NSW GOVERNMENT

NSW Resources Regulator

TECHNICAL REFERENCE GUIDE

POWERED WINDING SYSTEMS

Part 3: Vertical shaft winders (drum, friction, shaft sinking and emergency winders)

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Date	Version	Amendment
January 2020	1	Original version Supersedes MDG 33 (1998), MDG 12 (1992), MDG 26 (1999) and MDG 2005 (2003). Reflects 2020 NSW WHS legislative framework. Developed in consideration of current Australian standards, international standards, the EES008 series and industry feedback from the 2011 consultation process for draft MDG 33 (1-7) series.

DOC18/469856

Contents

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1. Introduction

1.1. Scope and application

Part 3 of the *Technical Reference Guide: Powered winding system* series covers the specific design requirements applicable to the following vertical shaft winding systems:

- ***Vertical shaft drum winding system*** means a drum winding system that operates in a vertical shaft.
- ***Friction (Koepe) winding system*** means a vertical shaft winding system in which conveyances are raised and lowered by means of multiple ropes passing over a driving sheave, such that the driving force is transmitted from the sheave to the ropes by friction.
- ***Shaft sinking winding system*** means a drum winding system that is used on a short term basis for the development, equipping or refurbishment of vertical shafts. A shaft sinking winding system is relocatable and is not a permanent fixture.
- ***Emergency egress winding systems*** means a winding system that is used solely for emergency egress.

The following definitions are provided for further clarification of the above terms:

- ***Winding system*** has the same meaning as it has in clause 3 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.
- ***Drum winding system*** means a winding system in which a conveyance is raised and lowered by means of a single rope attached directly to the conveyance and the rope is wound onto a cylindrical drum. A drum winding system includes a winder with two drums (double drum), each raising and lowering a conveyance.
- ***Vertical shaft winding system*** means a winding system that operates in a vertical shaft and includes vertical shaft drum winding systems; friction (Koepe) winding systems; shaft sinking winding systems; and emergency egress winding systems.

Note: As shown in the table below, parts 1 (General requirements), 4 (Ropes) and 5 (Winder control systems) also apply to vertical shaft winding systems.

WINDER TYPE	APPLICATION OF *TRG: POWERED WINDING SYSTEMS*				
	Part 1: General requirements	**Part 2**: Drift winders	**Part 3**: Vertical shaft winders (drum, friction, shaft sinking and emergency winders)	**Part 4**: Ropes	**Part 5**: Winder Control systems
Drift	☑	☑		☑	☑
Vertical shaft drum	☑		☑	☑	☑
Vertical shaft friction (koepe)	☑		☑	☑	☑
Shaft sinking	☑		☑	☑	☑
Emergency egress	☑		☑	☑	☑

Part 3 of the series should be used by designers, manufacturers, owners and end users with consideration to:

- designing new powered winding systems (PWS)
- verifying new PWS
- applying for design registration of PWS
- altering existing PWS
- carrying out five yearly audits of PWS
- reviewing PWS designs following an incident
- altering, maintaining or repairing PWS.

1.2. Abbreviations and definitions

For the purposes of this guide, the abbreviations and definitions in *Technical reference guide: Powered winding systems – part 1: General requirements* apply.

1.3. References

Refer to the Appendix for a list of Australian and international standards referenced in this series.

Note: All Standards referred to in this series relate to the current revision of the Standard, as amended from time-to-time.

2. Design and construction

2.1. General description

2.1.1. Vertical shaft drum winders

Note: Shaft sinking winders (refer to clause 2.1.3.) are a type of vertical shaft drum winder.

Vertical shaft drum winders wind people and/or materials in vertical mine shafts, using one or two ropes coiling typically onto a single drum. Drums may also be configured to use two drums for the same shaft (double drum) with a conveyance attached to each rope and drum. Drums and driving machinery are located at ground level, in a house or room, at sufficient distance to give the required fleet angle, with the rope positioned over the shaft by a headsheave.

Figure 1 Vertical shaft drum winder - shaft top installation

Figure 2 Ground mounted, vertical shaft double drum winder

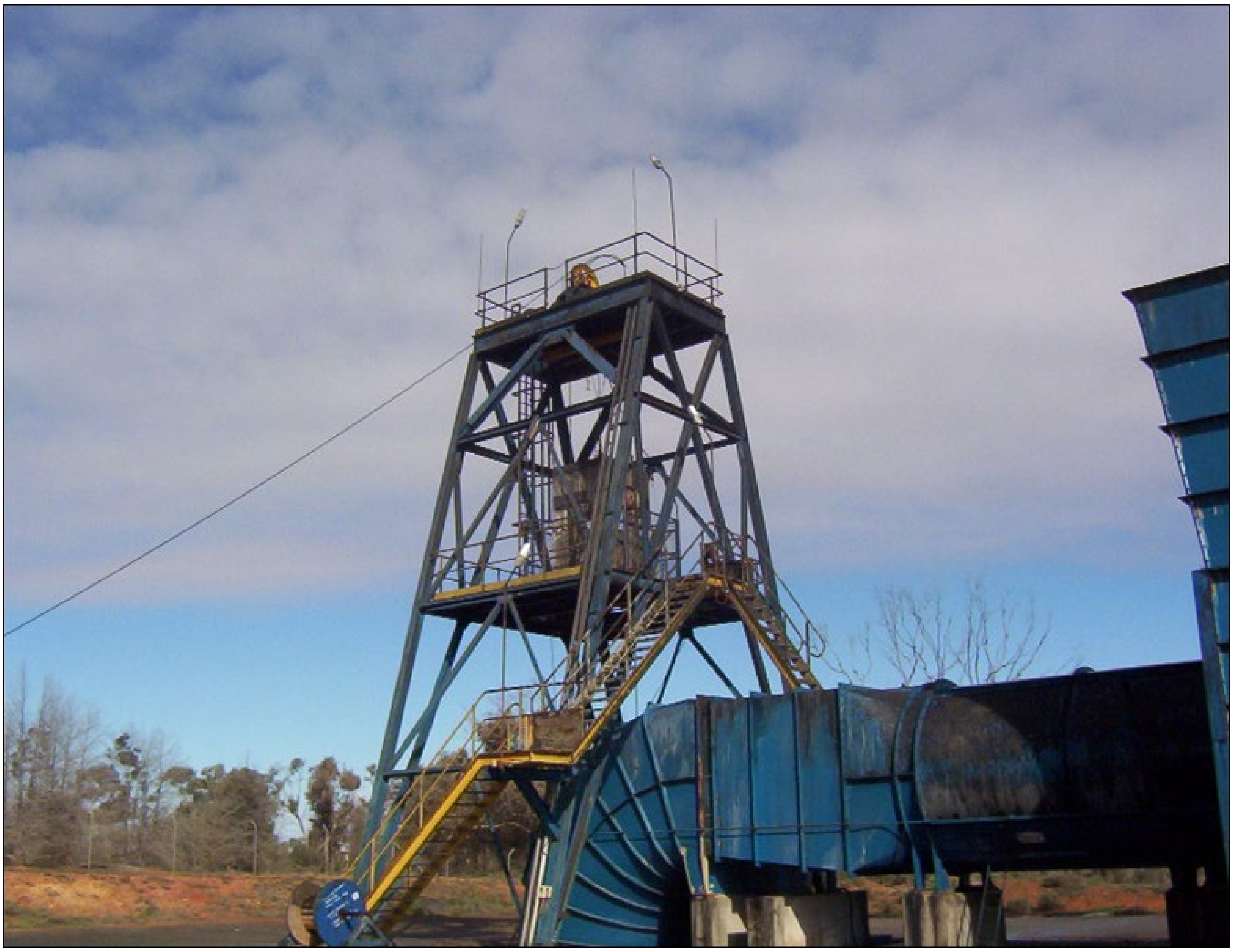
2.1.1.1. Single drum personnel and material winders

