GUIDELINES

MINE WINDERS
PART 3: VERTICAL SHAFT WINDERS

MDG 33.3

This version has been submitted to the Coal Safety Advisory Committee (CSAC) and is issued for industry comment. Any comments should be forwarded by 30 November 2011 to Lyndon Hughes at: lyndon.hughes@industry.nsw.gov.au

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PUBLICATION HISTORY

- First published October 1998 as MDG 33, for drum winders
- This Industry DRAFT, November 2011 now incorporates all winders.

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FOREWORD

Mine winders are important items of infrastructure in the underground mining industry and there are many installations operating in the NSW mining industry. These installations comprise many variations of design ranging from single rope drum vertical shaft and drift slope haulage systems and vertical shaft friction winder systems.

Mine winders are considered as high risk plant, the failure of which has potential for multiple fatalities. Some mine winders have potential to carry in excess of 150 people in a single lift. The MDG 33 guideline provides guidance in managing the risks associated with the design, commissioning and use of mine winders.

The application of mine winders range from those designed for personnel transport only to those designed for both personnel and materials transport duty and to those designed solely for the purpose of materials haulage. These winders are permanent items of the operational mine's infrastructure. In addition there are shaft sinking winders required for relatively short term projects associated with the development of new or extension of existing underground mines.

This revision of MDG 33 is not limited to drum winders; it collates all winder types and includes information previously provided in MDG 12 ‘Guideline for the construction of friction winder’, MDG 2005 ‘Electrical technical reference for the approval of power winding systems’ and MDG 26 ‘Guideline for the examination, testing and discard of mine winder ropes’.

The guideline is provided in seven parts. This is part 3.

Part 1: General requirements
Part 2: Drift winders
  Part 3: Vertical shaft winders
Part 4: Shaft sinking winders
Part 5: Friction winders
Part 6: Winder control systems
Part 7: Examination, testing & retirement of mine winder ropes

This is a “Published Guideline”. It provides an industry benchmark for engineering standards and fit-for-purpose equipment. It represents acceptable industry practice for reducing lifecycle risks associated with mine winders.

The guideline makes reference to the suite of Australian Standards that have been developed over the past years for mine winders. Adoption of this technical information and the appropriate use of risk assessment techniques should foster “Safe Winding Practices”.

The foundation work by the late Les Melane is gratefully acknowledged in the original publication of this guideline

A feedback sheet is provided in MDG 33.1. Constructive comment is essential to help the Department improve this Guideline.
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Vertical Shaft Drum Winders
Shaft Top Installation – A

Vertical Shaft Drum Winders
Shaft Top Installation - B
1 PURPOSE AND SCOPE

1.1 PURPOSE
The purpose of the guideline is to protect persons against harm to their health, safety and welfare through the elimination or minimisation of lifecycle risks associated with shaft winders.

1.2 SCOPE
This guideline sets out recommended minimum safety requirements for the design, construction and maintenance of shaft powered winding systems. It covers the design of vertical winders including the layout, associated structures and equipment, conveyances and environmental considerations.

1.3 APPLICATION
This Guideline applies to all vertical shaft mine winders. This guideline should be used by designers, manufacturers, owners and users when –

a) Designing new mine winders
b) Independently verifying mine winders
c) Applying for design registration of mine powered winding systems
d) Altering existing mine winders
e) Carrying out five yearly audits on mine winders
f) Reviewing winder designs following an incident
g) Altering, maintaining or repairing mine winders

1.4 ABBREVIATIONS AND DEFINITIONS
For the purposes of this Guideline, the abbreviations and definitions in MDG 33.1 apply.

1.5 STANDARDS AND GUIDELINES
For a list of Standards and guidelines are applicable to vertical drum winders, see APPENDIX A.
2 VERTICAL WINDERS DESIGN AND CONSTRUCTION

2.1 DRUM WINDERS – GENERAL REQUIREMENTS

The vertical shaft drum winder shall be suitable for the purpose for which it is being used, and shall have effective and suitable:

(a) Brakes.
(b) Brake locking devices and brake interlocking devices
(c) Means of controlling power to the winding engine
(d) Means of preventing an overwind or underwind
(e) Means of preventing a conveyance travelling at an excessive speed
(f) Means of safely stopping and holding a conveyance if an overwind occurs
(g) Means of monitoring the movement of every conveyance in the shaft
(h) Means of detecting slack rope and safely stopping the winder.

Winders shall be securely anchored to foundations.

Winders shall be separately housed except when shaft sinking, or where two winders serve the same shaft.

Winders shall have local manual controls independently placed such that a person operating one winder is not distracted by movement or signals associated with the other engine.

The designer should be alert to any possible event that could cause the conveyance to stop at a position other than a specified platform level, and could affect the safety of personnel in the conveyance. The design shall encompass ways of either removing personnel to a safe place, or moving the conveyance by means other than normal winding to a specified platform level.

The design of the system shall include ladders, stairs, platforms and walkways to provide safe and convenient access to all parts of the winding system that require inspection, examination and testing, non destructive testing, adjustment cleaning or service. All components shall comply with AS1657-1992 Fixed platforms, walkways, stairs and ladders-Design, construction and installation.

Provision shall be provided in the shaft for the chairing of the conveyance, skips and or counterweight to eliminate any risk to people performing this task.

2.2 DESCRIPTION AND LAYOUT

2.2.1 general

Vertical shaft drum winders are those which wind men and/or materials in vertical mine shafts, using one or two ropes coiling 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 being positioned over the shaft by a headsheave.

2.2.2 Single Drum personnel Winding

Designed generally for winding men and small equipment only, the winder may have a single cage. Normally these are slow speed winders where high volume is not needed. They are suitable for emergency egress or shallow seams where
higher cost, more sophisticated winding is not required. The winder is normally manually driven.

2.2.3 Single Drum Materials Winding

Designed generally for winding small volumes of materials using a single skip, these winders are slow speed and usually manually driven. They may have a personnel cage attached to the skip for emergency egress and shaft inspection.

2.2.4 Double Drum Materials Winding

Intended for service or materials production winding, the winder is designed to raise one fully loaded skip or cage while lowering another empty skip or cage.

The winder loads may be balanced by using balance ropes or counterweights to reduce power consumption.

