Guidance Note QGN 30.2

Shaft construction metalliferous mines – Shaft sink – Engineering and design

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 and instruction to the SSE and those involved in the engineering design of shaft sinking and proposed winding equipment.

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Contents

1 Scope

Mine winders are important items of infrastructure in the underground mining industry. These installations comprise of many variations of shaft sinking winding systems and shaft construction design. Shaft sinking winders are used for relatively short term projects associated with the development of new or extension of existing underground mines.

This document is part 2 of a 3 part guidance note for Shaft Construction in Metalliferous Mines. It provides guidance and instruction to the site senior executive (SSE) and those involved in the engineering design of the shaft and associated winding equipment. The outcome from this section is that shaft sinking equipment must be designed for the intended purpose. This includes the shaft sinking system as a whole.

2 Shaft sink – Engineering design

2.1 Infrastructure Layout

Key Considerations:

- Footprint necessary to sink the shaft and construct the associated infrastructure
- Access to, capacity of, and location of site services
- Environmental conditions
- Relationship to and impact of/on existing infrastructure
- Traffic management

Hazards/Events:

- Contact with services, buried or overhead
- Restricted work space
- Inundation
- Personnel struck by moving plant and equipment

Hazard Controls:

- Sufficient space for the tasks being performed including laydown, preassembly and construction
- Traffic management to control the flow of mobile equipment
- Earthworks and civil works to mitigate extreme weather events:
  - Batters / Bunds / Bunkers
  - Water run off (sumps)
- Services supply and isolation points
- 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
- The winder house floor adequately elevated to ensure it is not flooded in the event of heavy local rain.
- Electrical cable floor pits, fitted with appropriate covers and have adequate water drainage

References:

- MQSHR 2017 Part 6 Facilities and processes
  - s 45 Mine layout, design and construction
- MQSHR 2017 Part 10 Plant generally

2.2 Foundations and Collar

The foundation design should conform to the current relevant Australian Standards and building codes.

Foundations are inclusive of the following:

- headframe
- winders

- winder building
- collar.

Key Considerations:

- Geomechanical / environmental
- Height of foundations and infrastructure relative to flood zones
- Adequate water drainage
- Forces imposed on structures and foundations (operational and environmental)
- Concrete specifications
- Reinforcing
- Foundation bolts and anchorage
- Steelwork
- Lightning earth rods, earth grid installation
- Alignment and position of the infrastructure foundations
- Influence of existing infrastructure / services

Hazards/Events:

- Collapse or failure of foundation
- Unstable ground conditions
- Movement of foundations infrastructure
- Storm water inundation

Hazard Controls:

- A geomechanical report that includes:
    - o ground conditions
    - o soil reactivity
    - o soil resistivity
    - o ground water regime
    - o site levels and expected drainage
    - o concrete specifications and associated quality assurance
    - o 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
    - o compaction of ground.
- A complete set of foundation calculations and drawings, certified by a person accredited to do so, available and provided to the persons undertaking construction and the SSE

References:

- MQSHR 2017 Part 6 Facilities and Processes
    - o s 45 Mine layout, design and construction
- AS/NZS 1170 Series Structural Design Actions
- AS 3600 Concrete structures
- AS 1012 Series Methods of testing concrete

Precast and Cut and Fill Shaft Collars

2.3 Electrical Installation

Consideration should be given to how the site power supply will be delivered and distributed to the shaft sinking operations.

Key Considerations:

- Sufficient capacity of electrical supply to meet all shaft sinking activity throughout the life cycle
- Backup power supply
- Documented design/calculations:
  - fault level and load flow calculations
  - protection coordination calculations
  - arc flash / arc blast assessments
  - step and touch potentials (prospective touch voltage)
- Data preservation during brown outs or power outages (PLC/computer)
- The positioning of transformer, switch rooms, motor control centre (MCC)
- Delivery of electrical system into the shaft
- Mains firing lines and initiation systems
- Lightning protection
- Location Isolation and earth leakage devices
- Potential of hazardous atmosphere
- Fire detection and suppression

Hazards/Events:

- Damage to critical electrical infrastructure
- Exposed live electrical components
- Arc-flash/Arc-blast
- Lightning
- EMI – electromagnetic induction

Hazard Controls:

- Arc-flash and Arc-blast rated switchgear
- Engineered earth system
- Engineered lightning protection system
- Emergency power supply
- Backup power supply to run and maintain critical emergency functions
- Transformers and other electrical equipment outside the winder house must be secure and protected

References:

- MQSHR 2017 Part 4 Electrical
  - s 29 Protection from live parts of electrical equipment
  - s.31 Voltage rise
- MQSHR 2017 Part 10 Plant Generally
- MQSHR 2017 Part 13 Winders
- Safety Bulletin 136 – Mine and quarry electrical installation design expectations
- AS/NZS 3000 Electrical Installations (Known as the Australian/New Zealand Wiring Rules)
- AS/NZS 3007 Electrical equipment in mines and quarries – Service installations and associated processing plant
- AS/NZS 3017 Electrical installation - verification guidelines
- AS/NZS 3019 Electrical installation - periodic verification
- AS 1768 Lightning protection
- AS/NZS 1020 The control of undesirable static electricity
- AS 2187 Series Explosives

2.4 Winding System

The shaft sinking winder system could be an amalgamation of existing individual sub-components that are combined for use at a particular project or location, rather than being a single engineered system.

