CODE OF PRACTICE

Mineral exploration drilling

MIAC

Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety

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Disclaimer

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Foreword

Basis for code of practice

This code of practice is issued by Resources Safety under the *Mines Safety and Inspection Act 1994*, with the endorsement of the Mining Industry Advisory Committee (MIAC) and approval from the Minister for Mines and Petroleum.

A code of practice is a practical guide to achieving the standards of occupational safety and health required under legislation. It applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following a code of practice would achieve compliance with the duties in the legislation in relation to the subject matter of the code. However, like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that may arise. Duty holders need to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the legislation may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

Scope and application

This code is a practical guide to assist those involved in mineral exploration to develop and implement safe systems of work for drilling operations, particularly in remote areas. Although specifically targeting mineral exploration drilling, the code may also be a useful source of information for other drilling applications.

Who should use this code of practice?

You should use this code if you have functions and responsibilities for managing risk on drilling operations for mineral exploration. The code may also be used by workers and safety and health representatives who need to understand the hazards and risks associated with exploration drilling.

How to use this code of practice

The code includes references to both mandatory and non-mandatory actions.

The words “must” or “requires” indicate that legal requirements exist, which must be complied with. The word “should” indicates a recommended course of action, while “may” indicates an optional course of action.

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PART 1
RISK MANAGEMENT APPROACH

1 Introduction

1.1 Aim

Drilling in any environment is potentially hazardous but mineral exploration in remote locations, such as those encountered in Western Australia, presents additional risk factors. This code of practice provides a practical and accessible guide to assist in the identification of hazards and risk factors associated with drilling operations. It is written to be used by anyone involved in drilling operations, from the driller's offsider to the managing director, and addresses hazards associated with the drilling methods commonly used in Western Australian exploration (see Section 1.3).

1.2 Structure

The code is structured to support a risk management approach that encourages all personnel to:

- anticipate and recognise hazards
- assess the probability and severity of harm that may arise
- identify and implement appropriate controls.

The risk management approach is most effective when:

- hazards are addressed at the design or planning stages
- the workforce is consulted throughout the process
- control measures are regularly monitored and reviewed for effectiveness.

The code of practice describes minimum requirements that provide an acceptable level of risk. However, it may be possible, under some circumstances, to operate at the same or a lower level of risk using alternative control measures. The code is not intended to prevent innovative safety measures, and other practices and equipment that give at least equivalent safety performance may be considered. Documents such as audits, risk assessments, action plans and maintenance records must be kept for as long as the drilling operation continues and at least six years after the operation is abandoned or suspended.

This code of practice is focussed on the hazards of exploration drilling. However, pre- and post-drilling activities raise their own particular issues that need to be considered. Chapter 2 of Part 1 highlights hazards associated with the preparation of camps, work sites and drill pads.

The provision of instruction, information, training and supervision are critical to risk management. Although not specifically discussed in each hazard chapter, they are an essential component of any risk control strategy and are discussed in Chapter 3 of Part 1.

Part 2 comprises the major hazard categories identified for the remote exploration environment. For each chapter, the first section summarises the rationale for the hazard's inclusion and identifies the equipment, activity or environment that may give rise to it. This summary may assist in identifying the sources of the risk.

The second section focuses on the direct and contributing factors to consider when assessing the risk of injury or harm to health from the hazard. This allows operators to develop site-specific solutions – each drilling operation will have its own complexity and specific requirements.

The third section provides examples of control measures to assist in risk mitigation. Rather than being overly prescriptive, the content aims to provide a basis for considering how best to manage the risk. Use the hierarchy of control when implementing controls to eliminate the hazard or reduce the risk. Low-level controls such as providing personal protective equipment (PPE) or administrative measures should only be used as a last resort or to support other control measures.

The final section provides further information, including incident summaries that highlight what can go wrong.

Part 3 comprises chapters on emergency management and another on emergency response planning.

The code's chapters are designed to stand alone so they can be used for operational purposes such as training, auditing and toolbox presentations.

1.3 Commonly used exploration drilling methods

Auger drilling

Auger drilling is a method of drilling holes by cutting or gouging with the chiselled tip of a rotating drill bit. The drill stem is shaped like a helical screw and is driven rotationally into the ground. The rotational penetration of the drill bit produces drill cuttings that are lifted to the surface by the helical edges or flights of the rotating drill stem. Auger drilling can produce boreholes quickly and efficiently, although the rate of penetration depends on the type of formation being drilled. Water is commonly used to hydrate dry holes to improve penetration and help lift cuttings. Auger drilling can reach depths of around 20 m, depending on the material being drilled and size of the rig and stem. Rotation is slow, rarely exceeding 30 rpm, but involves high torque. The rods are typically 1.5 or 3 m long, and require care when handling due to their weight and sharp flight edges.

Auger drilling is commonly used to take samples in soft unconsolidated ground during the reconnaissance stage of mineral exploration, often for environmental and geotechnical sampling, but is also used in construction and mining.

Augers are available in various sizes. For reconnaissance exploration projects, small augers mounted on trucks are often used, whereas large augers are used for construction drilling (e.g. sinking foundation piles) and bucket augers for bulk sampling.

Percussion rotary air-blast (RAB) drilling

RAB drilling employs a blade bit, tricone rotary bit (roller bit) or downhole hammer to penetrate rock. The drill bit, which is usually tungsten tipped, is mounted at the end of a hollow drill pipe through which compressed air (or air mixed with foam or water) is pumped down the hole during drilling. Cuttings are returned to the surface by upward flow under pressure between the drill pipe and the wall of the hole. RAB drilling can achieve depths of more than 50 m but can be ineffective below the water table, where the annulus between the drill pipe and the surrounding formation can become clogged with debris, precluding removal of drill cuttings from the hole. This can be overcome by the use of stabilisers (also known as reamers), which are lengths of tubular steel attached to the drill string to ream or line the hole to prevent formation water and debris entering the hole. Stabilisers commonly have tungsten-buttons on their walls to break down the cuttings rising from the borehole.

RAB drilling is used primarily for first-pass mineral exploration and development, where reasonable quality samples can be readily obtained. It is also used for water bore drilling and blast-hole drilling in mines.

Most RAB drilling is carried out by light-weight rigs with relatively small compressors (around 600 cfm at 250 psi). The rods are relatively light and have a small diameter (typically less than 60 mm).

Air-core drilling

Air-core drilling employs hardened steel or tungsten blades to bore a hole into unconsolidated ground. The drill bit generally has three blades. Drill rods are hollow and are fitted with an inner tube within the outer barrel, similar to the rods used for reverse circulation drilling (described below). Drill cuttings are recovered by injection of compressed air into the annulus between the inner tube and the inside wall of the drill rod, and are lifted to the surface by upward air flow through the inner tube. Samples are then passed through a sample hose into a cyclone where they are collected in buckets or bags.

Air-core drilling uses small compressors (around 600 cfm at 250 psi) to drill through the weathered layer of loose soil, sand and rock fragments (regolith) covering bedrock and is unsuitable for drilling into fresh rock. Air-core drills may achieve slightly greater depths and better sampling quality than does RAB drilling. Rotation speeds are typically 50 to 100 rpm.

For mineral exploration, air core drilling is generally preferred over RAB drilling as it provides cleaner samples. Cuttings are removed inside the drill rods and are less prone to contamination than those obtained by auger or unstabilised RAB drilling, where cuttings may be contaminated as they are brought to the surface between the outside of the drill rod and the walls of the hole.

Air-core drill rigs usually require a sizable support vehicle, normally a truck, to carry diesel, water and other supplies needed for rig maintenance.

Reverse-circulation (RC) drilling

RC drilling is similar to air-core drilling in that the drill cuttings are returned to the surface via an inner tube inside the drill rods. However, RC rigs commonly have a much greater capacity and are designed to handle much larger downhole equipment, with rods that are typically 6 m long and weigh about 200 kg. Penetration is achieved by a pneumatic reciprocating piston known as a downhole hammer (DHH), which drives a drill bit (typically 115 to 150 mm in diameter) with round protruding tungsten-carbide buttons that can cut hard rock. RC drill rods rotate at speeds of 30 to 50 rpm.

Before commencing deeper drilling, a collar (PVC or metal piping) is installed at the surface to prevent unconsolidated material collapsing into the hole. Collars may extend to 30 m depth, depending on the stability of the surface formations. Where bedrock is exposed at the surface, collars may not be required.

Circulation is achieved by pumping air down the drill rods between the outer and inner tubes, with the air returning up the inner tube and lifting cuttings to the surface. At the surface, the cuttings are directed through a hose into a cyclone for collection and bagging.

RC drilling generally produces dry cuttings, as the large rig-mounted compressors (around 1,000 cfm at 500 psi) that produce reverse circulation also pump air ahead of the advancing drill bit, thus drying the rock. Space is at a premium on the rig deck and a booster compressor may be required, so compressors are usually mounted on an auxiliary vehicle. Several such stand-alone compressors (each providing 900 to 1150 cfm at 300 to 350 psi) may be used, in which case all are connected to the rig by high-pressure hoses via a multi-valve manifold.

Although RC drilling is air-powered, water may be injected when collaring a new hole, to reduce dust, and to assist in lifting cuttings to the surface. In the latter case, an additive known as super foam is mixed with water and pumped down the rod string. This mixture makes sandy cuttings adhere to each other and increases sample recovery.

RC drill rigs are considerably larger than RAB or air-core rigs and typically reach depths of 300 to 500 m, although it can be more. This method is slower and more expensive than RAB or air core drilling, but achieves better penetration in harder rocks. It is less expensive than diamond coring (described below) and is thus the preferred method for most preliminary mineral exploration work. However, due to the size and weight of the rigs, good roads to all sites are essential.

RC rigs are usually accompanied by a support vehicle and an auxiliary vehicle, normally trucks. The support vehicle carries diesel, water and maintenance supplies; the auxiliary vehicle usually carries an auxiliary compressor and booster compressor.

Diamond core drilling

Diamond core drilling differs from other drilling methods used in mineral exploration in that a solid core of rock (generally 27 to 85 mm in diameter, but can be up to 200 mm), rather than cuttings, is extracted from depth.

The diamond drill bit comprises a short steel shank with a cutting head using natural ("surface set") or man-made ("impregnated") diamonds as the cutting medium. In softer sedimentary formations (e.g. during geotechnical investigations or coal exploration), other cutting elements may be used, such as tungsten-carbide and polycrystalline diamond compacts (PCD). Impregnated bits using man-made diamond compacts are preferred for hard-rock applications because they can drill a wider range of formations. Water is the usual circulation fluid used to remove the cuttings and cool the drill bit.

As the drill bit advances, a cylindrical core of rock progressively fills a double-tube core barrel immediately above the drill bit. Core samples are periodically recovered by lowering a cable with an overshot down the drill string, attaching it to the top of the inner tube (inner barrel) of the core barrel, and winching it to the surface. The inner barrel is fitted with a core lifter mechanism to prevent core from dropping out during recovery. While the core sections are being removed from the inner tube and placed in core trays, a replacement inner tube is lowered into the hole so that drilling can recommence. This is referred to as the wireline system.

For drilling through coal, clay-bearing, or fractured rock, triple-tube core barrels are sometimes used to improve the quality of the core recovered. For this method, a stainless steel split tube is fitted inside the inner tube of the double-tube system. At the surface, the split tube can be opened to reveal the core in virtually undisturbed condition.

Multipurpose drill rigs that can operate in either an RC or diamond core drilling role are sometimes used, particularly in isolated locations. These rigs can commence drilling in RC mode (known as pre-collaring) and change to diamond coring when the target depth is reached, thus overcoming the need for a second rig.

Rotation speeds during diamond core drilling can vary from 150 to 400 rpm for surface set bits, to more than 1,500 rpm using impregnated bits. Compared with RC rods, diamond drill rods are relatively light. An unusual feature of diamond coring is that the annulus (i.e. distance between the rod and wall of the hole) is typically only 3 to 4 mm.

Drilling depths greater than 2,500 m can be achieved with diamond core drilling. Penetration is much slower than other drilling methods because of the hardness of the rocks usually encountered and the time involved in retrieving core at depth. Under average conditions, the rig can produce 30 to 40 m of core per shift, with samples having a very high integrity.

The typical drilling operation comprises a truck-mounted rig, support truck to carry items such as the rods, casing, fuel and water, and a 4WD field vehicle.

Heliportable rigs allow good samples to be collected from almost any location.

Sonic drilling

Sonic drilling uses high-frequency, resonate energy to advance the core barrel or casing. During drilling, the resonant energy is transferred down the drill string to the bit face at various sonic frequencies. Simultaneously rotating the drill string evenly distributes the energy and impact at the bit face.

The resonant energy is generated inside the sonic head by two counter-rotating weights. A pneumatic isolation system inside the head prevents the resonant energy from transmitting to the drill rig and preferentially directs the energy down the drill string.

The sonic driller controls the resonant energy generated by the sonic oscillator to match the formation being encountered to achieve maximum drilling productivity. When the resonant sonic energy coincides with the natural frequency of the drill string, resonance occurs. This results in the maximum amount of energy being diverted to the face. At the same time, the friction of the soil immediately adjacent to the entire drill string is substantially reduced, resulting in very fast penetration rates.

Sonic drilling is particularly useful when hard-to-drill formations are encountered and a high level of sample recovery is required.

A sonic drill rig is similar in size and set up to a conventional air core drill rig.

