipment;
- providing welfare facilities such as first aid and washing facilities;
- involving and consulting with workers.

Involve your workers, so you can be sure that what you propose to do will work in practice and would not introduce any new hazards.

If you control several similar workplaces containing similar activities, you can produce a model risk assessment reflecting the common hazards and risks associated with these activities.

You may also come across model assessments developed by trade associations, employers' bodies or other organisations concerned with an activity. You may decide to apply these model assessments at each workplace, but you can only do so if you:

- satisfy yourself that the model assessment is appropriate to your type of work;
- adapt the model to the detail of your own work situations, including any extension necessary to cover hazards and risks not referred to in the model.

4. Record your significant findings

Make a record of your significant findings – the hazards, how people might be harmed by them and what you have in place to control the risks. Any record produced should be simple and focused on controls.

Any paperwork you produce should help you to communicate and manage the risks in your business. For most people this does not need to be a big exercise – just note the main points about the significant risks and what you concluded. An easy way to record your findings is to use the basic risk assessment templates included in this toolkit (Template 1 or Template 2).

When writing down your results keep it simple, for example 'fume from welding – local exhaust ventilation used and regularly checked'.

A risk assessment must be suitable and sufficient, i.e. it should show that:

- a proper check was made;
- you asked who might be affected;
- you have dealt with all the obvious significant hazards, considering the number of people who could be involved;
- the precautions are reasonable, and the remaining risk is low;
- you have involved your employees or their representatives in the process.

If your risk assessment identifies several hazards, you need to put them in order of importance and address the most serious risks first. Identify long-term solutions for the risks with the biggest consequences, as well as those risks most likely to cause accidents or ill health. You should also establish whether there are improvements that can be implemented quickly, even temporarily, until more reliable controls can be put in place. Remember, the greater the hazard the more robust and reliable the measures to control the risk of an injury occurring will need to be.

Regularly review your risk assessment

Few workplaces stay the same. Sooner or later, you will bring in new equipment, substances and procedures that could lead to new hazards. So, it makes sense to review what you are doing on an ongoing basis, look at your risk assessment again and ask yourself:

- Have there been any significant changes?
- Are there improvements you still need to make?
- Have your workers spotted a problem?
- Have you learnt anything from accidents or near misses?

Make sure your risk assessment stays up to date.

Templates for risk assessment forms

Risk assessment form – Template 1

All employers must conduct a risk assessment.

Below is an example / sample entry for a common hazard to illustrate what is expected (this entry is taken from an underground mining activity). Look at how this might apply to your business, continue by identifying the hazards that are the real priorities in your case and complete the table to suit. You can print and save this template so you can easily review and update the information as and when required.

COMPANY NAME:	DATE OF RISK ASSESSMENT:

What are the hazards?	Who might be harmed and how?	What are you already doing?	Do you need to do anything else to control this risk?	Action by who?	Action by when?	Action status
Write Example: Silica dust	Drill operators and underground equipment operators can inhale silica dust from the working environment	Wet drilling is only allowed. Good mechanical ventilation is provided within underground mining areas	Measure dust exposure levels of personnel working underground	Occupational Hygiene staff	Every quarter of the year	In Progress

You should review your risk assessment if you think it might no longer be valid (e.g. following an accident in the workplace or if there are any significant changes to hazards, such as new work equipment or work activities)

Risk assessment form – Template 2

COMPANY NAME:	**REPORT REFERENCE:**
REPORT REFERENCE:	**DATE OF RISK ASSESSMENT:**
ASSESSORS NAME:	**REVIEW DATE:**

Area / Activity	**Hazards**	**People at risk** (Who might be exposed)	**Control measures in place**	**Risk Rating**	**Control measures required**	**Action by: whom & when?**
Write Example: Blasting and handling of rock materials in open cast quarry	Silica Dust	Blasting crew, dump truck operators and general work crew may inhale airborne silica dust	Quarry follows adequate re-entry times after blasting. Rock surfaces and surrounding works are wetted down with water before blasting. Dump truck operators work within closed operator cabins	Low	Measure dust exposure levels of personnel	Occupational Hygienist 01-June-2017

You should review your risk assessment if you think it might no longer be valid (e.g. following an accident in the workplace or if there are any significant changes to hazards, such as new work equipment or work activities)

Good practice: Advanced risk assessment manual

1. Introduction

This standard is intended to provide [INSERT COMPANY / ORGANISATION NAME] with a systematic strategy for evaluating potential employee exposure to the hazards presented by chemical, physical, and biological agents. The sections that follow will provide the basic principles for performing the various activities required for qualitative risk assessment, written exposure assessment planning, and quantitative assessment (sampling) of various chemical and physical stressors.

The standard also establishes a process to determine the need for medical surveillance.

2. Scope and purpose

This standard is applicable to all Industrial/Occupational Hygiene personnel employed by [INSERT COMPANY HERE]. The purpose of this standard is to provide [INSERT COMPANY HERE] with a consistent and systematic approach to conducting Industrial Hygiene evaluation efforts.

3. Definitions

Action Level (AL) – The level of exposure that triggers corrective action; the AL is typically 50% or half of the Occupational Exposure Limit (OEL).

Acute – Occurring over a relatively short time, from seconds to several hours.

ALARP – As Low as Reasonably Practicable.

Area monitoring – Exposure monitoring conducted with a device in a fixed location in the workplace.

Biological agent – Microorganism present in the workplace associated with adverse health effects.

Ceiling limit (C) – The exposure limit that must not be exceeded during any part of the workday. If instantaneous monitoring is not feasible, the ceiling will be assessed as a 15-minute Time-Weighted Average (TWA) exposure (unless otherwise specified) that must not be exceeded at any time during a workday.

Chemical agent – An organic or inorganic substance present in the workplace and associated with adverse health effects. Chemicals to be sampled may include raw materials, waste products, and decomposition products to which the employee(s) may be exposed. The identification of the chemicals to be monitored for may be obtained from Flow Sheets, Safety Data Sheets (SDSs) and interviews with operations, maintenance, and engineering personnel of the client company.