Regardless whether they are an amalgamation or a single system, they should be subject to an engineering assessment and design review to ensure the components are compatible and fit for the intended purpose/project.

Key Considerations:

- Depth and diameter of shaft
- Operating environment
- Shaft construction method
- Winder system specifications:
  - type
  - size
  - capacity
- Compatibility of the winding system components
- Maintainability
- Previous operating history

Hazards/Events:

- Failure of the winding system:
  - headframe
  - rope and attachments
  - control systems
  - drivetrain
  - uncontrolled / unintended movement of a winding system.

Hazard Controls:

- All winder equipment should comply with the relevant Australian Standards, in particular, AS 3637 Series Underground mining – Shaft Equipment and AS 3785 Series Underground Mining – Winding suspension equipment.
- All components of the winding system:
  - are designed by persons holding suitable technical competencies who have experience with the design of such structures
  - are engineered as a single system or are compatible with each other to be able to ensure the effective functionality of the winding system, an overarching risk assessment, such as a Hazard and Operability Study (HAZOP) should be applied to the winding system and its components
  - the final design, calculations and detailed drawings for the winder system should be reviewed
  - the risk assessment and review form part of the records that are kept and maintained for the winder system.
- All previously used components have a service history and associated documentation to confirm they meet the original design criteria and are fit for purpose.

References:

- MQSHR 2017 Part 4 Electrical
  - s.31 Voltage rise
- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations
- AS 3637 Series Underground mining – Shaft equipment
- AS 3785 Series Underground mining – Winding suspension equipment
- Safety Bulletin no 136 – Mine and quarry electrical installation design expectations

- AS/NZS 3000 Electrical Installations (Known as the Australian/New Zealand Wiring Rules)
- AS/NZS 3007 Electrical equipment in mines and quarries – Service installations and associated processing plant
- AS/NZS 3017 Electrical installation - verification guidelines
- AS/NZS 3019 Electrical installation- periodic verification
- AS 1768 Lightning
- AS/NZS 1020 The control of undesirable static electricity

2.4.1 Winder Drum Assembly

Key Considerations:

- General design and construction of winder drums:
  - Size and shape
  - Drum flange height
  - Hawse hole or rope entry position
  - Rope anchorage
  - Shaft and bearings
- Overwind / underwind
- Multi-layer coiling
- Base plate and anchor bolts
- Grooved or smooth drum web
- Guarding of the drum and drive
- Structural/surface condition of previously used drums
- Rope compatibility with drum and fleet angle

Hazards/Events:

- Impact loading on rope (unsafe coiling)
- Failure of drum shaft
- Failure of mounting
- Nip points and moving parts
- Rope whip and harmonics

Hazard Controls:

- NDT drum and components for previously used drums
- QA/QC for previously used drums
- Guarding of nip points/moving parts
- Wedges and risers as needed on drum flanges
- Drum diameter to match rope diameter

References:

- AS 1403 Design of rotating steel shafts
- AS 4100 Steel structures
- AS 1554 Series Structural steel welding
- AS/NZS 3679 Series Structural steel

2.4.2 Winder Brakes

The winder braking system should be designed to apply directly to the drum, be failsafe and capable of bringing the winder to a controlled stop and hold it under all conditions. The performance of winder mechanical brakes, should be adequate for both service and emergency duties.

Key Considerations:

- The operating parameters of the winders:
  - the maximum load that the winder would experience during operation
  - speed

    - maximum acceleration / deceleration
- Type of brakes
- Number of brakes
- Safety factor for brakes and associated components
- Independence of the braking circuits
- Test methodology for brakes
- The efficiency of the brakes
- Access for maintenance and testing
- Method of operation and control
- Environmental operating conditions

Hazards/Events:

- Uncontrolled movement of conveyances
- Inability to stop and hold the conveyances
- Failure of one brake circuit
- Insufficient or excessive rates of retardation

Hazard Controls:

- Each winder drum shall be fitted with at least two independent fail-safe braking systems fitted directly to the drum:
    - a failure of a component within one braking system must not affect the operation of the other system
    - independent brake systems must not apply to the same brake path
    - each brake system must be designed so that each brake system is capable of being tested independently
    - emergency braking function should be designed not to injure personnel during retardation.
- Each brake system designed to hold twice the maximum static out of balance load, taking in account the rope weight, attachments, conveyances and rope layering on the drum.
- Band brakes should not be used in shaft sinking operations.
- The winder drive system capable of providing sufficient torque to be able to test and confirm that each brake system is capable of holding twice the maximum static out of balance load.
- The following information relating to the winder brakes provided and maintained for the winder:
    - the method and parameters for conducting brake tests
    - operating and maintenance manual that includes:
        - detailed drawings and specifications
        - engineering design calculations
        - recommended inspection and maintenance frequencies.
- Each brake system fitted with monitoring and warning devices (refer to winder control systems).
- Design of winder components takes into account the environmental and operational conditions to ensure that they do not affect the operation of the brake system.