2 Site and drill pad preparation

2.1 Introduction

While this code of practice emphasises the hazards of exploration drilling, it is also important to consider pre- and post-drilling activities, which include:

- mapping, sampling and surveying
- camp preparation
- gridline preparation
- work site preparation
- drill pad preparation
- downhole surveying
- demobilisation and rehabilitation.

There are numerous incidents where personnel have died or been seriously injured through inadequate recognition of exploration hazards and risks. Thorough planning and preparation are critical elements for effective management of the hazards associated with these activities, many of which are addressed in Part 2 of the code of practice.

Some specific considerations when preparing camps, work sites and drill pads are listed below.

2.2 Site preparation

- The exploration area has been surveyed, and hazardous ground conditions delineated (e.g. old workings) or addressed (e.g. previously capped drillholes).
- Overhead powerlines or overhanging vegetation, underground services and other obstructions have been clearly identified.
- The camp is located to reduce exposure to natural hazards (e.g. fuel load, flood plains).
- The maintenance and storage facilities, and eating and ablution amenities are located to reduce exposure to drilling hazards and ensure hygienic conditions are maintained.
- Tracks to the camp and work sites are suitable for drilling, support and emergency vehicle access.
- There is a traffic management system for the camp and work sites, including designated parking areas and escape routes.
- Safety and warning signs at the camp and work sites are clear, legible and appropriately located.

2.3 Drill pad set-up

- The prepared ground or constructed pad is level and stable.
- The drill site is clear of natural hazards.
- Sumps have been constructed to contain all drilling fluids and are barricaded to prevent inadvertent access.
- Walkways around the drill site are clear of obstacles.
- Where required, edge protection is in place for the drill site.
- The drill rig and service vehicles are positioned and set-up to minimise exposure of personnel to drilling hazards.
- Access routes to the drill site are clearly marked.

3 Information, instruction, training and supervision

3.1 Introduction

All workplaces are required to have safe systems of work so that workers can carry out their work safely. The provision of information, instruction, training and supervision are an essential component of any risk management strategy. The following sections describe what this means in practical terms.

3.2 Information

Personnel must have the information necessary to complete tasks safely. This may include:

- manuals provided by original equipment manufacturers (OEMs)
- the operation's policies, procedures and plans
- applicable legislation, Australian and industry standards, and other guidance material.

3.3 Instruction

Personnel must be instructed about specific tasks to be undertaken, including their hazards and risks, the controls to be applied, and the job steps necessary to complete the tasks safely.

Instructional tools such as job safety or hazard analyses (JSAs or JHAs), safe work instructions or procedures (SWIs or SWPs) and standard operation procedures (SOPs) may be used to document the process, but should be reviewed and amended if equipment or conditions change.

Instructions must be approved by the supervisor or management.

3.4 Training

People must be competent in the tasks they are assigned. This means they must have the knowledge and skills necessary to perform the task safely. Competency is gained through training and experience while being supervised or mentored.

The risk management training provided must be appropriate to the assigned roles and responsibilities. It must provide information on:

- the risk management process
- task-specific safe work methods, including the safe use of tools and equipment and safe systems of work.

The effectiveness of training can be increased by using case studies, or examples, from mining workplaces to demonstrate risk management principles for specific hazards.

Assessment of competency should be evidence based and verified before work commences. Competency may be verified:

- by recognition of prior learning (RPL)
- by on-site recognition or validation of current competency (RCC or VOC)
- via the operation's training and development program.

All verification methods must include a documented assessment.

The Resources and Infrastructure Industry Training Package (RII09) was developed by industry and is available from SkillsDMC, the National Industry Skills Council for Drilling, Mining, Quarrying and Civil Infrastructure. It comprises units of competency that set out the minimum requirements for training and assessment. General drilling operations are specifically covered under Category 4.4.1 of the training package. Further information is available at www.skillsdmc.com.au

There must also be a system to ensure affected personnel are retrained and reassessed whenever systems of work or plant and equipment change, or new systems of work or plant and equipment are introduced.

3.5 Supervision

Senior drillers and supervisors are responsible for the quantity and quality of the output of others and contribute to the development of technical solutions to non-routine problems. Supervision of drilling operations includes managing assigned work areas and crews, communicating regularly with others, diagnosing and solving routine and non-routine problems, controlling work programs to ensure objectives are met, and maintaining operating records.

Senior drillers and supervisors ensure a safe workplace by:

- confirming that workers are trained and competent for the task undertaken
- providing clear work instructions
- inspecting and monitoring workplace conditions
- continuously evaluating worker performance and correcting unsafe acts
- reporting and rectifying hazards
- assuring implementation of the company's safety systems
- demanding compliance with safety rules and procedures.

An effective supervisor spends most of their time in the workplace engaged with the workforce conducting meaningful observations, consultation and interventions.

Moving into a supervisory or team leader role involves the application of a range of new skills. Much of the additional responsibility comes down to managing people, and to do this successfully requires a comprehensive range of workplace communication skills. Information about resources to assist in the transition of operators to supervisory or team leader roles is available at www.skillsdmc.com.au

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PART 2
DRILLING HAZARDS

4 Rotating and moving parts

4.1 Hazards

Serious and fatal injuries have resulted from entanglement or entrapment of personnel working close to rotating and moving parts on drill rigs.

People have also received eye and other injuries after being struck by projectiles ejected during maintenance or repair work, such as bit sharpening. Contact with equipment such as grinders and chainsaws can lead to abrasive, friction or cutting injuries.

Rotating and moving parts associated with drill rigs include:

- drill rods, drill strings and rod handlers
- drill head
- drill mast
- drive shafts
- winch drums
- cyclones, splitters, vehicle-mounted cranes and knife valves
- sprockets, chains, pulleys (sheaves) and drive shafts
- fan blades
- pump drive shafts
- alternators and generators.

4.2 Assessing the risks

Direct risk factors

- Exposure to rotating or moving parts

Contributing risk factors

- Inadequate or lack of safeguarding
- Necessity to remove guarding to access parts for operational and maintenance tasks
- Proximity of personnel to rotating or moving parts
- Disregard or lack of policies and procedures related to controls or isolation of rotating or moving parts

Rating severity of the risk

Exposure to these hazards can have fatal or extreme consequences, including amputation and scalping.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

4.3 Risk controls

- Conduct an audit of drilling operations to ensure that all practical measures have been taken to control risk associated with rotating and moving parts.
- Conduct a risk assessment to identify priorities for replacing, modifying or installing guarding.
- Develop an action plan with due dates and responsibilities for the replacement, modification or installation of guarding.
- Do not rotate drill rods without guarding in place or a safe system of work (e.g. isolation protocols, cut-out or interlock devices).
- A competent person should regularly review drilling operations to ensure the adequacy of guarding and systems of work.
- Install at least two emergency stops for the drill rig and test them regularly. One should be located at the rig control panel and at least one other at a location that is easily accessible during operation.

4.4 Further information

DEPARTMENT OF COMMERCE AND DEPARTMENT OF MINES AND PETROLEUM, 2009, Safeguarding of machinery and plant – code of practice: WorkSafe and Resources Safety, Western Australia, 59 pp.

Figure 4.1 Example of effective guarding on a diamond drill rig

Mines Safety Significant Incident Report No. 36

INJURIES SUSTAINED WHILE WORKING ON DRILLING MAST

During 1991, two persons were seriously injured in separate accidents while working up the mast of a drill rig. One worker lost three toes and the other received severe lacerations to a foot.

In 1992, a drill rig offsider lost his arm when his jacket was caught by the rotating drill rods and he was dragged between the rods and the mast. He had climbed up the mast to carry out maintenance work while the drill was operating.

Mines Safety Significant Incident Report No. 47

INJURIES SUSTAINED WHILE WORKING ON DRILLING MAST

An exploration driller was painting the bottom of the mast of the drill rig when his hair caught in the rotating drill rods of a Universal UDR-1000 drill rig. Drilling was in progress when he turned his head to check the control panel gauges. He was not wearing a safety helmet. The rotating drill rods pulled him into the gap between the rotating drill string and the mast. After having his jumper pulled from his body, he managed to free himself. The driller's injuries included hair pulled from the scalp, friction burns, lacerations and several soft tissue injuries.

Figure 4.2 Example of remote control console in combination with guarding. The operator is removed from rotating and moving parts of the drill rig

Figure 4.3 Example of effective guarding on a multipurpose drill rig

Mines Safety Significant Incident Report No. 61 and Mines Safety Bulletin No. 21

CAUGHT IN A ROTATING DRILL ROD – FATAL ACCIDENT

A driller found caught between the drill rod and mast of a diamond drill exploration rig. Before the accident, he was seen crouching near the rotating drill rod, apparently observing the return pulley and/or pull-down mechanism to monitor the penetration rate. He was not wearing any loose clothing. He sustained serious head and internal body injuries in the incident and later died.

Mines Safety Significant Incident Report No. 146

HAZARD POSED BY CYCLONE DRAW IN RC DRILLING

When a reverse circulation (RC) drill rig was drilling in dry ground, the large plastic bag on the sample splitter beneath the cyclone was occasionally sucked up inside the base of the splitter by the dust suppression fans. The offsider would reach inside the splitter and pull the sample bag out.

When wet ground was encountered, or when water was injected into the drill string, the sample cuttings tended to block the splitter and the splitter was removed. The sample bag was then held over the mouth of a short adaptor cone beneath the cyclone draw.

While drilling with the splitter off, the plastic sample bag was again sucked up, but this time inside the cone and into the draw. The offsider did what he had done before, reaching up to pull the sample bag out. However, the driller closed the draw at the same time. The sliding steel plate of the draw severed three of the offsider's fingers.

5 Compressed air systems

5.1 Hazards

Compressed air is by far the most dangerous of all fluids used in the drilling industry.

Unlike oil or water, a given volume of air can be reduced by compression. Once compressed, the smaller volume of air can be likened to a compressed spring; that is, it has the energy to return to its pre-compressed state if released. For example, debris from blown hoses can travel at speeds such that there is no time to react.

The uncontrolled release of stored energy can be lethal.

Compressed air systems can comprise:

- compressors and associated hoses
- compressor boosters
- sample hoses
- sample cyclones
- drill rods, bits and hammers
- air hoists
- air hoses used for cleaning.

5.2 Assessing the risks

Direct risk factors

- Uncontrolled release of air at high pressure

Contributing risk factors

- Hoses, couplings and air lines that are not suitable for the compressed air system
- Integrity of hoses, couplings, seals and air lines
- Blockages within the compressed air system
- Absence or inadequacy of hose restraints
- Material in the air stream
- Proximity of personnel
- Misuse of compressed air

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Exposure to this hazard can have extreme consequences, including being struck by unrestrained hoses or ejected objects, injection of air into the body (embolism) and eye injuries.

5.3 Risk controls

- Hoses, couplings, seals and air lines must be appropriately rated for the compressed air system being used.
- To minimise the use of high-pressure hoses, consider using engineered systems with designated connection points.
- Install at least two emergency stops on the drill rig and test them regularly. One should be located at the control panel and at least one other at a location that is easily accessible during operation.
- Install at least one emergency stop for each auxiliary compressor unit and test them regularly.
- To shut off or redirect the air supply in the event of a hose or coupling failure or blockage; consider using shut-off and relief valves in compressed air lines.
- To assess the integrity and monitor wear of hoses, couplings and fittings, a competent person must regularly check the compressed air system, and take immediate corrective action where necessary. Air receivers must be regularly inspected and certified as complying with regulatory requirements.
- To prevent uncontrolled movement if a hose or coupling fails, install fit-for-purpose restraining devices, such as chains, slings, full-length hose stockings and whipchecks, on compressed air hoses. The anchor points for restraining devices must be appropriately rated and fit-for-purpose.
- Implement procedures for the safe removal of blockages in compressed air systems.
- Implement preventative maintenance programs for compressed air systems.
- Before performing any maintenance or repairs, ensure pressure is released from the compressed air system, or implement isolation procedures for stored energy.
- Restrict access to high-risk areas associated with compressed air systems.
- To eliminate the risk of air injection; do not use air hoses to clean personnel.

5.4 Further information

Resources Safety, **www.dmp.wa.gov.au/ResourcesSafety**

- Mines Safety Bulletin No. 49: Use of compressed air for cleaning purposes
- Mines Safety Bulletin No. 71: Booster compression explosions – reverse circulation (RC) drilling

Mines Safety Significant Incident Report No. 3

COMPRESSED AIR HOSE CONNECTION – FATAL ACCIDENT

An exploration driller's assistant was struck on the head by a large-diameter compressed air hose that blew off its fitting on a cyclone sampler. He received serious head injuries, which proved fatal. The air hose was clamped to the fitting but there was no restraining chain or sling.

Mines Safety Significant Incident Report No. 92

RC DRILL RIG 3" SAMPLE HOSE CONNECTION – SERIOUS ACCIDENT

A driller employed on an exploration rig was struck on the upper right side of his body and arm by a 3" diameter cyclone sampler air hose that blew off its fitting above the driller's operating platform. He received serious injuries to his ribs and right lung and a severely crushed right arm, which had to be amputated. The air hose was held on the fitting by a claw type 4 bolt hose clamp. The hose assembly was fitted with a commercially made whipcheck using 6 mm-diameter wire rope.

