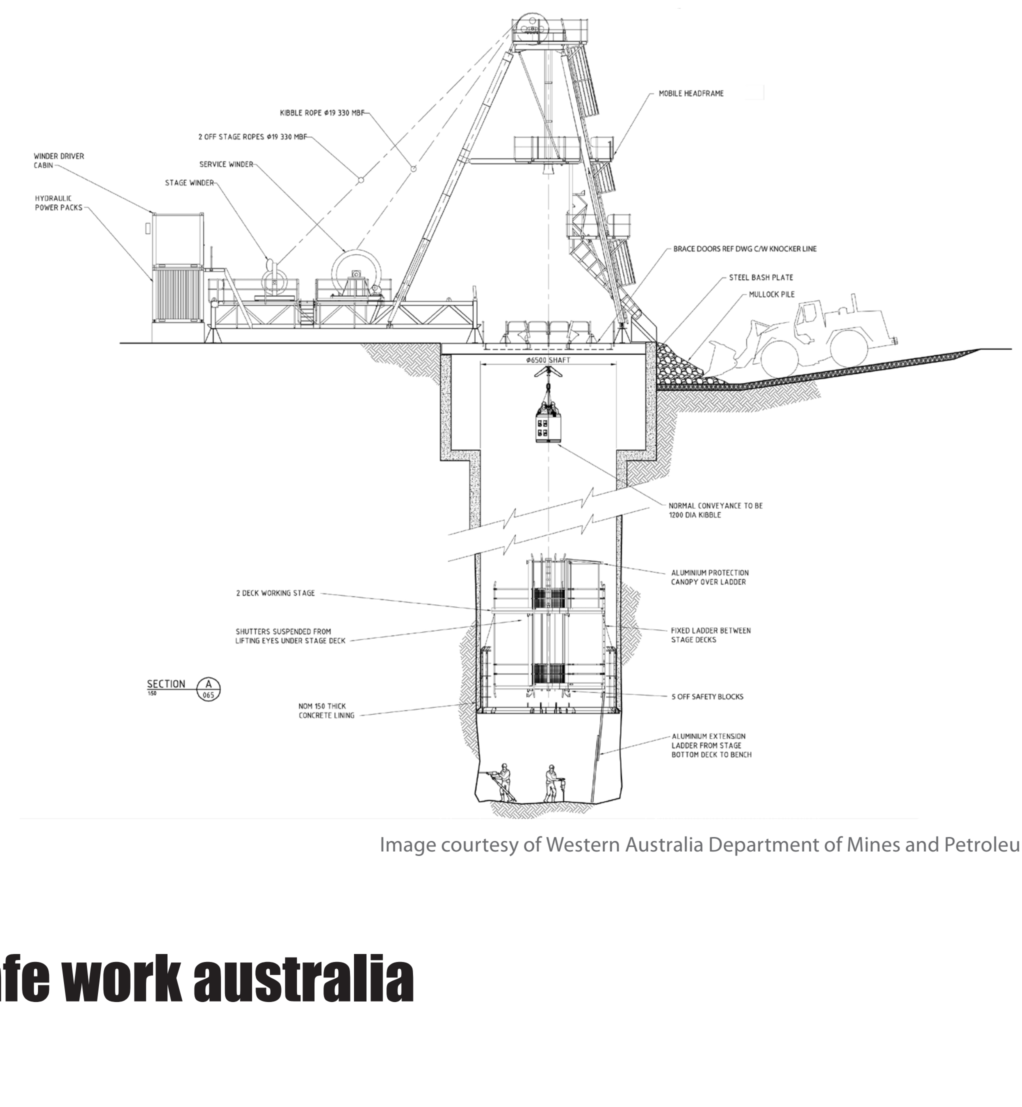
DRAFT

Code of Practice

UNDERGROUND WINDING SYSTEMS



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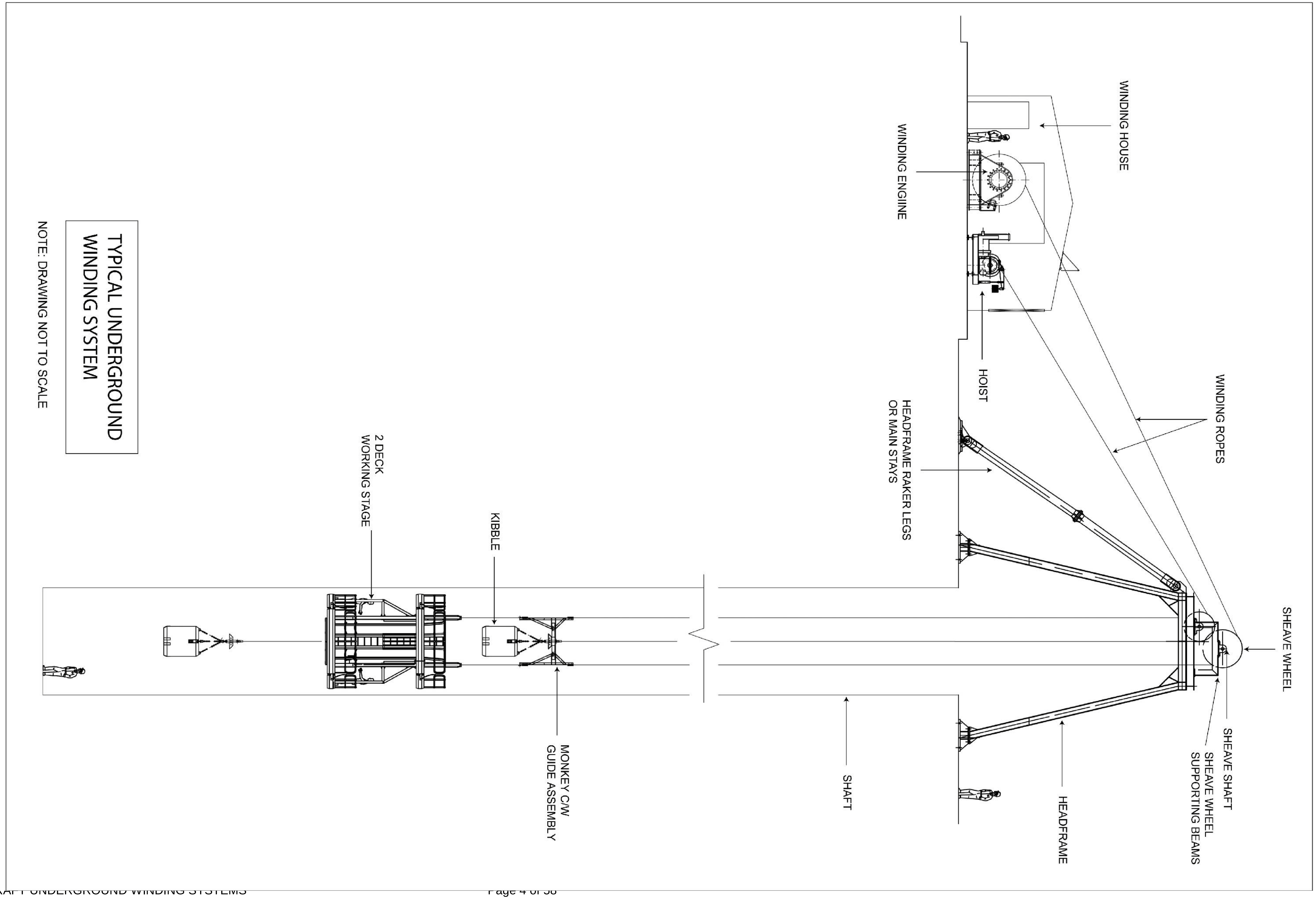
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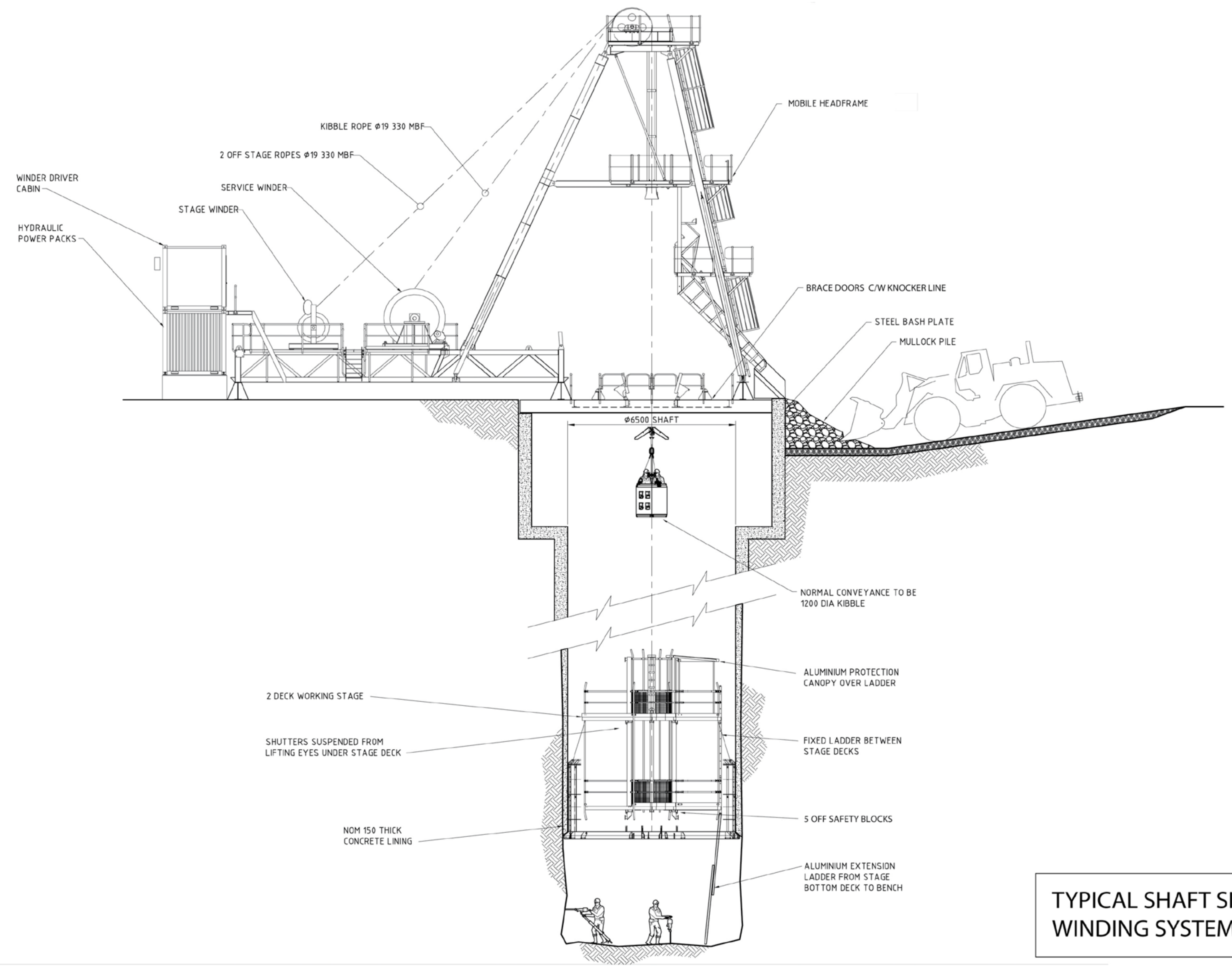


TYPICAL SHAFT SINK WINDING SYSTEM

NOTE: DRAWING NOT TO SCALE

FOREWORD

This Code of Practice (this Code) on underground winding systems is an approved code of practice under section 274 of the *Work Health and Safety Act* (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the Work Health and Safety Regulations (the WHS Regulations).

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and Regulations. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the WHS Act and Regulations may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice.

This Code has been developed by Safe Work Australia in conjunction with the National Mine Safety Framework Steering Group as a model code of practice under the Council of Australian Governments' *Inter-Governmental Agreement for Regulatory and Operational Reform in Occupational Health and Safety* for adoption by the Commonwealth, state and territory governments.

A draft of this Code was released for public consultation on *[to be completed]* and was endorsed by the Select Council on Workplace Relations on [*to be completed*].

SCOPE AND APPLICATION

This Code has been developed to provide designers and operators of underground winding systems, with information which details the critical elements that should be addressed in the design, commissioning tests and inspections, maintenance tests and inspections, and operation.

Design procedures for headframes, sheave wheels, sheave shafts, ropes, conveyances, attachments and foundations have been included, which provide reference to the relevant standards.

All components of underground winding systems, should be designed by a suitably qualified engineer, who has substantial experience with the design of such structures. The design calculations and drawings for underground winding systems, should be reviewed by an independent suitably qualified engineer. The review engineer should be from a different company to the design engineer, to avoid a potential conflict of interest. The review engineer should also have substantial experience with the design of such structures.

The design and review engineers, should provide design and independent review statements, certifying that the design of all components of the underground winding system, complies with this code of practice and all relevant Australian Standards. The statements should be signed, and details of the design and review engineer's qualifications should be provided. A copy of the design and independent review statements should be placed on file at the mine.

How to use this Code

In providing guidance, the word 'should' is used in this Code to indicate a recommended course of action, while 'may' is used to indicate an optional course of action.

This Code also includes various references to provisions of the WHS Act and Regulations to provide context with legal requirements. These references are not exhaustive.

The words 'must', 'requires' or 'mandatory' indicate that these legal requirements exist, which must be complied with.

1 DESIGN OF WINDING SYSTEMS

1.1 Headframes

All headframe structures and foundations should be designed In accordance with AS 3785.5 “Underground mining – Shaft equipment Part 5: Headframes”. Clause 2.2 (d) (i)(a)(1) requires the design load to be:

Design rope break load (Frb) = 1.2 x rope break load.

The rope break load is obtained from the rope manufacturer’s specification for the type of rope chosen. (For example, a 16mm diameter rope with a tensile grade of 2070 MPa and a non-rotating fibre core type of construction has a rope break load of 165 kN.)

The headframe structure including the columns, base plates and holding down bolts, should be designed in accordance with AS 3990 “Mechanical equipment – Steelwork”. The permissible stresses referred to in AS 3990 may be increased from working stress to yield stress, because the headframe analysis is based upon a factored rope break load.

Therefore the following permissible stresses may be used:

COMPRESSIVE STRESS	Fac	=	Fy
BENDING STRESS	Fb	=	Fy
SHEAR STRESS	Fv	=	0.57 Fy

(where Fy = yield stress of steel)

The maximum slenderness ratio of the columns and compression members should not exceed 180 as described in AS 3990 Clause 4.6.

The concrete and reinforcement details for all foundations should be designed in accordance with AS 3600 “Concrete Structures” for all load cases. Stability and deflection of the headframe must be checked.

1.2 Sheave wheels and sheave shafts

Sheave wheels

All sheave wheels should be designed in accordance with AS 3785.7 “Underground Mining – Shaft equipment Part 7: Sheaves”.

Design load conditions

- **Static design** - Sheave wheels should be designed for a static design load, using the design rope break load plus the sheave wheel self weight. In addition to these loads, the effects of the fleet angle forces should be considered, particularly induced bending stresses in the sheave wheel spokes. The combined axial and bending stresses of each component should not exceed 0.9 times the yield stress of the steel.

- **Fatigue design** - Components are also to be checked for a fatigue design load, using the maximum working static dead and live loads and a safety factor of 1.3.

- **Rim surface stress** - The surface stress between the rope and the rim groove should be checked, using the conveyance payload plus the self weight of the conveyance, rope and attachments.