Single drum personnel winders are designed generally for winding people and small equipment using a single conveyance. They are typically slow speed winders where high volume is not needed.

Small, single drum material winders are also this type of design when only small volumes of materials using a single skip are transported, rather than people. These may have a personnel conveyance attached to the skip for emergency egress and shaft inspections.

These types of winders are often used for emergency egress in shallow seams and for small mining operations where larger numbers of workers underground, higher cost and higher capacity winding loads are not required.

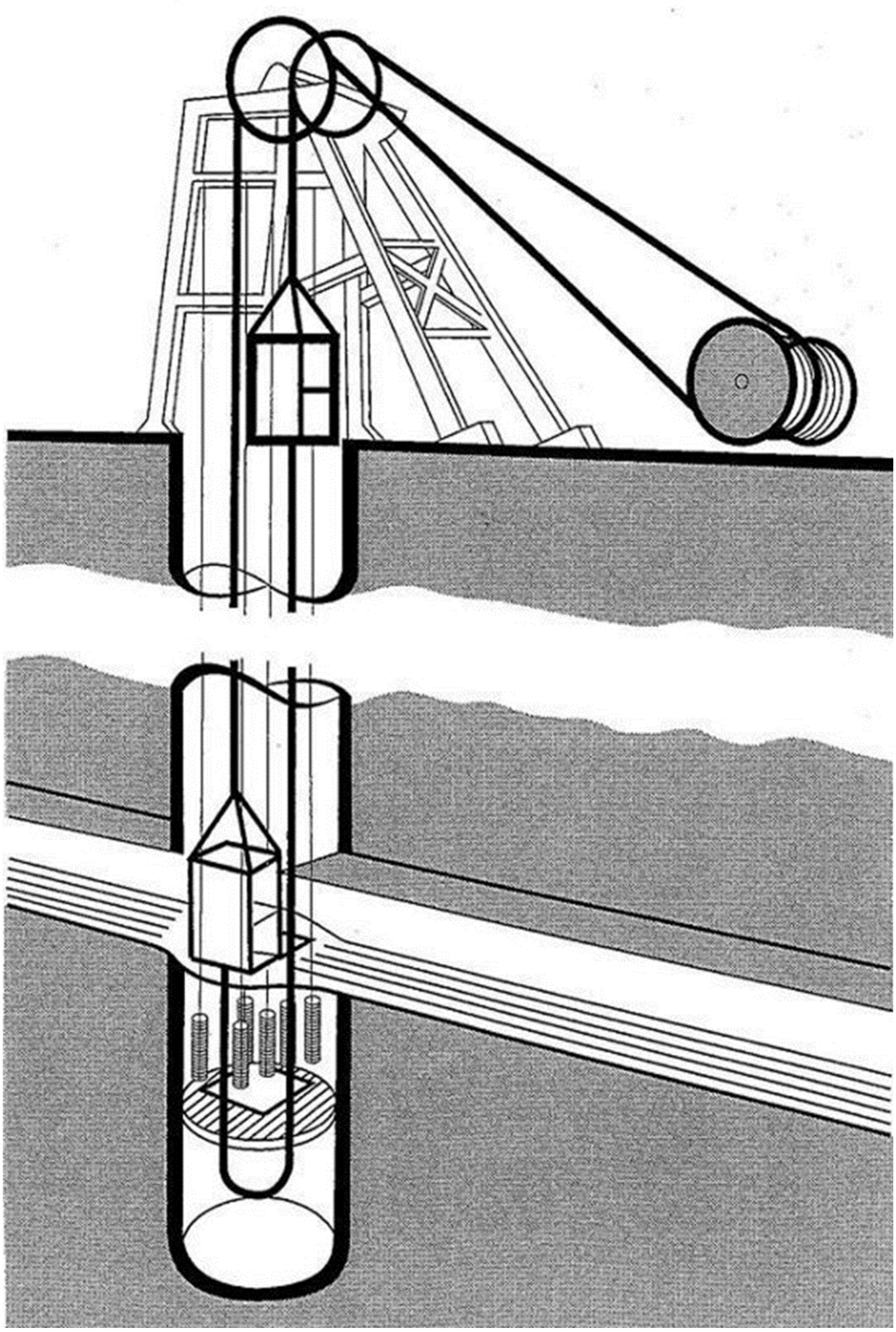
Figure 3 Single drum personnel winder - Shaft top installation



2.1.1.2. Double drum personnel and materials winders

Double drum personnel and materials winders provide an alternate winding drive arrangement providing service or materials hoisting in a vertical shaft. They are designed to raise one fully loaded skip or personnel conveyance while lowering another empty skip or personnel conveyance. The winder loads may be balanced by using balance ropes or counterweights to reduce power consumption. The skips may be fitted with personnel conveyances for emergency egress and shaft inspections.

Figure 4 Double drum vertical shaft winder including balance ropes



2.1.2. Friction (koepe) winders

A friction winder is a vertical shaft winding system in which conveyances transporting either people or materials are raised and lowered by means of friction between single or multiple head ropes and a driving sheave.

The friction hoist was invented by Frederick Koepe, so they are often called Koepe winders.

Friction winders are mounted on the ground above the mine shaft, or at the top of the headframe. Friction winders use tail ropes and counterweights and do not have the haulage rope fixed to the drum, but instead passed around it. The tail ropes and counterweight offset the need for the motor to overcome the weight of the conveyance and hoisting rope, thereby reducing the required horsepower of the winding motor by up to 30%, with the overall power consumption remaining the same.

