4 MECHANICAL EQUIPMENT - DESIGN AND CONSTRUCTION

4.1 Loads and Powers

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Photographs of a Multi-Rope Winder under construction and as completed.

4. MECHANICAL EQUIPMENT - DESIGN AND CONSTRUCTION

4.1 Loads and Powers

When designing components for the winder system, establish the winder loads first. The method of determining the loads and torques will vary depending on the type of winder, but the principles remain the same.

4.1.1 Load and Torque

4.1.1.1 Some loads, such as the material mass, or the skip/conveyance mass, remain constant. Other loads will vary depending on the depth of wind, deceleration rates, or acceleration rates. Frictional and windage forces must also be considered.

4.1.1.2 The winder design will also take into account the shaft configuration requirements, such as depth of shaft and conveyance mass.

4.1.2 Load Cycles

4.1.2.1 The decision on the winder capacity for production winding will depend on the colliery requirement, and will normally be selected on the basis of a required "Tonnes per Hour" of operating time. Having established the Tonnes per Hour required, the engineer can design the winder to output this quantity of coal.

4.1.2.2 When designing for production (bulk) winding the aim should be to lift as large a nett load as possible for a given output. This will keep rope speeds and accelerations as low as possible and therefore reduce peak loads and the RMS power required to operate the winder.

4.1.2.3 For man riding winding, the design of the winder will be governed by the number of personnel which the winder will be required to transport, the size of the shaft, and the time requirements for transportation. Man riding winders vary greatly in capacity, from just a few personnel to up to more than one hundred in single or multideck cages.

4.1.2.4 For drift winding of personnel and/or materials, the size of the winder will be governed by the maximum materials load required to be transported to the drift bottom. Modern drift winding's goal is to transport large machinery to underground seams without having to dismantle it. These winders have an "End of Rope" capacity of from 40 to 100 plus Tonnes. The drift winder is also designed to transport personnel to and from the surface. It is not unusual to transport up to 140 persons at a time in rail mounted conveyances.

4.1.2.5 In all cases, determine winder duty cycles. The duty cycles will relate the speed and torque at specific stages of the wind, to time. This exercise should be carried out for all variations of the winding requirements including heavy and light loads.

4.1.3 Winding Speeds and Accelerations

Winding speeds and accelerations can vary enormously from winder to winder. However there are acceptable ranges of speeds and accelerations which are suitable for modern winding, and a wise designer will stay within these ranges unless employing specific and expert advice.

4.1.3.1 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 lessor depth winding speeds will decrease. Decelerations and accelerations of around 0.75 to 1.5 metres/sec^2 are common. The designer should consider man riding requirements where man riding cages are fitted to skips.

4.1.3.2 Winding speeds and accelerations for conveyances essentially used for man winding should have speeds and accelerations consistent with the comfortable transporting of personnel. Winding speeds of 4 to 6 metres/sec are common for shafts up to 500 metres. As shafts become deeper, speeds may be increased. Decelerations and accelerations of 0.5 to 0.75 metres/sec^2 are acceptable for normal motor control. Section 3 (Brakes and Braking Systems) covers emergency drum brake requirements.

4.1.3.3 With drift winders the safe speed for winding depends largely on the condition of the rail track. Modern drift haulages are located in drifts having a drift slope of around 1 in 3.5. Steeper slopes and unsuitable brakes on transport conveyances have created problems stopping the conveyances in cases of runaway.

4.1.3.4 Drift haulage speeds suitable for well maintained track are 3 to 4 metres/second for man riding, and up to 2 metres/second for heavy materials winding.

4.1.3.5 Accelerations and decelerations for drift winders should be no more than 0.75 metres/sec^2 on the drift, and no more than 0.5 metres/sec^2 on the turnout.

4.1.4 Rope Selection

When designing a winding system first establish a rope size. This will be an iterative process and will depend on the “End of Rope” mass. Until final designs are settled, the mass of the conveyance and attachments will be estimated. Use the required Factors of Safety (See Section 2 - Ropes) to determine the rope size and thus the mass of the rope. Once the rope size has been selected, attachment masses can be estimated. Cage and skip masses may be obtained from previous jobs, from manufacturers, or from experience.

Example 4.1 Rope Selection

A vertical single drum winder is required to carry 20 persons from the surface to an underground seam located at 400 metres deep. Select a rope suitable for the winder.

Mass of a miner and equipment	= 88 Kg
Factor of Safety required on rope	= 10
Mass of personnel in cage	= 20*88 = 1760 Kg
Estimated cage	= 4000 Kg
Estimated attachments mass	= 200 Kg
Estimated rope mass (5 Kg/M)	=(400+15)*5 = 2075 Kg

∴ Mass on rope at drum =8035 Kg

$$= \frac{8035*9.81}{1000}$$

= 78.8 kN

∴ Minimum rope breaking strain = 78.8*10
= 788kN

For shaft over 400 M deep use Non-rotating rope
(Ref section 2.3.1)
From AS1426 Steel wire ropes for mines select ø36 Gd 1770 Non-rotating rope.
Breaking Strain 891 kN Mass 5.49 kg/M.

Recalculate with actual rope mass =(400+15)*5.49
Rope Mass = 2278.35 Kg

Total static load at drum

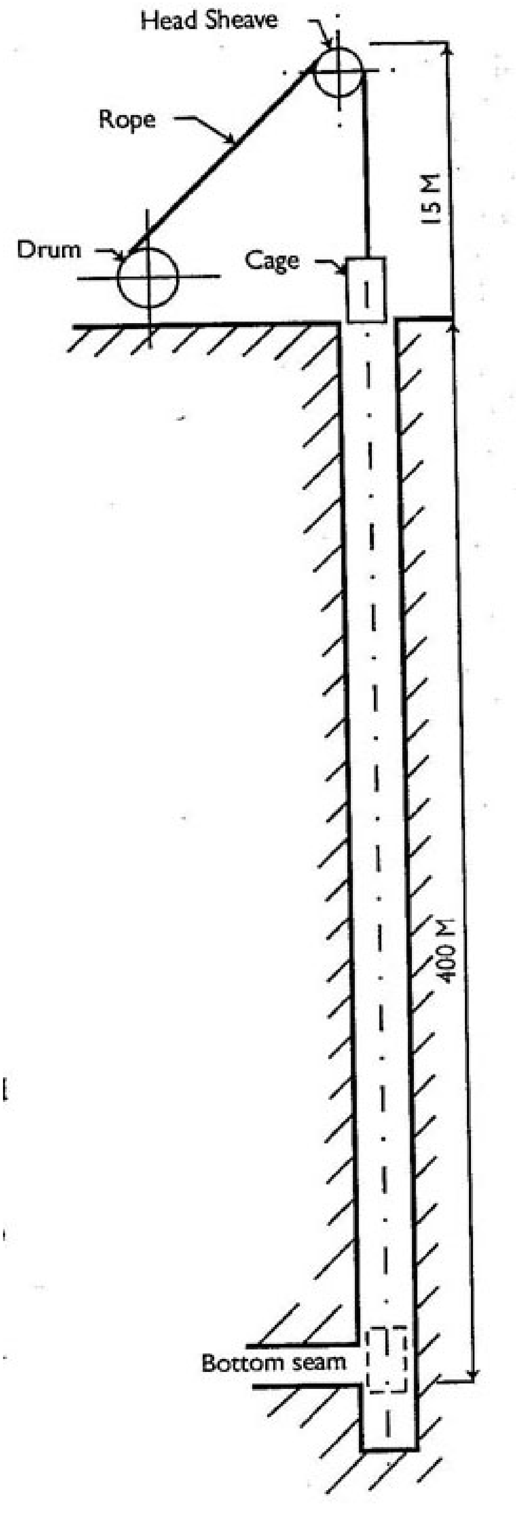
$$= \frac{8238.35*9.81}{1000}$$

= 80.82 kN

∴ Rope Factor of Safety

$$= \frac{891}{80.82}$$

= 11.02 > 10

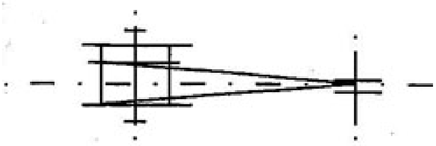


Rope Selection

Fig 4.1

Note: This rope selection will be a preliminary only selection and must be rechecked when cage and attachment masses are finalised.

Example 4.2 Drum Parameters Selection



For a vertical single drum winder with a surface to underground seam depth of 400 metres, select the drum dimensions necessary to correctly coil and store the rope.

Assume a rope diameter of 36mm
Assume a rope angle from drum to sheave of 45°
Assume the drum will have parallel rope grooves.

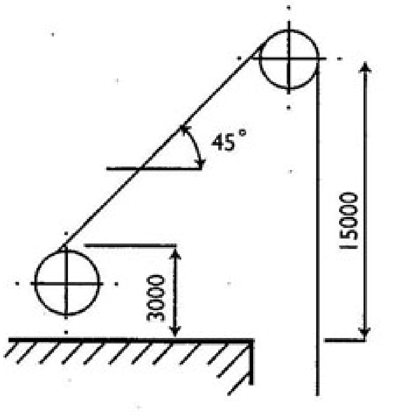


Fig 4.2

From Section 2.3.5.2
Fleet angle required = 1.5°

Distance from drum to sheave = 17 m

Therefore
Drum Width = 2*(Distance to sheave*Tan 1.5)
2* 17* Tan1.5* 1000 = 890.4 mm

Drum to Rope Ratio = 70
(Section 2.3.5.1)

Therefore
Minimum Drum Diameter = 70*36
= 2520mm

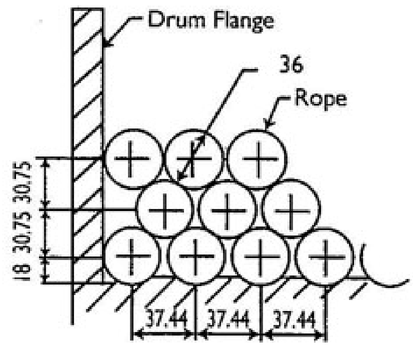


Fig 4.3

Pitch of rope groove = 36 + 36*0.04
(Section 2.3.5.4) = 37.44 mm

Therefore
Number grooves = $\frac{890.4}{37.44}$
= 23.78
say = 24 grooves

Therefore Drum width = 24*37.44
= 898.56 mm

Actual fleet angle = Tan^{-1} (449.28/17000)
= 1.514°

Allow 3 dead coils on drum at all times

Working rope Dia	= 2520 + 36	Working rope length	= (24-3)*π*2.556
1st Layer	= 2556 mm	1st Layer	= 168.63 Metres
Working rope Dia	= 2556 + 2*30.75	Working rope length	= 23 * π* 2.6175
2nd Layer	= 2617.5 mm	2nd Layer	= 189.13 Metres
Working rope Dia	= 2617.5+2*30.75	Working rope length	= 24*π*2.679
3rd Layer	= 2679 mm	3rd Layer	=201.99

Total drum capacity with 3 Layers = 559.75 metres
Capacity required = 400+50
= 450 metres < 559.75

4.1.5 Torque

The power and torque for a drum winder can be developed from the following requirements. The torque needed to:

- lift/lower the load at constant speed
- accelerate the load and system at a nominated acceleration rate
- decelerate the load and system at a nominated deceleration rate
- overcome frictional resistances.

When considering these torque and power requirements, keep in mind the following:

4.1.5.1 As the "End of Rope" load is lowered or raised, the rope mass creating torque at the drum will increase/decrease due to the change of mass of rope hanging from the sheave.

4.1.5.2 However, since the overall rope length is constant, the accelerating/decelerating torque due to the inertia of the rope will be constant.

4.1.5.3 Friction resistances are expressed as:
(a) torque to overcome rope friction
(b) torque to overcome shaft friction.

4.1.5.4 Values for friction have been derived over the years by various methods including friction formulae. However the best source of friction values is found from experience. As a guide the following values may be used:

Winder Type	Rope Friction	Shaft Friction
1. Vertical winding with rope guides	$\mu = .05$	$\mu = .13$
2. Vertical winding with wooden shaft guides	$\mu = .05$	$\mu = .15$
3. Drift haulage winding with good drift tracks	$\mu = .03$	$\mu = .06$

4.1.6 Inertia

To calculate the torque required for accelerating or decelerating the load and system, calculate the system inertias first. System inertias will generally be referred to the drum.

4.1.6.1 Inertia is the resistance of a body to being moved. Rotational inertia is the resistance of rotating bodies such as drums, gears, head sheaves etc., to being accelerated or decelerated (braked). Rotational inertia, also known as the Polar moment of Inertia, J_m, has the dimensional units Kg m² and the general equation $J_m = \Sigma m_j r_j^2$

4.1.6.2 To accelerate the winding system additional torque will be needed to overcome the components' resistance to movement.

4.1.6.3 The polar moments of inertia are related to the mass and shape of the moving parts. To calculate the inertia for a component, such as the winder drum, the component is broken down into smaller parts, or segments, and the segment inertia calculated. The summation of the individual segments becomes the inertia for the component.

4.1.6.4 In winder system design, the inertia is referred to the drum shaft in order to establish the torque at the driving shaft.

4.1.6.5 The values for the various shapes required to establish a component inertia can be found in standard texts or Machinery's Handbook. Some values will be taken directly from manufacturers' catalogues (such as for gearboxes, couplings, motors). The designer should ensure that the units being used are the same.

4.1.6.6 Components not directly associated with the drum axis should have the inertia referred to the drum shaft. Inertias of linear moving masses will have an equivalent inertia referred to the drum shaft.

4.1.6.7 **Shaft Loads** include ropes, skips, cage, attachments, etc.
Inertia at Drum Shaft = Mass * Drum Radius²

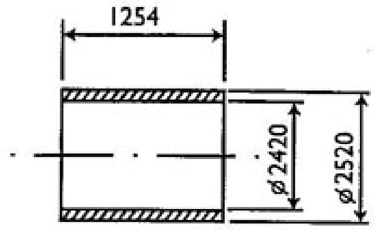
4.1.6.8 **Head sheaves**
Inertia at Drum Shaft = Head sheave inertia *((Drum Dia)/(Sheave Dia)²

4.1.6.9 **Motor armature**
Inertia at drum = Motor Inertia * gear ratio²

4.1.6.10 Gearbox inertia is normally given by the gearbox manufacturer as the inertia at the input shaft
Inertia at Drum Shaft = Inertia Gearbox (Input) * Gear ratio².

Example 4.3 Calculate Polar Moment of Inertia

A winder drum has been designed for a single drum winder carrying personnel to a seam depth of 400 metres. Find the Polar Moment of Inertia for the drum. Fig. 4.4 shows a cross section of the drum.



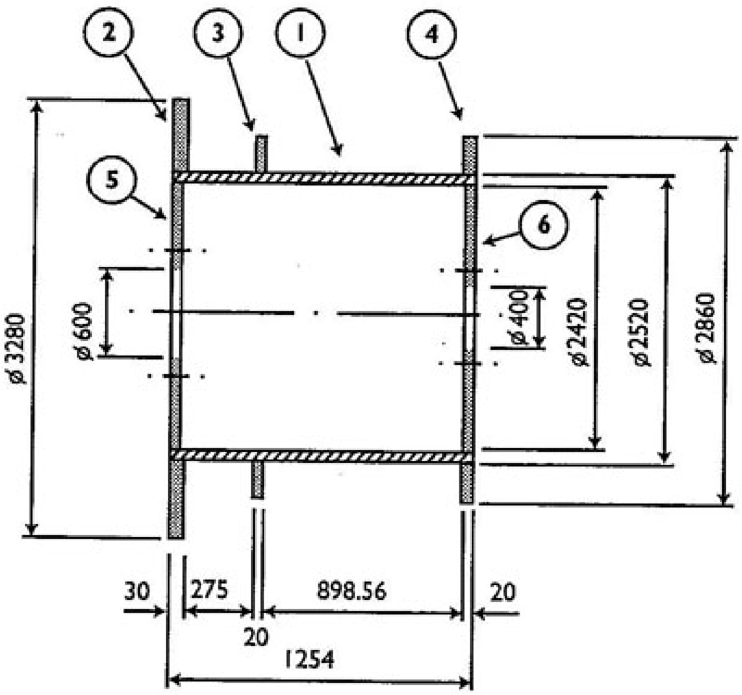


Fig 4.4

Polar Moment of Inertia for Winder Drum = 10017.48 Kg M^2

4.1.7 Accelerating and Decelerating Torque

Having calculated or otherwise obtained the system inertia at the drum shaft, use the following formula to find the torque required to overcome the rotational inertias:

$T = J_m\alpha$

where: T is torque in NM
J_m is rotational inertia in KgM^2
α is angular acceleration in radians/second^2

4.1.7.1 Generally the required acceleration for the winder will be given at the conveyance in units of metres/second^2. These units are converted to angular acceleration or deceleration at the drum rope PCD.

$$\alpha\ (\text{Radians/sec}^2) = \frac{\text{Linear Acceleration} * 2}{\text{Rope PCD}}\ (\text{metres/sec}^2)$$

4.1.8 Static Torque

Static torque is that torque required to hold the load stationary at a nominated depth, ignoring frictional resistances.

4.1.8.1 For vertical shafts

$$T = \frac{\text{Mass (Kg)} * 9.81}{1000} * \text{Drum Radius (M)}$$

where T is torque in kNM.

4.1.8.2 For inclined shafts (drifts)

$$T = \frac{\text{Mass (Kg)} * 9.81}{1000} * \text{Sin Gradient angle} * \text{Drum Radius (M)}$$

where T is torque in kNM.

4.1.9 Accelerating or Decelerating Torque

The torque required at the drum shaft to accelerate or decelerate the winder system will be the summation of the various torques created by inertias, frictional resistances, and static torques. With deceleration, frictional resistances are often ignored because frictional resistances vary, and so cannot be relied upon when considering the braking requirements of winders.

Total Torque = Static Torque + Torque to Inertia + Torque from friction.

Example 4.4 Calculate torque to accelerate system

A vertical winder has components with the following calculated moments of inertia and masses. Find the system inertia and the torque required to accelerate the system when the conveyance is at the bottom on the shaft. Assume a gearbox ratio of 40.16:1 and a maximum acceleration rate of 1.5 m/s^2.

Component	Component Inertia Kg M^2	Component Mass Kg	Inertia referred to Drum Shaft Kg M^2	
Drum	10017.5			= 10017.5
Drum Shaft	1.6			= 1.6
LS Coupling	9.3			= 9.3
Gearbox	0.15		$.15*40.16^2$	= 241.92
HS Coupling	3.5		$3.5*40.16^2$	= 5644.89
HS Brake	5.2		$5.2*40.16^2$	= 8386.7
Motor	35.0		$35*40.16^2$	= 56449
Headsheave	2500.0		$2500*(2520/2000)^2$	= 3969
Cage		4200	$2278*(2.52/2)^2$	= 3616.6
Rope		2278	$4200*(2.52/2)^2$	= 6667.9
Payload		1760	$1760*(2.52/2)^2$	= 2794.17
			$J = \Sigma mk^2 = 97789.6$ Kg M^2	

Angular acceleration at drum $= \dfrac{\text{linear acceleration} * 2}{\text{Drum diameter}}$

$= \dfrac{1.5 * 2}{2.52}$

= 1.1905 Radians/second^2

Additional torque to accelerate $= J\,\alpha$

= 97789.6 * 1.1905

= 116429.2 NM

= 116.43 kNM

Static torque at shaft bottom = static load * drum radius

= 80.82 * 2.52/2

= 101.84 kNM

Torque to overcome friction = static torque * friction coeff.

= 101.84 * .18

= 18.33 kNM

∴ Total torque to accelerate =116.43 + 101.84 + 18.33

= 236.6 kNM

4.2 Winder Drum Design

The purpose of the winder drum is to accommodate the winding rope, together with any excess or testing lengths. It also provides a secure anchorage for the rope and allows the rope to scroll correctly on the drum.

4.2.1 General Construction of Winder Drums

Modern practice is to fabricate the winder drum using rolled steel plates for the shell. Such drums have flexible end connections in comparison with rigid end connections (with much stiffening) used in older drum construction. (See Section 2.3.5 for a guide to sizing the drum for the selected rope).

4.2.1.1 Fabricated drums are normally in mild steel plate. Plates shall be certified free from laminations and inclusions. Any inclusions present at the time of rolling are likely to become laminations during rolling, and the plate could be rejected after much of the work has been done.

4.2.1.2 Before any machining commences the fabricated drum should be stress relieved and all major welds ultrasonically proved.

4.2.1.3 The brake disc path may be welded or bolted to the drum. Both methods have been successfully used. Currently drum design favours the bolted-on approach.

4.2.1.4 The brake disc material should normally be Grade 350 steel. Other steels of equivalent or greater hardness may be used, depending on the brake forces and thermal requirements of the brake system.

4.2.1.5 Give special attention to the shell-to-endplate connection and the method used for welding. The connection must be flexible enough to avoid weld cracking.

4.2.2 Design Methods for Drums

Use an acceptable stress analysis method to calculate drum design stresses. A procedure known as the Atkinson and Taylor method has been successfully used to design many winder drums using flexible endplate practice.

4.2.2.1 For Grade 250 steel a maximum shell compressive stress of 150 MPa should not be exceeded.

4.2.2.2 For Grade 250 steel bending stresses in the shell should not exceed 40 MPa, and bending stresses in the end plates 60 MPa.

Older Spoked Stiff Winder Drum Design

Modern Flexible Fabricated Drum Design

4.2.3 Rope Fleet Angles

The width of the drum between the rope flanges will be governed by the required fleet angle to give correct scrolling of the rope. Excessive fleet angle results in abrasion of the rope and of the rope grooves. Insufficient angle may lead to the rope overcoiling against the rope flanges.

4.2.3.1 For grooved drums and triangular strand or non-spin ropes the fleet angle should not exceed 2 degrees and an angle of 1.5 degrees is a good working angle.

4.2.3.2 For ungrooved drums use a maximum fleet angle of 1.5 degrees.

4.2.3.3 In the case of locked coil ropes the fleet angle should not exceed 1 degree 20 minutes.

4.2.4 Hawse Hole or Rope Entry Position

The rope is passed from the rope anchorage position, usually inside the drum endplate, to the first coil through a hole formed in the drum shell and known as the hawse hole. It is important that the correct position and side of the drum be determined for the hawse hole.

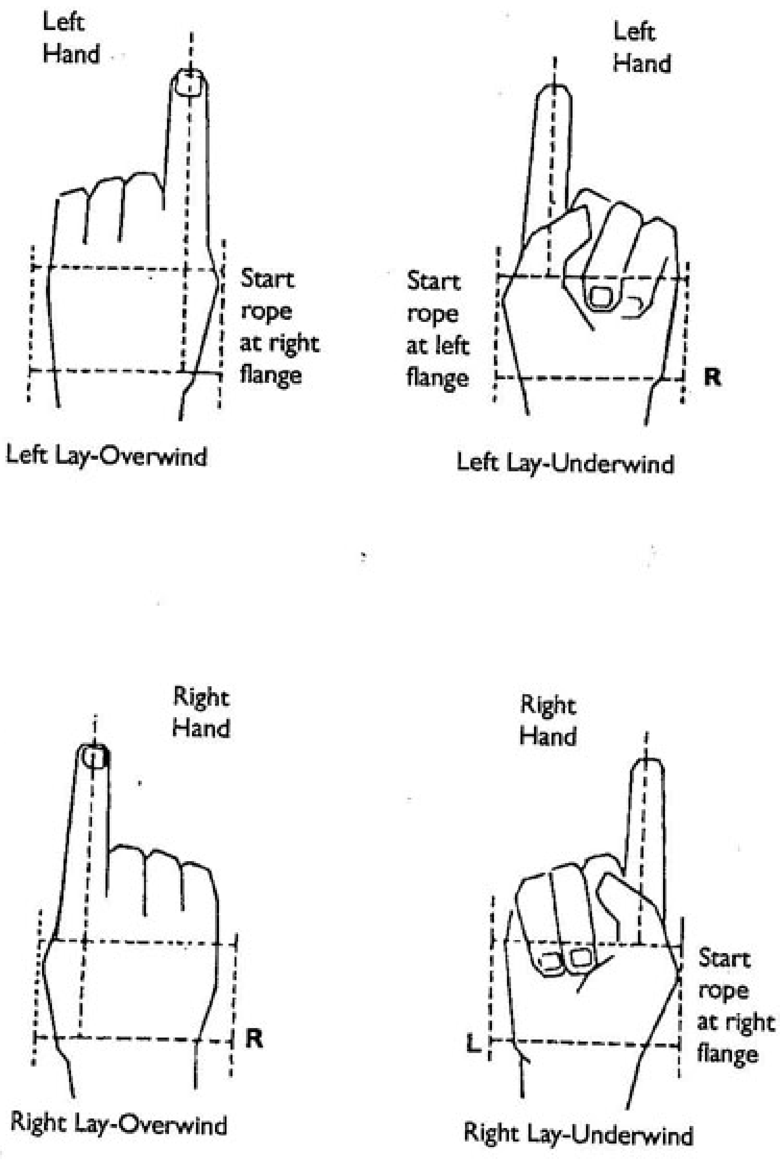
4.2.4.2 Where the centre of the sheave falls to one side of the drum rather than on the centerline of it, the hawse hole on that side should be used, irrespective of what hand of lay the rope is. The arrangement should also be such that the number of unused turns of rope on the drum is sufficient to cause the live turns of rope to always be on the side of the drum beyond the sheave centreline with respect to the hawse hole in use.

4.2.4.3 Always design hawse holes so that the rope enters the drum without sharp turns. All corners and sharp edges should be removed to avoid damage to the rope by nicking or crushing.

4.2.5 Wedges and Risers

To avoid abrasion of the rope on its first turn, fit a steel rope wedge against the flange in front of the hawse hole. When the rope fills the first layer and starts to return on the second layer, the rope will be lifted. At this point severe crushing can occur. To prevent this a steel riser is fitted to the flange and drum shell to lift the rope.