- **Material specifications** - Sheave wheels are generally cast from mild carbon steels, typically with a yield stress of 250 MPa, and are not required to be manganese steel. However, consideration should be given to impact properties at the lowest expected ambient temperature.

- **Critical construction elements**
  - The pitch circle diameter of the sheave wheel, should not be less than:
    - *80 times the rope diameter, for normal stranded ropes on winders.*
    - *28 times the rope diameter, for a hoist (as specified in AS 1418.1 "Cranes – Part 1 General requirements").*
    - *100 times the rope diameter, for locked-coil ropes on winders.*
  - The depth of the rope groove in the sheave wheel rim, should not be less than twice the rope diameter.
  - The sheave wheel rim internal radius, should be between 0.53 and 0.55 times the rope diameter (as specified in AS 3785.7).

Sheave shafts

All sheave shafts should be designed in accordance with AS 3785.7 and AS 1403 "Design of rotating steel shafts."

Design load conditions

- **Static design** - Sheave shafts should be designed for a static design load, using the design rope break load, plus the sheave wheel and the sheave shaft self weight. The bending stress and shear stress should not exceed 0.9 times the yield stress of the steel.

- **Fatigue design** - Sheave shafts should be designed for a fatigue design load, using the maximum working static dead and live loads. Rotating sheave shafts should be designed in accordance with AS 1403, using a safety factor (Fs) of 1.3. Non-rotating sheave shafts should be designed in accordance with the following equation from AS 3785.7, (using the appropriate values from AS 1403).

$$D^3 = \frac{5000\ KsK}{Fu.\ Fr}(1.3\ Fu + Fr)\left(Mq + \frac{Pq\ D}{8000}\right)$$

Material specifications

- **Australian standards -** AS 3785.7 Clause 4, requires that sheave shafts be manufactured from steel complying with the relevant Australian Standards, and the physical properties (eg tensile and impact strength) should be verified by test. Also the steel should be selected with due regard to impact properties at the lowest expected ambient temperature. AS 1403 requires that the steel used should have an ultimate tensile strength of approximately 900 MPa. The Standard also requires the steel to have an elongation of not less than 5 percent, on a gauge length of 5.65 $\sqrt{So}$ when tested to AS 1391 (where So = original cross sectional area).

- **Typical steel grade for sheave shafts -** The typical steel grade used for sheave shafts, is X9931 (formerly known as EN25). This steel has been hardened and tempered in accordance with AS 1444, to obtain an ultimate tensile strength of 850MPa, and to provide the appropriate impact properties.

- **Steel grade selection -** Steel grade X9931 contains approximately 1.5% manganese. However it is not mandatory that the steel used for sheave shafts be a manganese type of steel. For example, other chemical elements such as chromium may provide the necessary impact properties. The steel grade chosen should be hardened and tempered in accordance with the relevant Australian Standard, to provide the appropriate tensile strength and impact properties.

- **Charpy v-notch impact valves -** AS 2772: Part 2 "Iron and steel for colliery haulage and winding equipment Part 2. Wrought steel "(British Standard), may be used as a guide in selecting the appropriate impact properties (Charpy V-notch impact values at testing temperature).

- **Stress raising characteristics** - AS 1403 requires that the manufacture of sheave shafts should achieve a smooth finish of lightly stressed portions, particularly at stress concentrations (for example, at changes of shaft diameter). Radii at steps in diameter and at the bottom of keyways should be as large as practicable.

1.3 Factors of safety for winding ropes

- **Calculation of winding rope factor of safety** - The winding rope factor of safety should be calculated as follows:

$$\text{ROPE FACTOR OF SAFETY} = \frac{\text{ROPE BREAK LOAD}}{\text{MAXIMUM ACTUAL LOAD}}$$

- **Maximum actual load** - The MAXIMUM ACTUAL LOAD is the maximum static load at the sheave. This load includes the conveyance tare load, the payload, the maximum self weight of the rope and the self weight of all attachments. The maximum actual load is calculated for when the conveyance is at the lowest operating level of the shaft.

- **Rope break load** - The ROPE BREAK LOAD is obtained from the rope manufacturer's specification for the type of rope chosen. For example, a 16mm diameter rope with a tensile grade of 2070 MPa and a non-rotating fibre core type of construction, has a rope break force of 165kN.

- **Minimum factors of safety for winding ropes** - The minimum factors of safety for winding ropes are as follows.

DRUM WINDING OPERATIONS

Proposed Use	Minimum Factor of Safety
Transporting persons, or where the safety of persons is involved	7.5 - 0.001L
Transporting rock or materials, where the safety of persons is not involved	5.5 – 0.0003L
Transporting rock in a shaft used exclusively for that purpose	4.5
Transporting a machine or part of a machine at a speed of less than 2 metres per second	5
For ropes raising and lowering a sinking stage	6

(Where L is the depth of wind in metres)

1.4 Conveyances and monkeys

All conveyances, including stages, kibbles, skips and cages, should be designed in accordance with AS 3785.4 "Underground mining – Shaft equipment Part 4: Conveyances for vertical shafts".

Design load conditions

- **Dead loads** - The dead loads should consider the total self weight of the conveyance structure, including any attached sheave wheels and sheave shafts.

- **Live loads** - The live loads should consider normal rated loads, suspended loads, chairing loads and infrequent concentrated floor live loads.

Main load-bearing components

- **General** - AS 3785.4 applies load factors of safety for the design of the main load-bearing components. These components generally include the transom beams, the sheave wheel support beams, the columns and the main connections.

- **Load factors of safety** - The load factors of safety are applied to various load case combinations, for either AS 3990 or AS 4100 (the Steel Structures Codes), depending upon whether the working stress design method or the limit state design method is used.

  Example: Using the working stress design method to AS 3990, for a dead load and normal live load combination, the following load factor of safety would apply:

$$\mathbf{A} = \mathbf{6.6} \times \frac{\mathbf{Fy}}{\mathbf{Fu}}$$

  Where Fy = Yield stress of steel used. Fu = Ultimate stress of steel used.

  For a mild steel (Fy = 250 MPa and Fu = 410 MPa.) $\therefore$ **A = 4.024**

  Factor A would then be applied to each main load-bearing steel member and connection. For a steel beam under bending stress, this would therefore equate to an overall factor of safety (SF), on the working load compared to the ultimate stress, of:

$$\begin{aligned} \mathbf{SF} &= \mathbf{4.024} \times \frac{\mathbf{1}}{\mathbf{0.66}} \times \frac{\mathbf{410}}{\mathbf{250}} \\ &= \mathbf{10.0} \end{aligned}$$

  That is, AS 3785.4 would apply a factor of safety of 10.0, to the design of the main load bearing beam (working load compared to the ultimate stress)

Other load bearing components

All other load-bearing components, are designed for the most adverse of the combination dead and live load cases, *without the application of the load safety factor.* Examples of these components would be the floor beams and floor plates of a stage or a cage.

Critical construction elements

AS 3785.4 requires other detailed design and dimensional issues for conveyances to be addressed. These include (but not limited to) the following critical issues:

- **Conveyances for people**
  - The minimum clear height above the floor to be 2.0 metres.
  - The roof shall be designed for a uniformly distributed load of 7.0kpa. The roof shall be made of a minimum of 5mm thick steel plate, grade 250 steel (mild steel).

- The floor space shall be at least 0.2 square metres per person.

- **Conveyances for ore**
  - Kibbles used for the transport of people, should be provided with at least a 3 chain suspension system.
  - Steps to be provided inside and outside of the kibble for personnel access.

<u>Monkeys and conveyance roofs - overhead protection</u>
Each person working or travelling in or on a conveyance in a shaft, should have overhead protection from falls of rock or material down the shaft.

A conveyance roof, or a monkey, should be designed for a distributed load, equivalent to a surface pressure of 7 kPa, and having a strength at least equivalent to a 5mm thick steel plate.

<u>Monkeys and conveyances - guide assemblies</u>
To ensure the stability of the conveyance under load conditions, all conveyances should be provided with sufficient guide wheel or slipper assemblies, on the top or the bottom, or both. The following exceptions apply:

- Kibbles, where the shaft depth is 50m or less, and
- Shaft sinking stages

The vertical distance between guide assemblies should be proportioned to minimise the probability of the conveyance jamming in the guides. This distance should not be less than the horizontal distance between these assemblies. (The “aspect ratio” of vertical distance to the horizontal distance, should be greater than, or equal to 1.0, as specified in AS 3785.4). Guide assemblies may be sliding or rolling types.

<u>Cage safety, appliances and testing</u>
(1) Each cage and skip in which persons are transported, should be fitted with a suitable appliance to prevent its sudden fall down the shaft, in the event of rope or winding system failure.
(2) A new or rebuilt cage, should not be used in a shaft, until it is provided with safety appliances required by this part (1).
(3) Safety appliances required by part (1), should be tested by a drop test each 2 weeks.
(4) A cage used or intended to be used for transporting heavy equipment, should be fitted with suitable chairing devices, for the purpose of loading and unloading heavy equipment.
(5) Each cage or skip in which personnel are transported, that is not fitted with such safety appliances, should be fitted with a slack rope detection device in proper working order, that:
  (a) is designed to give notice by visual or audible signal to the driver of the winding engine, when a slack rope situation occurs, and
  (b) will initiate emergency brake action application to the winding engine.

1.5 Components of attachments

All components of attachments, between the winding ropes and the conveyances, should be designed in accordance with AS 3637 “Underground mining - Winding suspension equipment”. Such components of attachments, include drawbars, rope sockets, chains, links, shackles, pins, and detaching hooks.

Material specifications

Components of attachments, should be manufactured from "Type A component steel" (as referred to in AS 3637). Type A component steel is commonly referred to as "manganese steel", because it generally comprises approximately 1.5% manganese in its chemical composition.

Chemical composition

AS 3637 requires that the cast chemical analysis of Type A component steel complies with the following:

CHEMICAL COMPOSITION FOR A TYPE A COMPONENT STEEL

Element	Chemical composition (cast analysis), percent	
	Min	Max
Carbon	0.10	0.23
Silicon	0.10	0.55
Manganese	1.20	1.70
Sulphur	-	0.04
Phosphorus	-	0.04

Residual elements. Percentages of elements up to the following amounts shall be considered as incidental:

a) Copper ……………………………..0.35 percent maximum
b) Nickel ………………………………0.35 percent maximum
c) Chromium …………………………..0.35 percent maximum
d) Molybdenum ………………………..0.35 percent maximum

Mechanical properties

AS 3637 requires that the mechanical properties of Type A component steel, complies with the following:

MECHANICAL PROPERTIES FOR TYPE A COMPONENT STEEL

Property	Minimum Value		
	Limited ruling section, mm		
	≤100	>100 ≤150	>150
Yield strength	320 MPa	300 MPa	280 MPa
Tensile strength	500 MPa	460MPa	430 MPa
Elongation on 5.65√So	24%	23%	22%
Charpy V-notch value (longitudinal) at – 10^{o}C	80 J	60 J	55 J

Heat treatment

AS 3637 requires that the heat treatment of Type A component steel, be carried out within the following temperature ranges:

- Harden in oil or water at a temperature between 870^{o} and 910^{o}c.
- Temper at a temperature between 500^{o} and 660^{o}c.

Load static factor of safety

All components of attachments should be designed for a load static factor of safety of 10.0. This factor of safety is referred to in AS 3637.1 "Underground Mining – Winding suspension equipment. Part 1: General requirements"

Chains and shackles

Where chains and shackles are used for kibbles, cages and stages, and a safety chain is not used, the components of attachments should be designed for a combined load static factor of safety of 20.0. These components of attachments, include the chain links, master links, intermediate links, joining links, and shackles.

Rope detaching appliances

Provision should be made in each drum winding installation, other than a hoist installation, for a suitable appliance to detach the rope from the conveyance (including skips, cages and kibbles), in the event of an overwind, and to prevent the conveyance, once detached, from falling down the shaft.

The distance between the detaching device on the headframe, and the matching portion on the conveyance, should be at least 3 metres, when the conveyance is in its highest normal operating position.

Specific design requirements

- All components of attachments, should not include any screwed suspension member, which would be subject to axial tension forces.
- All components of attachments, should not have any <u>main</u> component that has been welded.
- All components of attachments, should not include any open hook arrangement.

Protective coating on type a component steels

Any protective coating which could affect the heat treatment of any components of attachments, including hot-dipped galvanising, should NOT be used.

Generally, components of attachments with type A component steel, may be protected by paint or inorganic coatings, provided the coating does NOT restrict the movement of the components or inhibit the effectiveness of non-destructive testing.

Hammerlocks

There have been some occasions in the past, where hammerlocks have been used with chain and shackle arrangements for kibbles, cages and stages. With these chain and shackle arrangements, the hammerlocks were used to connect the chains to the shackles.

Hammerlocks should NOT to be used with winding system attachments, under any circumstances. Hammerlocks do NOT comply with AS 3637 - they are not manufactured from Type A component steel (manganese steel).

The pins which are driven into position, can possibly fall out due to wear between the pins and the body of the hammerlock. Also the pins are a high carbon grade steel (not manganese steel) with poor impact properties, and therefore are susceptible to embrittlement by strain age hardening, and hence failure can occur.

Links manufactured from type A component steel, should be used with chain and shackle arrangements, instead of hammerlocks.

1.6 Winding engines and hoists

A winding engine is any machinery used to raise or lower, (by means of a rope or ropes), conveyances in a shaft or winze for the transport of persons, material, or rock. However this does not include any lifting machine, endless rope haulage or scraper winch installation.

A hoist is a single undivided drum winding engine, driven by a motor or engine having a capacity not exceeding 25 kilowatts.

Suitability of a winding engine

A winding engine must be suitable for the purpose for which it is used. It must have effective and suitable:

- Brakes
- Except in the case of lift apparatus, brake locking devices and brake interlocking devices
- Means of controlling power to the winding engine
- Means of preventing an overwind
- Means of preventing a conveyance or counterweight travelling at an excessive speed
- Means of safely stopping and holding a conveyance or counterweight in the event of an overwind, and
- Means of monitoring the movement of every conveyance in the shaft.

Design and construction of a winding engine

A winding engine should be designed and constructed to include:

- Each winding engine should:
    - o be firmly anchored to secure foundation.
    - o be separately housed except at a shaft sinking or where two winding engines serve the same shaft.
    - o have local manual controls independently located in such a manner, that a person operating one winding engine is not distracted by movement or signals associated with the other engine.
    - o avoid the use of single line components wherever practicable. Where their use is unavoidable they should be designed so as to avoid danger: for example they may be designed to fail safe.

- Controls: where more than one means of control are provided, interlocking should ensure that the winding engine will only respond to the controls which have been selected. This requirement does not apply to the stop switch or the emergency stop facility.

- Facilities to enable routine maintenance***:*** facilities should be incorporated into the winding apparatus, to enable routine maintenance and tests to be carried out safely and effectively.

Drum diameters of winding engines and hoists

The diameter of a drum, should not be less than:

- 80 times the rope diameter, for normal stranded ropes on winding engines.
- 28 times the rope diameter, for a hoist (as specified in AS 1418.1).
- 100 times the rope diameter, for locked-coil ropes on winding engines.

Flanges on drums of winding engines

- On the drum of each winding engine, (used for raising or lowering persons) horns, flanges, or other appliances should be designed to prevent the rope from slipping off the drum.

- If horns or flanges are provided on a drum of a winding engine, the horns or flanges should project not less than 2 rope diameters or 100 millimetres, (whichever is the greater) beyond the outermost rope layer on the drum.