The head and balance rope configuration usually varies between two to six ropes depending on the duty cycle required.

For depths exceeding 1000 metres, it is critical that non-spin or rotation-resistant constructions ropes are used and that rope load balancing and equal driving sheave/drum circumferences are maintained to ensure good rope and sheave liner life.

Figure 5 25-tonne, tower-mounted person and material friction winder house

Figure 6 Two-deck conveyance

Figure 7 Tower-mounted friction winder house

Figure 8 Ground-mounted friction winder

Figure 9 Friction winder drive arrangement

2.1.3. Shaft sinking winders

2.1.3.1. Overview

Shaft sinking winders:

- are a type of vertical shaft drum winder
- are relatively small, low speed, low load winders
- wind personnel and/or materials in a vertical conveyance using a single rope coiling onto a drum
- are typically made up of two separate winding systems being a:
    - **cage (kibble) winder** (refer to clause 2.1.3.2)
    - **stage winder** (refer to clause 2.1.3.3).

Vertical shaft sinking is specialised work and should be undertaken by an experienced shaft sinking contractor. As there is no shaft to start with, shaft sinking winders have requirements that are different to those of permanent winders.

The methods used for shaft sinking vary and often demand considerable flexibility. In relation to design, the method to achieve safe operational integrity and outcome must be carried out through the use of hard engineering design barriers rather than administrative controls wherever possible.

The winder drum and driving machinery is often located in a winding house that positions the head sheave, rope and conveyances over the shaft at ground level and at a distance sufficient to give the required fleet angle, with the rope positioned over the shaft by a head sheave and supporting headframe structure. Or a complete self-contained unit mounted on foundations adjacent to the shaft.

Figure 10 Shaft sinking winder cage

Figure 11 Modern shaft sinking winder in position over the shaft

Figure 12 Headframe for a typical stage winder

Figure 13 Cage and stage vertical drum winders

Figure 14 Typical headsheave on a shaft sinking winder

2.1.3.2. Cage (kibble) winders and equipment

A cage (kibble) winder:

- is a vertical shaft drum winder with a kibble as the means of personnel and materials transport
- provides transport of people or materials to the working platform within the shaft
- is configured similar to a shaft winder with the kibble or cage suspended from the rope being the conveyance
- generally operates at higher speeds and lesser loads to stage winders for improved efficiency of the shaft sinking operations
- is often guided by the stage winder ropes for stability and to prevent obstructions in the shaft during travel.

The kibble (or bucket) must be:

- designed to maximise stability
- sized to suit the shaft, winder, and load capacity required
- designed to minimise the risk of it catching on any obstruction during its travel in the shaft
- shown to comply with AS 3785.4.

Generally, the kibble is an open-type bucket with two or three point attachment lugs equally spaced around the perimeter for attaching the lifting chains. A lazy sling arrangement is sometimes used to tip sinking kibbles.

Operator protection and guarding must be provided on the transport cage to provide protection against any nip, shear or collision points during operation.

Kibbles designed to be self-tipping on the release of a locking mechanism must not be used for personnel riding.

Any kibble used for personnel riding must:

- be sufficiently sized to prevent people falling out. An individual travelling in a kibble where more than one third of the person’s body is outside the conveyance must use a safety belt securely anchored inside the kibble

- have protective guarding and or isolation systems to prevent contact of people with stationary objects or other obstructions during their use
- have falling object protection fitted
- have sufficient toe holds, steps and hand-holds, to allow safe loading and unloading of people.

2.1.3.2.1. Chains used for suspending kibbles

Chains used for suspending kibbles must:

- be of identical dimensions and strength, except where two-legged chains consisting of a standard and a long chain are used
- 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
- provide for a static design factor not less than 10
- be new attachments at the start of each project use or have the attachments shown to comply to AS3637.1 and AS3637.6.
- be subject to in-service inspections and examinations to meet AS 3637.1 Appendix A criteria

Figure 15 Kibble winder and kibble suspension

2.1.3.3. Stage winders and stage equipment

Stage winders (the name usually given to the work platform or stage and its winding system) are:

- used during shaft sinking for lowering, raising and adjusting the stage in the shaft
- usually only moved as the shaft development takes place
- designed to raise and lower the stage or work platform
- must be designed to maximise stability and be prevented from becoming caught on other items including the cage winder and other shaft obstructions.

The stage winder requirements should be the same as those for vertical shaft drum winders. However, due to the nature of shaft sinking operations some deviation from winding practice may be unavoidable.

The shaft sinking stage is a moveable single or multi-deck structure suspended in the shaft and designed to form a working platform for shaft sinking activities.

Multiple stage winders, in either single fall or multiple falls of rope are often used to increase the load carrying capacity of the stage. Stages are normally raised and lowered at low speeds, typically 0.1m/s to 0.3m/s.

The stage structure design loads must be in accordance with AS 3785.4. A stage is defined as a conveyance.

Stages must be designed to minimise the possibility of overturning.

The stage platform must have protective guarding and/or isolation systems to prevent contact of people with any nip or shear points during use.

Ropes must be attached to the stage through apparatus designed to load the ropes as uniformly as practical.

Any part of the stage structure that is constructed using hinged sections must be securely bolted together before people are allowed to work on the structure during shaft sinking activities.

While the stage is stationary in the shaft it must be secured to the side of the shaft by jacks or other devices to prevent it swinging.

Figure 16 Typical bottom-of-shaft arrangement showing work platform (or stage)

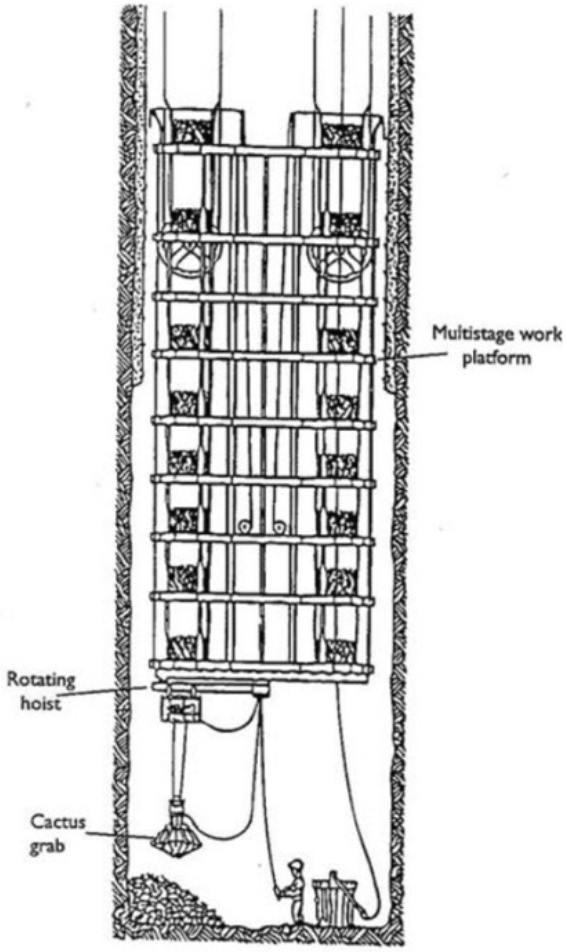


Figure 17 Top deck of stage in shaft below surface collar

2.1.3.4. Shaft doors during sink operations

During shaft sinking operations, adequate provision must be made, and maintained, to prevent spillage falling down the shaft during dumping operations.

