Guidance Note QGN 30.3

Shaft construction metalliferous mines – Shaft sink operations

Mining and Quarrying Safety and Health Act 1999

March 2018

Queensland Government

Reference is made to the following legislation as applicable to a Mine or Quarry in Queensland:

- *Mining and Quarrying Safety and Health Act 1999*
- Mining and Quarrying Safety and Health Regulation 2017

This Guidance Note has been issued by the Mines Inspectorate of the Department of Natural Resources, Mines and Energy (DNRME) to provide guidance to SSEs and others involved with shaft construction activities on the identification of hazards, risks and their potential controls throughout the various stages of shaft construction.

This Guidance Note is not a Guideline as defined in the *Mining and Quarrying Safety and Health Act 1999* (MQSHA) or a Recognised Standard as defined in the *Coal Mining Safety and Health Act 1999* (CMSHA). In some circumstances, compliance with this Guidance Note may not be sufficient to ensure compliance with the requirements in the legislation. Guidance Notes may be up-dated from time to time.

To ensure you have the latest version, check the DNRME website: https://www.business.qld.gov.au/industry/mining/safety-health/mining-safety-health/legislation-standards-guidelines or contact your local Inspector of Mines.

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This publication has been compiled by the Mines Inspectorate, Department of Natural Resources, Mines and Energy.

Contents

1 Shaft pre-sink activities

1.1 Initial Site Works

Initial site work includes levelling the site, establishing roadways, installation of boundary fencing, digging trenches for site services, associated buildings and amenities.
The initial site setup comprises of a number of tasks. These are often carried out by different contractors and can occur in parallel.

Key Considerations:

- Control and management of site and workplace access
- Site surveys
- Positioning of major infrastructure and plant
- Roadways
- Traffic management
- Drainage
- Site services
- Sequence of works
- Control of contractors

Hazards/Events:

- Personnel struck by moving plant and equipment
- Contact with site services
- Congested working areas

Hazard Controls:

- Traffic management plan
- Documented site layout plan/drawings/surveys
- Schedule of works
- Contractor management plan

Reference:

- MQSHR 2017 – Part 6 Facilities and processes.

Example of shaft collar construction

1.2 Collar Establishment

The shaft collar is the uppermost portion of the shaft. It typically extends from ground surface level down to solid bedrock, into which the collar is anchored. It should be designed to provide a protective barrier to prevent water and soil from entering the shaft.
The collar also provides a rigid support around the shaft to protect it from external loading conditions caused by both the headframe, which is constructed on top of the shaft, and horizontal stresses resulting from nearby structures such as a winder house. Generally there are two methods used, and each method has its own hazards and risks that should be managed and controlled.

Cut and Fill – a method where the site of the shaft collar and general vicinity is completely excavated using benching methods. The shaft collar is then constructed and the surrounding area then backfilled. This method is normally employed where a shaft sub-brace is needed.
Precast – involves the trenching of the collar perimeter to a pre-determined depth (typically 6-7 metres) which is backfilled with concrete to form the concrete foundation of the collar. Material is then excavated from within the collar perimeter to allow for the final collar fit out.

Key Considerations:

- Method of construction
- Nature and condition of the ground
- Collar design:
  - Loading
  - Shape and size
  - Foundation
  - Concrete mix specifications and associated quality assurance (QA)
- Collar elevation in respect to potential flooding
- Lightning protection earth grid installed within the collar/headframe
- Underground structures that could interfere with the collar and shaft construction
- Survey checks and drawing confirmation
- Positioning shaft services and orientation within the shaft
- Emergency response preparedness is adequate
- Consideration of the positioning and orientation of the winder building, winder controls to headframe in relation to sun glare at sunrise and sunset, impairing the winder driver's vision
- Layout of roadways
- Positioning of support facilities and amenities

Hazards/Events:

- Contact with infrastructure or services
- Trench collapse or collar failure
- Inundation or flooding
- Personnel struck by plant or moving equipment
- Personnel struck by falling objects
- Personnel falling from height
- Personnel overcome by fumes or toxic atmosphere

Hazard Controls:

- Identify key quality controls and ensure that inspection and monitoring is carried out at regular intervals and results recorded (concrete QA, ground support, alignment and orientation)
- Develop a project plan and schedule of works
- Conduct regular contractor / project meetings
- Establish edge protection next to:
  - Shaft collar
  - Excavations
- Ensure personnel are inducted and competent to perform their tasks
- Establish and implement procedures for working at heights
- Appropriate ventilation
- Suitable shoring and support for excavations and trenches

References:

- MQSHR 2017 Part 6 Facilities and Processes
  - s 45 Mine layout, design and construction
- MQSHR 2017 Part 4 Electrical
- AS/NZS 1170 Series Structural design actions

- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete
- AS 1891 Series Industrial fall-arrest systems and devices

Example of Precast and Cut and Fill Shaft Collars

1.3 Pre-Sink Beyond the Collar

This is the start of the actual shaft sinking activities. The aim is to sink the shaft to a depth where it is possible to install the shaft sinking stage. There should also be enough room for firing to take place in the shaft without damaging the shaft sinking stage. It is carried out utilising a slewing crane or slewing headframe, kibble and a mucking system using traditional shaft sinking cycles such as:

- Drill & blast
- Muck out spoil
- Install ground support
- Concrete line
- Install and extend shaft services: e.g. air, water, and ventilation ducting

Key Considerations:

- The final depth of the pre-sink
- The method of sinking and extraction of muck
- Ground support
- Conveyance of persons, materials and equipment
- Obstructions within the shaft that could hinder the free passage of the conveyance
- Emergency procedures and methods of extracting persons
- Systems for preventing unauthorised personnel and mobile equipment from entering the collar area or falling into the shaft
- Competence and experience necessary for crane operator and winder driver
- Methods of communication between the crane operator or winder driver and persons in the shaft or on the shaft conveyance
- Ventilation
- Overhead protection

Slewing Crane:

- Expected loads to be lifted by the crane
- Position of the crane during hoisting and dumping of spoil
- Isolation and control of access into the crane slew zone

Hazards/Events:

- Fly rock exiting collar area from blasting
- Persons falling from height
- Persons struck by falling objects
- Engulfment:
  - fall of ground
  - concrete failure
  - inrush of water

- Asphyxiation of persons working in the shaft from fumes and gasses
- Failure of lifting/winding equipment
- Uncontrolled movement of conveyances
- Persons crushed by moving plant or equipment

Hazard Controls:

- Establish the maximum depth that an unguided conveyance can be used in the shaft. Generally this is no more than 50 metres
- Fit for purpose crane:
  - the rated capacity when persons are suspended should not be exceeded.
  - conduct a daily brake test against a known weight
  - ensure failsafe brakes are fitted
  - ensure no freefall or over speed crane controls are available during shaft sinking processes
  - ensure that exhaust fumes from crane do not contaminate shaft and conduct regular gas tests
  - utilise a load cell to prevent overloading
- Blasting processes:
  - ensure that blast plans and procedures are developed and followed
  - utilise blast mats when firing close to the surface or collar area
- Shaft conveyances:
  - ensure that all loose debris is removed or washed down from underneath the kibble
  - ensure that kibbles are not overfilled (marks or maximum weight)
  - ensure that appropriate handrails and kickboards are fitted to work platform conveyances
  - all persons must use fit for purpose anchor points, fall restraint or arrest systems
  - conveyances fitted with protection from falling objects
- Fit for purpose controls on the crane:
  - testing of brakes and ropes
  - free fall options that should be disconnected
  - testing of anti two-block devices

References:

- MQSHR 2017 Part 7 Hazardous substances and dangerous goods
- MQSHR 2017 Part 10
  - s.100 Selection and design
- AS 1418.1 Cranes, hoists and winches – Part 1: General requirements
- AS 2550.1 Cranes, hoists and winches – Safe use Part 1: General requirements
- Explosives Act 1999
- Explosives Regulations 2003
- QGN 11 Use of explosives in underground mines
- AS 2187 Series Explosives

2 Main sink setup – Installation

2.1 Installation of Winders and Winder House

This involves the installation of the winder including associated control systems, mechanical, electrical and hydraulic components. This activity normally occurs at the same time as the pre-sink and introduces additional personnel to the shaft surface working environment.

Key Considerations:

- Develop and implement a schedule of works
- Design layout and plan
- Survey and alignment of winding system:

    - centre to the shaft
    - rope fleet angles
- Access to site services (power, air, water, communications)
- Availability of backup power supply
- Protection of the winder from the elements:
    - water drainage
    - temperature regulation and climate control inside the winder house
- Vermin control
- Suitable building construction rating (cyclone proof)
- Interaction between work groups and schedule of works

Hazards/Events:

- Environmental conditions
- Structural failure of winder house
- Persons falling from height
- Persons struck by falling objects
- Failure of lifting equipment
- Uncontrolled movement of crane
- Persons crushed by moving plant or equipment

Hazard Controls:

- Review designs and ensure quality control when installing winders, winder buildings and auxiliary equipment
- Ensure that supervisors are undertaking regular inspections/audits and that standards and procedures are enforced
- Establish a system to control and manage access of personnel and equipment in and around the winder house
- Ensure lifting plans are developed prior to conducting lifts

2.2 Installation of Shaft Sinking Headframe

The construction of the headframe occurs after the pre-sink is complete, the headframe can either be solely for the shaft sink or it could the permanent headframe that will be used for construction then production.