Winding engine - power required
A winding engine should be capable of raising the maximum design unbalanced load from the bottom of the shaft or winze.

Power cut off
The source of power to a winding engine should not cut off unless it is safe to do so.

Indicators and gauges

- A winding engine should be fitted with a gauge or other suitable instrument, in proper working order, which will indicate to the winding engine driver whether or not power is available to the engine.
- A winding engine, other than a hoist, should be provided with a depth and speed indicator, driven from the driving sheave or drum shafting.
- A winding engine should not be used for winding, while a depth or speed indicator is disconnected.
- A winding engine should be fitted with an ammeter that is maintained in proper working order, and clearly indicates to the driver the level of electric current being drawn by the electric motor driving the winding engine.

Stop switch
All winding engines should be fitted with a stop switch, for the purpose of stopping the engine and applying the brakes. This stop switch should be placed within easy reach of the driver.

Speed control
Each winding engine should be provided with an effective automatic device, (that is constantly engaged and built into the winding engine) that prevents overwinding and over-speeding. This automatic device should be constructed -

- To prevent the shaft conveyance from exceeding a speed 10% greater than the approved maximum designed speed,
- To control the speed of the shaft conveyance in any part of the shaft to predetermined limits, and
- To prevent the shaft conveyance from exceeding a speed of 2 metres per second when being landed at the lowest entrance to, or at the bottom of the shaft.

Safety circuits
Safety circuits should not be dependent upon single line component functions essential to safety. Safety circuits should also be protected against electric shock.

Hoist controls
All hoists installations should be fitted with a power control appliance, (which returns the power application to neutral and applies the braking system) when manual pressure is removed.

Acceleration control

- The driver of a winding engine should ensure that a cage or skip in which any person is travelling, is not accelerated or decelerated by the winding engine, at a rate greater than 1.5 metres per second per second. In the case of an emergency, deceleration should be not less than 2 metres per second per second, and not more than 5 metres per second per second.

- With an automatic winding engine, the automatic controls should not allow the winding engine to exceed the acceleration and deceleration rates prescribed in (a) above.

Push button controls

- When a winding engine is being used to carry any person, and it is being operated by push button control, the winding engine should be stationary, (unless all shaft doors and the cage doors in connection with that engine are properly closed).
- Provision may be made to open shaft doors, when a winding engine is being used to carry materials, if the conveyance is within 10 metres of a landing and the engine is subject to inching control only.
- If a winding engine has push button control from within the cage, a device should be provided which, when operated, will cause the engine to stop.
- All persons who operate a winding engine with push button controls, should be fully instructed in the safe operating procedures for the engine, and any emergency procedures that have been devised to cope with accidents involving, or malfunctions of, the system.

Prevention of overwind

Devices should be provided in the shaft headframe, or tower, that remove the power from the winding engine and, by automatic application of the brakes, bring the winding drum or driving sheave to rest, before any shaft conveyance, counterweight or rope attachment reaches any permanent obstruction to its passage.

Backing out devices

Any device provided on a winding engine to permit backing out from an overwound position, should respond to manual control only, and permit withdrawal from the overwind position only.

Winding engine fire precautions

- In each winding engine room, suitable and sufficient apparatus should be provided and maintained to extinguish any fire which may break out.
- If a winding engine is situated in a headframe or tower of a shaft-
  - suitable and sufficient apparatus should be provided to automatically extinguish any fire which may break out, and
  - effective precautions are taken, to prevent any flammable liquid used in connection with the winding engine or any apparatus installed in the headframe or tower, from entering the shaft.
- The manager of a mine should ensure that each winding engine room, is kept clean and free from any unnecessary combustible material.

Drum winding in single gear

- If a winding engine is provided with 2 drums, except in an emergency, a person should not be raised or lowered in a shaft conveyance connected with the engine, while one of the drums is out of gear and loose on the drum shafting on which it operates.
- If a double drum winding engine has one drum out of gear, that drum should be prevented from revolving whilst out of gear.

Drum brakes for winding engines

Each drum of each double drum winding engine should be provided with one or more brakes. The drum of each single drum winding engine other than a hoist should be provided with 2 or more brakes. Each brake –

- however applied, acts directly on the winder drum,
- is designed, adjusted and maintained, so as to stop safely and hold the cage or skip under all conditions of loading, direction of travel and speed,
- can be applied manually by the winding engine-driver, irrespective of the action of any safety device that may act to apply the brake or brakes,
- is automatically applied when the supply of power to the winder fails, or when the pressure of any fluid or other medium used as a means of controlling the brakes, falls below a predetermined level,
- is automatically applied, if an earth fault occurs in the electrical control circuit of push button controlled winding engines,
- when applied to that drum, is capable of supporting a load equivalent of 2 times the maximum static load normally hoisted by that drum, from the lowest operating position in the shaft, and
- so far as is practicable, is provided with a steel tension member between individual sole plates of brake shoes.

The braking system of each drum winding engine, should be designed in such a way that the failure of any one component in that system, will not prevent the winding engine from being brought safely to rest.

Push button and automatically controlled drum winders, should also be provided with a suitable device, which will automatically apply the brake before it becomes worn sufficiently to affect its safe operation.
Each part of each braking system of a drum winder, should have a minimum factor of safety of not less than 10. Screwed members in tension, (the failure of which would render the brake inoperative) should have a minimum factor of safety not less than 15.

The performance of winding engine mechanical brakes, should be adequate for both service and emergency duties and meet the following requirements:

- *Drum winding apparatus with two conveyances* or a conveyance and counterweight – the brakes should be capable of holding the drum stationary, when the loads are balanced and the normal maximum torque is applied in either direction by the winding engine,
- *Drum winding apparatus with one conveyance* - the brakes should be capable of holding the drum stationary, when the fully loaded
- conveyance is halfway down the shaft, and the normal maximum downwards torque is applied by the engine,
- *Clutched drum winding apparatus* – when the drum(s) are clutched, the brakes should be capable of holding the drum(s) stationary, when the loads are balanced and the normal maximum torque is applied in either direction by the winding engine. In the declutched condition, the brakes should be capable of exerting a suitable braking torque. If manwinding is to take place with a drum declutched other than in an emergency, the driven drum should be used for manwinding, and should be provided with two brakes or one disc with two independent braking calliper units which, when the other drum is declutched, are capable of exerting a braking torque not less than that defined in (b) above for a drum winder with one conveyance.

Brake system pumps should be prevented from starting, when the brake lever is not in the fully applied position, except in the case of the automatic operation of pumps in an accumulator system. Where brakes are operated by hydrostatic power, fluid thermal and level protection systems should be fitted. Where liquid controllers are operated by a hydraulic servo unit, this unit should be fitted with fluid thermal protection. The protective devices should:

- Give an alarm to the person controlling the winding engine, when a predetermined limit above normal operating temperatures is exceeded,
- In the case of unattended winding apparatus after completion of the wind, prevent further winding and stop the hydraulic pumps if a predetermined unsafe limit is attained.

In drum winding systems, to minimise the risk for injury to persons when the brake is applied following an emergency trip, excessive retardation of the conveyance should be avoided. To achieve this the maximum retardation of the drum should not exceed $5m/s^2$, be not less than $2m/s^2$ and should preferably be less than $3.5m/s^2$.

Steps should be taken to prevent contamination of brake paths or linings, eg by moisture or oil, since this may lead to serious reduction of braking torque. These steps should include the adequate heating of winding engine houses. Where this is impractical, local heating to prevent condensation on braking surfaces should be considered. Monitoring devices should be provided to give warning of conditions likely to lead to condensation problems.

<u>Electrical braking</u>
Electrical braking should be provided for all electrical winding apparatus where it is practicable to do so. However some existing backshaft winding apparatus used for manwinding, may not include such facilities in view of their low speed and infrequent use. Where electrical braking is provided, the facility to apply it either automatically or by the winding engineman, should remain available at all times after the initiation of an emergency trip, or until the mechanical brakes have been proved to be on (eg by pressure/limit switches) and preferable substantially effective.

Push button winding apparatus and new winding apparatus used for man winding, should have electrical braking designed so that in the event of an emergency trip, it is retained and applied automatically to compensate for any loss in the effectiveness of the mechanical brakes, and to ensure that the winder is brought safely to rest at predetermined retardation.

The simultaneous application of electrical and mechanical brakes, should where practicable avoid retardations likely to cause injury, or in the case of friction winding apparatus, cause slip.

Power retained for electrical braking on d.c. winding apparatus is also available for driving. Consequently the design of the control system should prevent the application of driving torque following an emergency trip.

<u>Brake locking</u>
All winding apparatus should be provided with an effective means of locking the mechanical brakes in position when they are fully engaged. This device should be set to operate automatically, and should be designed to operate in the event of the loss of power.

The brake locking device should comprise:
- a locking mechanism on the control linkage of the mechanical brake, which is engaged when that brake is full applied and prevents release of the brake, or
- a valve, which when operated, exhausts fluid supply pressure and, when the brake is fully applied, prevents its release.

At each manwinding level, there should be automatic indicators clearly visible to persons transmitting signals there from, which show that the brakes are fully engaged and locked in that position. This does not apply at underground levels during shaft sinking.

Each winding level should be provided with a brake lock actuating device, which enables persons working on a conveyance or counterweight to ensure that it cannot be moved inadvertently. This does not apply to lift apparatus, or at underground levels during shaft sinking.

During normal manwinding, the brake locking device should be interlocked with the shaftside equipment, to prevent the winding apparatus from being set in motion if:

- any shaftside barrier or gate is not fully closed,
- any platforms or shaftside equipment protrude into the path of a conveyance, or
- any emergency stop button has not been reset after an emergency signal.

Drum brakes for hoists

All hoists should be provided with at least one brake system that -

- acts directly on the hoist drum,
- is designed, adjusted and maintained to stop safely, and hold the shaft conveyance under all conditions of loading, direction of travel and speed,
- is capable of being manually applied by the hoist driver, irrespective of any safety device that may act to apply the brake,
- will be automatically applied when -
  - o the supply of power to the hoist fails, or
  - o the pressure of any fluid or other medium used as a means of controlling the brake, falls below a predetermined level,
- has a brake holding capacity, capable of supporting a load not less than, 1.5 times the maximum static load normally hoisted from the lowest operating position in the shaft,
- has parts that have a factor of safety of not less than 10, with screwed members in tension having a factor of safety of not less than 15, and
- if it is the only brake on the hoist, has no welding on single line components, if the failure of the weld would render the brake inoperative.

1.7 Shaft guides

This requirement does not apply to a shaft during shaft sinking.

In each vertical shaft over 50 metres in depth, in which persons or materials are transported by machinery other than hand winches, guides should be provided to within 20 metres from the bottom of the shaft, and efficient means and appliances for steadying the load should be provided and used.

2 COMMISSIONING TESTS AND INSPECTIONS

When a winding system is first installed it should be properly commissioned to ensure that it complies with all the requirements necessary for its safe operation. A number of specialists may be used for this work on different parts of the system. The work should be supervised by competent persons appointed by the owner. Such persons need not be part of the mine organisation, but they should be competent to assess the overall safety of the system to which each part contributes. A full report of the commissioning procedures and the results of any tests and examinations carried out, should be made and signed by the appointed persons. A copy of the report should be kept at the mine and be readily available for reference, so that any subsequent tests can be compared with the performance at the time of commissioning.

If any modifications are subsequently made which are likely to affect the safety of the system, or the way in which it is operated, they should be thoroughly tested to ensure that the winding system fully meets the requirements necessary for its safe operation. A modification to one part of the system, may affect other aspects of its performance and it may be necessary to retest the system, not just that part which has been modified. The manager should appoint a competent person to supervise any test and examinations necessary, and make a full written report to confirm that the winding system is safe for further use. This report should be kept with the commissioning report. Any changes made to the winding system, which would be likely to affect its operation, should be notified to the winding engine driver and any other person appointed to supervise or control its safe operation.

2.1 Headframes and foundations

The headframe structural steelwork, including steel members, bolts and welds, should be inspected by the design engineer or the design review engineer. This inspection should be carried out after the headframe structure has been erected at the mine, and
prior to commissioning. The inspection should check for compliance of the structure against the design drawings, AS 3990, AS 1554 “Structural Steel Welding Code”,

AS 1511 “High-strength Structural Bolting Code”, and AS 1657 “Fixed platforms, walkways, stairways and ladders- Design, construction and installation”. The headframe and winding engine or hoist foundations should be inspected for structural integrity and compliance with AS 3600 “Concrete structures”.

A report should be compiled and signed by the inspection engineer, listing the structural components inspected, and the documents of compliance.

2.2 Sheave wheels and sheave shafts

The manufacture, testing and inspection of sheave wheels and sheave shafts, should be in accordance with AS 3785.7.

Physical properties
The grade of steel used for sheave wheels and sheave shafts, should be tested for their physical properties. Generally sheave wheels are cast and machined from mild carbon steel, and sheave shafts are cast and machined from X9931, a manganese steel. Test samples for the grades of steel for sheave wheels and sheave shafts, should be subject to destructive tensile tests and Charpy V-Notch impact tests (at the lowest expected ambient temperature). These tests should be in accordance with the relevant Australian Standards. Test results for

tensile strength and Charpy V-Notch values, should be certified as complying with the chosen design physical properties, refer page 8 to 10.

Mechanical properties

Sheave wheels and sheave shafts should be subject to magnetic particle examination (MPE), and either radiographic or ultrasonic examination after final machining, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity. These tests should be in accordance with AS 1065 “Non-destructive testing – Ultrasonic testing of carbon and low alloy steel forgings”, AS 1171 “Methods for magnetic testing of ferromagnetic products and components”, AS 2574 “Non-destructive testing – Ultrasonic testing of steel castings and classification of quality”, and AS 3507 “Non-destructive testing – Radiography of steel castings and classification of quality”. All welds should be non-destructively tested in accordance with AS 1554.

For example, a defect in a sheave shaft, such as an undetected hydrogen inclusion, could lead to a catastrophic shear failure of the sheave shaft. To ensure that sheave shafts are free of such defects, all sheave shafts should be cast and machined longer than required, to enable through testing. Following the rough machining process, the sheave shaft should be subject to either radiographic or ultrasonic examination. Following the final machining stage, the process of radiographic or ultrasonic examination should be repeated, together with MPE. The sheave shaft should be certified as being free of defects, which could affect the mechanical properties and hence the structural integrity.

2.3 Winding ropes

Rope manufacturer’s specification

Before any winding rope is placed in service, a true copy of the maker’s certificate giving full details of the construction of the rope, the class of steel used, and the breaking force of the rope, should be placed on file at the mine. Each rope should comply with the design drawings.

Rope break test

If the maker’s certificate supplied is not authentic, or does not apply to the particular rope in question, a certificate may be obtained by means of a test of the breaking force.

Any test of the breaking force of a rope, should carried out on a sample cut off the end of the rope.

Previously used ropes

Before a rope which has previously been in service, may be used for any other winding purpose, a complete history of the rope and the details of its proposed use, should be placed on file at the mine. Each rope should comply with the design drawings.

Rope splicing

A person should not use splicing for any rope attachment.
Ropes which have been spliced should not be used for hoisting in a shaft or winze.

Rope capping

The method used for capping a winding rope, should be of a proven design that provides a minimum factor of safety of 7, when applied to the maximum static load on the capped end of the rope.

A winding rope which is capped, to secure the rope to a shaft conveyance or counterweight by means of a capel or socket, should not be used at any time unless that capping has been made within the period of 6 months immediately preceding its use.