Mines Safety Significant Incident Report No. 119

DRILLER'S OFFSIDER BLASTED WITH SAMPLE DUST UNDER PRESSURE

A driller's offsider received serious facial injuries when a sample hose on a reverse circulation (RC) exploration drill rig ruptured under pressure. The driller was attempting to clear a blockage in the hose by attaching a blow-back sub and applying high-pressure air into the sample hose. The sample hose failed near the cyclone. The offsider was walking past the cyclone when the hose ruptured, blasting his face with abrasive sample material.

Figure 5.1 Example of engineered compressed air system on an RC drill rig

Figure 5.2 Example of full-length hose stockings and anchor points on an RC drill rig

Mines Safety Significant Incident Report No. 135

ALUMINIUM DRILL ROD FAILURE

A reverse circulation (RC) drill rig was drilling at a depth of about 94 m when the aluminium head drill rod failed. The failed section was located within the drill hole casing a short distance down the hole below the slips table of the drill rig. The slips table was next to the drill crew work area.

When the rod failed, a sudden and uncontrolled release of high-pressure compressed air from the split flowed up the inside of the drill collar, dislodging the steel drill rod slips at the surface.

Fortunately, the drill crew working in the area was not injured and there was no other damage. There would almost certainly have been injuries if the failure had occurred above, at or nearer to the surface.

Since the occurrence, the mining company and drill rig owner have removed all aluminium drill rods from service.

Mines Safety Significant Incident Report No. 145

DRILLER'S OFFSIDER STRUCK BY DUST DEFLECTOR BOX OR "WEAR BEND"

A driller's offsider was fatally injured when he was struck by a 40 kg "wear bend" that became detached from the cyclone at an exploration drilling site.

The wear bend assembly broke away from the welded flange on the cyclone as the driller was attempting to clear a blockage in the sample hose by using high pressure compressed air. The driller's offsider was standing next to the sample hose. He was struck by the wear bend and sample hose, and suffered fatal head and other injuries.

6 Hydraulic systems

6.1 Hazards

Hydraulic systems use fluid under high pressure. Although not as dangerous as compressed air, the risks associated with hydraulic systems should not be underestimated. The potential hazards arising from the use of hydraulic fluids are pressure, temperature, flammability and toxicity. For example, in atomised form, such as a high-pressure pinhole leak, hydraulic fluid can readily ignite, causing a flash fire with a substantial fireball.

Serious and fatal injuries have resulted from exposure to any one or a combination of these hazards.

Hydraulic systems comprise:

- hydraulic pumps
- fluid reservoirs
- hydraulic cylinders
- tubes, pipes and hoses
- control valves.

6.2 Assessing the risks

Direct risk factors

- Uncontrolled release of hydraulic fluids at high pressure and/or temperature
- Flammability of hydraulic fluid
- Toxicity of hydraulic fluid
- Exposure to hot hydraulic components

Contributing risk factors

- Hoses, couplings and oil lines that are not suitable for the hydraulic system
- Integrity of hoses, couplings, seals and oil lines
- Absence or inadequacy of hose couplings and fittings
- Failure to relieve accumulated energy (i.e. pressure) from a hydraulic circuit
- Movement associated with depressurisation of hydraulic system
- Proximity of an ignition source
- Proximity of personnel

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Exposure to these hazards can have serious consequences, including:

- injection under the skin resulting in open wounds and infection
- burns and injuries from fires or explosions
- burns and injuries when opening a pressurised system
- thermal burns from contact with hot equipment
- eye injuries from exposure to hydraulic oil under pressure.

6.3 Risk controls

- Hoses, couplings, seals and hydraulic lines must be appropriately rated for the hydraulic system in use.
- To minimise the use of high-pressure hoses, use engineered systems where practicable.
- To minimise wear of hoses, reduce sharp edges or use shielding (e.g. Kevlar or rubber wrapping).
- If suitable, use non-flammable and non-toxic hydraulic fluids.
- Install at least two emergency stops on the drill rig and test them regularly. One should be located at the control panel and at least one other at a location that is easily accessible during operation.
- To prevent ignition of hydraulic fluids released by component failure, install screens or configure hoses and lines to minimise interaction with hot components or electrical sources.
- Install an automatic fire suppression system.
- To assess the integrity and monitor wear of hoses, couplings and fittings, including self-centring hydraulic levers, a competent person must regularly check the hydraulic system, and take immediate corrective action where necessary.
- Never use hands or fingers to search for or confirm hydraulic leaks. Gloves do not protect against this injection hazard.
- During depressurisation of hydraulic systems, ensure personnel are clear of moving parts or restraints are in place to prevent unexpected movement.
- Implement preventative maintenance programs for hydraulic systems.
- Before performing any maintenance or repairs, ensure pressure is released from the hydraulic system or implement isolation procedures for stored energy.
- Restrict access to high-risk areas associated with hydraulic systems.

6.4 Further information

Safe Work Australia, www.safeworkaustralia.gov.au

- NOHSC, 1999, Work-related deaths associated with hydraulic equipment in Australia, 1989-1992

Occurrence report – 2010

The drilling crew had removed a hydraulic rotation motor from the head of an RC rig to replace the motor. A replacement motor was onsite, but the required drive gear was not fitted. With the assistance of a driller's offsider, the driller was attempting to remove the drive gear from the damaged motor using a 10 t capacity gear puller. He was standing over the motor and puller when the gear drive suddenly came free from the shaft. The puller hit his mouth but the injuries were not serious.

Occurrence report – 2010

While pulling rods during RAB drilling, a hydraulic line on the drill rig ruptured, spraying hydraulic oil over the hot exhaust manifold. The oil ignited causing a minor fire. The fire was put out using the rig's fire extinguishers.

Figure 6.1 Example of enclosed engine and hydraulic system that minimises the potential for interaction with hot surfaces, and facilitates fire and noise suppression

Occurrence report – 2011

An O-ring on the hydraulic fitting of a drill rig's rotation motor pump split and leaked oil. The wind blew some of the oil onto the turbo motor, about 1.5 m away. It was a hot day and the drill string was bogged, so the motor was working harder and was hotter than normal. The hydraulic oil ignited upon contact but the emergency stop was activated and the small fire extinguished quickly. The hoses had been checked that morning during the pre-start check.

Occurrence report – 2008

The drillers had just completed a hole and were pulling rods when the offsider noticed a small fire on the turbo. The driller immediately hit the emergency stop, shut down the hydraulic system and activated the onboard rig fire suppression system. Three fire extinguishers from support vehicles were also used to extinguish the fire. No-one was injured. The incident investigation revealed that a hydraulic hose on the drill rig had ruptured just above the point where it coupled with the mantle on the rig mast, and the spray of oil had ignited upon contact with the hot turbo and engine exhaust.

Figure 6.2 Example of turbocharger that has been insulated to reduce the surface temperature and eliminate an ignition source

7 Hazardous substances and dangerous goods

7.1 Hazards

Spill and leaks of flammable and combustible substances present a fire hazard.

Exposure to hydrocarbons may result in dermatitis and other illnesses. Contact with acids can cause chemical burns.

Spilt or leaking oil and fuel can present a slip hazard to employees. Split hydrocarbons can also attract dirt and dust from the drilling operation, which makes detection and monitoring of leaks difficult.

The hazardous substances and dangerous goods most commonly used in drilling operations are:

- diesel
- petrol
- acids
- oils
- grease.

7.2 Assessing the risks

Direct risk factors

- Uncontrolled release of hazardous or dangerous materials
- Flammability of substance
- Toxicity of substance
- Corrosivity of substance
- Low friction coefficient (slipperiness) of substance

Contributing risk factors

- Transport, storage and handling
- Integrity of hoses, couplings, seals and lines
- Proximity of an ignition source

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Exposure to these hazards can have serious consequences, including:

- burns and injuries from fires, explosions or spills
- loss of equipment from fires or explosions
- health effects from skin contact, inhalation or ingestion.

7.3 Risk controls

- Ensure the dangerous goods inventory is maintained and reviewed regularly, and reduced where practicable.
- Ensure current material safety data sheets (MSDSs) are available for all products used on site, and control and response measures are implemented as necessary.
- Containers (e.g. drums, tanks), hoses, couplings, seals and lines must be rated for the substance in use.
- To assess the integrity and monitor wear of containers, hoses, couplings and fittings, a competent person should regularly check all storage and handling systems.
- Implement procedures for the safe transfer of substances. To avoid overfilling, particularly with fastfill systems for fuel, never allow dangerous goods to be transferred unattended.
- To prevent ignition of flammable and combustible substances released by component failure, install screens or configure hoses and lines to avoid interaction of released flammable substances with hot components and electrical sources.
- Sufficient spill response equipment to deal with a complete failure of the largest container of hazardous substances or dangerous goods.
- Use self-bunded containers, bunded pallets or portable bunds for hazardous substances or dangerous goods.
- Install an automatic fire suppression system on the drill rig, and provide appropriate fire fighting equipment where flammable substances are used elsewhere on site.
- Implement preventative maintenance programs for all flammable substances systems.
- Clean up all spills of hazardous substances or dangerous goods and dispose of cleaning aids (e.g. absorption pads).
- Personnel should use appropriate personal protective equipment (PPE) to avoid contact when handling hazardous substances or dangerous goods.

7.4 Further information

Australian Standard, **www.saiglobal.com**

- AS 1940:2004 The storage and handling of flammable and combustible liquids
- AS 3780:2008 The storage and handling of corrosive substances

Mines Safety Significant Incident Report No. 20

DRILLING RIG FIRE

Two men working near a drill rig were burnt by a fireball from the diesel engine when a component failed.

A flexible hose in the engine oil cooling circuit had failed at the connection to the heat exchanger (which formed part of the engine radiator system) and oil was sprayed into the cooling fan. The oil became atomised and was sprayed as a cloud in and around the engine compartment. The oil mist was ignited on contact with hot engine components (most likely the exhaust driven turbo charger), generating a fireball that enveloped the unit and extended a metre or two beyond it.

Figure 7.1 Example of bunded pallets

Occurrence report – 2010

During drilling, a driller's offsider noticed flames coming from the engine bay of the drill rig. He pushed the rig's emergency stop and activated the fire suppression system. After the fire was extinguished, an inspection revealed that a fuel injector line had cracked and severed completely, spraying diesel onto the turbo casing, where it ignited.

About a week later, the driller was manoeuvring the drill rig onto a new drill site and noticed smoke coming from the engine bay. He pushed the rig's emergency stop. After the fire was extinguished using a fire extinguisher, an inspection revealed that another fuel injector line had cracked and severed completely, spraying diesel onto the turbo casing, where it ignited.

Figure 7.2 Example of spill equipment

Occurrence report – 2010

A driller's offsider was refuelling an RC drill rig. When he removed the fuel hose, fuel splashed onto the engine manifold and ignited. The fire was extinguished using a fire extinguisher.

Figure 7.3 Example of drive-on bund

8 Electricity

8.1 Hazards

Electrical hazards exist in almost all workplaces. Contact with electricity can be lethal or result in serious and permanent injuries. Use of wet electrical equipment after rain is a common cause of electric shock. Electric arc flashes during welding can cause burns and eye damage. Fires caused by electrical faults can injure people and damage or destroy equipment.

Electrical hazards encountered during drilling operations and at camp sites include:

- generators and lighting plants
- welding and maintenance equipment
- inverters
- vehicle electrical systems
- overhead powerlines
- electrical appliances (e.g. laundry and kitchen equipment, tools, personal items)
- electrical cables and extension cords
- electric fences

8.2 Assessing the risks

Direct risk factors

- Exposure to live electrical power sources

Contributing risk factors

- Inappropriate electrical modifications
- Electrical defects
- Proximity of personnel
- Proximity of fuel
- Poor work practices
- Absence or inadequacy of isolation
- Damage to equipment
- Wet conditions

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Any exposure to electricity can have extreme consequences, including electrocution, electric shocks, burns and fibrillation of the heart.

Electrical faults can lead to fires.

8.3 Risk controls

- Electrical work must be undertaken by licensed electricians.
- Electrical equipment and installations must be correctly isolated before maintenance or repair work commences.
- Use safety switches and residual current devices (RCDs).
- Use voltage reducing devices (VRDs) on welding equipment.
- Implement electrical inspection, testing and tagging programs to ensure electrical equipment and safety devices are maintained in good working order.
- Electrical equipment must be rated for the expected working conditions.
- Plan the site to allow for the appropriate placement of electrical equipment, cables and cords.
- Implement safe systems of work for the use of electrical equipment and systems, particularly after rain.
- To prevent ignition of hydrocarbons released by component failure, install screens or configure hoses and lines to minimise interaction with electrical sources.

8.4 Further information

Resources Safety, **www.dmp.wa.gov.au/ResourcesSafety**

- Mines Safety Bulletin No. 30: Ingress of water into electrical equipment
- Mines Safety Bulletin No. 56: Mining industry electrical accidents

Welding Technology Institute of Australia, **www.wtia.com.au**

- Technical Note No. 7: Health and safety in welding (2004)
- Technical Note No. 22: Welding electrical safety (2003)

Australian Standard, **www.saiglobal.com**

- AS/NZS 3001:2008 Electrical installations – Transportable structures and vehicles including their site supplies

State Law Publisher, **www.slp.wa.gov.au**

- Electricity Regulations 1947
- Electricity (Licensing) Regulations 1991

Occurrence report – 2010

A field assistant replacing a door latch on the wall of an exploration van unknowingly drilled through the electrical wiring for a light switch. The van was powered and the RCD tripped. However, the electrical incident was not identified until the next day when it was realised there was no power. The van was then disconnected from the power supply and tagged out. The severed wiring was repaired by the contract electrician.