Key Considerations:

- The design, layout and plan
- The centring and alignment of:
    - headframe and head sheaves to the shaft
    - winder to the headframe and head sheaves
- Working at heights
- Interaction between work groups and schedule of works
- Site resources to be utilised

Hazards/Events:

- Working at height and over open shaft
- Persons falling from height
- Personnel struck by falling plant or equipment
- Personnel crushed by moving plant and equipment
- Structural failure of headframe

Hazard Controls:

- Construct as per designs and ensure quality control
- Ensure that supervisors are undertaking regular inspections/audits and that standards and procedures are enforced

- Ensure personnel are inducted and competent to perform their tasks
- Establish and monitor procedures for working at heights
- Ensure that the work area around the shaft is levelled, compacted and suitable for cranes and heavy lifts
- Establish exclusion/drop zones for crane lifts
- Installation of barriers and signage immediately around the headframe collar area
- Ensure that all kick boards and handrails are installed correctly and fastened
- Ensure installation of lightning antenna, aircraft warning lights on top deck of headframe

References:

- MQSHR 2017 Part 4 Electrical
- AS 1657 Fixed platforms, walkways, stairways and ladders – Design, construction and installation
- AS/NZS 1891 Series Industrial fall-arrest systems and devices

Example of headframe construction

2.3 Roping-up Conveyances

This process involves installing the sinking stage into the shaft and the roping up of the sinking stage and associated conveyances to the various winder drums.

Key Considerations:

- Method and process for the installation and chairing of the sinking stage into the shaft
- Method and process for the installation of the ropes
- Method of communication
- Rope suitability and history
- Handling and protection of winder ropes during rope up
- Securing the winder ropes prior to final attachment
- Installation of rope onto winder drum:
  - tensioning
  - drum flange height
  - rope scrolling
  - maximum rope lays
  - minimum coils
- Competency of personnel
- Rope capping and fitting attachments
- Compatibility of rope and attachments

Hazards/Events:

- Personnel falling from height:
  - from headframe
  - from collar down the shaft
  - from the stage
- Personnel struck or crushed by moving equipment:
  - uncontrolled movement of the rope
  - caught by cable reeler

- Loss of control of rope:
  - rope whip
  - bird caging / Bird nesting
  - high tension
  - anchor point failure
  - tagline fails or breaks
- Loss of conveyance down shaft:
  - incorrect chairing
- Uncontrolled movement of the winder/rope drums:
  - ropes damaged or kinked during handling processes
- Failure of rope anchor points or lifting equipment
- Rope diameter not matching the winder drum, drum grooves or sheaves

Hazard Controls:

- Ensure personnel are inducted and competent to perform their tasks
- Establish and monitor procedures for working at heights
- Identify and establish exclusion zones while roping up
- Documented method of communication between winder/winch driver, riggers, crane drivers and rope handlers
- All conveyances secured or chaired off using designed anchor points and attachment slings
- Confirm rope is fit for purpose:
  - check history
  - obtain test certificate
  - non Destructive Testing (NDT) records
  - diameter should meet drum and sheave wheel design parameters.
- Rope should be tensioned to at least 50% of the working tension when installed on the winder drum
- Maintaining adequate rope tension on the winder drum, whilst reeling in or out
- Rope handling equipment (winches, deflection sheaves) adequately secured and where appropriate capable of holding and stopping the rope
- Method of reeving and handling the ropes to prevent damage

References:

- AS 3637.5 Underground mining – Winding suspension equipment – Rope swivels and swivel hooks
- AS 3637.6 Underground mining – Winding suspension equipment – Shackles and chains

2.4 Shaft Collar Door Installation

Collar doors seal the shaft entrance at the shaft collar to provide safe access to the main winding conveyance when it is on the surface. They also provide overhead protection to personnel working within the shaft when the kibble is being tipped on the surface or when other activities are being conducted at the shaft collar.
Where hinged doors are used, when in the open position, the doors should form a barrier to the open shaft preventing personnel or equipment accessing the shaft.

Key Considerations:

- Design layout and plan
- Process and sequence of installation
- Orientation of doors
- Overhead obstructions
- Working next to an open shaft
- Fall prevention
- Operation of mobile equipment in the vicinity of the shaft

Hazards/Events:

- Material or equipment falling down shaft:
  - activity is concentrated around the open shaft
  - collar doors get dropped
- Personnel falling from height
- Personnel struck or crushed by moving equipment:
  - use of cranes/forklifts/jacks
  - movement of collar doors

Hazard Controls:

- Ensure that the doors are fitted according to design
- All open cavities around the shaft collar sealed using kick boards, rubber seals preventing loose objects falling down the shaft
- Collar doors should have sufficient rope clearance gap
- Barrier fencing and bunding around the shaft collar
- Fall prevention systems to be utilised

References:

- MQSHR 2017 Part 10 Plant generally
  - S.108 Monitoring
- MQSHR 2017 Part 13 Winding operations
  - S.124 – Control measures to protect against persons and things falling into shafts
  - S.128 – Monitoring and maintaining winding equipment

Example of shaft collar door in closed and open positions

2.5 Rope Socketing

Rope socketing is carried out once the roping-up is complete. It is the process where a rope socket is attached to the end of the rope, so that the rope can be connected to a shaft conveyance.

Key Considerations:

- Compatibility of socket and rope
- Socket rated for load
- Socket suitability and history
- Method of attachment (resin or white metal)
- Competency of personnel
- Testing and proof loading of installed socket

Hazards/Events:

- Failure of the socket or attachments
- Burns from hot metal or chemicals
- Uncontrolled movement of the rope

Hazard Controls:

- The rope socket must match the rope size
- The method used for attaching the socket to a rope, should provide a minimum factor of safety not less than that of the rope and should be in accordance to Original Equipment Manufacturer (OEM) specifications
- Rope socketing must be conducted by a competent person
- Where a rope socket is fitted to a rope prior to arrival on site, it should not be used unless it can be demonstrated that the socket was correctly fitted
- After fitting and prior to use, rope sockets maybe tested to their working load limit on site

References:

- MQSHR 2017 Part 10 Plant generally
  - s.100 Selection and Design
  - s 93 Training
- AS 3637.1 Underground mining – Winding suspension equipment - General requirements
- AS 3637.3 Underground mining – Winding suspension equipment – Rope cappings
- AS 2759 Steel wire rope –Use, operation and maintenance

Examples of preperation and fitting of a rope socket

3 Commissioning and testing

Once the construction and installation of the winders, headframe, conveyances and associated infrastructure is complete, commissioning of the winding system must be carried out to ensure that the winding system and all the associated safety features function as designed and as intended.

A full report of the commissioning procedures, and the results of any tests and inspections carried out, should be made and signed off by competent persons.

Key Considerations:

- The final design, calculations and detailed drawings for the winder system
- The final design risk assessment
- What components are part of the winding system
- Tests or checks to verify the installation is within the design specifications
- The critical safety functions for the winding system to be inspected and tested
- Conformation of proof loading on conveyances
- Functional overload tests of the winding system
- Sequence of the commissioning tests
- How are the inspections and tests to be performed

- Documenting the results of tests or checks conducted
- Commissioning management structure

Hazards/Events:

- Critical plant failure during commissioning
- Uncontrolled movement of plant or equipment
- Injuries to persons resulting from equipment or systems failure

Hazard Controls:

- Commissioning risk assessment taking in consideration the following:
  - the final design, calculations and detailed drawings for the winder system
  - the final design risk assessment
  - the individual winding system components
- Documented commissioning plan and associated report:
  - sequence of tests to be carried out
  - ensure that all the critical safety functions are inspected, tested and checked
  - necessary proof loading tests
  - recording of actual results
  - recording of any alterations or changes made during the commissioning
- Contingencies to manage or control plant that functions outside the design specifications
- Skills and competencies necessary for the persons to perform the commissioning
- The commissioning plan and associated reports form part of the records maintained for the winding system

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 9 Persons on site
  - s 93 Training
- MQSHR 2017 Part 10 Plant generally
  - s 100 Selection and design
- MQSHR 2017 Part 13 Winding operations
- AS/NZS 3000 Electrical installation (Known as the Australian/New Zealand wiring rules)
- AS/NZS 3007 Electrical equipment in mines and quarries – Surface installations and associated processing plant
- AS/NZS 3017 Electrical installation - verification guidelines
- AS/NZS 3019 Electrical installation - periodic verification
- AS1768 Lightning protection
- AS/NZS 1020 The control of undesirable static electricity
- Safety Bulletin 136 – Mine and quarry electrical installation design expectations

4 Operation of winding systems

4.1 Control of Winding Operations

The SSE must ensure that a person is appointed to control winding operations prior to commissioning and operation of the winder and that the role and responsibilities of the person to control winding operations are documented. The appointed person should have the necessary technical competencies and skills to perform this task.