Chronic – Occurring over a relatively long time, including weeks to years.

Excursion limit – Excursion limits apply to those TLV-TWAs that do not have TLV-STELs. Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday, and under no circumstances should they exceed 5 times the TLV-TWA, if the TLV-TWA is not exceeded.

Hazard – The probability of impairment of health following exposure to a specific substance. The level depends on toxicity of the substance, time of exposure, and its use and absorption rate.

Manufacturer's Guideline Limit (MGL) – Established by manufacturers of substances for which a published exposure limit either does not exist or is deemed inappropriate (i.e., does not provide adequate protection) by the manufacturer.

Safety Data Sheet (SDS) – Written or printed material concerning a hazardous material which is prepared in accordance with a specified standard such as 29 CFR § 1910.1200(g).

Monitoring – Is a continuous programme of observation, measurement and judgment of an environmental stress which has been identified and requires observation. It is the systematic surveillance of hazards in the workplace to which workers may be exposed.

Occupational Exposure Limit (OEL) – Is the maximum concentration of an air contaminant to which an employee can be safely exposed for an eight-hour period in one day (over a normal work life).

OEL-Control Limit (OEL-CL) – Is the maximum concentration of an airborne substance, averaged over a reference period, to which employees may be exposed by inhalation under any circumstances, and is specified together with the appropriate reference period in Table 1 of Annexure 1.

OEL-Recommended Limit (OEL-RL) – Is the concentration of an airborne substance, averaged over a reference period, at which, per current knowledge, there is no evidence that it is likely to be injurious to employees if they are exposed by inhalation, day after day, to that concentration.

Permissible Exposure Limit (PEL) – Limit published and enforced by OSHA as a legal standard. A PEL carries the same definition as TLV and is typically an 8-hour TWA unless otherwise noted.

Personal monitoring – Exposure monitoring conducted with a device worn by an employee while he/she performs work.

Physical agent – Mechanical or electromagnetic energy, such as noise, heat, vibration or radiation, present in the work environment associated with adverse health effects.

PPE – Personal Protective Equipment. Devices worn by workers to protect against hazards in the environment.

Recommended Exposure Limit (REL) – Limit published by the National Institute for Occupational Safety and Health (NIOSH). RELs are defined as 8-hour TWA airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.

Risk – Is the potential for a hazard to cause bodily harm or injury.

Risk assessment – Is "the characterization of the potential adverse health effects of human exposures to environmental hazards". In a risk assessment, the extent to which a group of people has been or may be exposed to a certain agent (chemical, physical or biological agent) is determined, and the extent of exposure is then considered in relation to the kind and degree of hazard posed by the agent, thereby permitting an estimate to be made of the present or potential health risk to the group of people involved.

Sampling – Is a process consisting of the withdrawal or isolation of a fractional part of a whole. In Industrial Hygiene, the taking of a sample is usually to determine the extent or magnitude of the environmental stresses.

Similar Exposure Groups (SEGs) – A group of employees who likely experience similar exposure to chemical or physical agents. The exposure must be similar enough so that monitoring a randomly selected group of workers in the SEG provides data which can be used to predict the exposure of the general population of workers in the SEG.

Short-Term Exposure Limit (STEL) – Limit that is usually a 15-minute TWA exposure that must not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV-TWA, PEL-TWA, or REL-TWA.

Threshold Limit Value (TLV) – Published by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs are defined as 8-hour TWA airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.

Time-Weighted Average (TWA) – Exposure concentration for a conventional 8-hour workday and a 40-hour workweek.

4. Standard

4.1. Technical requirements / competencies

4.1.1. The Industrial/Occupational Hygienist shall be responsible for the administration and supervision of the Industrial Hygiene Risk Assessment and Sampling Standard.

4.1.2. The Industrial Hygienist shall be a qualified Industrial Hygiene Professional. Evidence of qualification will include:

a) Certification by a nationally recognized organisation, e.g. South African Institute of Occupational Hygiene (SAIOH) or the American board of Industrial Hygiene (ABIH), and / or

b) A Master's degree in Industrial Hygiene or a closely related discipline, and / or

c) A Bachelor's degree in Science or Engineering with a minimum of five years' experience in the practice of industrial hygiene, and / or

d) Any other recognised or equivalent qualification or equivalent registration, e.g. A Certificate in Mine Environmental Control as required by the South African Mine Health and Safety Act.

4.1.3. Industrial hygiene field surveys and sampling (including all equipment preparations and set up of sampling trains) shall be performed by qualified personnel (List the job categories / level of your personnel here) who have been formally trained in sampling methods and instrumentation.

a) The training may be accomplished internally within [INSERT COMPANY NAME] or through an approved third party service provider.

4.2. Industrial hygiene risk assessment

4.2.1. A baseline Industrial Hygiene Risk Assessment (IHRA) is conducted within a workplace to determine the current health risk status of the organisation.

4.2.2. This baseline exposure assessment will assist the workplace in setting priorities and develop a standard by which the Industrial Hygiene (IH) risks will be addressed.

4.2.3. The identified hazards should be treated through the organisations risk management strategy.

4.2.4. The IHRA will be reviewed at the following frequencies:

a) Periodically to ensure effectiveness and latest good practices;

b) After any significant changes are made to operating conditions, equipment and personnel;

c) At least every two (2) years.

4.2.5. These reviews will be documented.

4.3. Risk assessment process

4.3.1. An industrial/occupational hygiene risk assessment will be conducted to identify the health risks associated with potential employee exposures to materials and other agents.

4.3.2. Risk assessments will evaluate the current conditions in an industrial/mining operation.

4.3.3. Risk assessments will assume the absence of Personal Protective Equipment (PPE).

4.3.4. The risk assessment process will cover all employees on all days for all agents. In practice, this includes all product-associated agents (e.g., chemical mixtures represented by SDSs), process-associated agents (e.g., by-products, products of combustion, waste products, intermediates, etc.), and significant exposures to physical and biological agents (e.g., noise, heat stress, radiation, pathogenic bacteria, etc.).