The skips may be fitted with personnel cages for emergency egress, and shaft inspection.

2.2.5 Shaft Sinking Winding

Designed for vertical shaft sinking and development, these winders are often used in conjunction with stage winders which support a movable working platform called a "stage". See Part 4, Section 6 for special additional features which may be required when vertical shaft drum winders are intended for shaft sinking duties.

2.3 GUIDE SYSTEMS FOR VERTICAL SHAFTS

Guides are used to ensure that the skip or cage will travel from the shaft top to shaft bottom, and return, safely, without fouling or causing damage. Guides shall be provided in every shaft with a depth greater than 50 metres.

2.3.1 Fixed Guides

Fixed or rigid guides are of square or rectangular section attached to the shaft walls by attachment fixtures and which guide the cage over the length of wind.

Fixed guides may be manufactured from steel and are often made from rectangular hollow section or rail section. Cages or skips are often fitted with shoes and roller guide wheels to maintain the correct position in the guides.

Fixed guides may be made from rectangular wooden sections. This is normally the case for small capacity shafts. Cages are provided with a catching system (dogs) which engage the wooden guides if a rope break occurs. The skip or cage is also fitted with shoes and guide roller wheels to maintain the correct position in the shaft.

2.3.2 Rope Guides

Rope guides may also be used to guide the skip or cage.

The total overall cost of equipping and maintaining a shaft with rope guides is considerably less than with fixed guides; however the rope guides require a larger shaft diameter.

Rope guides have less lateral vibratory movement and less frictional resistance to the travel of the conveyance. This results in considerably less fatigue and tensile stresses being imparted to the winding rope.

Where rope guides are used, there is no provision for arresting the conveyance on the guide ropes if the winding rope or suspension gear fails.
2.3.3 Fixed Entry Guides

When rope guides are used the shaft shall 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 shall direct the skip into the scrolls, and/or maintain clearances needed to load and discharge the materials. Clearances shall be kept as small as possible to prevent undue impact loads.

For personnel winding, the fixed guides shall keep the cage positioned at the platform level to assist in personnel loading and unloading. Clearances between guides and cages shall be kept to approximately 10mm.

Fixed entry guides shall be fitted with appropriate tapers or entry design to safely guide the cage or skip onto the main guide body from the rope guides. Such tapers shall be of sufficient strength to resist any impact forces from a misaligned conveyance.

Supporting steelwork for the fixed guides shall have sufficient strength to absorb impact forces from the entering/exiting conveyances. Provide sufficient adjustment to allow re-alignment of the guides due to continual impact, or to misalignment due to shaft movement or other circumstances.

The recommended length on the entry side (under the conveyance at the unload position) for entry guide 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 personnel, and to limit damage caused by conveyance impact on the guide system.

2.4 SAFETY DEVICES FOR VERTICAL SHAFT DRUM WINDERS

Special attention shall be given to the design of safety devices required for the safe control of vertical shaft drum winders.

2.4.1 Inspection and Testing

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

2.4.2 Detaching Gear

The shaft shall be provided with an efficient means for detaching each ascending conveyance from the rope, and holding it stationary if overwinding occurs.
The detaching hook is the device commonly used.

The hook and the associated equipment should be purchased from reputable manufacturers of suspension equipment and shall conform to the relevant Standards (See AS3637.2-2005 Underground Mining-Winding Suspension Equipment. Part 2: Detaching Hooks. Provisions for Factors of Safety and Testing).

A safety catch system shall be provided to catch and hold the conveyance when the conveyance becomes detached in the event of overwinding. Design requirements for catch systems are covered by AS3785.1-2006 Underground mining-Shaft equipment. Part 1 - Drum winding overwind safety catch systems.

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

The winder maintenance plan shall include a schedule for the inspection and testing requirements for detaching hooks.

2.4.3 Over speed, Overwind, Control and Protection

Special attention shall be given to the design of devices required for the safe control of vertical shaft drum winders.
For winders the electric/electronic equipment used for winder control is detailed in the Mine Winder Control Systems documents. The electrical monitoring components used to transmit the required signals shall be driven directly from the non-drive end of the drum shaft.

Drive equipment for limit switches, encoders and tacho generators shall 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.

### 2.4.4 Arresting Devices

Danger to persons in a descending conveyance following an over wind shall be prevented by providing suitable arresting devices below the lowest winding level. Alternatively, the automatic protection shall 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.

Arresting devices should 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 one brake component, whichever is the greater.

The maximum deceleration of the arresting device should not exceed 2.5G (ignore transient peaks of less than 0.04 seconds duration).

Provide bottom sump steelwork with access ladders and platforms to enable safe inspection of the arresting equipment and sump steelwork.

### 2.5 CONVEYANCES

AS3785.4-2002: Underground mining-Shaft equipment. Part 4, Conveyances for Vertical Shafts, sets out the requirements for designing, constructing, and inspecting conveyances in vertical shafts.

#### 2.5.1 Safety monitoring for personnel riding conveyances

To ensure the safety of persons riding in the conveyance, the following conveyance and platform gate monitoring shall be required.

Conveyance doors shall be monitored as closed and locked before the winder can be moved.

Platform gate doors shall be monitored as closed and locked before the winder can be moved.

Platform gate doors shall not be able to be opened unless the conveyance is positioned at the landing.

Conveyance doors shall not be able to be opened once the conveyance has moved away from the landing.

### 2.6 SIGNALLING AND COMMUNICATION

All shafts equipped with winders, shall be provided with suitable means to:

(a) Give audible and visual signals to; and

(b) Receive audible and visual signals from; and

(c) Communicate by speech with

These shall be provided at any place where any such means of signalling and communication is necessary to enable the winder to be used safely.
2.7 HEADSHEAVES

Headsheaves shall be designed in accordance with AS 3785.7-2006 Underground mining – Shaft equipment. Part 7: Sheaves.

2.8 WINDER HOUSE FOUNDATIONS AND HEADFRAME STRUCTURES

Design foundations for the winder house to the rope break tension plus 20% before failure. For this condition failure means "no longer able to support the winder working loads".

2.8.1 Foundation design

Foundation design for winder drums, associated machinery, headframes and headsheave supports, should be undertaken, and/or checked by a competent civil design engineer.