Key considerations:

- Operation of winding system in accordance with designer's and manufacturer's specification
- Effective maintenance regime
- High level of competency for winder drivers

Hazard/events:

- Uncontrolled movement of conveyance
- Failure of winding component
- Objects striking workers within the shaft

Hazard controls:

- Persons who operate and maintain the winder are competent to the established standard
- The activities of maintenance and operational personnel are coordinated
- Records of operation, inspection, testing and maintenance are kept
- Prestart inspections, monitoring of safety devices and features and scheduled maintenance are carried out
- That the OEM are included in operating practices, inspection and maintenance schedules
- That effective signalling and communication systems are established and maintained
- That emergency response procedures and equipment are established, maintained and tested
- Procedures and process are developed and implemented for the safe movement of persons and materials
- That accidents or incidents involving the winder are investigated causes identified and corrective actions implemented

References:

- MQSHR 2017 Part 9 Persons on site
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations

4.2 Winder Driver Responsibilities

It should be recognised that the operation of a shaft sinking winder needs a specific skill set and competency operate each shaft sinking winder.

Key considerations:

- Competency and verification of competency of winder drivers
- Operation of the winder during testing and/or maintenance
- Winder available for operation at all times when workers are in the shaft
- Alternate winder driver in the event that the nominated winder driver becomes unfit for duty
- Operation of the winder by trainee winder drivers
- Roster for winder drivers
- Fatigue management

Hazards/Events:

- Winder driver does not understand operation of the winder
- Winder driver not fit for duty
- No winder driver at the control console

Hazard controls:

In relation to the operation of the winder, the winder driver should:

- not operate the winder unless fit for work or suffering from fatigue
- conduct pre-start checks inclusive of brakes, safety interlocks for conveyances, upper limits and perform a test run up and down the shaft prior to work commencing
- not operate a winder that has faults which may affect its safe operation and the safety of persons
- maintain an auditable record regarding the status and condition of the winders
- report and record any faults or defects to enable repairs to be undertaken
- ensure that the person to control winding operations is kept informed of the status and condition of winders

- have a clear view, between the controls, winder drums and the shaft collar (alternatively cameras with good visibility should be utilised)
- confirm intended movement of winder with workers prior to operation of winder
- for the purpose of shift handover confirm and record the position (depth) of the stage conveyance within the shaft
- trainee winder drivers must only operate the winder if they are adequately supervised to prevent an unacceptable level of risk.

In relation to the fitness of the winder driver, the following should be part of their health assessment:

- Hearing
- Vision
- Epilepsy
- Cardiovascular disease
- Any other condition that could interfere with the ability of the person to operate the winder

References:

- MQSHR 2017 Part 9 Persons on site
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations
  - s 122 Appointment of persons to control winding operations

4.3 Winder System Prestart Checks

The SSE must ensure that the condition of the winding system is monitored using documented procedures.

Key considerations:

- Design specifications and operating parameters
- OEM instructions specific to the winding system
- Specific items determined during commissioning
- Safety critical functions
- Pass/fail parameters
- Performance of the static brake test in accordance with procedure.
- Documented and form part of the maintenance system and records

Hazards/Events:

- Suspended load
- Uncontrolled or unintended movement
- Damage to rope and/or rope attachments
- Insecure items that could fall down the shaft

Hazard controls:

The pre-start checks should be carried out at the start of every shift and include but not be limited to the following:

- Operation and function of the brakes
- Function of Emergency stops, limit switches, interlocks and overwinds
- Communication systems (bells/signals/phones and radios)
- Condition of ropes, sheaves and attachments
- Conveyances (specific to each conveyance):
  - winder rope attachments
  - structural damage

Conveyances, other than a stage, must be tested by making a trip up and down the shaft through its normal operating range at full operating speed after the following events:

- When winding equipment is repaired to an extent that could affect the equipment’s safe operation

- A rope is recapped
- The winder is stopped for more than 8 consecutive hours
- After a seismic event that could affect the safety of winding operations

Reference:

- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations

4.4 Shaft Signals and Communication Systems

The SSE and person to control winding operations must ensure that there are at least two effective communication systems between the winder driver, braceman and persons within the shaft. If one of the communication systems fail, all shaft work should stop until that communication has been restored.

Key considerations:

- Communication systems
  - Knocker line
  - Electronic bells and voice
  - Telephone or two way
  - Camera and voice over communication using wireless technology and/or leaky feeder cables
- Back-up system
- Testing and maintenance
- Competency in line with training needs analysis
- Return signals to confirm instruction given

Hazards/Events:

- Communication system not understood by workers
- Communication system unreliable
- Worker entrapped due to conveyance not moved as intended

Hazard controls:

- Movement of a stage should be given by a visual as well as an audible system
- Code of signals for knocker line should be standardised and posted at all positions from where signals need to be given.
- All movement requests should be acknowledged by a signal from the winder driver prior to movement of the winder

An example of the code of signals are below:

Knocks or Rings **Kibble Winder**	What is Signified
1	Stop – Signal to be returned by driver when the conveyance is or has been brought to rest.
2	Lower
3	Raise
4	“Men On” Winder conveyance
2-2	All Clear
4-4	“Mark” Kibble/Conveyance
5	Danger – Lock Out Winder
5	Winder driver confirms lockout and isolation

6	Caution Equipment under Kibble/Conveyance
6-1	Kibble OFF
6-2	Kibble ON
6-6	Change Winders
8	Release conveyance from “Danger” signal. Signal to be returned by driver before a command signal is given.
12	**Accident signal**
Knocks or Rings **Stage Winder**	What is Signified
6-6	Change Winders
1	Stop – Signal to be returned by driver when the conveyance is or has been brought to rest.
2	Lower
3	Raise
4-4	“Mark “ Stage/Conveyance
5	Danger-Lock Out Winder
5	Winder driver confirms lockout and isolation
1-2	Lower No 1 Drum
1-3	Raise No 1 Drum
1-2-3	Levelling Complete
12	**Accident signal**
Knocks or Rings **Service Signals**	What is Signified
5	Danger-Lock Out Winders / Revert to Service signals
5	Winder driver confirms lockout and isolation
5-2	Start Concrete
1	Stop concrete
5-3	Concrete Complete/Wash Out
7	Firing Warning
7-7	Explosives On/Off
8-1	Water Off
8-2	Water On
9-1	Air Off
9-2	Air On
10-1	Fan On
10-2	Fan Off
Knocks or Rings **Plumb-Bobs or Lasers On/Off**	What is Signified
5	Danger-Lock Out Winders / Revert to Service signals / Revert to winder
5	Winder driver confirms Danger-Lock Out Winders / Revert to Service signals / Revert to winder

11	Plumb-Bobs or Lasers On/Off
1-2	Lower No 1
1-3	Raise No 1
1	Stop & Lock
2-2	Lower No 2
2-3	Raise No 2
1	Stop & Lock
3-2	Lower No 3
3-3	Raise No 3
1	Stop & Lock
4-2	Lower No 4
4-3	Raise No 4
1	Stop & Lock
Knocks or Rings **Slew Headframe**	What is Signified
1	Stop
1-2	Slew Left
1-3	Slew Right
5	Danger-Lock Out Winder/Slewing Headframe
5-1	Winder driver confirms lockout and isolation
6-6	Change over winder/slewing headframe

Reference:

- MQSHR 2017 Part 13 Winding operations

4.5 Movement of Persons and Materials

The SSE must ensure that suitable procedures and standard work instructions are in place for the movement of persons and material within the shaft.

Key considerations*:*

- Methods of accessing and egressing conveyances
- Entering and exiting conveyances
- Security of materials whilst being transported in or hanging below a conveyance

Hazards/Events:

- Entrapment of workers
- Working at height
- Insecure objects in shaft
- Injured worker within the shaft

Hazard controls:

- All persons should wear a fall restrain or fall arrest system, whilst travelling in or working on shaft conveyances
- Persons and material must not protrude outside the travelling envelope of the conveyance
- Persons should only to ride in kibbles that are free from muck
- Where Persons travel in a conveyance with equipment, tools or explosives these should be contained or restrained with sufficient room for the person

- Persons should not travel in a conveyance when equipment, long pipes, hanging rods or materials of similar form, are slung below the conveyance
- A tag line should not be used where equipment, long pipes, hanging rods or materials of similar form are slung below the conveyance when it is being lowered
- Effective and safe recovery of injured persons in an emergency.

References:

- MQSHR 2017 Part 11 Procedures and standard work instructions
  - s 114 Procedures and standard work instructions for particular operations
- MQSHR 2017 Part 13 Winding operations
  - s 125 Conveyances
- As 1891 Series Industrial fall-arrest systems and devices

4.6 Winder Faults

The SSE and person to control winding operations must ensure that there are suitable procedures and instructions in place in the event of a fault or failure of a winder.

Key considerations:

- Availability of competent workers who can Identify critical faults that should be further investigated and assessed if they recur
- Recording and reporting requirements:
  - shaft workers
  - supervisor
  - persons to control winding operations (PTCWO)
  - SSE
- Utilisation of back up or alternative power supplies

Hazards/Events:

- Workers unable to travel in conveyance
- Injured worker unable to be brought to surface

Hazard controls:

- If man-riding conveyance fails, alternate means of conveyance to be available
- Clear instruction of who can reset/clear what faults and under what circumstances including the authorisation and use of bridges and by-passes. This must include a log
- Escalation process where the fault can't be cleared or multiple resets have occurred within a given time period

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations

5 Main sink

5.1 Drilling Shaft Shot Holes

The activities of drilling the shot holes to advance the shaft sink is fundamentally the same for 'Blind sink', 'Strip and Line' and 'Horidiam' shaft mining processes. In the case of a Blind sink, instead of drilling and firing the full floor, the option exists to bench the floor in two stages.

This option is used where ingress of water into the shaft is an issue allowing the leading bench section to be used as a sump. The muck is then removed via kibbles to the surface.

