ICMM
International Council on Mining & Metals

Good Practice Guidance on Occupational Health Risk Assessment

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List of Acronyms

HIA	Health Impact Assessment
HIRA	Hazard Identification and Risk Assessment
HOC	Hierarchy of Control
HRA	Health Risk Assessment
OEL	Occupational Exposure Limit
PPE	Personal Protective Equipment
SEG	Similar Exposure Groups
HEG	Homogeneous Exposure Groups

Contents

Foreword

Healthy workers are essential to the success of mining and metals companies, and ICMM member companies are driven in their protection of the health and wellbeing of both workers and local communities by ICMM's Sustainable Development Principle 5: To seek continual improvement of our health and safety performance.

ICMM has developed a set of tools to help site practitioners assess and address the risks posed by hazards in the mining and metals sector – this Good Practice Guidance on Occupational Risk Assessment provides those practitioners with the information and tools they need to assess the health and wellbeing of employees and contractors. A sister publication, Good Practice Guidance on Health Impact Assessment allows responsible companies to substantively assess the impacts of their operations on the health of the local communities, alongside environmental and social impacts.

Workforce protection should be seen in the context of a vision of 'Zero Harm'- ensuring that a workplace culture is embraced that recognizes occupational illnesses are preventable, that ensures repeat occurrences of occupational disease do not occur, and promotes the setting and implementing a consistent set of standards to prevent occupational illness.

This Good Practice Guidance identifies the occupational health impacts of mining and metals processing, outlines good practices in the identification of hazards and exposed workers, assists practitioners in estimating exposure levels and assessing the effectiveness of controls and explains the importance of quality analysis and reporting. The ICMM publication HERAG – Health Risk Assessment Guidance for Metals (2007) and its fact sheets provide detailed scientific support on metals-specific issues to the processes laid out here.

It is our intention that this publication provides a practical tool to assist companies in protecting the health and wellbeing of their workforce, and it aims to represent leading practice for companies operating in the mining and metals sector today.

Dr R. Anthony Hodge, President

8

SECTION 1:

Introduction

1.1 Purpose of the Guide

This guide is an information resource for conducting Occupational Health Risk Assessments (HRAs). It is intended for mining and metals managers and advisors who are responsible for ensuring the occupational health and wellbeing of employees and third party contractors. Though the guidance focuses on the occupational heath risks to employees and contractors in a mining and metals operation it is important to note that these risks can also affect the wider community living around that operation.

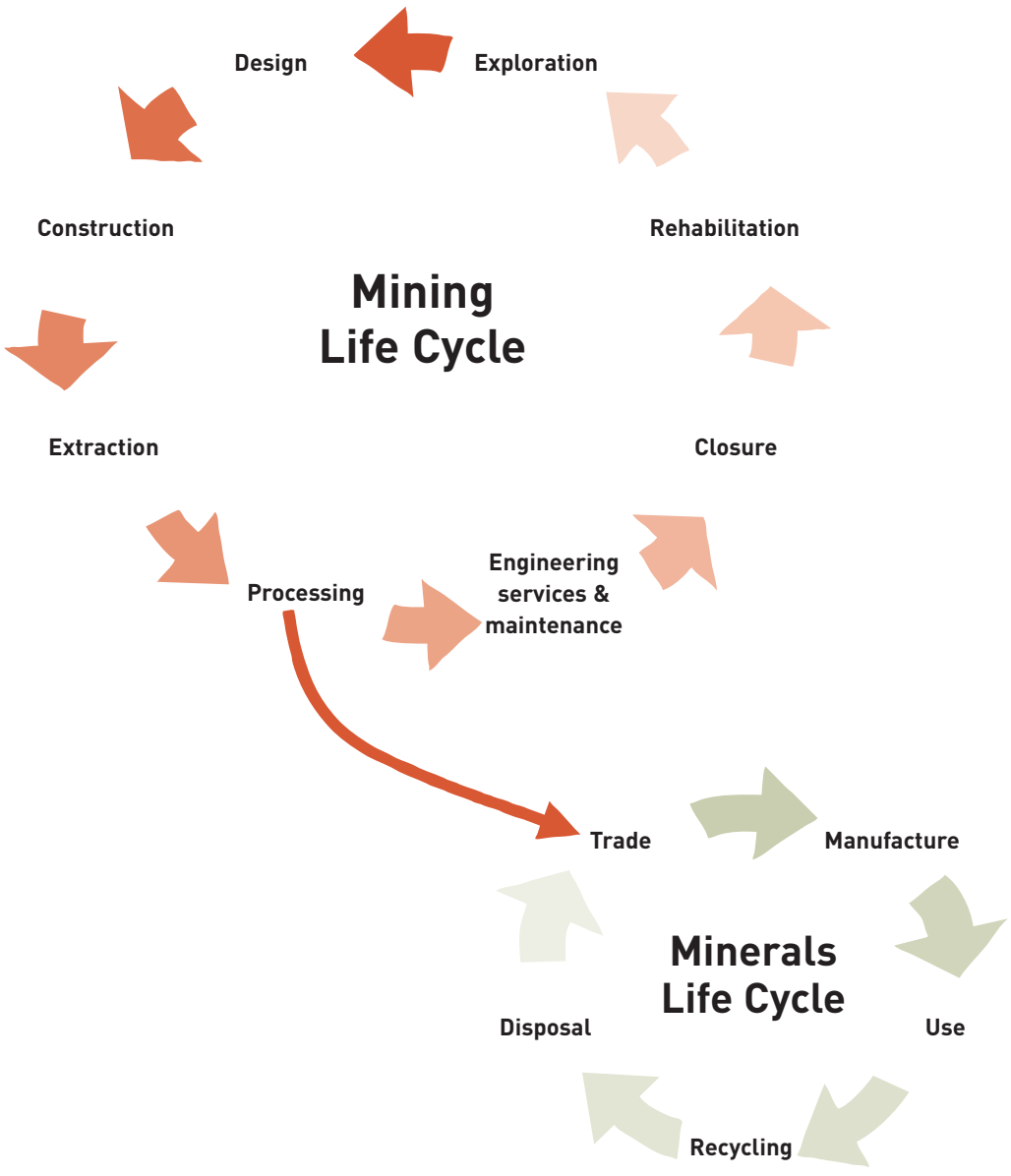
The aim of occupational HRAs is to systematically and proactively identify health hazards in the workplace, assess their potential risks to health and determine appropriate control measures to protect the health and wellbeing of workers. The HRA process is a partnership between occupational health advisors, occupational / industrial hygiene advisors, managers and operational staff with each - depending on the circumstances - using their knowledge, experience and skills to support the HRA process.

HRAs within the mining and metals sector is especially complex because of the breadth and range of the mining lifecycle which includes (See Figure 1):

- exploration
- design
- construction
- operation/extraction
- processing
- engineering services and maintenance
- closure
- rehabilitation / remediation.

This lifecycle also encompasses the movement of products, equipment and personnel by road, rail, air and sea and the associated transportation networks and distribution facilities, (e.g. ports and warehouses) as well as the manufacturing, recycling and disposal of goods made from the metals and minerals extracted from mines.

Figure 1 The mining and minerals lifecycles[1]



There are no specific figures for the international mining and metals sectors but every year, across all industries around the world, 160 million suffer occupation-related illnesses[2 3]. The world's biggest workplace killers are cancer (32 per cent of all work-related deaths), circulatory diseases (23 per cent), injuries (19 per cent) and communicable diseases (17 per cent).

[1] Adapted from International Institute for Environment and Development (IIED), World Business Council for Sustainable Development (WBCSD) and London School of Hygiene and Tropical Medicine. (2001). Worker and Community Health Impacts Related to Mining Operations Internationally: a rapid review of the literature. Mining, Minerals and Sustainable Development Project (MMSD).

[2] International Labour Organization. (2003). Safety in Numbers: pointers for a global safety culture at work. Geneva.

[3] International Labour Organization. (2007). Safe and healthy workplaces making decent work a reality. Geneva.

Workers are an important and valued part of the mining and metals sector and that places a moral obligation on the sector, alongside the legal obligations placed on them, to protect the health and wellbeing of their workers.[4] This moral obligation is increasingly being embedded within the sector through the adoption of the vision of zero occupation-related harm within a wider health and wellbeing at work policy.

The vision of zero occupation-related harm encompasses three key aspects:

- Developing a workplace culture across an organization which recognises that all occupation-related illnesses are preventable.
- Making a consistent and sustained effort to ensure that there are no repeat occurrences of occupational diseases in any workplace setting of an organization.
- Setting and implementing a simple, consistent and non-negotiable set of health and safety standards across an organization that aim to prevent occupation-related illnesses.