4.2.5.1 Wedges and risers should be approximately 20 rope diameters long.



Method of Determining Direction of Coiling

Courtesy Haggie Steel Ropes Limited

4.2.6 Rope Vibrations

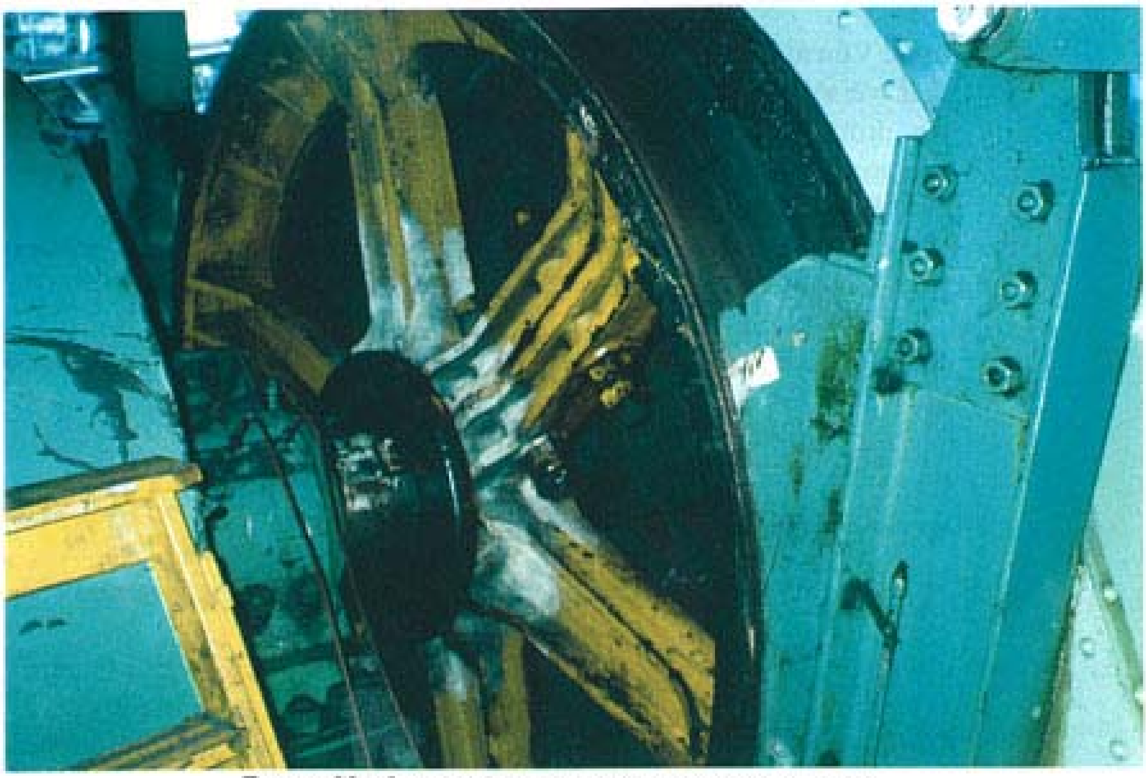
Transverse vibrations or oscillation of the rope between the headsheave and the drum is a problem sometimes encountered on drum winders when operating with multi-layers of rope. These oscillations may occur during some part of the winding cycle. It is always good practice to check for these oscillations in the design stage, since they are difficult to overcome once the winder is in place.

4.2.6.1 The frequency of the fundamental vibrations may be measured from

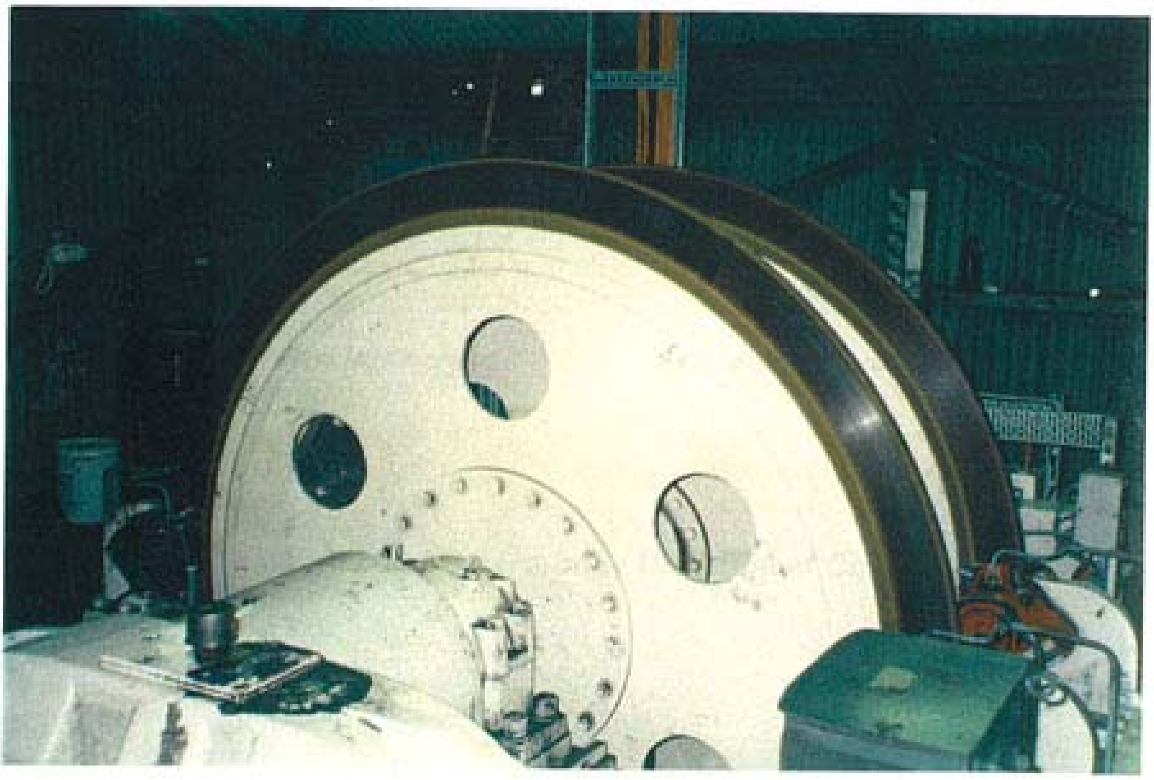
$$\omega = \frac{1}{2L_c} \frac{\sqrt{F}}{\sqrt{m}}$$

where ω = fundamental frequency in cycles/sec
L_c = distance from headsheave to drum in metres
F = tension in rope in metres
m = mass per unit length of rope in Kilograms/metre

4.2.6.2 Ensure that the impulses from the turn cross-overs on the drum do not coincide with the fundamental frequency of the rope. Second and third harmonics should also be checked where higher rope speeds are being used.



Drum Shaft Attachment - Keyed Arrangement



Drum Shaft Attachment - Bolted arrangement

4.3 Shaft Design

4.3.1 Fatigue

Shaft design for winder drums will generally accord with AS1403 - Design of Rotating Steel Shafts For Fatigue. Use the maximum acceleration or braking loads.

4.3.1.1 In shaft design examine torque, bending moments, and axial loads, and any combination of loads. All loads should be considered, including normal working, accelerating, braking, heavy materials, erection, and special heavy lift loads.

4.3.1.2 Use a fatigue factor of 1.3 when designing the shaft.

4.3.1.3 In general, the shaft material should be 1040 or 1045 grade steel. This provides an economical shaft with good fatigue and machining properties. Steels having higher tensile properties may be used but, unless designing for strength, there is little economic or engineering gain.

4.3.1.4 Generally the shaft will be designed on the maximum peak loads calculated from acceleration and braking loads, as defined by AS1403. Consider using a cumulative fatigue damage calculation when determining the effects of a small number of heavy loads on the fatigue life of the shaft.

4.3.1.5 Check shafts for deflections to confirm that bearing selection is within deflection tolerances. High speed shafts require additional attention to ensure vibrations are kept within limits.

4.3.2 Strength

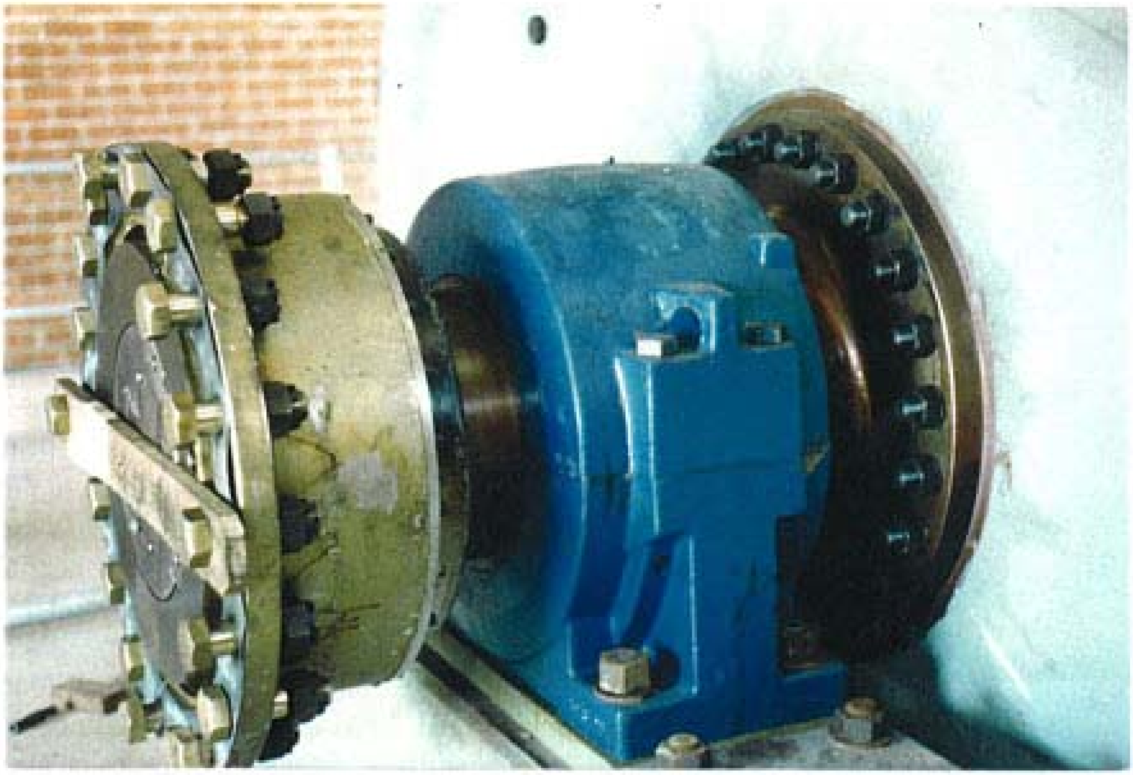
Check shafts for strength. The winder shaft should resist the breaking strain of the rope plus 20% without permanent deformation.

4.3.3 Bearings

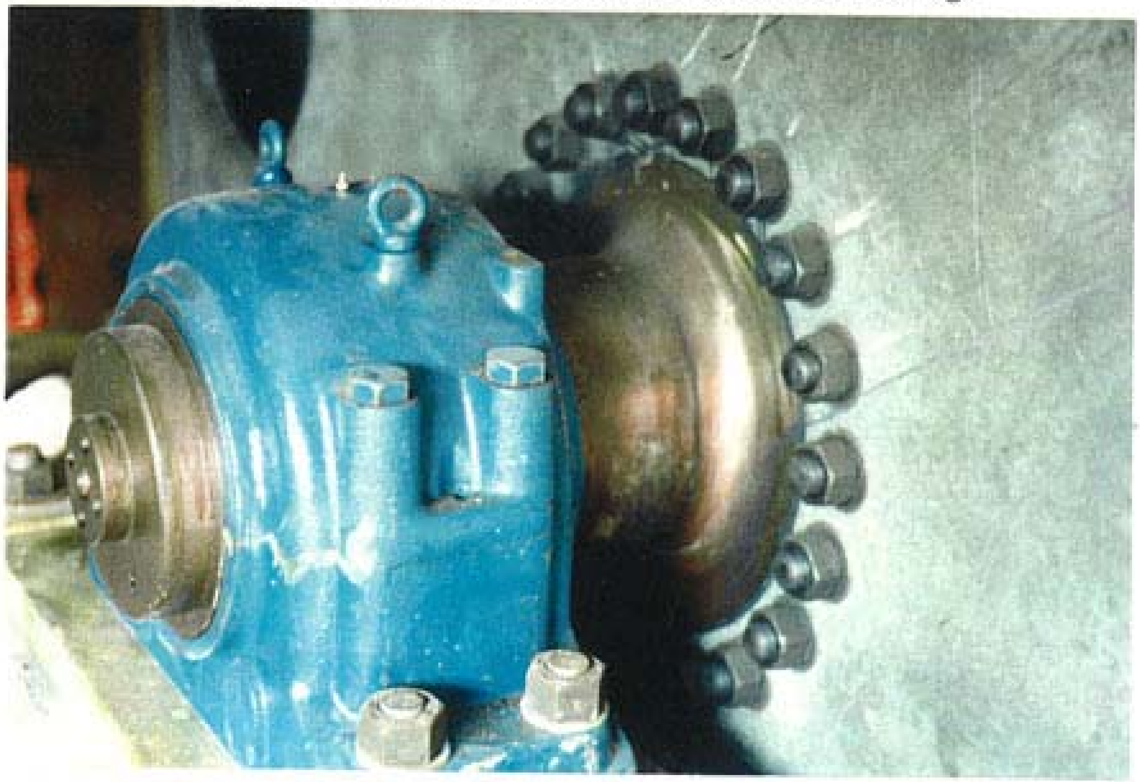
Select shaft bearings using normal bearing selection procedure.

4.3.3.1 Calculate bearing life based on the life of the winder and on a safety factor that ensures overall system reliability.

4.3.3.2 To minimise fatigue problems check bearing housings, housing caps and housing hold down bolts for strength, using the minimum rope break strength plus 20% without failure.



Coupling end shaft connection for 80 Tonne Drift Haulage



Non-Coupling end of drum shaft for 80 Tonne drift haulage

4.3.3.3 Wherever possible use four (4) housing bolts and cap screws. Always record and correctly implement bolt and cap screw tightening torques (refer to Section 4.10).

4.3.4 Shaft to Drum Connection

Where possible avoid using keys to connect shafts to drums preference is for bolted connections (refer to Section 4.10). When keys are used check them for both fatigue and strength.

4.3.4.1 Keys fitted to winder shafts should be a tight side fit to avoid fretting caused by any inertial movements of masses.

4.4 Gears, Gearboxes and Couplings

Using gears and/or gearboxes in the winder drive system is a common method of speed reduction/torque increase for the winder drum. Some contemporary large winder designs, however, eliminate the gearbox or gears and couple the motor armature directly to the drum shaft. Technological advances also allow the armature to be built inside the drum. However, these techniques are not yet common, and should only be used where the manufacturing experience is available.

4.4.1 Selection of Gearboxes

Ratings of gearboxes for use with drum winders should be based on both a fatigue and a strength basis.

4.4.1.1 The fatigue and strength ratings selected for gearboxes or gears should be based on either the maximum peak loading due to acceleration or braking, or preferably, on a cumulative fatigue damage analysis that takes into account all load cycles, including any heavy lift or abnormal load conditions.

4.4.1.2 A service factor for durability of 1.5 should be a minimum for winder gears and gearboxes.

4.4.1.3 A service factor for strength of 1.75 should be a minimum for winder gears and gearboxes.

4.4.1.4 Select a service life of 40 years as a minimum for winder gears and gearboxes.

4.4.1.5 Give special consideration to the thermal rating of hardened and ground gearboxes. Where possible, gearboxes should be sized to avoid using external cooling systems.

4.4.2 Gearbox Monitoring

Gearbox monitoring is recommended for automatic winders. Sensors should be used to monitor:

(a) High lubricating oil temperature
(b) Low lubricating oil level
(c) High bearing temperature

4.4.3 Bull Gears and Pinions

When bull gears and pinions are used as the final reduction drive gears, service factors for fatigue should be 1.5 minimum. Service factor for strength should be a minimum of 1.75.

4.4.3.1 Adequately seal gears and pinions to prevent lubrication splash and contamination of brake discs.

4.4.3.2 Shaft sections of the gear pinions should have sufficient strength to resist rope break plus 20% without failure.

4.4.3.2 Select bearing housings, caps and bolts to resist rope break plus 20% without failure.

4.4.4 Manual Gear Reduction

Avoid gearboxes with manual gear changing for heavy material loading. If gearboxes are fitted with high/low reduction gear change, the gear change mechanism should be positively locked into position, and should be interconnected with the low speed brakes to ensure that the gearbox change mechanism cannot be moved out of gear unless the low speed brakes are locked on. (See Brake testing - Section 3)

Example 4.5 - Selection of a gearbox for winder duty

Calculate the values for the Torque-Speed-Time duty cycle for a single drum winder winding to a seam depth of 400 metres with a load of 20 persons. Assume 40 cycles per day for a 7 day per week operation over a period of 40 years. Assume an acceleration and deceleration rate of 1.5 metres/second^2 and a maximum speed of 4 metres/sec. The conveyance will creep out of and into the fixed guides at 1 metre/second for a distance of 5 metres.

Values for each section of the cycle will be calculated and presented in a table as follows:

Descending	Drum RPM	Time (Sec)	Distance (M)	Torque (kNM)	Total Hours
Section 1	0	0		41.75	
Acceleration	7.58	0.667	0.33	41.72	108.20
Section 2	7.58			93.04	
Const. Speed	7.58	5.667	5.33	93.38	811.12
Section 3	7.58			41.38	
Acceleration	30.31	7.667	10.33	41.04	324.45
Section 4	30.31			93.72	
Const. Speed	30.31	101.835	389.67	119.46	15276.28
Section 5	30.31			235.89	
Deceleration	7.58	103.835	394.67	236.23	324.45
Section 6	7.58			119.80	
Const. Speed	7.58	108.835	399.67	120.14	811.12
Section 7	7.58			236.56	
Deceleration	0	109.502	400.00	236.60	108.20
Ascending					
Section 8	0	0		236.60	
Acceleration	7.58		0.35	236.56	108.20
Section 9	7.58			120.14	
Const. Speed	7.58	5.667	5.33	119.79	811.12
Section 10	7.58			236.23	
Acceleration	30.31	7.667	10.33	235.89	324.45
Section 11	30.31			119.46	
Const. Speed	30.31	101.835	389.67	93.72	15276.28
Section 12	30.31			41.04	
Deceleration	7.58	103.835	394.67	41.38	324.45
Section 13	7.58			93.38	
Const. Speed	7.58	108.835	399.67	93.04	811.12
Section 14	7.58			41.72	
Deceleration	0	109.502	400.00	41.75	108.20
		Σ = 219 Sec			Σ = 35527 Hrs

Note: Total hours @ 40 cycles/day for 40 years $= \frac{40 * 219}{3600} * 40 * 365$

= 35527 Hours (continuous life)

Example 4.5 (Continued)

The duty cycle for the winder may be presented with the Torque-Speed-Time graphs taken from the previous table. Selection of the gearbox can now be based on a cumulative fatigue damage calculation. For a commercial gearbox, the gearbox rating is normally given with a life rating of 20000 hours with a service factor of 1. An equivalent torque rating can be obtained from table Ex 4.5 for 20000 hours equivalent life.

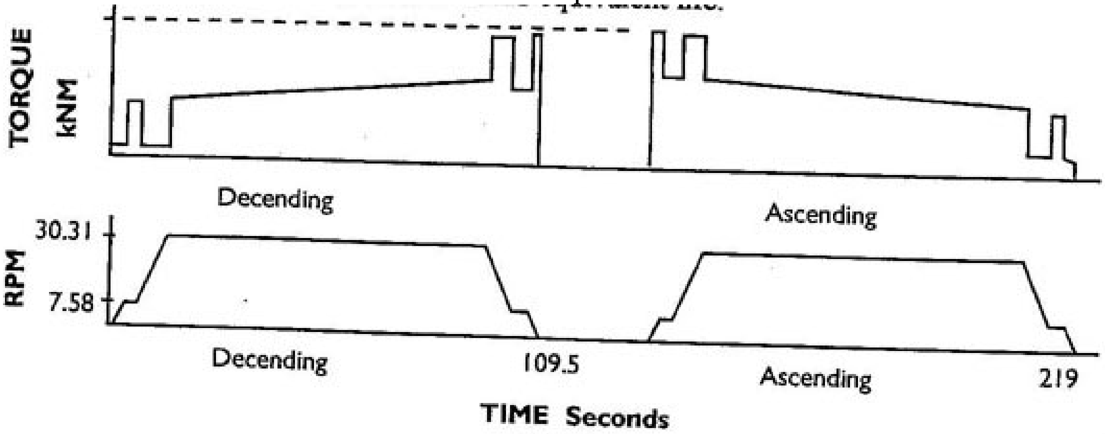


Fig 4.5

Equivalent life Design Torque and Speed analysis
Component reference: Selection of gearbox

Data for cumulative fatigue analysis -

Step No	Total Time Hours	Speed In RPM	Speed Out RPM	Torque In kNM	Torque Out kNM
1	108.2	0	7.58	41.75	41.725
2	811.12	7.58	7.58	93.04	93.38
3	324.45	7.58	30.31	41.38	41.04
4	15276.28	30.31	30.31	93.72	119.46
5	324.45	30.31	7.58	235.89	236.23
6	811.12	7.58	7.58	119.8	120.14
7	108.2	7.58	0	236.56	236.6
8	108.2	0	7.58	236.6	236.56
9	811.12	7.58	7.58	120.14	119.79
10	324.45	7.58	30.31	236.23	235.89
11	15276.28	30.31	30.31	119.46	93.72
12	324.45	30.31	7.58	41.04	41.38
13	811.12	7.58	7.58	93.38	93.04
14	108.2	7.58	0	41.72	41.75

S-N slope index P for component material 3.5

Analysis output -

Design torque	=	129.307 kNM	Design speed	=	30.31 RPM
Design hours	=	20000	Design KW	=	410.397

(Cumulative fatigue calculation courtesy **MECH-PAK**™ software)

Gearbox rating	Durability	= 410.4 * 1.5
		= 615.6 kW with Service factor 1.5
	Strength	= 410.4 * 1.75
		= 718.2 kW with Service Factor 1.75
	Peak Torque	= 236.6 * 2
		= 473.2 kNM with Safety Factor 2

4.5 Clutches

The normal method of changing levels for double drum winding is to declutch one drum and turn the declutched drum to relocate the conveyance to a different level. This is achieved with a toothed clutch. The clutch housing is attached to the winder drum. The clutch body slides on the shaft. When considering clutches associated with winders, this is the main purpose of the clutch, however other component areas such as gearbox clutches may also be required. The standard clutch design principles apply to all toothed clutches.

4.5.1 Clutch Design

Design the clutch to acceptable clutch design principles. Winder clutches are normally designed using involute or straight splines. If using involute splines, the standard DP (Inch) or Module (Metric) system shall be adopted.

4.5.2 Interlocking of clutches and brakes

Before the winder drums can be declutched, the drum brakes on the declutched drum must be positively locked on. (See Section 3 - Brakes).

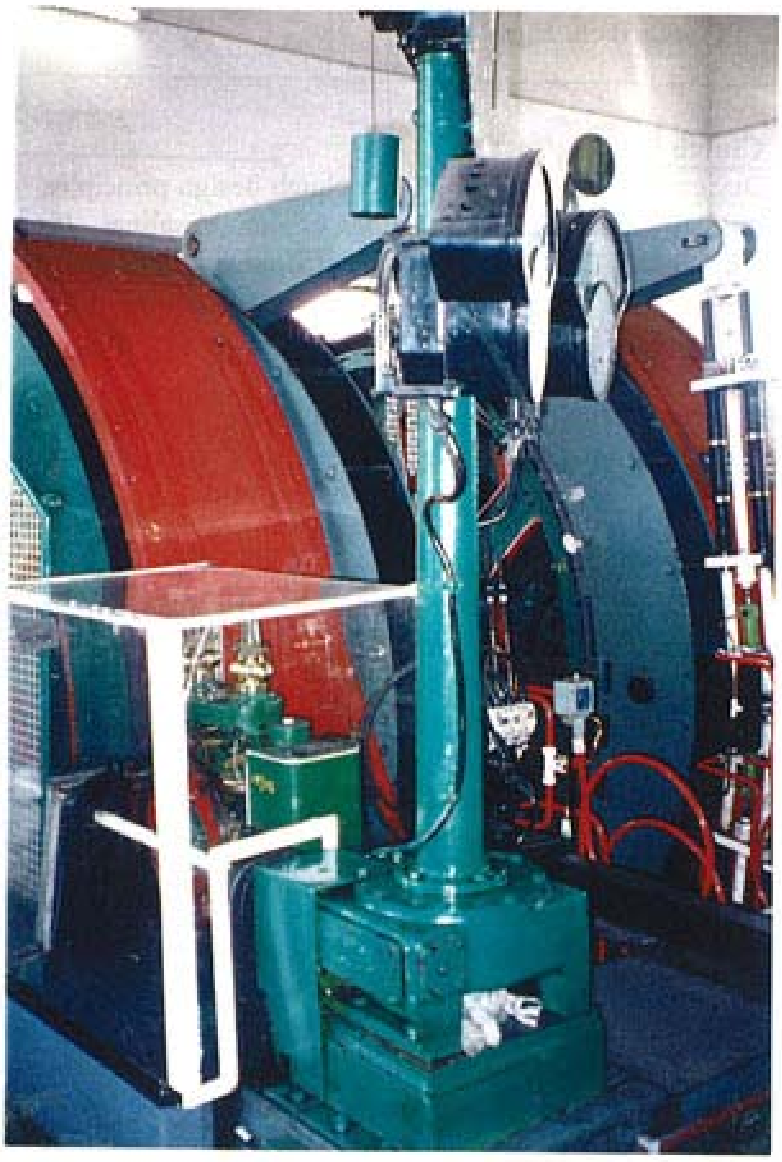
4.5.3 Clutch Factors of Safety

If a winder drum clutch fails, the winder drum brake will be the means of arresting the conveyance. Drum brakes would be activated by the drum overspeed and broken shaft control system which must be independent of a clutch failure. Therefore the factors of safety required for the clutch should regarded as being the same as those required for the shaft, i.e. 1.3 on fatigue rating and a minimum of 2 on strength.