A rope which has been recapped, should not be used on any winding engine unless on the last occasion on which it was recapped, the capping was moved a distance of not less than 150 millimetres along the rope towards the standing end of the rope.

2.4 Conveyances

The manufacture, testing and inspection of conveyances, should be in accordance with AS 3785.4.

Weighing

The completed conveyance should be weighed. The measured weight should be within 5% of the assumed weight used in the design calculations, for the conveyance and the rope factors of safety.

Main load-bearing components

Main load-bearing components, including all bolts, should be visually examined to ensure compliance with the drawings, and all materials should be 100% examined ultrasonically, in accordance with AS 1710 “Non-destructive testing of carbon and low alloy steel plate – Test methods and quality classification”, or AS 3670 “Non-destructive testing-Ultrasonic testing of universal beams and columns”, as applicable , to ensure that the materials are free of defects which could significantly affect their mechanical properties.

All welded joints should be examined non-destructively in accordance with AS 1554. The types of non-destructive tests should be specified by the design engineer.

Proof load tests

- **Cages and stages** - Every cage and stage after manufacture, should be subjected to a proof load test, by supporting the complete assembly from the attachment connection points, and loading the floor of the assembly with a test load equal to twice the conveyance rating, for 30 minutes.

- **Skips** - Every skip after manufacture, should be subjected to a proof load test, by supporting the complete assembly from the attachment connection points, and loading the floor of the assembly with a test load equal to 1.5 times the conveyance rating, for 30 minutes.

- **Results** - There should be no permanent deformation of any main load-bearing component after removal of the test load, Any deflection under load should be measured. The deflection of the transom beam of the conveyances, should be measured and checked against the design calculations. Test certificates detailing deflections should be placed on file at the mine.

2.5 Components of attachments

The manufacture, testing and inspection of attachments, should be in accordance with AS 3637.

Chemical composition

The method of sampling for chemical analysis, should be in accordance with AS 1213 “Iron and steel - Methods of Sampling”. Chemical composition should be determined by procedures which are in accordance with AS 1050 “Methods for the analysis of iron and steel”, or AS K1 “Methods for the sampling and analysis of iron and steel”, as appropriate.

A chemical analysis of the steel from each ladle, should be made to determine the proportions of specified elements. In cases where it is impracticable to obtain samples form liquid steel, analysis of test samples should be taken in accordance with AS 1213.

The cast analysis of the steel should conform to the limits detailed on page 21.

Mechanical properties

- Heat treatment - Heat treatment should be carried out within the following temperature ranges:
    - o Harden in oil or water at a temperature between 870°C and 910°C.
    - o Temper at a temperature between 500°C and 660°C.

- Destructive tensile tests and charpy v-notch impact tests - One tensile test piece and three Charpy V-Notch impact test pieces, from each heat or cast batch, should be subject to tensile and impact tests, to check material compliance with the minimum requirements for mechanical properties specified on page 13.

Proof load tests

Each component of attachment, and each assembly of attachments, should be held between connectors of the correct size, and a tensile force equivalent to 2.5 times the safe working load applied.

No component should have suffered any permanent deformation, which could adversely affect the function or mechanical properties of the component or assembly.

Non-destructive tests

Non-destructive testing should be carried out, to ensure that each Type A component is free from defects, which could significantly affect the mechanical properties of the component.

Each component should be examined for surface discontinuities, by magnetic particle examination in accordance with AS 1171. The limits for permissible imperfections are specified in AS 3637.5 “Underground mining – Winding suspension equipment Part 5: Rope swivels and swivel hooks”, and AS 3637.6 “Part 6: shackles and chains”.

2.6 Shackles and chains

- **Chain links** - Notwithstanding the prohibition on welding specified on page 14, butt welding may be permitted in the manufacture of chain links. The welding process should be selected to produce a chain that complies with the requirements of AS 3637.6

- **Shackle bodies** - Shackle bodies should be made from solid stock devoid of welding. In forging, upsetting should not be permitted, and the rounded section should be drawn from oversize stock of sufficient size, to allow the eye portion to be formed without upsetting.

- **Proof load tests** - Each new shackle and chain should be subjected to the proof load test specified on page 23. Separate links of chains are not required to be proof loaded. Care should be taken to ensure that the chains are placed in the testing machine without twist, and that the end connections correctly apply the proof load.

- **Master links** - Each new master link of a conveyance chain, should be subjected to the proof load test specified on page 23, except that the proof load should be 2.5 times the conveyance chain rating.

- **Shackle connections** - In the case of shackles, the connections to the shackle, should be such that the proof load should be applied to the crown of the shackle bow or 'dee', and to the centre of the shackle pin, in an appropriate manner.

- **Length of chains** - The maximum variation in length between any pair of chains, in a new conveyance chain, should not exceed 4mm. The discard provisions on length variation, between any pair of chains in a used conveyance chain, as given In AS 3637.1, should apply.

2.7 Winding engines and hoists

Drum shafts

- Physical properties - The grade of steel used for drum shafts, should be tested for their physical properties. Generally, drum shafts are cast and machined from X9931, a manganese steel. Test samples for the grades of steel for drum shafts, should be subject to destructive tensile tests and Charpy V-notch impact tests (at the lowest expected ambient temperature). These tests should be in accordance with the relevant Australian Standards. Test results for tensile strength and charpy V-notch values, should be certified as complying with the chosen design physical properties.

- Mechanical properties - Drum shafts should be subject to magnetic particle examination (MPE), and either radiographic or ultrasonic examination after final machining, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity. These tests should be in accordance with AS 1065,
  AS 1171, AS 2574, and AS 3507.

  For example, a defect in a drum shaft, such as an undetected hydrogen inclusion, could lead to a catastrophic shear failure of the drum shaft. To ensure that drum shafts are free of such defects, all drum shafts should be cast and machined longer than required, to enable thorough testing. Following the rough machining process, the drum shaft should be subject to either radiographic or ultrasonic examination.

  Following the final machining stage, the process of radiographic or ultrasonic examination should be repeated, together with MPE. The drum shaft should be certified as being free of defects, which could affect the mechanical properties and hence the structural integrity.

Drum brakes

- Non-destructive tests - All brake components of each brake on a winding engine or a hoist, should be examined for surface discontinuities by magnetic particle examination, in accordance with AS 1171. Each brake component should be certified as being free of surface cracks, which could affect the structural integrity of the brake component, and lead to failure of the braking system.

- Brake holding capacity tests - Each brake on a winding engine or a hoist, should be applied for a period of 30 minutes, with a test load of 2 times the maximum static load normally hoisted for a winding engine (1.5 times for a hoist), from the lowest operating position in the shaft. The drum should be marked prior to the test, to determine if the drum rotates during the test. Each brake should be certified for the specified brake holding capacity. The test load for the brake holding capacity test, should not exceed the load based upon the winding rope minimum factor of safety, refer page 10.

- Brake efficiency tests - Each brake on a winding engine or a hoist, should be applied with an empty conveyance at the lowest operating level in the shaft, and an attempt made to drive the conveyance in a downward direction, by applying torque to the winding engine or hoist drum.

- Brake release tests - The brakes on a winding engine or hoist, should be released, with an empty conveyance at the lowest operating level in the shaft. The drum should be marked prior to the test, to determine if the drum rotates during the test. This test measures the frictional resistance of the winding engine or hoist to motion.

Previously used winding engines and hoists

Where a winding engine or hoist, has been previously used on another shaft, the drum shaft and each brake component, should be examined for surface discontinuities by magnetic particle examination, in accordance with AS 1171. Each drum shaft and brake component, should be certified as being free of surface cracks, which could affect the structural integrity of the drum shaft or braking system.

Performance tests of winding engines and hoists.

Performance tests should be carried out, for a winding engine or hoist, which certify that it is capable of performing each design requirement listed on page 16 to 20, and within the limitations that apply in relation to its working.

3 MAINTENANCE TESTS AND INSPECTIONS

Schedules should be prepared, detailing the inspections, examinations, tests or maintenance and their frequency, in relation to individual winding system components, and ensure that they are kept up to date. Special provision should be made for any necessary testing of winding system components, before they are brought back into service after a period out of use.

A formal system should be developed and maintained, to ensure that the inspection, examinations, tests and maintenance, are safety carried out on each winding system component, as specified in this section.

Any person carrying out tests, maintenance, inspections or examinations should, before leaving the mine, make a written report of the work carried out, any defects found and remedial action take. Where a defect is found which is likely to affect safe working, remedial action should be taken before winding recommences.

3.1 Headframes

The headframe structural steelwork, including steel members, bolts and welds, should be inspected, at least yearly, for scoring, scuffing, pitting and corrosion. All bolts should be inspected to ensure that they are tightly fitted.

The critical structural components of the headframe, should be subject to magnetic particle examination, at least yearly, to ensure there are no surface discontinuities which could affect their structural integrity. These tests should be in accordance with AS 1171. These critical structural components, should include the sheave wheel supporting beams, the main stays or raker legs, and their connection plates, bolts, pins and welds. All welds should be examined non-destructively in accordance with AS 1554. Each critical structural component, should be certified as being free of surface cracks, which could affect the structural integrity of the headframe.

3.2 Sheave wheels and sheave shafts

The sheave wheels, sheave shafts and bearing assembly, should be inspected, at least weekly, for scoring, scuffing, pitting and corrosion. Bearing bolts should be inspected to ensure they are tightly fitted.

The sheave wheels, sheave shafts and bearing assembly, should be subject to magnetic particle examination, at least yearly, to ensure there are no surface discontinuities, which could affect their structural integrity. These tests should be in accordance with AS 1171. All welds should be examined non-destructively in accordance with AS 1554. Each sheave wheel, sheave shaft and bearing assembly, should be certified as being free of surface cracks, which could affect the structure integrity of the head sheave assembly.

Sheave wheels and sheave shafts should be subject to either radiographic or ultrasonic examination, at lease every 10 years, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity. These tests should be in accordance with AS 1065, AS 1171, AS 2574, and AS 3507.

3.3 Winding ropes

Winding rope log book

Each mine at which a winding rope is used, should provide at the mine a winding rope log book, in which the information referred to in this section should be recorded.

A record of the history of each winding rope used in the mine, should be entered in the winding rope log book.

The record of the history of a rope entered in the winding rope log book, should include –

- the certificate number of that rope,
- the name of the shaft or winze in which the rope is used,
- the compartment of the shaft in which the rope is used,
- the date on which the rope was put on,
- the dates on which the rope was shortened,
- the dates on which the rope was re-capped,
- the dates of destructive and of non-destructive rope testing,
- the result of destructive or non-destructive rope testing,
- the date when the rope was taken off and the reason, and
- the dates of the examination, cleaning, and oiling of the rope.

A person who makes an entry in the winding rope log book, should sign that entry as soon as practicable after making the entry.

Winding rope and guide rope inspections

A competent person should carefully examine –

- at least daily, the winding rope or ropes whilst they are travelling at a speed not exceeding one metre per second,
- at least weekly, the guide ropes and the balance ropes while they are travelling at a speed not exceeding one metre per second.

If any serious weakness or defect in a rope or winding appliance is discovered, as a result of an examination –

- the person who discovers the weakness or defect, should immediately report the weakness or defect to the manager of the mine, or to the manager's representative, and
- a person should not be lowered or raised by the rope or appliance until the weakness or defect is remedied.
- *Detection of broken wires in any drum winding rope, in use, must be closely monitored to ensure that the rope does not become unsafe due to rapid deterioration.*

The results of all inspections, together with action taken to remedy any weaknesses or defects found, should be recorded in the winding rope log book.

Winding rope destructive tests and maintenance

Tests

Each rope used on a drum winding engine should,

- be recapped at intervals of not more than 6 months,
- have 2 metres cut from the shaft conveyance or counterweight end, and sent to a testing station for destructive tensile testing, at intervals of not more than 6 months, and

- have at the end of the first year after it has been installed, a sufficient length cut from the shaft conveyance or counterweight end, to enable a breaking and elongation test to be made of 2 metres of the rope, which has repeatedly passed over the head sheave, at a testing station.

<u>Maintenance</u>
If there are 2 or more layers on the drum, a rope used on a drum winding engine, should be cropped at yearly intervals, at the drum end, in a manner that will ensure that, the position of the crossover points of the rope on the drum are changed.
Winding rope non-destructive tests
The structure of the drum winding rope should be examined at intervals of not more than 6 months, over its entire working length, by a non-destructive method for the purpose of determining any deterioration. The condition of the rope as ascertained from that examination, should be recorded in the winding rope log book.

<u>Test reports</u>
A test report should be made of any destructive or non-destructive test carried out on a winding rope.

Winding rope discard criteria
A rope used in a mine hoisting or haulage installation, should be immediately withdrawn from use if -

- a physical inspection by a competent person shows that the rope appears to be unsafe for the use to which it is subjected,
- the breaking force of the rope by tensile test is less than 90% of the breaking force of that rope when new, or
- a non-destructive examination of the rope by a competent person using non-destructive testing equipment, shows that continued use of the rope, is not consistent with safe operation of the hoisting or haulage installation.
- <u>*The number of broken wires, excluding filler wires, in any section of a rope equal to one lay length, exceeds 5% of the total number of wires in the rope, excluding filler wires.*</u>

Winding rope maintenance
<u>*Any broken wires found during visual inspection (on the outer strands of the rope) must be "tucked" inwards to prevent further damage to the rope.*</u>

Winding ropes should be lubricated with a suitable lubricating compound, at intervals of not more than one month. A rope used in a shaft or winze should be cleaned and oiled or dressed in a manner that minimizes wear and corrosion.

3.4 Guide ropes and rubbing ropes

Inspections
At suitable intervals depending on the conditions in which they are used, guide and rubbing ropes and their fittings should be examined. At positions most liable to deterioration, the ropes should be cleaned at regular intervals, their surfaces inspected for corrosion and uneven wear, the diameter measured, and a check made for any fractures of the wires.

Maintenance
Guide and rubbing rope may deteriorate due to fatigue at the headgear termination. At suitable intervals, depending on the conditions in which they are used, the terminations should be remade, and the ropes lifted by an amount not less than 1.5 times the length of the termination. Guide and rubbing ropes should be discarded when the outer wires have lost

more than one third of their depth. The effect of uneven wear may be reduced by regular turning of the rope. When ropes are lifted they should be rotated by a quarter turn. If this is carried out at five yearly intervals, surface wear will be evened out over a 20 year lifespan.

3.5 Conveyances

Inspections

All conveyance components, and in particular, the main load-bearing components, should be inspected, at least daily, for scoring, scuffing, pitting and corrosion. All bolts should be inspected to ensure they are tightly fitted.

Non-destructive tests

The main load-bearing components, should be subject to magnetic particle examination, at least yearly, to ensure there are no surface discontinuities, which could affect their structural integrity, These tests should be in accordance with AS 1171. All welds should be examined non-destructively in accordance with AS 1554. Each main load-bearing component, should be certified as being free of surface cracks, which could affect the structural integrity of the conveyance.

The main load-bearing components should be subject to either radiographic or ultrasonic examinations, at least every 10 years, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity. These tests should be in accordance with AS 1065, AS 1171, AS 2574, and AS 3507.

Tests after repairs

A cage, skip or other shaft conveyance, should not be used for raising or lowering persons, until it has made at least one complete trip up and down the working portion of the shaft, following -

- any stoppage for repairs which may affect the safe running of the winding engine,
- any repairs to the shaft or shaft conveyance or counterweight,
- any stoppage in shaft hoisting exceeding 4 hours duration, or
- the occurrence of any seismic event.