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 10 Plant generally
    - s.100 Selection and design

Examples of disc and shoe brake assemblies

2.4.3 Winder Ropes

Key Considerations:

- Purpose of and anticipated load on rope
- Maximum shaft depth
- Rope compatibility with drum, sheaves and attachments
- Rope properties:
  - lay
  - non spin
  - breaking strain
- Rope history including:
  - inspection
  - testing and NDT
- rope certificates
- rope capping

Hazards/Events:

- rope fails in service:
  - overload
  - mechanical damage/fatigue
  - corrosion
- overwind of conveyance, rope braking and conveyance falling down shaft or onto collar.

Hazard controls:

- The rope should be compatible with the drum, sheaves and attachments.
- The rope load used in the factor of safety calculation based on the worst case scenario and the following should be considered:
  - conveyance including its payload
  - mass of the rope down the shaft
  - wind load (downcast shafts)
  - live loads
  - rope attachments.
- Rope length such that:
  - there is sufficient length for rope cropping during the life of project
  - a minimum of three (3) complete dead coils are retained on the drum at all times.
- The winding history maintained for all ropes and should include:
  - the rope certificate (manufactures specification)
  - the date on which the rope was installed
  - the dates when the rope was cropped
  - the dates when the test samples were removed from the rope
  - the certificate for the destructive and non-destructive rope testing.

- Conduct regular rope maintenance and inspections.
- Rope capping performed by competent persons as per OEM instructions.
- If existing capping integrity on the rope cannot be confirmed the rope should be removed from service.
- When establishing the safety factor to be applied to a particular rope the following should be taken into account:
  - hoisting speed
  - torque applied to the rope
  - depth of shaft
  - diameters of rope
  - maximum of acceleration/deceleration
  - type of rope construction / configuration
  - type of duty / use i.e. will it be hoisting men or material
  - duty cycles
  - environmental conditions
  - number of ropes
  - monitoring / maintenance of ropes
  - frequency of NDT
  - worst case rope load
  - the minimum breaking force (MBF).
- While the MQSHA and MQSHR do not stipulate a factor of safety, when establishing the factor of safety, take account of industry accepted practice – see example in table below:

Proposed Use of Rope	Minimum Factor of Safety
Raising and lowering a man-cage or kibble	7.5 less 0.001L, where L is depth of shaft.
Raising and lowering a sinking stage	>6

References:

- AS 2759 Steel wire rope – Use, operation and maintenance
- AS 1394 Round steel wire for ropes
- AS 3569 Steel Wire Rope – Product specification
- AS 4812/NZS Non-destructive examination and discard criteria for wire ropes in mine winding systems
- AS 3637.1 Underground Mining – Winding suspension equipment Part 1: General Requirements
- AS 3637.3 Underground Mining – Winding suspension equipment Part 3: Rope cappings

2.4.4 Winder Control Systems

Winder control systems include all mechanical, electrical, electronic, and computerised systems for controlling the operations of the winding system. The control system shall prevent, as far as reasonably achievable, any shaft conveyance from overwind, overload and over-speed.

Key Considerations:

- Determination of the operating parameters
- Critical safety functions of the winding system that need to be monitored and controlled to ensure the winder remains within the operating parameters:
  - overwind
  - load
  - speed
  - deceleration/acceleration
  - slack rope
  - conveyance position within shaft
  - braking function:

        - condition
        - position
    - position of equipment that could impede the travel of conveyances
    - motor current
- The nature, type and position of devices that will be used to monitor and control the critical safety functions
- Where and how to display and record the output of the safety critical functions
- Communications
- Signalling system
- Management of over voltage / under voltage effects

Hazards/Events:

- Uncontrolled / unintended movement of a winding system
- Conveyance collides with an obstruction within the shaft
- Overspeed of conveyances
- Overload of the conveyance or winding system
- Overwind

Hazard Controls:

- Design and install the control system in accordance with the legislation and applicable standards.
- All safety critical functions and devices needed to monitor and control the safe use of the mine winder shall be identified and documented by the designer.
- The engineering design should determine the minimum safety integrity level or minimum category level for each identified safety function:
    - safety circuits shall not be dependent upon single line component.
- If the winding system operates or functions outside its design parameters, the control system shall automatically intervene and bring the system to a safe state.
- The engineering design to provide for a detailed manual which includes:
    - the operating parameters, functional description, software and schematics
    - an inspection and maintenance regime.
- Transient voltage protection.
- Cameras strategically placed for critical visual monitoring.
- Backup versions and copies of critical control parameters.

When considering the controls necessary for the winding system the following should be taken into account:

Winder:

- The motor fitted with current monitoring that indicates the load on the motor and when entering a potential overload brings the system to a safe state.
- Indications provided for:
    - self-centre control and positive action
    - raise and lower control lever
    - interlock between winders enabling only one conveyance to be moved at a time
    - brakes:
        - wear
        - air gap
        - Position (applied/released)
        - temperature
    - winder drum rollback
    - drum speed
    - motor speed
    - differential speed between drum and motor.

Hydraulic System:

- Oil temp e.g. oil temperature too low or too high
- Hydraulic system pressure

Rope:

- Slack rope
- Unsafe coiling
- Load monitoring
- Cross head separation

Speed:

- Speed indicators:
  - overspeed
  - ramp speed at:
    - stage approach
    - collar approach.