In a Strip and Line sink, the floor is normally fired as a full face with the spoil being dumped down the existing shaft or pilot-hole. This process also uses a shaft plug, allowing personnel to safely work on the floor.

In a Horidiam sink, the shaft is constructed by widening the diameter of an existing shaft, with the drilling cycle commencing from the top of the shaft and the blasting cycle commencing from the bottom of the shaft. This method requires that all shaft construction work be undertaken from a purpose built Horidiam stage. Blasted material falls freely to the bottom of the shaft and is then mucked out in the same way as for the Strip and Line method. As this method results in a rough wall finish, the final shaft is normally used as an unlined ventilation shaft.

There are two primary issues that need to be managed as part of the sinking cycle, these are overbreak and underbreak which are generally a function of ground conditions, drilling accuracy and powder factor.

Overbreak increases the hazards associated with barring down the walls and installing ground support. It also increases the amount of concrete required. If over break is excessive, it introduces the hazard of having to jack the stage over and could also overload the formwork due to the additional concrete to fill the void.

Underbreak creates issues associated with movement of formwork and the reduction in the thickness of concrete over the area of the underbreak with the risk of reducing the strength of the lining.

There are two ways of drilling the shot holes:

- from the floor using hand drill machines (i.e. hand sinkers) or portable shaft jumbos
- from a purpose built drilling system attached to the stage.

The type of shaft, ground conditions, shaft diameter and proposed shaft depth usually determine what system will be best suited and what drill equipment will be utilised.

Key Considerations:

- Method of shaft sink
- Ground conditions and ground support
- Method of drilling utilised
- Overbreak and underbreak
- Aquifers and existing voids (water, gas)
- Misfires
- Maintaining a vertical plumb shaft
- Lighting / visibility
- Ventilation
- Fall prevention

Hazards/Events:

- Injuries to persons:
  - struck by flying material
  - struck or crushed by moving equipment
  - persons falling from height
  - persons struck by falling equipment
  - dust, noise, vibration and fumes
  - persons being entangled with rotating equipment
- Flooding shaft
- Drilling into a misfire
- Working in restricted space:
  - collar pipes
  - water lines
  - airlines and oilers
  - sump pump

- drill machines
- drill steels
- blow pipe

Hazard Controls:

- Provide adequate supervision, so worker activities can be observed and monitored to ensure compliance to procedures
- Provide drillers with a blast plan to ensure holes are drilled to the correct depth, angle and diameter as per the blast design
- Clean floor properly and inspect for misfires/buttholes, washout and treat accordingly
- Post blast, verify shaft alignment
- Cover or probe drill, if expecting water, review water management systems
- No activities to occur in the shaft above the drillers
- Lock out stage and provide an 'overhang mark' to the winder driver prior to drillers accessing floor
- No work on the floor unless adequate ventilation is in place
- Ensure that air and water manifolds are within easy reach of the drillers
- Prior to drilling, temporary ground support should be installed to within a metre of the floor
- Check scale the walls prior to drilling commencing
- The noise, vibration and dust/fumes levels need to be monitored or assessed and PPE provided that is rated for the conditions
- When using a drill jumbo on the floor, it is setup, levelled and secured
- Where there is a pilot-hole and personnel could fall down, a shaft plug should be utilised

Example of drilling shot holes in the floor of the shaft

5.2 Charge-up & Firing

The use of explosives as part of a mining cycle is not new however there are some unique hazards and risks that should be considered and controlled when used for shaft construction.

Key Considerations:

- Ground conditions and geology
- Shaft sink method
- Fragmentation
- Overbreak and underbreak

- Whether the shaft is to be lined or unlined
- Blast design and planning
- The amount of water present
- The explosives products to be used
- Intended initiation systems to be used
- Fly rock control and stemming
- Over pressure from blast
- Area to be charged

Hazards/Events:

- Injuries to persons:
  - struck by flying material
  - persons falling from height
  - persons struck by falling material
- Unintended initiation of explosive:
  - stray electric current
  - material dropped onto the charged face
  - hot or reactive ground

Hazard Controls:

- ensure that a suitable blast design and plan is developed
- ensure that procedures for the use and handling of explosives specific to the shaft sink are developed and implemented, including:
  - handling and transport within a shaft:
    - explosives not transported with other equipment
    - detonators and explosives to be transported in separate containers
  - management and control of misfires
  - tag board procedures
  - blast clearance, accounting for personnel and firing
  - interaction between the shaft sink and other operations
  - methods of stemming
  - initiation methods
  - a Trigger Action Response Plan (TARP) for weather events
- Ensure that personnel who handle and use explosives hold the required competencies and clearances
- Provide the “floor mark” to the winder driver prior to charging commencing
- Methods to ensure that a conveyance does not touch a charged floor
- Methods to extract persons off a charged floor
- No work to be conducted in the shaft while charging is taking place
- Establish minimum clearances between the blast and conveyances in the shaft
- The stage should be raised out of the blast zone. The parked stage position should then be identified and recorded by the winder driver prior to firing
- Position the stage at a safe location prior to blasting
- Post blast re-entry procedures
- The shaft fan should be turned “off” and collar doors opened just prior to blasting. After blasting, the ventilation fans are turned back “on” to clear the smoke, fumes and gases from within the shaft
- No safety fuse to be used in shafts
- Secure, firing lines, plumb-bob wires and any loose cables that could interfere with the Stage/ Cross Head guide ropes

References:

- MQSHR 2017 Part 7 Hazardous substances and dangerous goods

- MQSHR 2017 Part 9 Persons on site
  - s 93 Training
- Explosives Act 1999
- Explosives Regulations 2003
- QGN 11 Use of explosives in underground mines
- AS 2187 Series Explosives

5.3 Re-Entry after Blasting

Normally after a blast there is a waiting period prior to re-entry into the shaft, to allow for any shot delays and blast fumes to clear from within the shaft.

Key Considerations:

- Re-establishment of ventilation
- Ensure blast fumes are clear
- Inspection of conveyances, shaft infrastructure and shot
- Communication between the stage and the shaft floor

Hazards/Events:

- Personnel overcome by gasses or blast fumes:
  - insufficient ventilation
  - vent tube/vent bag blocked or damaged
  - no or ineffective gas testing
- Personnel struck by falling rock:
  - fly-rocks caught from blast behind services brackets, water-rings, shaft formwork
- Damage to stage and ropes
- Damage to shaft services
- Misfires
- Falling from conveyances
- Kibble or man-cage collides with the floor or hangs up:
  - No overhang (stage level) or floor marks (bottom of shaft)
- A shaft conveyance contacts an obstruction within the shaft

Hazard Controls:

- Ensure ventilation is re-established post blast prior to re-entry:
  - gas testing completed and recorded where necessary
- Wash, check scale and make safe on re-entry
- Inspect infrastructure and stage for blast damage
- Inspect for misfires

References:

- MQSHR 2017 Part 7 Hazardous substances and dangerous goods
- MQSHR 2017 Part 13 Winding operations
- MQSHR 2017 Part 14 Work environment
- Explosives Act 1999
- Explosives Regulations 2003
- AS 2187 Series Explosives

5.4 Muck Out – Blind Sink

The receptacle to remove spoil from a blind sink is known as a “kibble” and can differ in size to meet winding design parameters and the duty cycle. For this section, mucking out encompasses the movement of the kibble from the hangover mark to the shaft floor, being filled and returned to the hangover mark on its way to the surface to be tipped.

The type of mucking equipment used is usually determined by the type of shaft being constructed, for example, either ‘blind sink’ or ‘strip and line’ process.
Other considerations that could affect the selection of equipment utilised are the diameter, depth of the shaft and the winding system duty calculations and limitations.
The mucking system could include a temporary or permanent mechanical mucking device attached to the working stage, or an independent mucker such as a small excavator working from the bench.

Key Considerations:

- Type of mucking methods and equipment utilised for shaft size
- Methods for securing and positioning of conveyances
- Methods of extraction
- Roles and responsibilities of shaft crews
- Ventilation
- Sequencing of ground support installation

Hazards/Events:

- Persons struck or crushed by moving plant or equipment:
  - the size of equipment within a restricted space
  - interaction between mucking equipment, kibbles and personnel
  - uncontrolled movement of kibble
  - persons on the stage being struck by a moving kibble
  - manhandling kibbles
  - mucker contacts the kibble
  - multiple operations within a restricted space
  - over extension of vertical muckers
  - winch failure of the cactus grab
- Unintended movement of the stage:
  - stage not locked with jacks
  - kibble contacts the stage
- Persons struck by falling equipment and materials:
  - over-filling the kibble
  - materials and rock falling down shaft
  - unstable and unsupported ground
  - dropped from the stage
- Equipment fire
- Dust and fumes
- Misfired explosives
- Persons falling from height:
  - persons on the stage falling either through the kibble well or from the stage conveyance
- Uncontrolled release of energy, either air or hydraulic

Hazard Controls:

- The stage is centred and secured in the shaft, its position marked by the winder driver and the winder locked out prior to mucking commencing
- The stage designed so that during the mucking cycle no part of a person can protrude into the kibble well or travel zone
- All kibble wells guarded and fenced
- Maintenance and servicing of mucking and winding equipment done by competent persons and as a minimum to the OEM’s instructions
- Mucking and winding equipment subject to prestart inspections and checks.
- During the mucking cycle unsupported walls checked and supported as necessary
- Design or structure the work methods to eliminate having personnel on the floor within the strike zone of mucking equipment when kibbles are being loaded

