Occupational Health Hazards in Minerals Exploration- Assessing the Known and Unknown.

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ABSTRACT

Minerals exploration workers operate amongst a wide range of occupational health hazards that in some cases result in potentially excessive exposures. In addition, the likelihood of exposure to some hazards may be unpredictable due to workplace variables. Characterising hazards in a typical fashion may not always be cost effective or practical for exploration activities.

By applying a practical framework that qualitatively assesses occupational health hazards, risks can be effectively identified and processes put in place to further characterise the risk and/or put controls in place to manage the risk level.

INTRODUCTION

Exploration and associated contract drilling activities in QLD work throughout a range of geological and geographical settings. Activities primarily revolve around Diamond and/or Reverse Circulation (RC) Drilling with other associated works such as Induced Polarisation (IP), rehabilitation and construction of drill pads, sumps and roads. In almost all scenarios, drilling activities are outsourced to contracting companies who supply the specialist services and equipment.

Sites commonly strive to strike a balance between resourcing and cost effectiveness. In comparison to a typical heavy industry site, a large portion of QLD exploration sites may not have the breadth of resources at hand to adequately assess health hazards and effectively apply controls. The risk that each health hazard poses may also be inconsistent as geological structures, tasks and environmental conditions change.

Health hazard identification and assessment for exploration activities is an important part of managing the health and safety of workers. Basic health hazard identification and assessment principles can be applied by sites and controls subsequently implemented as required.

LEGISLATIVE REQUIREMENTS

Both the ‘Coal Mining Safety & Health Act 1999’ and ‘Mining & Quarrying Safety & Health Act 1999’ place an obligation on the Site Senior Executive to provide a safe place of work, which includes contractors and employees alike.

Both pieces of legislation require that periodic monitoring is carried out on hazards that are likely to create an unacceptable level of risk.

HEALTH HAZARDS

A number of health hazards will be inherent to most exploration activities. Additional hazards will be present depending on a number of variables such as exploration methods, geology and environmental conditions. Typical hazards that exploration workers may be exposed are:

1. Airborne particulates- Exposures to particulates will vary widely depending on the geology and drilling techniques. Both *Inhalable* and *Respirable* sized particles are generated from exploration activities. These size classifications have Occupational Exposure Limits (OEL's) that must be applied. Other particulates that are classified as hazardous substances may also be produced from exploration activities and will be dependent on the mineralogy:

   Respirable Crystalline Silica (RCS) is a known class 1 carcinogen and is present in most exploration activities at varying concentrations.

   Asbestiform material is a known class 1 carcinogen and may also be encountered during exploration activities. Seams may be encountered with highly variable exposures as a result.

   Typically dependant on the resource, other particulates such as *heavy metals* and *Coal dust* may also be drawn to the surface from drilling activities. Precautions may need to be taken for inhalation, skin contact and/or ingestion of such substances.

   Dry RC drilling methods and in particular collaring processes are known to cause significant quantities of ambient dust as a seal is not adequately formed and dust can escape around the side of the drill rod. Splitting samples is a subsequent task where high exposures are expected. Rehabilitation practices that involve cutting and emptying sample bags with fine particulate matter may also lead to excessive exposures.

   On occasion, disturbance from surface winds and traffic may cause exposure limit exceedances to exploration personnel who are working outdoors on non dust producing tasks.

2. Noise- Noise Induced Hearing Loss (NIHL) may be permanent and is caused by over exposure to noise. Drilling activities historically generate excessive noise sources as high energies are generated and required for effective drilling. Noise levels may vary between equipment type, drilling medium and drill depth. Collaring holes, pneumatic releases and auxiliary boosters to RC drill rigs are known to increase noise levels.

   Drill rigs come in varying configurations and thus emit different noise levels, but implementation of noise controls at the design stage has been lacking. Poorly maintained and older drill rigs typically pose a higher risk, but generally speaking noise is a high risk for all drilling activities.

3. Vibration- Occupational vibration exposures can be broken down to Hand Arm Vibration (HAV) or Whole Body Vibration (WBV) exposures.

   WBV exposures are typically generated from standing on drill platforms (coupled to the drill) and travelling on access roads across exploration leases.

   HAV exposures are likely to originate from contact with any high frequency motorised components such as hand tools and the drill operating console.