Occurrence report – 2011

Two driller's offsiders received electric shocks from a 5000V DC electric fence while lowering the side gate on a booster truck parked 1 m from the electric fence. Their lower backs had come into contact with the electric fence when they stepped backwards. ECG scans were conducted on-site and in hospital to confirm there were no ill effects.

Occurrence report – 2011

While inserting steel casing into a water bore, a driller's assistant received two electric shocks in rapid succession. At the time, he was assisting with the welding of casing as it was inserted into the bore. He was holding the flange between the two lengths of casing when he received the shock.

Occurrence report – 2009

The spin drier on a camp washing machine had stopped working so a driller had investigated. He received a small electric shock upon touching a wire connected to the motor. There were no ill effects but the incident was not reported to management until two days later.

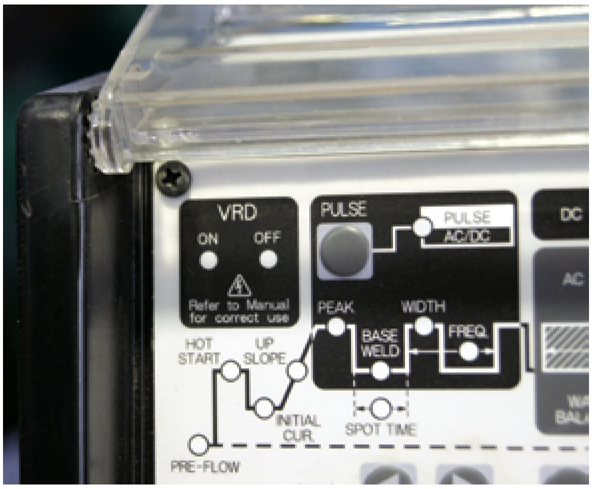

Figure 8.1 Example of VRD on welding equipment

Figure 8.2 Example of hydraulic hoses and electrical cables that are protected and separated with nylon sleeves

9 Manual tasks

9.1 Hazards

Manual tasks undertaken during drilling operations include physical work such as lifting, lowering, pushing, pulling, carrying, moving, holding or restraining anything. They also include work with repetitive actions (e.g. hammering), sustained postures (e.g. operating plant) and concurrent exposure to vibration (e.g. driving a truck).

Hazardous manual tasks can lead to musculoskeletal disorders including:

- acute injuries, where a single exposure to high force results in sudden damage to the musculoskeletal system
- chronic injuries resulting from cumulative wear and tear on the musculoskeletal system, and caused by repeated or prolonged exposure to lower levels of force.

Hazardous manual tasks on a drill rig include:

- rod handling
- sample handling
- use of hand tools
- moving fittings, core trays, and fuel and oil drums
- carrying loads while changing levels or twisting
- clearing drill sites
- tyre changing
- tyre repairs, including use of split rims.

9.2 Assessing the risks

Direct risk factors

- Postures and movements of worker
- Forces (exertion) involved in tasks
- Duration and frequency of tasks

Indirect risk factors

- Work environment
- Systems of work, work organisation and work practices
- Exposure to vibration

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

The risk of developing a musculoskeletal disorder significantly increases where there is more than one risk factor present in the task. Non-engineered modification of tooling (e.g. cut-down pipe wrench used on break-out systems) can increase the risk of injury.

9.3 Risk controls

- Eliminate or mitigate hazardous manual tasks associated with drilling activities (e.g. use automated drill-rod handling systems, break-out systems and sample splitters).
- Eliminate the use of non-engineered, modified tooling.
- Review the nature of loads and how they are handled (e.g. use of mechanical aids or assistive devices), and address as necessary.
- Review the hazards associated with hand tools, plant and equipment used during manual tasks, and address as necessary.
- Review the hazards associated with tyre changing and repairs, and address as necessary.
- Review the hazards from exposure to repetitive tasks or vibration, and address as necessary.
- Incorporate ergonomic specifications in purchasing procedures.
- Plan the site to allow for orderly movement of personnel, equipment and materials.

9.4 Further information

Resources Safety, www.dmp.wa.gov.au/ResourcesSafety

- Training package: Prevention of musculoskeletal disorders from performing manual tasks in mining workplaces (2010)
- Manual tasks in mining fact sheet series

Occurrence report – 2010

A driller's offsider injured his wrist while lifting drill rods.

Occurrence report – 2009

A driller attempting to remove a drill bit from a drill rod barrel lost his balance when the drill bit suddenly released. He rolled his full weight onto an ankle, and broke his leg just above the ankle joint.

Figure 9.1 Example of mechanised rod handler on an RC drill rig

Figure 9.2 Closer view of rod handling arm shown in Figure 8.1

Occurrence report – 2010

A driller's offsider was tensioning a bolt on a diamond drill rig when his shoulder dislocated, possibly aggravating a pre-existing condition.

Occurrence report – 2010

A driller's offsider was hitting a piece of diamond drill core with a rubber mallet to remove it from the core barrel. The impact jarred his wrist. The injury was reported and he continued with light duties. However, the wrist was swollen the next morning. No breaks were detected in the initial X-ray but a follow-up X-ray two weeks later indicated that the wrist was fractured.

Occurrence report – 2011

A driller's offsider dislocated his shoulder while flicking a RAB drill rod from its horizontal position on the drill rod tray to a vertical position so it could be added to the drill string.

Figure 9.3 Example of tyre handler on a light vehicle

Figure 9.4 Example of tool drawer under tray of a light vehicle

10 Working at height

10.1 Hazards

Serious and fatal injuries have resulted when workers have fallen from height.

Work areas at height for drilling operations include:

- rig masts
- rig decks
- truck trays.

10.2 Assessing the risks

Direct risk factors

- Height of work
- Fall path
- Landing area

Contributing risk factors

- Ascending and descending drill masts
- Accessing drill rigs, support vehicles and associated plant
- Loading and unloading tools and equipment
- Jumping from heights
- Absence or inadequacy of fall prevention system

Rating severity of the risk

Height alone does not determine the consequences of a fall. What people contact as they fall and where they land also affects the severity of outcomes.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

10.3 Risk controls

- Eliminate hazards or hazardous work practices at height (e.g. automatic greasing system for mast lubrication points, ground-level fuel and oil refill points).
- Provide alternative means of access (e.g. ladders and walkways incorporated during equipment design) rather than working at height.
- Barricade or enclose areas of fall risk with edge protection or install handrails.
- Implement fall injury prevention systems for tasks that involve working at height.

10.4 Further information

DEPARTMENT OF CONSUMER AND EMPLOYMENT PROTECTION, 2004, Prevention of falls at workplaces – code of practice: WorkSafe, Western Australia, 112 pp.

Australian Standard, **www.saiglobal.com**

- AS/NZS 1891:2007 Industrial fall-arrest systems and devices

Figure 10.1 Example of static line and sliding brake fitted to mast of a drill rig

Occurrence report – 2010

A driller's offsider rolled his ankle when stepping off the work platform at the back of the rig. The platform was about 40 cm above the ground and he had stepped onto rough ground created by an animal footprint. He was unable to continue work and received medical treatment. An X-ray later revealed that he had broken his ankle.

Occurrence report – 2010

A driller's offsider was refuelling an aircore drilling rig from a service truck parked adjacent. After refuelling, the offsider climbed onto the vehicle in preparation for rolling up the hose into its housing area. As he was climbing down, he caught his leg in the fuel hose, which was draped under his line of descent. He fell about 1.5 m, landing on his shoulder and injuring it.

Occurrence report – 2010

A driller's offsider fell 1.4 m from a compressor truck to the ground while packing up high pressure hoses. He had walked backwards off the catwalk while dragging a disconnected hose.

Figure 10.2 Display of fall arrest equipment (unpacked)

Figure 10.3 Example of steps, walkway and handrails for safe access to a drill rig

11 Falling objects

11.1 Hazards

Serious and fatal injuries have resulted when workers have been struck by falling objects.

A drill rig and its components are subjected to high levels of stress during operation and transport. The associated vibration and jarring can dislodge or damage rig parts and associated plant and cause them to fall.

Objects that may fall include:

- drill rods, bits and hammers
- wire-line equipment, including blocks, sheaves and inner tubes
- hoses and fittings
- top drive units
- rod holders and carousel parts
- tile boxes
- loads carried by vehicle-mounted cranes
- shackles and pins
- tools
- sheared bolts.

11.2 Assessing the risks

Direct risk factors

- Height of fall
- Weight and shape of object
- Drop zone
- Point of impact

Contributing risk factors

- Integrity and design of rig components
- Use of tools and equipment at height
- Poor housekeeping or maintenance
- Proximity of personnel to drop zones

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

The height from which objects fall is not the only factor determining the consequences of personnel being struck by them. The weight, shape and trajectory of the object and where it strikes the person also affect the severity of outcomes.

11.3 Risk controls

- Ensure all rig components are regularly inspected and maintained.
- Implement preventative maintenance programs for rig components.
- To prevent a rig part falling as a result of attachment failure, secure high-risk components (e.g. tile boxes, sample hoses) with a restraint (e.g. chains, wire slings).
- Where practicable, provide edge protection and attachment points to secure tools with a lanyard.
- Plan tasks to minimise the requirement for tooling deployed at height.
- Establish "working at height" toolkits (e.g. lightweight, fit-for-purpose, multipurpose, lanyard attachment).
- Implement procedures for tasks that involve working at heights.
- Delineate drop zones and restrict access to them.

11.4 Further information

Safe Work Australia, www.safeworkaustralia.gov.au

- Falling objects fact sheet

Mines Safety Significant Incident Report No. 87

DRILL ROD HANDLING – SERIOUS ACCIDENT

A driller's offsider received serious spinal injuries during reverse circulation (RC) drilling when a 6 m-long drill rod weighing 270 kg fell on him as the drill crew was removing a string of drill rods from a vertical hole.

Mines Safety Significant Incident Report No. 109

FITTING OF TILE BOXES ON DRILLING RIGS

A tile box assembly broke loose on a reverse circulation (RC) drill rig, and fell 6 to 8 m. The assembly and return hose attachments weighed about 300 kg. The driller, who was standing at the control panel while operating the rig, was struck by the assembly and received severe head and other injuries.

Occurrence report – 2010

During diamond core drilling, the rods had become bogged and the torque had been increased in an attempt to free the rods. Several bolts snapped under the increased pressure and a guide rail fell free of the head and mast, narrowly missing the driller.

Occurrence report – 2011

Drillers were unsilting an RC hammer when the top of the 4 m starter rod fell towards the control panel and came to rest on the side of the mast. The starter rod had been screwed into the head at the top and the bottom hammer sub. As the bottom hammer sub was being unscrewed from the starter rod, the top of the rod had unscrewed from the head and fallen. No-one was injured.

Occurrence report – 2011

A driller's offsider was struck on the head and knocked to the ground by a top plate that had detached from a drill rig mast. He was wearing a hard hat.

Occurrence report – 2011

A roller bit about 4.5 m long and weighing a tonne was resting on a hold cover plate after being disconnected from the leader drill rod so the driller's offsider could attach the winching bung and then the winch rope. As the offsider approached the disconnected bit, he noticed it was swaying in the break-out wrench. As he stopped and stepped backwards, the bit slipped out completely. It was too heavy to be supported by the slip table assembly guide, and the whole lot collapsed. No-one was injured. An investigation revealed that the mast had not been tilted to support the bit; the table guide was not designed to hold the oversized bit; the table guide welds were located underneath each bracket, limiting the structural strength, and had been fatigued by the weight of the bit and repeated use; and there was no program for regularly inspecting the guide welds, which would have been obscured in any case by mud and grease build-up.

Figure 11.1 Example of tool lanyard that attaches to user's wrists or belt, and allows tools to be switched between hands while working at height

12 Working in hot environments

12.1 Hazards

Western Australia is subject to extreme environmental conditions, with temperatures ranging from below zero in winter, to over 50°C in summer. Hot conditions can be exacerbated by humidity, depending on the location and season.

Workers in mineral exploration can be regularly exposed to heat or cold stress. Exposure to cold can lead to hypothermia but hyperthermia is considered the more significant risk for Western Australian climatic conditions. Serious and fatal injuries have resulted from heat strain and dehydration.

12.2 Assessing the risks

Direct risk factors

- Temperature
- Radiant heat
- Humidity
- Wind velocity

Contributing risk factors

- Extended frequency and duration of exposure
- Lack of acclimatisation
- Frequency, duration and intensity of physical activity
- Certain medical conditions and medications
- Lack of physical fitness
- Drug and alcohol use
- Dehydration
- Type and amount of clothing

Rating severity of the risk

Exposure to heat stress can result in heat oedema, rash, fatigue and cramps.

Increased or continued exposure to heat stress can lead to dizziness or fainting, heat exhaustion or heat stroke.

Heat stroke may result in permanent damage to the brain and other vital organs, or even death.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

12.3 Risk controls

Controls to manage the risks associated with heat stress can be directed towards the work environment, tasks being carried out, and the individuals performing the tasks.