A door (or doors) for covering the sinking compartment must be provided, and maintained, at the collar of every shaft while sinking operations are in progress.

The shaft door(s) must be kept closed at all times (refer to example in figure below) when workers, tools or materials are being loaded onto, or unloaded from, the kibble or cage at the collar of the shaft, or when the kibble is being dumped, unless suitable alternative protection is provided to prevent spillage falling down the shaft.

Shaft doors may not be needed to be in place during pre-sink operations where other means is provided to control the risk.

People must not be allowed to enter or leave a conveyance, or to load materials into or unload from a conveyance at the collar level, unless the doors have been closed and the conveyance lowered onto the doors.

Any doors or other shaft protective devices which, when moved into the haulage way or travel area of a shaft would interfere with the free passage of the conveyance, must be so equipped that their position is positively indicated to the winder driver.

Figure 18 Shaft top doors in closed position

Figure 19 Shaft top doors in open position

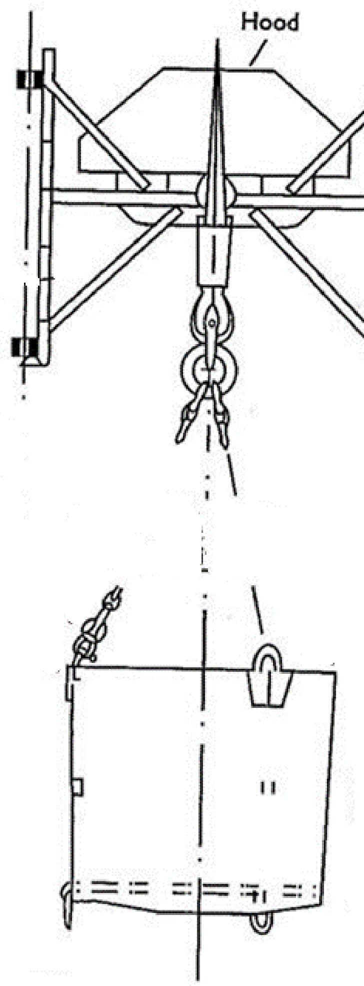
2.1.3.5. Winder interlocks

Where there are two winding systems in the same shaft, they must be interlocked so that whenever either system is selected for personnel winding, the other cannot be used in any alternative mode.

Interlocking with the kibble winder control system must be provided so that:

- when winding is taking place, tipping chutes are clear of the path of the conveyance
- during an ascending wind, the shaft top doors are open whenever a conveyance is in a zone extending from a safe stopping distance below the doors until it is above the doors, and
- before discharging conveyances into the tipping chutes, all shaft top doors are closed.

Figure 20 Typical outline of kibble and crosshead arrangement



2.1.4. Emergency egress winders

Emergency egress winders are used strictly for emergency egress to the mine. They should also support the service and maintenance requirements within the shaft that they operate.

Note: The applicable requirements for an emergency egress winder will depend on the type of winder it is. For example, if the emergency egress winder is a type of vertical shaft drum winder, it must comply with the requirements applicable to any other vertical shaft drum winder (i.e. all parts of this TRG series excluding Part 2 which is only applicable to 'drift winders'.)

Where additional drivelines are provided to an existing PWS to provide for emergency winding use, the entire PWS under this condition, is to be shown compliant to this guide. Such arrangements are often termed 'pony drives'.

Figure 21 Small emergency egress winder

2.2. General requirements

The designer of vertical shaft winders should be alert to any possible event that could cause the conveyance to stop at a position other than a specified platform level, in turn causing a risk to the safety of people in the conveyance. The design must encompass ways of either removing such people to a safe place, with or without use of the conveyance in this situation.

Adequate chairing (mechanical support) facilities must be provided to enable the conveyance, skips and/or counterweight to be chaired in the shaft without posing any risk to people performing these tasks.

Vertical shaft winders must be suitable for the purpose for which they are being used. They must be securely anchored to foundations and must have effective and suitable:

- brakes
- brake locking devices and brake interlocking devices
- means of controlling power to the winding engine
- means of preventing an overwind or underwind
- means of preventing a conveyance travelling at an excessive speed
- means of safely stopping and holding a conveyance if an overwind occurs
- means of monitoring the movement of the conveyance in the shaft

In addition, friction winders must have multiple ropes and must have effective and suitable means of:

- safely stopping the winder and
- detecting rope slip.

Note: There are still some single rope friction winders in use. Unless specifically a shaft sinking, emergency or unique project design winder, these should not be incorporated into a new winder.

2.3. Guide systems

Guides are used to ensure that the skip or personnel conveyance will travel from the shaft top to shaft bottom and return safely without fouling or causing damage.

The type of guiding arrangement is a function of variables including operating speeds, dynamic loads, shaft and conveyance sizes etc.

Guiding systems must be provided in every shaft with a depth greater than 50 metres.

The guide system design must provide safe conveyance control at each end of the wind.

2.3.1. Fixed guides

Fixed or rigid guides:

- are generally a square or rectangular section attached to the shaft walls by attachment fixtures and which guide the conveyance over the length of wind
- may be manufactured from steel and are often made from a rectangular hollow section or rail section
- may also be made from rectangular wooden sections. This is normally the case for small capacity shafts.

Conveyances are often fitted with shoes and roller guide wheels to maintain the correct position in the guides.

2.3.2. Rope guides

Rope guides:

- may be used to guide the conveyance
- generally require a larger shaft diameter than fixed guides
- have less lateral vibratory movement and less frictional resistance to the travel of the conveyance.

Note: Rope guides have no provision for arresting the conveyance on the guide ropes in case the winding rope or suspension gear fails.

2.3.3. Fixed entry guides

When rope guides are used, the shaft must be equipped with a section of fixed guides at the top and bottom loading stations, which guide the conveyance into the tipping or unloading station.