In addition to the cost of occupational ill health in terms of preventable human suffering, which affects not just workers but their families and communities, work-related illness also directly impacts on the productivity and bottom line of companies in the mining and metals sector. This is usually through:

- higher presenteeism and absenteeism
- under-utilization of expensive production plants
- decreases in economies of scale
- lower worker morale
- higher turnover rate
- loss of skilled and experienced workers
- loss of investment in training and development
- difficulties in recruiting new high-quality workers.

Alongside this, companies in the sector will also have to bear the costs of:

- health care for the affected workers
- compensation and/or damages to sick or disabled workers or to the families of workers that are killed
- higher insurance premiums
- legal advice
- regulatory fines
- damage to premises and equipment
- disputes and protracted negotiations with trade unions, public authorities and/or local residents
- loss of reputation
- loss of business
- loss of competitiveness
- in high-profile cases the, complete or partial, loss of the licence to operate.

[4] See ICMM Sustainable Development Principle 5 – www.icmm.com

Photo courtesy Newmont

1.2 Occupational Health Impacts

Introduction

There are a large number of hazards in the mining and metals sector that can pose a potential risk to health and wellbeing.

This section illustrates the range of health problems that can occur in relation to the various types of exposure in mining and metals workplaces. The list is not exhaustive and the risk profile of any particular worker will depend on the exact nature of their role and their individual exposures.

The Physical Environment

The physical environment where exploration, mining, ore extraction and processing takes place can cause health impacts in the following ways:

- **Physical injury** from accidents involving moving machinery, movement of mining products and from working with explosives and detonating devices
- **Musculoskeletal disorders** associated with various work activities e.g. where manual handling is a feature or repetitive motion are required and whole-body vibration
- **Noise-induced hearing loss** associated with occupationally related excessive noise exposure
- **Hand arm vibration syndrome** and other musculoskeletal consequences from hand-arm transmitted vibration
- **Skin cancer** from working outdoors in direct sunlight
- **Effects from both ionising and non-ionising radiation** e.g. cataracts
- **Heat exhaustion, hypothermia and various other health effects** from exposure to extremes of temperature

The Effects of Hazardous Substances

Exposure to some of the major hazardous substances encountered in the mining and metals sector can result in a number of important health effects. These are listed below to illustrate the range of potential problems.

- **Skin disorders (burns, contact dermatitis, cancer)** from contact with a wide range of chemicals including acids, alkalis, solvents, fuels, lubricants and resins. For example:
    - **Irritant contact dermatitis** from some fuels, solvents, lubricating oils and greases
    - **Allergic contact dermatitis** from epoxy resins used in adhesives and the salts of some metals including nickel and chromium (e.g. in cement)
- **Intoxication, through to asphyxiation and death** can result from the inhalation of some gases and vapours including the toxic gases hydrogen sulphide, carbon monoxide and sulphur dioxide
- **Acute pneumonia** may result from exposure to blasting fumes

- **Damage to the respiratory tract** from exposure to airborne chemicals (dusts, gases and aerosols) eg. Silicosis, coal worker's pneumoconiosis and asbestosis arising from exposure to crystalline silica, coal dust and asbestos respectively, lung cancer and mesothelioma from exposure to asbestos and nasal sinus cancer from exposure to nickel subsulphide and acid mists.
- **Damage to internal organ systems** such as the lung, kidney, liver, bone marrow and brain from the absorption of chemicals and metals through the skin, respiratory and digestive tracts.

Onset of symptoms in relation to exposure

When considering how to monitor for the development of adverse health effects from exposures in the workplace it is important to consider the timeframe over which the health effects manifest themselves.

Acute health effects are those that are more likely to be immediately obvious to the individual and where it is often possible to attribute cause and effect. Acute health effects usually appear within hours of exposure. For example, contact with an irritant vapour may lead to watering eyes, sneezing, coughing, irritation and, in extreme cases, respiratory distress.

Chronic health effects are ones that can develop over a longer period of exposure. On occasions these will be conditions where the severity of the symptoms or disease, or the risk of harm, is related to the accumulative exposure to the hazard over a period of months or years. Chronic health effects usually occur after repeated exposure over days, weeks and months. Examples of such conditions would be noise-induced hearing loss and hand arm vibration syndrome.

Long latency is a feature of many occupationally acquired diseases where the development of the signs and symptoms of the condition occur many years after the exposure that is implicated in causation. Examples include the development of mesothelioma (following asbestos exposure), other lung cancers and pneumoconiosis (silicosis, coal worker's pneumoconiosis, asbestosis) which can occur decades after exposure has ceased.

Other occupational hazards to health

The mining and metals sector, as with all employment sectors will on occasions encounter cases of 'stress' and other adverse mental health and wellbeing effects which are attributable to, or contributed to by, occupational factors, including shift work. A further potential adverse health effect is chronic fatigue brought about by the intense physical demands of mining and metals activities.

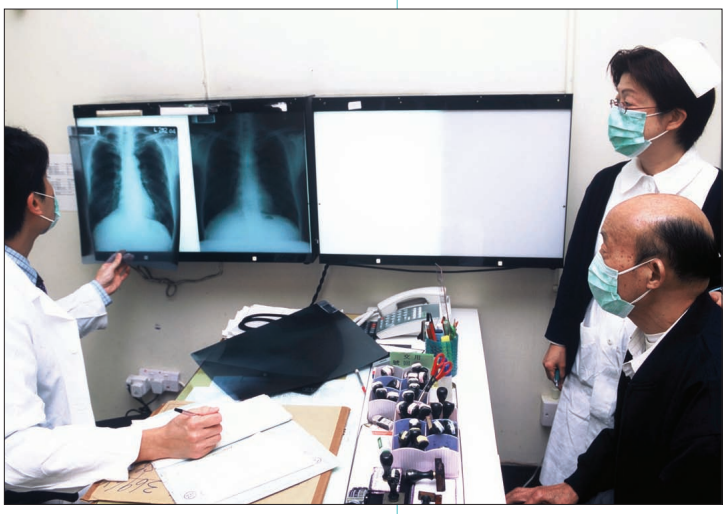


Photo courtesy Lung Health Image Library/Pierre Virot

1.2 Occupational Health Risk Assessment

Introduction

Health risk assessment involves four key elements:

- identification of hazards,
- examination of the potential health effects,
- measurement of exposures and
- characterisation of the risk.

An Occupational Health Risk Assessment (HRA) is therefore the structured and systematic identification and analysis of workplace hazards with the aim of reducing the risks of exposure to these hazards through the development and implementation of avoidance, control and control failure recovery measures. In the occupational setting, it is the preliminary component to health risk management.

Health risk management is the decision-making process involving considerations of political, social, economic and engineering factors combined with risk assessment information to develop, analyze and compare options and to select between them.[5]

Steps in an HRA

An HRA is generally a cyclical and iterative process rather than a simple linear one. An HRA is generally made up of the following steps:

1	Identify the health hazards and their harmful health effects
2	Identify the exposed individuals and groups (i.e. Similar Exposure Groups)[6]
3	Identify the processes, tasks and areas where hazardous exposures could occur
4	Assess, measure or verify the exposures
5	Analyze the effectiveness of existing control measures
6	Analyze the potential health risks of the hazardous exposures (e.g. compare against occupational exposure limits)
7	Prioritize the health risks (high, medium and low)
8	Anticipate potential new and emerging health risks
9	Establish a risk register
10	Set priorities for action
11	Develop, implement and monitor a risk control action plan or review existing risk control action plan
12	Maintain accurate and systematic records of the HRA or amend existing Risk Control Action Plan and use alternative and/or additional control measures
13	Review and amend at regular intervals or earlier if changes to processes or new developments are proposed

[5] International Council of Metals and the Environment. (2001). Risk assessment and risk management of non-ferrous metals: realizing the benefits and controlling the risks.

[6] The term 'Similar Exposure Groups' (SEGs) is now increasingly accepted and is used throughout this guidance document in place of the older term 'Homogenous Exposure Groups' (HEGs). HEGs is a term commonly applied in South Africa. Both terms refer to workers exposed to similar risks.

Figure 2 provides a flow diagram of the above steps and how the health risk assessment cycle works for both new and existing operations.

Types of HRA

There are three broad types of HRAs that are each conducted at different levels and at different times:

- Baseline HRAs
- Issues based or targeted HRAs
- Continuous HRAs

A **baseline HRA** is used to determine the current status of occupational health risks associated with a facility. This tends to be a very wide ranging assessment that encompasses all potential exposures.