4.5.4 Commercial Clutches

If a commercial clutch unit is being selected the clutch should use a service factor of 2.0 for vertical winders and 1.75 for drift winders. In all cases the strength of the clutch should be checked against the worst possible load.

Photograph - Double Drum Clutch Arrangement



4.6 Brake Calipers and Brake Supports

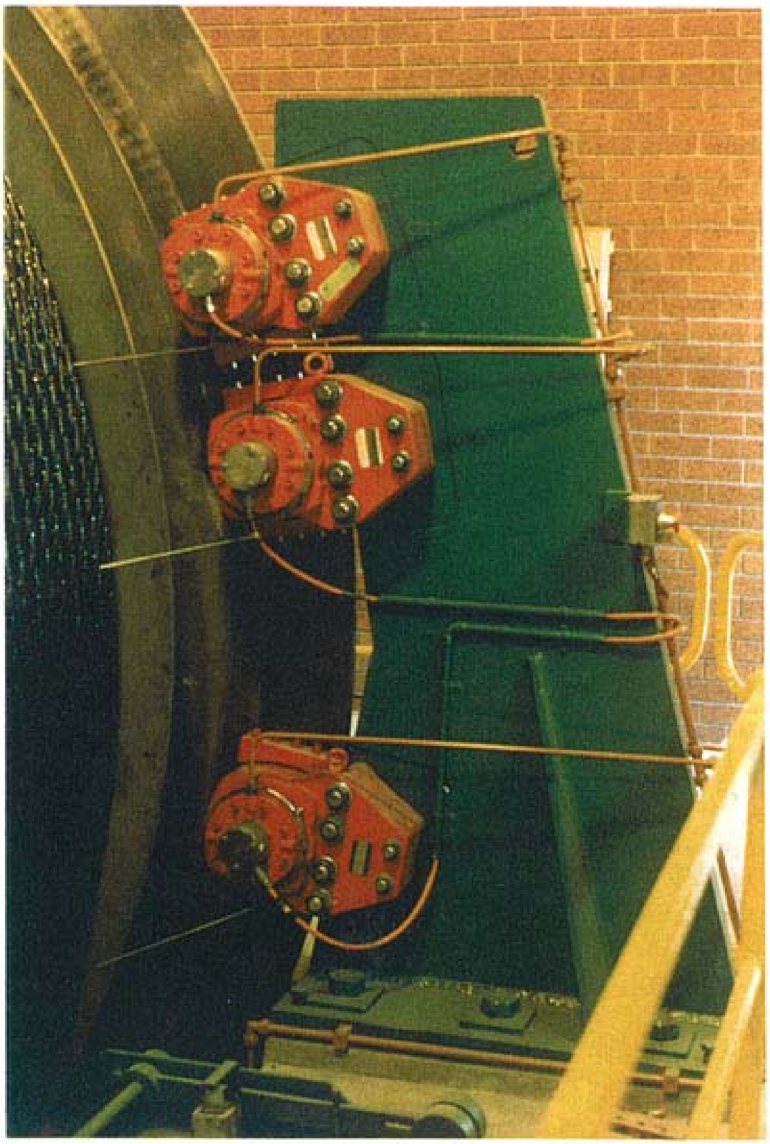
Modern drum winders use disc brake calipers in single or multiple units acting on a brake disc which is attached directly to the drum by a bolted or welded connection. Older winders have various configurations of brake paths, posts, and brake components. In all cases the brake must apply a braking torque to the drum, and hence the rope, to stop the conveyance and winder system in a controlled manner within the requirements of the statutory authority (See Section 3 - Brakes and Braking Systems).

4.6.1 Calculation of Braking Torque

Various texts are available on brake torque calculation. The brake torque calculations should be supported by available literature on the frictional and thermal properties of the brake lining material being used. Factors of safety for brake components and capacity should be as given in Section 3. Post caliper brakes shall act in both directions.

4.6.2 Band Brakes

Band brakes are normally unacceptable for drum winders, however, some band brakes still exist on extremely slow moving stage winders. In most cases these brakes are uni-directional. On smaller units the efficiency of the brake is lowered substantially by the stiffness of the brake band and calculations should reflect this.



Multiple disc brake calipers on 80 Tonne drift haulage

4.7 Handrails, Guards, Ladders, Stairways

All equipment, machinery, moving components, etc. supplied as component parts or as complete units, when finally commissioned and ready for service, shall be provided with adequate guards, railing and fences, ladders, platforms and stairways, to ensure the protection of operators, service personnel, inspectors, and any other person involved in the operation and maintenance of the winder, haulage or associated equipment.

4.7.1 Definitions (Ref: NCB Codes and Rules for Minimum standards of fencing and guarding)

4.7.1.1 "A Fence is a barrier of finite height mounted on the ground or floor which deters persons from access to particular areas, machines, etc. (Note: A mesh covered or solid fence installed in accordance with "reach curves" is classified as a guard)."

4.7.1.2 "A Guard is a barrier which prevents persons from being in contact with or within dangerous proximity of particular parts of machines, etc."

4.7.1.3 "A Permanent Guard or Fence is one forming an integral part of the machinery, equipment or site, or secured to it by mechanical fasteners."

4.7.2 Design Principles

The following principles shall be observed in the design of all guards and fences.

4.7.2.1 Guards shall be designed and positioned, so far as is reasonably practicable, to protect personnel from hazard.

4.7.2.2 Guards shall be designed to take into account the practical considerations that will arise in service.

4.7.2.3 To maintain observation and ventilation, guards should normally be made of a mesh material, suitably protected at the edges. However in some cases a solid guard may be preferable.

4.7.2.4 The mesh material shall be of a type which resists distortion and adequately maintains its original aperture dimensions throughout its service life.

4.7.2.5 Guards shall be provided with sufficient joints or other features to facilitate initial installation and subsequent maintenance operations.

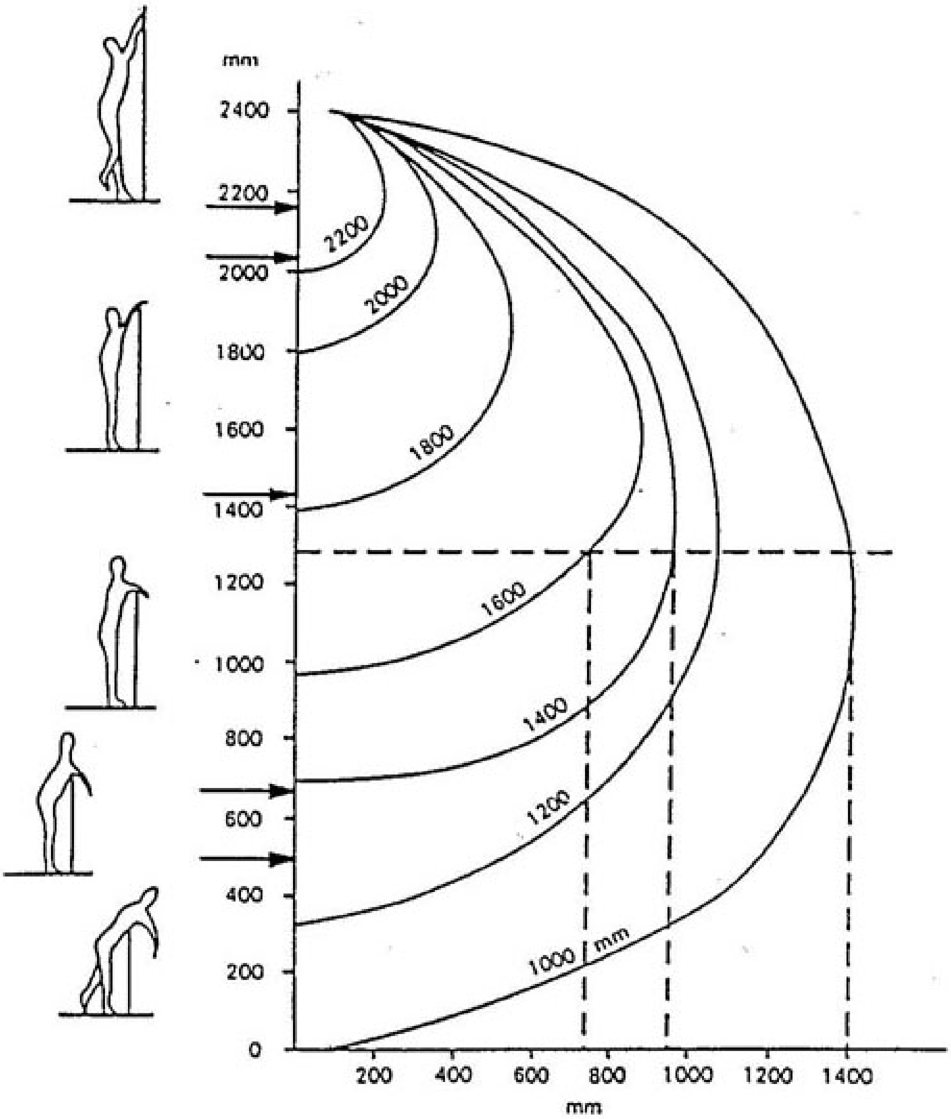


FIG. 1 - Reasonable reach curves for guards of different heights.
Based on Table 2

The reach curves (Fig. 1) are interpreted as follows: to calculate the guard distance for a dangerous part 1200 mm from the floor or working platform, follow a horizontal line from the point 1200 mm on the vertical axis until it intersects the reach curves, each of which is marked with the height of the guard to which it applies. The distance of reach can now be read off on the bottom scale, vertically below the point of intersection. Thus, the 1300 mm line intersects the reach curve for a guard 1600 mm high at a point 750 mm which is the distance of reach.

Ref: NCB Codes and Rules for minimum standards of fencing and guarding

4.7.2.6 Where practicable the design shall enable safe lubrication without removing the guard. Where this is impracticable, arrangements shall be made to ensure that lubrication can be achieved without danger (e.g. for the machinery to be stopped).

4.7.2.7 Where it is necessary to carry out routine adjustments with machinery in motion, the design shall allow for this without the need to remove the guard.

4.7.2.8 Guards shall be designed so that individual sections have adequate strength and stiffness for transporting and installing, and when in use are sufficiently robust to retain their shape and designed clearance from moving parts. This may be achieved either by using mesh or plate of adequate inherent stiffness, or by using lighter mesh or plate with suitable additional stiffening.

4.7.2.9 All metallic guards shall be protected against corrosion to a standard appropriate for the application.

4.7.2.10 Where sheet metal is used it shall be a minimum thickness of 1.5mm. Adequate ventilation must be provided.

4.7.3 Fence Design

The following additional general principles shall be observed in the design of a fence for safeguarding machinery.

4.7.3.1 The height of the fence and the clearance from any moving parts shall comply with reach curves Figure 1 and dimensions from Table 2.

4.7.3.2 Where panels are attached to one side of a supporting structure they shall be on the side of the structure away from the machinery so that, if the panels are dislodged, they will tend not to fall on to the machinery.

4.7.3.3 When determining the safe distance needed for access prevention to dangerous points by persons reaching over a guard, the following factors shall be taken into account:

- height above the ground at nip point (a)
- height of the horizontal edge (b)
- horizontal distance to the edge from the nip point (c)
- reaching distance (G) - 850mm.

TABLE 1
Relationship of mesh sizes to minimum clearances between guard and moving part.

Standard wire gauge		Diameter (mm)		Mesh size		Minimum clearance from inside of guard to moving part	
Main	Cross	Main	Cross	mm	in	mm	in
16	16	1.60	1.60	12 x 25	1/2 x 1	20	2/4
14	14	2.00	2.00	12 x 12	1/2 x 1/2	20	2/4
12	12	2.50	2.50	12 x 76	1/2 x 3	20	2/4
				25 x 25	1 x 1	80	3 1/4
				25 x 50	1 x 2	80	3 1/4
10	10	3.15	3.15	12 x 12	1/2 x 1/2	20	2/4
				12 x 25	1/2 x 1	20	2/4
				12 x 76	1/2 x 3	20	2/4
				25 x 50	1 x 2	80	3 1/4
				50 x 50	2 x 2	80	3 1/4
8	8	4.00	4.00	25 x 25	1 x 1	80	3 1/4
				25 x 50	1 x 2	80	3 1/4
				50 x 50	2 x 2	80	3 1/4
6	6	4.50	4.50	50 x 50	2 x 2	80	3 1/4

Notes

1. The above table shows rectangular and square mesh sizes that are included in NCB Specification No. 575 ‘Welded Steel Fabric for Machinery Guards’.

2. The use of rectangular or square mesh sizes in excess of 50 mm for machinery guards is not recommended except where the other dimension is less than 20 mm.

3. Should it be necessary to use a mesh shape that is other than square or rectangular then the minimum clearance from the inside of the mesh to the nearest moving part should be determined in the following manner:
   - (i) if a 12 mm diameter bar will not pass through the mesh aperture then the clearance shall be a minimum of 20 mm;
   - (ii) if a 12 mm diameter bar will pass through the mesh aperture then the clearance shall be a minimum of 80 mm;
   - (iii) mesh with an aperture through which a rectangular probe 20 mm x 46 mm will pass shall not be used.

4. Where woven wire mesh is used for machinery guards then the mesh should be firmly attached to a suitable rigid frame such that the mesh aperture dimensions are adequately maintained.

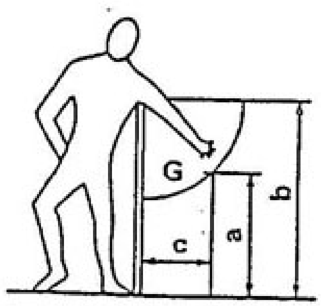
5. The use of expanded metal is acceptable for machinery guards provided that all sharp edges are eliminated.

Ref: NCB Codes and Rules for minimum standards of fencing and guarding

TABLE 2 REACH TABLE:
Safe distance needed for prevention of access to dangerous points by reaching over a guard

Height of edge of guard *b*	2400	2200	2000	1800	1600	1400	1200	1000
Height of nip point above ground *a*	Horizontal distance, *c*, from nip point							
2400	-	100	100	100	100	100	100	100
2200	-	250	350	400	500	500	600	600
2000	-	-	350	500	600	700	900	1100
1800	-	-	-	600	900	900	1000	1100
1600	-	-	-	500	900	900	1000	1300
1400	-	-	-	100	800	900	1000	1300
1200	-	-	-	-	500	900	1000	1400
1000	-	-	-	-	300	900	1000	1400
800	-	-	-	-	-	600	900	1300
600	-	-	-	-	-	-	500	1200
400	-	-	-	-	-	-	300	1200

All dimensions in millimetres G = 850 mm



§ Extracted from ISO/TR 5045-1979 (E)

- Dimension *b* should not be less than 1000 mm because of the risk of falling into the danger zone.

Ref: NCB Codes and Rules for minimum standards of fencing and guarding

4.7 Handrails, Guards, Ladders, Stairways (continued)

4.7.4 Fixed platforms, walkways, stairways and ladders

Wherever personnel require access to or from landings, headframes, sumps, floorways, shafts; emergency access to or from conveyances, or other; when there is a need to load or unload personnel, or where people may be engaged in inspections or maintenance, then platforms, walkways, stairways and ladders shall be provided.

4.7.4.1 All ladders, platforms, stairways and walkways shall conform to AS1657 - Fixed platforms, walkways, stairways and ladders - Design, construction and installation.

4.7.4.2 When designing ladders, platforms, stairways and walkways, allow for the safe removal of injured personnel.

4.8 Foundations

4.8.1 Foundation design

Foundation design for winder drums, associated machinery, headframes and headsheave supports, and rope roller supports including crest and side guide or turnout roller support structures should be undertaken, and/or checked by a competent civil design engineer.

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

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

4.8.2 Headframe, guide and arrester systems

Headframe, guide systems and arrester system foundation design shall note the requirements of AS 3785 Parts 1 to 8.

4.8.2.1 For single rope drum winders and for drift winders, the foundations for drums and head sheaves shall allow for the maximum rope break condition plus 20% without failure of either the concrete or steel support structure. For this condition failure means "no longer able to be used to support the winder working loads".

4.8.2.2 For all drum winders, foundation bolts shall be capable of resisting all fatigue loading cycles, and shall consider the maximum rope break condition plus 20% without permanent failure. For this condition failure means "no longer able to support the winder working loads".

4.8.3 Foundation bolts

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

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

4.8.3.2 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.

Winder foundations showing pit and footings.

4.9 Headsheaves

The general requirements for headsheaves used for drum winders are compiled in AS3785 Part 7 - 1993 for the sheave, sheave shaft and bearings.

4.9.1 Calculations

4.9.1.1 Appendix A of AS3785.7 gives constructional proportions for rim sections for both plain rims and rims with inserts. Calculations should substantiate the use of these dimensions.

4.9.1.2 Design calculations shall be provided for both fatigue and strength considerations. Strength calculations shall assess the rope break condition and shall evaluate the rope forces at rope break condition plus 20% without failure of any sheave assembly component. For this condition failure means "no longer able to support the winder working loads".

4.9.2 Head sheave support bolts and structure

Head sheave support bolts and the support structure design should encompass the fatigue loads and the rope breaking loads.

4.9.2.1 When calculating stresses in the sheave components, always base stresses on the maximum worn condition for the head sheave rim.

4.9.3 Wheel Diameter to Rope Ratio

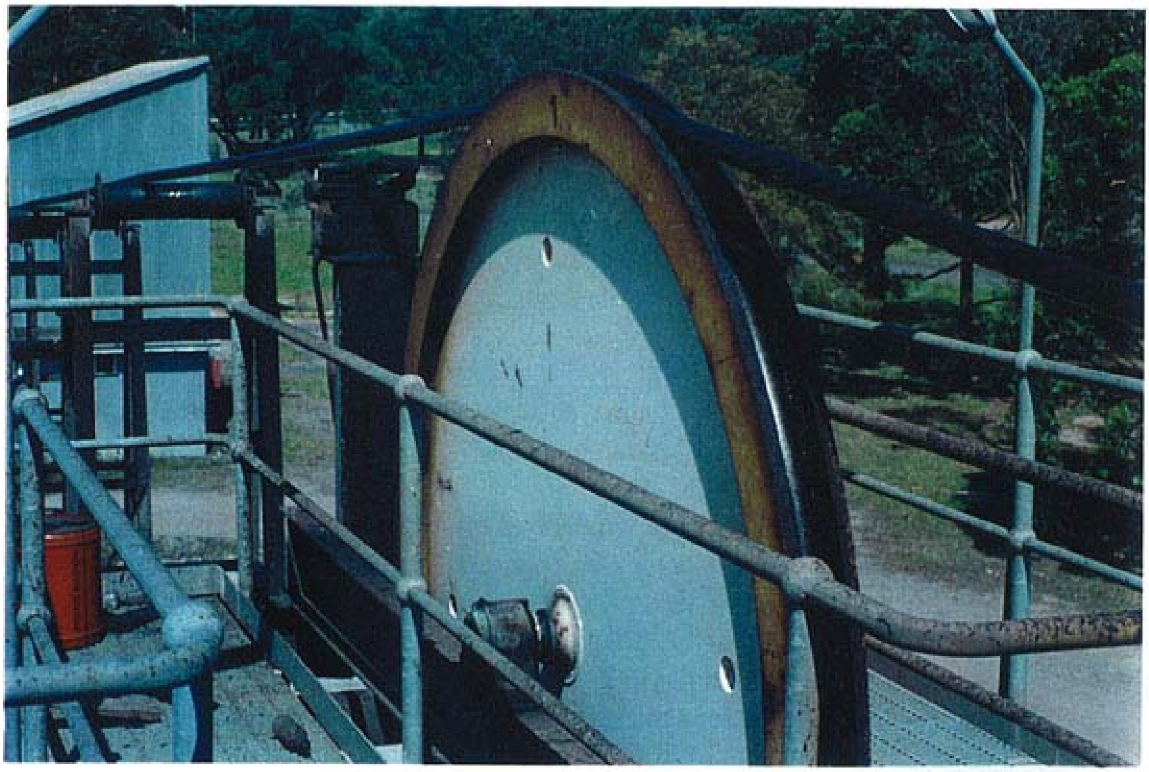
In general the sheave wheel diameter to rope diameter ratio is the same as that required for the drum.

4.9.3.1 In the case of sheaves for vertical drum winders using triangular stand ropes this can be from 70:1 to 100:1.

4.9.3.2 In drift haulage winders where the angle of wrap is low, the wheel to rope diameter ratio may be as low as 50:1 for triangular strand ropes.

4.9.3.3 In all cases the final wheel to rope diameter ratio should be checked with the rope manufacturer to ensure final suitability.

Older Style Spoked Headsheave



Modern Fabricated and Machined Headsheave

Headsheave Installation - Shaft winder

Headsheave Installation - Drift Winder

4.9.4 Sheave Wheel materials

Materials for the wheel construction will depend on the type of manufacture. Sheave wheels may be cast in either steel or meehanite (or SG iron) or be fabricated from rolled steel and flat plate. Grey cast iron is not considered suitable for sheave wheels and should be avoided.

4.9.4.1 See AS3785.7 for the testing of sheave materials.

4.9.4.2 The most appropriate material for sheave wheel shafts is Grade 1040 or 1045 steel. Little economical or engineering advantage is gained by using higher tensile grades of steel.

4.9.5 Headsheave Wheel Construction

The headsheave wheel construction may vary with the type of duty required.

4.9.5.1 Flat plate construction consists of a profiled circular steel plate with the rope groove machined in the outer circumference. The wheel may be lightened to reduce inertia by profile cutting the web area to form spokes or lightening holes. Bosses are added to build up the hub to provide stability and reduce shaft stresses. If welding processes are used the sheave should be stress relieved. These sheaves are used for slow speed, non-production requirements such as stage winders.

4.9.5.2 Cycle spoke type headsheaves consist of a cast rim and hub with steel bars integrally cast into the hub and rim to form spokes. This type of wheel has been popular for production winding for many years due to its low inertia.

4.9.5.3 Cast meehanite or cast steel construction wheels may be either single piece or split halves which are machined, keyed and bolted together. Split type sheaves are used when large diameter sheave size becomes a transport problem.

4.9.5.4 Fabricated sheave wheels using a combination of a cast rim and hub and cold rolled steel section for the spokes are common.

4.9.6 Headsheave Design

Headsheave design is in three sections: the wheel, the shaft and the hub. AS3785.7 covers many of the design requirements.

4.9.6.1 The static design load should be the design rope break load (the rope break load * 1.2). This should include the effects of the fleet angle.

4.9.6.2 For static design the combined stress should not exceed 0.9 * yield stress.

4.9.6.3 For static design the combined buckling stress should not exceed 0.9 times the Euler buckling stress for components in compression.

4.9.6.4 For fatigue design assess the effects of the fleet angle and groove misalignment, along with any dynamic or vibrational loadings.

4.9.6.5 Calculate the maximum allowable fatigue stress using a rational analysis method (e.g. Goodman diagram) and allowing a fatigue reserve factor of 1.3.

4.9.6.6 The bearing stress between the rope and the rim groove at the maximum working load should not be greater than 3.1 MPa. A general figure of 2 MPa is often used.

4.9.6.7 See AS3785.7 for the required shaft design. Limit shaft deflection to 1 in 2000 at the maximum working load.

4.9.6.8 See AS3785.7 for bearing design and life requirements.

5. DRIFT HAULAGES - DESIGN & CONSTRUCTION

OVERVIEW

5.1 General Description and Layout

A drift haulage is a system of shaft winding in a declined shaft or tunnel, the gradient of which does not exceed 1 in 3. The drift haulage winder is a single drum winder hauling conveyances which travel on rail tracks in the inclined shaft.

The drift haulage has a slope inclined to the horizontal. Therefore the rope must be supported by rollers for the complete distance from the drum to drift bottom. Any horizontal curves must be equipped with both horizontal and vertical rollers to control and protect the rope.

5.1.1 General Parameters

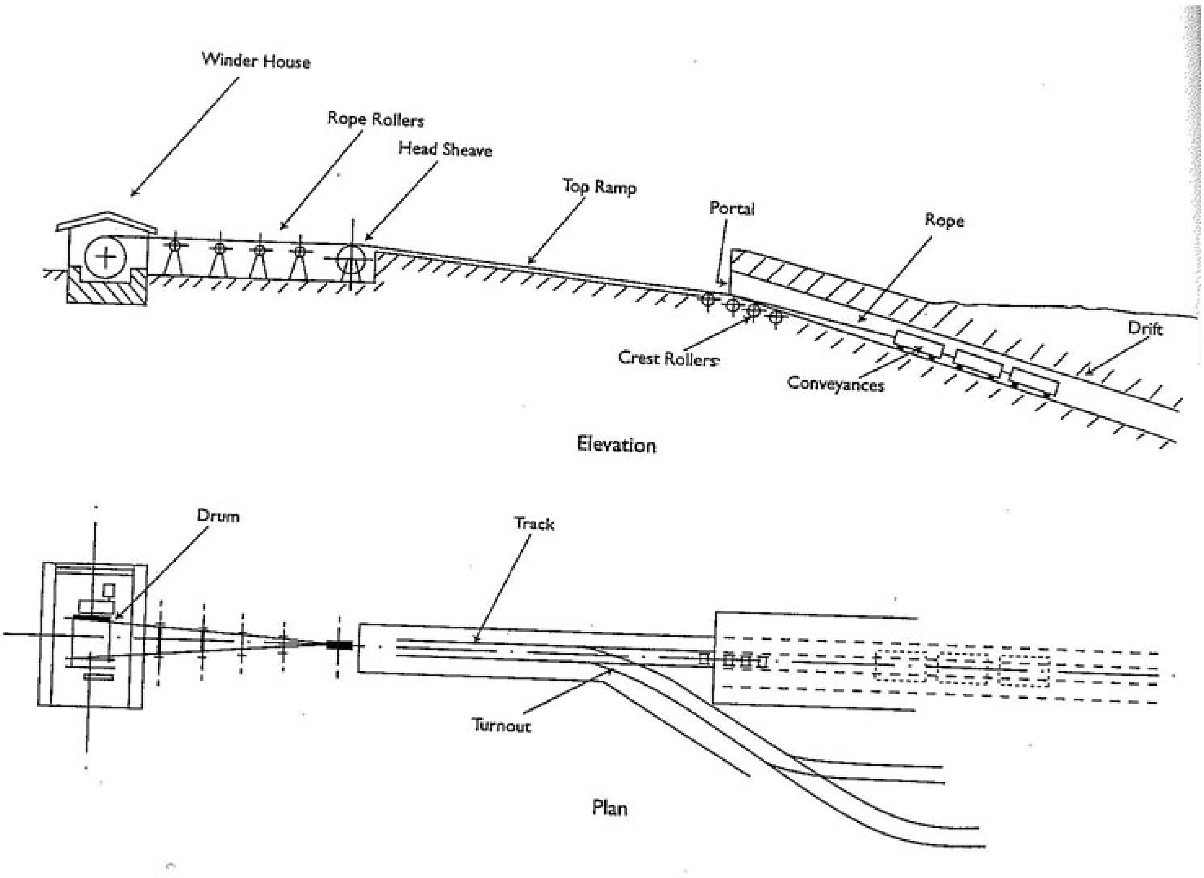
To maintain some uniformity of drift haulage parameters the following parameters are established and generally accepted in the coal industry.