For materials winding, the fixed guide section must direct and unload the conveyance via scrolls. Design operating clearances must be such that the conveyance is directed smoothly at all times.

For personnel winding, the fixed guides must keep the conveyance positioned at the platform level to assist in loading and unloading people. Clearances between guides and conveyances should be kept to approximately 10 millimetres.

The design of fixed guides must provide for the smooth entry of the conveyance or skip following on from the rope guide system. Taper mechanisms must be of sufficient strength to resist any impact forces caused by conveyance misalignment. They must provide sufficient adjustment to allow realignment of the guides due to wear, impact and misalignment over the intended life.

Consideration should be given to the length of entry guides on the entry side (under the conveyance at the unload position) which should be at least equal to the conveyance height (not including entry tapers).

Restrict the entry speed of the conveyance into fixed guides to allow for the comfort and safety of people and to limit damage caused by conveyance impact on the guide system.

2.4. Safety devices

Safety devices must be provided for the safe control of vertical shaft winders.

Any safety device used to detect an event that may lead to the winder stopping by emergency brake application must be easily accessible for inspection and testing to ensure that the function for which it is intended is achieved.

Figure 22 Headframe safety catches

Figure 23 Wooden arresting device and safety catches

2.4.1. Underwind and overwind protection systems

Note: The electric/electronic equipment used for winder control is detailed in *TRG: Powered winding systems - Part 5 'Control systems'*.

The electrical monitoring components used to transmit the required signals must be driven directly from the non-drive end of the drum shaft.

Designers must stipulate the distance for overwind and underwind for unplanned emergency/malfunction and show these as being safe under all operating conditions including the failure of the control of safety systems.

Arresting systems should be incorporated in winding installations to limit the injury or damage resulting from an overwind or underwind, which may follow a malfunction or failure of the winder control or safety system (or both). Such devices may be installed in the headframe and/or at the bottom of the shaft.

Overwind protection systems absorb the energy of motion of a conveyance overrunning the design upper limit of travel. In the case of vertical shaft winders, this is done in combination with early detaching of the conveyance from the hoist rope. Detaching is carried out via an additional detaching hook activation mechanism. This is installed at a position that maintains winder component integrity necessary for peoples' safety in an overwind event.

The ascending conveyance should be fully engaged into the catchgear before the point of entry to the arrestors, and should remain fully engaged in the catch gear throughout the maximum operating distance.

Crash beams that are fixed to the headframe structure must have the crash load applied as a static load and shown acceptable (see AS 3785.5).

Underwind protection systems similarly absorb the energy of motion of a conveyance overrunning the design lower limit of travel. Common examples include the drawing of metal strip through roller sets causing cyclic plastic bending of the strip, the conversion of kinetic energy of the conveyance into strain energy applied to the metal.

Consideration must be provided for loads associated with the descending conveyance.

The overwind or underwind protection must be designed and set so that there is a clear and nominated braking distance below the conveyance after a safety trip, and the lowest landing will not be passed at excessive speed. For this purpose the braking distance and landing speed should be based on the brake force remaining after failure of any one component during the most severe out-of-balance personnel winding condition.

Bottom sump steelwork with access ladders and platforms must be provided to enable safe inspection of the arresting equipment and sump steelwork.

Conveyances must be provided with safe unloading provisions following overwind into arresting systems at both top and bottom sections of the shaft.

The winder maintenance plan should include a schedule for the inspection and testing requirements for the arresting system, where applicable and the safety catch system.

2.4.1.1. Overwind protection shaft sinking

Note: This clause only applies to shaft sinking winders.

For shaft sinking purposes a detaching hook is not required when the requirements of this clause are met. This places additional design consideration to the upper and lower limits of travel for conveyances to ensure safe stopping as intended

Primary and secondary overwind systems are required to meet the requirements specified in *Technical reference guide: Powered winding systems – part 5: Control systems.*

Note: Where the lower limit for undertravel is shown and specified to vary with the production requirement, the risks and subsequent controls that are necessary to ensure safe operation and use in this condition should be included in the design and operational risk assessment.

The headframe must include, for each conveyance, a penultimate overwind switch and an ultimate overwind switch, connected into two different control circuits each of which is arranged to cut off the power to the winder and apply the mechanical brakes. These switches must be connected to tensioned trip wires or similar devices operated by the conveyance.

The overwind distance above the ultimate overwind switch should be sufficient to allow the conveyance to be brought safely to rest with 50% of the mechanical braking effort from the maximum monitored approach speed (not greater than 2 m/s).

A crash beam designed to resist rope break strength plus 20% must be located under the head sheave. For this purpose the sheave support beams may be used.

Design variables that may affect the conveyance travelling and operating clearances such as allowable loads, speed, guide rope tensions and the like must be specified and shown acceptable both at design and commissioning periods.

Any automatic conveyance operation that may have safety outcome effected as a result of the relocation of the work stage, should be nominated and specified as requiring adjustment as necessary to ensure safe outcome at all times.

2.4.1.2. Underwind for shaft sinking

Note: This clause applies only to shaft sinking winders.

Shaft sinking operations, given their nature, do not provide for a fixed underwind control system. The method provided to manage the risks associated with underwind and persons on the conveyance must be provided and shown to provide an equivalent control.

2.4.2. Safety catch system

A safety catch system must be provided to catch and hold the conveyance in the event of overwinding. Safety catch systems must be designed in accordance with the design requirements in AS 3785.1.

During an overwind resulting from loss of control, the conveyance will enter the arresting system to be brought to rest.

The overwind safety catch system should act to limit the distance that a conveyance can fall back following such an overwind.

2.4.3. Vertical shaft drum winder detaching gear

The vertical shaft drum winder must be provided with an efficient means for detaching each ascending conveyance from the rope, and holding it stationary if overwinding occurs. Control of the conveyance in this instance is critical.

Consideration must be given to using attachments designed with folding capacity together with retardation and keeping arrangements as necessary to enable the required conveyance to come to rest and be supported safely. Folding attachments limit inertial load into the detaching hook and catch system.

The possibility of damage to the conveyance, the conveyance suspension gear, and the conveyance contents should be avoided by designing the conveyance suspension equipment with sufficient length and freedom of movement to ensure that the conveyance can rise unimpeded until the kinetic energy is harmlessly dissipated. The system must be capable of operation without excessive wear and damage that would prevent ongoing use.

Where necessary, arrestors may be used that reduce the distance of travel required for the folding links.

Adequate operating clearances must be provided together with provision for removal of people and conveyance from an overwind position.

The detaching hook is the device commonly used.