4.3.5. Where appropriate, equivalent materials can be grouped into one assessment (e.g., welding rods, lubricants, refractories, cutting oils, etc.).

4.3.6. Household consumer products present in the workplace (e.g., aerosol paints, etc.) need not be assessed provided these products are used in a manner like household application.

a) Risk assessments are required if consumer products are used in quantities or at a frequency significantly greater than household use, or are found to contain a toxic chemical.

4.3.7. All significant routes of exposure will be considered including skin contact and inadvertent ingestion where personal hygiene practices are important.

4.4. Occupational Exposure Limits

4.4.1. Occupational Exposure Limits as required by regulatory bodies and/or established by [INSERT COMPANY NAME] shall be utilized for workplace exposures to air contaminants, noise, radiation, etc.

4.4.2. OELs for air contaminants and noise are expressed as the following:

a) Full shift time-weighted average values.

b) Short-term exposure limits.

c) Excursion limits.

d) Ceiling limits (C).

4.4.3. Biological OELs are available for some materials and are employed where the main route of exposure is skin absorption and/or inadvertent ingestion.

4.4.4. OELs for ionizing radiation are generally expressed as a cumulative dose.

4.4.5. Excursion limits: Short-term exposure limits have not been established for most agents with an eight-hour time-weighted average (TWA) OEL. Nevertheless, excursions will be controlled even when the 8-hour TWA is below the permissible limit.

a) In the absence of a peak exposure limit, the ACGIH-recommended excursion limit of three times the OEL for no more than 30 minutes during a work shift will be applied.

4.5. Qualitative occupational hygiene risk assessment

4.5.1. In conducting a qualitative occupational hygiene risk assessment, the following information will be gathered and/or activities completed:

a) Development / compilation of a materials Inventory, including safety data sheets;

- Information on the quantities of materials in use.
- Process intermediates and by-products; and their chemical and physical properties.

b) A review of the health effects associated with agents, including the routes of exposure, the adequacy of the toxicological data, and the rationale for the OELs.

c) Observation of the workplace processes and tasks and the frequency and duration of the associated exposures.

d) A review of installed engineering controls and their reliability in maintaining adequate control of employee exposures.

e) A review of prescribed work practice controls, employee training, and their reliability in maintaining adequate control of exposures.

f) Observations, comments, and data from employees, HSE group, occupational healthcare professionals, and others regarding the conditions of exposure and health effects.

g) A review of available historic exposure data, including positional measurements of exposure and occupational hygiene sampling data from other similar workplaces.

h) Identification and classification of Similar Exposure Groups (SEGs) to facilitate the assessment of exposures for all employees who experience similar exposure to agents.

- Refer to Appendix A for the workflow process that is used to develop SEGs. SEG documentation should include the following minimum data elements as noted in Table 1 below:

TABLE 1- SEG Data Elements

NO.	ELEMENT	EXAMPLE
1	Location	Company / Facility
2	Risk Assessment Date	05-June 2017
3	Assessor	John Thompson
4	Start Date of Exposure	04-Jun-2017
5	End Date of Exposure, if available	N/A
6	Process Unit or Department	Business Unit
7	Job	Drill Operator
8	Task	Rock Drilling
9	Environmental Agent	Crystalline Silica Dust
10	Route of Exposure	Inhalation

4.6. Evaluation of Similar Exposure Groups (SEG's)

4.6.1. An exposure assessment is a judgment about the acceptability of an exposure for an SEG.

a) Exposures are judged to pose either an Acceptable or Unacceptable health risk.

- The underlying basis for this determination is the professional judgment of the Industrial Hygienist's estimate of the SEGs' exposure relative to the OEL. The exposure assessment process is illustrated in Appendix B.

4.6.2. Risk assessment worksheet, will be used in documenting the evaluation of SEGs and associated Significance Ratings.

a) This worksheet shall be signed and dated upon completion.

4.6.3. To indicate significance of the risk(s) associated with exposure to a health hazard, the health effects of health hazards and the anticipated levels of exposure are awarded ratings as indicated in Tables 2 and 3 below.

Note: The health risk assessment process assumes the absence of personal protective equipment when evaluating risk.

TABLE 2: EVENT FREQUENCY DEFINITIONS	
PROBABILITY	**DESCRIPTION**
Very High (A)	Continuous contact (daily) with agent. Contact with agent at concentrations ≥ Occupational Exposure Limit (OEL). Expected probability 100%.
High (B)	Frequent contact (monthly) with agent. Contact with agent at concentrations ≥ 50% of the OEL, but less than the OEL.
Moderate (C)	Intermittent contact (yearly) with agent. Contact with agent at concentrations < 50% of the OEL, but ≥10%of the OEL.
Low (D)	Infrequent contact (within decade) with agent. Contact with agent at concentrations < 10% of the OEL.
Insignificant (E)	Unlikely contact (every 100 years) with agent. Totally unexpected in the life of the plant.

	TABLE 3: SEVERITY OF CONSEQUENCES DEFINITIONS			
	SEVERITY			
CONSEQUENCE	**Catastrophic (1)**	**Serious (2)**	**Minor (3)**	**Negligible (4)**
Health & Safety (Injury & Illness)	Fatality or Permanent Disability Long term health effects leading to fatalities, or significant irreversible human health effects to >50 persons	Injury(s) requiring hospitalization (beyond observation); Irreversible disability or impairment (>30%) to one or more persons.	Objective but reversible disability / impairment.	Low-level short-term subjective inconvenience or symptoms. No measurable physical effects

4.7. Risk analysis (risk rating)

4.7.1. The risk is a function of the severity of the hazard and probability of that hazard/event presenting itself. The factors for severity and probability are determined by using the above-mentioned tables (Table 1 & 2). These factors are multiplied to determine the significance rating, i.e. Significance = Severity x Probability. Refer to Table 3 to determine the risk ranking based on the significance.