- To ensure that kibbles are not overfilled, the height of the muck within a kibble should be below the lip of the kibble
- The mechanical muck-out device or system must not interfere with the kibble well travel way or interfere with its free travel
- Clear method of communication between the person on the floor handling the kibbles and the winder driver
- Do not use quick release rope or chain attachments on winding system
- Kibbles used should have a three point lifting lug system, utilising a three legged chain, with drop nose pins
- Where multiple kibbles are used a process or procedure must be implemented to manage the risks associated with landing and positioning of empty kibbles
- Awareness of the swing associated with winding loaded kibbles from the floor when multiple kibbles in use
- Any loose material that could fall from the kibble must be cleaned off prior sending it up the shaft
- Ensure where diesel powered mucking equipment is used suitable and effective fire suppression system is used
- Ensure where diesel powered mucking equipment is used it is sized so that it can be raised and lowered through the stage
- Consider the remote control of the mucking equipment from the stage

Reference:

- MQSHR 2017 Part 11 Procedures and standard work instructions
  - s 114 Procedures and standard work instructions for particular operations
- MQSHR 2017 Part 13 Winding operations
  - s 124 Control measures to protect against persons and things falling into shafts
  - s 125 Conveyances
- AS 3637.1 Underground mining – Winding suspension equipment - General requirements
- AS 3637.6 Underground mining – Winding suspension equipment - Shackles and chains

5.5 Tipping Muck on the Surface

For this section tipping muck on the surface encompasses the approach of the kibble to the collar doors and the subsequent activities associated with tipping spoil from the kibble and the return of the kibble below the collar doors.

Key Considerations:

- Tipping process and method
- Slewing or fixed headframe and height clearances
- Collar door design and operation
- Rock spillage control
- Stockpiling and handling of spoil
- Interaction with personnel

Hazards/Events:

- Rock or equipment falling down the shaft:
  - spillage from the tipping chute
  - spillage from behind splash guards
  - collars doors not cleaned
  - material caught in kibble chains
- Persons being struck or crushed by plant:
  - moving collar doors and tipping chute
  - kibble trolley
  - mobile equipment

- Kibble fouls on collar doors or tipping chute:
  - swinging kibble
  - sequence or interlock failure
  - failure of the collar door control or activation

Hazard Controls:

- Conduct regular inspections of collar door and tipping chute limits and interlocks
- Where trolleys are used:
  - they are manually handled on and off the collar doors
  - trolley rails have a stop block
  - be attached to a safety chain
- Manage stockpiles and spillage to prevent material flowing towards collar doors and shaft
- When a slewing headframe is used an audible and visible alarm is activated when the headframe slews
- Ensure that the winder driver is able to monitor, including vision of the collar doors, the kibble approach to the collar, tipping chute and in the case of a slewing headframe the slew zone

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 13 Winding operations

5.6 Muck Out – Strip and Line

For this section, 'mucking out' includes the removal of the spoil material from the shaft floor, tipping it down the pilot-hole and ensuring that the brow at the base of the pilot-hole remains open. Mucking can either be undertaken from the stage or from the shaft floor.

When mucking from the stage, stage mounted muckers are used to tip or scrape spoil directly into the open pilot-hole. The mucker operators are positioned on the stage.

Shaft floor mucking incorporates the use of a purpose built pilot-hole plug installed in the pilot-hole, and a mucking unit such as a mini excavator positioned on the plug or bench. The pilot-hole plug is constructed to allow spoil to be scraped or pushed down the shaft.

Key Considerations:

- Mucking method and machines to be utilised:
  - Mucking from the floor:
    - landing and retrieval of machines and personnel
    - interaction with the pilot-hole plug:
      - installation of plug into pilot hole prior to mucking
      - suitability of plug with raise-bore hole i.e. diameter fit and the fit over a broken pilot hole
      - suitability with the mucking machine being used
      - with personnel on shaft floor
      - anticipated loads on the plug
    - uneven bench
    - personnel working in the proximity of a vertical opening
    - location of machines when not in use
  - Mucking from the stage:
    - distance to the floor
    - position and protection of mucker operator and controls
  - Size of the machines
- Methods for securing and positioning of conveyances
- Removal / installation of the pilot-hole plug and / or the installation of mucking plug
- Oversize spoil

- Ventilation
- The installation of ground support during the mucking cycle
- Removal of mucked spoil at shaft bottom

Hazards/Events:

- Persons falling from height:
  - Persons falling down pilot-hole:
    - no plug
    - plug failure
    - overbreak leaves cavity or opening around plug
  - Persons on the stage falling either through the kibble well or from the stage conveyance
  - Persons riding a plug during installation or retrieval
- Contamination of mine ventilation:
  - exhaust fumes
  - blocked pilot-hole
- Persons struck by falling, flying or ejected material:
  - no overhead protection on mucker
- Persons struck or crushed by moving equipment:
  - operating in restricted space
  - failure of a stage mounted mucker
  - plug contacts stage
- Equipment fire
- Unstable and unsupported ground:
  - ground support not sequenced with mucking progress
- Dust and fumes
- Misfired explosives
- Unintended movement of the stage:
  - stage not jacked or locked

Hazard Controls:

- Install pilot-hole plug if and when persons are on the shaft floor
- Fall arrest systems are worn and used where there is a gap that persons could fall through between the floor and the pilot-hole plug,
- Fall arrest equipment used when traversing between the shaft floor and the stage conveyance
- Ensure that no personnel other than the mucker operator are on the shaft floor while mucking is taking place
- Where mucking takes place from the stage, no personnel should be on the shaft floor
- Ensure that blast rock size is suitable and can fall down the pilot-hole without it obstructing the shaft
- Conduct regular inspections at the shaft bottom, to ensure the brow remains open during the mucking cycle
- Check and inspect the shaft plug prior to each use to ensure that it is fit for use
- Whilst mucking is in progress the stage conveyance should be locked in position
- Interaction with personnel on the stage, floor and winder driver
- Ensure that any diesel operated machinery has fire suppression or suitable fire extinguishers fitted

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 13 Winding operations
- AS 1891 Series Industrial fall-arrest systems and devices

Example of a shaft plug

5.7 Muck Extraction at Shaft Bottom

This section applies to work performed at the bottom of the pilot-hole, extracting blasted material using Load Haul Dump machines.

Key Considerations:

- Excavation processes and procedures
- Communication and interaction with shaft and other operational personnel
- Interaction and control measures to remove the muck from below the pilot-hole
- Ventilation restriction or blockage within the pilot-hole or shaft
- Remote bogging and muck removal
- Inrush of materials and water
- Dust suppression

Hazards/Events:

- Persons being struck or crushed by rock:
  - shaft crew muck into pilot-hole, while mucking takes place at the bottom of the shaft
  - communication breakdown between shaft crew and operational personnel
  - mud rush
- Air contamination from dust and fumes:
  - pilot-hole blockage

Hazard Controls:

- Establish and document the communication method and interactions between the shaft sink crew and operational personnel
- To conduct regular inspections at shaft bottom to verify brow clearance height
- Shaft sink activity to cease when mucking at shaft bottom takes place
- Install pilot-hole plug when mucking at shaft bottom takes place
- Shaft bottom to be barricaded while shaft sink activities are occurring above
- Barricade to be positioned at a distance to ensure that falling material cannot be ejected beyond the barricade
- Ensure that blast rock size is suitable and can fall down the pilot-hole without it obstructing the shaft

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 13 Winding operations

6 Mucking systems

6.1 Overshot Muckers

An overshot mucker is an air operated track driven front end loader that tips the mucked material behind itself by lifting the bucket over the machine and past the operator into the kibble. The operator and controls are positioned on the side of the loader. A good air supply is essential and the delivery hose system can be easily damaged during operation.

This method of excavating is rarely used nowadays due to design and operational inefficiency of this machine. Where an overshot mucker is used the shaft diameter should be large enough to accommodate it. The unit has the potential to crush an operator or bystander in a restricted work space.