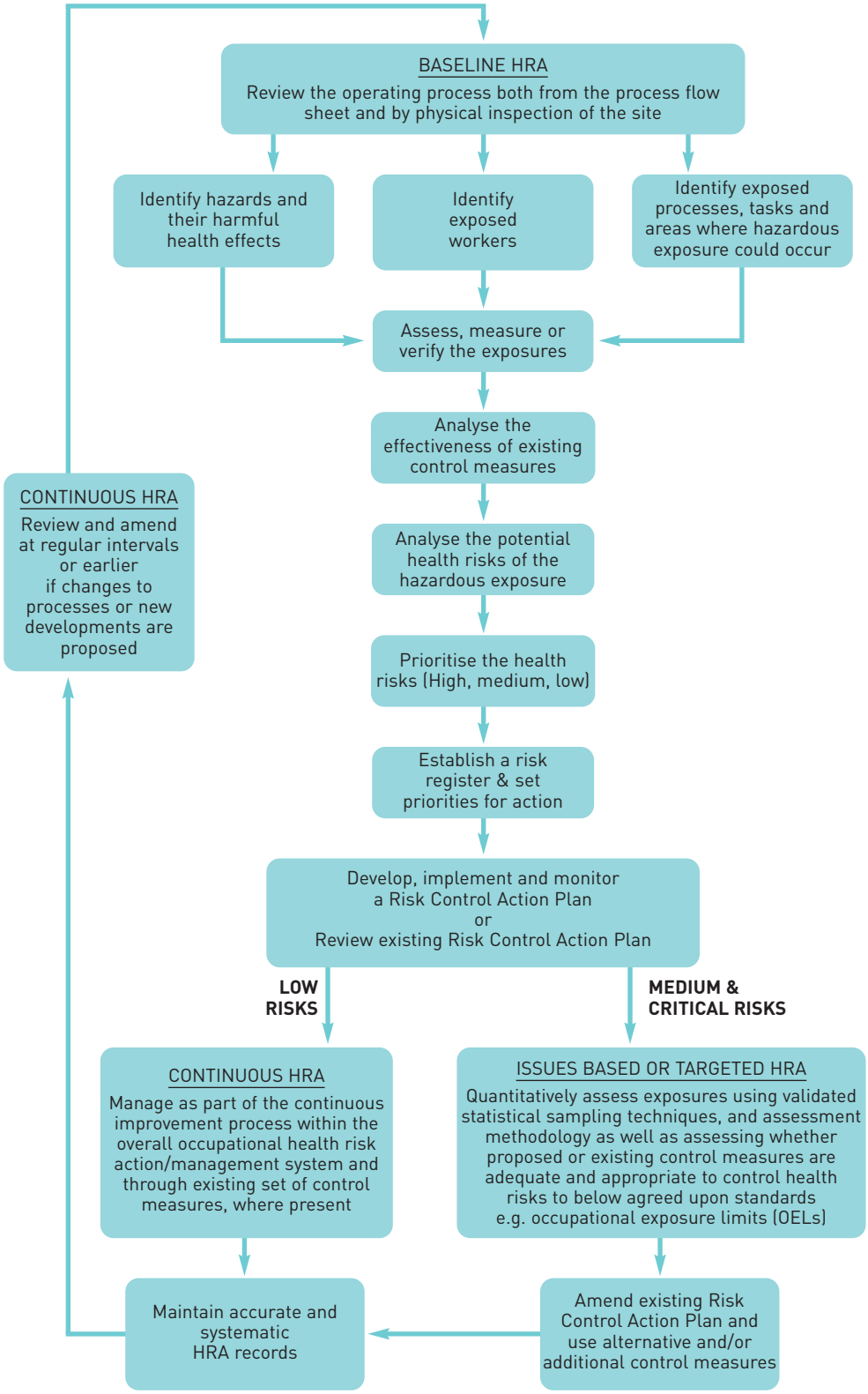
An **issues-based or targeted HRA** is designed to provide a detailed assessment of specific processes, tasks and areas that have been identified as priorities in the baseline assessment.

A **continuous HRA** is an ongoing monitoring program or a schedule of regular reviews to determine whether conditions have remained the same, whether changes in processes, tasks or areas have occurred and whether these changes have modified any hazardous exposures and hence any potential health risks. A management of change program can also be considered as being part of a continuous HRA program.

An HRA can be **qualitative** involving a qualitative assessment of exposures and/or risks (e.g. baseline HRAs) or **quantitative** involving the measurement of exposures and/or the quantification of the potential health risks (e.g. issues based HRAs).

Photo courtesy Oz Minerals

Figure 2: The health risk assessment cycle for new and existing operations



When to do an HRA

All three types of HRA are generally undertaken in the mining and metals sector although each is conducted at different points in time during the HRA cycle. A baseline HRA is conducted first - this identifies priority hazards, risks and areas that need additional assessment. An issues-based or targeted HRA is then instigated. The development of an exposure sampling strategy and control monitoring program within a continuous HRA provides data that further informs the original baseline HRA. A new issues-based HRA may then be undertaken, and so on, in an ongoing and iterative process.

An HRA, or the review of an existing HRA, should be considered in the following situations:

- All routine and non-routine new activities and developments (exploration, design and construction)
- All existing operations (operation and extraction)
- Where there are changes to existing activities (expansion, replacing an old process with a new one)
- Post-operating activities (closure and remediation/rehabilitation)
- Following an incident/accident.

New developments, processes, activities and working methods

A **baseline or issues-based** HRA, undertaken at the conceptual and detailed design stages of new developments, processes and activities, provides an opportunity for the implementation of the most cost-effective approaches for the elimination and reduction of hazards in the workplace.

This HRA should generally focus on the plans and process descriptions and discussions with design engineers, occupational health and hygiene specialists and operational staff to identify:

- Potential health hazards
- Tasks and activities where workers might be exposed to these hazards
- Likely levels of exposure
- Appropriate exposure limits
- Likely baseline health and well-being of potential workers.

This information should then be used as a key input into the overall design of a mine, allowing the design of exposure controls, the implementation of appropriate standards for such controls, and the development of operating procedures.

Photo courtesy Oz Minerals

Existing Operations

A **continuous** HRA is more suitable for existing operations with a focus on potential exposures during both routine and non-routine operational activities as well as normal, abnormal and emergency conditions. It is important that the possibility of long latency diseases is assessed and that adequate data is collected to ensure appropriate controls, in the first instance, and to provide for the follow up of employees upon closure.

Change to Existing Activities

Changes in processes and tasks, as well as additional development, should trigger a **review** of the existing baseline and continuous HRAs. This review would generally focus on whether there is a need to conduct a full HRA of the whole operation; an HRA of that specific process or task; or the incorporation of the change into the existing HRA through minor amendments to the HRA and the existing risk control action plan.

Closure and post-operation

An **issues-based** HRA should generally be undertaken when a mine or other facility is closed. Closure brings a different set of health issues concerned with dismantling plant, buildings and equipment. These include residues, hazardous materials, naturally occurring radioactive substances, asbestos, etc. There is also likely to be a need to clean up any contaminated land before divestment. The closure HRA should also consider the possibility of long latency diseases and provide for the follow up of employees with the relevant exposures. Lastly, workers in the mine are likely to lose their jobs and this may lead to anxiety, stress, depression and other mental health and wellbeing effects.

Following an incident

Should there be an incident, e.g. failure of a control measure, then a **review** of the existing baseline and continuous HRAs should be undertaken to ascertain the causes of the incident and prevent future occurrences. Incident data should inform the calculation of the frequency of exposure although it is also important to review incidence data from the mining sector as a whole.

New versus existing operations

A **baseline** HRA will be needed for all new operations. However for existing operations it is likely that a baseline HRA has already been done – this should be reviewed and an issue-based HRA instigated as necessary. It is worthwhile for new operations to review HRAs conducted for similar existing operations. This can fast track the progression from baseline to issues-based HRA though conducting a baseline HRA for any new operation is vital.

Scope of an HRA

It is important to define the objectives and boundaries of the HRA. This judgement should be made after discussions with managers and worker representatives.

The major boundary for any HRA are the physical boundaries. Some examples of physical boundaries are:

- A complete operational site with a well-defined activity, such as an individual mine, a set of clustered mines or an office block or operational complex
- An individual process unit within a large mining complex
- A group of functions which support a single business process

Other aspects that should be considered include whether the focus is on specific processes, tasks or workers and whether exposures will be estimated qualitatively or measured and quantified (i.e. whether the HRA will be qualitative or quantitative) which is very dependent on past experience and exposure data collection from similar processes or tasks. Section 3.1 provides further guidance.