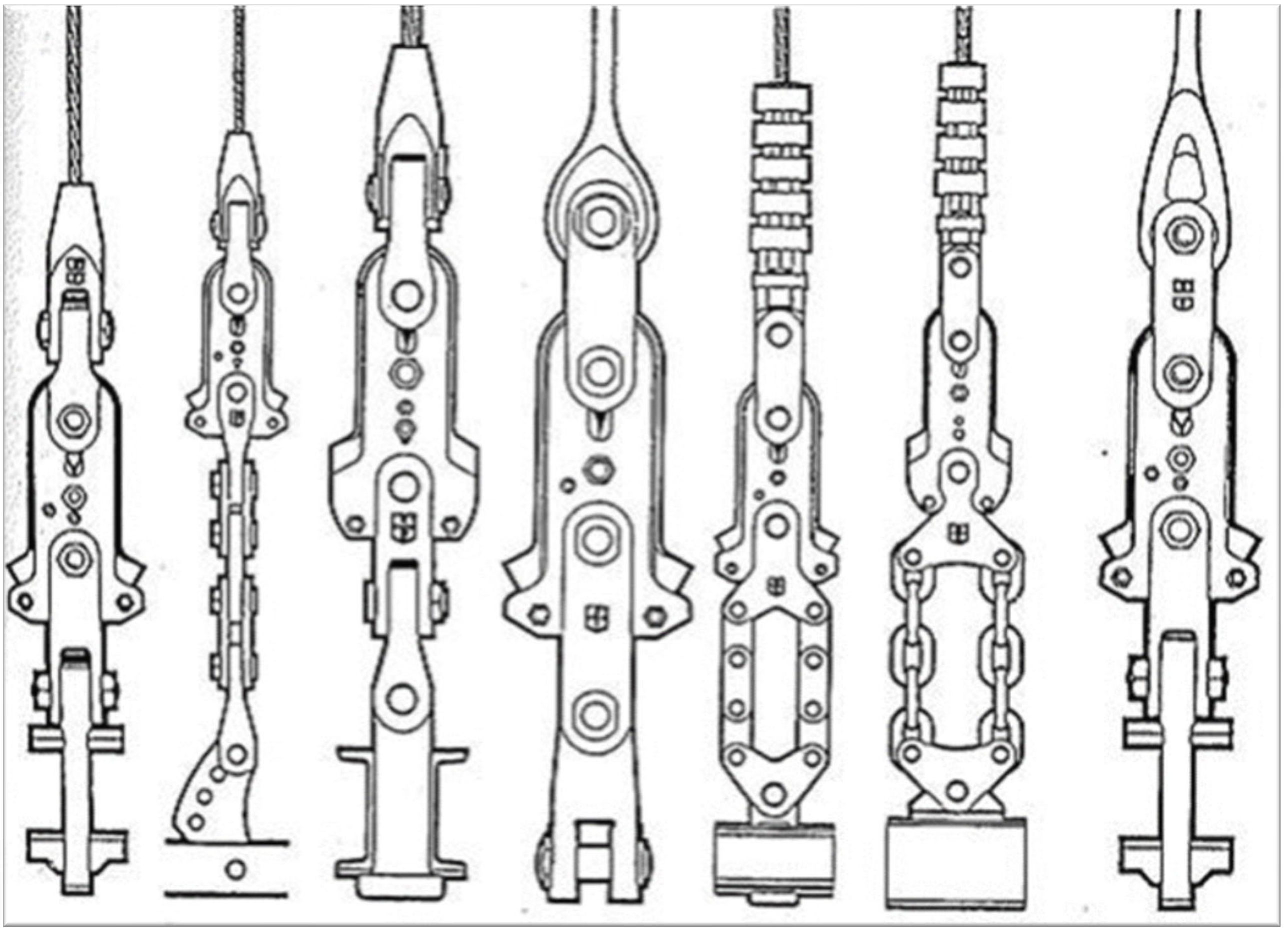
The hook and the associated equipment should be purchased from competent, reputable and specialist manufacturers of suspension equipment. Supplier obligations are specified within WHS obligations. Components must conform to the relevant Standards (see AS 3637.2).

The designer must ensure detaching components are fit for purpose and provide normal service operations without the possibility of wear and tear and compromise of the original design.

Platforms and ladders must be installed to allow for the safe unloading of personnel from the conveyance if an overwind occurs and the conveyance detaches.

The winder maintenance plan should include a schedule for the inspection and testing requirements for detaching hooks and all related attachments and catch components.

Figure 24 Typical suspension units with detaching hook (from Barker-Davies Catalogue: Barker Davies & Company Ltd, U.K.)



2.4.4. Overspeed protection control

The electrical monitoring input devices for overspeed control must be driven directly from the drum shaft.

Drive equipment for limit switches, encoders and tacho generators must be driven by drive gears, synchronous/timing belts or chain and sprockets positively connected to the shafts with keys or pins. Grub screws should not be used to transmit torques.

2.4.5. Arresting systems and devices

Design requirements for arresting systems must be designed in accordance with AS 3785.2.

At the design entry velocity, the arrestor system must decelerate the conveyance(s) within the allowable deceleration rates and bring the conveyance(s) to rest before the point of impact.

The ascending conveyance should be fully engaged into the catchgear before the point of entry to the arrestors and should remain fully engaged in the catchgear throughout the maximum operating distance.

A winder that is designed to transport people only should not be designed to rely on arrestors to bring the load to the specified controlled stop.

The use of risk management techniques is recommended to ensure safe outcomes for the transport of people in conveyances and also for the mitigation of equipment damage where people are not involved.

The automatic protection must be set so that there is a clear braking distance below the conveyance after a safety trip, and the lowest landing will not be passed at excessive speed. For this purpose the braking distance and landing speed should be based on the brake force remaining after failure of any one component during the most severe out-of-balance personnel winding condition.

Design calculations are required to support operating clearances and capacities of the arrestors.

The maximum distance provided by design must be greater than the calculated stopping distance of conveyance travelling through the arrestor system. The conveyances must not exit the arrestor system before being brought to rest by top and bottom crash beams. The ascending conveyance must remain engaged in the catchgear throughout the maximum operating distance.

The arresting devices must be tested to validate the design and shown to achieve the specified theoretical stopping distance of the specific application. The manufacturer, in conjunction with the system designer should provide a procedure to achieve an acceptable means for this testing.

Conveyance overwind and entry into the arrestors is generally infrequent. Design consideration must be provided regarding corrosion protection systems, seizure of potential moving parts and provision of inspection and maintenance requirements.

Design calculations are required to support operating clearances and capacities of the arrestors.