A complete set of foundation calculations and drawings, certified by a person accredited to do so, should be provided for the mine record system.

The foundation design shall be carried out to the current relevant Australian Standard civil and structural codes.

2.8.2 Foundation bolts

All foundations shall use multiple foundation bolts to transmit loads to mass concrete.

Bolt calculations for both fatigue loadings and rope break or strength loadings shall be included in the foundation calculations.

Bolt tightening torques shall be included in the calculations. Foundation design should consider maximum bolt loadings transmitted to the mass concrete by bolt tightening to a maximum torque of 0.65 × proof stress of bolt material.
Head frames shall be designed in accordance with AS3785.5-1998. Underground mining-Shaft equipment: Part 5 Headframes.

2.9 VERTICAL SHAFT DRUM WINDER ROPES

Typically the generally standard for vertical shaft drum winder rope construction is non-spin (locked coil) rope.

2.9.1 General

For design purposes select rope diameters and strengths should be as set out in AS3569 Steel wire ropes. The final selection and recommendation shall be made in co-operation with the wire rope manufacturer.

For automatic winders a maximum of five layers of rope shall be used to maintain correct scrolling of the rope.

The acceptable method of attaching conveyances to the rope for vertical shaft drum winders is with a wedge type Capel (refer to MDG 3004 SR97/3 - Wedge Capel/Rope Attachment Analysis).

A rope lubricator shall be provided to externally lubricate the rope. The lubricator should be located adjacent to the head sheave wheel. Sections of the rope which cannot be lubricated with the lubricator should be hand lubricated as required.

Allow for adequate access to working platforms to enable the safe non-destructive examination of winding ropes.

2.9.2 Rope Factors of Safety and Retirement

2.9.2.1 Factors of Safety

The rope breaking force to be used for calculating the Rope Factor of Safety for the winding installation shall be the lesser of either the minimum breaking force for the rope when new or the actual breaking force.

2.9.2.2 Drum winder rope factor of safety

The drum winder rope factor of safety shall be calculated by dividing the breaking force of the rope (See Clause 2.1), by the sum of the maximum load to be raised or lowered by the rope plus the total mass of rope acting as load due to gravity when fully let out.

The factors of safety for drum winder ropes shall –

a) satisfy the criteria in the table below, and

b) shall be not less than 6.0:1 where the safety of personnel is involved, unless justified by a detailed engineering dynamic analysis and the winder control system continuously monitors dynamic forces in the rope.
<table>
<thead>
<tr>
<th>Circumstance</th>
<th>Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transporting persons, or where the safety of persons is involved</td>
<td>$\geq 7.5 - 0.001L$ to a minimum of FOS of 6.0:1</td>
</tr>
<tr>
<td>Transporting of rock or materials, where the safety of persons is not involved</td>
<td>$\geq 5.5 - 0.003L$</td>
</tr>
<tr>
<td>Transporting rock in a shaft used exclusively for that purpose</td>
<td>$\geq 4.5$</td>
</tr>
<tr>
<td>For ropes raising and lowering a sinking stage</td>
<td>$\geq 6.0$</td>
</tr>
</tbody>
</table>

NOTE: L is depth if the wind in metres.

2.9.2.3 Guide Ropes and Rubbing Ropes

Every guide rope and rubbing rope used at a mine shall, when newly installed, have a breaking force at the point of suspension of not less than 5 times the heaviest static load to which the rope may be subjected.

The ropes referred to above should not be used if the factor of safety falls below that nominated above.
2.9.3 General Rope Requirements

No rope that has been joined or spliced shall be used as a winding, balance or guide rope.
A used rope shall not be used unless it can be proven through non-destructive testing, destructive testing and a report from a person competent in wire ropes that it is safe to use.


When attaching the winding rope to the winder drum a minimum of three (3) complete dead coils shall be retained on the drum at all times.

When attaching the winding rope to the winder drum, the rope shall be anchored to the drum with a suitable clamping device or system. The Factor of Safety of the clamping device or system shall be not less than the rope Factor of Safety. Spare rope stored on the drum shall not be considered as reducing the load on the anchorage.

Sufficient allowance on the total length of winding rope shall be made for cutting rope samples for destructive testing.

For construction of typical ropes used in mine winding systems refer. AS3569. Steel wire ropes.

2.9.4 Winding Ropes

Winding ropes are classified as those ropes supporting the conveyance and directly carrying the personnel and/or materials load.

For vertical shafts the rope construction should be based on the type of conveyance guides.

For vertical shafts with fixed wooden or steel guides guiding the conveyance for the complete depth of the shaft, the winding rope should be a preformed triangular (flattened) strand rope. These ropes are highly resistant to crushing and wear, have good strength to diameter ratio properties and a good strength to weight ratio.

For vertical shafts with rope guides, the winding rope should be Non-Spin (locked coil) or "Fishback" Non-Spin construction for depths exceeding 300 metres.

In all cases the rope construction for the particular application should be referred to the rope manufacturer for final recommendation.

2.9.5 Head Sheave Diameters

Head sheaves shall be designed to AS3785.7-2006 - Underground mining - Shaft Equipment - Part 7: Sheaves.

2.9.6 Rope Installation

When installing new rope on the drum, the dead coils on the drum should be tensioned to at least 50% of the working rope tension.

2.9.7 Rope Lubrication

Winding ropes are delivered with the rope internals lubricated. Close attention should be paid to this lubrication process.

2.9.8 Slack Rope Protection

Slack rope can be dangerous to both personnel and equipment. It forms when the conveyance no longer exerts a tension force on the rope allowing the rope to become slack. This could happen if the conveyance is not freely moving, jams,
derails or malfunctions or the winder overwinds. Devices shall be provided to
detect the formation of slack rope.

2.9.9 Multi-Layer Coiling

The maximum number of rope layers should be limited to five (5) layers.

Typical Winding Ropes
Fig 2.4
Typical Winding Ropes (contd.)

Fig 2.4
2.9.10 Guide and Rubbing Ropes

2.9.10.1 General

In vertical shafts guide ropes shall be anchored at one end and tensioned by a suitable means at the other. The tensioning device shall be capable of exerting a constant tension to the rope due to variations of rope stretch, temperature variations and ground movements.