Setting up an HRA team or advisory group

Ideally the HRA should be carried out by a multi-disciplinary team with a range of specialist skills, including those associated with the process or task being assessed. The exact number of people involved in the HRA and the range and level of skills required depends on:

- The size and complexity of the facility, process or area being assessed
- The nature and severity of the hazards and health risks involved

In some circumstances, there may be only one occupational health or hygiene practitioner on site and in this case an advisory group should be established to support the process and scope the HRA. In general, where an HRA team or advisory group is set up it should include:

- An occupational health or hygiene advisor with experience of conducting HRAs
- A management representative from the facility, process or area being assessed
- A worker representative with knowledge of the facility, process or area being assessed
- Other specialist staff as required e.g. designers, engineers, toxicologists or ergonomists

A management representative is worthwhile as early engagement can ensure that the findings of the HRA are acted upon quickly. A worker representative can be a valuable part of an HRA team or advisory group as they can bring detailed knowledge of the process, activity or area being examined, as well as insights as to how tasks are actually performed. This helps to ensure that the analysis of the potential health risks is accurate. In addition, their involvement in the HRA is likely to increase their understanding and appreciation of health hazards and support the development of a zero harm mindset among workers.

Additional specialists can be part of the core HRA team, part of the wider support base that are consulted when needed, or may act as peer reviewers of the final draft HRA before it is finalized.

Key competencies needed to conduct an HRA

The key individual and team competencies needed to undertake HRAs successfully are shown in Table 1.

Table 1: Key competencies for undertaking occupational HRA

Domain	Competency
Knowledge	An understanding and experience of conducting HRAs. An understanding of the workplace operations being assessed. An understanding of the methods for controlling exposures and reducing risks in mining and associated workplaces.
Organizational	The ability to collect information systematically and comprehensively.
Scientific	The ability to predict any potential departures from expected or observed practice and understand its significance. The ability to undertake simple diagnostic tests, for example using a smoke tube to test air movement, simple sound level metering or using colorimetric tubes, etc. The ability to identify and review the relevant scientific and technical literature. The ability to look critically at existing arrangements. The ability to observe so that you can clearly appreciate the activity being performed and the significance of what you are seeing, particularly where written procedures are not being followed. The ability to assess exposures and estimate the potential health risks arising from them. The ability to develop credible, statistically valid and robust conclusions from the analysis of health risks.
Medical	Knowledge and understanding of the health effects of major physical, chemical, biological, ergonomic and psychological exposures in the mining and metals sector.

Domain	Competency
Managerial	The ability to investigate, and pursue with management, whether hazardous exposures need to occur in the first place. The ability to perceive the range and limitations of possible control measures and their relative reliability.
Communication	The ability to ask the right questions to operational staff, managers and advisors and understand the significance of the answers. The ability to specify and follow up on the type of control measures needed and their implementation. The ability to record findings in an understandable manner.
Personal	An awareness of the limits of own competence and the confidence and persistence to be able to ask for, and get, specialist assistance when required.

Photo courtesy Anglo American/Vismedia

SECTION 2:

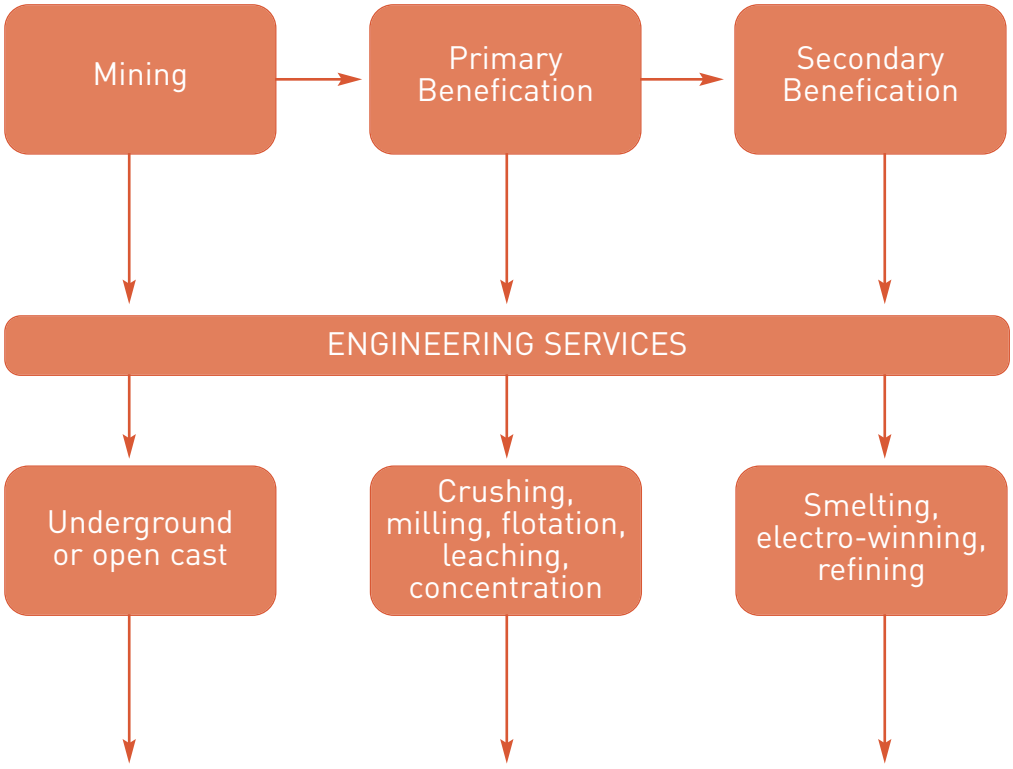
Identification of issues

2.1 Identifying Health Hazards

Introduction

Mines are complex workplaces involving the entire spectrum of extraction, crushing, milling, flotation, smelting and refining as well as engineering processes from the operation of chemical processes, heavy equipment and electrical maintenance to electronics. Operations are often located in remote environments and it will be important to also consider issues around security, the potential for natural catastrophes, travel risks, medical evacuation capability, the standards of local health facilities etc. The range of potential exposures is therefore extensive. Figure 3 illustrates the main elements of the mining and mineral process and how they influence the types of hazards found.

Figure 3: Illustrative flowchart for a mining operation



For the various stages of a mining operation the categories of hazards remain the same:

- Physical environment
- Chemical
- Biological
- Ergonomic
- Psychological

However, the particular types of hazards which predominate within each of the above five categories changes at the mining, primary beneficiation and secondary beneficiation stages as well as for each of the activities within these stages.

STEP 1: DESK-TOP ANALYSIS

The first step in identifying health hazards is a desktop analysis. This is particularly useful where records of previous HRAs and other employment records are available. Some examples of the types of records that might be available are:

- Incident reports
- Audit reports
- Previous HRAs
- Occupational illness and injury reports
- Equipment maintenance and fault reports
- Health surveillance records[7]
- Sickness absence reports
- Previous occupational hygiene surveys
- Site inspections
- Minutes of health and safety meetings
- Material Safety Data Sheets (MSDS)

A review of the design of the facility, together with blueprints and schematics of the individual area or process, and related health records will help to systematically identify the potential health hazards that are present or might occur. A simple checklist such as the one shown in Table A1, in the Appendix, can be useful in doing this.

STEP 2: WALK THROUGH SURVEY

A walk-through survey of the area, process or task enables the assessor to get a sense of the types of potential health hazards, the levels of exposure, the types of workers and workers' general levels of health and physical and mental functioning through the careful use of the senses – vision, hearing, smell and feel.

Some key aspects to be considered

Physical environment issues

- What noisy equipment or processes are present?
- Are cutting and welding activities carried out which emit infra-red or ultra-violet light radiation? Is any equipment used which emits ionising radiation?
- What tasks involve exposure to hand arm transmitted or whole body vibration?
- Are there any working areas where extremes of heat, cold or humidity are present or could occur?
- Are there any specialist tasks involving changes in atmospheric pressure, e.g. tunnelling work under compressed air?
- Is ventilation adequate? Is there a good supply of fresh air and extraction of potentially harmful gases?

[7] Health surveillance can vary from simple questions from trained supervisors to comprehensive medical supervision undertaken by an occupational health physician. It is important to assess the strength of evidence and determine the appropriate weighting given to the information that is available. An adverse report from a responsible person undertaking screening skin inspections will generally have less weight than of an occupational physician or a dermatologist who diagnoses an occupational skin disorder.

Chemical agents

- Are workers exposed to chemicals that could affect normal physical or mental functioning in the short or long term?
- What chemicals are being used? Review the site hazardous chemicals register if available.
- Does the process allow for chemicals to be mixed and could that give rise to a hazard?
- What products, by-products and wastes (gaseous, liquid or solid) are being produced?
- What potentially hazardous building construction materials have been used?

Biological issues

- What systems are present for drinking water, effluent, sanitation and sewage? What is the potential for pathogenic microorganisms?
- What washing facilities are present? Are they adequate for the number of workers and are they cleaned regularly?
- Does the site have a legionella management and control program?
- In restaurants and canteens and eating places, what is the potential for insects, rodents and microorganisms?
- Are there air-conditioning systems? What is the potential for pathogenic microorganisms?
- Are there any disease carrying insect or rodent vectors in the local environment e.g. malaria carrying mosquitoes, leptospirosis and plague carrying rats, etc?