Shaft Controls:

- Overwind protection:
  - for each conveyance, an overwind and an ultimate overwind limit should be provided
  - each shall be connected into two different control circuits arranged to cut off the power to the winder and apply the brakes when activated
  - the distance between the overwind limit and ultimate overwind limit should be sufficient to enable the conveyance to stop before it reaches the ultimate overwind limit
  - the distance between the ultimate limit and the arrestors / catchers should be sufficient to enable the conveyance to stop before it reaches the arrestors / catchers
- Tipping Chute Interlocks:
  - position of tipping chute
  - tipping chute, collar doors and conveyances are interlocked:
    - prevent conveyances from colliding with tipping chute
    - prevent tipping when the collar doors are open
- collar door position open/closed
- stage upper limit
- stage gates
- position in shaft:
  - stage
  - kibble / man-cage.

Location of E-stops:

The winding system should be fitted with emergency stops at appropriate readily accessible locations, for example:

- Winder MCC
- Tipping chute
- Brace
- Winder control room
- Man-cage/kibble (if used for man riding)
- Stage (every deck)
- Shaft bottom
- Other locations as identified by the design risk assessment

Communication system:

At least two independent methods of communication that function under all conditions should be provided, in the following locations as a minimum:

- Winder MCC
- Winder control room

- Brace
- Service conveyances
- Stage (every deck)

Visual Monitoring:
Within the winder control room a monitor should be installed to view the following locations:

- Tipping chute
- Ultimate overwind approach limits
- Sheave deck
- Collar doors
- Stage, on every deck

References:

- MQSHR 2017 Part 4 Electrical
- MQSHR 2017 Part 10 Plant generally
  - s.100 Selection and design
  - s 102 Plant controls and control systems
- MQSHR 2017 Part 13 Winding operations
  - s.126 Winders
- AS/NZS 4024 Series Safety of machinery
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

Examples of winder controls

2.5 Headframe and Components

The design chosen for a headframe is usually dictated by the site layout whether above or below ground level and revolves around shaft depth, winder capacity, rope strength, winder duty calculations, safety features and dimensions of equipment that needs to be lowered down the shaft.

Key Considerations:

- The maximum design loads (inclusive of dead loads, live loads, rope break, wind loads etc.)
- Shaft size (depth, diameter)
- Head sheave arrangement
- Environment
- Geomechanical conditions
- Height
- Dimensions of plant equipment lowered down the shaft
- Size and shape of the collar doors
- Method of tipping muck
- Normal operating requirements to accommodate conveyances plant and equipment

- Overwind protection:
  - o Approach limits/speeds
  - o Arrestors/catchers
- Permanent or temporary headframe
- Access for inspections and maintenance

Hazards/Events:

- Structure failure
- Winding conveyances/plant equipment colliding into the headframe structure
- Persons struck by falling objects
- Persons falling from heights
- Entanglement

Hazard Controls:

- Access ways and platforms must be provided up the headframe to allow for inspection, testing and maintenance.
- The distance above the ultimate overwind position should be sufficient to allow a conveyance to be brought to a controlled stop.
- Allow for the safe unloading of personnel from a cage or kibble if an overwind occurs
- Recovery method:
  - o restoring power supply in an overwind situation
  - o detached conveyance
  - o conveyance suspended within jack catches.
- Headframe should be of sufficient height to allow conveyances, plant and/or equipment to be suspended and lowered through the shaft collar without impeding or interfering with the operation of the collar doors.
- Engineering design drawings, specifications, calculations, inspections and maintenance procedures are documented and maintained.

References:

- MQSHR 2017 Part 13 Winding operations
  - o s.100 Selection and design
- AS 3785.1 Underground Mining – Shaft equipment Part 1: Shaft overwind safety catch system
- AS 3785.2 Underground Mining – Shaft equipment Part 2: Shaft winding arresting systems
- AS 3785.3 Underground Mining – Shaft equipment Part 3: Drum winding gripper systems
- AS 3785.5 Underground Mining – Shaft equipment Part 5: Headframes
- (withdrawn)AS 4100 Steel structures
- AS 3990 Mechanical equipment – Steelwork

Examples of a shaft sinking headframe

2.5.1 Head Sheaves

Key Considerations:

- Configuration of head sheaves and number of ropes proposed:
  - shaft type
  - insert type
  - bearing type
- Compatibility of sheave with rope
- Access for inspection and maintenance
- Loads on the sheave

Hazards/Events:

- Structure failure
- Damage to structure, rope and components
- Persons falling from height
- Entanglement

Hazard Controls:

- Conduct, daily, weekly and monthly routine visual inspections
- Access ways and platforms must be provided up the headframe to allow for inspection testing and maintenance
- Engineering design drawings, specifications, calculations, inspections and maintenance procedures are documented and maintained
- Conduct non-destructive testing (main loadbearing components)

References:

- AS 3785.7 Underground mining shaft equipment – Part 7:Sheaves
- AS/NZS 4024Series Safety of machinery
- AS 1657 Fixed platforms, walkways, stairways and ladders-Design construction and installation

2.5.2 Tipping Chute

Key Considerations:

- Prevention of rock / water spillage into shaft or around shaft collar
- Functional interlocks and sequencing:
  - conveyance does not collide with the tipping chute
  - collar doors are closed prior to the tipping chute being lowered or raised
- Mass of the loaded kibble
- Method of tipping
- Tipping chute controls, operation and actuation
- Access to the tipping chute for inspection and maintenance
- Design of tipping system to minimise wear on attachments

Hazards/Events:

- Failure of the tipping chute
- Personnel struck by falling material
- Kibble colliding with tipping chute structure
- Damage to winder ropes and attachments

Hazard Controls:

- Tipping chute sized according to kibble load capacity
- Discharge angle of chute should be designed to allow material to flow freely
- Function interlocks
- Splash back barrier

- Kibble travel limits / speed control:
  - approaching collar doors
  - approaching ultimate overwinds
  - approaching stage conveyance.

Reference:

- AS 1657 Fixed platforms, walkways, stairways and ladders - Design construction and installation

2.6 Collar Door Design

Collar doors seal the shaft entrance at the shaft collar to provide safe access to the main winder conveyance (kibble/man-cage) when it is on the surface and provides 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.

Key Considerations:

- Load rating
- Size of the door opening
- Number and position of rope centres within the shaft
- Guarding around shaft collar doors when opened
- Stage chairing points
- Direction from which plant and equipment is brought onto the collar door

Hazards/Events:

- Failure of the collar doors
- Personnel, plant, equipment or material falling down shaft
- Personnel being struck by falling objects
- Conveyances colliding with collar doors
- Rope damage

Hazard Controls:

- Collar doors designed:
  - so that when in the open position passage of all conveyances and equipment is achieved with adequate gap clearance
  - to be rated for a specific load capacity and designed to overhead protection standards
  - to be manually opened and closed in the event of a power failure.
- Where hinged doors are used they should form part of the barrier to the open shaft.
- Ensure that the closed doors are sealed and do not allow any items to fall down the shaft.
- In the event of a power failure the doors remain in the position they were in.

References:

- MQSHR 2017
  - s.108 – Monitoring
  - s.124 – Control measures to protect against persons and things falling into shafts
- AS/NZS 1891 Series Industrial fall-arrest systems and devices

2.7 Conveyances

2.7.1 Kibble

The kibble design is relatively simple compared to a man-cage. However the structural factors of safety given for personnel riding conveyances should be observed where the kibble is used for carrying personnel.

Key Considerations:

- The intended use for the kibble and associated loads:

    - muck only
    - man-riding
    - concrete
- The size of the kibble well in the stage
- The stability of the kibble whilst being raised and lowered
- Access and egress provisions for personnel
- Provision to secure tools and equipment being transported within the kibble
- Ensuring where personnel are riding in the kibble that they are confined within the perimeter of the kibble
- Overhead protection
- The intended method for loading and tipping
- Communication systems
- Height clearance between collar doors and headframe

Hazards/Events:

- Personnel struck by falling objects
- Kibble conveyance fouls on shaft infrastructure
- Personnel are injured or crushed as a result of body parts protruding outside the kibble
- Falling down shaft when transferring from one conveyance to another

Hazard Controls:

- A kibble used in shaft sinking should be of robust construction and shall be of a shape that will permit its free travel between the highest and lowest points of travel
- The gap clearance between the kibble and conveyances do not allow for a person to be caught or crushed between the kibble and conveyance
- Lead-in on top and bottom of the kibble, with an aspect ratio that eliminates fouling
- Kibbles used for the transport of people or material, should be provided with at least a three chain suspension system
- Kibbles designed to be self-tipping on the release of a locking mechanism should not be used for personnel riding
- Steps to be provided inside and outside of the kibble for personnel access
- Kibbles used for the purpose of man-riding designed so that persons are not exposed to an open shaft and are fully protected from any pinch points and attached to the kibble
- Capacity rating and unique kibble identification indelibly marked on the kibble
- Where equipment is to be transported within the kibble suitable restraint and anchor points should be provided
- Chains and shackles used for the suspension of a kibble should be a matched set and should be designed, constructed and tested in accordance with Australian Standards
- All chains, shackles and other attachments should be uniquely identified and indelibly marked
- Kibble chains should be of sufficient length to ensure that the included angle at the apex of the suspension of any two chains is not greater than 60 degrees
- Kibble chains should have a combined factor of safety of not less than 20
- Communication and Emergency Stops should be available for use e.g. pendant control, and radio communication
- Proof loading

References:

- MQSHR Part 13 Winding operations
    - s.125 Conveyances
- AS 3785.4 Underground mining – Shaft equipment Part 4: Conveyances for vertical shafts
- AS 3637.6 Underground mining – Winding suspension equipment Part 6: Shackles and chains

2.7.2 Man-cage

Key Considerations:

- The size, capacity and intended loads of the man-cage
- The stability of the man-cage whilst travelling
- Access and egress provisions for personnel
- Ensuring where personnel are riding in the man-cage that they are confined within the perimeter of the conveyance
- Functional Interlocks
- Overhead protection
- Communication systems
- Equipment falling out of or protruding from the man-cage
- Location of battery sets
- The compatibility with site emergency response equipment