- Ensure workers are aware of the underlying causes of heat strain, recognise its symptoms and know how to respond.
- Personnel at risk from heat stress (e.g. workers with pre-existing medical conditions such as cardiovascular disease or febrile illnesses such as influenza, and workers not acclimatised to site conditions) must be monitored at the workplace:
  - for signs of heat strain
  - to ensure that they follow work–rest and hydration regimes.
- Provide weather protection (e.g. tents, shade) and cool rest and recovery areas.
- Implement acclimatisation policies covering new employees and those returning to work after a break.
- Adjust hours of work so that physically demanding work is done in cooler periods of the day, and schedule regular breaks and task rotation.
- Where practicable, workers should wear clothing suitable for the environment (e.g. cotton drill fabric).

12.4 Further information

DEPARTMENT OF MINES AND PETROLEUM, 2009, All about heat: MineSafe vol. 19 no. 3, p. 31.

DI CORLETO R., COLES G., AND FIRTH I., 2003, Heat stress standard and documentation for use in the Australian environment: Heat Stress Working Group, Australian Institute of Occupational Hygienists, 59 pp.

Mines Safety Significant Incident Report No. 95

DEATH OF EXPLORATION WORKER

A nineteen-year-old employee died after exposure to extreme heat during exploration. He was a student and had little previous field experience.

Occurrence report – 2007

A driller's assistant suffered heat stress while working in temperatures reported to be in the mid-forty degrees Celsius. He was taken to hospital, where he received intravenous fluids before being discharged the next morning.

Occurrence report – 2010

A driller's offsider suffering heat stress had felt faint and dizzy and had stopped sweating. He still felt faint after resting and drinking so was taken to hospital for medical aid. He returned to work on light duties for 24 hours.

Occurrence report – 2010

A driller's offsider passed out while setting up a drill site and was taken to hospital. The maximum temperature had been 36°C and he had consumed about 10 L of water over the day. Tests indicated that his body was low on electrolytes, causing him to pass out and his body to cramp.

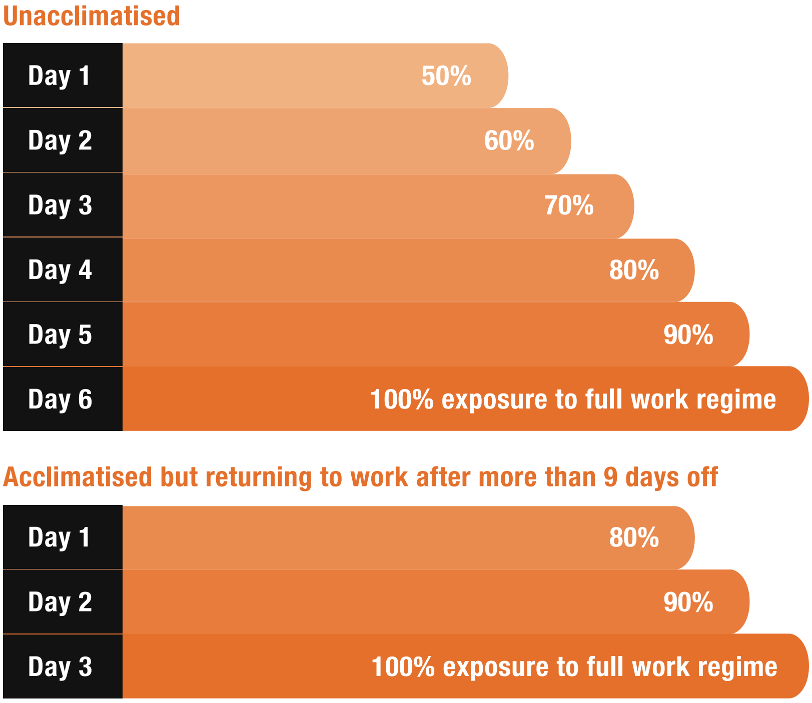

Figure 12.1 Recommended acclimatisation schedule

Figure 12.2 Example of shade shelter at a diamond core drill site

Figure 12.3 Example of air-conditioned cabin for operator

13 Fatigue and mental wellbeing

13.1 Hazards

The remote and isolated working conditions encountered during Western Australian exploration drilling programs, coupled with extended hours and intensive work, can result in major health and safety issues such as fatigue, stress and anxiety. These include lapses in concentration and judgement, poor decision making, and behavioural issues such as risk taking, reduced situational awareness, bullying and aggression.

13.2 Assessing the risks

Direct risk factors

- Hours worked, including travel and shiftwork
- Repetitive physically demanding tasks
- Mental demands of work
- Production pressures
- Administrative pressures

Contributing risk factors

- Extended exposure to hazards (e.g. extreme temperatures, noise, vibration, dust, hazardous substances)
- Inadequate quality and quantity of sleep and rest
- Inadequate job skills
- Fitness for work
- Relationship stresses
- Poor or indequate diet

Rating severity of the risk

Fatigue and stress increase the likelihood of human error and therefore the risk of serious injury or harm to health.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

13.3 Risk controls

- Develop and implement policies and procedures to address fatigue and support mental wellbeing at the workplace.
- Schedule regular breaks and task rotation.
- Targets should be achievable and allow for downtime:
  - due to mechanical breakdown
  - for routine maintenance
  - caused by external factors such as bad weather.
- Ensure management and workers are aware of the underlying causes of fatigue and stress, can recognise the symptoms and know how to respond.

13.4 Further information

DEPARTMENT OF COMMERCE AND DEPARTMENT OF MINES AND PETROLEUM, 2006, Working hours – code of practice: WorkSafe and Resources Safety, Western Australia, 32 pp. (includes risk management guideline)

DEPARTMENT OF COMMERCE AND DEPARTMENT OF MINES AND PETROLEUM, 2008, Alcohol and other drugs at workplace – guidance note: WorkSafe and Resources Safety, Western Australia, 27 pp.

DEPARTMENT OF CONSUMER AND EMPLOYMENT PROTECTION, 2007, Prevention and management of violence, aggression and bullying at work – code of practice: Resources Safety, Western Australia, 31 pp.

DEPARTMENT OF CONSUMER AND EMPLOYMENT PROTECTION, 2007, Dealing with bullying at work – guideline: Resources Safety, Western Australia, 11 pp.

Energy Institute, UK, www.energyinst.org/hfbriefingnotes for briefing notes on human factors

Health and Safety Executive, UK, www.hse.gov.uk for guidance material on human factors, including information on fatigue, the fatigue risk index and stress

Figure 13.1 Your camp is your home away from home – think about its location and whether you can relax after work

Figure 13.2 It is important to have a comfortable camp that is welcoming – and a good sense of humour!

14 Dust

14.1 Hazards

Drilling operations can generate substantial amounts of dust that not only reduce visibility but, more significantly, can result in long-term health effects from the inhalation of particles and fibres. Although nuisance or general dust has no specific toxic properties, it can overload lung clearance mechanisms.

Exposure to some particle types in dust can lead to:

- lung disease (e.g. asbestos and other fibrous minerals, silica)
- systemic toxicity (e.g. radioactive particles, toxic metal-bearing minerals)
- scarring or irritation of the respiratory tract.

In addition to the dusty environments commonly encountered at mineral exploration sites, dust is generated during drilling, particularly at the:

- T-piece or stuffing box
- splitter
- cyclone (top vent)
- collar
- outlet for the outside return.

14.2 Assessing the risks

Direct risk factors

- Geology and hydrology
- Drilling method

Contributing risk factors

- Stage of drilling (commencement of hole)
- Absence or inadequacy of dust suppression measures
- Position of drill rig relative to other work areas, support vehicles and camp
- Weather conditions, particularly wind velocity
- Poorly fitting respiratory protection

Rating severity of the risk

The severity of the risk relates to the volume of dust, duration of exposure, and the composition of the particulates and fibres.

14.3 Risk controls

- Assess dust exposure and implement a dust management plan. Where fibrous minerals may be present, incorporate a fibrous minerals management plan.
- When designing drilling programs, assess the likelihood of encountering fibrous, radioactive or toxic metal-bearing minerals (e.g. using historical geological records).
- Use diamond drilling rather than reverse circulation (RC) drilling in areas identified as high-risk for fibrous minerals.
- Use wet drilling methods.
- Ensure dust produced by drilling is collected and contained.
- Where dust collection and containment are not practicable, dust should be directed away from personnel and camp areas (e.g. piped downwind).
- All staff required to wear respirators should be fit tested and trained in respirator use. Powered air-purifying respirators are recommended for bearded people.
- Disposable respirators should be replaced regularly to prevent build-up of dust.

14.4 Further information

DEPARTMENT OF MINES AND PETROLEUM, 2010, Management of fibrous minerals in Western Australian mining operations – guideline: Resources Safety, Department of Mines and Petroleum, Western Australia, 47 pp.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Occurrence report – 2010

Fresh fibrous material (crocidolite) was intercepted while wet RC drilling. The geologist identified the asbestos in the rig's cyclone. Drilling was shut down and the comapny's fibrous minerals clean-up procedure activated.

Occurrence report – 2011

During RC drilling of channel sediments, suspected blue asbestos was intersected in the first 2 m but not noticed until almost a week later when field staff picked up the samples. The asbestos management plan was initiated to deal with the immediate contamination. A review of procedures was then conducted.

Figure 14.1 Example of a dust extraction system on an RC drill rig

Figure 14.2 Example of water-injected RC drill rig

15 Noise

15.1 Hazards

The drilling environment is noisy. Prolonged exposure to high levels of noise can result in permanent and irreversible damage to hearing. The quality of life for a person with severely impaired hearing is likely to be reduced.

The ambient noise generated by drilling operations includes that from:

- drilling engines
- air compressors
- generators
- vehicles
- radios
- sirens
- warning signals.

The highest (or peak) noise levels may represent an immediate risk to hearing and can be generated by:

- the release of compressed air
- use of tools (e.g. impact of hammer).

15.2 Assessing the risks

Direct risk factors

- Noise emissions

Contributing risk factors

- Excessively noisy equipment
- Proximity to sources of noise
- Absence or inappropriate use of hearing protection
- Need to communicate while operating equipment
- Poorly fitting hearing protection

Rating severity of the risk

Exposure levels above 85 dB(A) represent an unacceptable risk to hearing. Control measures must be implemented when people are exposed to:

- an average noise level of more than 85 dB(A) for an eight-hour working day (LAeq,8h)
- peak noise levels in excess of 140 dB(lin).

These exposures are often exceeded during drilling operations.

15.3 Control measures

- Develop a noise control plan, including procedures for noise surveys, dosimetry (personal noise exposure measurements and recording) and audiometry (hearing tests).
- Set noise emission goals for the design of new plant and equipment to maintain the lowest possible level of noise exposure.
- Purchase quiet plant and equipment ("buy quiet" policy).
- Use noise suppression devices and techniques (e.g. enclosures, screens, silencers).
- Where the noise exposure standard can be exceeded, provide hearing protection that enables effective communication.
- Ensure plant and equipment are checked regularly and maintained in good condition.
- Attach prominent signage to delineate areas where hearing protection is required.
- Attach noise labels to items of fixed plant, where appropriate, to provide a simple hazard warning.
- Develop a hearing protection program. Ensure all employees recognise when and where hearing protection is required, and that they comply with the program.
- Develop a fit-testing program for hearing protection.

15.4 Further information

DEPARTMENT OF CONSUMER AND EMPLOYMENT PROTECTION, 2005, Noise control in mines – guideline. Resources Safety, Western Australia, 47 pp.

Australian Standard, www.saiglobal.com

- AS/NZS 1269 Set:2005 Occupational noise management

Safe Work Australia, www.safeworkaustralia.gov.au

- National standard for occupational noise [NOHSC: 1007(2000)] 2nd edition

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Figure 15.1 Example of an enclosure to suppress noise on a drill rig

Figure 15.2 Example of noise suppression system on an air compressor

16 Ionising radiation

16.1 Hazards

Naturally occurring radioactive materials (NORM)

Low concentrations of uranium and thorium and their radioactive decay products are present throughout much of the earth's crust. Higher than usual concentrations of these radionuclides can be brought to the surface during drilling of uranium or thorium mineralisation, and may present a radiation hazard if workers are exposed.

Dust provides the greatest source of potential exposure to radioactive substances during drilling operations.

Equipment

Nuclear borehole loggers and portable XRF analysers are sometimes used during exploration drilling programs. They emit ionising radiation of sufficient activity to constitute a significant health hazard if not handled appropriately.

Exposure to the ionising radiation emitted by analytical equipment presents a more immediate and severe health hazard than that posed by exposure to NORM.

In Western Australia, the use of artificial radioisotopes is strictly regulated by the Radiological Council under the *Radiation Safety Act 1975*.

16.2 Assessing the risks

Direct risk factors

- Direct gamma irradiation from radioactive materials
- Inhalation of radioactive dust particles
- Inhalation of radon or thoron gas and decay products
- Ingestion of radionuclides

Contributing risk factors

- Radioactive materials in core samples, drilling sludge, drill cuttings and borehole logging equipment
- Radioactive dust particles in the air
- Temperature inversions trapping the radioactive gases radon and thoron
- Personal hygiene (radioactive dust on hands and clothing while eating or smoking)

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

- Dose rates from NORM encountered during uranium or thorium exploration are generally low enough for simple precautions (see Section 16.3) to be sufficient to protect against radiation exposure.
- Borehole logging sources can be significant health hazards if they are not adequately shielded or handled with appropriate care.

16.3 Risk controls

- For uranium, thorium or mineral sands exploration, or where a nuclear borehole logger is used, implement a radiation management plan approved by the State mining engineer and Radiological Council.
- Implement a general dust management plan and ensure workers are trained in its application.