Ergonomic issues

- Do workers have to carry out heavy manual tasks?
- Are workers involved in repetitive, awkward or unnatural movements; or do they have to remain in a static position for long periods?
- Do they wear occlusive protective clothing that restricts free movement or requires greater exertion?
- Does the job require immediate mental alertness and agility? Could fatigue, distraction and the use of medication create a hazard?

Psychological issues

- Is the job organization, in terms of shift patterns, rotations, resources and workload likely to lead to sleep disturbance and/or mental stress?
- Is there harassment, discrimination, bullying or violence either explicit or implicit?
- Is there restructuring of the organization or business unit and/or a change or redeployment of workers?

- Are workers isolated from family, friends and other social support networks or working alone?
- Are there culture, faith and language issues?
- Is there a lack of leisure and recreation opportunities?
- Is there a system in place for workers to pass on issues and complaints? How well is it used?

STEP 3: RATING HAZARDS

Hazards can also be numerically rated in terms their likely health effects as shown in Table 2. This supports the accurate assessment and prioritization of risks by highlighting those hazards that could give rise to significant harm to workers.

Table 2: Illustrative example of criteria to rate hazards (see also Tables 5-7)

HAZARD RATING	DEFINITION
1 **Minor health effects**	Exposure at this level is unlikely to lead to harm.
2	Non-life threatening reversible health effects.
3	Adverse health effects that are permanent but do not significantly affect quality of life or longevity. Health effects that may be mildly limiting or disabling and therefore could lead to a change of occupation and lifestyle.
4 **Significant and severe health effects**	Adverse health effects that are generally permanent and could lead to a significant reduction in quality of life and/or longevity. Continued exposure is generally likely to lead to permanent physical or mental disability or a long term limiting illness.

2.2 Identifying Exposed Workers

Introduction

Where there are large numbers of workers it may not be practical to assess the risks for each individual worker. In such cases it is more effective and efficient to identify groups of workers with similar exposure levels. These groups are generally referred to as Similarly Exposed Groups (SEGs).

Identifying exposed workers by Similar Exposure Groups

A sensible approach is to divide workers by process or areas of work and then to subdivide them by occupation and generate groups of workers with similar exposures i.e. Similar Exposure Groups (SEGs). In this way the exposure and risks to workers can be better captured and assessed accurately. SEGs may be based upon tasks or area of work depending on the structure of the working environment, and should include third party contractors where exposed.

It is important to develop a reasonable number of SEGs, not too many and not too few, as too few will not differentiate the exposures of workers narrowly enough and too many will become difficult to manage. The exact number will depend on the ranges of different processes and hence categories of exposure under consideration.

Typical examples of occupational groups by process or area of work are:

- Ore extraction worker
- Ore transfer truck drivers
- Smelting plant maintenance staff
- Office administrative staff
- Laboratory technicians
- Mine geologists and engineers

It is important when developing SEGs to list all the key processes and tasks that are undertaken by workers doing similar jobs so that hazards can be systematically and comprehensively identified. It is useful to draw on workers' own experiences and to discuss with workers the activities that they are undertaking in a particular area of work to ensure that all the potential exposures have been identified. As a general rule of thumb a worker should be assigned to a SEG based on which areas and/or processes where he/she spends 80% of their time.

Identifying exposed workers by susceptibility

It is also worthwhile identifying whether there are any workers that are potentially more susceptible or vulnerable to some hazards than other workers such as:

- Pregnant women and nursing mothers
- New recruits or temporary workers because they do not know what hazards are present and how to avoid or deal with them
- Workers with pre-existing occupational and non-occupational illness and any other form of physical or mental limitation identified by the medical surveillance program.

- Workers operating in high hazard areas or processes
- Ageing workforce
- Smokers or other substance users, including medications, where this may increase the health risk from an occupational hazard

Photo courtesy Anglo American/Vismedia

2.3 Identifying Potentially Hazardous Processes, Tasks and Areas

Introduction

To systematically identify and assess processes, tasks and areas where exposure to hazardous agents may occur and to assign workers to the most appropriate SEGs, it is important to review:

- processes and tasks
- equipment and machinery
- environment and location
- medical surveillance records and trends[8]

Processes and tasks

When reviewing processes and tasks some important things to consider are:

- Routine, non-routine and emergency situations
- Hours of work
- Shift rotation
- Control measures already in place

Equipment and machinery

When reviewing equipment and machinery some important things to consider are:

- Its design and condition
- How it is used and the training being provided
- Whether it is malfunctioning or inoperable
- Whether it is being maintained
- Its location in relation to other activities
- Associated hazards e.g. dust, noise, vibration, radiation, heat or exhaust emissions

Environment and location

When reviewing the environment and location some important things to consider are:

- Adequacy of ventilation
- Appropriate temperature regulation
- Humidity
- Ergonomic design of the work space
- Lighting
- Physical space available to move around in

[8] These records are held by the occupational health clinic and only concern medical examinations and tests done in relation to exposures in the workplace. They thus differ from personal medical records that are held by the employee's personal doctor or primary care records that may be held by the occupational health clinic. Personal medical records are confidential but there may be some access to anonymised medical surveillance records. In general, consolidated data or information that has had the identification removed may be viewed. Should it be necessary to view an individual's record without removing their identity then the employee's permission will need to be sought.

Controls

- What controls are in place?
- At what level in the hierarchy of controls are they? (See section 3.2)
- Are they effective?
- Are they being maintained?
- If PPE is used:
    - Is it appropriate and effective?
    - Has training been provided?
    - Is its use monitored?
    - Is it maintained?

Photo courtesy Xstrata

SECTION 3:

Assessment

3.1 Assessing Exposure Levels

Introduction

The aim of estimating exposure levels is to characterize exposures in terms of their intensity and duration for SEGs, processes, tasks and areas. Exposures can be estimated indirectly and qualitatively or quantified by direct measurement. All exposure measurements should follow a validated statistical sampling and assessment methodology as well as quality control procedures. Figure 4 provides a decision flowchart to aid decision-making on which exposure measurement strategy to use in a particular context.

Indirect qualitative assessment of exposures

Indirect qualitative assessment of exposure can be made either during a walk through survey to identify the potential health hazards, or based on previous direct quantitative measurements of exposure, or a combination of the two. The level of exposure is assessed by taking into account the hazards that have been identified, the SEGs that have been defined and the processes, tasks and areas that have been considered through the review of documents, the walk through survey and discussions with managers and workers.

Direct quantitative assessment of exposures

Direct measurement of exposures to health hazards should be considered when:

- Doubts arise about compliance with recognized exposure limits
- Excessive exposure could involve serious health effects
- Justification is needed to implement control measures
- The choice of control measures depends on the levels of exposure
- The effectiveness of a control measure needs to be evaluated
- Workers' concerns need to be alleviated
- It is, or has become, a regulatory requirement
- Investigating or responding to reported health effects

Key questions to consider when estimating exposures

The following points can help in estimating exposure levels:

- Are levels of exposure consistently high or low, are there peaks and troughs in the levels of exposure and are they continuous or intermittent?
- Note any aspects of processes and tasks that may increase exposure
- Speak to staff to understand their perceptions and experience of the task and the associated hazards
- Review non-routine and intermittent activities, e.g. maintenance operations, loading and unloading and changes in production cycles
- Take account of unplanned but foreseeable events such as interruptions in work activity, potential for accidental exposure and machinery failure
- Review whether the medical emergency response arrangements are

appropriate e.g. first aid measures and transfer of victims to specialist facilities

- Consider whether workers not directly involved in a particular activity but present in the vicinity are exposed to a hazard.

Rating exposures

Exposures can then be rated using a scale based on an Occupational Exposure Limit (OEL) or other health standard (See Table 3). When rating exposures it is important to consider:

- All the relevant routes of exposure
- Potential cumulative exposures
- Any limitations in health standards if the standard does not consider all routes. For example, potential dermal or ingestion risks are generally not taken into account when OELs are set.[9]

NB: For carcinogens and reproductive toxicants (known and suspected), meeting an OEL is not adequate; exposures must be 'As Low As Reasonably Achievable or Practicable' (ALARP).[10] There must be an annual documented review of exposure controls for these substances.

Table 3 uses a simple exposure rating system for illustrative purposes. In practice, exposure ratings can range from negligible through low, medium/moderate, and high to very high/critical.