4. Naturally Occurring Radioactive Material (NORM)- Exploration workers are at risk of radiation exposures to uranium, thorium and associated decay from products in the drill and core cuttings. The primary route of exposure for NORM in this circumstance is inhalation and ingestion. Exposures will vary significantly depending on mineralisation, dust exposure and distance from drill core cuttings.

   Risk of exposure is low unless there is evidence that uranium, thorium and associated decay may be present in mineralisation.

5. Thermal Stress- QLD Environmental conditions can vary substantially from sub zero to over 50 degrees Celsius depending on the locality. Exploration sites typically work a >10hr shift and will rarely have access to air-conditioned crib rooms. Exposures to extreme thermal environments are common and full acclimatisation is not always undertaken or practical.

   Additional radiant heat can be generated from diesel engines, compressors and generators. High ambient temperatures can be coupled with a generally moderate to high whole body workload.

6. UV Radiation- as with thermal stress, staff are exposed to external conditions for >10hrs per day with extended rosters resulting in a higher annual dose rate then people working a conventional shift in the same conditions. Precautions need to be made to protect workers from health effects associated with UV radiation.

7. Chemicals- possible health effects are dependent on the chemical compound and exposure duration. Skin contact with hydrocarbons and drill fluids is the main route of exposure and although they present a low risk, skin sensitisation (i.e. rashes and dermatitis) may occur.

   Some drilling activities require polyurethane foam to be mixed with an isocyanate catalyst for collar stabilisation purposes. Toxic substances are being handled in this scenario and PPE is required for the task.

8. Ergonomics- Ergonomic injuries have historically been in the form of lifting injuries due to the repetitive nature of tasks and lack of mechanical aids. Repetitive manual handling of sample bags (generally 10-30kg) from RC drill rigs is a high risk task. A portion of drill rigs now have mechanical aids for lifting and positioning drill rods that can weigh upwards of 30kg each. Manually tightening/loosening drill rods with a wrench is a repetitive task involving high exertion, where this practice has been replaced by hydraulic wrenches on most drill rigs.

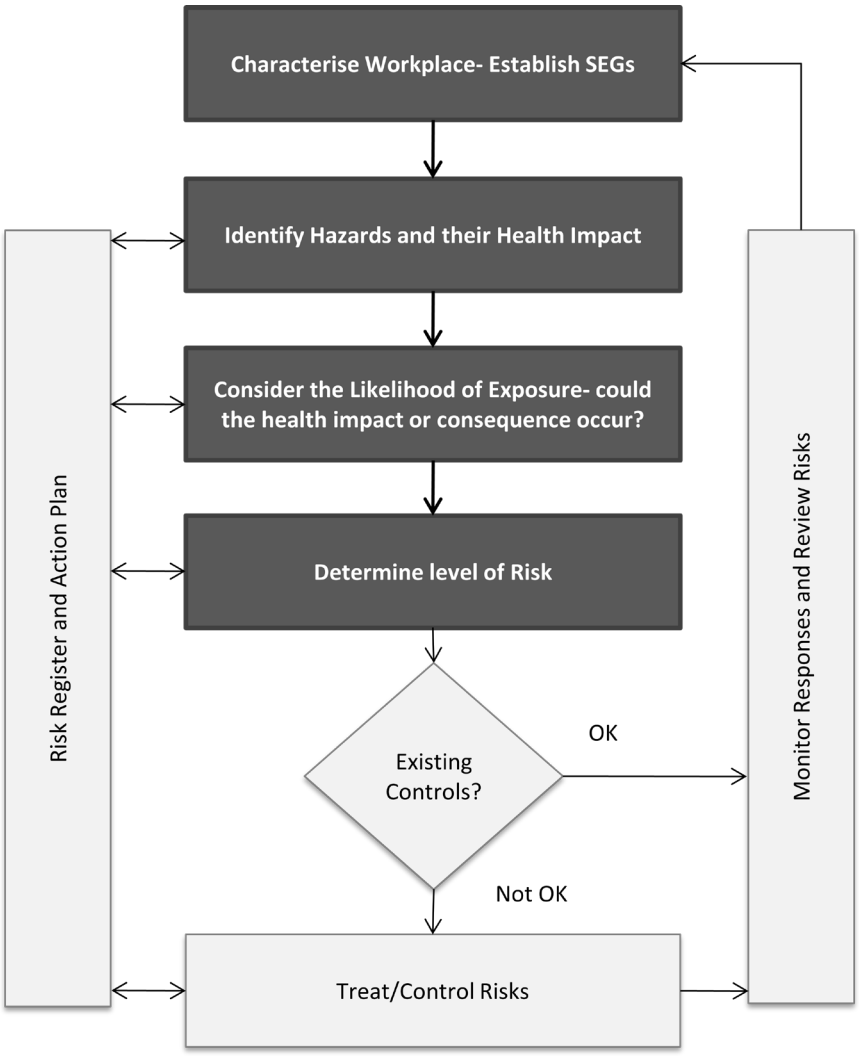
9. Water- remote exploration camps generally store their own water at camps or collect rain water to use for drinking and secondary use purposes. Chlorination of water sources is not commonly carried out to Australian Drinking Water Guidelines (ADWG) requirements. Microbial hazards may cause serious health effects whereby effective controls should be in place to manage water quality.