	TABLE 4: RISK RANKING MATRIX			
	SEVERITY			
PROBABILITY	Catastrophic (1)	Serious (2)	Minor (3)	Negligible (4)
Very High (A)	1A	2A	3A	4A
High (B)	1B	2B	3B	4B
Moderate (C)	1C	2C	3C	4C
Low (D)	1D	2D	3D	4D
Insignificant (E)	1E	2E	3E	4E

SIGNIFICANCE RATING	
1A, 1B, 2A	Unacceptable risk
1C, 2B, 3A	High risk
1D, 2C, 3B, 4A	Medium risk
1E, 2D, 2E, 3C, 3D, 3E, 4B, 4C, 4D, 4E	Low risk

4.8. Occupational hygiene sampling programme

4.8.1. A quantitative occupational exposure assessment is the process of collecting data such as air samples or direct reading device information, and comparing the collected data with applicable exposure limits or toxicological information.

4.8.2. The objective of the quantitative assessment is to address SEGs characterized as 'Uncertain' in the qualitative exposure assessment and to establish baseline exposure data.

a) Exposure data are generally collected through personal air sampling

- In this strategy, "sampling" is referred to as the process of determining exposures on selected days for making reasonable observations of exposures on both sampled and un-sampled days.

b) Exposure assessment data are used to demonstrate compliance with occupational exposure limits. To appropriately utilize exposure data for epidemiology and other future applications, it is necessary to employ a random sampling strategy whose purpose is to create a database that accurately reflects the magnitude and variation in exposure for all employees.

4.8.3. Once a qualitative occupational exposure assessment has been performed and the SEGs have been classified, a quantitative occupational exposure assessment will be developed in accordance with the following:

a. SEGs initially judged as Uncertain will be reclassified after the acquisition and examination of exposure data and health effects information as follows:

- Insignificant, Significant or Unacceptable.
- A statistically significant number of samples must be collected to assess SEG uncertainty, but the Industrial Hygienist may use professional judgment to reclassify the exposure as Insignificant, Significant, or Unacceptable without regard to the number of samples taken.

b. If the SEG is judged 'Significant' or 'Unacceptable' and inhalation is the route of exposure, a calculated number of random samples (sample size dependent on the international method employed to calculate the sample size, such as OESMM, etc.) will be collected to establish baseline data.

- Although documented exposure assessments are required for all SEGs judged Significant or Unacceptable, no minimum number of samples is required if the exposure occurs less than twelve days per year.
- The samples will be collected within six months following the qualitative risk assessment where the exposure frequency is daily and within one year where the exposure frequency is less than daily.

c. In collecting personal air and noise samples, a random sampling strategy will be employed to the greatest extent feasible.

- A common practice is to arbitrarily schedule sampling dates and then on those dates, randomly choose among employees in the SEG.
- If the sampling data are to be used inferentially, the data is to be randomly collected.
- Although there are practical limitations to collecting true random samples, this strategy is essential to minimizing bias in the database.
- Personal samples collected through a random sampling strategy are termed baseline samples or continuous monitoring samples

d. Exposure data will be acquired through personal monitoring in the breathing or hearing zone of personnel, outside of any personal protective equipment, thereby measuring exposures as if no personal protective equipment was being used.

e. Air sample collection and analyses will be guided by the methods outlined below (list specific standards used by your own organisation, examples are indicated below):

- NIOSH Manual of analytical methods
- OSHA Technical sampling manual
- As directed by country-specific Regulation and/or applicable 'Substance-specific standards / Regulations'
- Samples shall be analyzed only in appropriately accredited laboratories (i.e., SANS/ISO/IEC 17025 or equivalent).

f. A new baseline shall be established if a significant change has occurred in exposure levels affecting the risk assessment decision.

g. An Industrial hygiene sampling plan shall be created and updated at least every 12 months using data from the Qualitative risk assessment and Occupational hygiene sampling results for that period.

- Monitoring shall be consistently conducted in accordance with the documented annual Occupational hygiene sampling plan.

h. Periodic sampling after the baseline has been established will be done in accordance to Appendix C, applicable substance-specific standards/regulations and/or company procedures.

4.8.4. The company/organisation will maintain a database containing pertinent information for all industrial hygiene measurements collected for purposes of quantifying employee exposures to agents. This database will contain at least the following data elements for each sample:

a) Sample date
b) SEG description
c) Assessment period, such as 15 minutes for STEL samples or 8 hours for TWA samples
d) Identity of the employee who was sampled and a description of the pertinent personal protective equipment in use.
e) Identity of the person who collected the samples or performed the measurements.
f) Strategy employed in collecting the samples, such as random, worst-case, or diagnostic.
g) Sampling method, instrument calibration data, analytical method, and analytical laboratory.
h) Measured exposure level and unit of measure.

4.8.5. The company/organisation shall update the risk assessment worksheets in accordance with the sampling results obtained.

4.8.6. A written interpretive report shall be developed based on the occupational exposure assessment and monitoring results for each SEG evaluated.

a) The written interpretive report shall be updated as required by exposure re-assessments.

b) Minimum elements of the interpretive report shall include the following:

- A description of the environmental conditions present at the time of the assessment or sampling,
- Interpretation of sampling results, and
- Develop and provide corrective actions (including any protective measures to be taken) for those results at or above the occupational exposure limit.

c) Corrective actions shall be documented and communicated to the affected stakeholders.

4.9. Risk assessment data management

4.9.1. All occupational hygiene sampling data will be collected using the form below:

a) Field Sampling Record Form – Chemicals (Provided on the CD)

4.9.2. The following information must be documented on these forms (as applicable):

a) Sample Number

b) SEG Number

c) Sample Type: Personal, Area, etc.

d) Employee Information: Employee Number, Name, PPE, Shift, Position.

e) Sample Location: Branch, Building, Department, etc.

f) Task: Brief description of the task being monitored or full-shift.

g) Equipment/Method: Sample equipment and collection media.

h) Sample Time/Volume: Start/Stop Times, Initial/Final Flow Rate (if applicable).

i) Environmental Conditions: Temperature, Pressure, Humidity, Wind Direction/ Speed, etc.

j) TWA Assumptions: Exposure during un-sampled time.

k) Requested analytes: Record the results, units of measure, and name of the sampled analytes.

l) Comments field: Critical information will be captured in this field regarding the conditions of exposure and any observations made during inspections/data collection.