The bottom sump steelwork must be provided with access ladders and platforms to enable safe inspection of the arresting equipment as applicable, guide rope tension weights, safety devices and sump steelwork.

Figure 25 Arresting device in vertical shaft headframe

2.4.5.1. Arresting devices for vertical shaft drum winders

Arresting devices for vertical shaft drum winders:

- must be capable of safely arresting the worst case out-of-balance descending personnel conveyance, at an impact speed of not less than half full winding speed, or the maximum speed resulting from an overspeed trip with reduced brake force consistent with failure of a critical brake component on a given brake path, whichever speed is the greater.

- should be designed for the maximum allowable deceleration for the system. Engineering design calculations are required to support this requirement. Test procedures should be developed, with results shown acceptable during the commissioning process.
- must protect people in case of under-winding.
- should be dimensioned for an entry speed equal to a minimum of half the highest normal winding speed and for a deceleration equal to the maximum allowable.

The maximum deceleration of the arresting device must be such that potential for injury to people inside the conveyance is minimised, and should not exceed 1.0G (ignore transient peaks of less than 0.04 seconds duration).

2.4.5.2. Arresting devices for friction winders

A friction winding arresting system requires the descending conveyance to enter the bottom arrestor before the ascending conveyance entering the top arrestors. This induces theoretical rope slippage on the friction drum and meets rope break and design deceleration requirements.

- Top and bottom arrestors must be provided for both conveyances for a friction winder.
- Arresting devices must be capable of safely arresting a fully loaded descending personnel conveyance, at an impact speed of not less than 1.6 m/s, or the maximum speed resulting from an overspeed trip with reduced brake force consistent with failure of any critical brake component on a brake path, whichever speed is the greater. Engineering design calculations are required to support this requirement.
- Test procedures should be developed, with results shown acceptable during the commissioning process.
- The maximum deceleration of the arresting device must be such that potential for injury to people inside the conveyance is minimised and should not exceed 1.0G. (ignore transient peaks of less than 0.04 seconds duration).

2.5. Conveyances

The requirements for designing, constructing, and inspecting conveyances in vertical shafts must be in accordance with AS 3785.4.

Figure 26 Vertical shaft personnel riding conveyance

2.5.1. Safety monitoring for personnel riding conveyances

To ensure the safety of people riding in the conveyance, the following conveyance and platform gate monitoring must be provided:

- Conveyance doors must be monitored as closed and locked before the winder can be moved.
- Brace and platform gate doors must be monitored as closed and locked before the winder can be moved.
- Platform gate doors must not be able to be opened unless the conveyance is positioned at the landing.
- Conveyance doors must be mechanically locked so they can only be opened when the conveyance is docked at a landing. There must also be an interlock with the drive function to stop the winder in the event the door opens away from a landing.
- Conveyance doors for people must not be able to be opened once the conveyance has moved away from the landing.

For appropriate guarding refer to *TRG: Powered winding systems – Part 1 'General Requirements'* and AS 4024.1 Series.

Where maintenance, repair or emergency tasks require doors to be open when the conveyance is away from a landing, safe systems of work should be documented and followed. Control barriers must follow the hierarchy of controls.

2.6. Headsheaves

Headsheaves must be designed in accordance with AS 3785.7.

Figure 27 Headframe mounted friction winder headsheaves

2.6.1. Friction winder sheave/rope configuration

The ratio of drive sheave to rope diameter should not be less than in the following table:

Final design ratio, together with the rope specifications, must be supported with confirmation from the rope manufacturer that the specific design regarding loads, speeds and cycles of use are acceptable.

ROPE SIZE	STRANDED		LOCKED COIL	
	No Reverse Bending	Reverse Bending	No Reverse Bending	Reverse Bending
Up to 31.75mm diameter	70:1	80:1	85:1	95:1
From 31.75mm to 44.45mm diameter	80:1	90:1	95:1	105:1
Above 44.45mm diameter	85:1	95:1	100:1	110:1

The coefficient of friction between the rope treads on the driving sheave and the winding ropes must be such that there will be no slip under worse case load conditions and maximum brake load conditions.

The rope-to-groove friction coefficient must not be less than 0.25.

The diameter of any deflecting sheaves must be not less than 0.9 times the diameter of the corresponding driving sheave.

The angle of contact of the rope on the deflecting sheaves must be sufficient to prevent the rope slipping on deflecting sheaves.

Figure 28 Ground-mounted friction winder driving sheave and ropes

Figure 29 Ground-mounted friction winder house, ropes and headframe

2.7. Winding speeds and accelerations

In raising or lowering material, the maximum winding speed should not exceed 20 metres per second.

In raising or lowering people, the maximum winding speed should not exceed 15 metres per second.

Variations above these recommendations must be supported with extensive dynamic analysis and tests including comparisons of reference to statutory and standards compliance applicable at that time. Best practice principles should be outlined and applied.

Operating speeds, acceleration and deceleration rates to landing and overtravel positions, under all failure conditions, must be shown safe for personnel transport.

Winding speeds and accelerations can vary enormously from winder to winder. The acceptable ranges of speeds and accelerations that are suitable for winding are given in this clause. The winder must be within these ranges unless employing specific and expert advice and a risk assessment and detailed engineering analysis shows no additional risk is created.

Winding speeds and accelerations for bulk winding can be relatively high. Speeds up to 15 metres/second are common in deep shafts of up to 1000 metres. For shafts of lesser depth, winding speeds may decrease. Decelerations and accelerations of around 0.75 to 1.5 metres/sec^2 are common. The designer must consider people-riding requirements where personnel riding cages are fitted to skips.

Where the use of a conveyance includes transport of people, speeds and accelerations must be consistent with the comfortable transporting of people. Winding speeds of four to six metres/sec are common for shafts up to 500 metres. As shafts become deeper, speeds may be increased. Normal motor control should keep decelerations and accelerations in the range 0.5 to 0.75 metres/sec^2.

2.7.1. Design and performance principles for friction winders

Under no circumstance of brake application or failure of any components, within either brake path, must braking torque be produced that will cause the winding rope to slip on the drive sheave.

In every case brake application must be fail to safety.

The worst case loading conditions, inclusive of emergency braking during cyclic deceleration must be shown to provide a nominated margin of safety that prevents rope slip on a friction winder driving sheave.