HAZARD IDENTIFICATION & ASSESSMENT

This hazard identification, assessment and control process has been adapted from *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management Strategies*.

Health hazards should be systematically identified and controlled using risk management principles. The risk management process schematic shown in Figure 1 is recommended. This particular paper looks to cover hazard identification through to determining the level of risk (dark boxes).

Figure 1. Health Hazard Risk Management Schematic



Source: *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management Strategies.*

1. Workplace characterisation (SEG's)

Similar Exposure Groups (SEG's) are a group of employees/contractors whose exposure to health hazards within the boundaries of routine work is similar.

By establishing SEG's the risk management process can be applied to a group rather than individuals, as such streamlining the process with an almost identical outcome.

There is no simple way of determining these groups (SEG's) as the variables are endless. Most commonly SEG's are developed based on jobs types, for example- *RC Driller; Diamond Driller; RC Offsider; Diamond Offsider; RC Sampling Technician; RC Geologist; Diamond Geologist; Drilling Supervisor; etc*.

SEG's should be continually reviewed and re-established as new information comes to hand, or where changes in conditions may affect workers exposure.

2. Hazard Identification

Health hazards for exploration workers will invariably change from site to site and may even change significantly for some hazards between drill holes. There will however be a portion of high risk hazards that are inherent in the nature of work performed, where this may include:

- Noise
- Particulates
- UV Radiation

It's important to note that although hazards may be transferable, the resulting level of risk may not be.

Identification of health hazards onsite should be a systematic process that looks at the full gamut of possible health hazards. Health hazards may come in the form of biological, chemical, ergonomic and/or physical hazards, where all of these groupings should be considered.

a. Identifying Hazards

The process will vary depending on the complexity of the site and exploration activities, but the core principal involves reviewing information at hand and performing a thorough site inspection.

Information at hand may include:

- Exploration activities, including drilling method and type;
- Number of people exposed.

- Hazard characterisation- health effects; route of entry; acute or chronic health effects; additive or synergistic; how often are SEG's exposed.
- Chemical manifest and MSDS's;
- Environmental Conditions;
- Rosters and shifts worked;
- Inferred or confirmed geological makeup of rock, and;
- Relevant documentation - legislation, industry standards/guidelines, incident reports, health & hygiene monitoring data outcomes and experiential learnings;

Site inspections for the purpose of health hazard identification are known as *'walkthrough surveys'*. Where possible, walkthrough surveys should be conducted whilst routine exploration activities are underway to capture a true representation of health hazards. Measuring worker exposure to health hazards is not essential at this stage, but may be performed if the appropriate equipment is available. A suitable pro forma should be used during the walkthrough survey and conditions documented so that health hazards can be characterised.

The identification process may be performed prior to exploration in a desktop assessment, but identified hazards should be confirmed and another assessment performed once exploration has begun.

b. Consequence Rating

Once hazards have been successfully identified, determining the inherent consequence of each hazard is the next step.

Table 1. Health Hazard Consequence Ratings

RATING	CONSEQUENCE	DESCRIPTION
5	SEVERE	Can cause multiple fatalities or significant irreversible effects.
4	MAJOR	Can cause a single fatality or irreversible health effects or disabling illness to one or more persons.
3	MODERATE	Can cause severe, reversible health effects of concern- could result in a LTI.
2	MINOR	Can cause reversible health effects of concern that would typically result in a MTI.
1	NEGLIGIBLE	Can cause reversible health effects of little concern that would result in a FAI at the most.