4.10. Data statistics

4.10.1. Statistical analyses can give exact descriptions of exposure profiles for testing against some hypothesis of OEL exceedance.

a) Whenever statistical methodologies are employed, larger sample sizes may be necessary.

b) In most cases, inferential statistics are not needed to interpret baseline data.

c) There are some instances, however, in which the ramifications of the interpretation are critical or sensitive either in terms of health risk to employees or the capital expense of engineering controls. In those situations, the Industrial/ Occupational Hygienist is encouraged to employ a statistical methodology.

4.10.2. The use of statistics for interpreting data must be done carefully with a large dose of professional judgment. Practical problems with non-randomized samples, non-stationary (changing) exposure distributions, and autocorrelation, reducethe accuracy of statistically based exposure assessments. The Industrial Hygienist must be cognizant of the difference between statistical significance and practical significance.

4.10.3. Statistical analyses of exposure data are used to describe exposure (descriptive statistics) or make inferences about exposure (inferential statistics).

a) Inferential statistics use the characteristics of exposure distribution to estimate probabilities associated with exposure values.

b) A log normal distribution of exposure values is present in most industrial workplaces.

4.10.4. The determination of acceptability or unacceptability of the data quality collected is a professional judgment; statistics are inputs to professional judgment.

a) The Industrial / Occupational Hygienist can employ the use of the Industrial Hygiene Statistics Spreadsheet (provided) published by the AIHA to analyze data (Provided).

4.10.5. Data analyzed through the AIHA spreadsheet will provide the following descriptive statistics for each SEG:

a) Number of samples.
b) Geometric mean.
c) Geometric standard deviation.
d) Range of sampling results.
e) Percent of samples exceeding permissible limits.

4.11. Occupational hygiene risk re-assessments

4.11.1. Workplace exposure will be re-assessed whenever there is a significant change in the process, equipment, material, jobs, tasks, or work practices.

4.11.2. Re-assessments are necessary whenever new and significant information becomes available on the toxicity of a material, or a change occurs in the OEL.

4.11.3. Significant changes in the workforce will be identified and considered in re-assessing exposures.

a) Risk assessments may be affected by a re-organisation of the workforce affecting the designation of SEGs.
b) Another possible effect is a significant change in average exposure levels resulting from a redistribution of tasks.
c) Finally, significant changes in employment may affect risk assessments.

4.11.4. Changes in agents may also affect the risk assessments.

a) Certainly, changes in the identity, quantity, and physical characteristics of agents may affect the risk assessments.
b) Moreover, a significant change in the health effects information or an OEL for an agent may affect the risk assessment.

- For example, a change in the OEL may affect the risk assessment where an exposure previously deemed acceptable, may now be unacceptable.

4.11.5. Qualitative occupational hygiene risk re-assessments shall be reviewed every two years. These reviews shall be documented.

4.12. Criteria for employee medical surveillance

4.12.1. Employees will be enrolled in the relevant medical surveillance standard if any one of the following criterion are met:

a) Five percent or more of the exposures to air contaminants exceed 50% of the OEL
b) Exposure to air contaminants or noise occurs on a less-than-daily basis, as with intermittent tasks and exceeds 50% of the OEL for an 8-hour shift for twelve or more days per year.
c) Five percent or more of exposures to air contaminants exceed 50% of the peak (excursion limit) OEL, STEL, or Ceiling Limit, for air contaminants.

4.13. Exposure controls

4.13.1. Exposure controls will be employed whenever occupational hygiene sampling data indicates potential overexposure for any SEG.

4.13.2. Such controls will include engineering or administrative controls whenever feasible.

4.13.3. PPE, such as respiratory protective equipment, will be utilized under the following conditions/circumstances:

a) Whenever engineering or administrative controls are not feasible;
b) While engineering controls are being installed;
c) When engineering controls are not working properly; or,
d) During the repair of these controls.

c) Area / Location Where Sample Collected
d) Work Task / Activity Performed
e) Sample Result, and
f) Conclusions and Recommendations.

4.15. Record keeping

4.15.1. Generally, industrial / occupational hygiene records are characterized as 'Personnel Records' to be managed in accordance with the company/organisations policy for such records.

a) Management of these records may be dictated by local regulation.

4.15.2. Industrial Hygiene records and Medical records will be maintained in separate files.

a) Industrial Hygiene records include exposure assessment data and exposure measurement data (e.g., biological monitoring data collected specifically to assess the magnitude of employee exposure to an agent).

4.15.3. Risk assessments must be documented to derive lasting value from the observation-based judgments made by the Industrial Hygienist.

4.15.4. All risk assessment documents will be maintained in accordance with country-specific regulatory requirements and timeframes.

5. Responsibilities

5.1. Industrial/Occupational hygienist

The Industrial / Occupational Hygienist is responsible for:

- Supervision of the Industrial Hygiene Risk Assessment and Sampling Standard.
- Conducting and leading the risk assessment process jointly with operational areas / business units.
- Where necessary, the design and implementation of appropriate monitoring and hazard control procedures.
- Designing monitoring strategies/plans for identified industrial hygiene hazards/stresses.
- Reporting occupational hygiene sampling results to affected personnel / stakeholders.

5.2. Company employees

Employees are required to participate in the IH Risk Assessment and in particular are responsible for:

- Following instructions in relation to the wearing of monitoring equipment.
- Avoid actions which will contribute to erroneous monitoring results.
- Convey any relevant information which has the potential to influence the interpretation of results.

5.3. Management personnel

a) Responsible for ensuring that identified controls are implemented in accordance with the hierarchy of controls.
b) Responsible for ensuring that the results of the IH Risk Assessment are reviewed, consolidated and reported to their Leadership Teams.