5.1.1.1 The general drift gradient for personnel and materials winding is 1 in 3.5

5.1.1.2 The rail used for the drift track should be AS1085 41Kg/M rail.

5.1.1.3 The standard track gauge for drifts should be 1067mm. This is the measurement between the inside head of the rails.

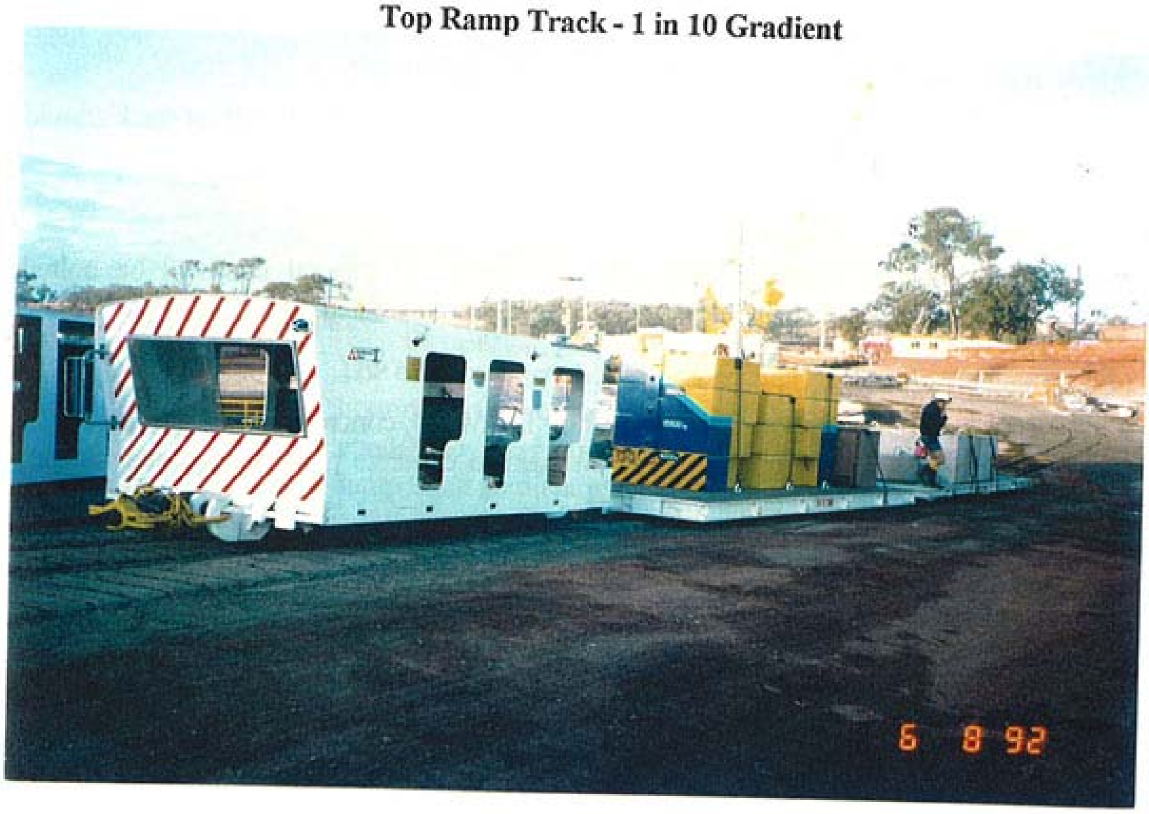
5.1.1.4 The standard rope for drift haulage use is preformed triangular (flattened) strand rope of grade 1770 MPA wire (see clause 2.3.3).



Drift Haulage System Layout

Fig 5.1

Top Ramp Track - 1 in 10 Gradient



Control car with loaded flat-tops - Maximum end of rope load 108 Tonnes

5.2 Drift Profiles, Gradients and Layout

5.2.1 Drift Tracks and Turnouts

Before beginning the final design position the winder, headsheave, top ramp and turnouts in relation to the portal. Determine the length of ramp needed and the turnout configuration by the length of trains and the storage or parking turnouts required.

5.2.2 Track Tolerances

To maintain the drift track in an acceptable condition, consider using the following tolerances:

5.2.2.1 The tolerance on the straight track rail gauge (including wear) should be -0.00 to +5mm. On curves the tolerance may be increased to +5 to +10mm to prevent the possibility of derailment. The tolerances may be varied in accordance with the drift transport track braking system used.

5.2.2.2 The tolerance on the rail head width should be 0.00 to -4mm. (i.e. a 4mm wear allowance).

5.2.2.3 The maximum deviation in height across the track on straight sections shall be 10mm from the horizontal.

5.2.2.4 The maximum allowable twist over any 5 metre length of track should be 10mm.

5.2.3 Rail Track Connections

Any standard rail connection may be used. In general this will be bolted connections with fishplates, but rails may be butt welded.

5.2.4 Rail Track Support

Track will be supported in the drift on hardwood, concrete or steel sleepers. On ramp sections the track may be fastened to concrete ramps using steel sleeper plates and Pandrol clips.

5.2.5 Conveyance Brake System

When selecting the rail mounting and rail connection consider the type of conveyance brake dump system being used.

5.2.5.1 If pad type dump brakes are in use or to be used then the rail connection should ensure the top surfaces are flush. If rail grip type brakes are used such as **FRANLANE** brakes, rail connecting fish plates must not protrude above the rail head.

5.2.5.2 Where top ramps have the walkway surface level with the rail leave a sufficient gap adjacent to the rail head to allow the dump brakes to fully engage the rail.

5.2.6 Top and Bottom Ramps

The slope has a top and bottom section of lessor slope than the drift proper, to allow for the loading/unloading of personnel and materials.

5.2.6.1 The top ramp section is outbye of the portal and has sufficient distance to accommodate the train, the top turnout curve, any over-run required, and sometimes the head sheave support.

5.2.6.2 The top ramp is constructed from concrete or steel fabrication, or a combination of concrete and steel. The top ramp gradient may vary from a gradient of 1 in 15 to 1 in 12 for manually operated winders, to a gradient of 1 in 12 to 1 in 8 for automatic winders. The steeper gradient on automatic winders is required to ensure adequate acceleration of the loads down the top ramp.

5.2.6.3 Fit the top ramp with the following safety devices:
1st overtravel limit device
End of Track limit device.
Note: These limits are required in addition to any drum limits on the winder.

5.2.6.4 The distance from the first overtravel limit device to the end of track must be sufficient to accommodate the length of the train when the device trips the winder in an emergency stop at the maximum ramp speed.

5.2.6.5 The bottom ramp should be a section of track located at the end of the bottom vertical curve. The length of the bottom ramp should be long enough to accommodate the full train length. The normal bottom ramp track gradient is 1 in 20.

5.2.7 Vertical Curves

Vertical curves should be as large as practical. Small curves can create rope wear problems at the top crest curve, undue crest roller wear, and problems with vehicle coupler mechanisms. Always check track curves to ensure that they can be negotiated without fouling.

5.2.7.1 The normal vertical radius should be 100 metres.

5.2.7.2 The top crest radius should be fitted with crest rollers spaced unequally to avoid rope vibrations.

5.2.7.3 Allow for adequate drainage of the top crest rollers to avoid contamination of the roller bearings, and to prevent corrosion.

5.2.8 Horizontal Curves

Horizontal turnout curves must be large enough to allow free movement of the vehicles onto the ramp.

5.2.8.1 The standard turnout curve is 30 metres radius.

5.2.8.2 Guide rollers and timber sleepers should be used to control and protect the rope at the turnouts.

5.2.9 Multiple Seams

The drift haulage may be used to service multiple seams. Appropriate loading/unloading stations and control systems will be required at each seam station.

5.2.9.1 When designing the drift and interseam turnout systems, give consideration to the control and protection of the rope. The main drift from portal to drift bottom should always be straight. Avoid turns, changes in direction, or gradient changes in the drift whenever possible.

5.2.10 Ramps

Ramp station design should always consider the safety of personnel getting on or off conveyances, or loading/unloading materials from flat-tops or other transporting vehicles. Factors include adequate surface treatment, lighting, safety signs, buffers and loading facilities.

5.3 Drift Haulage Safety Device Design

Special attention shall be given to the design of devices required for the safe control of drift haulages.

5.3.1 Inspection and Testing

Any safety device used to detect an event that may lead to the winder stopping through application of the emergency brakes, must be able to be inspected and tested easily to ensure that it achieves its intended function.

5.3.2 Travel Zones and Speed Control Functions

For automatic winders the electric/electronic equipment used for winder control is detailed in the electrical section of the guideline. The electrical monitoring components used to transmit the required signals should be driven directly from the non-drive end of the drum shaft, or from the last drive component of the drive system.

5.3.2.1 The drum "end of shaft" equipment will normally consist of:

- Travel limit switches (to monitor/control conveyance travel)
- Control encoder (for speed control)
- Tacho generator (to monitor broken shaft failure)

5.3.2.2 The winder motor shall also be fitted with a tacho generator (to monitor broken shaft failure).

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

5.3.2.4 The tacho generator must always be located at the end of the drum control drive train.

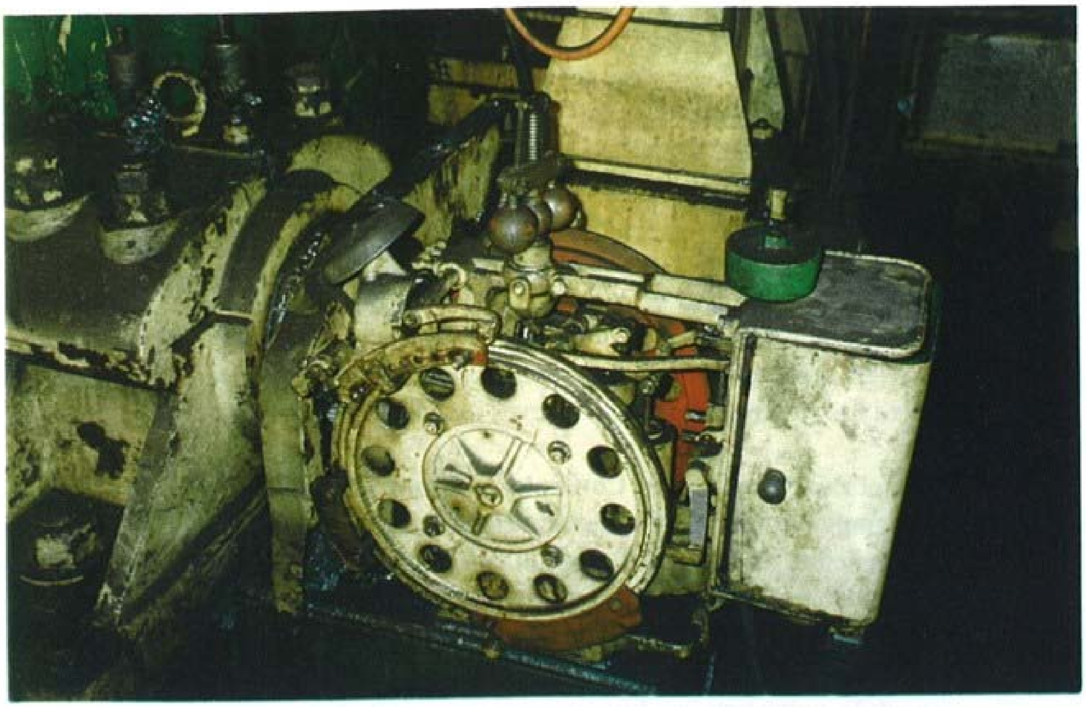
5.3.2.5 End of shaft equipment should always be driven directly from the winder drum or winder drum shaft.

5.3.3 Safe Coiling Monitor

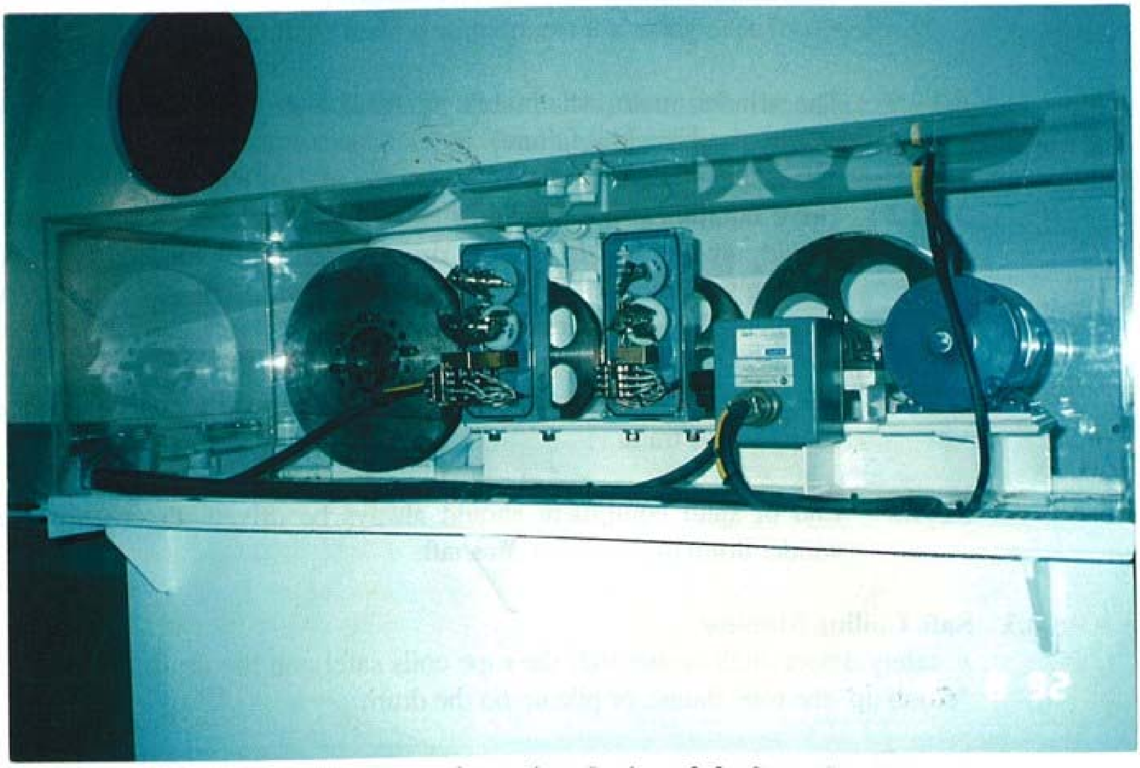
A safety device shall ensure that the rope coils safely on the drum and does not "climb up" the rope flange, or pile up on the drum.

5.3.3.1 The device consists of a bar located between the flanges at a distance of approximately one half of a rope diameter from the outer most layer of rope. In the event of overcoiling the rope will hit the bar which activates a switch to stop the winder.

5.3.3.2 The safe coiling bar will also monitor slack rope at the drum.



Older style referencing device of shaft mechanism.



Modern style referencing device of shaft mechanism

5.3.4 Slack Rope Monitor

A safety device shall ensure that in the event of slack rope being detected, the winder will stop.

5.3.4.1 The device consists of a bar located under the rope adjacent to the head sheave. When a slack rope event allows the rope to hit the bar, the bar will activate a limit switch to stop the winder.

5.3.5 End of Travel Track Limits

A safety device shall be located on the top ramp track to be activated by the control car (or vehicle attached to the rope) and stop the winder if the conveyance over travels (passes a pre-determined distance) on the ramp.

5.3.5.1 The winder drum over-travel limits should be activated before the ramp over-travel limit.

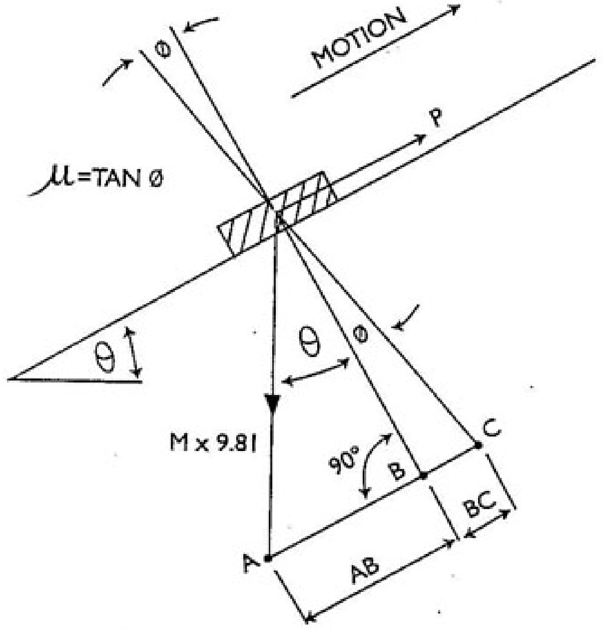
5.3.6 End of Track limits

A safety device shall be located at the end of the track. In the event of the conveyance hitting the device, the device will activate an emergency stop on the winder.

5.3.7 Derail Safety Device

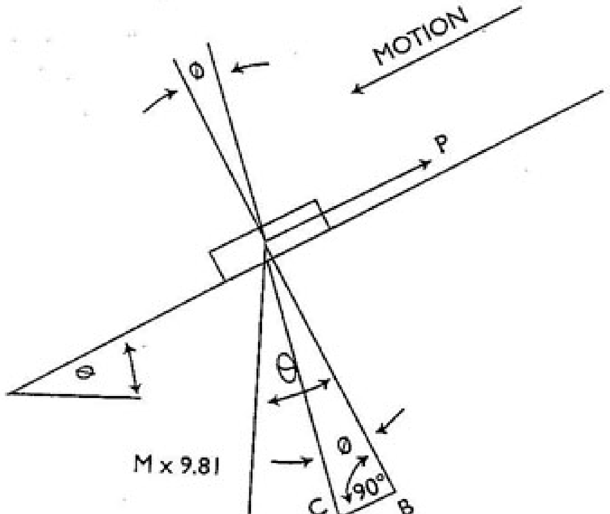
A safety device shall be fitted to the control car which, in the event of a control car derailment, will activate an emergency stop.

5.3.7.1 The device consists of a bar located under the control car and positioned over the track. In the event of a derailment, the bar hits the track and activates an emergency stop.



$$AB = M*9.81 \sin\theta$$
$$BC = M*9.81 \cos\theta \tan\phi$$
$$AC = AB + BC$$
$$= M*9.81 (\sin\theta + \cos\theta \tan\phi)$$
$$= P \text{ (Newtons)}$$

Fig 5.2



$$AC = AB - BC$$
$$= M*9.81. (\sin\theta - \cos\theta \tan\phi)$$
$$= P \text{ (Newtons)}$$

Fig 5.3

5.4 Drift Winder Design Requirements

5.4.1 Force required to move a body on an inclined plane

The elementary problem of mechanics common to all drift haulage systems is that of moving a body on an inclined plane.

5.4.1.1 Motion up the plane (drift)

Suppose that a body of mass M (Kg) rests on a plane inclined at an angle θ to the horizontal, and that when the plane is tilted through a certain small angle ϕ from the horizontal, the body just begins to slide down the plane. In other words, the coefficient of friction $\mu = \text{Tan}\ \phi$. For conveyances and rolling stock with track in good order, the angle ϕ varies between 2.5 and 3.5 degrees.

When the body is moved up the inclined plane by a force P applied parallel to the plane we have from Fig 5.2:

$$\mathbf{P = M*9.81(Sin\theta + Cos\theta Tan\phi)}\ \text{(Newtons)}$$

5.4.1.2 Motion down the plane (drift)

Similarly, to prevent a body of mass M (Kg) sliding down a plane (see Fig 5.3) the hold back force applied parallel to the plane:

$$\mathbf{P = M*9.81(Sin\theta - Cos\theta Tan\phi)}\ \text{(Newtons)}$$

5.4.1.2 Static force on the drift

When calculating static Factors of Safety as required by the DMR Inspectorate for rope or components used on conveyances, or for static brake capacity calculations, the frictional component is deleted in the plane equation and the static force to hold the mass M (Kg) becomes:

$$\mathbf{P_{static} = M*9.81 * Sin\theta}\ \text{(Newtons)}$$

5.4.1.3 Static rope force in the drift

Similarly, the static force for the rope may be calculated and should be added to the static ‘end of rope’ load mass for Factor of Safety calculations. Note that the worst position of the load should be considered, i.e. at drift bottom on the maximum slope. Therefore for drum brake static capacity calculations the loads will include both the ‘end of rope’ loads and the rope slope loads.

5.4.2 Deceleration and Braking Rates

In general the inbye accelerations will be governed by the ramp and drift slope and the various frictions in the system. For fully automatic haulage systems the ramp slope and mass of the control car are critical in getting the empty control car to accelerate from a maximum outbye stationary position on the top ramp.

5.4.2.1 For manually operated haulage systems a top ramp slope of 1 in 15 is acceptable with a minimum conveyance mass of 7 Tonnes.

5.4.2.2 For automatic haulage systems with up to 60 Tonnes end of rope load a top ramp slope of 1 in 12 is acceptable with a 7 Tonne (empty) control car.

5.4.2.3 For automatic haulage systems with up to 60 Tonnes end of rope load, a top ramp slope of 1 in 10 is acceptable with a 10 Tonne (empty) control car.

5.4.2.4 For design calculations use accelerations in the order of 0.75 metres/sec^2 for drift deceleration/acceleration rates with 0.5 metre/sec^2 on the ramps.

5.4.2.5 For haulage system braking refer to Section 3.4.

5.4.3 Rope Rollers

The rope rollers support the rope from the drum to the head sheave. These rollers will vary in width from the widest roller near the drum, to the narrowest roller near the headsheave. The distance between the rollers will depend largely on the mass of the rope.

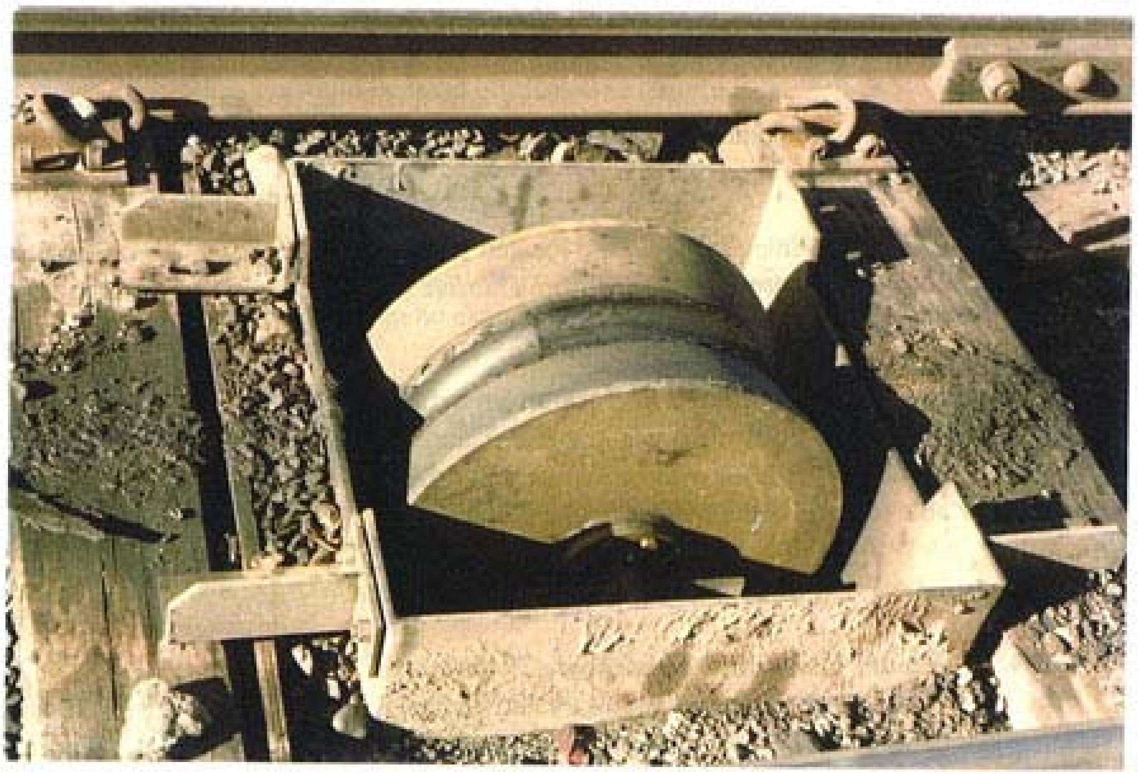
5.4.3.1 The distance from the drum to the headsheave will generally be in the order of 40 metres. The fleet angle of 1.5 degrees should be maintained.