Hazards/Events

- Falling down shaft when transferring from one conveyance to another
- Man-cage conveyance fouls on shaft infrastructure
- Personnel are injured or crushed as a result of body parts protruding outside the man-cage
- Failure of communication
- Failure of interlocks
- Personnel struck by falling objects

Hazard Controls:

- Lead-in on top and bottom of the man-cage, with an aspect ratio that eliminates fouling
- The gap clearance between the man-cage and conveyances does not allow for a person to be caught or crushed between the man-cage and conveyance
- Ensure gap clearances of collar doors and stage conveyances are adequate to prevent fouling
- The sides of each compartment of the man-cage covered with metal plates or expanded metal to prevent any part of a person or material in the man-cage from protruding outside the man-cage
- The floor of the man-cage should be solid
- Doors do not protrude outside of the man-cage envelope when opened
- A double actioned door latch should be fitted to a man-cage
- Man-cage doors should be interlocked with winder
- Provision to secure tools and equipment being transported within the man-cage
- Communication system and failsafe stop button should be fitted within the man-cage
- A fall arrest system and attachment point fitted within the man-cage
- Communication, stop switch and signalling system
- Provisions for access and egress
- Proof loading
- Battery set should be positioned under the floor

Reference:

- AS/NZS 3785.4 Underground mining – Shaft equipment Part 4: Conveyances for vertical shafts

2.7.3 Stage

Key Considerations:

- The diameter of the stage matches the intended diameter of the completed shaft
- The size, capacity and intended loads for the stage
- The ability for muckers and equipment to pass through the stage kibble well

- The ability to traverse the sinking stage past the shaft services (e.g. air, water, vent duct) during all stages of shaft construction
- Overhead protection (top deck)
- Positioning of ropes and attachments:
  - Guide rope configuration
- Kibble well lead-In entry and exit points
- The ability to monitor the loads on the stage
- Position of the mucker controls to protect the operator from a moving kibble
- The ability to stabilise the stage (stage-jacks)
- Design of crosshead stop block
- Permanent installation of lighting for each work deck
- Fall arrest systems
- Stage entry/exit points
- Lifting anchor points

Hazards/Events:

- Falling down shaft
- Stage conveyance fouls on shaft infrastructure
- Personnel are injured or crushed between moving conveyances
- Failure of communication
- Failure of interlocks
- Personnel struck by falling objects

Hazard Controls:

- Covered under stage deck layout
- Conveyance travel way is fully enclosed ensuring no persons , equipment or tools can protrude in the pathway of travelling conveyances
- Fall arrest system and attachments available on each work deck of the stage
- Stage has a fall arrest retrieval system available
- Adequate lighting for the detail of the task being performed, fitted to all stage work decks
- Stabilizing jacks should be fitted when using stage mounted muckers
- Overhead protection must be provided
- Handrails and kick boards fitted to all decks
- Safety meshing fitted around the kibble well between decks
- Ladder-ways have fall arrest system or cages provided
- Trapdoors fitted with self-closing device or hand rail around opening
- Modular handrails
- Design of crosshead stopblock to prevent crush injuries
- Load cells
- Provision for storage, i.e. scaling bars/jack picks
- Stage deck layout:
  - Muckers
  - Drilling equipment
  - Shotcrete / grout pumps
  - Octopus
  - Stage rope sheaves (self-levelling)
  - Stage jacks
  - Distances between decks to match services/shuttering
  - Gap clearances between stage and shaft wall kept to a minimum
  - Self-closing and self-locking gates with full height of meshing/guarding
- Chairing / anchor point provision
- Proof loading

References:

- MQSHR Part 13 Winding operations
    - s.124 Control measures to protect against persons and things falling down the shaft
- AS/NZS 3785.4 Underground mining – Shaft equipment Part 4: Conveyances for vertical shafts
- AS 1657Fixed platforms, walkways, stairs and ladders – Design, construction and installation

2.8 Suspension Attachments

2.8.1 General Specifications

All attachments, lifting and slinging equipment should be designed, manufactured, installed and maintained as detailed in the relevant Australian Standards.

Key Considerations:

- Rated for the maximum load
- Compatibility with other attachments and components
- Inspection and testing history

Hazards/Events:

- Failure of attachments or lifting equipment
- Personnel struck by falling equipment

Hazard Controls:

- All components are designed to Australian Standards
- Engineering design drawings, specifications, calculations, inspection and maintenance procedures must be documented and maintained
- All components must be uniquely Identified
- Components should be matched

References:

- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations
- AS 3637.1 Underground mining – Winding suspension equipment – Part 1: General requirements
- AS 3637.2 Underground mining – Winding suspension equipment – Part 2: Detaching hooks
- AS 3637.3 Underground mining – Winding suspension equipment – Part 3: Rope cappings
- AS 3637.4 Underground mining – Winding suspension equipment – Part 4: Drawbar and connecting links
- AS 3637.5 Underground mining – Winding suspension equipment – Part 5: Rope swivels and swivel hooks
- AS 3637.6 Underground mining – Winding suspension equipment – Part 6: Shackles and chains

2.8.2 Crosshead Guidance System

A Crosshead is attached to guide ropes, to steady a conveyance travelling in the shaft. The stage ropes are generally used as the guide ropes for the conveyance.