16.4 Further information

DEPARTMENT OF CONSUMER AND EMPLOYMENT PROTECTION AND THE CHAMBER OF MINERALS AND ENERGY WESTERN AUSTRALIA, 2010, Managing naturally occurring radioactive material (NORM) in mining and mineral processing – guideline. Resources Safety and The Chamber of Minerals and Energy, Western Australia.

Australian Radiation Protection and Nuclear Safety Agency, www.arpansa.gov.au

- Radiation Health Series No. 28 Code of Practice for the Safe Use of Sealed Radioactive Sources in Borehole Logging (1989)
- Radiation Protection Series No. 2 Code of Practice for the Safe Transport of Radioactive Material (2008)
- Radiation Protection Series No. 2.1 Safety Guide for the Safe Transport of Radioactive Material (2008)
- Radiation Protection Series No. 9 Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)
- Radiation Protection Series No. 15 Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM) (2008)

Australian Uranium Association, www.aua.org.au/Content/HandbooksandGuides.aspx

- Radiation Workers' Handbook – Radiation Control in the Mining & Mineral Processing Industry (2009)

Radiological Council, www.radiologicalcouncil.wa.gov.au for information on safe practices in the use of radiation

Occurrence report – 2008

A downhole geophysical logging technician rolled his vehicle while travelling between the drill site and exploration office. He was taken to hospital where it was confirmed that he was not injured. The vehicle had to be isolated and the site secured until a qualified technician could confirm that the radioactive sources were intact and there had been no leaks.

Figure 16.1 Example of exclusion zone under radiation management plan

Figure 16.2 Example of radiation monitoring station

Figure 16.3 Example of personal geiger counter

17 Hot work

17.1 Hazards

The hazards associated with hot work such as welding, cutting and grinding include hot metal, radiant heat and sparks. Under normal conditions, these may be well controlled within dedicated work areas such as workshops. The lack of specialised equipment and dedicated work areas in remote regions can make the hazards associated with hot work difficult to control. Also, the person undertaking the hot work may be engrossed in the task and not notice spot fires that start. These can quickly escalate to bushfires, which may have serious consequences including injuries and property loss.

Exploration activities that involve hot work include:

- repairs or maintenance using gas or electrical welding equipment
- repairs using cutting equipment
- bit sharpening using air-powered grinders.

Bulldozer or excavator blades that strike rock, such as during clearing or rehabilitation activities, can also produce sparks, with similar consequences.

17.2 Assessing the risks

Direct risk factors

- Production of heat and sparks

Contributing risk factors

- Proximity of combustible material
- Proximity of personnel
- Weather conditions, particularly wind velocity and temperature
- Poor work practices
- Absence or inadequacy of fire-fighting resources

Rating severity of the risk

The risk of a bushfire resulting from hot work increases with hot, windy conditions and the presence of dry vegetation.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

17.3 Risk controls

- Establish hot work procedures appropriate for the conditions and available emergency resources.
- Do not undertake hot work when total fire ban conditions exist.
- Restrict hot work to specially designated areas (e.g. bare ground) that, where practicable, are within the line of sight of other crew members.
- Take appropriate steps to minimise fire hazards at the work area, such as removing or shielding combustible materials.
- Ensure fire-fighting resources (e.g. extinguisher, buckets of water) are readily accessible at the work area.

17.4 Further information

Resources Safety, www.dmp.wa.gov.au/ResourcesSafety

- Mines Safety Bulletin No. 90: Total fire bans and implications for mining operations

Occurrence report – 2010

While clearing an exploration drill pad in a rocky area, nearby spinifex was set alight by a spark from the bulldozer's blade. The dozer operator quickly extinguished the fire, which resulted in a small burn area of about 2 m.

Figure 17.1 When setting up an area for hot work, consider where sparks might be carried by the wind. Choose a location that minimises the risk of fire and can be seen by other crew members. Before starting any work that may generate sparks, ensure you have adequate fire-fighting resources for emergency use

18 Extreme weather and bushfires

18.1 Hazards

Western Australia is subject to severe weather events such as tropical cyclones and severe thunderstorms. In remote areas, bushfires started by lightning or other ignition sources (e.g. camp fires, burn-offs) can burn for weeks or months, particularly during periods of drought. Serious and fatal injuries have resulted from inadequate identification, planning and preparation for these hazards.

18.2 Assessing the risks

Direct risk factors

- High winds
- Flooding
- Lightning
- Fire

Contributing risk factors

- Drill rig and associated plant, vehicles and infrastructure (e.g. caravans) not designed for cyclonic conditions
- Failure to monitor existing, perceived low-threat bushfires
- Failure to recognise drainage and run-off characteristics of surrounding terrain
- Failure to recognise potential for lightning strikes and associated bushfires
- Failure to secure loose objects in anticipation of high winds

Rating severity of the risk

- Climate and season are factors to consider when determining the likelihood of severe weather events for a particular location.
- Severe thunderstorms are localised events, usually affecting smaller areas than tropical cyclones and floods, so their impacts are often underestimated. They can occur at any time of the year.
- Flash floods often occur when a thunderstorm moves slowly so that a small area receives a lot of rain. Local drainage and run-off characteristics also control the area of greatest impact.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

18.3 Risk controls

- Implement incident management and emergency response plans to deal with severe weather events and bushfires.
- Implement tracking and monitoring protocols for severe weather events and bushfires.
- Use geomorphological information to identify areas susceptible to flooding or flash flooding.
- Develop a lightning protection policy and ensure all personnel on site understand its application (e.g. "If you hear it, fear it. If you see it, flee it.").
- Use a portable lightning detector to assess the likely impact of distant storm activity.
- If there are signs of suspected lightning strikes, check plant and equipment before use.
- Implement procedures for crossing watercourses.
- To minimise the potential for objects becoming projectiles during high winds, anchor or secure loose objects that cannot be stored in designated storage areas.

18.4 Further information

Resources Safety, **www.dmp.wa.gov.au/ResourcesSafety**

- Mines Safety Bulletin No. 46: Lightning – hazards and safeguards
- Mines Safety Bulletin No. 60: Lightning strikes – managing the risks
- Mines Safety Bulletin No. 79: Cyclone – emergency preparation, planning and preparedness

Bureau of Meteorology, **www.bom.gov.au**

Fire and Emergency Services Authority of Western Australia (FESA), **www.fesa.wa.gov.au**

North Australian Fire Information, **www.firenorth.org.au**

Mines Safety Significant Incident Report No. 148

TROPICAL CYCLONE GEORGE

Severe Tropical Cyclone George crossed the Western Australian coast near Port Hedland in March 2007, causing extensive damage to areas in the north of the State. The eye passed over a rail construction accommodation camp, about 90 km inland, while the cyclone was at Category 3 intensity.

The winds associated with the cyclone displaced some accommodation units, which separated from their tie-downs and hit adjacent units. Some units broke up and the pieces caused further damage. There were about 230 workers at the camp. Two people were killed and 22 injured.

Occurrence report – 2011

A grass fire burnt the field camp, destroying tent accommodation containing camp beds, swags and personal items, and a supply tent containing sample bags, chip tray boxes and tyres.

Figure 18.1 Example of a hand-held lightning detector

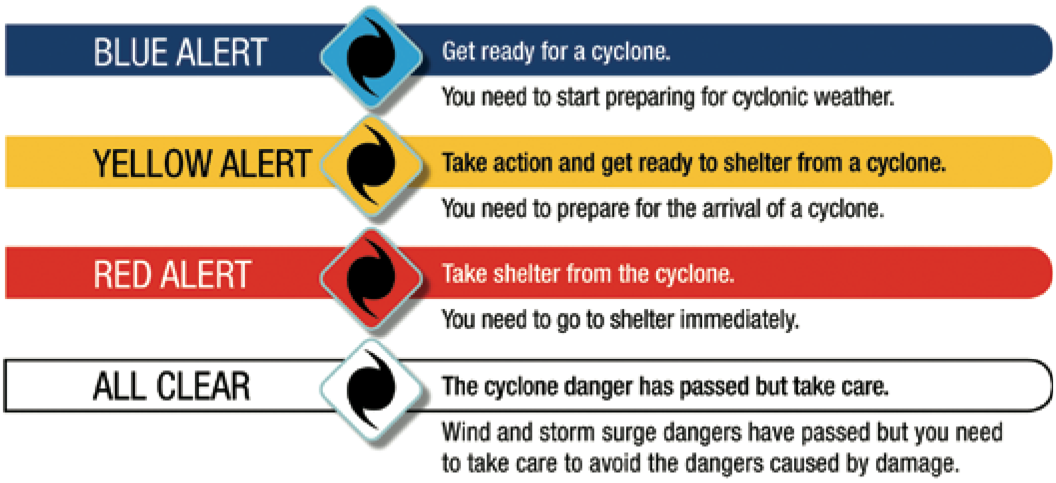

Figure 18.2 Cyclone alert rating used in Western Australia (www.fesa.wa.gov.au)

Fires can threaten suddenly and without warning.

Watch for signs of fire, especially smoke and flames.

Know your Fire Danger Rating and be aware of local conditions.

Have your bushfire survival plan and kit ready.

To seek information listen to local radio, go to **www.fesa.wa.gov.au** or call the FESA information line on **1300 657 209**.

Call 000 to report a fire.

FIRE DANGER RATING	WHAT DOES IT MEAN?		WHAT SHOULD I DO?
CATASTROPHIC 100+	• These are the worst conditions for a bush or grass fire. • If a fire starts and takes hold, it will be extremely difficult to control and will take significant firefighting resources and cooler conditions to bring it under control.	• Spot fires will start well ahead of the main fire and cause rapid spread of the fire. Embers will come from many directions. • Homes are not designed or constructed to withstand fires in these conditions. • The only safe place to be is away from bushfire risk areas.	**YOU NEED TO ACT NOW** • Put your survival first and leave bushfire risk areas the night before or early in the day - this is your best option. • Act immediately - do not wait and see: ▸ leave now ▸ avoid forested areas, thick bush or long, dry grass ▸ take shelter if you cannot leave
EXTREME 75-99 SEVERE 50-74	• These are very hot, dry and windy conditions for a bush or grass fire. • If a fire starts and takes hold, it will be unpredictable, move very fast and difficult for firefighters to bring under control. • Spot fires will start and move quickly. Embers may come from many directions.	• Homes that are prepared to the highest level, have been constructed to bushfire protection levels and are actively defended may provide safety. • You must be physically and mentally prepared to defend in these conditions. • The only safe place to be is away from bushfire risk areas.	**YOU NEED TO GET READY TO ACT** • Only stay with your property if you are prepared to the highest level. This means your home needs to have been constructed to bushfire protection levels eg. enclosed eaves, covers over external air conditioners, metal flyscreens etc. • You must be well prepared and able to actively defend your home if a fire starts. This means you have the right equipment and resources to put out fires around your home eg. enough water supply, petrol/diesel portable pump, generator, protective clothing etc. • If you are not prepared to the highest level, leaving bushfire risk areas early in the day is your safest option.
VERY HIGH 32-49	• These are hot, dry and possibly windy conditions for a bush or grass fire. • If a fire starts and takes hold, it may be hard for firefighters to control.	• Well prepared homes that are actively defended can provide safety. • You must be physically and mentally prepared to defend in these conditions.	**YOU NEED TO BE AWARE** • Well prepared homes that are actively defended can provide safety. This means you have the right equipment and resources to put out fires around your home eg. enough water supply, petrol/diesel portable pump, generator, protective clothing etc.
HIGH 12-31 LOW-MODERATE 0-11	• If a fire starts, it is likely to be controlled in these conditions and homes can provide safety. • Be aware of how fires can start and reduce the risk.	• Controlled burning may occur in these conditions if it is safe – check to see if permits apply.	• Check your bushfire survival plan • Monitor conditions • Action may be needed • Leave if necessary

Figure 18.3 Fire danger rating used in Western Australia (www.fesa.wa.gov.au)

19 Light vehicle movement

19.1 Hazards

In addition to the risks usually associated with driving in remote areas, the way that light vehicles are used for drilling operations can introduce additional risks that may not be obvious. Light vehicles are commonly modified to facilitate exploration work (e.g. addition of water tanks, air compressors), are used to carry heavy or bulky loads, and tow caravans or trailers. These activities can change the vehicle's stability and configuration.

The issues associated with parking on slopes above camps, or work areas, may also be overlooked in the planning process.

Hazards to be aware when using light vehicles include:

- loss of control
- contact with obstacles (e.g. livestock, native fauna, trees)
- runaway vehicles
- poor visibility and collision with oncoming traffic.

19.2 Assessing the risks

Direct risk factors

- Fatigue and mental wellbeing (see Chapter 12)
- Driving style
- Road and ground conditions
- Terrain
- Visibility

Contributing risk factors

- Travel distance, duration and time (e.g. sunrise, sunset)
- Failure to recognise changing conditions
- Driver competence and experience
- Stability and configuration of light vehicle when modified, loaded or towing
- Inadequate maintenance practices
- Inadequate site traffic management, including parking practices
- Weather conditions
- Other road users

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Exposure to the hazards associated with the use of light vehicles can have serious consequences, including crashes and rollovers, and unattended vehicles rolling into exploration camps.