5.4.3.2 Check the distance between rollers to avoid vibrations caused by the natural frequency of the rope.

5.4.3.3 Vary the centre to centre distance of the rollers to avoid vibrations caused by rope pitch.

5.4.3.4 Position the top of the roller at least 10mm below the straight line from headsheave to drum. The rollers must only support the rope mass and should not be subjected to any rope tension from the end of rope mass.

Drift rope haulage rope roller.



Drift rope haulage crest roller

5.4.3.5 The roller should have rope flanges to contain the rope and an outer polyurethane sleeve which protects the rope.

5.4.3.6 Design roller shafts, bearings and barrels as required by Section 4.3

5.4.4 Crest Rollers

The rope is supported and controlled at the top vertical curve at the portal by crest rollers. The crest rollers will be subjected to the full rope tension forces and should be designed for fatigue life and to rope break tension plus 20%.

5.4.4.1 Crest roller spacing will be governed by rope tensions. Spacing should be checked to ensure vibrations are set up by the rope natural frequencies.

5.4.4.2 Stagger crest roller spacing to avoid vibrations that could be caused by the rope pitch.

5.4.4.3 Design roller shafts, bearings and barrels as required by Section 4.3.

5.4.5 Drift Rollers and Rope Protection

To support the rope in the drift, suitable rope rollers are required. The rope rollers can be supplied commercially and are mounted in the drift at intervals of from 4 to 7 metres depending on the rope mass and speed.

5.4.5.1 Stagger the spacing of the rollers to help prevent rope vibrations from the rope pitch.

5.4.5.2 Where turnouts are located in the drift, use suitable wooden sleepers to protect the rope from abrasive wear as the rope crosses the rails.

5.4.6 Headsheave Supports and Ramp Structure

Design all head sheave support structure to resist the maximum rope break tensions plus 20% without failure. For this condition failure means "no longer able to support the winder working loads".

5.4.6.1 See Section 4.9 for headsheave design.

5.4.7 Winder House and Headsheave Foundations

When designing foundations for the winder house and the headsheave work to the rope break tension plus 20% before failure. For this condition, failure means "no longer able to support the winder working loads".

5.4.7.1 For foundation design see Section 4.8.

5.4.8 Drift Haulage Rope

The generally accepted standard for drift haulage rope construction is preformed triangular (flattened) strand rope, right hand, langs lay, of grade 1770 MPa wire. For general rope requirements see Section 2.

5.4.8.1 For design purposes selected rope diameters and strengths should be as set out in AS1426 - Steel wire ropes for mines. Make the final selection and recommendation in consultation with the wire rope manufacturer.

5.4.8.2 To maintain correct scrolling of the rope for automatic drift haulages, use a maximum of three layers of rope.

5.4.8.3 The acceptable method of attaching conveyances to the rope for drift haulages is with a white metal filled rope socket and pin, or a precast fluted white metal plug and tail type socket in accordance with AS3637.3. Rope inspections and capping changes shall be carried out as per legislative Shafts & Roadways Regulation, standards and guideline (MDG 26) requirements.

5.4.8.4 Safety chains in accordance with AS3751 shall be fitted between the haulage rope and the control car as required by AS3785.8.

5.4.8.4 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.

5.4.9 Testing the Rope Capping

With a new rope, or after any re-capping of the rope, and before winding with persons, the haulage shall make at least five winds with a load equivalent to the maximum load, then be examined for any visible defects.

5.5 Manual and Automatic Drift Winders

Drift haulage systems may be designated as manual, that is driven from the winder house by a winder driver, or automatic, that is press button operated similar to an automatic lift.

5.5.1 Manual Winders

For manual winders a driver control station is situated in the winder house. The driver responds to signals and controls the winder as required.

5.5.1.1 The driver controls normal service winding and braking with proportional control of the motor. Service braking is also controlled by the driver via a brake lever which proportionally controls the braking effort.

5.5.1.2 Emergency braking from signals such as overspeed or over-run are executed directly by the winder controls (see Section 3 for braking).

5.5.1.3 Manual winders shall be equipped with the following safety devices:

(a) **Dead man lever**. If the driver ceases to depress the lever the winder shall be brought to an emergency stop.

(b) **Emergency Stop Button**. Located near the driver, its purpose is to cut off the power supply to the winder, other than for winder braking, and to automatically apply the winder brakes. Emergency stop buttons shall also be located at the portal area and in the conveyance.

(c) **Primary over travel limits.** If the winder overwinds an alarm will sound and then the winder shall be brought to an emergency stop. Primary over travel limits shall be driven from the winder drum.

(d) **Ultimate over travel limits (Track limits)**. If the primary overwinding limits fail the track limits will activate and bring the winder to an emergency stop.

(e) **Overspeed limits.** If the winder drum overspeeds the winder shall be brought to an emergency stop.

(f) **Power loss.** If a loss of power to the winder occurs the emergency brakes shall bring the winder to a stop.

(g) **Slack rope device.** If slack rope forms at the surface a device will detect the slack rope, signal a slack rope alarm, and bring the winder to an emergency stop.

(h) **Rope speed indicator.** This should be marked with normal maximum speed and maximum permissible speed for personnel winding.

(i) **Conveyance indicator.** This indicator shows the position of the conveyance in the drift.

5.5.1.4 Control rooms must have adequate means of escape in the event of fire or mishap. Winder houses must be provided with two paths of escape from any fire in the control room or winder room. Winder rooms must have adequate fire equipment and alarms located as required by the statutory bodies.

5.5.1.5 The winder shall be provided with suitable means to:
(a) give audible and visual signals to
(b) receive audible and visual signals from
(c) communicate by speech with
any place where any of these means of signalling and communication are necessary to enable the winder to be used safely.

5.5.1.6 Signalling systems should give both audible and visual signals which must be heard and displayed simultaneously at the drift portal, the winder room, and drift bottom stations. Visual signals should be so positioned in the winder room that the driver can see them easily.

5.5.1.7 Speech communication should not be used to request winder movement except where the communicating parties have agreed that the signalling system is defective. In that case the speech communication shall only be used to complete the wind. The speech communication system shall not use the mine telephone switchboard system.

5.5.1.8 Signal boards clearly defining signals used at the colliery shall be placed in clear view of the driver and signalling stations. Standard signalling procedures should be adhered to.

5.5.1.9 If the control car is removed from the rope socket in order to lower heavy end of rope loads, special care must be taken to prevent the effects of rope twist. Written procedures should be in place defining the methods to be used for changing end of rope loads attached directly to the rope.

5.5.2 Automatic Winders

Most modern drift haulage systems operate fully automatically. The winder is operated from the control car permanently attached to the rope, from call and send stations at the portal, bottom loading stations and a control station in the winder house. The winder can be manually controlled from either the control car or the winder room. The control stations govern winder action.

5.5.2.1 Normal service winding and braking is controlled either automatically in the case of call or send signals from call/send stations, or by radio signal from a control car driver.

5.5.2.2 Emergency braking from signals such as overspeed or over-run, are executed directly by the winder control system (see Section 3 for braking).

5.5.2.3 Automatic winders shall be equipped with the following safety devices:

(a) **Control car dead man lever.** Under manual control from the control car, if the driver ceases to depress the lever, the winder shall be brought to an emergency stop.

(b) **Emergency Stop Buttons.** These are positioned at various locations to cut off the power supply to the winder, other than for winder braking, and to automatically apply the winder brakes. Emergency stop buttons shall also be located at the portal area, in the conveyance, in the winder room and at any position deemed necessary for the safe operation of the winder. If a button has been depressed, it shall stay depressed until reset. The winder shall stay stopped until reset from the winder room panel.

(c) **Primary over travel limits**. If the winder overwinds an alarm will sound and then the winder shall be brought to an emergency stop. Primary over travel limits shall be driven from the winder drum.

(d) **Ultimate over travel limits (track limits).** If the primary overwinding limits fail, the track limits will activate and bring the winder to an emergency stop.

(e) **Winder overspeed limits.** If the winder drum overspeeds the winder shall be brought to an emergency stop. Winder overspeed limit will be set at 10% above the maximum top speed of the winder.

(f) **Conveyance overspeed limits.** If the conveyance overspeeds the winder shall be brought to an emergency stop. The conveyance overspeed limit will be set at 15% above the maximum top speed of the winder.

(g) **Power loss.** If the power to the winder is lost the emergency brakes shall bring the winder to a stop.

(h) **Slack rope device.** If slack rope forms at the surface a device will detect the slack rope, signal a slack rope alarm, and bring the winder to an emergency stop.

(j) **Safe rope coiling device.** If the rope does not coil correctly on the drum a device will detect unsafe coiling, signal an unsafe coiling alarm, and bring the winder to an emergency stop.

(k) **Rope speed indicators.** These are in the winder room and in the conveyance, and should be marked with normal maximum speed and maximum permissible speed for personnel winding.

(l) **Conveyance indicator.** This is an indicator in the winder room showing the position of the conveyance in the drift.

(m) **Broken shaft detection alarm.** If a break occurs in the drive train from the winder motor to the final limit of the end of drum limits, a device will signal an alarm and will bring the winder to an emergency stop.

(n) **Brake lift and brake wear alarms.** To monitor correct brake operation, all brakes (or brake calipers) shall be fitted with brake lift and brake wear limit devices. If a malfunction or limit actuation occurs, the winder shall be brought to a stop.

5.5.2.4 There should be adequate means of escape from the winder room in the event of fire or mishap. A minimum of two escape routes must be provided. Winder rooms must have adequate fire equipment and alarms located as required by the required by the outcomes from the risk management process. It is noted that any fire suppression or protection equipment installed shall meet requirements of relevant Australian Standards and legislation.

5.5.2.5 The haulage system shall be provided with an acceptable control system (see electrical section) and a voice communications system which allows communications between winder room, call stations and the conveyance.

5.5.2.6 If the control car is removed from the rope socket in order to lower heavy end of rope loads by manual control, special care must be taken to prevent the effects of rope twist. Written procedures should be in place defining the methods to be used. Such procedures should result from a risk management process.

5.5.2.7 Brake requirements, testing, operations and maintenance shall be carried out as required by Section 3.2.

5.5.2.8 Men and material drifts should be fitted with turnout points which protect the drift by automatically positioning to the turnout when the drift is not in use, or when the loads are outbye of the points.

5.5.2.9 Men and materials drifts should be fitted with a load sensing device which will, when sensing overload for the nominated winder mode, reduce the speed to an acceptable level, or in the case of maximum load overload, show an alarm; stop the winder before it can proceed down the drift; and retain the points in the outbye direction. To achieve this result, the ramp and turnout gradient required should be examined.

5.5.2.10 To sense non-movement of the car and compare it to drum rotation control car motion detection equipment should be installed. This device will assist detection of slack rope and prevent kinking of the rope.

5.6 Control and Personnel Cars

The Australian standard for personnel conveyances used in drifts with a gradient not exceeding 1 in 3 is AS3785.8 - Personnel conveyances in other than vertical shafts. This standard is applicable for both control and personnel cars.

5.6.1 Control Cars

The control car is the car permanently attached to the end of haulage rope and in which is mounted all control equipment needed to safely control all normal functions of the haulage, for transporting personnel and materials in the drift.

5.6.1.1 The control car must have sufficient mass to enable it to accelerate from rest on the top ramp without the winder tripping out on the slack rope limits.

5.6.1.2 For automatic winders the control car should be fitted with a derail device that will signal the winder to apply the emergency brakes if the control car derails.

5.6.1.3 Hydraulic pumps needed to charge the car braking system should be accessible to allow pumping from a position which will not cause injury if the car moves during the pumping up operation. The car dump valve should be readily accessible in case it is needed during the operation.

5.6.2 Personnel cars

Personnel cars are attached to the control car to form a train. Up to 3 cars may be used. Each personnel car may be designed to convey up to 40 individuals.

5.6.2.1 Personnel car hydraulic pump up system should be designed to have individual car system oil returned to a tank in each car.

5.6.2.2 Hydraulic pumps required to charge the car braking system should be accessible to allow pumping from a position which will not cause injury if the car moves during the pumping up operation. The car dump valve should be readily accessible in case it is needed during the operation.

5.6.2.3 Individual personnel cars must be capable of being pumped up without the oil transferring to other cars.

Drift haulage control and personnel cars   (Man Transport System)

Drift haulage control and flat top   (Materials Transport System)

5.6.3 General: Control and Personnel Cars

The following applies to both control car and personnel cars.

5.6.3.1 Cars shall be designed for the following track parameters

- Minimum vertical curve — 30 metre radii
- Minimum horizontal curve — 25 metre radii
- Minimum length of straight between curves of opposite hand — 1370mm

5.6.3.2 The wheelbase should not be less than 36% of the body length.

5.6.3.3 The end throw of the car body on the sharpest curve should not exceed 100 mm.

5.6.3.4 The suspension should be able to cater for a maximum local rail depression of 50mm at any single wheel without the tread of any wheel leaving the rail.

5.6.3.5 The design shall allow for a car, fully loaded at one end, overhanging one axle, and empty elsewhere, to transmit to the rails at the remaining axle or bogie, a vertical static force of not less than 25% of the tare weight of the car.

5.6.3.6 The design shall allow for the car, fully loaded down one side only, overhanging the two wheels (or 4 bogie wheels), to transmit to the rails at the opposite side of the car, a vertical static force of not less than 25% of the tare weight of the car.

5.6.3.7 For the purposes of 5.6.3.5 and 5.6.3.6 the design should be based on a passenger mass of 88 Kg.

5.6.3.8 Unless otherwise agreed upon, the height of the centreline of the coupling from the level rail when unladen, shall be 300mm.

5.6.3.9 Structural design shall be as required by AS3785 Part 8 Clause 5. The main load bearing members, or chassis, of cars shall have sufficient tensile strength (UTS) to resist a design rope break load (rope break * 1.2).

5.6.3.10 The main load bearing members, or chassis, shall be capable of withstanding a compressive load of 100 kN without permanent deformation.

5.6.3.11 Safety hooks and chains shall be fitted to all cars as required by AS3785 Part 8. Unless otherwise agreed upon, the transverse centre distance between the safety chain hooks should be 750mm to 1067mm.

5.6.4 Conveyance Car Brakes

Each car shall be fitted with a track brake system as required by AS3785 Part 8.

5.6.4.1 For single axle cars using pad type dump brakes, the brake shoes shall be secured to the underside of the frame of the car immediately adjacent to each wheel, and outside the wheel base.

5.6.4.2 For cars with bogie systems using pad type dump brakes, the brake shoes shall be mounted on the bogie centre line between the bogie wheels.

5.6.4.3 All track brake systems shall be constructed so that when operating all brakes shall contact the rail to independently carry the load (i.e. no brake will lift off the rails due to rail misalignment).

5.6.4.4 In addition to the requirements of AS3785 Part 8 Clause 6.4, the cars shall be equipped with:

- A manually operated pump for generating the required operating pressure for the braking system.
- A pressure relief valve set to the required operating pressure for the braking system.
- A pressure gauge marked with the normal working pressure declared by the manufacturer of the system.
- A manually operated valve to apply the brakes, in an emergency, on each car and to any other car to which they are connected.
- An overspeed device located in the control car and driven from the rail wheels, to apply the brakes, in the event of overspeed in either direction, within the application times given in AS3785 Part 8. The overspeed device shall be capable of being tested up to the maximum nominated speed plus 15% with the car stationary. The speed of the overspeed trip required to apply the brakes shall be specified by the purchaser.
- The hydraulic fluid used in any system should be suitable for the operating requirements of the system. Ambient temperatures, operating pressures and seals, and fire risks should be considered.

5.6.5 Conveyance Brakes Performance Testing

The rail track brakes on any personnel carrying car must, in the case of an emergency, stop the conveyance, or train, at not less than 0.5 m/s^2 as required by AS3785 Part 8. The track brake system shall be designed to allow accessibility for testing, examination and maintenance.

5.6.5.1 Performance testing of the dump brake system, or an equivalent method, whereby it is shown that the brakes will act on the rails on which they are operating to stop the car within the decelerations rates required by AS3785 Part 8, shall be carried out at least every 12 months.

5.6.5.2 Performance test records shall be recorded in a book kept for this purpose. The records must be available to an Inspector upon request. Such records shall include the state of the rails on which performance testing was undertaken. For example the rails may be wet, dry, sunken, straight etc. Such record should be objective, accurate and factual.

5.7 Flat-Tops and Materials Transporters

The drift haulage system may be used to transport materials between the surface and seams. This involves using flat-tops of various designs to carry materials such as rubber tyred vehicles, miners, longwall components etc. For automatic haulages, generally the flat-top is coupled directly to the control car. Occasionally the flat-top is attached directly to the end of rope socket when lowering heavy loads, which would exceed the maximum winder capacity when attached to the control car.

5.7.1 Flat-top Design

In general, use the objective of AS3785 Part 8 - Personnel conveyances in other than vertical shafts, as the basis for flat top design for as it relates to couplings, safety chains, and structural design.

5.7.1.1 The flat-top body strength members or chassis shall be designed to resist the tensile force equivalent to the design rope break force. If the design includes cover plates for decking and underframes in the strength calculation, use an adequate corrosion allowance.

5.7.1.2 The flat-top body or chassis shall be designed to resist a minimum compressive force of 100 kN without permanent deformation.

5.7.1.3 Every flat-top shall be fitted with safety chains. Unless otherwise agreed upon, the transverse centre distance between the safety chain hooks should be 750mm to 1076mm and should generally match the centre distance on the control car.

5.7.1.4 Fat-top overall dimensions shall be determined by agreement and be suitable for the vehicle's required duties. The designer must consider the negotiation of both vertical and horizontal curves to be encountered at the mine site under both full and empty load conditions.

5.7.1.5 The design should include sufficient inspection covers to fully inspect bogies, axles, wheels and pins to inspect and maintain the flat-top.

5.7.1.6 Include sufficient load tie down points to fully secure the load under maximum emergency winder brake conditions. Where special purpose vehicles are used, the tie down points must be located in positions that will fully support the load under all conditions.

5.8 Environmental Considerations

5.8.1 Oil Spillage

Give special attention in the design to the control of oil spillage, splash or contamination with water drainage.

5.8.1.1 If winder drums are located in a pit, the pit should be sufficiently drained to ensure all oil, or oily water that may escape into the pit, is properly collected and treated before reaching storm drains or open ground.

5.8.1.2 Pits should be fitted with alarms to indicate flooding and to stop the winder (see 3.1.11.4 and 3.1.11.5). If drainpipes are fitted duplicate the pipes to reduce the risk of fouling. If gravity drainage is unavailable fit the pit with an automatic pumpout system. Pumps should not pump pit water into the stormwater drainage system without adequate treatment.

5.8.2 Winder House

The winder house design should allow for the effects of heavy rain and local flooding.

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

5.8.2.2 Cable tray channels should be well drained and any water collected should be treated before being discharged into storm water drainage.

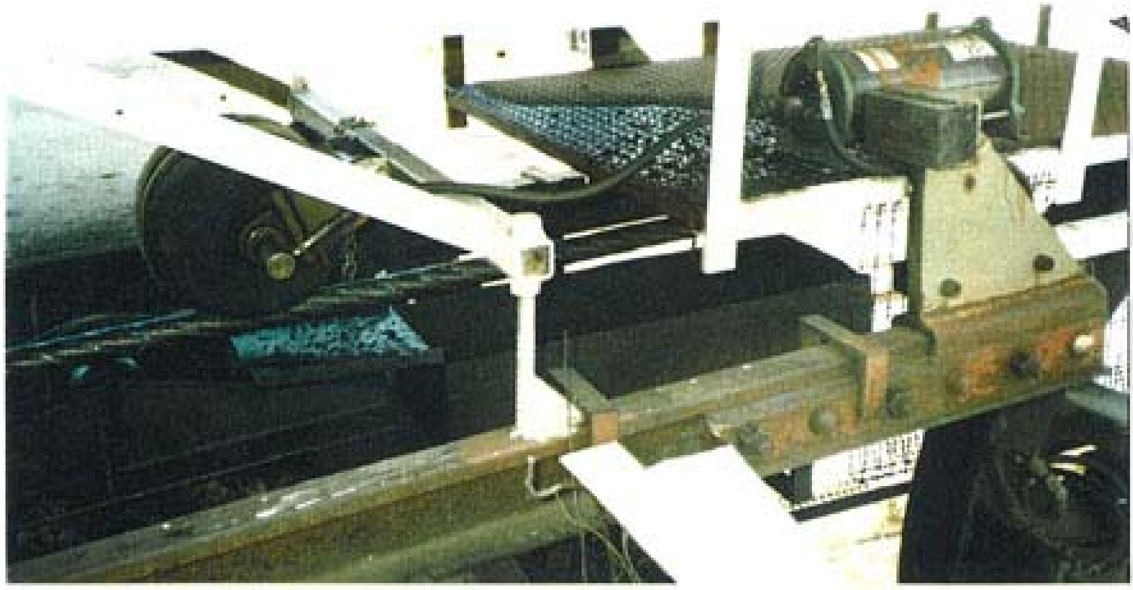
5.8.2.3 Automatic winder houses shall have a security system which prevents unauthorised persons from entering without permission.

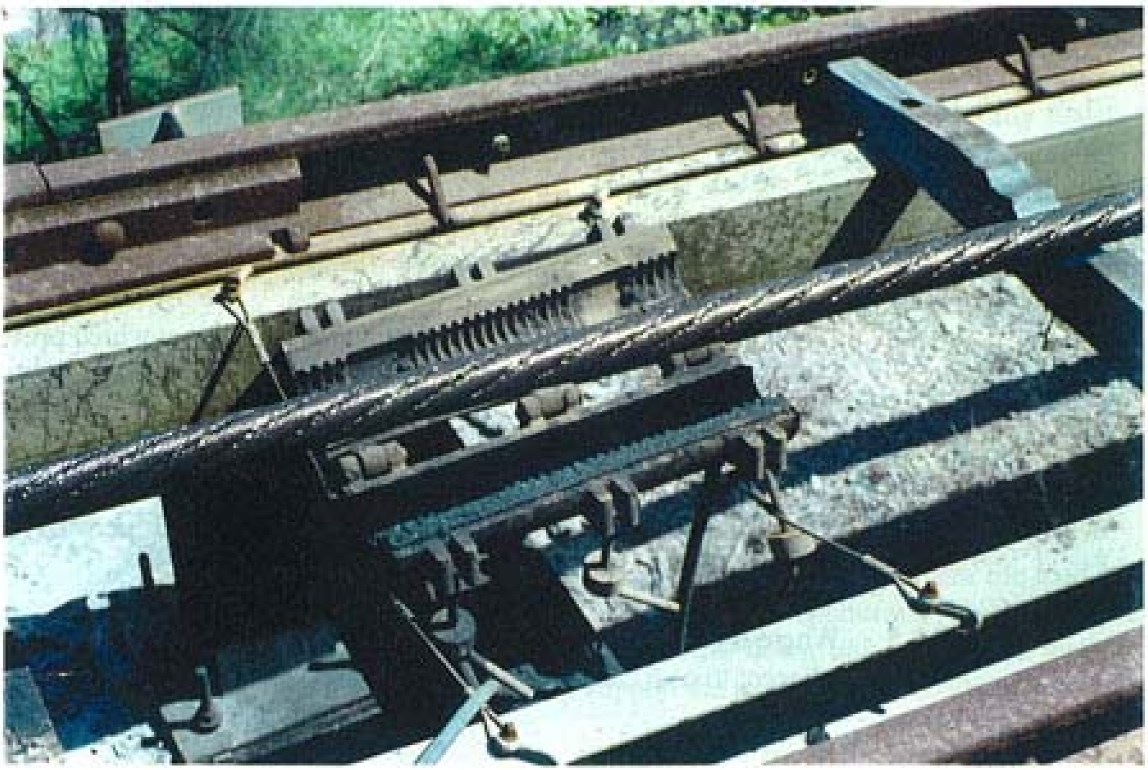
5.8.2.4 Transformer and other electrical equipment outside the winder house shall be protected at all times by appropriate wire or other enclosures with suitable security which prevents unauthorised persons from entering without permission.

5.8.2.5 Where the winder is installed in a dusty or dirty environment, such as adjacent to coal conveyors, consider pressurising the winder house.

5.8.3 Rope Lubricant

Use trays or other means to gather and control rope lubricant spray or drips from the rope. Any water run-off in the area should be treated before disposal in the storm water drainage system.