Key Considerations:

- Size of shaft and method of sinking
- Other available alternative mucking methods
- Mucker size:
  - height clearance when mucking into kibble
  - travel way clearance thru the collar and stage conveyance when winding up and down shaft
- Overhead protection for the operator
- Operation of the overshot mucker with other personnel on the shaft floor
- Landing and positioning of the kibbles to allow the mucker to tip into them
- Handling and protection of the air supply hose while the mucker is operation

Hazards/Events:

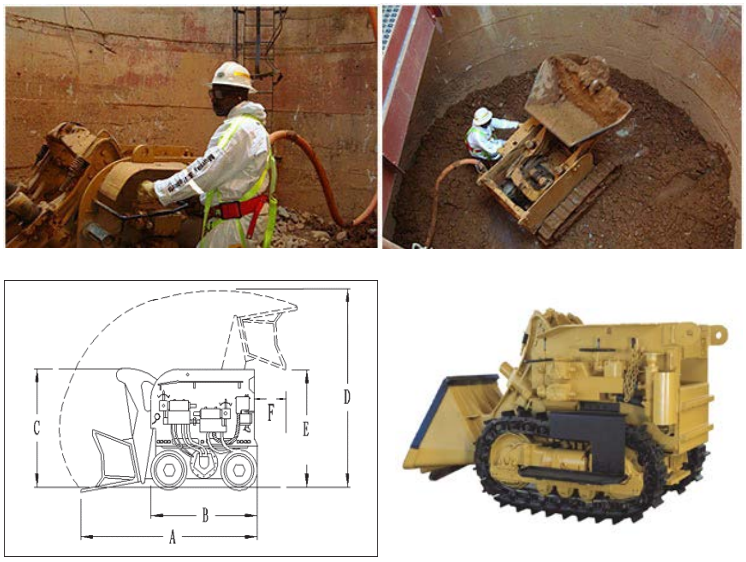
- Personnel struck or crushed by moving plant or equipment:
  - operator crushed by mucker boom
  - operator crushed between wall or kibble
  - operator caught in the chain drive
  - uncontrolled or unintended movement of the mucker
  - offsider hit or crushed by mucker
  - personnel struck or crushed by kibble
- Personnel struck by falling material
- Personnel falling from height:
  - off stage
  - down the pilot-hole
  - shaft sink progresses below an off-shaft development
- The mucker fouls or catches on the shaft stage or collar doors whilst being raised or lowered into the shaft
- Personnel injured or struck by a failed air supply hose

Hazard Controls:

- Limit the number of personnel on the floor while mucking is taking place
- Additional personnel should not enter the operating zone of the mucker while it is operational
- Operator to be vigilant and spotters should keep air hose clear from getting squashed against shaft wall or run over by machine tracks
- A spotter should have access to an air supply cut off valve remote to the machine so that it can be easily activated in the event of an air supply hose failure
- Personnel other than the operator should not enter the operating zone of the machine prior to shutting off the air supply
- Ensure all debris has been removed prior to transporting the mucker up or down the shaft (wash down when finished)

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 13 Winding operations



Example of overshot mucker

6.2 Excavators

This method for mucking utilises a slewing excavator that is operated either on the shaft floor or positioned on the pilot-hole plug depending on the shaft sink method. The excavators come in different sizes and depending on the application there are a number of attachments available. The major limitation with the use of an excavator in a shaft environment is the ability for the excavator to pass through the kibble well in the stage when being lowered or raised from the shaft floor.

Key Considerations:

- Size of shaft and method of sinking
- The dimension of the excavator and its ability to pass through the collar door and stage kibble well
- Overhead protection for the operator
- Operation of the excavator with other personnel on the shaft floor
- Landing and positioning of the kibbles to allow the excavator to muck into them
- Diesel engine operating in the shaft
- Shaft ventilation
- Access for operator and maintenance activities

Hazards/Events:

- Exhaust fumes
- Fire
- Excavator rolling over
- Equipment or material falling down the shaft:
  - plug failure
- Persons on the shaft floor while the excavator is operating
- Excavator fouls or catches on the shaft stage or collar doors
- Persons struck or crushed by operating equipment:
  - using excavator to position kibble
  - kibble swings whilst being hoisted
- Personnel struck by falling equipment:
  - no overhead protection on mucker
  - kibbles not cleaned off and overfilled

    - machinery not cleaned off before being hoisted
- Operation in restricted space

Hazard Controls:

- The excavator must be fit for purpose:
    - be fitted with suitable engineered certified lifting points
    - approved safety pins should be fitted for all attachments
    - able to fit through the collar doors and shaft kibble well
    - should not need to be assembled or disassembled to enable it to be raised or lowered in the shaft
    - be subject to routine scheduled maintenance and inspections (OEM minimum)
    - be subject to regular exhaust emission monitoring and testing
    - where the excavator is positioned on a shaft plug ensure the plug is adequately engineered and the excavator is secured
    - where it is intended for the excavator to push or move kibbles an assessment is made to ensure that the excavator is operating within its design parameters (OEM specs)
    - be fitted with seatbelts and overhead protection
- Ensure adequate fire suppression system and or fire extinguishers are fitted to the excavator
- When not in use the excavator should be removed to the surface
- A system of positive communication between operator, personnel on the floor, stage and winder driver
- Personnel on the floor should remain in an identified safe area (outside of the slew radius) whilst excavator is operating
- Personnel other than the operator should not enter the operating zone of the excavator while it is operating
- The excavator is not to tram unless all personnel are accounted for and are in a identified safe area clear from the tram path
- Ensure adequate ventilation is available to clear engine exhaust fumes from the shaft
- The excavator is cleaned and examined for loose material prior to it being raised or lowered in the shaft

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
    - s 100 Selection and design
- MQSHR 2017 Part 13 Winding operations
- MQSHR 2017 Part 14 Work environment

Example of excavator being lowered into shaft and used for mucking at shaft bottom

6.3 Stage Mounted Shaft Muckers

There are two types of stage mounted shaft muckers:

- Cactus Grab
- Vertical Shaft Mucker

Both types are operated from the stage and are mounted to the bottom deck of the stage conveyance. When not in use they are normally retracted and chaired to the stage. A cactus grab utilises a split and hinged bucket fitted with curved jaws or teeth (grab) to dig into and extract the loose rock.

The most common type of cactus grab units used are:

- pneumatic winch rope type - fitted to a monorail beneath the stage conveyance.
- The grab is raised and lowered using the winch rope
- Electric over hydraulic cantilever boom type - the grab is raised and lowered by either pneumatic or hydraulic rams

A pneumatic winch rope type cactus grab can also be fitted to cranes for the purpose of excavation during the shaft pre-sink. No personnel are to be in the shaft during this process.

Vertical shaft muckers are commonly pneumatically powered and use a clam shell scoop to extract material. They are raised and lowered via a pneumatic cylinder.

In large diameter shafts it is common to have multiple units fitted to the stage conveyance that are operated in tandem during the mucking cycle.

Key Considerations:

- Shaft diameter and sinking method
- The number, size and type of stage mounted muckers to be used
- Design of the stage to accommodate the stage mounted muckers (weight and operation)
- Stage mounted muckers effect on:
  - winding system (weight, movement)
  - stage conveyance balance during operation
  - swinging motion effect on ropes and attachments
- Height clearance when mucking into kibbles
- The dimensions of the stage mounted muckers are such that they can be lowered and raised through the stage kibble well and collar doors for maintenance
- Power supply (air, electrics) :
  - initial installation
  - ongoing extension as sink progresses
  - isolation
- Position of the mucker operator and the mucker controls to protect the operator from a moving kibble
- Interaction and protection of personnel on the shaft floor while the mucker is operating
- Methods of communication between the mucker operator, personnel on the floor and the winder driver

Hazards/Events:

- Uncontrolled movement of the stage:
  - stage not jacked and locked
  - kibble contacts stage conveyance
- Personnel on the shaft floor struck or crushed by mucker:
  - restricted space
  - poor visibility of operator with the shaft floor
  - communication breakdown between operator and floor-man
  - mucker over-extends or cables fail
  - the cactus grab overbalances and falls over
  - uncontrolled movement of the swinging cactus grab
  - muckers not restrained when not in use
- Vertical mucker operator being struck by moving kibble:
  - operator positioned within the travel envelope of the kibble
- Personnel struck by flying material

- Uncontrolled release of pressure (air or hydraulic)
- Electric shock
- Personnel falling from height:
  - accessing the cactus grab cabin from a kibble
  - from the stage

Hazard Controls:

- Ensure stage mounted muckers, winches, shaft conveyance and winding system are engineered and assessed as compatible
- A system of positive communication between mucker operator, personnel on the floor, stage and winder driver
- Limit shaft personnel on shaft floor
- Personnel on the floor should remain in an identified safe area (outside of the mucking zone) whilst muckers are operating
- Lock stage into formwork/shaft walls using stage jacks, during the mucking cycle
- Lower stage frequently during the mucking cycle to limit overextension of the muckers
- Establish regular inspection and maintenance of the muckers and components
- Utilise correctly rated hoses, lines and fittings
- Install whip lash slings and burst sleeves on hoses

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations

Example of cryderman and cactus grab muckers

7 Shaft lining and support

7.1 Installation of Ground Support

By its very nature as shaft construction progresses, a large variety of ground conditions and rock types are encountered. As the construction of the shaft progresses, geotechnical assessments must (44) be carried out to ensure that the ground support is effective. The purpose of ground support is to secure the ground and control the risk of personnel being struck by falling rocks.

Key Considerations:

- The nature and type of ground conditions the shaft will be constructed in
- The findings and recommendations from geotechnical drilling and associated reports
- Ground support systems to follow the geotechnical recommendations outlining the proposed ground support:
  - type of rock-bolts to be used
  - the length of rock-bolts to be used
  - mesh type and specifications
  - specifications and thickness of concrete lining
- The sinking method that is being used

- The intended final purpose of the shaft
- Ground water management
- The type of ground support to be installed
- QA/QC of installed ground support and concrete

Hazards/Events:

- Failure of ground support
- Persons struck by falling rock

Hazard Controls:

- Ground support regime that will effectively secure the ground
- Ground support installed in sequence with the shaft advance
- Persons don't work under unsupported ground
- Concrete lining to follow secondary ground support, with limited exposure without concrete lining in place (e.g. formwork length + 1m)
- QA/QC of ground support installation including reporting of such things as:
  - location and number of bolts installed
  - water ingress
  - faults / shear zones
  - areas of poor ground
- Cover drill where wet or poor ground conditions are expected (ground stabilisation / water seal)
- Trained, competent personnel and supervision
- Processes and procedures to be followed
- Fit for purpose equipment
- Site preparation (level floor and good housekeeping)
- Good understanding of upcoming ground conditions (probe drill if necessary)
- Regular inspections by geotechnical personnel
- Sound and scale the ground before bolting begins

References:

- MQSHR 2017 Part 6 Facilities and processes
  - s 44 Ground control
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations
- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete

Example of installation of shaft support

7.2 Shotcrete

There are two types of shotcrete application – wet mix and dry mix. Each method has its particular use to assist with rock support.