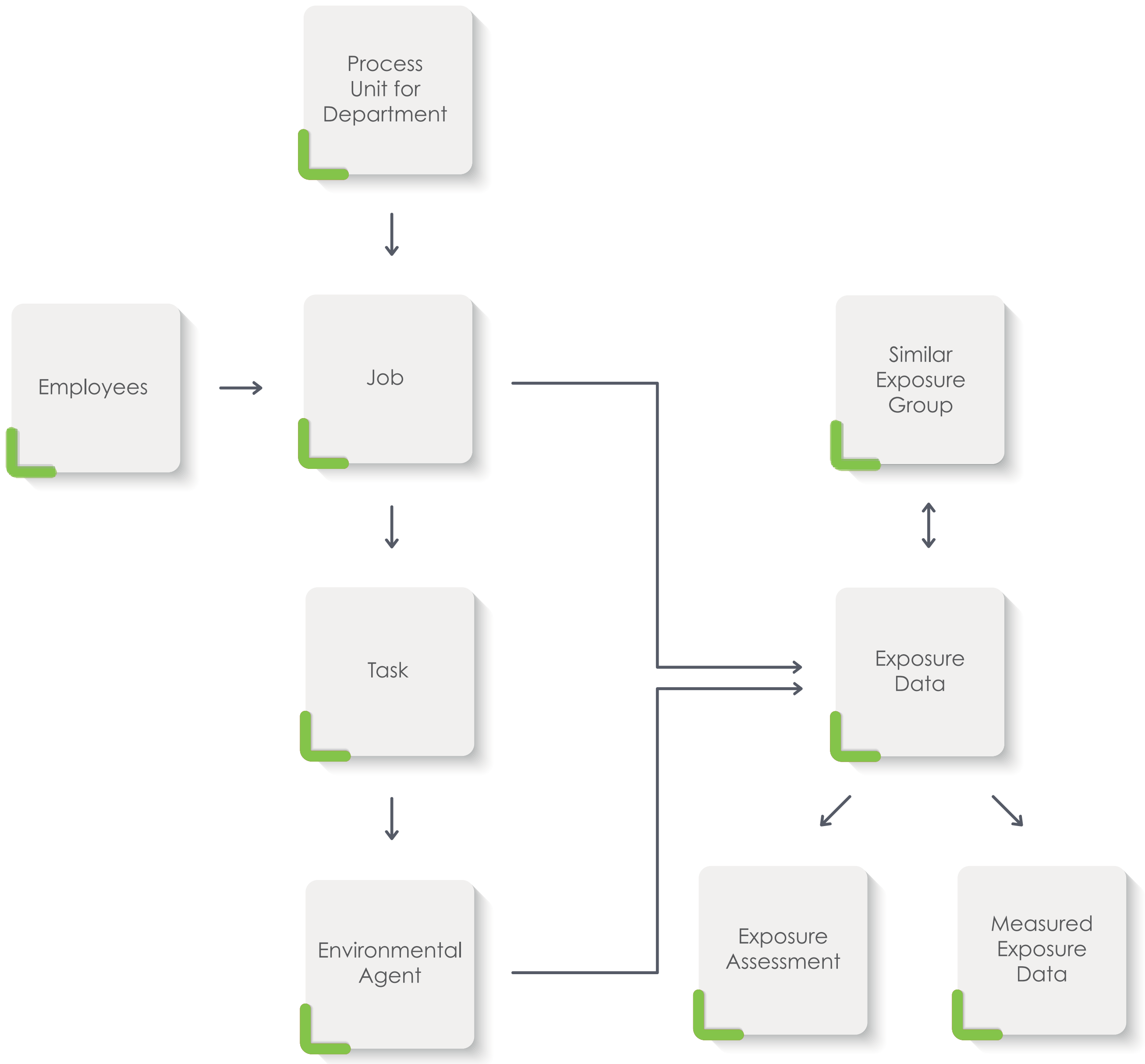
6. References

- A Strategy for Assessing and Managing Occupational Exposures, Third edition. William H. Bullock and Joselito S. I gnacio. American Industrial Hygiene Association (AIHA) Press. ISBN 1-931504-69-5.
- Occupational Exposure Sampling Strategy Manual (OESSM), published by the National Institute for Occupational Safety and Health (NIOSH), Publication No. 77-173 of 1977, United States of America: Department of Health, Education and Welfare
- Title 29 of the Code of Federal Regulations, Section 1910.1000, Air Contaminants (OSHA).
- American Conference of Governmental Industrial Hygienist's (ACGIH), Threshold Limit Values and Biological Exposure Indices Booklet.
- Hazardous Chemical Substances Regulations, 1995, South Africa
- Occupational Health and Safety Act,1993 (Act No. 85 of 1993), South Africa