19.3 Risk controls

- Follow the recommendations of the original equipment manufacturer (OEM) for vehicle inspection and maintenance.
- Assess vehicle modifications and load configuration to determine the likely effect on vehicle stability and profile, and address as necessary.
- Establish procedures for the terrain and conditions likely to be encountered during travel.
- Monitor ground, road and weather conditions.
- Implement procedures for traffic management around work areas and camp sites, including park-up areas.

19.4 Further information

Royal Automobile Club (RAC), www.rac.com.au for information about country driving (in safe drivers section)

Occurrence report – 2011

A drill support truck rolled backwards down a slope into the camp when someone attempted to move the truck further up the slope from its parking spot near the container. The truck rolled over a couple of tents, including the recreation tent. There were people around at the time, but fortunately no-one was injured.

Occurrence report – 2011

A driller was driving back to camp along the main access (a gravel road) at about 10.30 pm when he lost control and rolled the vehicle.

Figure 19.1 Ensure vehicle-trailer and load configurations are appropriate for the anticipated conditions

20 Heavy vehicle movement

20.1 Hazards

Rig movements can generate hazards that may lead to serious or fatal injuries or serious damage to a drill rig. Contact with overhead powerlines can result in electrocution or destruction of the rig by fire. Contact with trees and vegetation can introduce combustible material into the system, which may ignite under suitable conditions. Rig components damaged in transit may not be obvious or visible until the rig is operational, when their failure can affect safe operation.

Hazards to be aware of when moving heavy vehicles include:

- movement over rough or uneven surfaces
- movement over sloping or boggy ground
- contact with powerlines
- contact with overhanging objects such as trees
- movement with the mast raised can place undue stress on components and affect rig stability.

20.2 Assessing the risks

Direct risk factors

- Type, size and configuration of vehicle
- Stability of vehicle
- Road and ground conditions
- Terrain
- Distance to be travelled

Contributing risk factors

- Failure to follow manufacturer's recommendations for rig movement
- Site accessibility
- Rig modifications
- Integrity of drill rig and components
- Overhead objects
- Weather conditions
- Absence or inadequacy of spotters or guides

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Rating severity of the risk

Exposure to these hazards can have serious consequences, either directly (e.g. electrocution due to contact with powerlines) or indirectly, if components fail due to damage sustained during movement.

20.3 Risk controls

- Follow the recommendations of the original equipment manufacturer (OEM) for rig movement.
- Assess modifications to the OEM's design to determine the likely effect on stability, design specifications and rig or vehicle profile, and address as necessary.
- Establish procedures for the terrain and conditions likely to be encountered in transit, including identifying the locations of powerlines.
- Monitor ground, road and weather conditions.
- Implement procedures for the manoeuvring of drill rigs and equipment, including identifying the roles and responsibilities of designated spotters.
- Implement preventative maintenance programs to avoid in-transit damage.
- After rig movements, a competent person should do a pre-operational check of the rig and its components.

20.4 Further information

Resources Safety, www.dmp.wa.gov.au/ResourcesSafety

- Mines Safety Bulletin No. 85: Mobile equipment contact with high-voltage overhead powerlines

Mines Safety Significant Incident Report No. 51

FAILURE OF MAST SUPPORTS ON DRILL RIGS

A strut supporting the mast of a drill rig failed at the connection to the main frame. The hydraulic rams prevented the mast from completely collapsing, but it hit the cabin shell and broke a cabin window.

In a similar incident, the bracket connecting the boom to the main frame of a drill rig failed and the mast fell to the ground.

Although no-one was injured in either of these incidents, failures of this type have a high potential to cause serious or fatal injuries.

Occurrence report – 2011

A low loader carrying a rod truck and truck-mounted diamond drill rig drove onto the road shoulder to avoid a puddle. The edge was soft due to recent rain and the left-hand side of the loader sunk into the mud. The chains holding the drill rig broke and it toppled onto its side. The driver hit his head on the windscreen and damaged the ligaments in one shoulder.

Figure 20.1 Consult the OEM's manual for instructions and recommendations regarding rig movement

21 Remoteness of exploration

21.1 Hazards

Lack of preparation for working in remote locations can exacerbate the consequences of dangerous incidents.

Some of the hazards associated with drilling in remote locations are:

- vehicle or aircraft crashes
- limited capacity to provide urgent medical diagnosis and treatment
- personnel getting lost.

21.2 Assessing the risks

Direct risk factors

- Distance from medical and emergency services
- Accessibility of workplace (e.g. lack and condition of roads)

Contributing risk factors

- Absence or inadequacy of trip planning, particularly for rarely travelled routes
- Absence or inadequacy of emergency response and incident management plans
- Absence or inadequacy of communications
- Absence or inadequacy of medical facilities and expertise
- Available modes of transport
- Roadworthiness of vehicles
- Airworthiness of aircraft
- Fitness for work

Rating severity of the risk

Distance to and accessibility of the workplace are the major contributors to the severity of the risk when working remotely. However, the interactions of these and other factors also influence the severity of the risk.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

21.3 Risk controls

- Establish procedures to plan and monitor safe travel to and from work in remote locations.
- Implement communication, emergency response and incident management plans that reflect the remote conditions and address operational needs, and ensure personnel are trained in their application and how to use the equipment.
- Establish protocols for selecting fit-for-purpose modes of transport.

21.4 Further information

DEPARTMENT OF MINES AND PETROLEUM, 2011, Mine safety matters – travelling in remote areas. Resources Safety, Western Australia.

GOVERNMENT OF QUEENSLAND, 2004, Minerals exploration safety guidance note, Department of Natural Resources and Mines, Queensland, 70 pp.

Royal Flying Doctor Service of Australia, www.flyingdoctor.org.au for information about safe outback travel

Civil Aviation Safety Authority (CASA), www.casa.gov.au for information about aviation requirements in remote areas

Mines Safety Significant Incident Report No. 163

EXPLORATION EMPLOYEE LOST IN REMOTE BUSH

During demobilisation of an exploration tenement site in the Pilbara, a contract driller went missing for about 30 hours. He had walked through scrub to retrieve a support vehicle about 6 km from the campsite but became lost when he failed to first find the vehicle and then access tracks and gridlines in the area. His colleagues raised the alarm some six hours after he was last seen. The driller became dehydrated and disorientated, and spent the night in the bush. He was found about 10 km from the campsite and treated for dehydration at the local regional hospital.

Occurrence report – 2007

A driller's offsider travelling with supplies from town was reported overdue. The driller travelled the route searching for him and found the supply truck crashed on the side of the road. The offsider was unconscious on the ground. The emergency response team from a nearby mine responded to assist the offsider, who had serious head injuries, a fractured leg and suspected internal injuries. The injured man was flown to Perth for medical treatment.

Figure 21.1 Example of remote area trauma kit

Figure 21.2 Example of personal location beacon

22 Natural gases

22.1 Hazards

Pockets of methane and other hazardous gases can be intersected during drilling. The presence of combustible gases can result in explosions and fires. Personnel can also be exposed to asphyxiant and toxic gases.

22.2 Assessing the risks

Direct risk factors

- Geology and hydrology

Contributing risk factors

- Drilling method
- Stage of drilling (depth of hole)
- Absence or inadequacy of gas monitoring systems
- Site dynamics (positioning of drill rig relative to other work areas, support vehicles and camp)
- Weather conditions, particularly wind velocity

Rating severity of the risk

The severity of the risk is related to:

- volume of the gas pocket
- composition of the gas
- duration of gas release.

Methane is the most common combustible (explosive) gas encountered during drilling.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

22.3 Risk controls

- When designing a drilling program, assess the likelihood (e.g. using geological or hydrological data) of intersecting gas-bearing strata.
- Implement procedures for monitoring and managing hazardous gases released during drilling, and ensure workers are trained in their application.

22.4 Further information

Resources Safety, www.dmp.wa.gov.au/ResourcesSafety

- Mines Safety Bulletin No. 74: Explosive gases associated with mining

GOVERNMENT OF QUEENSLAND, 2004, Minerals exploration safety guidance note, Department of Natural Resources and Mines, Queensland, 70 pp.

Occurrence report – 2007

A driller noticed the air was shimmering above a drill hole while pulling the core tube. He immediately shut down the rig and informed camp personnel and management. He waited for the gas to abate before attempting to lower the tube. However, the gas emission continued. A gas detector borrowed from a mine site confirmed the presence of methane, carbon monoxide and hydrogen sulphide. An attempt to flush the hole was unsuccessful, with no water return. An investigation suggested that the gas was encountered higher in the hole but the water column had restricted emissions. Faint gas smells had been detected earlier in the drilling but had been considered normal. In order to proceed safely, the gas-emitting part of the hole had to be cemented and then drilled out. Only faint traces of gas were detected but the drill rig was pulled off the hole as soon as the target horizon was drilled. Monitoring equipment is now kept on site and a large fan operates to dissipate any gas emerging from the drill hole collar and direct it away from the rig.

Figure 22.1 Example of hand-held gas monitoring equipment

Occurrence report – 2007

During diamond core drilling to test for nickel sulphide mineralisation, the driller and offsider detected a strong smell of hydrogen sulphide gas when removing the drill head from the drill string to insert a new drill rod. Gas then bubbled up the drill string and splashed mud onto the offsider. The rig motor was shut down and gas detecting equipment deployed to test for dangerous gases around the drill collar. The test results were above the safe limits set by the company's procedures so the site was vacated and the supervising geologist advised. The gas levels at the drill site were then periodically surveyed.

23 Existing workings

23.1 Hazards

Abandoned mine workings, costeans and drillholes are commonplace in regional Western Australia. Deterioration over time of old fences or other barriers to access can make them ineffective. Potentially serious injuries or death can result from falls, ground collapse, engulfment, asphyxiation or personnel being struck by projectiles ejected from old drillholes penetrated during drilling.

The hazards include:

- unprotected mine openings
- ground subsidence
- eroded or open drillholes
- plugs and debris ejected from adjacent drillholes.

23.2 Assessing the risks

Direct risk factors

- Working or travelling in areas containing existing workings

Contributing risk factors

- Unidentified or obscured existing workings
- Past poor abandonment practices
- Absence or inadequacy of drillhole rehabilitation
- Proximity to previous drill sites during infill drilling

Rating severity of the risk

The more historical mining and previous drilling that has occurred in an area, the greater the exposure to the hazards associated with existing workings.

23.3 Risk controls

- When designing a drilling program, assess the likelihood (e.g. using historical records, geological maps and aerial photographs) of encountering historical workings and previous drilling. Record this information on a plan and make it available to geological staff and drilling personnel.
- Before commencing drilling, survey the drill site and delineate hazardous areas. Barricade high-risk areas, forbid entry into old workings and, if necessary, rehabilitate existing drillholes.
- At the completion of drilling, plug and rehabilitate all drillholes.

23.4 Further information

DEPARTMENT OF MINES AND PETROLEUM, 2007, Mineral exploration/rehabilitation activities guidelines, Environment Division, Western Australia, 13 pp.

DEPARTMENT OF INDUSTRY AND RESOURCES, 2005, Old mine workings – stay out and stay alive! Safety and Health Division, Western Australia.

DEPARTMENT OF MINES AND PETROLEUM, 2011, Mine safety matters – openpit mining over old workings. Resources Safety, Western Australia.

GOVERNMENT OF QUEENSLAND, 2004, Minerals exploration safety guidance note, Department of Natural Resources and Mines, Queensland, 70 pp.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

Mines Safety Significant Incident Report No. 79

EXPLORATION DRILL HOLE INTERSECTIONS

A reverse circulation (RC) drill rig carrying out surface exploration drilling intersected an old drill hole that had been plugged and was no longer visible from the surface. An increase in air pressure in the old hole resulted in the cement plug being blown out of the hole — narrowly missing the driller's offsider.