Tensioning may be by dead weights positioned in the shaft sump, or by spring loading the rope at the top or bottom ends. Other arrangements or combinations of tensioning the ropes may be used.

(Ref: AS3785.6 1992: Underground mining-shaft equipment. Part 6 - "Guides and rubbing ropes for conveyances")

2.9.10.2 Guide Rope Tensioning

2.9.10.2.1 General

In all cases, the tension in the ropes shall be capable of being measured and adjusted to maintain the correct tension.

In general, the selection of guide ropes is based on experience. If guide ropes are not correctly positioned and tensioned, high frequency forces of low magnitude are imparted to the winding rope. The smoothest running conditions are obtained with four (4) guide ropes fitted to one side of the cage with
staggered tension weights. The images below give examples of guide and rubbing rope layouts and the table below suggests rope tension weights.

Correct tensioning of the guide ropes has been learnt from experience. The tension required is nominally 1 Tonne per 100 metres of shaft depth up to 500 metres. When the shaft is over 500 metres in depth to 1200 metres in depth, a linear increase up to 9 Tonnes is recommended.

For production and men and material winders, rope guide diameters should be maintained at 40mm minimum to 1200 metres and 50mm diameter over 1200 metres. For second egress winders, reduced rope sizes may be used, consistent with the reduced load and speed.

In some shafts, the variations in shaft depth due to moisture changes make the use of spring loaded guide ropes unacceptable. The geotechnical conditions of the shaft should be investigated before the selection of the tensioning device is finalised.

Guide Methods Used For Conveyances
Fig 2.6
<table>
<thead>
<tr>
<th>Depth of Shaft (Metres)</th>
<th>Minimum Size of Guide Ropes (mm)</th>
<th>Minimum Guide Weight or Tension (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>0-200</td>
<td>30</td>
<td>3.0</td>
</tr>
<tr>
<td>200-400</td>
<td>34</td>
<td>4.0</td>
</tr>
<tr>
<td>400-600</td>
<td>38</td>
<td>5.0</td>
</tr>
<tr>
<td>600-800</td>
<td>42</td>
<td>6.0</td>
</tr>
<tr>
<td>800-1000</td>
<td>44</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Typical Guide Rope Layouts
Fig. 2.7
2.9.10.2.2 **Number of Guide Ropes**

The number of guide ropes has been found to depend on the depth of the shaft. The following minimum number of guide ropes should be used:

(a) Up to 200 metres in depth, 2 guide ropes per cage.
(b) From 200 to 500 metres, 3 guide ropes per cage.
(c) Over 500 metres, 4 guide ropes per cage.

2.9.10.2.3 **Type of Guide Rope**

Guide and rubbing ropes should be half locked or locked coil construction rope. The outer wires should be sufficiently large to avoid frequent replacement due to wear. All wires should be rust resistant.

2.9.10.2.4 **Guide Rope Clearances**

The clearance between conveyances and the conveyances and shaft walls should be no less than 300mm.

Should lesser clearance be required, rubbing ropes should be used between the conveyances when the clearance is between 100m to 300m.

2.9.10.3 **Guide Rope Inspection and Rotation**

Guide and rubbing ropes should be periodically examined for wear and general condition. They should be cleaned, examined and measured at all points liable to deterioration, and other selected positions along their length, including those sections above and below the top and bottom landings.

The interval between these examinations should not exceed 12 months. A record should be maintained of all measurements and the inspection and assessment comments.

Guide ropes tend to wear unevenly owing to the rubbing action of conveyance shoes at positions where the lateral movement is greatest (e.g., entrances to the fixed guides, top and bottom landings). Where uneven wear occurs it is usual practice to rotate the guide ropes at intervals in order to equalise.

To minimise the effect of fatigue at a point where vibration is arrested (at the gland), the ropes should be lifted at appropriate intervals (through a distance of not less than 1.5 times the length within the capping or gland) and the termination remade.

Any rotation or lifting of the guide or rubbing ropes should be recorded in the guide rope documentation.

2.9.11 **Guide Rope Lubrication**

A wire rope needs lubrication both during manufacture and throughout its working life. It also often needs a preservative, and the grease and oil used serves both of these purposes. Once the rope has been made it is extremely difficult to lubricate the interior. Therefore it is important that the lubrication or greasing carried out during manufacture shall be thorough.

Rope wear can be reduced to a minimum by the use of anti-wear materials for guide slippers, and well lubricated rope.

Corrosion can be kept to a minimum by efficient lubrication, the most susceptible being the fixing points at top and bottom. The use of galvanised wires generally assists to overcome corrosion problems.
Where corrosion in a shaft is considered to be a problem, the use of half-locked coil ropes have advantages in that the resistance to corrosion is greater since the clearances through which moisture can penetrate are smaller.

2.10 ROPE ATTACHMENTS

When selecting the attachments, expert guidance should be sought from a reputable manufacturer and the use of AS3637.3-1997 "Underground Mining - Winding Suspension Equipment" Part 3: Rope cappings used as a reference.

2.10.1 Wedge Type Capels

Wedge type capels are commonly used as attachments for attaching the rope to the conveyance or guide weights used in vertical shafts (refer to Figure 2.8).

Special care should be given to the lubrication and assembly of capels. Only lubricant recommended by the manufacturer should be used.

2.10.2 Rope Sockets

For both slope haulage and underlay shaft winder systems, fluted plug and tail and white metal filled type rope (see Figure 2.9) sockets should be used to attach the conveyance to the rope.

2.10.3 Rope Attachment Suspension Arrangement

Typical arrangements of rope attachment suspension systems are shown in Figures 2.10 and 2.11.

NOTE: Figure 2.11 represents a multi-rope arrangement e.g. a friction winder and is included for completeness.
Wedge Type Rope Capel
Fig 2.8
White Metal Filled Rope Socket
Fig 2.9
Head Rope Suspension arrangement consisting of inserted Cone and Tail Socket, Humblie Type Detaching Hook, Drawbar and Transom Support.

Wedge Type Capel connected to a King Type Detaching Hook, Drawbar and Suspension Pedestal Support.