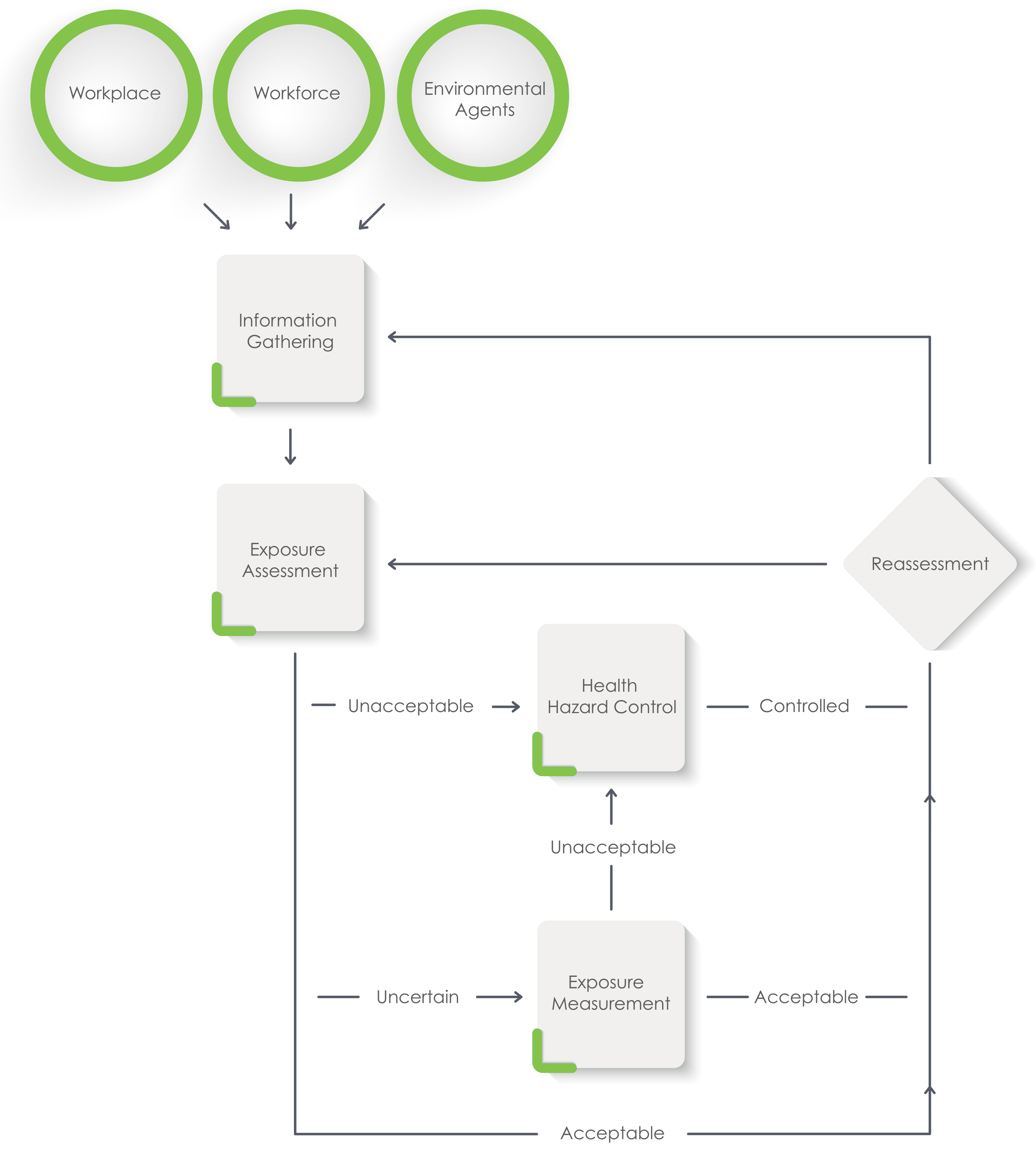
Appendices

Appendix A – Similar Exposure Group Work Flow Process
Appendix B – Exposure Assessment Process
Appendix C – An example of a Periodic Sampling Frequency methodology

Appendix A – Similar Exposure Group work flow process



Appendix B – Occupational hygiene risk assessment process



Appendix C – An example of a periodic sampling frequency calculation methodology

AIR CONTAMINATES ONLY		
Geometric Mean of baseline(GM)	**Toxicity**	**Approximate sampling Frequency in years**
50% the OEL	High Low	2 3
50% the OEL and 100% the OEL	High Low	0.5 1
100% the OEL	High Low	2 mos. 3 mos.

Notes:

1. Materials are classified "High" or "low" toxicity. High toxicity materials exhibit chronic health effects (e.g.,carcinogens, sensitizers, reproductive toxins, etc.) or an acute oral LD_{50} <50> mg/kg. Low toxicity materials include noise, primary irritants, and nuisance dust.

2. Unacceptable exposures may be sampled at the 2 - or 3 - year frequency, regardless of the data's geometric mean relative to the OEL.

PERIODIC SAMPLE SIZE Air Contaminants		
Number of employees in job class (N)	**Geometric Standard Deviation of baseline data (GSD)**	**Minimum number of samples (N)**
<10	≤2.00	3
	>2.00	5
≥10	≤2.00	7
	>2.00	9

Good practice: Dust sampling procedure

1. Introduction

Sampling is conducted to quantify occupational exposures to workplace stressors. In most cases, when a qualitative positive determination is made, sampling is necessary to determine the extent of the exposure, adequacy of control methods in use, or additional controls required to eliminate or minimize the hazard.

2. Scope & purpose

This procedure covers the sampling methodologies to be utilized by personnel conducting dust exposure sampling. The procedure is applicable to all personnel employed at [INSERT COMPANY NAME HERE]

3. Definitions

- Air monitoring means monitoring of concentrations of airborne hazardous chemical substances.
- Air Filter means a mechanical device that collects contaminants from an air stream.
- Compliance means to comply with health and safety legislation and / or recommended guidelines.
- Engineering Control Measures means control measures that remove or reduce the exposure of persons at the workplace by means of engineering methods.
- Hazardous Chemical Substance means any toxic, harmful, corrosive, irritant or asphyxiant substance or mixture of such substances for which an occupational exposure limit is prescribed, or for which an occupational exposure limit is not prescribed, but which creates a hazard to health.
- Monitoring means the planning and carrying out of a measurement programme and the recording of the results thereof.
- Occupational Hygiene means the anticipation, recognition, evaluation and control of conditions arising in or from the workplace, which may cause illness or adverse health effects to persons.
- Risk means the probability that injury or damage will occur.

4. Sampling procedure

This sections that follow describe the methods and work processes to be followed when conducting dust exposure sampling.

4.1 Equipment and consumable

4.1.1 The following equipment and consumables are required for dust/respirable dust sampling:

a) Primary flow calibrator

b) Air sampling pumps. Ensure pumps are clean and fully charged before use.

c) Sample holder / collection device

- 2 or 3-tier cassettes for regular particulate dust sampling.
- Dust cyclone meeting ISO Standard 7708 for respirable dust sampling.
  - ISO 7708 specifies a 50% (median) cut-point of 4μm for respirable dust

d) Dust collection filters as the applicable approved sampling methods [e.g. The National Institute for Occupational Safety and Health (NIOSH) sampling method or the Occupational Safety and Health Administration (OSHA) sampling method etc.].

- Mixed Cellulose Ester (MCE)
- Polyvinyl Chloride (PVC)

e) Tygon tubing

4.2. Calibration Considerations / Precautions

4.2.1 The purpose of calibration is to determine the volumetric flow rate that will pass through the sampling media during the time the sample is taken.

a) The flowrate is used to calculate total air volume.