Source: *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management Strategies &* AS4360:2004

In assessing an appropriate consequence level, data and literature currently available should be used to assess the possible outcome. *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management*

Strategies suggests further guidance on assessing the consequence level as well as listing classifications for a number of common health hazards.

It's important to note that combined effects of some health hazards may cause 'additive' or 'synergistic' outcomes. Expert advice must be sought if literature suggests this may occur.

3. Exposure Characterisation & Likelihood

Characterisation of health hazards in preparation for risk assessment may be by qualitative or quantitative means. Initial characterisations of unknown levels of risk are typically qualitative with quantitative assessments performed if the risk assessment indicates it as necessary.

A generic model for determining likelihood ratings is displayed in Table 2, where more in depth classifications for a range of hazards can be found in *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management Strategies*.

Table 2. Health Hazard Likelihood Ratings

RATING	LIKELIHOOD	DESCRIPTION
A	ALMOST CERTAIN	Regular contact with the potential hazard at very high levels.
B	LIKELY	Periodic contact with the potential hazard at very high levels or regular contact with the potential hazard at high levels.
C	POSSIBLE	Periodic contact with the potential hazard at high levels or regular contact with the potential hazard at moderate levels.
D	UNLIKELY	Periodic contact with the potential hazard at moderate levels or regular contact with the potential hazard at low levels.
E	RARE	Periodic contact with the potential hazard at low levels.

Source: *Australian Institute of Occupational Hygienists- Simplified Occupational Risk Management Strategies.*

Characterisation of hazards may be performed qualitatively, but quantitative assessment of hazards should be performed as a minimum when:

- Exposures could exceed occupational exposure limits.
- Exposures have resulted in complaints or adverse health effects.
- Exposures are to known carcinogens, reproductive toxins or ionising radiation.

In assessing the likelihood rating for a particular exploration health hazard, it may become evident that exposures to some hazards are likely to fluctuate significantly as mineralisation or productivity varies. As a result care needs to be taken when choosing a likelihood level so as not to significantly over or under estimate the risk. In addition, quantitative assessments need to be representative of the level of risk - for instance, it is unlikely that measuring particulate exposures once on 'dusty tasks' will indicate an accurate level of risk.

Even once the risk assessment has been performed, further characterisation may be required for unknown and high risks. Due to the variant nature of some health hazards, assessing the likelihood of exposure may be ongoing- i.e. asbestos, NORM and where health exposures encroach on the limit of control effectiveness.

4. Risk Assessment

In assessing the level of risk, health hazards are able to be prioritised for controls or additional characterisation to occur. Figure 2 provides a simple risk matrix using consequence and likelihood.

Figure 2. Health Risk Rating Matrix

Likelihood Rating	Consequence Rating: UNKNOWN	1 NEGLIGIBLE	2 MINOR	3 MODERATE	4 MAJOR	5 SEVERE
UNKNOWN	UNKNOWN					
A ALMOST CERTAIN		M	H	H	E	E
B LIKELY		M	M	H	H	E
C POSSIBLE		L	M	M	H	H
D UNLIKELY		L	L	M	M	H
E RARE		L	L	L	M	M

L= Low; M= Medium; H=High; E= Extreme

Any health hazards with a very low exposure potential do not necessarily need to be risk assessed, but must be documented and reviewed periodically along with other health hazards. Unknown levels of risk must be appropriately characterised to ensure enough information is at hand to undertake a risk assessment.

Generally speaking, sites will assess the likelihood and resultant level of risk by qualitative means initially. Once the level of risk has been estimated, high risk health hazards may then be quantitatively measured, or more in depth qualitative assessments performed to effectively identify the level of risk.

Risk assessments must be reviewed periodically or when conditions change. For exploration projects, this would typically be at each lease or any significant change in geological/environmental structure.

CONCLUSIONS

The majority of exploration operations have high health risks onsite, where each project should implement a systematic process to Identify, Assess and Control such hazards. This process may be performed internally by capable persons, but expert advice must be sought for complex hazards or scenarios. Care needs to be taken when assessing hazards as the likelihood of exposure for a number of hazards may vary significantly throughout the project life.

By qualitatively risk assessing exploration health hazards initially and further characterising hazards as deemed necessary by the risk assessment, resources can be focused and applied efficiently.

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