Examples of Single Rope Suspension Systems
Fig.2.10
2.11 CONVEYANCE AND ATTACHMENTS

When selecting the attachments, expert guidance should be sought from a reputable manufacturer.

2.11.1 Conveyance Vertical Shaft

Conveyances and attachments in vertical shafts shall comply with AS 3785.4-2002 “Underground Mining- Shaft Equipment” Part 4 - Conveyances for Vertical Shafts.
2.12 BRAKES

2.12.1 Design and Performance - General Principle

The principle which should be adopted for all winders is that the mechanical brakes shall be the ultimate means of retarding the winding system. The objective is that this principle should apply even in the event of the failure of any one component.

New mechanical brakes should be arranged so that they contain no single line component, the failure of which would prevent application of the brake, either directly by the winder, or by a safety device. All critical connecting pins shall be secured using split pins or similar means. Grub screws shall not be used.

2.12.2 Performance Criteria

Mine winder drum brakes shall meet the following statutory performance requirements:

(a) There shall be two independent mechanical braking systems. However so applied shall act directly on the winder drum.

(b) If one mechanical brake fails, the other shall be able to retard and stop the winder safely before the descending conveyance, carrying the rated load, reaches any obstruction.

(c) When all brakes apply, decelerations should not be so violent (greater than 0.5 g) that personnel travelling in the conveyance are injured.

(d) The brakes shall not overheat or fade during an emergency stop.

2.12.3 Brake Function

Mine winder drum brakes perform three prime functions:

(a) Service braking

(b) Parking braking

(c) Emergency braking.

Electrical motor control may be used for service braking.

2.12.4 Service braking

Service braking involves retarding or restraining the speed as required by the operator or automatic controls.

2.12.5 Parking braking

Involves holding the load safely when the wind is completed, or when power is disconnected for servicing or standing.

2.12.6 Emergency braking

Emergency braking is for slowing and stopping the winder before the conveyance, skip, kibble or stage, reaches the limits of travel. It shall occur when:

(a) The winder controls malfunction or winder control is lost.

(b) Power is lost

(c) An emergency stop is instigated by either personnel intervention or some protective device signalling an operating fault.
Typical drum winder brake configurations
Fig 3.1
Typical drum winder brake configurations (cont’d)

Fig 3.2
High pressure, pressure applied spring backup Caliper Brake

High pressure spring applied Caliper Brake

Typical drum winder brake configurations (cont’d)

Fig.3.3
Modern shaft winder (2\textsuperscript{nd} egress) drum fitted with disc caliper brake arrangement. Two brake paths are fitted to the drum. A 3\textsuperscript{rd} wet disc is located in the reduction box.

2.12.7 Brake Types

Drum winders may have drum shoe caliper brakes of various configurations (see Figs 3.1, 3.2 and 3.3), operating on a cylindrical brake drum, and incorporating a dead weight or spring applied system of brake force; or a system employing one or more disc calipers operating on a disc which incorporates hydraulic pressure to lift the brakes and spring force to apply the brakes.

2.12.8 Preferred Brake System

Where possible, multiple disc caliper brakes shall be used.

2.12.9 Brake Application

In every case brake application shall be "fail to safety".

2.12.10 Single Drum Winder Brakes

For single drum winders where persons are carried at any time, two (2) independent braking systems shall be installed, however so applied acting directly to the drum.

2.12.11 Brake Path

The second brake system shall not use the same brake path or disc used by the first system.

2.12.12 Brake Application

The first brake system shall always apply to stop the winder before any second brake system applies.
2.12.13 Brake Controls

Hydraulic control systems for the brake may be incorporated into an integrated control unit provided such a unit fails to safety.

2.12.14 Double Drum Winder Brakes

2.12.14.1 General

When a double drum winder is used, and personnel are to be transported at any time in the conveyance attached to one drum when the other drum is de-clutched, each drum shall have a mechanical brake attached directly to it.

2.12.14.2 Additional Brake Path

The winder shall have a third brake which shall be coordinated with the main drum brakes.

The third brake system shall not use the same brake path or disc used by the main drum brakes.

The brake systems attached directly to the drum shall always apply to stop the winder before any third brake system applies.

2.12.14.3 Drum De-clutching

Where the drums of a double drum winder are clutched the brakes should be capable of holding the drums stationary when the loads are balanced and the normal maximum torque is applied in either direction by the winding motor. In the declutched condition each drum brake should be capable of stopping the winder.

When a drum of a double drum winder is declutched, that drum shall not be capable of rotating. An interlocking system between brake and clutch should ensure that the brake cannot be removed from a declutched drum.

2.12.15 Brake Locking

All winders shall be provided with an effective means of locking the mechanical brakes in position when they are fully engaged, and these means should be set to operate automatically in the event of the loss of power.

2.12.16 Brake Component Factors of Safety

Wherever possible, single line components should not be used for brake linkages. When single line components are used, a minimum factor of safety of 10 shall apply to all brake components, except in the case of screwed threads. In this case a minimum factor of safety of 15, based on the root diameter of the thread, shall apply.

2.12.17 Disc Caliper Brakes

When disc calipers are used to brake the winder, multiple calipers should be used on the disc whenever possible. When selecting the type of caliper to be used, the expected braking cycles during the life of the winder should be taken into consideration.

2.12.18 Brake Capacity

The braking system shall be designed to bring the winder to a halt from an overspeed emergency trip condition without damage or injury to personnel or materials. The brake system should be designed with a margin of safety that allows for possible deterioration of performance.

For vertical shaft drum winders, each brake system on the winder shall have a minimum capacity of 200% of the maximum static out of balanced torque applied by the load to the winder.
2.12.19 Brake Deceleration Rate

When considering the application of braking effort, the protection of personnel being transported is a prime concern. For emergency braking the deceleration rate shall not be greater than 0.5g (4.9 m/s²) and not less than 1.0 m/s².

2.12.20 Brake Deceleration Range

When winders are used to transport both personnel and heavy loads, brakes shall be designed to maintain deceleration rates within the minimum to maximum load range.

2.12.21 Brake intensification

The total Braking System shall ensure that a multiplication of brake effort from multiple brake systems cannot cause damage or injury.