4.2.2 For general dust sampling, it is not necessary for the flowrate to be the exact flow specified in the method. Just be sure you know exactly what it is.

a) Take at least 3 flow measurements that agree within 5% and use the average of the readings as your flow rate measurement.

b) If pre-and post-averages differ by more than 5%, your sample is called into question.

4.2.3 Do not handle sampling equipment and consumable materials with your bare hands as this may cause contamination (both personally and to the sampling media)

a) Wear disposable nitrile gloves when preparing sampling equipment / consumables.

4.3. Pump flow calibration

4.3.1 Let your pumps run 5 minutes before calibration after removing them from the battery charger to let the flow stabilize.

4.3.2 The pump must be calibrated with representative sample media in line.

a) Use a clean set of media to collect the sample in the field after calibration.

4.3.3 When necessary (for respirable dust cyclones), use a calibration adapter to attach the sampler to the calibrator.

a) Alternatively, use a calibration jar of a size to fit the sampler.

b) Do not use an extremely large jar with the piston style calibrators.

c) Consider the "jar less" calibration method when using piston-style primary calibrators.

4.3.4 Ensure the primary flow meter (Calibrator) has been externally calibrated and within its calibration cycle prior to use.

a) Do not use equipment that is out of calibration.

4.3.5 Attach the cyclone to the calibrator pressure port and pump to the suction port.

4.3.6 After sampling, clean all parts of the cyclone, by utilizing an ultrasonic bath

a) Don't forget to clean the grit pot.

b) Dry the cyclone (Air-dry or blow-dry).

4.3.7 Record all pre-and post-calibration (after sampling) flow rates on the appropriate field sampling form or sampling register/log book.

4.4. Sample collection using sampling pumps (active sampling)

4.4.1 Discuss the purpose of the sampling strategy and select the employee to be sampled.

a) Advise the employee not to remove or tamper with the sampling equipment.

b) Inform the employee where and when the equipment will be removed.

4.4.2 Instruct the employee to notify the occupational hygiene inspector or supervisor should there be a need to temporarily remove the sampling equipment.

4.4.3 Place the sampling equipment on the employee so that it does not interfere with work performance.

4.4.4 Attach the collection device (e.g., filter cassette) to the shirt collar (i.e., within the employee's breathing zone).

a) The inlet orifice should generally be in a downward vertical position to avoid contamination.

b) Ensure the collection device inlet will not be covered by loose items of clothing.

c) Position and secure any excess tubing (if available) so as not to interfere with the work of the employee.

4.4.5 Turn on the pump and record the sample start time.

4.4.6 Do not leave sampling equipment unattended for extended periods.

a) Monitor the operation and employees throughout the work shift to ensure that sample integrity is maintained, and cyclical activities and work practices are identified.

b) Record the time course of events, taking detailed notes concerning airborne contaminants and other conditions to assist in determining appropriate engineering controls.

4.4.7 Prepare field blank(s) during the sampling period.

a) Blanks are prepared in the same manner as the actual sampling devices, except air is not drawn through them.

b) Blanks should also be from the same lot number as the samples collected.

c) For NIOSH sampling methods, a minimum of 2 field blanks are required for each set of samples of a specific type.

d) If a set contains more than 20 samples, the number of field blanks required by NIOSH is 10% of the total number of samples with all fractions rounded up.

e) NIOSH states that in no case are more than 10 field blanks required regardless of the number of samples in the set.

4.4.8 At the end of the sampling period turn off the pump and record the sampling end time.

4.4.9 Determine the sampling pump post-flow rate, before charging. Take at least 3 flow measurements that agree within 5% and use the average of the readings as your post-sampling flow rate measurement

4.4.10 Carefully remove the collection device from the pump and cap open ends (e.g., for cassettes, insert cassette plugs).

4.4.11 Prepare the samples for submission to an accredited analytical laboratory following an appropriate chain of custody process.

5. Responsibilities

5.1. Industrial/occupational hygienist

5.1.1 Shall be accountable and have oversight over the implementation of this procedure, and ensure that the requirements of this procedure are followed by all personnel.

5.1.2 Shall facilitate the periodic review of this procedure.

5.1.3 Maintain all records arising from the execution of this procedure.

5.2. Occupational hygiene practitioners / inspectors

5.2.1 Shall perform hazardous chemical substance (dust) sampling when requested and promote compliance with the requirements of this procedure.

6. Attachments - Advanced risk assessment sheet – Refer to the CD

7. References

- Occupational Health and Safety Act, Act No 85 of 1993, South Africa.
- Regulations for Hazardous Chemical Substances, 1995 as promulgated under the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) South Africa.

INSERT COMPANY LOGO HERE	[INSERT COMPANY NAME HERE] FIELD SAMPLING RECORD	Sample Number:

Filter Medium/Type:	MCE		GF		PVC		OVM-1		Other		

Dust Fraction Type:	Personal		Strategic		Date:

Business Unit / Section:	Sampling Location:

Person Exposed:		Start Time:
Staff No.	HEG No:	Stop Time:
Job Category:		Total Minutes:
Pump/Dosimeter type:	IH Equipment No:	Pre-sampling flow rate:
Ventilation Used:		Post- sampling flow rate:
Respiratory Protection Type:		Ave Flow rate:
Sampling / Analytical Method No:		Volume:

Gravimetric Analysis?	Yes	No	Substance/Agent:
Lab Analyses Required ?	Yes	No	Lab Name:

Occupational Exposure Details		OEL:		IDLH:
		STEL:		Action Level:
Shift	From:	To:		Work Team:

Deviations from Method (If any):

Environmental Parameters:	Temp (°C or K):	Relative Humidity (%):	Other:

Wind Speed (m/s or Km/hr):	Barometric Pressure (mm Hg or Pa):

Remarks / Comments / Observations:

Sampled by:	Signature:
Checked & Approved by:	Signature:

TB in the Mining Sector Southern African Programme (TIMS)

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