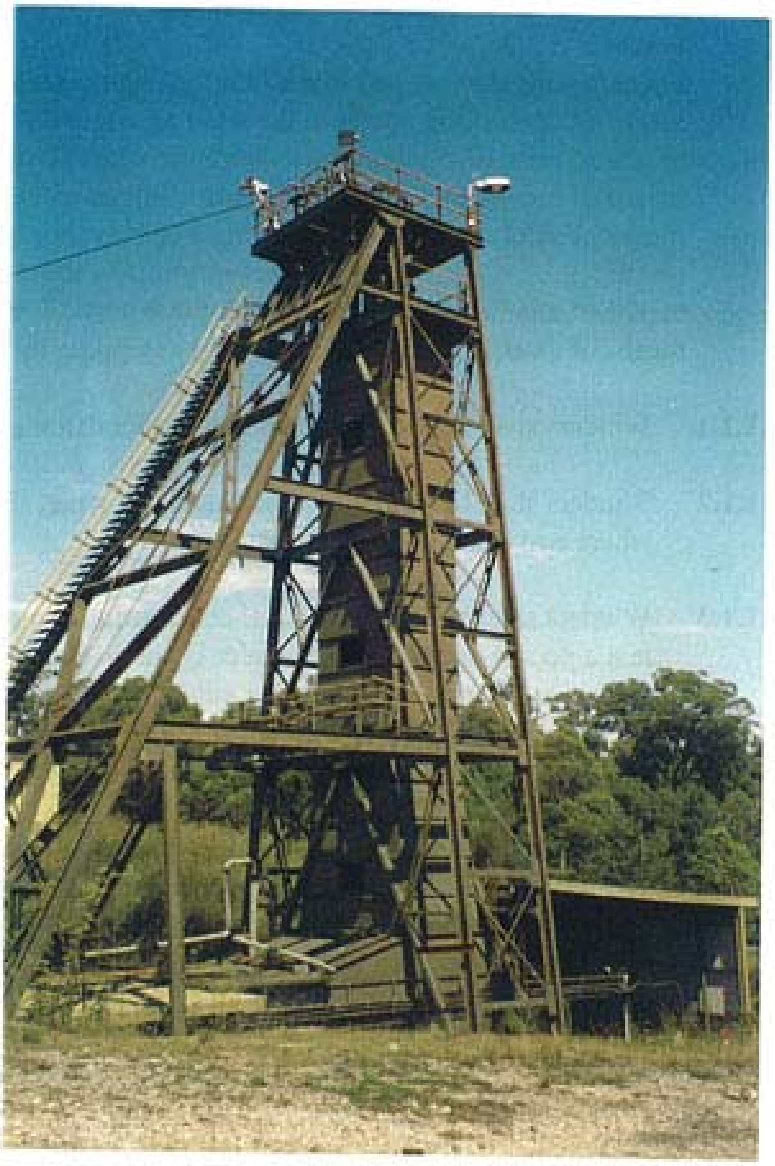


Rope haulage lubrication unit installed at Drift Gantry

6. VERTICAL SHAFT WINDERS - DESIGN & CONSTRUCTION

OVERVIEW

Vertical Shaft Drum Winders
Shaft Top Installation - A



Vertical Shaft Drum Winders
Shaft Top Installation - B

6.1 Requirements For Vertical Shaft Drum Winders

6.1.1 General Winder Requirements

The vertical shaft drum winder shall be suitable for the purpose for which it is being used, and shall 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 every conveyance in the shaft
- means of detecting slack rope and safely stopping the winder.

6.1.1.1 Winders shall be securely anchored to foundations (see Section 4.8).

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

6.1.1.3 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.

6.1.1.4 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 effect the safety of personnel in the conveyance. The design must 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.

6.1.2 Standards and Guidelines

The following Standards and guidelines are applicable to vertical drum winders:

- See `Section 1 for statutory requirements and approval procedures
- AS3785 Underground Mining - Shaft Equipment
  Part 1 - Drum winding overwind safety catch systems
  Part 2 - Drum winding gripper systems
  Part 4 - Conveyances for vertical shafts
  Part 5 - Headframes
  Part 7 - Sheaves
- AS3637 Underground Mining - Winding suspension equipment
  Part 1 - General requirements
  Part 2 - Detaching Hooks
  Part 3 - Rope Cappings
  Part 5 - Rope Swivels and Swivel Hooks
  Part 6 - Shackles and Chains.

6.1 Requirements for Vertical Shaft Drum Winders

6.1.3 Ropes

See Section 2 for rope requirements for vertical shaft drum winders.

6.1.4 Brakes

See Section 3 for brake requirements for vertical drum winders.

6.1.5 Design of Components

See Section 4 for design of vertical shaft drum winder components.

Vertical Shaft Drum Winder Headframe.

Vertical Shaft Drum Winder Conveyance (Production and men).

6.2 General Description and Layout

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.

6.2.1 Single Drum Man 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.

6.2.2 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.

6.2.3 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.

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

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

6.2.4 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 Section 7 for special additional features which may be required when vertical shaft drum winders are intended for shaft sinking duties.

6.3 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.

6.3.1 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.

6.3.1.1 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.

6.3.1.2 Fixed guides may be made from rectangular wooded 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.

6.3.2 Rope Guides

Rope guides may also be used to guide the skip or cage. See Section 2.4 for information on guide rope selection and maintenance.

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

6.3.2.2 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.

6.3.2.3 With rope guides there is no provision for arresting the conveyance on the guide ropes if the winding rope or suspension gear fails.

6.3.3 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.

6.3.3.1 For materials winding the fixed guide section will direct the skip into the scrolls, and/or maintain clearances needed to load and discharge the materials. Clearances are kept as small as possible to prevent undue impact loads.

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

6.3.3.3 Fit 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 must be of sufficient strength to resist any impact forces from a misaligned conveyance.

6.3.3.4 Supporting steelwork for the fixed guides must 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.

6.3.3.5 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).

6.3.3.6 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.

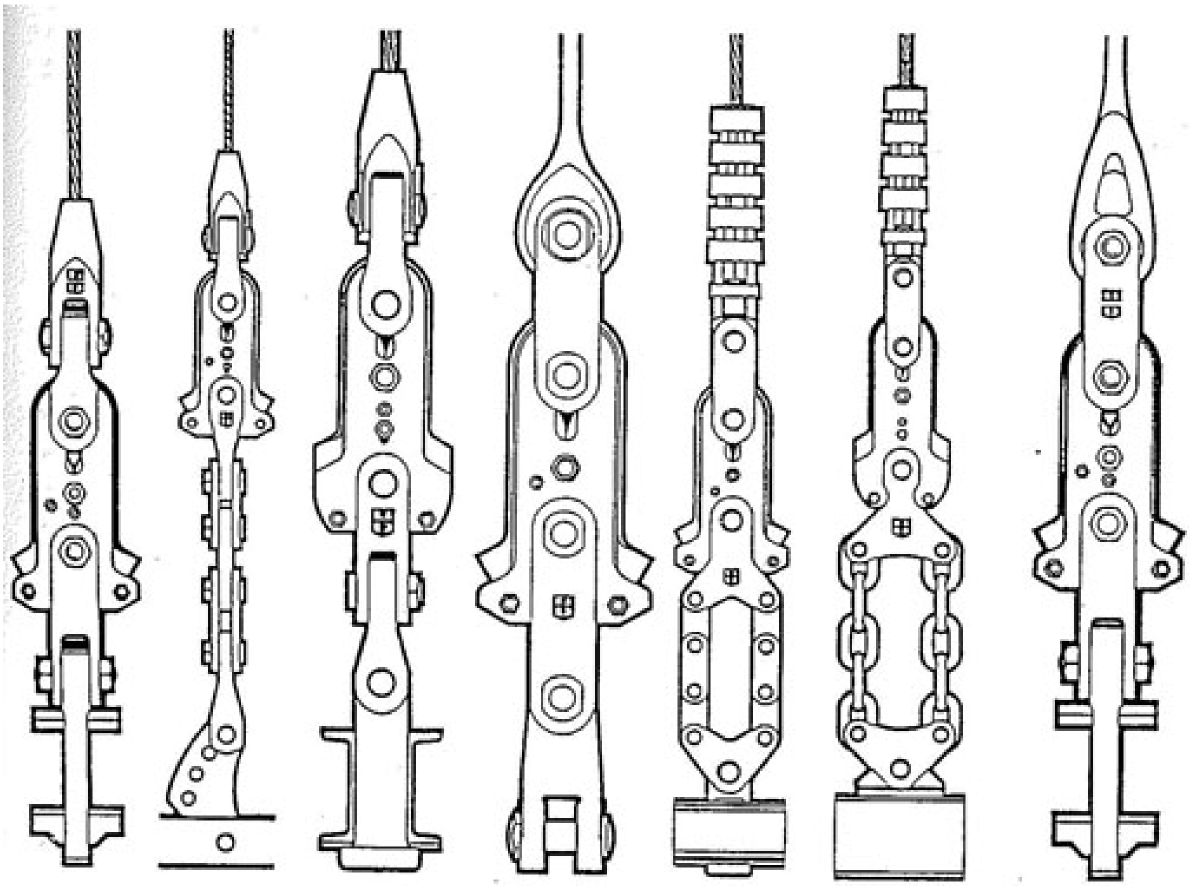


Fig 6.1 - Typical suspension units with detaching hook

(*from* Barker-Davies Catalogue:Barker Davies & Company Ltd, U.K.)

6.4 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.

6.4.1 Inspection and Testing

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.

6.4.2 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 (See Clause 10(1) of the Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation 1984.

6.4.2.1 The detaching hook is the device commonly used as the means of conforming to Clause 10(1) of the Regulation. The hook and the associated equipment should be purchased from reputable manufacturers of suspension equipment and must conform to the relevant Standards (See AS3637 Part 2 - Detaching Hooks. Provisions for Factors of Safety and Testing).

6.4.2.2 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 Part 1 - Drum winding overwind safety catch systems.

6.4.2.3 Platforms and ladders must be installed to allow for the safe unloading of personnel from the cage if an overwind occurs and the cage detaches (see Section 4.7.4).

6.4.2.4 See Clause 20 of the Regulation for inspection and testing requirements for detaching hooks.

6.4.3 Overspeed and Overwind Control and Protection

The electrical monitoring components used to transmit the required signals should be driven directly from the non-drive end of the drum shaft, or from the last drive component of the drive system. The electric/electronic equipment used to control automatic winders is detailed in the electrical section (not completed at time of publication).

6.4.3.1 All winders shall be fitted with a device or devices which prevent/s the conveyance from travelling at excessive speed, and beyond a predetermined position above the highest landing level in the shaft.

6.4.3.2 Fit winders with a designed normal winding speed in excess of 1.5 m/s with a permanently operative automatic contrivance, which when set for personnel riding causes the mechanical brakes to apply to:

(a) prevent the conveyance from landing at the bottom of the shaft, or at its lowest entrance, at a speed greater than 1.5 m/s, and

(b) limit the speed of an ascending or descending conveyance to avoid danger to any person travelling inside.

6.4.3.3 Double drum winders with clutched drums should have a separate drive from each drum to the appropriate part of the automatic device, or an automatic contrivance for each drum.

6.4.3.4 Overspeed devices that trip at a single speed are only suitable for winding speeds of less than 1.5 m/s. In these cases set the overspeed as close as possible to the overspeed limit without causing unnecessary trips.

6.4.3.5 Automatic contrivances used for overspeed and overwind protection have traditionally been mechanical types. However other types (e.g. electronic) may be used if they provide an equivalent level of safety.

6.4.3.6 Design the automatic contrivance to be constructed so as to eliminate single line components (including software programs) which would cause failure to an unsafe mode. If this is not possible, provide a monitoring system to detect failure, with an independent system which brings the winder to a stop. Further winding should be prevented until the failure has been investigated and the automatic contrivance proven acceptable.

6.4.3.7 If the automatic contrivance has separate modes for personnel winding and materials winding, it should be set to the personnel winding mode before individuals are allowed to enter the conveyance. This should be displayed on indicators at every landing and be clearly visible to persons transmitting signals from such landings.

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

6.4.4 Shaft Overwind Protection (Shaft Limits)

All winders shall be fitted with suitable ultimate overwind switches in the headgear to safeguard against the failure of the primary overwind protection. When operated by the conveyance, these overwind switches should withdraw power from the winder and apply the emergency brakes. The conveyance shall not be backed out of the limits without the overwind being recorded.

6.4.5 Arresting Devices

Danger to persons in a descending conveyance following an overwind 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.

6.4.5.1 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.

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

6.4.5.3 Provide bottom sump steelwork with access ladders and platforms to enable safe inspection of the arresting equipment and sump steelwork. (For other accesses refer to 6.9.1.4).

6.4.6 Safe Coiling Monitor

A safety device shall ensure that the rope coils safely on the drum and does not "climb up" the rope flange, or pile up on the drum.

6.4.6.1 The device consists of a bar located between the flanges at a distance of approximately one half of a rope diameter from the outer most layer of rope. In the event of overcoiling, the rope will hit the bar, activating a switch to stop the winder.

6.4.6.2 The safe coiling bar will also monitor slack rope at the drum.

6.4.7 Slack Rope Monitor

A safety device shall ensure that, when slack rope is detected, the safety circuit will trip, the winder stop, and audible and visual alarms will be given.

6.4.7.1 Such a device may consist of a bar located under the rope adjacent to the head sheave. If slack rope allows the rope to hit the bar, the bar will activate a limit switch to stop the winder.

6.4.7.2 Technology is now available to provide slack rope protection throughout the winding cycle. Such system of proven reliability is used for this purpose (See Appendix A - Example of the provision of slack rope and cage door monitoring).

6.4.8 Balance Rope Protection

Where balance ropes are used on double drum winders, a monitoring device should be installed to detect rope loop lift. When the loop lifts above its normal running position the winder will stop and audible and visual alarms will activate.

6.4.9 Conveyance Position Monitoring

All winders shall be provided with devices positioned so that they are visible to the winder driver in the winder room to monitor conveyance position and speed.

6.4.9.1 The conveyance speed indicator shall be marked with the maximum speed and the maximum speed permissible for man-winding.

6.4.9.2 An indicator shall show the position in the shaft of each conveyance.

6.4.9.3 Where conveyance position monitoring can be provided throughout the wind by systems of proven reliability, then consider using the systems for this purpose. A mark on the rope or drum is not by itself an effective means of monitoring the position of the conveyance.

6.4.10 Automatic Winders

Allow for the following additional protection where the winder room is unstaffed.

6.4.10.1 Thermal protection of all main bearings, winder brake paths, and winder motor bearings and windings.

6.4.10.2 Moisture detection on winder brake paths or preventive measures to avoid the accumulation of moisture.

6.4.10.3 Means of giving adequate warning of fire outbreak in the winder room. Consider a suitable fire suppressant system (refer to Section 5.5.2.4)

6.5 Conveyances

AS3785 Part 4, Conveyances for Vertical Shafts, sets out the requirements for designing, constructing, and inspecting conveyances in vertical shafts.

6.5.1 Safety monitoring for man riding conveyances

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

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

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

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

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

6.6 Signalling and Communication

All shafts equipped with winders other than shaft sinking 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

any place where any such means of signalling and communication is necessary to enable the winder to be used safely.

Vertical shaft winder cage

Vertical shaft winder counterweight

Shaft drum winder cage chain attachment arrangement.

6.7 Headsheaves

See Section 4.9 for headsheave design.

6.8 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".

6.8 1 See Section 4.8 for winder house foundation design.

6.8.2 See AS3785 Part 5 - Underground mining - Shaft Equipment - Headframes for headframe requirements.

6.9 Vertical Shaft Drum Winder Ropes

The generally accepted standard for vertical shaft drum winder rope construction is non-spin (locked coil) rope. See Section 2 for general rope requirements.

6.9.1 For design purposes select rope diameters and strengths as set out in AS1426 Steel wire ropes for mines. Make the final selection and recommendation in co-operation with the wire rope manufacturer (refer to Section 1.1).

6.9.1.1 For automatic winders use a maximum of three layers of rope to maintain correct scrolling of the rope.

6.9.1.2 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). Rope inspections and capping changes shall be carried out as required by the DMR Inspectorate.(make reference to MDG 26, Shafts and Roadways Regulation and AS3637.3).

6.9.1.3 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.

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

6.10 Environmental Considerations

6.10.1 Oil Spillage

Give special attention controlling oil spillage, splash, or contamination with water drainage.

6.10.1.1 If winder drums are located in a pit, ensure that the pit is 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.

6.10.1.2 Pits should be fitted with alarms to indicate flooding, and to stop the winder (see Sections 3.1.11.4 and 3.1.11.5). If drainpipes are fitted duplicate the pipes to reduce the risk of fouling. If gravity drainage is unavailable the pit should be fitted with an automatic pumpout systems. Pumps should not pump pit water into the stormwater drainage system without adequate treatment.

6.10.2 Winder House

The winder house design should allow for the effects of heavy rain and local flooding (and the direction of sunlight if the winder is manuallly operated).

6.10.2.1 Elevate the winder house floor levels to at least 150mm. above the local ground level to ensure that the house is not flooded during heavy rains.

6.10.2.2 Make provision for cable tray channels to be well drained, and any water collected to be treated before discharge into storm water drainage.

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

6.10.2.4 Transformer 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.

6.10.2.5 Where the winder is located in dusty or dirty environments, e.g. coal conveyors, consider pressurising the winder house.

6.10.3 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.

7. SHAFT SINKING WINDERS - DESIGN & CONSTRUCTION

OVERVIEW

7.1 General Requirements For Shaft Sinking

7.1.1 Winder Requirements

Vertical shaft sinking is specialised work and should normally be undertaken by an experienced shaft sinking contractor. Because they do not have a shaft to start with, shaft sinking winders and their associated stage winders have requirements that are different to those of permanent winders. The methods used for shaft sinking vary, also, and often demand considerable flexibility. However, as with permanent winders, safety shall not be compromised. All the safety features required by the Department of Mineral Resources must be meet.

7.1.1.1 These guidelines are not intended to cover every type of shaft sinking operation, but may be used as a guide to the standard method, i.e. with kibble and stage winders. Other methods may meet the guideline's intentions.

7.1.1.2 See Section 1 for statutory requirements and approval procedures for all drum winders.

7.1.1.3 The shaft sinking project will normally use a vertical shaft drum winder with a kibble as the means of personnel and materials transport, and a movable stage consisting of several working platforms lowered and raised by a double drum, low speed, stage winder.

7.1.1.4 Because of the nature of the shaft sinking operation, and difficulties encountered, some safety features normally required by the DMR Inspectorate for permanent winders, are, with written approval, exempt.

7.1.1.5 In general the winders used for the shaft sinking operation shall conform to Section 6: Vertical Shaft Winders, Design and Construction), and other parts referred to under that section, as required. Variations to the guidelines outlined in this section would normally be considered for exemption by the DMR Inspectorate.

7.1.1.6 Subject to the DMR Inspectorate written approval, and to conditions applying to the activity, the contractor may use a crane, with a kibble or bucket attached, to hoist the broken rock from the initial surface excavation, and from the shaft, to a maximum depth of 50 metres. A crane shall not be used if the shaft perimeter has been traversed by beams or any other structure which could obstruct the free passage of the kibble or bucket.

Shaft Sinking Winder using a vertical borer technique

Elevation

Shaft Sinking Winder using a vertical borer technique

End Elevation

Shaft sinking winder stage design using a vertical borer technique

Shaft Sinking Winder under construction

7.2 Shaft Sinking Winders

Shaft sinking winders are those which wind personnel and/or materials in a vertical conveyance called a kibble (or bucket) in the shaft, using a single rope coiling onto a drum. The winder drum and driving machinery are located in a house or room at ground level, at a distance sufficient to give the required fleet angle, with the rope being positioned over the shaft by a head sheave and supporting headframe structure.

7.2.1 Winder Construction

The winder construction and design will, in general, be as required by Section 6.

7.2.2 Overwind Protection

For shaft sinking purposes approval may be granted to eliminate a detaching hook. Where detaching hooks are not used, the headframe shall 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 shall be connected to tensioned trip wires or similar devices operated by the crosshead (rider).

7.2.2.1 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).

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

7.2.2.3 The movement of the conveyance shall be controlled so as to minimise the risk of collision with the stage. The automatic contrivance should be regularly adjusted to ensure that the speed of the conveyance cannot exceed 2 m/s when it is at or below the top level of the stage.

7.2.3 Shaft Doors

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

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

7.2.3.2 The shaft door, or doors, shall be kept closed at all times when personnel, tools or materials are being loaded onto or unloaded from the kibble 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.

7.2.3.3 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, shall be so equipped that their position is positively indicated to the winder driver.

7.2.4 Interlocking

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

7.2.4.1 When winding is taking place, tipping chutes are clear of the path of the conveyance.

7.2.4.2 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.

7.2.4.3 Before discharging conveyances into the tipping chutes, all shaft top doors are closed.

7.2.5 Winder Movement

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

7.2.6 Shaft Top Doors

Persons shall 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 them.

7.3 Guide Systems

There shall be provided in every sinking shaft exceeding 50 metres in depth, guides and guide attachments to prevent the kibble or other appliance from swinging while being lowered or raised in the shaft. Because the bottom of the shaft is moving downwards as shaft depth increases, guide systems used in permanent vertical shaft drum winders are not applicable to shaft sinking.

7.3.1 Guide ropes

In general the stage winder ropes are used as the guide ropes for the kibble. A crosshead (or monkey), is mounted on the main winder rope above the rope attachments to prevent the conveyance from swinging while being raised or lowered in the shaft. The crosshead slides on the stage winder ropes on brass slippers.

7.3.1.1 For rope guides, the ratio of crosshead depth to width should be approximately 1.5:1 unless proven designs are used.

7.3.1.2 The crosshead shall be installed whenever the shaft depth exceeds 50 metres and maintained to a distance of not more than 25 metres from the bottom of the shaft until the shaft sinking has been completed.

7.4 Kibbles and Equipment

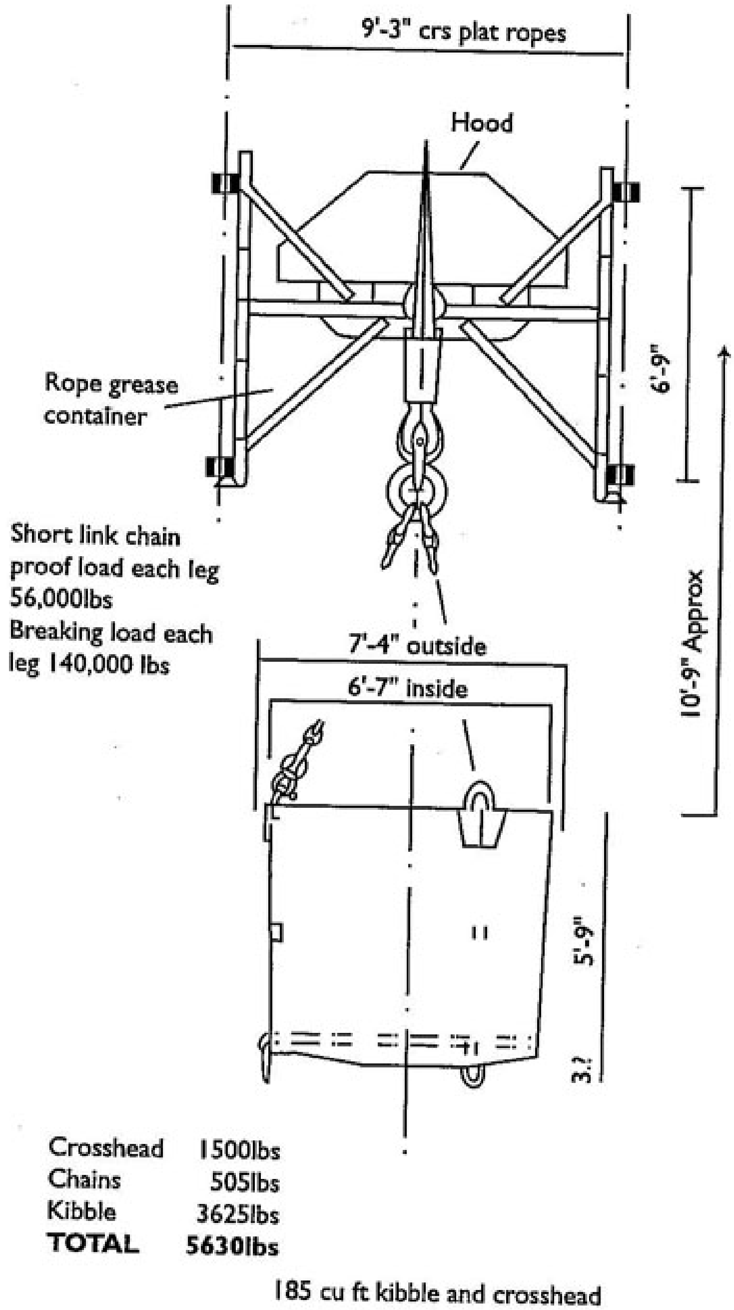
The kibble (or bucket) used for shaft sinking will be sized to suit the shaft, winder, and load capacity required, and shall be of such a shape as to minimise the risk of it catching on any obstruction during its travel in the shaft. Generally, the kibble is an open type bucket with two (2) or three (3) point attachment lugs equally spaced around the perimeter for attaching the lifting chains. A “lazy sling” arrangement is sometimes used to tip sinking kibbles.

7.4.1 Kibble Design and Construction

The kibble design is relatively simple compared to a skip or cage. However the structural factors of safety given for personnel riding conveyances shall be observed if the kibble is used for carrying personnel.

7.4.1.1 For structural strength requirements see AS3785 Part 4 Conveyances for vertical shafts.

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



Typical Kibble & Crosshead Arrangement

Fig 7.1

7.4.1.3 Any kibble used for personnel riding shall be sufficiently sized as to prevent persons falling out. An individual travelling in a kibble where more than one third of his/her body is outside the conveyance, shall use a safety belt securely anchored inside the kibble.

7.4.1.4 Any kibble used for personnel riding shall have sufficient toe holds, steps and hand holds, to allow safe loading and unloading of persons.

7.4.1.5 Chains used for suspending kibbles shall be of identical dimensions and strength, except where two-legged chains, consisting of a standard and a long chain, are used.

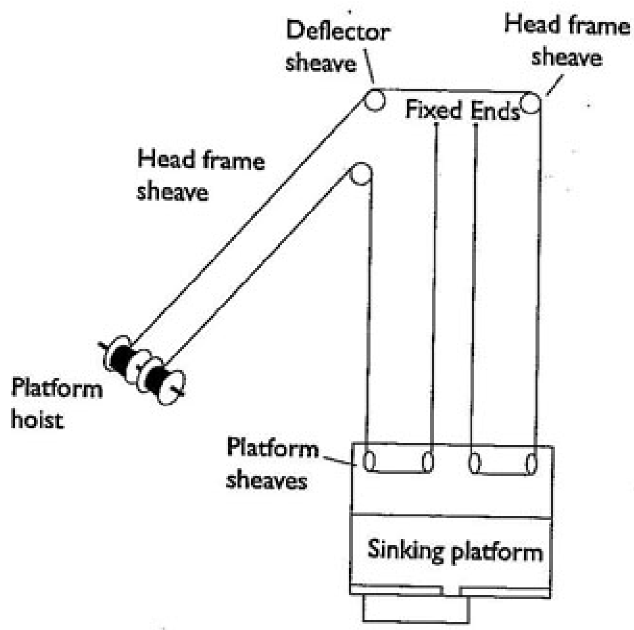
7.4.1.6 Chains used for suspending kibbles shall be of sufficient length to ensure that the included angle at the apex of the suspension of any two chains is not greater than 60 degrees.