2.12.22 Brake Testing

For every winder transporting personnel, or being used where personnel are working in the vicinity of the operation, brake capacity testing and recording shall be undertaken to the schedule below. The testing shall consist of both static and dynamic tests of all brake systems. Records shall be kept and be available to an Inspector upon request.

Static brake testing shall be conducted weekly.
Dynamic brake testing shall be conducted 6 Monthly

2.12.23 Brake Fade

The brakes shall not overheat or fade during an emergency stop to such an extent that will cause the brakes to fail.

2.12.24 Brake –Multiple Tests

The brakes shall be able to retard to rest at least twice in succession, a descending conveyance, approaching the lower limits of travel, carrying full rated load, and travelling at the maximum speed permitted by the overspeed device.

2.12.25 Brake Operation

Mechanical brakes shall automatically apply on:
(a) power failure;
(b) overspeed of haulage drum;
(c) overspeed of conveyance;
(d) overwind through limits;
(e) slack rope indication;
(f) rope over coiling on drum;
(g) lost motion on gear drive train;
(h) loss of system pressure in the brake control system;
(i) high level drum pit flood alarm; or
(j) Emergency stop buttons at any station.

Mechanical brakes shall also apply if initiated by a normal control stop by driver or the control system.

2.12.26 Brake Control System

The brake control system shall be designed to ensure that, in the event of a control failure or malfunction, the system will fail to safety. The brake control
circuit shall allow the winder to complete its cycle, but not recommence a new cycle if any of the following occurs:

(a) brake wear indication;
(b) faulty or stuck valve indication;
(c) low hydraulic oil level;
(d) low system pressure;
(e) earth leakage alarm;
(f) high temperature alarms including fire alarms; or
(g) low level drum pit flood alarm.

2.12.27 Brake Path Contamination

2.12.27.1 General
If a hydraulic unit is used to control the brake system it should be located and constructed to avoid contaminating the brake paths if a spillage, leakage, burst pipe, or oil spray occurs. Oil spray from any hydraulic leak on one brake system shall not be able to contaminate the brake path nor affect the effectiveness of the other brake systems.

2.12.27.2 Brake Lines
All hydraulic lines should be shielded to provide maximum protection to the brake path (disc) from contamination in the event of a pipe or connection failure.

2.12.27.3 Second Brake Path Contamination
The brake path (disc) shall be protected from contamination due to flooding. If the path (disc) is located where contamination is possible, alarms shall be installed to indicate that flooding has occurred, and the winder should be stopped. If the brake path (disc) is in a pit that could flood, then the second brake system shall not be located in that pit.

2.12.27.4 Pit Drainage
Any pit required to house the winding drum and brake path shall be adequately drained and protected with an alarm system. If natural drainage is unavailable because of the adjacent land levels, or other reasons, the pit should be fitted with an automatic pump-out system and alarms.

2.12.27.5 Winder Floor Levels
The foundations should be constructed such that the floor level of the winder house is at least 150mm above the local ground level. Where the winder house is not fully enclosed, provision should be made to drain water away from any pit.

2.12.27.6 Brake Path Condensation Contamination
Where climatic conditions are likely to cause condensation on the brake path of winder installations, provision should be made to prevent such contamination. This can be achieved by heating the winder house or by fan heating the brake path.

2.12.28 Brake Operation - Post Caliper Brakes

2.12.28.1 Brake Lining
New linings fitted to brake shoes shall be of asbestos-free material and should have a coefficient of friction within the range of 0.30 to 0.43. Linings used for this purpose shall be approved for this use by the brake lining manufacturer.
2.12.28.2 Brake Indicator

Brake engines or cylinders shall be fitted with indicators, visible for daily inspections, to show clearly that the cylinder piston is operating within the range of the cylinder. This indicator should work on a safety margin of at least 10% of the cylinder stroke.

2.12.29 Brake Application Time

Brake engines or cylinders and their control systems should be of such proportion and construction as to allow the brake application time, from receipt of an emergency stop signal to full brake application, to be less than one (1) second.

2.12.30 Brake Operation - Disc Calipers

2.12.30.1 Caliper safety devices

Each brake caliper shall be fitted with indicating and alarm devices to detect brake pad wear and brake pad lift failure.

2.12.30.2 Caliper Mounting

All brake caliper attachment bolts, stands and mounting posts shall have a factor of safety of 10 or greater. Multiple bolts shall be used for all attachment and foundation requirements.

2.12.30.3 Caliper – Disc expansion

Brake disc design should ensure that heating or expansion of the disc caused by brake applications does not reduce the braking capacity.

2.12.31 Hydraulic Power Units

A hydraulic control unit for activating the brakes shall be a fail-to-safety type system. The control system shall be designed to ensure that, in the event of a malfunction, the winder shall be brought to an emergency stop.

2.12.31.1 Brake Unit Specification

The hydraulic brake unit shall include:
(a) Duplicated main control valves
(b) Duplicated exhaust lines from control valves to reservoir
(c) Control valves monitored for correct operation
(d) Exhaust lines monitored for correct operation
(e) Low level hydraulic fluid alarm
(f) Low oil pressure alarm
(g) High oil temperature alarm
(h) Full flow filters of a size to ensure contaminates do not lead to seizure of valves
(i) Visual means of monitoring the power supply to individual solenoids

2.12.31.2 Brake control circuit

The brake control circuit should allow the winder to complete its cycle (return to docking position), but not commence a new cycle, if any of the following events occurs during the cycle:
(a) Faulty or stuck valve indication
(b) Low hydraulic oil level
(c) Low hydraulic oil pressure
(d) High oil temperature
2.12.31.3 Hydraulic Valves

Hydraulic valves shall be designed to minimise the potential for seizure.

2.12.31.4 Oil Spillage

The unit should be designed to confine within the unit construction, any oil spillage, leakage, or spray, due to pipes, seals or joints rupturing. Any collecting tray or container used for this purpose should be easily removable.

2.12.31.5 Oil Reservoir Capacity

The oil reservoir should be large enough to allow the completion of a cycle after a low oil level alarm has been activated.

2.12.31.6 Hydraulic Pumps

Dual oil supply pumps should allow either pump to be isolated for removal and servicing.

2.12.31.7 Brake Settings

Flow valves or other application components should be such as to accurately set the necessary brake application times for the winder to achieve the required deceleration rates. Once set, the components should have the capacity to lock the timing in place.