Shotcrete is a concrete placing process where concrete mixtures are conveyed through a hose then pneumatically projected at high velocity onto a surface to achieve high quality in-place compaction. It produces high-quality dense concrete, with a low water-cement mix (w/cm) ratio, low permeability, and a high cementitious material content.

With new technology available there are remote control spraying methods or hand spraying systems available, using wet or dry fibre reinforced mixes.

Key Considerations:

- Shaft diameter and depth
- Ground conditions and amount of water ingress
- Thickness and strength
- The delivery system to be used
- Curing time
- Potential for contamination of the existing ventilation system
- QA/QC of shotcrete

Hazards/Events:

- Personnel struck by falling material or equipment
  - Failure of shotcrete:
    - wet conditions
    - sprayed on too thick
    - no ground water pressure relief tubes installed
- Contamination of the air:
  - dry mix with limited ventilation
  - direction of airflow within the shaft
- Personnel falling from height:
  - off the stage
  - down a pilot-hole
  - from the collar if using a remote sprayer
- Personnel struck by flying material:
  - rebound
- Uncontrolled release of pressure:
  - blockage
- Chemical burns

Hazard Controls:

- Ensure that all shotcrete equipment is subject to a prestart check prior to operation
- QA/QC inspection and testing:
  - mix design
  - thickness testing
- Wash down surface area prior to shotcrete application
- Fall arrest systems to be worn

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete


Example of shotcrete being applied to shaft walls

7.3 Concrete Lining – Slip Formwork (kerb ring & shutters)

The slip formwork method of shaft lining can be used to line a shaft of any depth and is generally carried out from the top down and is advanced with the shaft sink.

This method of shaft lining also allows temporary or permanent anchor points for shaft services and infrastructure (air/water/power/conveyance guides) to be installed with the concrete pour. These anchor points are commonly referred to as concrete ferrules or 'nut boxes'. Slip formwork comes in two main pieces - a 'kerb ring' and 'sliding shutters'.

The kerb ring is used to position and anchor the sliding shutters as well as to form the base/floor of the intended concrete pour. The sliding shutters are curved sections of formwork that are assembled on top of the kerb ring to make up the formwork for the concrete lining.

The sliding shutters can be up to 6 metres long and are normally able to be split into shorter segments known as rings. This allows for shorter concrete pours in the event bad ground conditions are encountered.

In preparation for a concrete pour the kerb ring is lowered with chain blocks beyond the existing concrete to the desired level. It is positioned, aligned and locked using screw jacks, wedges and hanging rods. Once positioned, scribing bars are inserted in the kerb ring allowing the voids and gaps to be closed with timber, plastic and sandbags to contain the next concrete pour.

Once the kerb ring is set, the sliding shutters are lowered and connected to the kerb ring using chain blocks. The work of moving, positioning and securing the kerb ring and sliding shutters is conducted from the stage conveyance and shaft floor.

Key Considerations:

- The overall weight of the intended length of slip formwork inclusive of concrete
- The design and engineering of the kerb ring and sliding shutters:
  - hanging rods rated to suspend the entire formwork and concrete
  - scribing bars rated to support the concrete
  - positioning of guide plates (bull horns)
  - filler ring at top segments of sliding formwork
  - lifting lugs on each sliding shutter ring rated to suspend entire formwork
- The working load limit of chain blocks, slings, shackles, wall hangers and the anchor points rated for the total mass of sliding formwork
- The ability to split the formwork into segments in the event of poor ground conditions

Hazards/Events:

- Personnel struck by falling or moving equipment:
  - failure of chain blocks, lifting equipment and anchor points
  - dropping formwork
  - failure of scribing bars and hanging rods
  - unintentional movement of the stage conveyance
  - unintentional movement of sliding formwork, such as spring and release off the wall

- Engulfment from concrete:
  - catastrophic failure
  - slow leak
- Chemical burns

Hazard Controls:

- The lifting and attachment points for the sliding formwork must be designed and engineered for the anticipated loads (both on the formwork and the shaft)
- Lifting equipment must be rated for the loads
- Scribing bars, hanging rods, couplings and timbers must be rated and sized for the actual load
- Shock loading chain blocks and slings when releasing formwork from wall should be minimised
- The shaft conveyance winding system not be used to raise or lower the sliding formwork, when moving or positioning it in preparation for a concrete pour
- A procedure for raising, lowering and positioning the sliding formwork must be in place
- Personnel undertaking the slip formwork movement and positioning must be competent in slinging and movement of loads
- The lowering and positioning of the formwork should be coordinated by a competent person
- Ensure concrete meets correct specifications prior to sending down the shaft (slump tests, additives and mix ratio)

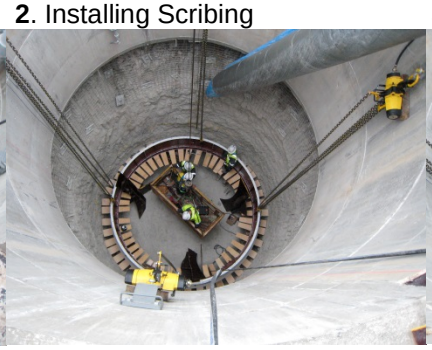
References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
  - s 100 Selection and design
- MQSHR 2017 Part 11 Procedures and standard work instructions
  - s 114 Procedures and standard work instructions for particular operations
- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete

Initial shaft concrete shutter installation:

1. Set up Kerbring

2. Installing Scribing



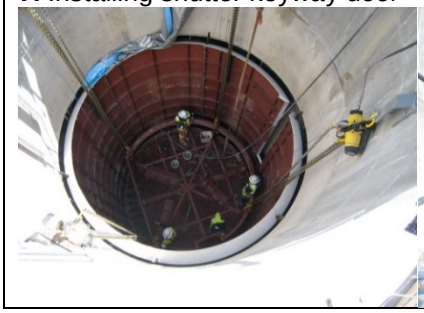
3. Concrete Kerbring + 1m Shutter

4. Installation of 3rd & 4th rings

5. Installing shutter panels

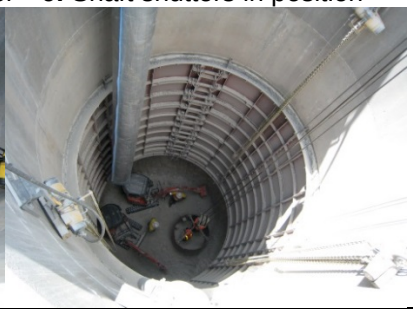
6. Installing remaining shutters

7. Installing shutter keyway door



8. Concrete the completed barrel

9. Shaft shutters in position



7.4 Concrete Delivery Systems

7.4.1 Concrete Slick-line

The concrete slick-line system consists of a surface hopper, a steel pipe column in the shaft, concrete kettle (remixer) at the bottom of the pipe column and a flexible delivery hose or hoses attached to the concrete kettle. Concrete is discharged into the surface hopper from an agitator truck. This method can be used for delivery of concrete to any shaft depth. It is also independent of the winding system.

Key Considerations:

- Movement of the agitator trucks around the shaft and hopper
- Method of communication and signalling between the stage and surface hopper/agitator truck
- Concrete specifications and mix design
- Timing for concrete deliveries between batches
- Slick-line specifications
- Slick-line vertical alignment
- Concrete overfilling and/or spillage within shaft
- Gap between the stage conveyance and the slip formwork

Hazards/Events:

- Equipment or material falling down the shaft:
  - slick-line fails
  - anchor points fail
  - overfilling surface hopper
- Personnel struck of crushed by moving equipment:
  - pipework
  - kibble
  - agitator trucks
- Release of concrete under pressure:
  - blockage, hopper, slickline, re-mixer kettle, delivery hose
  - wear plate or slickline blowout
- Overloading of stage or winding system:
  - failure to consider the additional weight of the delivery system
- Communication failure

Hazard Controls:

- Manage and control traffic movement at shaft collar and install bunding
- Provide controls to prevent the agitator truck from entering the shaft
- Provide suitable communication systems between persons on the stage and surface hopper/agitator truck, preferably separate to the winding system communication system
- Offset the hopper from the shaft and fit splash guards between hopper and shaft
- Ensure slick-line wall brackets are designed to take the weight of a blocked concrete slick-line
- Use seamless pipe for slick-lines and ensure that they are installed vertical and plumb to reduce wear
- Ensure regular inspection and maintenance of slick-line system is carried out, including cleaning and thickness tests
- Ensure that discharge hose/s are securely connected (muff coupling) to the kettle and fitted with a whip-lash sling in the event of separation
- Ensure that a procedure for unblocking the slick-line has been developed
- All nozzle-men handling the discharge hose wear goggles and face shields whilst discharging concrete

7.4.2 Concrete Kibble and Octopus System

This method of concrete delivery can be used for any shaft depth. The delivery of concrete is limited by the capacity and speed of the winding system, the size of the kibble and the depth of the shaft.