Key Considerations:

- Compatibility with ropes
- Ability to detect unintentional crosshead separation from conveyance
- Overhead protection
- Crosshead stop block height on the stage conveyance
- Guide rope configuration

Hazards/Events:

- Crosshead separates from travelling conveyance and fouls on guide ropes
- Damage to rope
- Personnel struck by falling equipment
- Personnel crushed between crosshead and stage

Hazard Controls:

- A shaft sinking crosshead for the winder system, should be designed and constructed to:
  - steady the kibble or other conveyance while it is travelling in the shaft
  - provide free travel for any conveyance travelling within the shaft
  - stop the winder if the crosshead is separated from the kibble inadvertently whilst in motion (a separation switch should be fitted)
  - provide personnel overhead protection, whilst travelling within a shaft.
- The crosshead guide shoes should be machined to match the rope diameter and monitored for wear.
- Crosshead stop blocks on the stage to be designed so that there are no pinch points for personnel.

References:

- MQSHR 2017 Part 13 Winding operations
- AS 3637.1 Underground mining – Winding suspension equipment – Part 1: General requirements
- AS 3637.3 Underground mining – Winding suspension equipment – Part 3: Rope cappings
- AS/NZS 3785.4 Underground mining—Shaft equipment Part 4: Conveyances for vertical shafts

2.9 Mobile Cranes

In general, the use of a crane and a work platform is governed by industry practice. However in shaft sinking the work platform that is, to all and intents and purposes, a single deck stage, should be treated as a stage. Refer to section 2.7.1.

Key Considerations:

- The total intended depth that the crane will be used for during the pre-sink
- The total load that the crane will lift during the pre-sink
- The intended position for the crane during the pre-sink
- The ability of the crane to carry the weight of the fully loaded conveyance, including the factor of safety
- The ability to limit or control some crane functions, such as freefall, slewing/stop position and ultimate hook position
- Method of communication between crane driver and personnel within the shaft
- The ability to confirm the weight of the load attached to the hook at all times
- Contingencies or backup plan in the event of a crane failure

Hazards/Events:

- Uncontrolled movement of the crane
- Uncontrolled or unintended movement of the stage conveyance
- Unguided conveyance with the potential to contact or foul on shaft wall or services

Hazard Controls:

- Ensure that the crane selected has current inspection and test certificates
- Crane is fitted with an additional brake on the hoist drum Establish the total mass of the fully loaded conveyances
- The rated capacity when persons are suspended should not be exceeded.
- Disable or limit any freefall control functions
- Confirm anti two-block and load cell are fitted to the crane and are functioning

- Prior to the initial lift commencing and thereafter daily, conduct a static brake hold test to confirm the brakes are capable of holding 1.6 times the rated capacity
- A shaft pre-sink that utilises a crane should not exceed 50m depth
- Ensure that the pad is of sufficient size and has adequate compaction of ground
- A second means of egress must be available in case of the failure or breakdown of the main crane

References:

- MQSHR 2017 Part 5 Emergencies
    - s.32 Risk management for emergencies
- AS 1418.1 Cranes, hoists and winches Part 1: General requirements
- AS 1418.5 Cranes, hoists and winches Part 5 Mobile cranes
- AS 2550.1 Cranes, hoists and winches - Safe Use Part 1: General requirements
- AS 2550.5 Cranes, hoists and winches – Safe use Part 5: Mobile cranes

2.10 Slewing Headframes

The design, function and controls of the winders for a slewing headframe are the same as those for fixed winders, refer to Section 2.4. This section relates to the key considerations, hazards and controls for the slewing function of the headframe.

Key Considerations:

- The base of the headframe when positioned and aligned to the shaft does not protrude into the shaft travel way
- Centring of the slewing headframe to the shaft before any travel within the shaft
- Ensuring that the slewing headframe does not move off centre whilst conveyances travel up or down the shaft
- Exclusion zones whilst operating

Hazards/Events:

- Uncontrolled movement of the slewing headframe
- Uncontrolled or intendant movement of the stage conveyance
- Unguided conveyance with the potential to contact or fouls on shaft wall
- Falling down open shaft

Hazard Controls:

- A locking system to ensure that the headframe is and remains positioned to the centre of the shaft when hoisting takes place
- This locking system is independent of the slewing drive or braking system
- An interlock to prevent or stop hoisting if the headframe moves off centre
- The headframe designed and positioned so that the base of the headframe does not protrude over the shaft
- Fencing and guarding around shaft collar when no collar doors are used
- Work platform designed to match the diameter of the shaft and provide overhead protection
- Rail stop blocks

References:

- MQSHR 2017 Part 10 Plant generally
- MQSHR 2017 Part 13 Winding operations
- AS 3785.5 Underground Mining – Shaft equipment Part 5: Headframes
- AS 4100 Steel structures
- AS 3990 Mechanical equipment – Steelwork
- AS/NZS 4024 Series

2.11 Mucking Systems

Key Considerations:

- The mucking system weight and dimensions
- Weight distribution of muckers in relation to the stage balance and swinging within the shaft
- In strip and line with a floor mounted mucker, the plug is able to support the load of the mucker
- Motion effect on ropes and attachments during operation
- Headframe height clearance
- Dimensions of kibble-wells and collar doors
- Positioning of controls for stage mounted muckers
- Falling object protection for floor mounted muckers
- Ventilation
- Access to stage mounted muckers for maintenance or repair
- Lifting and slinging points for muckers