3.6 Components of attachments

Inspections

The components of attachments, should be inspected , at least daily , for scoring, scuffing, pitting and corrosion. Bolts, pins and shackles, should be inspected to ensure they are tightly fitted.

At least half yearly, each detaching hook should be examined by dismantling, cleaning, gauging for deformation, checking for corrosion and other imperfections, and testing with crack detection equipment.

At least yearly, chains, chain links, shackles, pins and pin holes should be measured for wear.

Non - destructive tests

The components of attachments, should be subject to magnetic particle examination, at least yearly, to ensure there are no surface discontinuities, which could affect their structural integrity. These tests should be in accordance with AS 1171. All welds should be examined non-destructively in accordance with AS 1554. Each component of attachment, should be certified as being free or surface cracks, which could affect the structural integrity of the attachments.

The components of attachments, should be subject to either radiographic or ultrasonic examination, at least every 10 years, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity. These tests should be in accordance with AS 1065, AS 1171, AS 2574 and AS 3507.

Discard criteria for attachments
Any item of attachment between the winding ropes, balance ropes, and the cage, skip, kibble or counterweight, should be discarded on the completion of a period of 12 years in service.

Records for attachments
A record should be kept of all shaft conveyance attachments used in a mine, and the record should include -

- the name of the shaft or winze in which the attachment is used,
- the the location of that attachment on the conveyance, in the case of multi-rope attachments,
- the compartment of the shaft in which the attachment is used,
- the identification number of the attachment,
- the date on which the attachment was installed in service,
- the dates of the examinations, cleaning and oiling of each attachment required by these regulations,
- the date and result of each testing of each attachment, and
- the date of the removal of the attachment from service.

3.7 Winding engines and hoists

Inspections
The drum shaft and brake components, should be inspected, at least daily, for scoring, scuffing, pitting and corrosion. All bolts should be inspected to ensure they are tightly fitted.

Non-destructive tests
The drum shaft and each brake component, should be subject to magnetic particle examination, at least yearly, to ensure there are no surface discontinuities, which could affect their structural integrity. These tests should be in accordance with AS 1171. All welds should be examined non-destructively in accordance with AS 1554.

Each drum shaft and brake component, should be certified as being free of surface cracks, which could affect the structural integrity of the winding engine or hoist.

The drum shaft and each brake component, should be subject to either radiographic or ultrasonic examination, at least every 10 years, to ensure there are no defects which could affect the mechanical properties and hence the structural integrity, These tests should be in accordance with AS 1065, AS 1171, AS 2574 and AS 3507.

Brake tests
A Brake holding capacity test, refer page 26, should be carried out at least daily.

A brake efficiency test and a brake release test, refer page 26, should be carried out at least weekly.

Performance tests of winding engines and hoists.
Performance tests, refer p43, should be carried out at least weekly .

Testing of automatic contrivances

Arrangements should be made for regular testing of automatic contrivances to ensure that they are effective. At least weekly, the device provided to prevent an overwind, should be tested by raising each conveyance and counterweight, to pass above the point at which the device comes into operation to stop the winding apparatus at the top of the shaft.

At suitable intervals, tests should be carried out by attempting to land the descending conveyance at an excessive speed. These tests should be carried out at least half yearly, for electrically driven winding systems fitted with a supervisory device in addition to an automatic contrivance. Other installations should be tested 3 monthly. Tests to confirm the correct operation of the supervisory device, should be carried out as part of the series of tests on the automatic contrivance.

During the automatic contrivance tests, a person competent for the purpose, should record the distance travelled by the conveyance or counterweight past the landing at which the device or control system respectively operates, comes into operation at the top of the shaft.

Safety audit

All winding engine maintenance, should be verified by persons competent for the purpose, independent of the regular maintenance staff, (ie undertake a safety audit) at intervals not exceeding three years, to check that specified maintenance procedures are being properly carried out and recorded. The persons carrying out the audit should be independent of persons involved in maintenance, and should report their finds to the engineers responsible for electrical and mechanical engineering at the mine.

4 OPERATION OF WINDING SYSTEMS

4.1 Winding engine log book

The manager of a mine should keep in each winding engine room, a winding engine log book in which the following information should be recorded.

4.2 Winding engine – shift records

- The winding engine driver in charge of each shift, should record in the winding engine log book -
  - any peculiarities in the running of the engine,
  - any defects in any of the engines or winding system components under the driver's charge which the driver considers warrants repair or correction, and
  - any accident or incident that occurs in relation to the winding system.
- If -
  - 2 or more drivers are employed on the same winding engine in rotation of shifts, and
  - any defect in the working of the machinery is recorded in the winding engine log book,
  - the driver or drivers who follow the driver, who made the original entry, should make an entry in the book, confirming or otherwise commenting on the original entry.
- Each winding engine log book in the mine, and any entry in such a book, should be checked daily by the manager or by a person authorised in writing for that purpose by the manager. In respect of any entry, the manager or person authorised by the manager, should record in the log book in a suitable manner any repair or correction that has been effected.
- A person who makes an entry in a winding engine log book (whether a driver, the manager or another person) should properly sign and date the entry.

4.3 Winding engine to be available

If the usual means of exit from the underground workings of a mine is by winding Engine, the manager of the mine should ensure that while any person is underground, or at any other time when the engine is required to be used -

- the engine is kept ready for use, and
- unless push button automatically controlled winding is provided, a winding engine driver remains in control or effectively supervises the winding engine.

4.4 Testing of hoist drivers

- A person should not operate a hoist at a mine, and the manager of a mine should not permit a person to operate a hoist at the mine, unless —
  - the manager is satisfied that the person is competent to operate that hoist, and
  - the manager or a competent person has tested the person, and is satisfied that the person knows all relevant hoisting signals and procedures.
- The manager of a mine may determine that a person who operates a hoist at the mine, is no longer competent to operate that hoist.
- If the manager makes such a determination
  - the manager should notify the person accordingly, and
  - the person should not operate a hoist at the mine after the person receives that notification.
- A record should be made in the record book of -

  - the name of each person who is competent to operate a hoist,
  - the date on which the manager determined that the person was competent to operate a hoist,
  - the date on which the person was tested, and the name and signature of the person who carried out the test, and
  - if the manager makes a determination referred to in item (2) above
    - the date on which the determination was made,
    - the reasons for the determination, and
    - the date on which the operator was notified by the manager of the determination.

4.5 Winding engine drivers to have medical examinations

- This section does not apply to —
  - a person who is exempted from holding a winding engine driver's certificate, or
  - the operator of a hoist.
- Each person in charge of a winding engine at a mine, should attend before a medical practitioner for a medical examination -
  - before the person first takes charge of the winding engine,
  - either —
    - in the case of a person who has attained 65 years of age, before the expiration of 6 months from the day on which the person last had a medical examination, or
    - in any other case, before the expiration of 12 months from the day on which the person last had a medical examination, and
    - at such other times as the medical practitioner may require.
- A person who receives a medical examination, should forward to the manager of the mine, within 7 days after receiving that examination, a copy of the medical certificate.
- The medical certificate should state that the person is not suffering from deafness, defective vision, epilepsy, disease of the heart, diabetes or other infirmity to such an extent as would, or would be likely to, render the person unfit for his or her duties or liable to become suddenly incapable of controlling his or her engine.
- A person should not operate a winding engine, if a medical practitioner has certified that the person is not in a fit state of health to operate such an engine.
- An employer at a mine should not knowingly employ a person who does not have an appropriate medical certificate referred to above.

4.6 Winding engine drivers not to work for more than 8 hours

The manager of a mine should ensure that a person in charge of a manually operated winding engine, does not work for more than 8 hours in any 24 hour period.
In the event of an emergency, a person in charge of a manually operated winding engine may work for more than 8 hours, but not more than 12 hours in any 24 hour period.

> An ***"emergency"*** means any serious breakdown of plant, machinery or mine workings, or any other circumstance that could not have been reasonably foreseen, and that causes a hazard or danger to the health or safety of the personnel employed in or about a mine, or which could seriously affect the safety or security of the mine.
>
> The ***"hours"*** specified, include meal times but do not include time occupied in starting or closing down the machinery.

4.7 Operation of a winding engine

A person operating a winding engine at a mine, should ensure that the brake is fully applied, while any person is getting on or off the conveyance.

4.8 Persons or material not to be lowered by the brake

- A person should not lower a person, or any material in a winding conveyance, by means of the brake alone.
- A person should not enter or remain, or permit another person to enter or remain, in any cage, skip or kibble that is held or suspended by the brake alone, when the clutch of the winder drum is not engaged.

4.9 Driver not to be spoken to while on duty

A person should not speak to, or otherwise distract the driver of a winding engine, while the driver's machine is in motion, except –

- for the purpose of stopping the engine in an emergency, or
- if for any other reason it is necessary to do so for the safe operation of the engine.

4.10 Cage to be supported when repairs are being carried out

The manager of a mine should ensure that at all times, when repairs are being effected to the clutches or brakes of a winding engine, and if ropes are attached to the drums, any affected skip, cage or counterweight is removed or firmly supported while the work is in progress.

4.11 Signalling system

- The manager of a mine should ensure that each working shaft, in which a cage or skip is used, and each division of the shaft in which persons are raised or lowered, is provided with some proper means of communicating distinct and definite signals –
  - a) from the bottom working level of the shaft, from each entrance for the time being worked between the surface and the bottom working level, and from the surface brace to the winding engine room, and
  - b) from the winding engine room to the surface brace, and to the bottom working level of the shaft, and to each entrance for the time being worked, between the surface and the bottom working level of the shaft.
- The manager of a mine should ensure that-
  - a) competent persons are appointed to be platmen, bracemen or skipmen, responsible for communicating signals to the winding engine driver, and
  - b) except for signalling the accident signal, other persons do not communicate signals to the winding engine driver.
- Nothing in this section, prevents employees other than platmen, bracemen and skipmen, from communicating signals on a separate interplat signal system installed for that purpose.

Code of signals

The following signals comprise the Code of Signals –

Knocks or Rings	What is Signified
1	Stop — Signal to be returned by driver when the conveyance is or has been brought to rest.
2	Lower
3	Raise
4	Hoist to surface.
5	Danger signal — The conveyance should be moved until release signal 8 has been given.
6	Materials or equipment to be conveyed (cautionary signal). Signal to be returned by driver before a command signal is given when the driver should move the conveyance slowly.
7	Firing warning.
8	Release conveyance from “Danger” signal. Signal to be returned by driver before a command signal is given.
12	Accident signal — to be followed after a pause by the signal for the level where the conveyance is required.
1 pause 2 pause 3	Change to wind from a different level (throw in or out of gear). Signal should not be given while the conveyance is in motion.

The shaft conveyance should be raised or lowered, as required, in accordance with the following signals –

Winding signals – change of level

1 pause 1 To No. 1 level.
1 pause 2 To No. 2 level.
1 pause 3 To No. 3 level.
1 pause 4 To No. 4 level.
1 pause 5 To No. 5 level.
2 pause 1 To No. 6 level.
2 pause 2 To No. 7 level.
2 pause 3 To No. 8 level.
2 pause 4 To No. 9 level.
2 pause 5 To No. 10 level.
3 pause 1 To No. 11 level.
3 pause 2 To No. 12 level.
3 pause 3 To No. 13 level.
3 pause 4 To No. 14 level.
3 pause 5 To No. 15 level.
4 pause 1 To No. 16 level.
4 pause 2 To No. 17 level.
4 pause 3 To No. 18 level.
4 pause 4 To No. 19 level.
4 pause 5 To No. 20 level.
5 pause 1 To No. 21 level.
5 pause 2 To No. 22 level.
5 pause 3 To No. 23 level.
5 pause 4 To No. 24 level.
5 pause 5 To No. 25 level.
6 pause 1 To No. 26 level.
6 pause 2 To No. 27 level.
6 pause 3 To No. 28 level.
6 pause 4 To No. 29 level.

Winding Signals – Change of level
6 pause 5 To No. 30 level.
7 pause 1 To No. 31 level.
7 pause 2 To No. 32 level.
7 pause 3 To No. 33 level.
7 pause 4 To No. 34 level.
7 pause 5 To No. 35 level.
8 pause 1 To No. 36 level.
8 pause 2 To No. 37 level.
8 pause 3 To No. 38 level.
8 pause 4 To No. 39 level.
8 pause 5 To No. 40 level.

Unless preceded by the cautionary signal (6 knocks or rings), indicating that materials or equipment are to be conveyed, all signals from level to level, surface to level and level to surface, should be regarded as meaning that persons are being raised or lowered, and the engine driver should drive accordingly.

The pause between signals in the Code should be the space of time required to give 2 knocks or rings.

Winding signals – repairing shafts

When persons are engaged in repairing or timbering any shaft, special notice should be given to each driver who comes on duty on the winding engine. The signals 3-raise, and 2-lower, should then be taken as meaning, that persons are to be raised or lowered, and the winding should be done slowly and with great care.

Code of signals to be displayed

The manager of a mine should ensure that a copy of the Code of Signals is posted, and maintained in clear and legible form, in the winding engine room, at the surface brace, and at each working plat underground.

Signals to be known

- A person employed underground in a mine, at which a winding engine is used, should know the Code of Signals.

- An employer should not employ a person as a winding engine driver, platman, skipman or braceman in a mine, unless the person has satisfied the employer or manager that he or she —
  (a) knows the Code of Signals, and his or her duties and obligations, and
  (b) can perform efficiently his or her duties and obligations in that position.

Signals to be clear and correct

- A person who gives any signal at a mine, should ensure that the method of signalling is clear and distinct.

- A braceman, or any other person, on the surface of a mine, should not give verbal or visual signals to the winding engine driver.

- The manager of a mine should ensure that —
  (a) a winding engine driver has a clear view, between his or her station, and the shaft at the surface brace, or
  (b) if it is not practicable to comply with part (a) above, that indicators are provided that will efficiently provide for safety.

- A person should not -
  (a) give any wrong signal or cause any wrong signal to be given, or
  (b) ride in or upon any cage, skip or kibble at a time, when signals have been given informing the driver that no person is so riding.

Signals to be returned

(1) This section does not apply if automatic winding is used,
(2) Subject to part (3) below, a winding engine driver should, on receiving a signal, before beginning to wind, give a return signal, repeating the signal as received by the driver.

(3) The winding engine driver should not be required to return the signal “1” — to stop, when the skip or cage is in motion, or to return the signal as provided for in the sinking signals.

(4) After returning a signal, the winding engine driver should not move the cage, skip or kibble until —
   a) when raising or lowering any person, a period of at least 6 seconds has elapsed, or
   b) when raising or lowering materials, a period of at least 2 seconds has elapsed.

Communication by voice restricted

A person should not communicate signals by word of mouth, up or down any shaft, except -

- through a telephone properly fitted and isolated in a compartment, that is not used for hoisting, or
- by radio or radio telephone installed for that purpose.

4.12 Shaft conveyances – embarking and disembarking facilites

Each responsible person at a mine, should ensure that provision is made at all working levels, for persons to embark and disembark from a shaft conveyance safely.

4.13 Cages to be used in shafts

(1) Each responsible person at a mine should ensure that whenever a mine shaft exceeds 60 metres in depth, a suitable cage or skip is provided to raise or lower persons.

(2) Part (1) above, does not apply to a shaft during shaft sinking, where a kibble is available for that purpose.