Appendix

Standards referenced in this series

Relevant Australian Standards

AS 1065	AS 1065 Non-destructive testing - Ultrasonic testing of carbon and low alloy steel forgings
AS 1085.1	AS 1085.1 Railway track material – Steel rails
AS 1085.2	AS 1085.2 Railway track material - Fishplates
AS 1085.3	AS 1085.3 Railway track material - Sleeper plates
AS 1085.4	AS 1085.4 Railway track material - Fishbolts and nuts
AS 1085.7	AS 1085.7 Railway track material - Spring washers
AS 1085.8	AS 1085.8 Railway track material - Dogspikes
AS 1085.10	AS 1085.10 Railway track material - Rail anchors
AS 1085.12	AS 1085.12 Railway track material - Insulated joint assemblies
AS 1085.13	AS 1085.13 Railway track material - Spring fastening spikes for sleeper plates
AS 1085.14	AS 1085.14 Railway track material - Prestressed concrete sleepers
AS 1085.17	AS 1085.17 Railway track material - Steel sleepers
AS 1085.18	AS 1085.18 Railway track material - Screw spikes and threaded inserts
AS 1085.19	AS 1085.19 Railway track material - Resilient fastening assemblies
AS 1085.20	AS 1085.20 Railway track material - Welding of steel rail
AS 1085.21	AS 1085.21 Railway track material - Turnouts, switches and crossings
AS/NZS 1170.0	AS/NZS 1170.0 Structural design actions - General principles
AS 1171-1998	AS 1171 Non-destructive testing - Magnetic particle testing of ferromagnetic products, components and structures

NSW Resources Regulator

AS 1210-2010	AS 1210 Pressure vessels
AS 1403	AS 1403 Design of rotating steel shafts
AS 1554.1	AS 1554.1 Structural steel welding –Welding of steel structures
AS/NZS 1554.4	AS/NZS 1554.4 Structural steel welding - Welding of high strength quenched and tempered steels
AS/NZS 1554.5	AS/NZS 1554.5 Structural steel welding - Welding of steel structures subject to high levels of fatigue loading
AS 1657	AS 1657 Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS 1670.1	AS 1670.1 Fire detection, warning, control and intercom systems - System design, installation and commissioning - Fire
AS 1710	AS 1710 Non-destructive testing - Ultrasonic testing of carbon and low alloy steel plate and universal sections - Test methods and quality classification
AS 1735.2	AS 1735.2 Lifts, escalators and moving walks - Passenger and goods lifts – Electric
AS 2574	AS 2574 Non-destructive testing - Ultrasonic testing of ferritic steel castings
AS 2671	AS 2671 Hydraulic fluid power - General requirements for systems (ISO 4413, MOD)
AS 2759	AS 2759 Steel wire rope - Use, operation and maintenance
AS 2788	AS 2788 Pneumatic fluid power - General requirements for systems (ISO 4414, MOD)
AS 3507.2	AS 3507.2 Non-destructive testing - Radiographic determination of quality of ferrous castings
AS 3569	AS 3569 Steel wire ropes - Product specification

AS 3600	AS 3600 Concrete structures
AS 3637.1	AS 3637.1 Underground mining - Winding suspension equipment - General requirements
AS 3637.2	AS 3637.2 Underground mining - Winding suspension equipment - Detaching hooks
AS 3637.3	AS 3637.3 Underground mining - Winding suspension equipment - Rope cappings
AS 3637.4	AS 3637.4 Underground mining - Winding suspension equipment - Drawbars and connecting links
AS 3637.5	AS 3637.5 Underground mining - Winding suspension equipment - Rope swivels and swivel hooks
AS 3637.6	AS 3637.6 Underground mining - Winding suspension equipment - Shackles and chains
AS 3751	AS 3751 Underground mining - Slope haulage - Couplings, drawbars, and safety chains
AS 3785.1	AS 3785.1 Underground mining - Shaft equipment - Shaft overwind safety catch system
AS 3785.2	AS 3785.2 Underground mining - Shaft equipment - Shaft winding arresting systems
AS 3785.3	AS 3785.3 Underground mining - Shaft equipment - Drum winding gripper systems
AS/NZS 3785.4	AS/NZS 3785.4 Underground mining - Shaft equipment - Conveyances for vertical shafts
AS 3785.5	AS 3785.5 Underground mining - Shaft equipment - Headframes
AS/NZS 3785.6	AS/NZS 3785.6 Underground mining - Shaft equipment - Fixed guides, rope guides and rubbing ropes for conveyances

AS 3785.7	AS 3785.7 Underground mining - Shaft equipment - Sheaves
AS/NZS 3785.8	AS/NZS 3785.8 Underground mining - Shaft equipment - Conveyances for inclined shafts
AS 3990	AS 3990 Mechanical equipment - Steelwork
AS 4024	AS 4024 safety of machinery series of standards
AS 4024.1	AS 4024.1 Series Safety of Machinery (all sub-Parts as applicable)
AS/NZS 4024.1204	Safety of machinery – Electrical equipment of machines - General requirements (IEC 60204-1:2016 (ED. 6.0) MOD)
AS 4024.1503	Safety of machinery- Safety-related parts of control systems—General principles for design’
AS 4024.1604	Safety of machinery - Design of controls, interlocks and guarding—Emergency stop—Principles for design
AS 4100	AS 4100 Steel structures
AS 4730.2	AS 4730.2 Mining - Winding equipment - Braking systems
AS/NZS 4812	AS/NZS 4812 Non-destructive examination and discard criteria for wire ropes in mine winding systems
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS 61508 Series	Functional safety of electrical/electronic/programmable electronic safety-related systems
AS 61511	AS 61511 series of standards ‘Functional safety – Safety instrumented systems for the process industry sector’
AS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS/NZS ISO 9001	AS/NZS ISO 9001 Quality Management Systems - Requirements

AS ISO 31000	AS ISO 31000 Risk management - Guidelines

International standards

ISO 286-1	ISO 286-1 : Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 1: Basis of tolerances, deviations and fits
BS 7608	BS 7608 Guide to fatigue design and assessment of steel products
ISO Guide 73	ISO Guide 73 Risk management - Vocabulary
ISO 4309	ISO 4309 Cranes - Wire ropes - Care and maintenance, inspection and discard
ISO 4413	ISO 4413 Hydraulic fluid power - General rules and safety requirements for systems and their components
ISO 4414	ISO 4414 Pneumatic fluid power - General rules and safety requirements for systems and their components
IEC 31010	IEC 31010 Ed. 2.0 (Bilingual 2009) Risk management - Risk assessment techniques
ISO 12100	ISO 12100 Safety of machinery – General principles for design – Risk assessment and risk reduction
Other Reference	Safe man riding in Mines parts 1A and 1B, parts 2A and 2B, being the first and second report of the National Committee for Safety of man riding in shafts and unwalkable Outlets.
SABS 0293	Condition assessment of steel wire ropes on mine winders code of practice
ASTM E1571 – 11(2016)e1	Standard practice for electromagnetic examination of ferromagnetic steel wire rope