Table 3: Illustrative example of criteria for rating exposures

EXPOSURE RATING	OEL EXPOSURE BAND	DEFINITION	ACTION ZONE
Low	Less than 50% of OEL (<0.5 x OEL)	Frequent contact with the potential hazard at low concentrations, or infrequent contact with the potential hazard at moderate concentrations. Frequently can expect the exposure to be less than 10% of the OEL, or infrequently can expect the exposure to meet or exceed 10% of the OEL, but less than 50% of the OEL). Exposures are at or well controlled to below the OEL, there are less likely to be breaches of the OEL and this level of exposure is likely to cause little or no adverse health effect.	**SUPERVISORY** Sampling strategy is aimed at routine checks

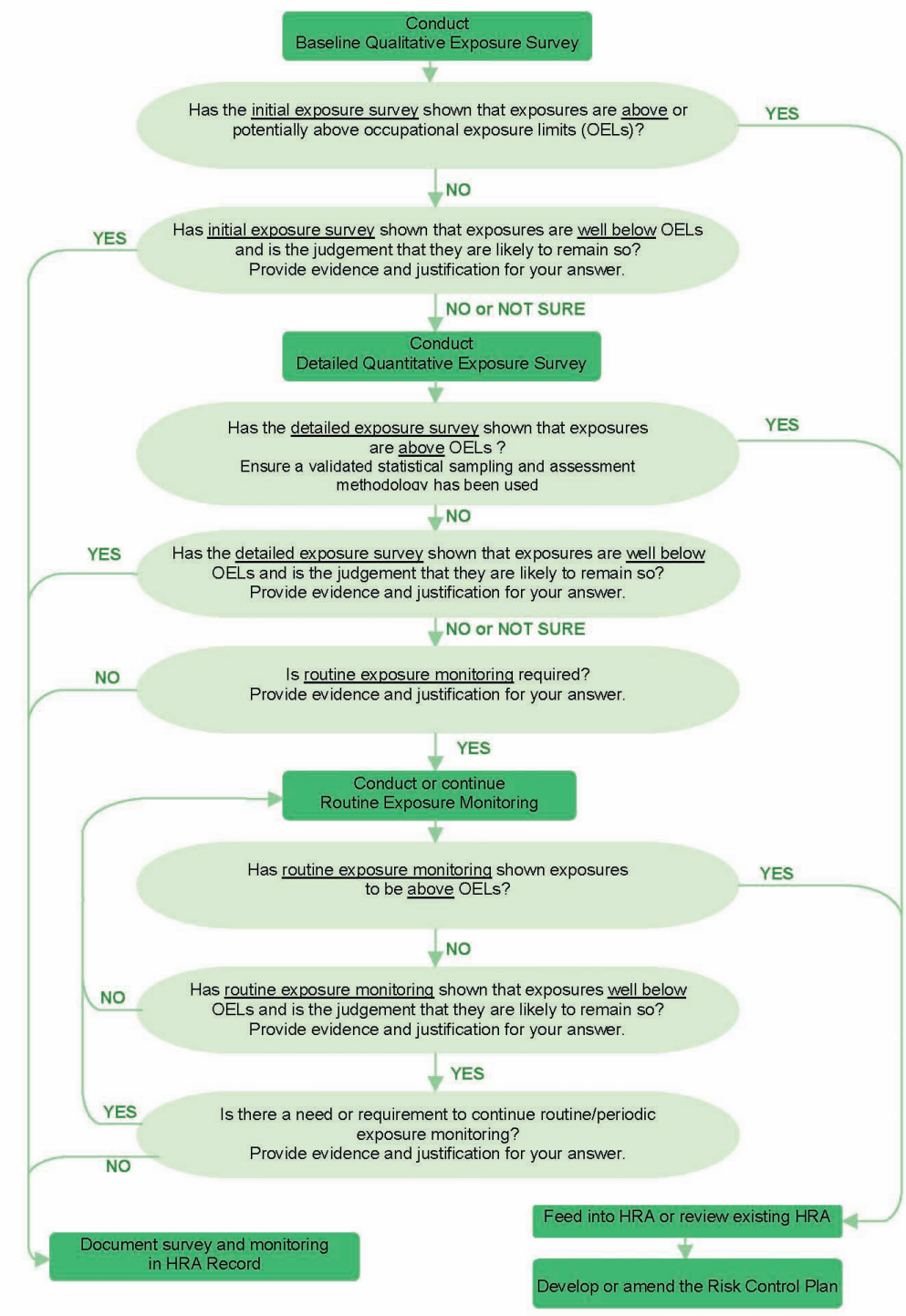
[9] ICMM and IEH. 2007.The Setting and Use of Occupational Exposure Limits: current practice.

[10] HSE UK. ALARP at a glance. http://www.hse.gov.uk/risk/theory/alarpglance.htm

EXPOSURE RATING	OEL EXPOSURE BAND	DEFINITION	ACTION ZONE
Medium/ Moderate	Between 50-100% of OEL (>0.5 - 1 x OEL)	Frequent contact with the potential hazard at moderate concentrations, or infrequent contact with the potential hazard at high concentrations. Frequently can expect the exposure to meet or exceed 10% of the OEL, but less than 50% of the OEL, or infrequently can expect the exposure to meet or exceed 50% of the OEL, but less than 100% of the OEL Exposures are at or controlled up to the OEL, there is a potential for breaches of the OEL and this may cause an adverse health effect in some workers e.g. vulnerable groups.	**CONTROL** Workplace sampling strategy is aimed at quality control and checking on controls Medical surveillance of workers exposed at >50% of OEL
High	At or greater than OEL (>OEL)	Frequent contact with the potential hazard at high concentrations, or infrequent contact with the potential hazard at very high concentrations. Frequently can expect the exposure to meet or exceed 100% of the OEL. Exposures are above and/or not controlled to the OEL and are likely to cause adverse health effects in the majority of workers exposed either in the short or long term.	**INTERVENTION** Controls must be put in place according to the hierarchy of controls. The objective should be to reduce exposure to below the OEL

OEL = Occupational Exposure Limit (or other health standard)

Figure 4: When to use the different types of direct exposure measurement surveys



3.2 Assessing the Effectiveness of Control Measures

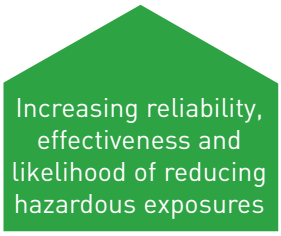
Introduction

Control measures are the interventions and actions - equipment, techniques, processes, protocols and education - that help to eliminate or reduce the levels of hazardous exposure.

Hierarchy of Control

There are several levels of control measures that can be put in place to deal with adverse exposures. These are generally termed the Hierarchy of Control (HOC). In order of reliability, effectiveness and likelihood of reducing exposures they are:

- Elimination
- Substitution
- Engineering (including isolation)
- Administration (including education and training)
- Personal protective equipment



Ideally, all hazards would be eliminated from the workplace, but in reality a mixture of 'lower level' controls in the hierarchy of control will be applied. For example, whilst education and training approaches alone are unlikely to achieve adequate control they are usually an essential element in ensuring that other measures are applied and used correctly. The HOC can be applied to all health hazards and one or more control measures from the different levels usually need to be put in place i.e. multi-level controls. However, not all the levels of control are applicable to every potential health hazard. An iterative process of reviewing hazards and controls should be implemented to ensure that a continuous drive 'up' the hierarchy of control is embedded in the operational culture.

Though personal protective equipment (PPE) should only be used as a last resort it can be a valuable addition to any hazard control program and, in some instances, may be the only effective option. When it is used it should be associated with a well planned program of training, routine maintenance and replacement.

The following are examples of how the hierarchy of control might work in a specific instance.

Elimination
Remove a major emission source of particulates and various gases by replacing diesel powered equipment, with electrically powered equipment.

Substitution
Electrically powered tools such as rock drills can emit lower levels of noise and vibration than pneumatically powered ones.

Engineering (including isolation)
In some areas such as ore processing plants, enclosures around screens and other noisy equipment can reduce noise levels in the remainder of the plant. Vibration reducing mountings and damping can reduce both vibration and noise levels. The

cabin design on mobile equipment plays a large role in improving operator comfort, reducing exposure to noise, dust, muscular stresses, extreme temperatures and reducing fatigue. Work refuges or cabins can be used in a variety of locations to isolate workers from hazards such as dust, noise, chemicals and heat.

Administration (including training and education)
Making changes to work procedures e.g. restricting when work is carried out or the number of hours worked, more frequent rotation of tasks and work permits to allow workers into designated areas can reduce exposure to hazards. Education and training to understand hazards and the measures taken to combat them are also important, especially where health hazards are linked to the proper use of equipment or a particular task e.g. manual handling.

Personal protective equipment
The use of personal protective equipment e.g. hearing protection devices, face masks, body suits, etc. can also protect workers from noise, dust and chemical exposures. However, this can never be regarded as an effective control as its effectiveness is very dependent on the user.

Key questions to consider when assessing control measures
Existing control measures can be either assessed directly on their ability to eliminate or reduce the levels of exposure through the measurement of exposures with and without control measures; or they can be inferred indirectly from existing information e.g. previous exposure measurements, the walk through survey and any available health records.