It utilises a purpose built concrete kibble to transport the concrete from the surface to the shaft bottom, where an ‘octopus’ at shaft bottom distributes the concrete evenly into the formwork. The concrete kibble is designed to carry and discharge wet mix concrete and is attached to the main winding system. The octopus is basically a funnel with multiple discharge hoses.

In preparation for a concrete pour the octopus is lowered down the shaft and locked into position (chaired) in the kibble well of the stage. During filling, the kibble sits on the collar doors to enable a concrete agitator truck to discharge into it.

Once filled the concrete kibble is lowered down the shaft to an overhang mark above the stage position. From there the kibble is lowered under the direction of personnel on the stage to the position where the concrete can be discharged into the octopus.

Key Considerations:

- Movement of the mobile equipment around the shaft and collar doors
- Positioning and attachment of the concrete kibble onto the winding system
- Concrete specifications and mix design

- Access to the shaft bottom when octopus and associated equipment is installed on the stage
- Concrete overfilling and/or spillage within shaft
- Design and size of concrete kibble and octopus matched to winding system, shaft and collar doors

Hazards/Events:

- Personnel struck or crushed by moving plant or equipment:
  - agitator truck
  - collar doors
  - forklift or trolley
- Persons struck by falling material:
  - concrete spillage at the collar doors
  - concrete kibble does not seal
  - octopus not cleaned properly
  - no overhead protection on top deck
- Plant and equipment colliding and damaging headframe, guide ropes or concrete kibble
- Collar door failure:
  - overloaded
- Concrete kibble contacts shaft infrastructure or stage:
  - concrete kibble is a different size and shape to a normal kibble
  - kibble not balanced
  - over-travel of the concrete kibble
- No conveyance access to the shaft bottom during concrete pour:
  - octopus blocks kibble well
- Falling from height

Hazard Controls:

- Ensure that the concrete kibble, attachments and lifting equipment are designed, rated and matched to the winding system
- Ensure that the weight of an empty and full octopus has been considered in the load calculations for the stage and winding system
- Overhead protection for personnel when working from the top deck
- Provide barricades and or stop-logs to prevent mobile equipment accessing the shaft or collar doors
- Ensure when equipment is being hoisted or lowered up and down the shaft all loose aggregate or concrete has been removed
- After the concrete kibble has been filled the collar doors should be washed off before they are opened
- Ensure that the concrete kibble does not rub on stage conveyance guide ropes
- Ensure that an overhang mark is established for each concrete pour or as the stage moves
- Ensure that discharge hose/s are securely connected (muff coupling) to the octopus and fitted with a whiplash sling in the event of separation
- All nozzle-men handling the discharge hose wear goggles and face shields whilst discharging concrete
- Ensure that a procedure for unblocking the octopus system is developed
- Stage to be centralised to the centre of the shaft

References:

- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete

Example of a concrete kibble and concrete octopus

8 Installation of shaft services

The shaft services installation can be described as:

- temporary services installed for the purpose of constructing the shaft and removed when construction is complete
- permanent services installed during or after shaft construction.

Temporary services could include the following:

- Compressed air
- Water
- Power cables
- Communication cables
- Mains firing lines
- Concrete slickline
- Water pump lines
- Ventilation ducting
- Plumb-bob lines
- Wall brackets

Permanent shaft services are dependent on the purpose of the shaft and could include the following items:

- pump discharge pipe column
- power cables
- communication / Leaky-Feeder cables
- water lines
- water rings
- concrete slickline.

Key Considerations:

- What services and infrastructure are needed for:
  - shaft construction
  - permanent installation
- Design and orientation of the infrastructure within the shaft
- Method of installation
- Method of attaching the services to the shaft wall

Hazards/Events:

- Personnel struck by falling equipment or material:
  - failure of shaft services anchor points

    - failure of the lifting and slinging equipment
    - services fall whilst being raised or lowered
    - no overhead protection on top deck
    - loss of control of services whilst lowering:
        - electric cable
        - polypipe
        - power cables
- Falling from height:
    - from the stage:
        - reaching out over the stage
        - climbing or standing on handrails
    - shaft collar:
        - manhandling the services
        - not enough clearance above collar doors
- Uncontrolled release of energy

Hazard Controls:

- No services installation to take place whilst personnel are below where the installation is taking place
- Gone to part 2Electrical cables installed in a separate location away from pipes or other services
- Slinging of loads done by competent persons
- When services are raised or lowered within the shaft all care must be taken to ensure that nothing fouls or gets entangled with the shaft infrastructure
- All items slung underneath a conveyance should have sufficient clearance above the collar doors when opened
- Air and water services should have lock out isolation points with bleed valves at the shaft collar and at intervals in the shaft as necessary
- Service lines such as air/water hoses should be pressure rated
- All free hanging services such as firing cables, knocker and plumb-bob lines should be secured within the shaft
- When installing or repairing services personnel should remain within the envelope of the stage and wear fall arrest/prevention system

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
- AS 1418.1 Cranes, hoists and winches Part 1: - General requirements
- AS 2550.1 Cranes, hoists and winches – Safe use Part 1: General requirements

9 Equipping the shaft

When shaft construction is completed, depending on the intended purpose of the shaft, additional steelwork and infrastructure may need to be installed. This can include:

- pentice
- rope change out platform
- loading station flasks
- steel guides, bunton beams
- ladders and access platforms

Whilst the shaft construction work itself is generally undertaken by a single contractor, shaft equipping can involve a number of contractors or groups working at various locations within and around the shaft.

Key Considerations:

- Increase in numbers of personnel and work activities
- Communication between the various work groups
- Interaction with the broader operation
- Increased movement of plant and equipment
- Lay down and pre-assembly areas
- Prioritisation of work activities and work flows:
  - Groups working above, below and beside each other
  - Effects on mine ventilation
  - Firing
- The size and weight of steelwork and material to be lowered down the shaft
- Shaft survey alignment

Hazards/Events:

- Personnel struck or crushed by moving plant and equipment
- Services or equipment falling down the shaft
- Personnel struck or crushed by falling plant or equipment
- Shaft conveyances contact or foul on shaft services
- Persons falling from height
- Uncontrolled movement of plant or equipment

Hazard Controls:

- Review the site management structure to ensure effective supervision
- Develop and implement a shaft equipping project plan/timeline/schedule
- Ensure that that effective communication systems and methods are in place to account for the increased workforce and activities
- Revise the traffic management plan
- Ensure that the personnel undertaking the shaft equipping are competent to perform their tasks
- Review the proposed procedures and standard work instructions for the intended tasks and conduct risk assessments as necessary
- Conduct regular planning and scheduling meetings
- Establish a system of regular workplace and job site inspections

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 6 Facilities and processes
- MQSHR 2017 Part 10 Plant generally
- AS 1418.1 Cranes, hoists and winches - General requirements
- AS 2550.1 Cranes, hoists and winches – Safe Use Part 1: General requirements

10 Maintenance of winding system

A maintenance schedule should be developed and implemented for the winding system. The schedule should be based on the design parameters and the OEM instructions.

Key Considerations:

- Competence of personnel
- Maintenance tasks
- Change management
- Documentation:
  - maintenance records
  - risk assessments

    - OEM documents
- Critical spare parts
- Structural integrity
- Lifecycle of components
- Scheduling of maintenance
- Software management
- Plant /equipment interaction

Hazards/Events:

- Structural failure
- Failure of components
- Personnel struck by falling objects
- Uncontrolled/unintended movement

Hazard Controls:

- Register of all plant and equipment that forms part of the winding system
- Document OEM instructions and specifications for inspection testing and maintenance
- Develop a maintenance schedule:
    - preventative
    - corrective
    - statutory requirements
    - non-destructive and destructive testing
- Documented maintenance practices:
    - record of values and outcomes
- Functional testing after maintenance
- Change management process
- Software management process
- Competencies necessary to perform the inspection testing and maintenance
- Defect management as a result of:
    - prestart inspection
    - routine maintenance
    - in service failure

References:

- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 11 Procedures and standard work instructions
- MQSHR 2017 Part 13 Winding operations

11 De-mobilisation of winding system

Once the shaft sink is complete and services have been installed or removed as necessary, the winding system has to be de-mobilised from site.

Key Considerations:

- The necessary qualifications and competencies of the personnel who are going to undertake the de-mobilisation activities
- Working at heights
- Interaction between work groups and schedule of works
- Site resources to be utilised
- Traffic management around the shaft and headframe area
- Access control of unauthorised personnel
- Lay down area for equipment
- Isolation of services such as power, water and compressed air

- Shaft barrier and cover

Hazards/Events:

- Working at height and over open shaft
- Material or equipment dropped from the headframe during de-mobilisation
- Structural failure of headframe
- Equipment dropped down shaft
- Injuries to persons:
  - electrocution
  - struck or crushed by moving equipment
  - persons falling from height
  - persons struck by falling equipment or material
- Failure to adequately secure plant or equipment as it is disassembled

Hazard Controls:

- Develop and implement a de-mobilisation plan, procedures and schedule:
  - sequence of the winding system disassembly
  - control and prevention of uncontrolled movement of winding system components
  - interaction between various work groups
  - laydown and staging areas
  - traffic management
  - crane operations and lift plans
- Ensuring that the persons undertaking the de-mobilisation are competent

References:

- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Risk management