(3) The underground manager of an underground mine should -
   a. fix the maximum number of persons allowed to ride at any one time, in a cage or other conveyance,
   b. ensure that number is posted up at the brace, and
   c. ensure that not more than that number of persons, rides at any one time in the cage or other conveyance.

(4) In fixing the maximum number of persons, allowed to ride at any one time in a cage or other conveyance, under part (3) above, the underground manager should ensure that there is at least, 0.2 square metres of floor space for each person in the cage or conveyance.

(5) A person should not travel in any cage or skip, without being accompanied by the platman or skipman, unless –
   a. the person is inspecting or repairing a shaft,
   b. an automatic winding engine is used,
   c. the person is authorised in writing by the manager to do so, or
   d. a load of persons is to be sent to the surface, directly from a level plat, or lowered from the surface, directly to a level plat when a change of shift takes place, and -
      i. the platman or skipman remains on the plat, and
      ii. a braceman is stationed on the surface.

(6) The manager of a mine should ensure that —
   a. a securely fastened gate or gates, is or are used, on each cage in which a person is travelling, and

b. the platman or skipman is responsible for the safe entry and exit, into and from the cage or skip, and for the proper fastening of the shaft and cage gate or gates.

(7) The manager of a mine should ensure that a competent person is appointed to be platman, or skipman and, except in the circumstances referred to in part (5) above, to accompany any person who travels in the cage or skip.

4.14 Use of ore skip by persons

- The manager and the underground manager of a mine, should ensure that a person is not raised or lowered in an ore skip in a vertical shaft, unless the person stands on the bottom of the skip or on a platform provided in the skip for that purpose, and provision is made for the safe entry and exit of the person.
- The manager and the underground manager of a mine, should ensure that all necessary precautions are taken, to ensure that persons travelling in skips are not put at risk, and that the winding engine driver is fully informed at all times, of this use of the skip or skips.

4.15 Persons not to travel with material

(1) A person should not travel, or permit another person to travel, in a shaft or winze, in or on any cage, skip, kibble, or other conveyance, which contains timber, pipes, rails, explosives, ore, waste rock or similar material, or tools.

(2) Part (1) above, does not prevent -

a. a person who is repairing a shaft, from travelling in or on a cage or skip, with tools or materials necessary for repairing the shaft,
b. a person from carrying small tools, if they are in a suitable container,
c. a person from travelling with the person's instruments,
d. a driver from travelling with the driver's locomotive or vehicle, or
e. a platman travelling in a cage or skip with tools, explosives or materials.

(3) A platman should not -

a. travel with any material that is not securely fastened, or secure in the conveyance, or
b. travel upwards with drill steel, timber, pipes or material of similar form.

(4) A person should not ride in a deck of a multi-deck cage, while a load other than passengers is in a higher deck.

(5) A person should not ride in a shaft conveyance, when equipment, long timber, rails or material of similar form is slung below the conveyance.

4.16 Drum winding in single gear

- If a winding engine is provided with 2 drums, the manager of the mine should ensure that, except in an emergency, a person is not raised or lowered in a shaft conveyance connected with the engine while one of the drums is out of gear, and loose on the drum shafting on which it operates.
- The manager of a mine should ensure that, if a double drum winding engine has one drum out of gear, that drum is prevented from revolving whilst out of gear.

5 FRICTION WINDING SYSTEMS

This section only applies to winding engine operations, in which the rope or ropes are driven by friction.

5.1 Winding ropes and balance ropes

Factors of safety for winding ropes and balance ropes

Proposed Use	Minimum Factor of Safety		
	Single rope	***2 or 3 ropes***	***4 or more ropes***
Transporting persons or where the safety of persons is involved	7.5	6.9	6.3
Transporting rock or materials, where the safety of persons is not involved	6.8	6.2	5.6
Transporting rock in a shaft used exclusively for that purpose	6.3	5.7	5.1
Transporting a machine or part of a machine at a speed of less than 2 metres per second	5	5	5
Balance ropes	6	6	6

For the calculation of the rope factor of safety, refer to p16.

Testing

(1) This section is in addition to any requirement in this code of practice, that winding installations be inspected.

(2) The manager of a mine should ensure that each hoisting rope used on a friction winding engine, is non-destructively tested, at intervals of not more than 6 months.

(3) The manager of a mine should ensure that each hoisting rope in a friction winding installation, is measured at intervals of not more than one month, to determine the total stretch of that rope.

(4) The manager of a mine should ensure that the results of each measurement, referred to in part (3) above, are recorded in the winding rope log book.

Period of service

The manager of a mine should ensure that, the period of service of any rope used for friction winding, does not exceed 2 years.

(1) The manager of a mine should ensure that, the period of service of any rope used as a balance rope, does not exceed 3 years.

(2) The manager of a mine should ensure that a rope is discarded, before reaching the period of service specified in this section if it shows –

a. by surface visual inspection or by non-destructive testing, more than 6 broken wires in any section equal to the length of one external lay,

b. a marked increase in the rate of stretch over the normal stretch noted during service,

c. marked corrosion, or

d. any other unsafe condition.

Testing after discarding

The manager of a mine should ensure that —

- samples are cut from significant parts along the length of discarded winding rope, and
- the samples are subjected to destructive tensile tests.

Dressing restricted

The manager of a mine should ensure that rope dressing, which would in any way, increase the danger of slippage on the driving sheave, is not used.

Splicing prohibited

The manager of a mine should ensure that a spliced rope, is not used as a winding or a balance rope in friction winding.

Tension adjustment

- The manager of a mine should ensure that multiple winding ropes on friction winders, are attached to the cage, skip or counterweight through apparatus, designed to load the ropes as uniformly as is practicable.

- The manager of a mine should ensure that if the attachments, are connected directly to the cage, skip or counterweight, means are provided for —
  (a) adjusting the length of the attachment, and
  (b) indicating unequal tension between ropes.

- The manager of a mine should ensure that each hoisting rope in a friction winding installation, is measured at intervals of not more than one month, to determine and ensure that tension is evenly applied.

5.2 Arresting devices

The manager of a mine should ensure that, in friction winding, an appliance is provided to prevent a shaft conveyance, from falling down the shaft following a winding rope failure.

5.3 Driving sheave

- The manager of a mine should ensure that, the driving sheave diameter of a friction winder, when measured at the bottom of the rope grooves, is not less than -
  (a) 100 times the diameter of the winding rope, when locked coil ropes are used, and
  (b) 90 times the diameter of the winding rope, when flattened strands are used.
- The manager of a mine should ensure that, the grooves of a multigrooved sheave are of substantially the same root diameter.

5.4 Deflection sheave

- The manager of a mine should ensure that, the diameter of any friction winding deflecting sheave, is not less than 0.9 times the diameter of the corresponding driving sheave.
- The manager of a mine should ensure that, the angle of contact of the rope on a deflecting sheave, is sufficient to prevent the rope slipping on the sheave.

5.5 Friction winder brakes

(1) The manager of a mine should ensure that, the driving sheave of each friction winding engine, is provided with 2 or more brakes and that each brake -

(a) however applied, acts directly on the driving sheave,
(b) is designed, adjusted and maintained safely to stop and hold the cage or skip, under all conditions of loading, direction of travel and speed,
(c) when applied by the means provided for use by the winding engine driver, is capable of producing a braking torque –
   (i) when transporting persons, of not less than 3 times, and
   (ii) when transporting rock or materials, of not less than 2 times,
   (iii) the maximum out-of-balance static torque, which will be applied to the driving sheave, by the normal loads to be carried by the winder,
(d) when applied by any means, is capable of producing a braking torque, not greater than 70% of that which will cause the winding rope to slip on the driving sheave, based on the minimum sliding coefficient of friction between the rope and sheave, under normal operating conditions,
(e) can be applied manually by the winding engine driver, irrespective of the action of any safety device, that may act to apply the brake or brakes,
(f) is automatically applied, when the supply of power to the winding engine fails, or when the pressure of any fluid or other medium, used as a means of controlling the brakes, falls below a predetermined level,
(g) is automatically applied, if an earth fault occurs in the electrical control circuit, of push button controlled winding engines, and
(h) so far as is practicable, is provided with a steel tension member, between individual sole-plates of brake shoes.

(2) The manager of a mine should ensure that, the braking system of each friction winding engine, is designed in such a way, that the failure of any one component in that system, will not prevent the driving sheave from being brought safely to rest.

(3) The manager of a mine should ensure that, push button and automatically controlled winding engines, are also provided with a suitable device, which will automatically apply the brake, before it becomes worn sufficiently to affect its safe operation.

(4) The manager of a mine should ensure that, each part of each braking system, has a factor of safety of not less than 10, and screwed members in tension, the failure of which would render the brake inoperative, have a minimum factor of safety of not less than 15.

5.6 Rope detaching appliances

The manager of a mine should ensure that, detaching appliances for cages, skips or counterweights, are not provided in a friction winding operation.

5.7 Synchronizing devices

- The manager of a mine should ensure that, each friction winding engine, is provided with a device, that will automatically synchronize, the depth indicator and the automatic speed control device, refer page 16, with the position of the conveyance in the shaft.

- The manager of a mine should ensure that, the synchronizing adjustment referred to in part (1), only takes place while the brakes are applied, and the winding engine is stationary.

5.8 Slip and direction indicators

The manager of a mine should ensure that, each friction winding engine is provided with -

(a) a device, which will indicate slip of the rope relative to the driving sheave, and stop the winder if a predetermined rate of slip is exceeded, and

(b) a device, for indicating in which direction the driving sheave is turning.

5.9 Loading limitations

The manager of a mine should ensure that, a friction winder is not loaded to the extent, that it will require more than 70% of the available braking torque, to stop and hold the driving sheave.

5.10 Cage chairing devices

The manager of a mine should ensure that, in friction winding no chairing device is provided in a shaft or on a cage.

5.11 Overwound conveyance arrester

(1) The manager of a mine should ensure that, in the headframe or tower, and in the part of the shaft below the lowest landing, for the time being in use, apparatus is provided, that is designed and constructed to ensure that, in the event of overwinding with a friction winder, the cage, skip or counterweight, as the case may be, is brought to rest without danger.

(2) The manager of a mine should ensure that, in the headframe or tower of the shaft, safety devices are provided that are designed and constructed, to prevent a cage, skip or counterweight, which has been brought to rest by apparatus provided under part (1), from falling down the shaft.

5.12 Shaft sump to be kept clear

(1) The manager of a mine should ensure that, when friction winding is used, the shaft sump is kept clear of water, debris or other material, to an extent that will prevent the balance ropes, from contacting that water, debris or other material.

(2) The manager of a mine should ensure that, a device or devices are provided, in the shaft sump region that will, if a balance rope loop rises vertically from its normal position, remove the power from the winding engine, and initiate an emergency brake application to the winding engine.

5.13 Inspection of shaft sump

The manager of a mine should ensure that, when friction winding is used, the space between the lowest stopping point, and the shaft sump, is equipped with ladders or other suitable means of access, to permit proper inspection and maintenance of that part of the shaft and the equipment.

6 SHAFT SINK WINDING SYSTEMS

This section applies only to, and in relation to, shaft sinking operations.

This section applies in addition to sections 1, 2 and 3, but if there is any inconsistency between a provision of this section and a provision of the other sections, the provision of this section prevails to the extent of the inconsistency.

6.1 New shaft sinking operations

The manager of a mine should ensure that, before sinking any new shaft or extending any existing shaft, plans and specifications are developed, showing –

- the location of the shaft,
- the general layout of the sinking project,
- details of the sinking and hoisting equipment and the conveyances, rope type and size and attachments to be used,
- the ventilation arrangements and
- any safety precautions that are to be taken, in respect of the proposed operation.

6.2 Use of crane

(1) The manager of a mine should ensure that, a crane is not used to hoist the broken rock from the initial surface excavation, or from the shaft, unless a risk assessment indicates it is a safe operation. If at any stage, the operation could create a hazard, the operation should cease immediately.

(2) The manager of a mine should ensure that, a crane is not used to hoist the broken rock from the shaft, at a depth exceeding 50 metres.

(3) The manager of a mine should ensure that, a crane is not used when the shaft perimeter has been traversed by dividers, or any other structure, which could be an obstruction to the free passage of the shaft conveyance.

(4) The manager of a mine should ensure that, any load lifted by a crane in shaft sinking operations, does not exceed 50% of the normal safe working load as provided in AS 1418.

(5) The manager of a mine should ensure that, any crane used is of a slewing type, and is located in a fixed position during the hoisting and dumping operations.

(6) The crane ropes and brakes should be tested in accordance with the test requirements detailed in sections 2 and 3.

(7) The driver of a crane, used to hoist the broken rock from the initial surface excavation, or from the shaft, should be competent to carry out such duties.

(8) The manager of a mine should ensure that, if a crane is used, an effective method of signalling is installed to allow communication with the driver.

(9) The manager of a mine should ensure that, a person is not raised or lowered from a shaft excavation by means of a crane unless the person -

a. travels in a kibble or similar conveyance;

b. wears a safety belt attached to the rope or conveyance if more than one third of the person's body is outside the conveyance; and

c. is within sight of a person stationed in a place to communicate with the crane driver.

(10) A person should not remain in the shaft excavation, while the crane is used to hoist broken rock by means of a grab.

6.3 Alternative means of travel

(1) The manager of a mine should ensure that, during shaft sinking operations, unless there is an alternative winding plant available, for the raising or lowering of persons in an emergency, in the event of power failure or winding plant failure, a substantial ladderway securely supported, at intervals of not more than 5 metres, is installed from the surface to the bottom of the shaft.

(2) The manager of a mine should ensure that, if a sinking stage is used, provision is made to permit travel from the shaft bottom to that stage.

6.4 Winding ropes

Minimum factors of safety

The manager of a mine should ensure that, the minimum factors of safety, to be used in shaft sinking operations, are –

- for ropes hoisting persons and materials or rock,
  7.5 — 0.001L where L equals the depth of wind in metres,
- for ropes raising and lowering a sinking stage, 6,
- for chains used for the suspension of a kibble, a combined factor of 20, and
- for all components of attachments, 10.

For the calculation of the rope factor of safety, refer to p16.

Inspection and maintenance of ropes

The manager of a mine should ensure that, the following inspection and maintenance procedures, are followed in relation to winding ropes, used to support a shaft sinking stage –

- the structure of each rope is examined at least weekly for-
  - the incidence of broken wires,
  - any obvious increase in the lay length,
  - any obvious corrosion, and
  - any other unsafe condition,
- each rope is lubricated at least monthly, with a suitable lubricating compound,
- if a physical inspection of the rope by a competent person, shows that it appears to be unsafe for use, the rope is discarded, and
- the period of service of any such rope, does not exceed 3 years.

6.5 Monkeys, crossheads and other conveyances

The manager of a mine should ensure that, if the depth of a shaft exceeds 50 metres, a kibble and monkey or crosshead arrangement, or some other conveyance, that is provided with an overhead cover, for the protection of persons when travelling, is used for haulage purposes in the shaft.

6.6 Kibbles and attachments

(1) The manager of a mine should ensure that, a kibble used in shaft sinking operations, is of robust construction, and is of a shape that will prevent it from catching on any obstruction, during its travel in the shaft.

(2) The manager of a mine should ensure that, the kibble is suspended by a bridle, or by means of at least 3 chains, equally spaced around the perimeter of the kibble top.

(3) The manager of a mine should ensure that, chains used for the suspension of the kibble -

i. are of identical dimensions and strength,

ii. are of sufficient length, to ensure that the included angle at the apex of the suspension of any 2 chains, does not exceed 60°, and
iii. are designed, manufactured and tested in accordance with AS 3637.6.