- What are the current standards used to determine the level and nature of the control measures?
- Are there existing control measures for processes, tasks and areas with high levels of exposure to hazards? Have these control measures been set up, operated and maintained appropriately?
- Are there high levels of exposure despite the control measures in place functioning effectively?
- Are working practices and the use of control measures different from that prescribed by workplace protocols and guidance?
- Are control measures part of an on-going maintenance program?
- Is there a regular assessment of the effectiveness of controls?

Rating control measures
Control measures can be rated in a similar way to exposures with a scale that classifies the level of inadequacy of the control measures currently in place and the potential need for action to remedy this (See Table A2 in Appendix).

SECTION 4:

Analysis and Reporting

4.1 Analysing the Health Risks and Prioritising Actions

Introduction

Once the exposures have been estimated by hazard, SEG and by process, task or area then it is time to analyze the potential health risks and the significance of those health risks categorised. This is often best done through the use of a 'risk rating table' or 'risk assessment matrix

Risk rating table or risk assessment matrix

The rating table classifies the exposures identified by their potential health consequences for SEGs (See Tables 5, 6 and 7). A rating or ranking is obtained by plotting the potential health consequence of each identified health hazard with the likely levels of exposures to it and by the likelihood of the hazard occurring or being present. The risk rating can be qualitative by assigning a rating as shown in Tables 5, 6 and 7 or it can be quantitative by using a pre-defined numerical ranking by using the formula:

RR = C x PrE x PeE x U

RR Risk Rating
C Consequence
PrE Probability of exposure
PeE Period of Exposure
U Uncertainty

The numeric values for each function of the equation can be found in table 8. As stated previously, the qualitative exposure ratings can be made up of three, four or five categories e.g. negligible, low, medium/moderate, high and very high/critical.

The exposure and likelihood ratings assigned should generally be based on a 'worst case' scenario. In this context it is important to take into account any regulations and company guidance before finalizing a risk rating.

Risk control action plan

Once the exposures have been assigned a risk rating, a risk control action plan can be developed which identifies the key priority areas for action and highlights what aspects need to be modified in the risk register for the process, task or area. This action plan should be integrated into the overall health risk management plan for the organization or business unit.

Table 5: Illustrative example of a risk rating table for hazards by likelihood of occurrence of a health hazard

		Likelihood of Occurrence of an Exposure to a SEG or in a process, task or area		
		Low	Medium	High
Health risk rating	**Description**	Unlikely to occur	Likely to occur sometimes	Likely to occur often
1	Exposure at this level is unlikely to lead to harm.	**NO/VERY LOW RISK**	**LOW RISK**	**MEDIUM RISK**
2	Non-life threatening reversible health effects.			
3	Adverse health effects that are permanent but do not significantly affect quality of life or longevity. Health effects that may be mildly limiting or disabling and therefore could lead to a change of occupation and lifestyle.	**LOW RISK**	**MEDIUM RISK**	**CRITICAL RISK**
4	Adverse health effects that are generally permanent and could lead to a significant reduction in quality of life and/or longevity. Continued exposure is generally likely to lead to permanent physical or mental disability or a long term limiting illness.			

Table 6: Illustrative example of a risk rating table for assessing the adequacy of existing control measures

		Levels of Exposure with Existing Control Measures Exposure Band OEL/ Standards-based		
		Low	Medium	High
Health risk rating	**Description**	0-50% of OEL	50-100% of OEL	Above OEL
1 2	Exposure at this level is unlikely to lead to harm. Non-life threatening reversible health effects.	**NO/VERY LOW RISK**	**LOW RISK**	**MEDIUM RISK**
3 4	Adverse health effects that are permanent but do not significantly affect quality of life or longevity. Health effects that may be mildly limiting or disabling and therefore could lead to a change of occupation and lifestyle. Adverse health effects that are generally permanent and could lead to a significant reduction in quality of life and/or longevity. Continued exposure is generally likely to lead to permanent physical or mental disability or a long term limiting illness.	**LOW RISK**	**MEDIUM RISK**	**CRITICAL RISK**

Table 7: Illustrative example of an action identification and/or information gathering table based on the extent of the potential health risk and the certainty of the exposure assessment

		Uncertainty rating		
Health risk rating	**Description**	Certain	Uncertain	Highly uncertain
1	Exposure at this level is unlikely to lead to harm.	No action needed	Information gathering needed	Information gathering needed
2	Non-life threatening reversible health effects.	No action needed	Information gathering needed	Information gathering needed
3	Adverse health effects that are permanent but do not significantly affect quality of life or longevity. Health effects that may be mildly limiting or disabling and therefore could lead to a change of occupation and lifestyle.	Control needed	Information gathering needed	**Control & Information gathering needed**
4	Adverse health effects that are generally permanent and could lead to a significant reduction in quality of life and/or longevity. Continued exposure is generally likely to lead to permanent physical or mental disability or a long term limiting illness.	Control needed	**Control & Information gathering needed**	**Control & Information gathering needed**

Table 8: Illustrative example for assessing the adequacy of existing control measures[11]

RR = C x PrE x PeE x U

RR Risk Rating
C Consequence
PrE Probability of exposure
PeE Period of Exposure
U Uncertainty

Consequence	Numerical Rating
Exposure at this level is unlikely to lead to harm.	1
Non-life threatening reversible health effects.	15
Adverse health effects that are permanent but do not significantly affect quality of life or longevity. Health effects that may be mildly limiting or disabling and therefore could lead to a change of occupation and lifestyle.	50
Adverse health effects that are generally permanent and could lead to a significant reduction in quality of life and/or longevity. Continued exposure is generally likely to lead to permanent physical or mental disability or a long term limiting illness.	100

Probability of exposure (as the likelihood of exceeding OEL)	Numerical Rating
Low	3
Medium	6
High	10

Period of exposure	Numerical Rating
Rare (once per year)	0.5
Unusual (a few times a year)	1
Short periods of time (a few times per month)	2
Continuous for between 2 and 4 hours per shift	6
Continuous for 8 hour shift	10

[11] Adapted from SIMRAC. (2001). Handbook of occupational health practice in the South African Mining Industry

Uncertainty in extent of hazard risk and exposure assessment	Numerical Rating
Certain	1
Uncertain	2
Very Uncertain	3

Calculated risk rating	Classification of risk	Action
400 and above	Intolerable risk	Requires immediate discontinuation/shutdown
200-399	Very high risk	Requires immediate mitigation action with a program to develop a permanent solution
70-199	High risk	Requires mitigation action as soon as possible
20-69	Potential risk	Requires mitigation action and/or monitoring
Under 20	Tolerable risk	Requires monitoring

Photo courtesy Oz Minerals

4.2 Documenting and Communicating the HRA

Introduction

Maintaining systematic and accurate records of the HRA and the priorities for action - as well as communicating the findings - are vital for ensuring that progress is made in reducing exposures and developing a zero harm culture in the workplace. Maintaining an auditable trail of information also facilitates future evaluations and assessments of the workplace risks to health.

Maintaining systematic and accurate HRA records

A written record of an HRA should be kept in a format that is decided on by your organization based on legal requirements. These records should:

- Contain sufficient information to ensure an audit trail on how the HRA was undertaken, the rationale for the approach used and how conclusions were arrived at.
- Include the findings of any exposure monitoring and health surveillance.
- Meet legal and organizational requirements
- Be readily retrievable when needed, for example, for internal/external audits, review by local or national authorities or periodic internal review.
- Be kept for at least 30 years or as long as required by national laws as these records will enable the evaluation of individual health effects and the accurate assessment of future insurance or liability claims for chronic health risks.

Communicating the HRA

The findings of the HRA should be communicated to all staff as part of a hazard and risk communication program. This could be through email, company intranet, company newsletter, bulletin on a notice board and through worker health and safety meetings.

It is also imperative that training materials are updated when there is new information from an HRA. When new control measures are identified they should become part of the existing monitoring program.

Photo courtesy Newmont

4.3 Review and Quality Assurance of the HRA

Introduction

It is important to quality assure and progressively improve the quality of the HRA process and the documentation of the HRA process over time. This can be done at the level of the individual HRA as well as a business unit and organizational level through the health management system.

Review of HRAs

Individual HRAs should be fully reviewed and revised every 3-5 years as a minimum. Where, for instance, HSE Annual Reports are published these require updates on the progress of HSE and HRA action plans. Any significant change which may have an impact on health risks, including changes in the work processes and activities or in the understanding of specific hazards and risks, should trigger a review of the HRA. Subsequently, there should be a review of any new control measures put in place.