Hazards/Events:

- The mucking units foul or catch on the collar doors or the stage kibble well whilst being raised or lowered
- Mucking units falls or detaches whilst being raised or lowered
- The weight or positioning of the mucking unit causes the stage to be off balance or overloaded
- Mucker operators being struck by the kibble whilst operating the mucker
- Fumes or fire
- Uncontrolled release of pressure (air or hydraulic)
- Uncontrolled movement of the stage

Hazard Controls:

- The mucking units sized so that they are able to pass through the kibble wells and collar doors
- Mucking units should have engineered, certified lifting points
- The shaft height clearance should be such that the mucking unit/machine can be fully slung with the collar doors open
- Controls for stage mounted muckers positioned so that no part of the operator protrudes in the kibble well during operation
- Overhead protection provided for floor operated muckers
- Diesel powered floor mounted muckers fitted with fire suppression and fire extinguishers
- Stage mounted muckers positioned so the stage is balanced or not overloaded
- Install whip lash slings and burst sleeves on hoses
- Slinging of mobile mucking machines from underneath the sinking stage should be avoided
- Where diesel engines are used, emissions are monitored and controlled
- For stage mounted mucking units an emergency stop must be positioned at the controls; in circumstances where the power-pack is remote to the controls then an additional emergency stop must also be located at the power-pack
- Shaft plugs designed and engineered:
    - Fit for its intended use (sealed plug or mucking plug)
    - Fit through a kibble well
    - Certified lifting attachment points
    - Rated to carry a load
    - Sized to match the reamed hole
    - When installed minimise the gap between the plug and floor
    - Not adversely affect ventilation flow when installed

Example of an overshot mucker

Example of an excavator in use during a shaft sink

Example of a cryderman mucker

Example of cactus grab muckers in use

References:

- MQSHR 2017 Part 10 Plant generally
- AS 4100 Steel Structures
- AS 3990 Mechanical Equipment – Steelwork

2.12 Shaft Lining Components

Key Considerations:

- The diameter of the shaft and the intended thickness of the concrete lining
- The method of securing, raising and lowering shutters
- The intended load of the anchor and lifting points
- The ability to split the formwork into shorter sections
- Method of delivering concrete down the shaft e.g. slick-line or concrete kibble

Hazards/Events:

- Personnel struck by falling concrete or plant
- An anchor point or lifting point fails
- Lifting equipment fails
- Concrete shutters fail under load

Hazard Controls:

- Position and design hopper to be offset to the shaft
- Slick-line and couplings should be rated to withstand potential pressures. This includes foreseeable abnormal circumstances such as blockages
- The method of raising and lowering the formwork in preparation for a concrete pour should be independent of the stage conveyance (attached to the shaft wall)
- Height of shutters and kerb ring able to be split into smaller sections to allow for altered conditions within the shaft
- Each chain block used to raise and lower kerb rings must be rated to carry the full load of the kerb ring and shutters
- The lifting lugs on the formwork sufficiently rated to carry the full load of the formwork and wall brackets
- Concrete ferrules – sized to ensure adequate concrete cover and designed to prevent them from pulling out of the concrete under load (e.g. secured with mesh and reinforcing bars)
- The key way within the formwork (concrete door) needs to be of sufficient size to allow the formwork to release off the wall when crimped
- The number and size of hanging rods calculated to ensure they are able to hold and carry the suspended concrete load of the full shutter height
- Kerb ring, scribing bars and associated timbers designed to carry the concrete load

References:

- AS 4100 Steel Structures
- AS 3990 Mechanical Equipment – Steelwork
- AS 3600 Concrete Structures
- AS 3610 Formwork for concrete

2.13 Shaft Services

Key Considerations:

- The ability to traverse the sinking stage past the shaft services (e.g. air, water, vent duct) during all stages of shaft construction
- Design and installation of services (e.g. electrical, ventilation, air, water, concrete slick line, communications, plum bob lines, mains firing line)
- Most adverse load imposed on wall mounting brackets and anchor points

- Most adverse pressure imposed on service pipes and components
- Load rating of all shaft wall brackets, bolts and nut-boxes.
- Load rating of all clamps and lifting points.
- Suitable ventilation

Hazards/Events:

- Uncontrolled release of energy (e.g. water, air, electrical)
- Personnel struck by falling plant
- Shaft services protruding into the conveyance travel way

Hazard Controls:

- Isolation points (air, water, power / electricity)
- Sufficient design pipework
- Wall brackets rated and must be fit for purpose
- Install water pressure reducers
- Mechanical protection and separation of electrical cables within shaft steelwork
- All free hanging services securely fixed to the shaft wall
- Slinging and wall mounted attachments rated and fit for purpose
- Services pipes rated and fit for purpose

References:

- MQSHR 2017 Part 10 Plant generally
    - s.100 Selection and design
- AS 4024.1603 Safety of machinery Part 1603: Design of controls, interlocks and guards—Prevention of unexpected start-up
- AS 4100 Steel Structures
- AS 3990 Mechanical Equipment – Steelwork