6.7 Overfilling of kibbles or skips

The manager of a mine should ensure that, all persons who are authorised by the manager to transmit signals, from the shaft floor to the stage hand positioned on the sinking stage, are instructed in writing by the manager to ensure that –

- the kibble is correctly attached to the winding rope,
- the kibble is properly loaded,
- no broken rock projects above the rim,
- tools, equipment and other materials for use in the mine are not carried together with broken rock, and are secured if they project above the rim of the kibble,
- nothing capable of causing injury is adhering to the outside of the kibble, and
- when the kibble is to be hoisted it is first raised sufficiently to hang free and then steadied.

6.8 Interlocking

The manager of a mine should ensure that, interlocking is provided with the winding engine control system, so that

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

6.9 Firing

The manager of a mine should ensure that, firing in shaft sinking operations, is electrically initiated from the surface, or from some other safe location.

6.10 Pentices

The manager of a mine should ensure that, when a shaft is to be sunk below any level which is being worked, it is protected below that level by a securely constructed pentice.

6.11 Timber bearer sets

The manager of a mine should ensure that, if timber is used to line a shaft, bearer sets or other means of support, are provided between working levels, or at distances of not more than 60 metres apart.

6.12 Protection

- The manager of a mine should ensure that, during shaft sinking operations, adequate provision is made and maintained, to prevent spillage from falling down the shaft during dumping operations.

- The manager of a mine should ensure that, a door or doors for covering the sinking compartment, are provided and maintained, at the collar of each shaft, while sinking operations are in progress.

- The manager of a mine should ensure that, unless suitable alternative protection is provided, to prevent spillage from falling down the shaft, the doors are kept closed at all times when -
    - persons, tools or material are being loaded into, or unloaded from, the kibble or skip at the collar of the shaft, or
    - the kibble or skip is being dumped.

6.13 Warning of obstruction

The manager of a mine should ensure that, 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, are equipped so that their position is positively indicated to the winding engine driver.

6.14 Signals

The manager of a mine should ensure that, signals other than the Code of Signals, refer to pages 35 to 39, are not used in a shaft sinking operation.

6.15 Hoisting and lowering of shaft sinking stage

The manager of a mine should ensure that, except in an emergency, the following procedures are followed, when a shaft sinking stage suspended by a stage winder, is in use –

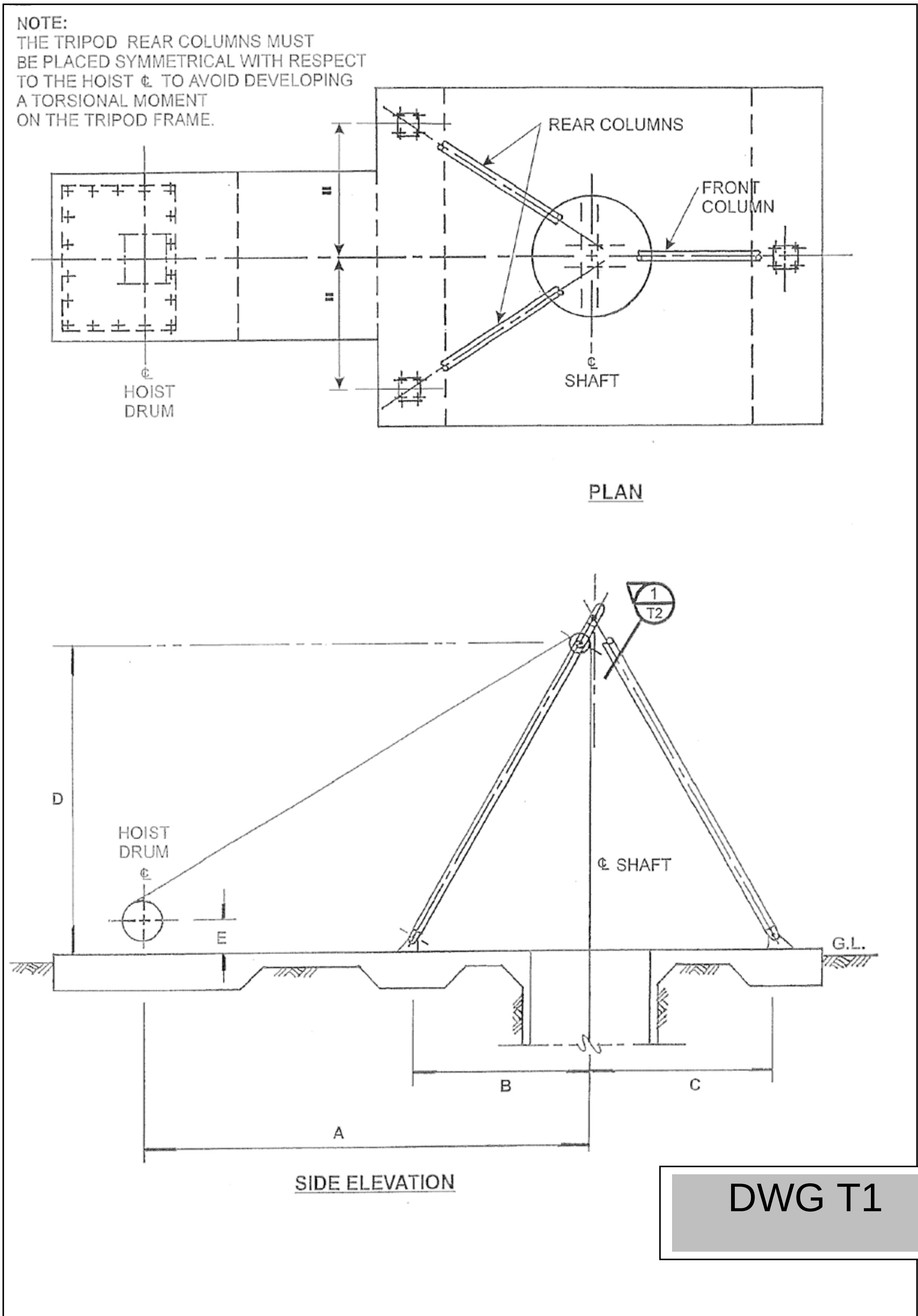
- stage winding is carried out, only when all other winding operations in the shaft have been stopped,
- when the stage is to be moved, the drivers of other winders are advised, and the stage is not moved, until their winds are completed and the conveyances are parked clear of the projected stage movement, and
- when the stage movement is completed, drivers of other winders are notified, and the drivers re-establish their stage position marks.

7. TRIPOD WINDING SYSTEMS

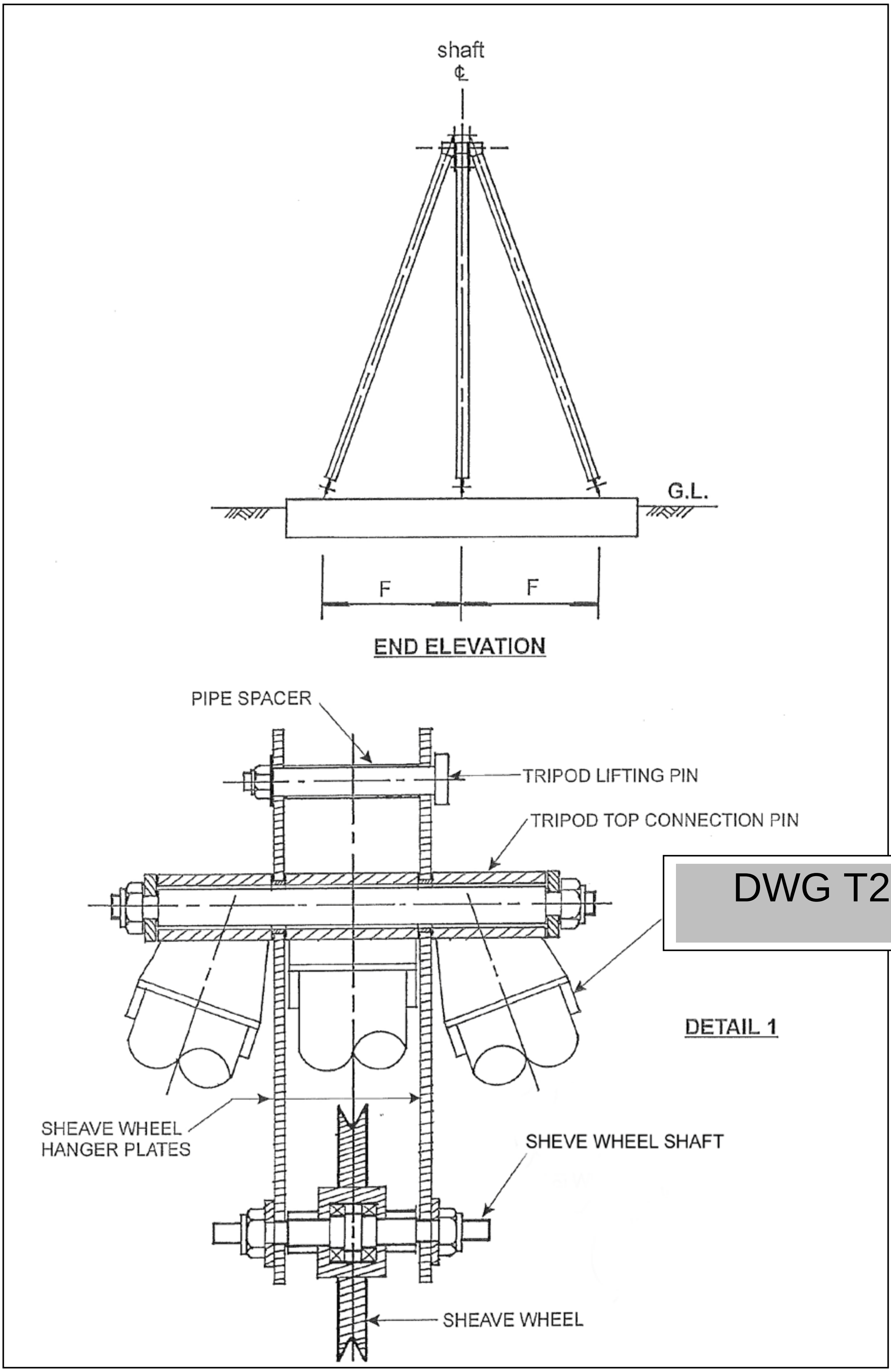
The use of tripods as part of winding systems is not encouraged under this code of practice. However if a tripod is considered necessary, this section provides designers of tripod structures, with information which details the critical elements that should be addressed in the design of such structures.

The configuration of the hoist and tripod columns, relative to the shaft centreline, is critical, and design methods are detailed, which eliminate uplift forces at the connection of the columns to the foundation. An incorrect tripod configuration, which allows uplift forces at the foundations, can lead to a catastrophic structural failure of the winding system.

Design procedures for tripod frames, sheaves, sheave shafts and foundations have been included, which provide reference to applicable Australian Standards.


NOTE:
THE TRIPOD REAR COLUMNS MUST
BE PLACED SYMMETRICAL WITH RESPECT
TO THE HOIST ℄ TO AVOID DEVELOPING
A TORSIONAL MOMENT
ON THE TRIPOD FRAME.
REAR COLUMNS
FRONT
COLUMN
℄
SHAFT
℄
HOIST
DRUM
PLAN
1
T2
D
HOIST
DRUM
℄
℄ SHAFT
E
G.L.
B
C
A
SIDE ELEVATION

DWG T1


shaft
℄
G.L.
F
F
END ELEVATION
PIPE SPACER
TRIPOD LIFTING PIN
TRIPOD TOP CONNECTION PIN
DETAIL 1
SHEAVE WHEEL
HANGER PLATES
SHEVE WHEEL SHAFT
SHEAVE WHEEL

DWG T2

NOTES:

THE STRUCTURAL INTEGRITY OF ALL TRIPOD INSTALLATIONS ARE DEPENDENT UPON THE FOLLOWING CRITICAL ELEMENTS:

1. **DIMENSIONS** A, B, C, D, E, & F MUST NOT VARY FROM THE DESIGN DRAWINGS.

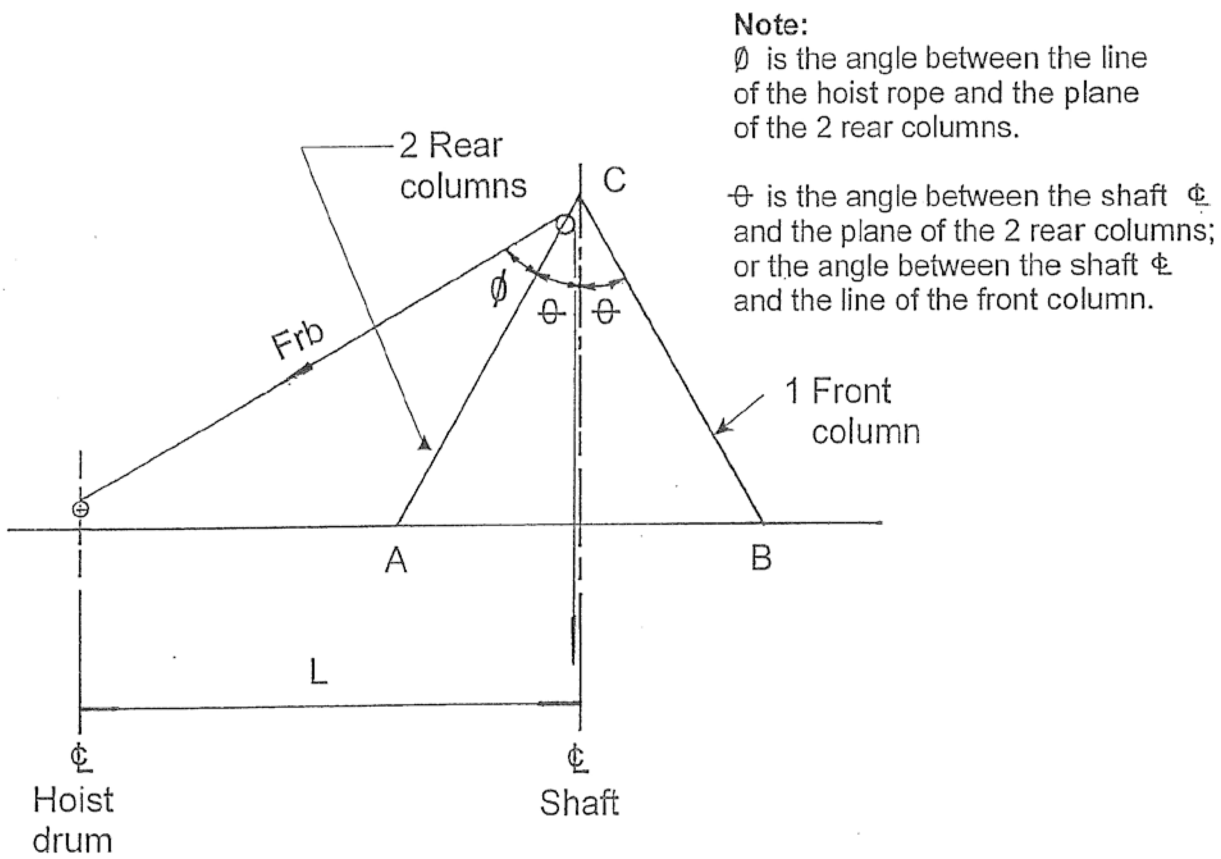
2. **THE CONCRETE FOOTINGS** MUST NOT VARY IN SHAPE AND SIZE FROM THE DESIGN DRAWINGS.WHERE THE TRIPOD COLUMNS BEAR UPON FOOTINGS WHICH ARE SEPARATE FROM THE SHAFT COLLAR SLAB, THESE FOOTINGS ARE TO BE TIED TO THE COLLAR SLAB WITH DOWEL BARS AND EPOXY GROUT (AFTER SCABBLING AND CLEANING THE SURFACE OF THE EXISTING CONCRETE). ALL CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGH OF 25 MPa AT 28 DAYS, AND A MAXIMUM SLUMP OF 100 mm.