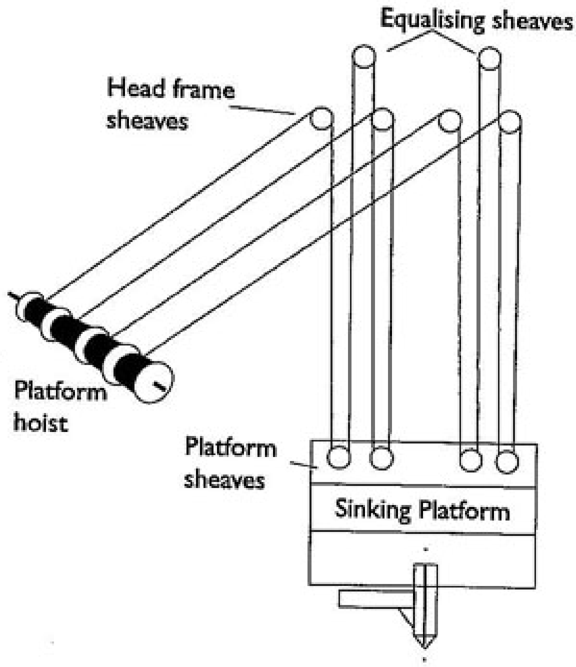
7.4.1.7 Chains used for suspending kibbles shall have a Factor of Safety not less than 10. Any screwed or threaded connection shall have a Factor of Safety of 15.

7.4.1.8 Any stairways, platforms or ladders used for safely loading or unloading persons to or from a kibble being used shaft sinking operations shall be as required by Section 4.7.4.

7.4.2 Arrestor Equipment

Arrestors are not required when shaft sinking, due to the problems that would be associated with conveyance arrestors at shaft bottom.





Typical stage rope layouts

Fig 7.2

7.5 Stage Winders

Stage winders are used during shaft sinking for lowering, raising and adjusting the stage in the shaft. In general the stage winder requirements shall be as those for vertical shaft drum winders (see Section 6). However, due to the nature of shaft sinking operations some deviation from winding practice may be unavoidable.

7.5.1 Brakes

The guidelines set out in Section 3 as requirements for drum winder brakes are also applicable for stage winding, with the following specific features.*

7.5.1.1 Brakes for stage winders may be exempt from dynamic testing.

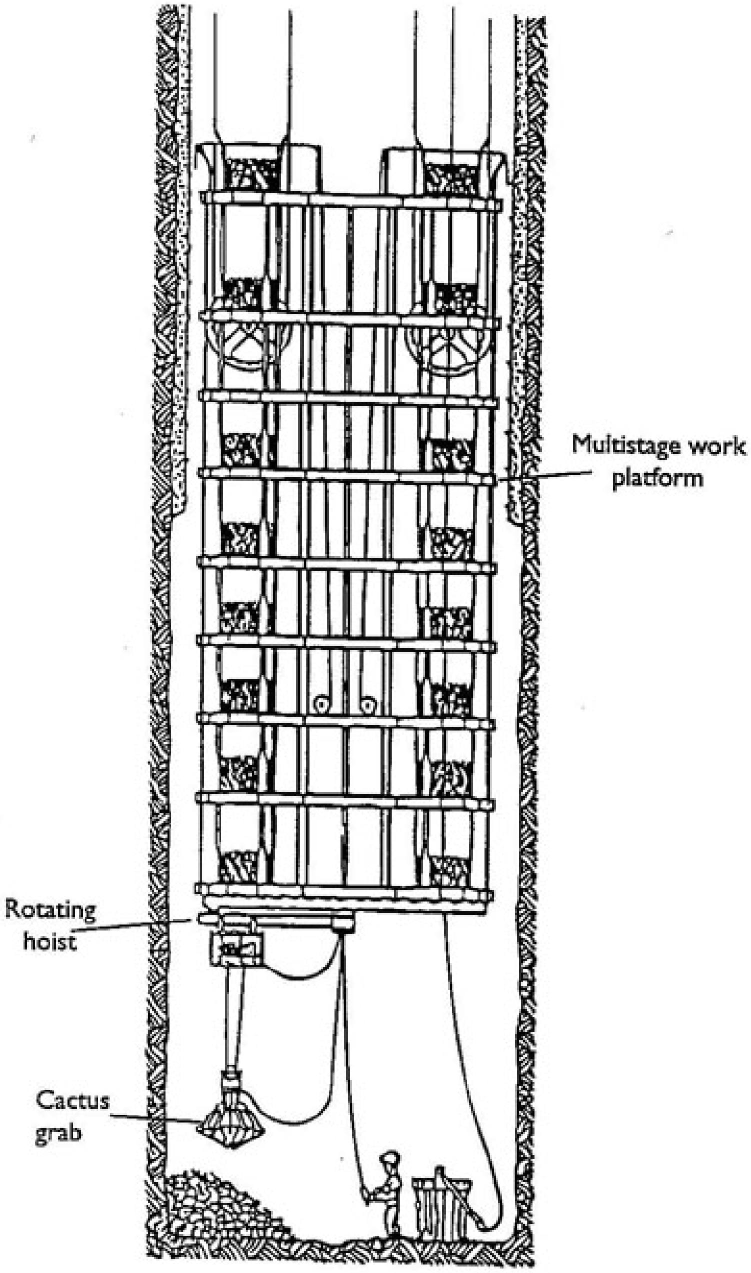
7.5.1.2 The brake capacity required for each brake of every stage winder shall be 200% of the maximum static torque with the stage at shaft bottom.

7.5.1.3 Stage winder brakes winders shall be statically tested before being used in any new shaft sinking application after the winder has been installed on site and before the shaft sinking commences.

7.5.1.4 Low speed drum brakes may be uni-directional band brakes. If the low speed drum brakes are uni-directional then the high speed brakes shall operate and be tested in both directions.

7.5.1.5 Brake application timing may permit the high speed (short reaction time) brake to engage first in order to assist stage levelling adjustments.

***NOTE** When the rope winding speed is less than 0.5 m/s the guidelines set out in subparagraphs 7.5.1.1 to 7.5.1.5 may be exempt, with written approval.



Typical bottom-of-shaft arrangement

Fig. 7.3

7.6 Stages and Stage Equipment

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.

7.6.1 Stage Structure Design

The stage structure design loads shall be as generally as required by AS3785 Part 4 - Conveyances for Vertical Shafts. A stage is defined as a conveyance hence requires DMR Inspectorate Approval.

7.6.1.1 Stages shall be securely fenced to prevent persons from falling. Stairways, platforms and ladders shall comply with AS1657 - Fixed platforms, walkways, stairways, and ladders.

7.6.1.2 Stages shall be designed to minimise the possibility of overturning.

7.6.1.3 Ropes shall be attached to the stage through apparatus designed to load the ropes as uniformly as is practical.

7.6.1.4 Any part of the stage structure which is constructed using hinged sections shall be securely bolted together before persons are allowed to work on the structure during shaft sinking activities.

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

8. COMMISSIONING AND TESTING PROCEDURES

OVERVIEW

8.1 New or Re-located or Upgraded Winders

8.2 Existing Winders

8.3 Shaft Sinking Winders

8.1 New or Relocated or Upgraded Winders

Prior to any commission the approval process must be undertaken as stated in Section 1.

8.1.1 No winder shall be commissioned to perform winding duties without testing and testing approval as required by Section 1.

8.1.2 A detailed testing program shall be submitted to the DMR Inspectorate prior to commencing final testing of the winder/haulage system. The DMR Inspector will assess and advise on:

(a) the adequacy of the testing program.

(b) the testing to be witnessed by the Inspector or his nominated representative.

Refer to MTR1 - "Test Report - Shaft Sinking Winding Apparatus."

8.1.3 To obtain approval for winders and winding equipment as required by Section 1, the new, upgraded, or relocated winder shall be tested at installation:

(a) to the maximum loads and speeds hoisted by the winder;

(b) to the minimum loads and speeds hoisted by the winder;

(c) to any combination of loads and speeds that will the winder to its worst hoisting duty.

8.1.4 Testing shall be carried out by:

(a) a competent electrical engineer in co-operation with

(b) a competent mechanical engineer in co-operation with the manufacturer and purchaser representatives. For this purpose, "competent" shall mean a person registered with the DMR Inspectorate as qualified to perform such testing.

8.1.5 Test records shall be retained and finalised for:

(a) submitting with approval documentation to the DMR Inspectorate and

(b) recording and filing by the purchaser or the mine.

8.1.6 Test records shall define all testing and record the results of such testing of safety equipment, safety equipment settings, brake settings, conveyance stopping distances, deceleration rates, test loads and certification, and any other tests relevant to the winder, or as required by the DMR Inspectorate.

8.1.7 A copy of the first page of the "Brake Record Book" kept for recording brake testing, showing completed entries for initial brake testing, shall be included with the test report.

8.1.8 Final testing approval and acceptance shall be by the DMR Inspectorate, who may:

- **(a)** inspect the installation and examine test records, specifications, drawings and design calculations and request that such documentation be audited by an independent examiner if required, and
- **(b)** be present at any or all of the tests (see Section 8.1.2) and impose any further tests as deemed necessary to ensure that the installation operates safely and to the satisfaction of the DMR Inspectorate.

8.2 Existing Winders

8.2.1 Existing installed winders should be tested:

- **(a)** when winder maintenance has involved replacement of parts which are components of the safety, brake, or drive systems of the winder;
- **(b)** when brake linings or brake calipers have been replaced;
- **(c)** when ropes, rope cappings, or attachments have been replaced;
- **(d)** as required by Manager's Rules for the safe operation of the winder.

8.2.2 Testing shall be carried out by persons authorised by the mine manager or his/her representative, as competent and authorised to perform such testing.

8.3 Shaft Sinking Winders

8.3.1 No winder shall be used for shaft sinking, or stage winding, without having first been tested to ensure all safety functions, features, stops, and all brakes, are operating correctly as required.

8.3.2 Testing of new shaft sinking winders, stage winders, and winders not previously used for shaft sinking shall be as set out in Section 8.1

8.3.3 Prior to commencing final testing for re-located shaft sinking winders the installer must submit a testing program to the DMR Inspectorate. The DMR Inspector will assess and advise on:

- **(a)** the adequacy of the test program;
- **(b)** any testing to be witnessed by the Inspector.

8.3.4 All testing carried out when stage sinking winders are relocated shall be entered into a book kept specifically for this purpose, and made available to the DMR Inspector when requested for examination.

8.3.5 Testing of re-located stage sinking winders previously used for shaft sinking, and having capacities exceeding, or the same as, those required at the relocated site, shall be carried out by a person authorised by the Mine Manager, or his/her representative, to do so.

8.3.6 Before commencing a new shaft sinking project, the shaft sinking winders, conveyances and associated components, shall be thoroughly examined for cracks, deformations, corrosion, or any other damage which could cause the winders to be unsafe. Non-destructive testing of drums, shafts and brake linkage components should be carried out. A completed inspection report including all tests shall be signed by a competent engineer and filed with the winder records.

8.3.7 No rope shall be used for shaft sinking purposes unless:

(a) It is new, certified, and complies with Section 2 of the guidelines.

(b) If the rope is used, i.e., it has been used on a previous shaft sinking projects, the rope shall comply with Section 2 of the guidelines, shall be non-destructively tested before re-use and examined by a competent engineer. The documented history of the rope shall be reviewed before the rope is accepted for re-use.

9. SAFETY AUDITS

OVERVIEW

9.1 Safety Audit Purpose

9.2 Safety Audit Procedures

9.3 Safety Audit Approval

9.1 Safety Audit Purpose

9.1.1 Every winder which has been in service for five years, or has been engaged in winding duties a period not exceeding five years since its last audit, shall be audited.

9.1.2 The purpose of the audit, to be known as "the safety audit" is to have all safety requirements of the winder, and associated equipment and documentation being used with the winding activities, verified as acceptable, by an external auditor.

9.1.3 The external audit shall be carried out by competent persons. For auditing purposes a "competent person" shall be one registered with the DMR Inspectorate as being acceptable to perform such tasks.

9.2 Safety Audit Procedures

9.2.1 The safety audit shall be designed to assess the safety condition of the winder and will address/review all safety aspects of operation, servicing, and maintenance of the winder. It should include, but not be restricted to, the following:

9.2.1.1 Review DMR Inspectorate approvals for the winder, including supplementary approvals.

9.2.1.2 Review design calculations, drawings, and specifications.
Note: For ongoing audits these documents may require only sighting if a previous audit indicates that the documents have been examined and are acceptable.

9.2.1.3 Verify that all safety devices are in place and functioning. List each device on a sheet, test for performance, and enter test results on the sheet.

9.2.1.4 Verify that a brake testing program is in place and is current. Verify that the brake record book is correctly kept.

9.2.1.5 Witness static and dynamic brake testing and ensure that persons authorised to conduct these tests are fully conversant with the purpose and method of safely carrying out this testing.

9.2.1.6 Inspect all conveyances, attachments, conveyance brakes, safety chains, and all other safety components, and verify the acceptability of all safety features.

9.2.1.7 Documentation relating to the competency of Winding Drivers/Operators with respect to that winder system shall be made available.

9.3 Safety Audit Approval

9.3.1 Any safety issue found during the audit, and needing attention, should be resolved with the mine manager and his/her representatives, and/or the winder owner in the case of a shaft sinking contract.

9.3.2 If a difference of opinion arises as to the requirement of a safety device or the consequence of a perceived hazard, that cannot be resolved, then the auditor shall seek the advice of the local DMR Inspector who will adjudicate.

9.3.3 To complete the audit, the auditor shall conclude the report with attachments which will clearly indicate the safety condition of the winder. The auditor will give a copy of the report to the mine manager, and send a copy to the DMR Inspectorate.

9.3.4 If sufficient time is not available to complete the audit by the due date, the mine manager may apply to have the time extended for up to six months.

9.3.5 Failure by the mine manager or owner to have a safety audit on a winder under his/her control completed and accepted by the DMR Inspectorate could render the winder approval invalid.

APPENDIX A

A.1 Operational requirements for a slack rope protection system

A.2 Example of system incorporation slack rope protection

APPENDIX B

NOTICES

APPENDIX A.1 Operational requirements for a slack rope protection system.

Ref: Safe Manriding in Mines. Part 1B

A.1.1 The system should indicate slack rope happening at any part of a wind.

A.1.2 The system should be capable of initiating a trip when the amount of slack rope exceeds 150mm at or near platform, shaft bottom or an inset, and preferably throughout a wind.

A.1.3 Accuracy and reliability should not be affected significantly by rope stretch, bounce, shocks to the conveyance or slack rope produced during normal winding operations.

A.1.4 Maintenance requirements should be minimal.

A.1.5 If batteries are used the load imposed on them should be such that the time between replacements will be as long as possible, but not less than one week, consistent with restrictions on weight and size.

A.1.6 The system should fail to safety. Alternately, any fault resulting in inaccuracy or non-operation should be self-revealing.

A.1.7 The system should be certified for use in flammable atmospheres.

A.1.8 Alarm and trip facilities should be provided.

A.1.9 Direction of travel to retrieve slack rope should be indicated.

A.1.10 The system should have built-in test facilities to check that it is functioning correctly.

APPENDIX A.2 Cage call system incorporating slack rope monitoring:

Description of a system operating at No. 2 Shaft Winder, Oakdale Colliery, NSW.

A.2.1 There are two separate systems, one for each skip, operating on different frequencies but both functioning basically as follows:

A.2.1.1 The system consists of a strain gauge load cell embedded in the chase block as a link between the capel and the skip. The analogue signal from the load cell is fed into a conditioning unit which converts the signal to a 12 bit binary number. This binary number is an input to the cage call unit which transmits the 12 bits up the shaft to a receiver, via microwave radio signals. The 12 bits are sent to the PLC as 12 digital inputs. The PLC then converts these to decimal code as tonnes. Parameters are then set in the PLC code for undertension, overtension. overload and skip failed to discharge, alarms.

A.2.1.2 In addition, the microwave system also transmits to the PLC the following information from the skip:

(a) normal and backup door closed signals;
(b) door open signal;
(c) 2 x emergency stop signals;
(d) 8 x slack rope mercury tilt switch signals: 4 on the capel and 4 on the chase block, positioned to detect capel or chase block tilting in all 4 planes;
(e) voice radio transmitter and receiver for voice communication to the winder driver.

A.2.2 Alarm Parameters

the load cell values are used in the PLC to provide the protection which will trip the winder safety circuit. (**Note:** empty skip weight is 8.6 Tonnes End of Rope; payload is 10 Tonnes).

A.2.2.1 **Undertension** protection is designed to detect skip hang-up and is set to trip at 2 homes under the empty skip weight. This was necessary to prevent false trips on acceleration down the shaft, and brakes-on at the end of normal travel up the shaft. (**Note:** can get up to 1 tonne decrease in the end of rope load due to these dynamics).

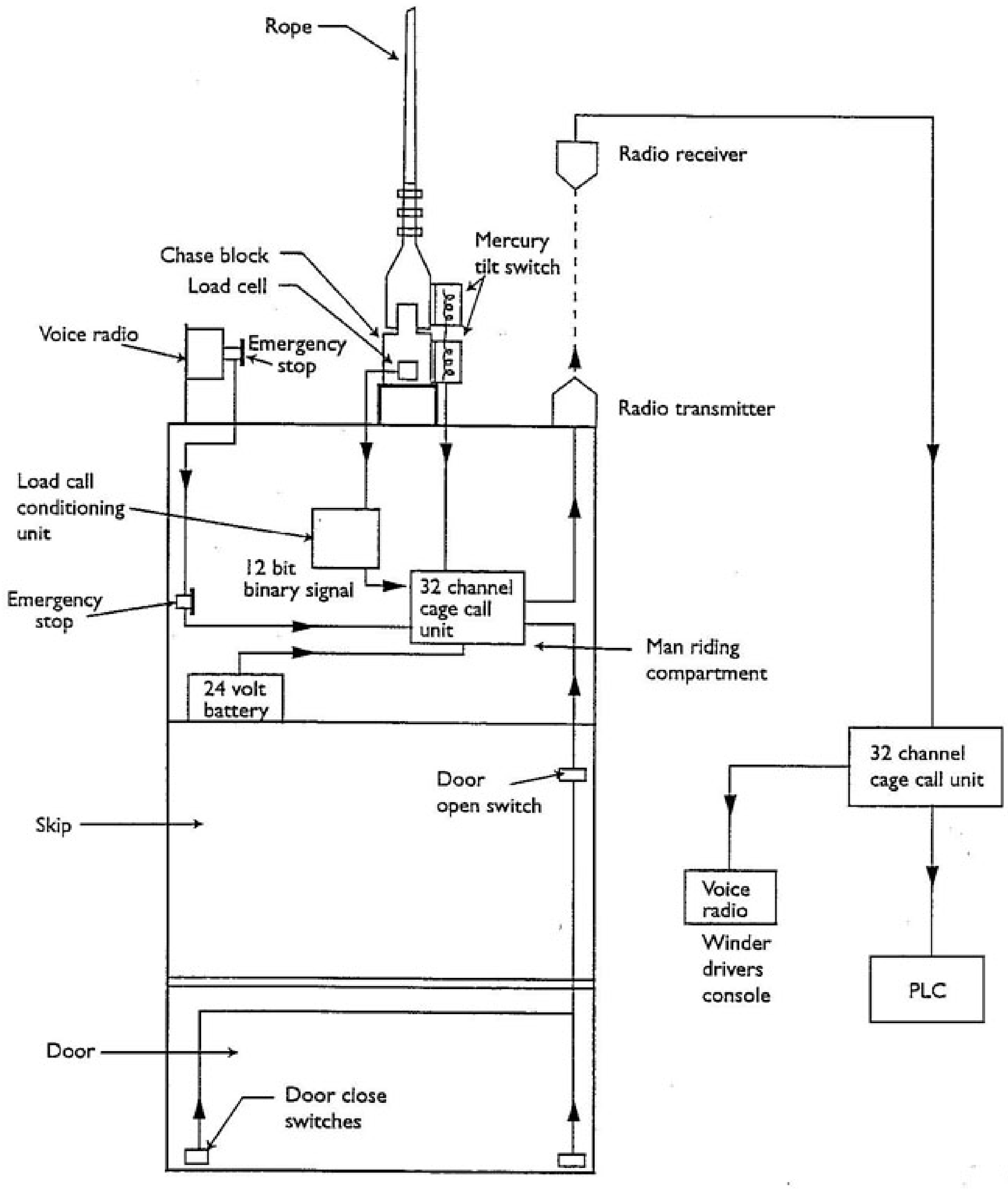
A.2.2.2 **Overload** protection is designed to detect too much load in the skip, and is set at 23 Tonnes. The PLC takes a snapshot of the End of Rope load at the instant the brakes are about to release after the skip is loaded. This allows the dynamic bounce to settle following loading (this dynamic can reach 25 Tonnes). 23 Tonnes is the normal safe working load of the rope and capel. (**Note:** The skip has the capacity to hold 15 Tonnes of coal before overflowing).

A.2.2.3 **Overtension** protection is designed to detect a 'snared' skip while winding up the shaft, and is set at 25 Tonnes. This is active for all the winding cycle and had to be set at 25 Tonnes to overcome false trips due to the dynamic rise in the End of Rope during loading and acceleration.

A.2.2.4 **Skip failed to fully discharge** protection is designed to prevent the winder sending a skip back down the shaft if it has not completely emptied. It is set at 11 Tonne End of Rope.

A.2.2.5 **Slack Rope Tilt Switches.** There are 8 mercury tilt switches on each skip; 4 on the capel and 4 on the chase block. They are set to detect tilting of the capel or chase block due to slack rope in all 4 planes. These have been tested to operate at approximately 30 degrees tilt from the vertical plane.

Fig A1 WinderCage Call System
Single Line General Layout



APPENDIX B

LIST OF NOTICES

(These Notices have been extracted from MDG 30 - Mechanical Compendium)

Notice Number	Date	Description
A10	5/12/83	Brake Failure - Automatic Haulage
A28	9/5/89	Slope Haulage Systems - Overspeed
A39	4/4/90	Winder Rope Life Extensions
A40	4/4/90	Australian Standards for Shaft Winding
A66	16/12/92	Resin Socket Capping for Winding Ropes
A72	29/11/93	Winder and Haulage Rope Cappings
A76	24/6/93	Shaft Winder System - Risk Assessment
B3	25/6/84	Chains
D5	26/6/85	Chains for Transporting Persons
D6	2/2/88	Brake Pad Material - Dump Brakes
D10	1/6/93	Powered Winder System - Risk Assessment
F15	2/1/90	Approval for Non Destructive Testing - Bullivants
F34	5/9/84	Notice Directing System Approval - Drift Haulage

Notice A10

File No.: M83/4076
Date: 5th December, 1983

Dear Sir

BRAKE FAILURE - AUTOMATIC HAULAGE

It was recently reported to me that, in a New South Wales coal mine, the brakes on an automatic drift winder failed to apply at the end of a wind.

As you are aware:-

* Automatic winders, whether shaft or drift, have brakes which are applied by spring or gravity and which are held off, during winding, by hydraulic or pneumatic pressure.

The following matters arose from the investigation:-

* In the particular winder concerned the brakes were held off by hydraulic pressure.

* To apply these brakes a solenoid energised - spring return spool valve was isolated from its power supply permitting the spring to return the spool and open the pressure line to its hydraulic reservoir.

* To ensure reliability the colliery had installed three such valves, any of which was capable of releasing oil pressure and permitting brake application.

* Each of these spool valves had been tested daily for operation and had given no evidence of failure to work.

* At the end of one particular wind all three spool valves failed to operate and consequently the brakes on the winders were not applied.

An inspection of the spool valves which failed to operate did not reveal any damage or reason for the failure.

The matter was then taken-up with the supplier of the valves who has advised that spring return spool valves may stick and not return under spring pressure in certain circumstances. The selection of spool valve type and capacity is accordingly quite critical to ensure reliable operation.

My Inspectors have reported that spool valves are used on most shaft and drift winders in New South Wales and that a proportion of such valves are inappropriately chosen for their specific application.

Notice A10 continues

Accordingly I require that you:-

(1) Check whether your colliery uses spring return spool valves in the braking system of any rope haulage.

(2) If so check that the valves are appropriate for their service and if not replace them with valves which are not subject to failure as indicated.

(3) Notify me in writing of what action you have taken in this matter.

If you have any question relevant to the above please contact Mr P Torr (02) 240 4248.

Yours faithfully

M.J. MUIR
Chief Inspector of Coal Mines

Notice A28

File No.: M84/5008
Date: 9th May, 1989

The Manager

Dear Sir,

RE: SLOPE HAULAGE SYSTEMS

Approval of slope haulage systems incorporate requirements for dual overspeed protection. These protection systems are as follows:

1. Overspeed of the Winding Apparatus.

   This protection system should be set to operate at a speed marginally in excess of the maximum operational winding speed.

2. Overspeed of the Control Car.

   This protection system should be set to operate at a speed marginally in excess of the winder overspeed protection system.

Approval of control car conveyances requires that the overspeed device be checked three (3) monthly as part of the Section 103 Scheme for the mine. Would you please ensure that the winder overspeed device is also included in the Scheme to be checked at the same interval.

Whilst not specifying the overspeed switch settings for the slope haulage system, it is suggested that the winder overspeed system set point be up to 10% of maximum winder operating speed with the control car overspeed system set point be up to 5% in excess of the winder overspeed system set point.

In addition your attention is dawn to the need for winding apparatus brake paths to be kept clean and uncontaminated. Section 103 Schemes are to incorporate inspections of brake paths and winder drum pits at appropriate intervals to ensure that contamination of brake paths is avoided.