Quality Assurance of HRAs

Within their quality assurance plans, companies and business units should have procedures in place to ensure that the requirements of current best practice in relation to assessing health risks are being met. The HRA process and individual HRAs should be regularly audited and appraised through a process of internal and independent external auditing. The scope of such an audit could include:

- The management system for conducting and implementing HRAs.
- The resources available to carry out and implement HRAs.
- The quantity and quality of HRA records.
- Remedial actions taken following HRAs.
- The effectiveness and maintenance of controls.
- Areas of non-compliance with occupational exposure limits.
- The documentation of work and health histories.
- Evaluation of the quality of the HRA by experienced and independent occupational health and hygiene professionals.

The ICMM Sustainable Development Framework requires third party assurance in a number of areas, and a specific procedure has been established to assist member companies in meeting their commitments. It is recommended that any external assurance for HRAs should be developed with consideration of the overall corporate assurance procedure.

Photo courtesy Newmont

4.4 Links between HRA and Health Impact Assessment (HIA)

Introduction

When carrying out an initial assessment of health related risks at a site associated with a new project, a major modification or prior to closure of an existing project, or prior to mine or operation closure, it is important to consider the health impacts on local community and the wider society. An assessment that assesses these types of risks or impacts is referred to as a Health Impact Assessment (HIA). This is a separate assessment to an HRA though there can often be important overlaps in the health risks faced by workers of a mining or metals operation and surrounding communities. Occupational HRAs assess the potential health risks or impacts 'within the fence' of a mining and metals operation and HIAs assess the potential health risks or impacts 'outside the fence' which are linked to the operation.

Please also see the companion ICMM report "Good Practice Guidance on Health Impact Assessment".

Definition of HIA

The Gothenburg definition of HIA is "a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population."[12]

HIA is the systematic analysis of the differential health and wellbeing impacts of proposed plans, programs and projects so that positive health impacts are maximized and negative health impacts minimized within an affected community. It works within an explicit value framework that promotes an assessment process that maximizes the health of a population and is democratic, equitable, sustainable and ethical in its use of evidence.

HIA is, therefore, about health protection, health improvement and health equity / inequality.

When are HIAs conducted?

Health Impact Assessments (HIA) are generally conducted where a project or operation has the potential to impact on the health of the local communities living nearby and before the project or operation is started. This can be a separate assessment but is now more usually undertaken as part of an integrated Environmental, Social and Health Impact Assessment (ESHIA).

The potential impacts on human health of industrial development are numerous and cut across many specialist concerns. Most industrial development projects are expected to have an indirect beneficial effect on health by increasing the resources available for food, education, employment, water supplies, sanitation and health services. Sometimes the indirect impacts include unexpected negative effects on health, although many of these can be avoided by careful planning. Adverse health impacts are most likely to affect the most vulnerable social groups, and this may serve to amplify the overall adverse effects. Such impacts can reduce the social and economic benefits expected from industrial development.

Experience shows that the Environmental and Social Impact Assessment (ESIA) often do not pay due attention to the health component. Health Impact Assessment offers an opportunity to identify health hazards in advance, and to coordinate with ESIA activities. The analysis of community health risks provides an opportunity both to implement risk controls and to incorporate health-promoting measures.

[12] The Gothenburg Consensus on health impact assessment (1999) was the product of a joint effort between the World Health Organization Regional Office for Europe and the European Centre for Health Policy and has been adopted worldwide

HIA methodology
HIA follows a similar methodology to EIA and SIA. The HIA process is generally made up of eight overlapping stages:

- Screening;
- Scoping;
- Baseline and community profiling, evidence gathering;
- Stakeholder involvement;
- Analysis of impacts;
- Develop mitigation and enhancement measures and/or making recommendations;
- Writing the HIA statement and presenting to decision-makers; and
- Follow up (monitoring of the health impacts and evaluation of the HIA process).

Though the steps above are presented as linear, HIA tends to be an iterative process where findings and issues that emerge in later steps mean that earlier steps are revisited and the scope and analysis amended accordingly.

Benefits of the Health Impact Assessment
Just as HRA demonstrates the value and care an organization has for its workers so HIA demonstrates an organization's care and concern for the welfare of the local communities. HIA can help to structure the thinking about how best to support, alongside local and national governments, the health and wellbeing of local people.

Sources of Further Information

Sources of Further Information

HERAG Health Risk Assessment Guidance for Metals. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 1, Assessment of occupational dermal exposure and dermal absorption for metals and inorganic metal compounds. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 2. Assessment of occupational inhalation exposure and systemic inhalation absorption. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 3. Indirect exposure via the environment and consumer exposure. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 4. Gastrointestinal uptake and absorption, and catalogue of toxicokinetic models. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 5. Mutagenicity. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 6. Quality screening procedures for health effects literature. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

HERAG Fact sheet 7. Essentiality. ICMM, EBRC, EUROFER and EuroMetaux. 2007.

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Risk Assessment and Risk Management of Non-Ferrous Metals Realizing the Benefits and Controlling the Risks. ICME. 2001.

Occupational Health and Safety Management Systems – Requirements. Occupational health and safety assessment series. BS OHSAS 18001:2007. BSI. 2007.

Occupational Health and Safety Management Systems — Guidelines for the implementation of OHSAS 18001. BS OHSAS 18002:2000. BSI. 2002.

Guide to Data Gathering Systems for Risk Assessment of Metals and Metal Compounds. ICME. 1999.

Useful Websites

ICMM Library
http://www.icmm.com/library

Library and archive of the publications of the International Council on Mining and Metals and its predecessor organizations.

Minerals Industry Risk Management Gateway

http://www.mirmgate.com/

This website enables users to find carefully-chosen good practice risk management information, identify hazards through the entire life cycle of operations and get decision-making help for both long and short term problems.

Good Practice Sustainable Development in the Mining Sector

http://www.goodpracticemining.org/

This website has been jointly developed by the International Council on Mining and Metals (ICMM), the United Nations Conference of Trade and Development (UNCTAD), the United Nations Environment Program (UNEP), and the UK Department for International Development (DfID) to provide access to a library of good practice guidelines, standards, case studies, legislation and other relevant material that are leading examples of their kind globally.

Appendix

Table A1: Checklist for identifying potential hazards

Potential Hazard	Likely to be found Yes/No/Not Sure	Details of specific hazard	Likely harmful effects	Acute/ long latency	Hazard rating	Where located – area/process/task
Physical						
Noise						
Vibration						
Pressure						
Radiation						
Heat and cold						
Chemical hazards						
Dusts						
Fumes (e.g. diesel)						
Vapours (e.g. solvents)						
Mists						
Liquids (e.g. acids)						
Gases						
Fibres						
Biological hazards (contact with viruses, bacteria, fungi, protozoan and worms)						
Contact with domestic and wild animals and insects						

Potential Hazard	Likely to be found Yes/No/Not Sure	Details of specific hazard	Likely harmful effects	Acute/ long latency	Hazard rating	Where located – area/process/task
Contact with infected workers and other people in the workplace						
Ingestion of contaminated food and drink						
Poor hygiene and waste disposal practices and facilities						

Ergonomic hazards

Job design (i.e. control, content, workload)						
Job organization (i.e. shift patterns, sleep deprivation, rotations)						
Poor working postures and repetitive motion (e.g. within the mine and in offices and warehouses)						
Poor hygiene and waste disposal practices and facilities						
Equipment design (e.g. cab and control design in mobile equipment)						

Potential Hazard	Likely to be found Yes/No/Not Sure	Details of specific hazard	Likely harmful effects	Acute/ long latency	Hazard rating	Where located – area/process/task
Psychological hazards						
Poor risk perception and risk-taking behaviour						
Isolation (e.g. lone workers in some areas						
Social Isolation (i.e. contact with family and friends and access to social support)						
Overcrowding and lack of privacy						
Communication problems (e.g. shyness, language problems)						
Discrimination						
Bullying and harassment						
Culture, faith/religion, local customs						
Leisure and recreation opportunities						
Substance abuse/dependence and smoking						

Table A2: Checklist for rating control measures

Process/ Task/Area	Are there existing control measures in place Yes/No	What are the specific measures in terms of HOC	Levels of Exposure (Critical, Medium, Low)	Effectiveness of Control Measures in Place (Poor, Adequate, Good)

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This book is printed on Challenger Offset 120gsm and 250gsm paper. A great proportion of the raw material used is the by-product from other processes i.e. saw mill waste and waste which results from forest thinning. The mill holds not only ISO 2002 but also ISO 14001 accreditation for their environmental management systems, which include an active policy on sustainable forestry management.

ICMM – International Council on Mining and Metals

The International Council on Mining and Metals (ICMM) is a CEO-led industry group that addresses key priorities and emerging issues within the industry. It seeks to play a leading role within the industry in promoting good practice and improved performance, and encourages greater consistency of approach nationally and across different commodities through its association members and member companies.

ICMM's vision is for a respected mining and metals industry that is widely recognized as essential for society and as a key contributor to sustainable development.

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