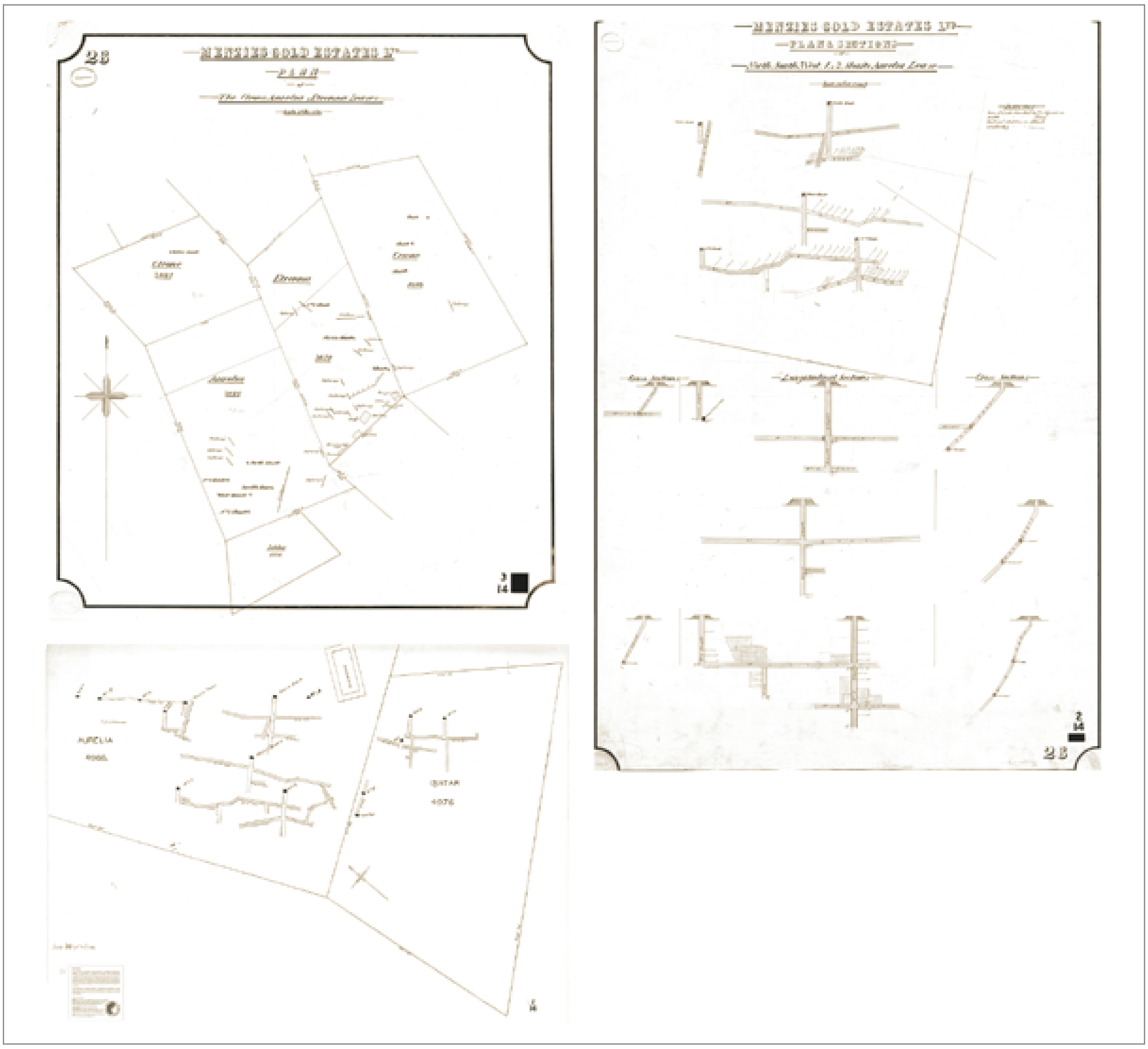

Figure 23.1 Resources Safety is the custodian of Western Australian mine plans dating back to the late 1880s. Contact rsdmineplans@dmp.wa.gov.au for information about accessing the mine plan collection

24 Housekeeping

24.1 Hazards

Maintaining a clean and tidy site with well organised operations, equipment and stores is an important part of a good housekeeping program. Poor housekeeping at a drilling operation, including the camp, can lead to injuries, fires and damage to health.

24.2 Assessing the risks

Direct risk factors

- Site layout
- Management of hazardous substances
- Management of fuel and ignition sources

Contributing risk factors

- Inappropriate work practices
- Inadequate maintenance practices
- Improper storage and handling of equipment and materials
- Non-adherence to site clean-up schedule
- Poor hygiene practices

Rating severity of the risk

Poor housekeeping can increase the risk of injuries from slips, trips, falls and being struck by falling objects. It can exacerbate injuries from hazardous manual tasks, contribute to electrical incidents, fires, spills and exposure to chemicals, and lead to disease following exposure to unhygienic conditions.

24.3 Risk controls

- Plan the site to allow for orderly movement of personnel, equipment and materials.
- Ensure tools and equipment are properly stored after use.
- Ensure plant and equipment are checked regularly and maintained in good condition.
- Manage the handling and storage of hazardous substances and fuels.
- Undertake daily inspections and clean-ups.
- Establish designated storage and rubbish disposal areas.
- Provide designated eating and ablution facilities with suitable waste disposal.

Risk controls

Ensure all personnel who may be exposed to these hazards receive adequate information, instruction and training to reduce the risk of injury.

Senior drillers and supervisors must ensure that personnel are competent for the assigned job, understand the hazards and job requirements, and follow the established procedures.

24.4 Further information

GOVERNMENT OF QUEENSLAND, 2004, Minerals exploration safety guidance note, Department of Natural Resources and Mines, Queensland, 70 pp.

Occurrence report – 2011

A driller's offsider was walking around an RC drill rig when he was struck in the back of the leg by the RC outside return pipe when it rotated.

Occurrence report – 2011

A drill support truck rolled backwards down a slope from its parking spot and into the camp when being moved. It rolled over several tents but there were few people around at the time and no-one was injured.

Occurrence report – 2007

A drill crew setting up a drill rig was about to start collaring the hole when the driller smelt something burning. The wiring loom from the starter motor and generator to the rig's control panel had been run under the engine and was on fire. The driller put out the fire using a fire extinguisher.

Figure 24.1 Example of well laid-out diamond core drill site showing designated storage area and use of crushed rock to minimise dust and improve underfoot conditions

Figure 24.2 Example of well laid-out drill site showing tool racks and equipment storage

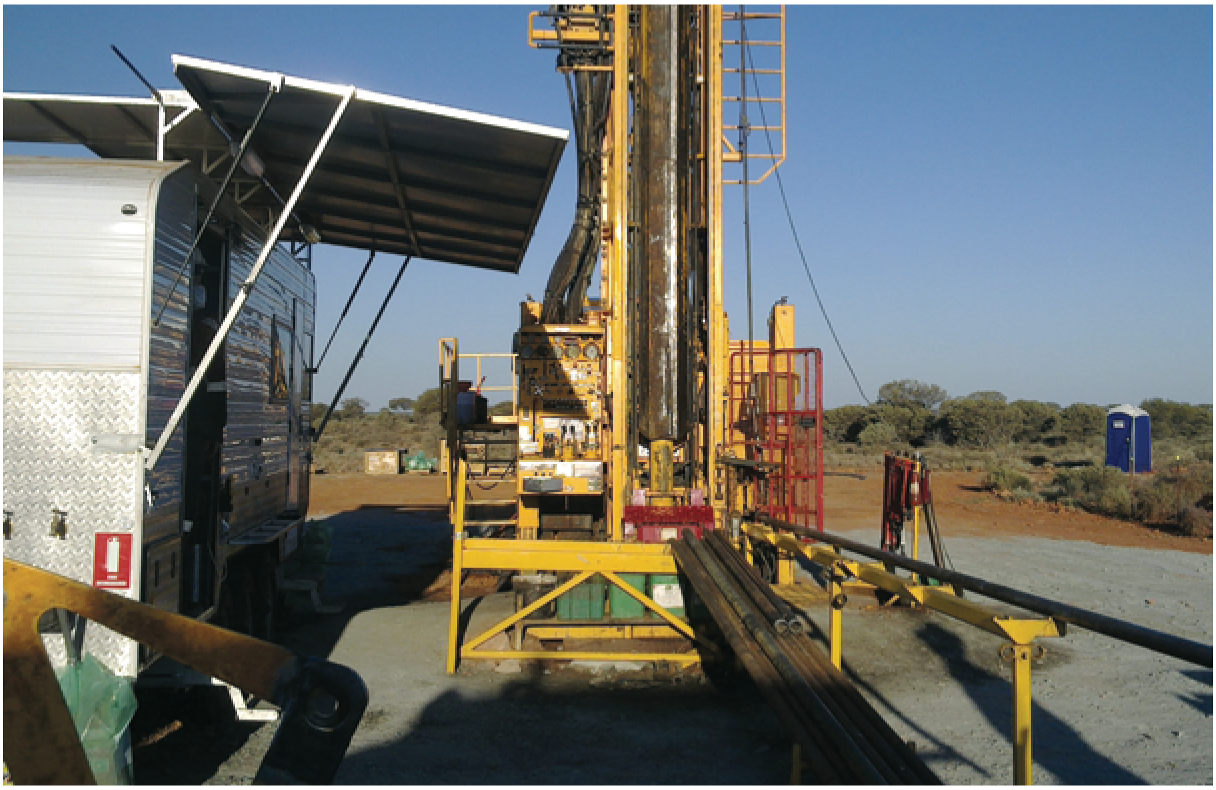
Figure 24.3 Example of a well laid-out drill site with clear pathways, shelter provided by caravan awning, and toilet located away from work area

3

PART 3 EMERGENCY PREPAREDNESS

25 Emergency management

25.1 Introduction

An emergency is an event, actual or imminent, that endangers or threatens to endanger life, and requires a coordinated response to ensure preservation of life and prevention of injury and illness. Emergencies are sometimes described as incidents or accidents, and can include natural disasters.

The potentially hazardous nature of mineral exploration drilling operations, and the often remote locations where they are carried out, mean that emergency management and emergency response planning are critical to the health and safety of personnel. In particular, effective communication and appropriate medical care during an emergency can be difficult to establish and sustain in remote areas.

Emergency management involves understanding the likelihood of an emergency occurring and its potential consequence, should the emergency occur being prepared to mitigate its effects, respond effectively, and recovering afterwards. Effective emergency management means that there are plans in place for all identified emergency scenarios so the response is comprehensive and coordinated.

The critical element of preparedness is the development of emergency response plans for identified emergency scenarios. All personnel should be familiar with the emergency response strategy before entering the site, to ensure they understand their responsibilities and what to do in an emergency.

25.2 Risk management approach

Emergency management involves:

- risk assessment – identify and analyse the hazards associated with potential emergency scenarios
- prevention – determine appropriate control measures to eliminate or reduce the impact of hazards
- preparedness – implement control measures to minimise the likelihood of emergencies, including emergency response plans
- response – implement the appropriate emergency response plan
- recovery – conduct a post-emergency review of the effectiveness of the emergency response plan and revise it as necessary.

Emergency management and response planning should focus on worst-case scenarios. Emergencies at drilling operations include:

- rollover or collision of vehicle or machinery
- fire on drill rig, vehicles or infrastructure
- collapse or failure of a drill rig or equipment
- missing person
- plane or helicopter crash
- remote diagnosis and medical treatment for
  - major trauma (e.g. fractures, severed limbs)
  - hyperthermia or hypothermia
  - electrocution or electrical burns
  - chemical burns or poisoning
  - illness or aggravation of existing medical condition
  - viral or bacterial infection
  - bites or stings
  - radiological exposure or contamination.
- violence or aggression, including physical or sexual assault
- bushfire, flood, cyclone, lightning strike or other natural event.

To assist in the development of emergency response plans, workers should be involved in the identification and analysis of worst-case scenarios to ensure:

- engagement and commitment to managing risk
- allocation of appropriate resources and promotion of risk-reduction activities
- increased understanding of the risks associated with drilling operations
- improved decision-making about risks and informed emergency response planning
- improved safety performance with a focus on prevention rather than response.

Useful information based on real-life emergencies may also be obtained from industry safety alerts.

26 Emergency response planning

26.1 Emergency response plans

Emergency response plans assign and document responsibilities and procedures in the event of an emergency. They should:

- be written in plain English
- be compiled and laid out to facilitate quick access to important information
- include appropriate use of illustrations such as maps
- be available to all personnel on site.

There should be document review and control procedures that ensure emergency response plans are maintained.

26.2 Content common to all plans

The following basic information should be included in all emergency response plans:

- name of the project, tenement, land title or lease
- GPS coordinates and geographical location (i.e. latitude and longitude)
- location in relation to nearest town
- contact details for the operating company and contractors
- contact information for persons or agencies that may need to be contacted during an emergency
- assignment of emergency response duties
- contact details and specific competencies for personnel trained in first aid, communications systems and other specialist fields (e.g. fire fighting)
- number of personnel on site.

A stand-alone page or pages with the above information should be prominently displayed in the workplace and kept with communications equipment.

26.3 Other considerations

Other matters to consider when developing emergency response plans for drilling operations include:

- duties of the person responsible for implementing the emergency response plan
- duties of site personnel during an emergency
- communication systems that will ensure all personnel are kept informed during an emergency, and the relevant external agencies are promptly informed and updated as the emergency response unfolds
- communication equipment to be used during an emergency (e.g. two-way radio, satellite phone, emergency-position indicating radio beacon or EPIRB)
- identification of muster points
- provision for evacuation of injured personnel
- provision for site evacuation
- developing clear written directions to the site, including maps, aerial photographs, and GPS locations for use by emergency services (e.g. Royal Flying Doctor Service)
- location of potential transfer sites for emergency transport vehicles
- location of potential helicopter or light aircraft landing areas
- equipment and facilities identified in the risk assessment necessary to deal with an emergency (e.g. first aid, fire fighting and rescue equipment), including equipment and services from external sources
- remote area first aid training for all workers and other training as appropriate (e.g. communications equipment, fire fighting).

Consultation may be appropriate with:

- Royal Flying Doctor Service
- local and major regional hospitals
- police, fire and emergency services
- first aid and healthcare providers
- industry safety regulators
- local shires
- occupants of adjacent land.

Emergency response plans should be regularly tested to ensure their effectiveness. Both “desk-top” tests and emergency response drills involving all onsite personnel should be carried out. Evacuation drills can be used to evaluate how people respond.

Debriefings conducted as soon as practicable after an emergency or drill will help identify modifications needed to improve the emergency response plan.

27 Useful links

Australian Emergency Management, www.em.gov.au

Bureau of Meteorology, www.bom.gov.au

Department of Health, www.health.wa.gov.au/services

Fire and Emergency Services Authority of Western Australia (FESA), www.fesa.wa.gov.au

Royal Flying Doctor Service, www.flyingdoctor.org.au

Safe Work Australia, www.safeworkaustralia.gov.au

State Emergency Services, www.ses-wa.asn.au

Western Australia Police, www.police.wa.gov.au

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