Yours faithfully,

J. G. Bailey
Chief Inspector of Coal Mines

Notice A39

File No.: M85/1478
4 April, 1990

The Manager

Dear Sir,

Re: WINDER ROPE LIFE EXTENSIONS

As you are aware, the Coal Mines Regulation Act 1982 limits the nominal acceptable period of service for friction winder head ropes to 2 years whilst friction winder balance ropes are limited to 3 years. Both these periods are, however, subject to extensions of time at the discretion of the Chief Inspector of Coal Mines, usually subject to certain conditions as deemed appropriate.

To allow for uniformity this Department has generally granted these extensions for a period that will result in their expiry on the 31st January annually. This allows Mines to utilise, what was in the past, the traditional Christmas shutdown period to change out ropes.

As a result of this the Inspectorate is of ten inundated with numerous extensions of rope life requests in December and January of each year.

A great many of these requests are- improperly submitted with not enough consideration being given to the lead time required for processing of the necessary documentation, nor with the correct references to File Numbers where available. Failure to provide current Engineering data and test results combined with statutory inspection copies is an added problem-

In an attempt to alleviate these problems and hence provide the most efficient service possible, the Department has formulated a new procedure for processing rope life files. Combined with certain recommendation that follow in this letter for attention by you at Colliery level, it is also envisaged that, over a period of time, sound statistical data relating to rope life history and performance levels will be accumulated.

This information may, in the future, be able to provide engineering support to those Mines who wish to leave ropes in service for periods in excess of five years. This new procedure will also apply for the recording of service histories of winding and haulage ropes as referred to in Clause 16 of the Shafts and Roadways - Underground Mines Regulation.

Notice A39 continues

The overlying point that must be realised is that correct references must be made to file numbers on ALL communications relating to a rope or set of ropes. The only communication where this will not be possible will be the initial notification from the Mine to the Inspectorate relating to the fitting of a new rope. The Department will inform the Mine of the new file number upon receipt of the Manager's notification.

A flow diagram is attached summarising the new procedure to be followed. By way of explanation the following points are made.

(1) Upon deciding to change a rope, identify the most worn and/or damaged sections and select three of these sections for sampling and non-destructive testing.

(A) : <u>FOR THE OLD ROPE(S)</u>

(2a) Remove the old rope(s) and cut out as selected suitable length samples to allow for a full report to be done on the strength and condition of each section. Identify each section for future reference detailing the defects existing within that sample at the time of removal, as observed by N.D.T. and visual examination.

(3a) Obtain tests reports referenced to your identification system and prepare a summary for submission to the Inspectorate and for your own files.

(4a) The Inspectorate will attach this information to the appropriate file then close this file and retain it for future reference.

(B) : <u>FOR THE NEW ROPE</u>

(2b) Upon fitting the new rope(s) notify the Inspectorate in accordance with Clauses 12(3) and 16(3) of the Shafts and Roadways - Underground Mines Regulation.

(3b) Arrange an initial N.D.T. to be carried out and forward the results to the Inspectorate.

(4b) The Inspectorate will initiate a new file for the new rope(s) and attach this notification to the file.
An acknowledgment of receipt of the notification will then be sent to the Mine detailing the new file number that must be used in any future correspondence relating to the new rope(s) during their period of usage.

With reference to requests for extensions of rope life, the following information must be supplied with the Manager's communication:

(i) File Number
(ii) Details of the rope(s) concerned, including dates of installation.

Notice A39 continues

(iii) Number of duty cycles and tonnage handled (where possible).
(iv) A copy of a N.D.T. report not more than 2 months old.
(v) Copies of recent Section 103 Inspections for ropes and winder apparatus; specifically the six most recent daily, weekly and monthly reports.
(vi) Any relevant additional- data, ie., re-anchoring dates, lubrication used.
(vii) The period of extension required.
(viii) The proposed date of the rope change-out.

To assist in these submissions it is suggested that each mine develop a standard proforma to tabulate the above requirements for any submissions to the Inspectorate.

In all cases it should be recognised that incomplete applications will be returned to the Mine for correction, leading to delays in the assessment of that particular application.

Your assistance in the introduction of this new procedure is greatly appreciated.

Should you require further assistance or clarification, please contact your local Inspector of Mechanical Engineering.

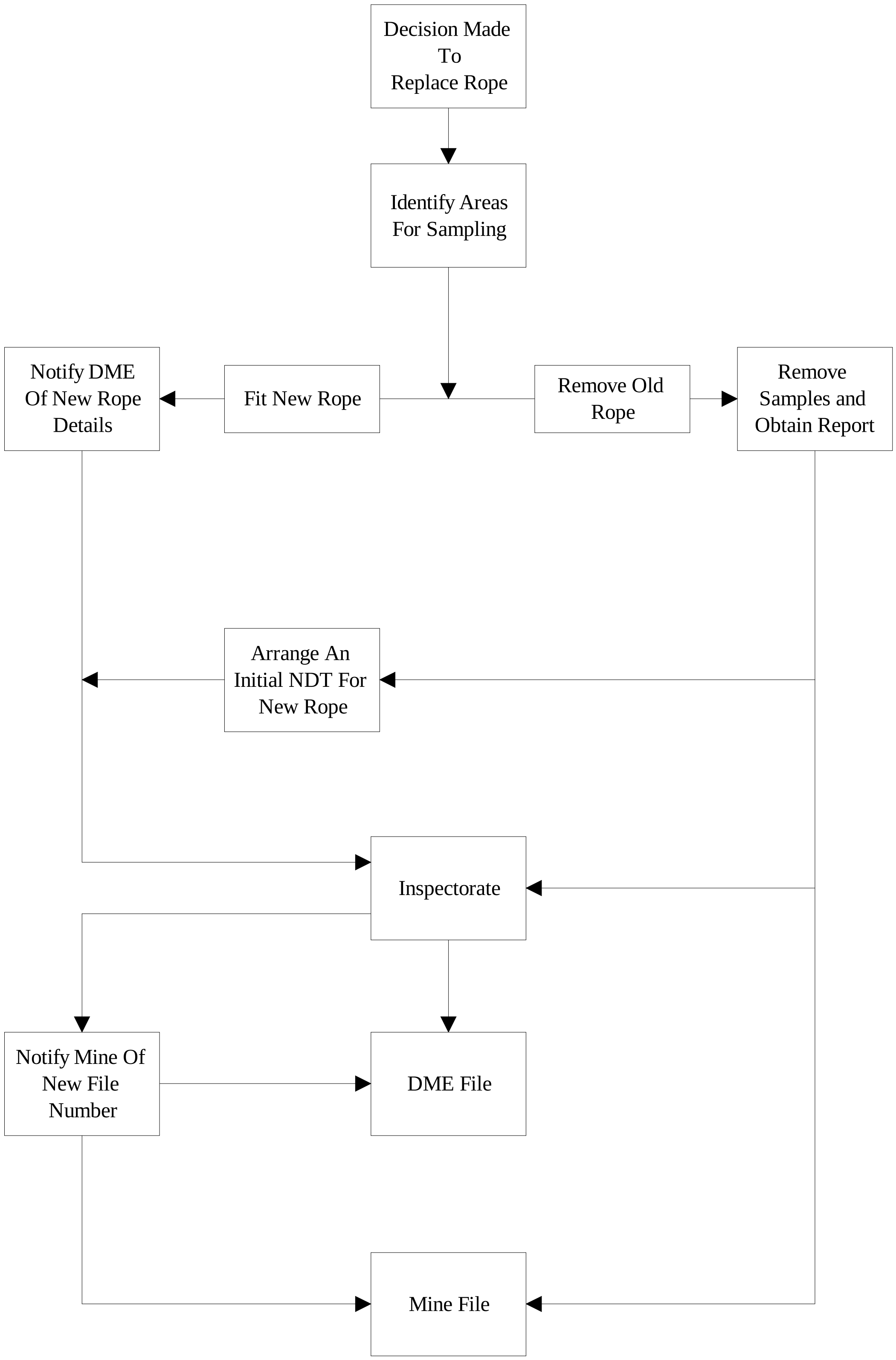
Yours faithfully,

J.G. Bailey
CHIEF INSPECTOR OF COAL MINES

APPENDIX 1 - flow diagram attached

Notice A39 continues

APPENDIX 1 - FLOW DIAGRAM



Notice A40

File No.: M79/4220
Date: 4 April, 1990

Dear Sir,

RE: AUSTRALIAN STANDARDS FOR SHAFT WINDING EQUIPMENT

Your attention is drawn to the publication of the following Australian Standards covering equipment used in association with vertical and slope haulage winders.

AS3637 - Underground Mining Suspension Equipment

Part 1 General Requirements
Part 2 Detaching Hooks
Part 3 Rope Cappings
Part 4 Draw bars and Couplings
Part 5 Rope Swivels and Swivel Hooks
Part 6 Shackles and chains

AS3751 - Underground Mining - Slope Haulage - Couplings, Drawbars and Safety chains.

* Denotes this standards is still only in draft form.

The above documents cover material and design aspects considered to be appropriate for this equipment and it would be anticipated that new or replacement equipment would be purchased in accordance with these standards unless a valid reason can be made to use alternative standards. The latter appear to be related primarily to replacement equipment.

Of importance to note is that the standards include "Recommendations for Inspection and Maintenance" which has been included to provide guidance in matters covering:-

(a) Inspection - frequency and type

(b) Permissible imperfections.

Notice A40 continues

It is requested that, where applicable, existing procedures for Inspection and Maintenance at the mine as nominated within the mines Section 103 Scheme for testing and examination of mechanical apparatus be reviewed in conjunction with the above referred recommendations. Should the review indicate that the 103 Scheme be amended, it is suggested that the matter be discussed with the local Inspector of Mechanical Engineering.

Yours faithfully,

J.G. Bailey
CHIEF INSPECTOR OF COAL MINES

Notice A66

File Reference No.: C92/0874
16th December, 1992

Attention: Mr. G.S. Miller - National Marketing Manager
Company: A. Noble & Son Ltd

Dear Sir,

RE: RESIN SOCKET CAPPING FOR WINDING ROPES.

In reference to your request, dated 3 December 1992, seeking approval/endorsement of resin capping of winder wire ropes as an alternative to the existing white metal system in use at coal mines, I can advise that the alternative system appears to be suitable for use. This determination has been based on information provided in your submission, the results achieved with the use of resin capping at the Londonderry Testing Station for the destructive testing of wire rope samples and the Inspectorate's field experience with this type of termination for guy/boom stay wire ropes.

It is to be understood that acceptance of the resin capping process is confined to polyester resin type material supplied under the "WIRELOCK" trade name, as accepted by British Coal Corporation. Its use shall be confined to the applications as nominated by British Coal "Notes Guidance for the Resin Capping of Wire Ropes". The procedures contained in the Notes of Guidance shall be utilised to determine the competence of persons appointed to make such cappings as required under Clause 21(2) of the Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation, 1984.

Please note that Clause 21 (6) of the above Regulation does not permit the use of non-metallic capping with ropes used in systems for transporting persons. In order to permit the use of "WIRELOCK" for this type of application it would be necessary for the mine to obtain an exemption from this Clause. This letter may be used as a basis to justify the granting of such an exemption.

Yours faithfully,

L.J. Roberts
Senior Inspector of Mechanical Engineering

Notice A72

File No.: C93/0246
Date: 29th November 1993

Dear Sir,

Re WINDER AND HAULAGE ROPE CAPPINGS

Subsequent to the Significant Incident Report No 93/5 issued in September 1993 relating to the systematic failure of a drum winder, it has been determined that the efficacy of winding rope attachments should be reviewed. This is of particular concern where the rope attachment is of the wedge cappel type design which was involved in the above referred incident. The type of lubricant used between the wedge and limb components was identified to be a critical element in the attachment's capacity.

The SIR included recommendations regarding the mechanical strength, friction factor and an indication that destructive testing should be considered for such components. Whilst these issues are undoubtedly currently being pursued it is appropriate that a formal program be adopted to at least establish that rope/attachment assemblies satisfy the requirements of a proof load test. Testing conducted on the assembly type involved in the incident resulted in non-conformance as slippage occurred at the proof load setting. Such proof load testing will not be detrimental to any componentry which would affect its future use providing that it satisfied the requirements of the standard. The scope of the test program specified herein is to cover all types of winding rope attachments used in shaft and drift haulage systems.

Consequently in order for the mine mechanical engineer to demonstrate compliance with the requirements of Clause 21 of the Coal Mines Regulation (Shafts and Roadways - Underground Mines)
Regulation, 1984, I require that the following criteria be met, where applicable, for each winding apparatus at the mine:

1. All winders and rope haulages which use a single rope capped with a split wedge type rope cappel for the transport of a conveyance shall have the rope/attachment assembly proof load tested by 1st April 1994.

2. All other winders including friction winders and rope haulages not included in the above shall have the rope/attachment assembly proof load tested by 30th June 1994.

   Note: Where multi-rope friction winders are in service it is only considered necessary to conduct the test on one (1) rope/attachment assembly.

Notice A72 continues

In order that the test program be conducted in an uniform manner the following matters shall be observed:

(a) For drum winders the proof loading shall be applied to the capped rope assembly as normally used on the winder. The assembly shall not be disassembled between removal from the winder and the proof load test. It is suggested that the test be conducted prior to the normal destructive rope testing as required by the regulation. Therefore additional rope should be removed when the rope with the assembled capping is removed to ensure that 2m of rope is available for the destructive test to be carried out after completion of the proof load test.

(b) For friction winders a spare capping and wire rope of the size and type used on the winder shall be assembled by the personnel who normally carry out this work at the mine. This assembly shall then be proof load tested.

(c) All proof load testing shall be conducted by an approved Testing Authority.

(d) Proof load testing of each assembly shall be to 2.5 times the safe working capacity of the capping in accordance with AS3637.1.

The rate of application of the load shall be identical with that used for destructive testing of ropes and the relevant Australian Standard for tensile load tests.

(e) Any movement of the rope relative to the capping shall be progressively measured and recorded as the load is increased. In addition other dimensions shall be measured and recorded in accordance with the capping manufacturer's procedure.

The type of lubricant used and the surface finish of mating components shall be also recorded where applicable.

(f) A dimensional check of the capping relative to the design drawing shall be conducted.

(g) A design check of the capping in relation to its application shall be conducted by a suitably experienced person.

(h) The mine mechanical engineer is to forward the results of each test to the inspector of mechanical engineering.

In addition to the above test program it is also intended to arrange for the ultimate testing of some rope/attachment assemblies. A decision on this matter will be finalised after completion of the proof load testing. However the option is available for ultimate load testing to be conducted in lieu of proof load testing. This should be discussed with the inspector of mechanical engineering.

Notice A72 continues

Whilst reference has been made to the requirements of the Coal Mines Regulation Act, the obligations of employers under Section .15 of the Occupational Health and Safety Act, 1983 to ensure the health, safety and welfare of their employees also need to be considered in determining a response to the above advice regarding ultimate load testing.

Information on detailed results of investigation and testing completed to date are available upon receipt of written request to Mr. W. Koppe at the above address.

Also please find enclosed Guide for Recording of Rope Capping Details prepared to assist the mine mechanical engineer to ensure that a quality records system is maintained for rope cappings.

Yours faithfully

L.J. Roberts
Senior Inspector of Mechanical Engineering
for Chief Inspector of Coal Mines

Notice A76

File No.: C93/0195
Date: 24th June, 1993

Dear Sir,

RE: SHAFT WINDING SYSTEM APPROVAL

The Coal Mines Regulation (Shafts and Roadways) Regulation, 1984 under Clause 7 requires that any mechanically operated winding or rope haulage apparatus used for transportation of personnel through any shaft or roadway be approved.

The attached Notice - "Specification of Requirement of Approval - Powered Winding System", which was gazetted on 18th June 1993, requires that a documented Risk Assessment be provided with any application for approval of a powered winding system or any variation to an existing approved system. This requirement specifically covers winding systems operating between the surface and underground and includes:

(a) shaft sinking projects, and

(b) winders whose prime function is the transportation of materials as personnel have to be transported to perform duties such as shaft inspections and accompany materials that are being transported.

The Notice is to be displayed on the mine notice board for a minimum of 30 days to permit its contents to be viewed by employees at the mine.

Yours faithfully,

L J Roberts
Senior Inspector of Mechanical Engineering for Chief Inspector of Coal Mines

Notice B3

File No.: Not Available
Date: 25th June, 1984

Dear Sir

NOTICE TO THE OWNER OF

Order under Section 174(5)
Coal Mines Regulation Act, 1982

In pursuance of Section 174(5) of the Coal Mines Regulation Act, 1982, No. 67, 1 hereby order that Clause 22(2) of the Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation 1984, which requires that chains referred to in subclause (1) of, the above clause "shall be manufactured from specified material" shall not apply until 30th June, 1985, subject to the following requirements:-

(1) All such chains shall be cleaned and examined at intervals not exceeding one year.

(2) Any cuts or nicks found during such examination shall be dressed out.

(3) When any chain link has its cross sectional area reduced from original dimensions, whether by wear or dressing, by more than 10% the chain shall be discarded.

(4) Where any chain link has suffered damage or is deformed the chain shall be discarded.

A copy of this exemption Shall be posted on the Colliery Notice Board for a period of at least 28 days.

Yours faithfully

M. J. MUIR
Chief Inspector of coal Mines

Notice D5

DEPARTMENT OF INDUSTRIAL RELATIONS

SYDNEY
COAL MINES REGULATION ACT 1982

File No.: M84/5010
Date: 26 June 1985

CHAINS FOR TRANSPORTING - PERSONS

In accordance with the requirements Of Clause 22 (2) of the Coal Mines Regulation (Shafts and Roadways - Underground Mines Regulation 1984, I hereby notify that the specification of material to be used for the manufacture of chains used in shafts and roadways for the transporting of persons shall be as follows:-

SCOPE

This specification covers the composition and heat treatment of steel to be used for the manufacture of chains, shackles, D-links and blocks where such equipment is to be used for the transporting of persons in a coal mine.

MATERIAL

The material hereby specified shall be in accordance with one of the following standards.

(1) Australian Standard A.S. M3 - 1951 (withdrawn). "1.5 per cent Manganese Steel".

(2) Australian Standard A.S. 1442-1983. "Carbon Steels and Carbon Manganese Steels". Grade XK 1315 F. Fine grained.

(3) Australian Standard A.S. 1442 - 1983. "Carbon Steels and Carbon Manganese Grade XK 1320 F. Fine grained.

(4) British Standard BS 2772: Part 2 - 1977. "Iron & Steel for Colliery Haulage and Winding Equipment". Grade 150 M 12.

Notice D5 continues

HEAT TREATMENT

Chains, shackles, D-links or blocks made from specified steel shall be heat treated either:-

(a) by normalising at a temperature from 880° C to 920° C by cooling followed in still air. Normalised items are to be re-normalised at intervals not exceeding three years.

(b) by hardening and tempering. Harden in water from a temperature of 870° C to 910° C and temper at a suitable temperature between 550° C and 650° C. Items which' have been hardened and tempered shall receive no further heat treatment during their service life which is not to exceed 15 years.

GENERAL

Other steels and/or treatments may be used subject to Individual approval by the Chief Inspector of Coal Mines.

J.G. Bailey
Acting Chief Inspector of Coal Mines

Notice D6

File Number: M82/2104
Date: 2nd February, 1988

Union Rubber & Engineering Pty Ltd.,
30-35 Sydney Street,
MARRICKVILLE 2204 10

ATTENTION: Mr. K. Weintritt

Dear Sir,

Re: FABREEKA SA47 Brake Pad Material

It has been brought to our attention that problem have been experienced with the bonding of the above material to the steel shoe plates used as part of the emergency dump brake systems fitted drift haulage mancars and self propelled rail mounted vehicles.

Accordingly it has been decided to accept your recommendation to only endorse the following organisations to carry out the bonding process.

(1) Union Rubber & Engineering Pty. Ltd., Marrickville.

(2) Hexham Engineering Pty. Ltd., Mayfield.

(3) Better Brakes Holdings Pty. Ltd., Smithfield.

(4) Toronto Brake Service Pty. Ltd., Toronto West.

(5) Central Brake Service (Newcastle) Pty. Ltd., Newcastle West.

It is understood that the bonding process shall be carried out in accordance with the attached specification.

It is requested that you advise the organisations above of this endorsement and that they provide certification in writing that all shoes supplied to coal mines after 1st March, 1988 are in compliance with the endorsement and the attached bonding specification.

Yours faithfully,

L.J. Roberts
Senior Inspector of Mechanical Engineering

Notice D6 continues

UNION RUBBER & ENGINEERING PTY. LTD

FABREEKA SA47 BRAKE PAD BONDING SPECIFICATION

The process of bonding Fabreeka brake pads to brake shoes is to be carried out strictly in accordance to the following specification. Supervision is to be responsible in maintaining that the job is carried out to the specification.

SURFACE PREPARATION

1. Brake shoe bonding surface to be dressed with rotary burr such that fresh parent metal is exposed.

2. Brush surface so that it is free of all waste metal.

3. Fabreeka SA47 brake pad to be buffed with a rotary burr. The grain of the Fabreeka is to be determined by buffing the material in different directions. Once the direction of the grain is established, the material will be buffed against the grain to obtain the roughest surface finish.

4. The Fabreeka is to be brushed clean of all residue.

MIXING

5. The adhesive to be used is REMA TIPTOP SC2000, Cement/hardener to be mixed.

6. Mix well cement SC2000 with 10% RF hardener. Mixture is to be used within 2hrs of mixing.

APPLICATION

8. Two coats of SC2000 plus hardener have to be applied to both metal and Fabreeka surfaces.

9. Allow first coat to dry for a minimum of 2 hrs.

10. Second coat is to dry only until it is slightly tacky to back of fingers (approx 10 minutes).

11. In the case of over drying, apply a third coat to both surfaces.

Notice D6 continues

ADHESION

12. Join surfaces and impact Fabreeka with a rubber.

13. Clamp joint such that pressure is applied evenly to the entire braking surface. Leave clamps on overnight.

14. Each end of the brake pad is to be clamped with a copper retaining strip and fastened with countersunk brass screws.

Notice D10

COAL MINES REGULATION ACT, 1982

Specification of Requirement of Approval
Powered Winding System

File No.: C93/0195
Date: 01 June 1993

It is hereby notified that the Chief Inspector of Coal Mines, pursuant to the provisions of Clause 6 (6) and (7) of the Coal Mines Regulation (Approval of Items) Regulation 1984 as amended specifies as being required to be approved generally any powered winding system or any modification or extension to any powered winding system and which is used to transport persons or materials between different levels from the surface to underground of an underground coal mine where any of the following criteria are met:

1) the powered winding system is composed of items or apparatus which fall within the scope of interpretations contained in Part-I Coal Mines Regulation (Shafts and Roadways) Regulation 1984 as amended

and

the powered winding system falls within the scope of interpretation of either the Coal Mines Regulation (Electrical - Underground Mines) Regulation 1984 as amended or the Coal Mines Regulation (Mechanical-Underground Mines) 1984 as amended.

2) the powered winding system is modified or extended to effect changes to the controls or ratings or means of protection from any hazard associated with the safe operation and the maintenance in safe working order of the powered winding system.

Approvals issued under this provision shall be based on a documented Risk Assessment which shall be provided by the applicant at the time of application for approval. The risk assessment is required to identify all of the hazards to health and safety which arise out of the operation of the powered winding system and to rank the assumed risk associated with each hazard after protective measures have been considered or adopted.

Any documented Risk Assessment which is provided in pursuance of approval under this provision may be the subject of an independent audit of the methodology used to assess the risks.

A A RECZEK
Senior Inspector
Electrical Engineering
For Chief Inspector
of Coal Mines

L J ROBERTS
Senior Inspector
Mechanical Engineering
For Chief Inspector
of Coal Mines

Notice F15

File No.: C89/1089
Date: 2 January 1990

The Manager
Bullivants Lifting Gear
P 0 Box 19
ALEXANDRIA

Dear Sir

Re: Approval for Non-Destructive Testing

It is hereby notified that the Chief Inspector of Coal Mines, for purposes of clause 16(1) (b), (c) and (d) of the "Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation, 1984" acknowledges "Bullivants Lifting Gear of O'Riordan Street, Alexandria" as an approved testing authority subject to the following conditions.

1 The laboratory shall be registered by NATA for the non-destructive testing of wire ropes and shall comply with the terms and conditions of that registration.

2 The type of equipment shall be limited to the following unless otherwise approved by the Chief Inspector:-

Rotescograph NDT machine model/Serial No. X6RX 8902 part No. RX 2C TAG 88.

3 The non-destructive testing of wire ropes shall comply with the requirements of the Coal Mines Regulation Act, 1982, as relevant for the equipment and its use.

4 A copy of this letter together with Laboratory Registration details and names of the authorised signatories shall be supplied to each coal mine where testing is performed.

Yours faithfully

L J Roberts,
Senior Inspector Mechanical Engineering
for Chief Inspector of Coal Mines

Notice F34

File No.: M84/5008
Date: 5, September, 1984

Department of Industrial Relations

Coal Mines Regulation Act, 1982

Notice Directing System Approval

It is hereby notified that the Chief Inspector of Coal Mine, as authorised by Clause 6(6) of the Coal Mines Regulations (Approval of Items) Regulation 1984 Requires that all slope drift rope haulage systems be approved.

M.J. MUIR
Chief Inspector of Coal Mines

Feedback Sheet

Your comments will be very helpful in reviewing and improving this Guideline for Design, Commissioning and Maintenance of Drum Winders (MDG 33).

Please copy and complete the Feedback Sheet and return it to:

Senior Inspector of Mechanical Engineering
Mine Safety Operations
NSW Department of Primary Industries
PO Box 344 Hunter Region Mail Centre NSW 2310
Fax: (02) 4931 6790
Phone: (02) 4931 6626
Email: mine.safety@dpi.nsw.gov.au

How did you use, or intend to use, this document?

What do you find most useful about this document?

What do you find least useful?

Do you have any suggested changes to the document?

Thank you for completing and returning this Feedback Sheet.