3. **WHERE CHEMICAL ANCHORS** ARE USED IN PLACE OF CAST-IN HOLDING DOWN BOLTS, SUCH ANCHORS ARE TO BE INSTALLED STRICTLY IN ACCORDANCE WITH THE MANUFACTURERS INSTRUCTIONS.

4. **THE PREPARED EARTHWORKS** MUST BE INSPECTED AND APPROVED BY THE DESIGN ENGINEER, PRIOR TO FOOTING CONSTRUCTION. PLACE LOOSE SAND FILL FOR COMPACTION IN LAYERS OF 400 mm MAXIMUM THICKNESS. FOR SANDY SOILS COMPACT SAND TO GIVE 8 BLOWS PER 300 mm WHEN TESTED WITH A STANDARD 16 mm DIAMETER PENETROMETER. WHERE FOOTINGS BEAR ON FIRM UNDISTURBED CLAY NO COMPACTION IS REQUIRED. ANY SOFT AND WET CLAY TO BE REMOVED AND REPLACED WITH COMPACTED UNIFORM DRY CLAY FILL OR CONCRETE.

DWG T3

7.1 Tripod frame analysis

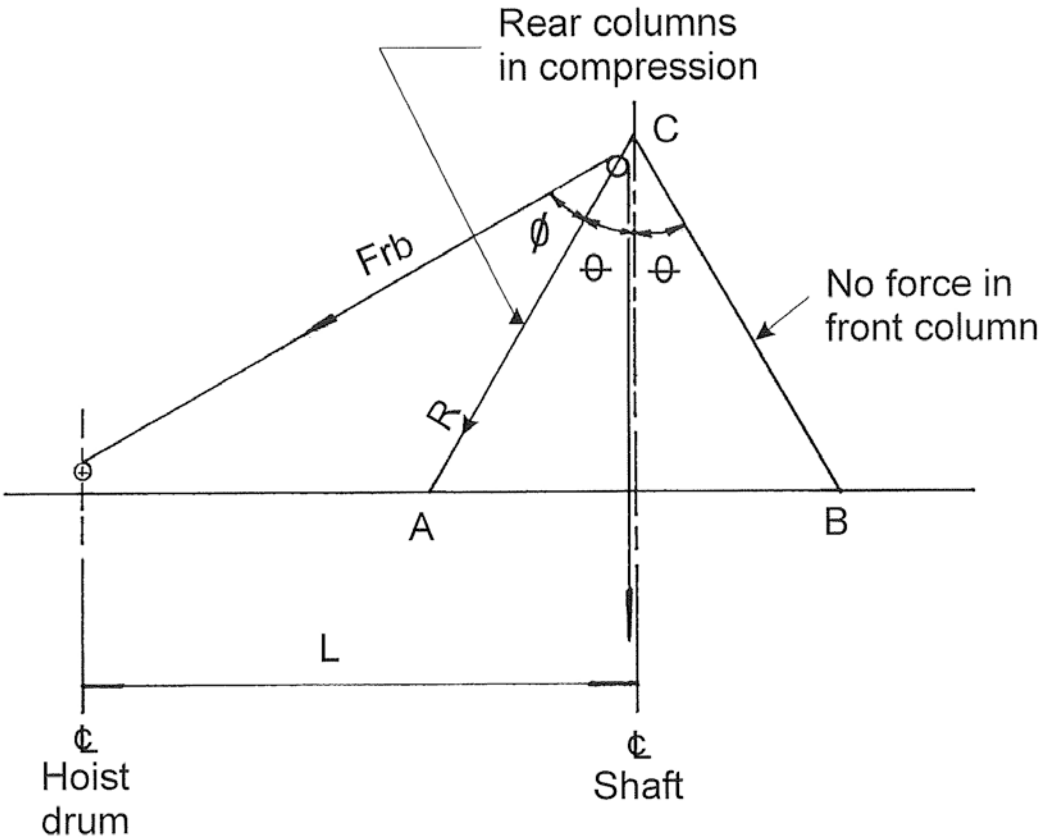


AS 3785.5 "Underground mining - Shaft equipment Part 5: Headframes" Clause 2.2 (d)(i)(a)(1) requires the design load to be:

Design rope break load (Frb) = 1.2 x rope break force.

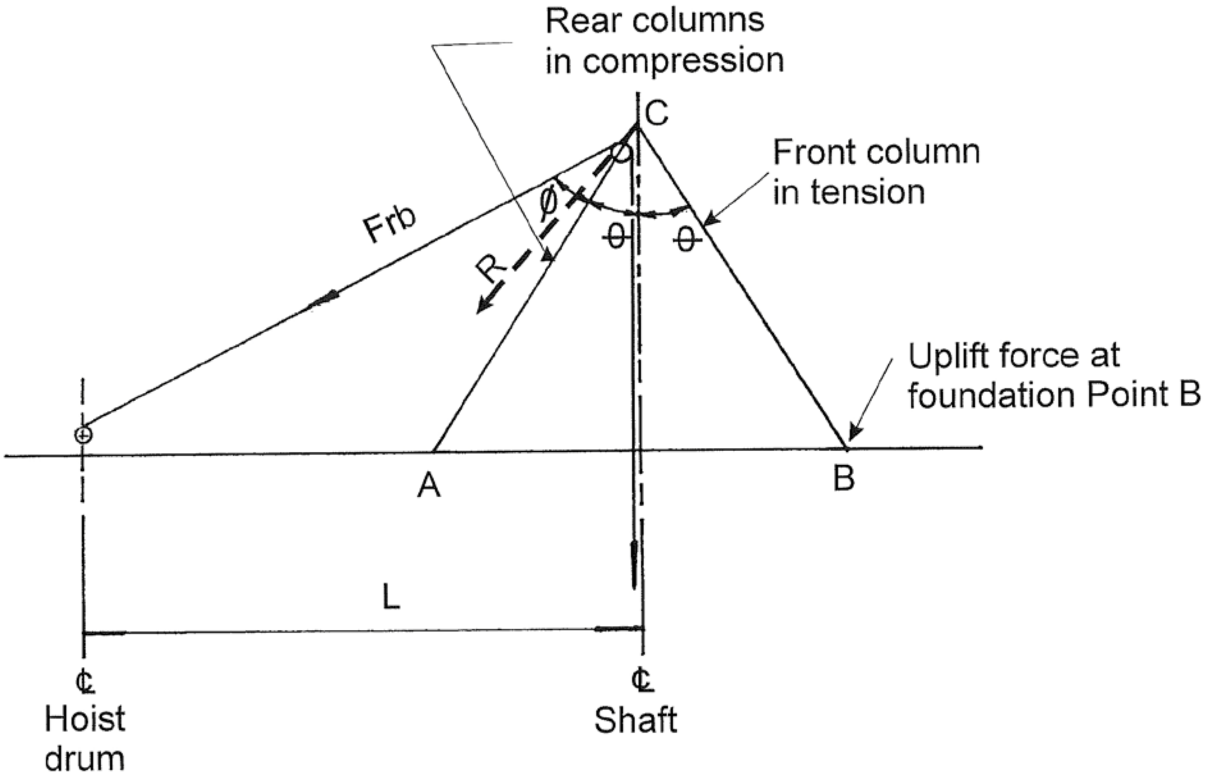
The rope break force is obtained from the rope manufacturer's specification for the type of rope chosen. For example, a 16mm diameter rope with a tensile grade of 2070 MPa and a non-rotating fibre core type of construction, has a rope break force of 165kN.

Depending upon the positioning of the hoist (distance L from the shaft centreline), the loads in the three tripod columns will vary, and it is possible to have three different load cases as follows:



case 1

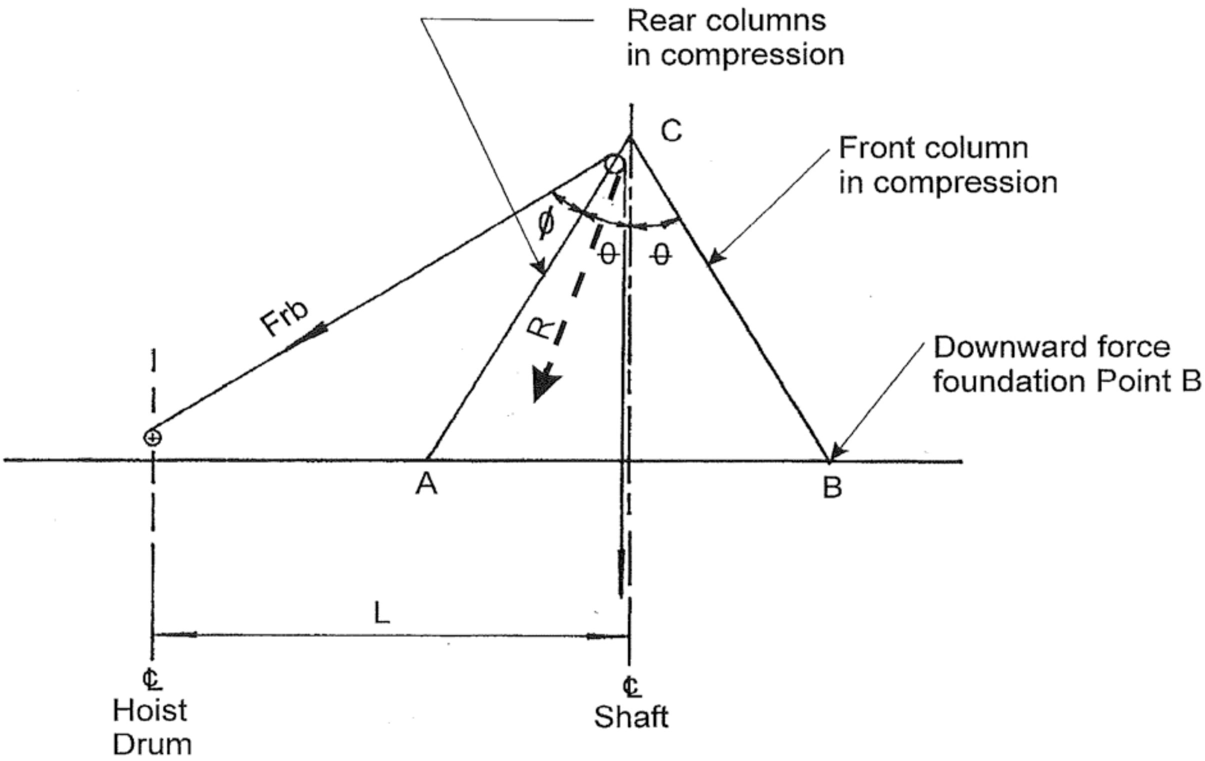
When angle □ is equal to angle □□□the resultant force R (the resultant force from the two Frb forces in the hoist rope) is in line with the two rear columns, with theoretically no force in the front column.



case 2

When angle is greater than angle the resultant force R moves to the left of the line of the two rear columns, such that tension is developed in the front column, which imposes an uplift force at the front foundation point B.

When angle is less than angle the resultant force R moves to the right of the line of the two rear columns, such that compression is developed in the front column, which imposes a downward force at the front foundation B. It is suggested that length L be decreased by at least 1.5 metres for this load case.



case 3

A tripod arrangement which develops tension in the front column, and therefore an uplift force at the connection of the front column to the foundation, can lead to a catastrophic structural failure of the winding system. Load case 2 defines a similar arrangement with a similar uplift force. *<u>Clearly the design of tripod structures, should adequately detail the position of the columns and the hoist, so that load case 2 is not possible under any situation.</u>*

Tripod structures should be designed for forces obtained from load case 1, and also checked for forces obtained from load case 3. The front column should have the same section size as the back columns, even though the design compression load in the front column, will be considerably less than the design compression load in the rear columns.

The tripod rear columns should be placed symmetrical with respect to the hoist centreline, to avoid developing a torsional moment on the tripod frame (refer drawing number T1).

7.2 Tripod frame design

The tripod structure including the columns, base plates, holding down bolts, sheave hanger plates and tripod top connection pin, should be designed in accordance with AS 3990 "Mechanical equipment - Steelwork". The permissible stresses referred to in AS 3990, may be increased from working stress to yield stress, because the tripod frame analysis is based upon a factored rope break load.

Therefore the following permissible stresses may be used:

COMPRESSIVE STRESS	Fac = Fy (yield stress)
BENDING STRESS	Fb = Fy
SHEAR STRESS	Fv = 0.57 Fy

The maximum slenderness ratio of the columns should not exceed 180, as described in AS 3990 Clause 4.6.

Foundations for the tripod columns, should be designed, so that the calculated maximum bearing pressure upon the soil, resulting from the applied design rope break load, does not exceed the permissible soil bearing pressure for the soil conditions present at the site. The concrete and reinforcement details for all foundations, should be designed in accordance with AS 3600 "Concrete Structures" for the applied forces referred to in Part B.

It is strongly recommended that all tripod columns, bear upon a one piece collar slab, as detailed on drawing number T1, to avoid the possibility of a separate foundation being uplifted. Where a one piece foundation is not possible, any column footings which are separate from the collar slab, should be positively attached to the slab as detailed on drawing number T3 (note 2).

7.3 Sheave wheel and sheave shaft design

Sheave wheel design

The sheave should be designed in accordance with AS 3785.7 "Underground mining - Shaft equipment Part 7: Sheaves." This standard requires the sheave to be analysed for a static design load (using Frb, the design rope break load) and a fatigue design load (maximum actual load applied to the sheave). Appendix A of this Standard also requires the sheave dimensions to be within defined limits.

The MSIR 1995 regulation 11.65 requires:

i) the diameter of the sheave used for a hoist installation, should not be less than that specified in AS1418.1 "Cranes (including hoists and winches) Part 1: General requirements" for classification of mechanism M8;

ii) the depth of the rope groove in the sheave should not be less than twice the diameter of the rope.

Sheave shaft design

The sheave shaft should be designed in accordance with AS 3785.7 and AS 1403 "Design of rotating steel shafts" for a static design load (using Frb, the design rope break load) and a fatigue design load (maximum actual dead and live loads applied to the sheave shaft).

7.4 Non-destructive testing

AS 3785.7 requires all components of the sheave assembly, namely, rims, spokes or web, hub, shaft and welds, but excluding bearings, to be non-destructively tested.

7.5 Rope factor of safety

The winding rope should have a minimum factor of safety as follows:

- (7.5 - 0.001L) for a rope used to hoist persons or where the safety of persons is involved;
- (5.5 - 0.0003L) for a rope used to hoist rock or materials;
- 6 for a rope used to raise or lower a sinking stage.
  (Where L is the depth of wind in metres).

The rope factor of safety may be calculated as follows:

$$\text{ROPE FACTOR OF SAFETY} = \frac{\text{ROPE BREAK LOAD}}{\text{MAXIMUM ACTUAL LOAD}}$$

The maximum actual load is the maximum static load at the sheave (conveyance tare load, payload and maximum weight of rope, with all attachments, when the conveyance is at the lowest operating level of the shaft). The rope break load, is the actual value as shown on the rope test certificate.