2.12.31.8 Brake Circuit

The hydraulic system circuits should have all components clearly identified. The final "as manufactured and installed" drawing should include all brake timings set at commissioning.

2.12.31.9 Security

To maintain security of the hydraulic unit, the control system should be designed to be enclosed in a lockable cabinet.

2.12.32 Air control of brakes

An air pressure control unit for activating the brakes shall be a fail-to-safety type system. The control system shall be designed to ensure that, in the event of a malfunction, the winder shall be brought to an emergency stop.

2.12.33 Electro-mechanical actuators

2.12.33.1 Design

When electro-mechanical actuators are used for activating the brakes, the system shall be a fail-to-safety type. The control system shall be designed to ensure that, in the event of a malfunction, the winder shall be brought to an emergency stop.

2.12.33.2 Time Delay

Thrusters should be fitted with time delays to accurately control the brake application.

2.12.33.3 Multiple Operation

The selected thruster actuated shoe brakes should dissipate the heat energy from at least two (2) repeated emergency stops, without brake fade.

2.12.34 Brake Caliper Posts

When brake calipers are mounted on brake mounting posts designed for the purpose of stacking brake calipers, a Factor of Safety of 10 on failure, when based on the worst brake load case, shall be used for the post design and
mounting bolt or foundation bolt design. In all cases, multiple mounting bolts should be used.

2.12.35 Drum Brake Discs

2.12.35.1 Disc Mounting
Brake discs mounted directly on the winder drum may be welded directly to the drum, or bolted to a drum flange.

2.12.35.2 Split Discs
Discs, which are bolted to the drum, may be split into segments to assist mounting and reduce heat distortion problems. Split discs should be keyed at the joint to maintain surface accuracy.

2.12.35.3 Tolerances
Straightness, flatness and run out tolerances on the brake disc should be to caliper supplier recommendations.

2.12.35.4 Material
Material used for the disc manufacture shall be suitable for the purpose and to the disc caliper supplier recommendations.

2.12.35.5 Dynamic Balance
Where high speed discs are provided for emergency high speed brakes, the discs should be dynamically balanced to the maximum overspeed RPM.

2.12.35.6 Disc Alignment
Brake discs should be aligned and fixed to prevent side movement in order to maintain the nominated air gaps and limit switch settings.

2.12.36 Effect of Drive Trains
Winder drive systems shall be designed to allow the brakes to be easily and accurately tested. Because of this requirement, the use of worm reduction gearboxes in the main drive system should be avoided. Where worm reduction gearboxes are to be used, information on reverse drive efficiencies and the effect on the brake efficiency and testing shall be documented. (Refer Section for further details on drive train information).

2.12.37 Operation and Maintenance

2.12.37.1 Non-Destructive Testing of Brake Components
All critical brake components shall be examined at pre-determined intervals.
NOTE: Refer Safe Manriding in Mines, Parts 1A and 1B, 2A and 2B

2.12.37.2 Non-destructive testing
Non-destructive testing is one of the means of ensuring the quality of some brake system components prior to service, by detecting defects. These procedures include magnetic inspection, ultrasonic testing and dye-penetrant methods.

2.12.37.3 Examination interval
Intervals between examinations can be influenced by a number of factors:
(a) Operational duty of the installation
(b) The stressing of a particular component
(c) The significance of the failure
(d) And the size of the designers acceptable imperfections.
2.12.37.4 Critical components

When considering the significance of failure in a braking system, critical components are defined as any component, the failure of which will result in the loss of at least 50% of braking area or force for any one brake system.

2.12.37.5 Duty

Intervals between examinations can be determined from the number of winds per year. A wind is defined as a single journey in a shaft or drift.
(a) Heavy Duty - more than 200,000 winds per year.
(b) Medium Duty -10,000 to 200,000 winds per year.
(c) Light Duty - less than 10,000 winds per year.

2.12.37.6 NDT of critical components

For brake components classified as critical, the frequency of non-destructive testing should be not less than as follows:
(a) Heavy duty - 1 year between examinations;
(b) Medium duty - 2 years between examinations;
(c) Light duty - 3 to 5 years between examinations.

Visual examination of non-critical components should be made at the time when full non-destructive tests are made on critical components.

2.12.37.7 Examination of pinned connections

At the examination all areas comprising pinned connections should be checked for freedom of movement. All pins should be removed and checked for wear and damage.

2.12.38 Brake Testing

2.12.38.1 General

Each brake of every winder shall be subjected to testing to the required design limits at the time of installation.

Brake capacity testing and recording to a pre-determined schedule shall thereafter be undertaken for every winder transporting personnel, or being used where personnel are working in the vicinity of operation.

The testing shall consist of both static and dynamic tests of all brake systems. The testing shall be recorded in the maintenance system at the mine.

2.12.38.2 Static tests

Static brake tests shall be carried out at least once per week. For production winders this may be required once per day.
(a) The purpose of the static brake test is to indicate the holding capacity of each brake path. Each brake in the system shall be tested to a minimum of 200% of the maximum static unbalanced torque applied by the load to the winder. The results of the tests shall be recorded.
(b) The normal method will be to locate the conveyance at a safe position and pull the brake path through the brakes by applying motor torque to each brake system in turn, until the required torque is reached or the brakes pull through.
(c) An established method for conducting the static tests and training operators should be documented.
(d) Static tests should only be carried out with all management safety requirements and rules in place.
(e) Static tests should only be carried out under the direction and supervision of a person authorised by the mine to conduct such tests.

All winders should be equipped with facilities to provide the results of all brake tests.

A system of reporting loss of brake efficiency should be part of the management plan in order to detect and correct any deterioration indicated by the recorded results.

Dynamic brake tests shall be conducted at least every six months.

2.12.38.3 Dynamic tests

Dynamic brake tests should only be carried out:
(a) After static tests have been performed and the results are acceptable
(b) After brake timing (all brake units) have been checked and verified
(c) With all management safety requirements and rules in place
(d) To written and approved procedures
(e) Under the direction and supervision of a person authorised by the mine to conduct such tests.

To carry out a normal dynamic brake test the following procedure should be adopted:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Ensure static brake testing and brake timing checks have been completed before proceeding to dynamic testing. Ensure emergency stop buttons are operating, overspeed devices have been checked and other safety devices are operational. Ensure documented procedures are in place.</td>
</tr>
<tr>
<td>Step 2</td>
<td>Load the conveyance with a dead load equivalent to the maximum person load or maximum out-of-balance person load. Ensure any electrical retardation will not occur during tests</td>
</tr>
<tr>
<td>Step 3</td>
<td>Position the conveyance at a point towards the bottom of the shaft, with ample margin to stop under brakes.</td>
</tr>
<tr>
<td>Step 4</td>
<td>Connect deceleration rate test recording equipment if available or mark rope with suitable tape to measure the stopping distances.</td>
</tr>
<tr>
<td>Step 5</td>
<td>With all brake systems in the operating state allow the winder to run to half speed, and then apply the brakes by activating an emergency stop (press button).</td>
</tr>
<tr>
<td>Step 6</td>
<td>With all brake systems in the operating state allow the winder to run to full speed, and then apply the brakes by activating an emergency stop (press button).</td>
</tr>
<tr>
<td>Step 7</td>
<td>Record loads and stopping distances. Calculate average deceleration rates. Sign and file the brake test sheets.</td>
</tr>
<tr>
<td>Step 9</td>
<td>Return the winder to its &quot;ready&quot; condition</td>
</tr>
</tbody>
</table>

2.12.39 Brake capacity Calculations

2.12.39.1 Calculations

Brake capacity calculations shall be documented for registration of all winders.
These calculations should include:
(a) Percentage of static load
(b) Deceleration rates
(c) Deceleration times
(d) Stopping distances
(e) Thermal efficiencies
(f) Brake component factors of safety

2.12.39.2 Information

Information presented for system certification should include:
(a) Brake control circuit
(b) Brake arrangement and type
(c) Brake friction material and characteristics
(d) Methods for recording brake test results.

2.12.40 Brake Dynamic Performance - General Comments

Each brake shall be capable of retarding and stopping the winder safely before
the descending conveyance carrying the rated load reaches any obstruction.

The conveyance should be retarded at a minimum of 1 m/s².

If while ascending the surface of the drum is retarded at greater than gravity \( g \) (9.81 m/s²) in a vertical shaft, or \( g \times \sin \alpha \) in a shaft inclined at \( \alpha \) to the horizontal, the conveyance will over-run the rope and the rope can become kinked or broken.

The ropes act as an elastic link between the drum and the conveyance. If the
braking effort builds up smoothly over an appropriate period of time, deceleration
at the conveyance will be only slightly different to the deceleration of the drum
and the conveyance will remain under control. If full braking effort is suddenly
applied, the conveyance will bounce significantly and the maximum deceleration
can be up to twice as great as at the drum, especially in deep shafts.

Personnel cannot withstand as high an acceleration rate as materials. A healthy,
attentive person can tolerate deceleration rates of around 6 m/s² either up or
down. Personnel are not likely to be injured if decelerations are limited to 5 m/s².
At low speeds (less than 2.5 m/s) individuals can withstand higher decelerations.

2.13 ENVIRONMENTAL CONSIDERATIONS

2.13.1 Oil Spillage

Special attention shall be given to controlling oil spillage, splash, or
contamination with water drainage.

Where a winder drum is located in a pit, the pit shall be drained sufficiently so
that all oil, or oily water that may escape into the pit, is properly collected and
treated before reaching storm drains or open ground.

Pits should be fitted with alarms to indicate flooding, and to stop the winder.
Where drainpipes are fitted, the pipes should be duplicated to reduce the risk of
fouling. If gravity drainage is unavailable the pit should be fitted with an
automatic pump out systems. Pumps should not pump pit water into the
stormwater drainage system without adequate treatment.
2.13.2 Winder House

The winder house design shall prevent heavy rain and local flooding from affecting the safe operation of the winder. Where the winder is manually operated, the winder house should provide shade.

The winder house floor levels shall be elevated to at least 150mm above the local ground level to ensure that the house is not flooded during heavy rains.

Provision shall be made for cable tray channels to be well drained, and any water collected shall be treated before discharge into storm water drainage.

Automatic winder houses shall have a security system, which prevents unauthorised persons from entering without permission.

Transformers and other electrical equipment outside the winder house shall be protected at all times by appropriate wire or other enclosures with suitable security, which prevents unauthorised persons from entering without permission.

Where the winder is located in dusty or dirty environments, e.g. coal conveyors, consideration shall be given to installing a ventilation system that pressurises the winder house with clean air.

The winder and winder house should be kept in a safe and clean condition, free of any slip or trip hazards. Any oil spills should be cleaned as soon as possible and any leaks contained by some means until permanent repairs can be done. At the completion of any maintenance or repairs all fluid drums full or empty, any tools, parts, timber, rags, and similar should be removed from the winder house and stored or disposed of as is appropriate.

2.13.3 Rope Lubricant

Use trays or other means to gather and control rope lubricant spray or drips from the rope. Treat any water runoff in the area before disposing in the storm water drainage system.
APPENDIX A  AUSTRALIAN STANDARDS

The following Standards are applicable to vertical drum winders:

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<th>Description</th>
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</thead>
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<tr>
<td>AS3785.2</td>
<td>Underground Mining - Shaft Equipment. Part 2: Shaft winding arresting systems.</td>
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<tr>
<td>AS3785.3</td>
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<td>AS3785.4</td>
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<tr>
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<td>Underground Mining - Winding suspension equipment. Part 1: General requirements</td>
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<td>Underground Mining - Winding suspension equipment. Part 4: Drawbars and connecting links</td>
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<td>Underground Mining - Winding suspension equipment. Part 5: Rope swivels and swivel hooks</td>
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<td>AS3637.6</td>
<td>Underground Mining - Winding suspension equipment. Part 6: Shackles and chains</td>
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<tr>
<td>AS1657</td>
<td>Fixed platforms, walkways, stairs and ladders-Design, construction and installation.</td>
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<td>AS3569</td>
<td>Steel wire ropes</td>
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<tr>
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<td>Non destructive examination and discard criteria for wire ropes in mine winding systems</td>
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</table>