NSW GOVERNMENT | Industry & Investment

TECHNICAL REFERENCE

EES008-2

Electrical Engineering Safety

Design of powered winding Systems

Definitions and winder types

Produced by Mine Safety Operations Branch
Industry and Investment NSW
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Public comment period

Please note that this technical reference is published in draft form for the purpose of obtaining public comment.

Your feedback is welcomed and will assist with reviewing and improving the document. A feedback form is provided in the appendices for your convenience.

The closing date for public comment is Friday 20 May 2011.

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Foreword

Industry and Investment NSW (I&I NSW) has a vision for electrical engineering safety, which is:

"A mining and extractive industry that has eliminated death and injuries from electrically powered and electrically controlled equipment."

Electrical engineering safety encompasses:

- Prevention of electric shock and burns, (electrocution, death or injury as a result of a shock, radiation burns, flash burns, burning particles and plasma)
- Prevention of electrical arcing and surface temperatures that have sufficient energy to ignite gas and/or dust
- Prevention of fires caused by the malfunction of electrical equipment
- Prevention of injury and death from unintended operation, failure to stop or failure to operate, of electrically powered and electrically controlled equipment
- Use of electrical technology to provide safe-guards and monitoring for non-electrical hazards and electrical hazards with a safety integrity level appropriate for the risk.

Supporting this vision is a philosophy of operation outlined in the Strategic and Operational Plan for Electrical and Engineering Safety in NSW Mines, which can be viewed at www.dpi.nsw.gov.au. The philosophy of operation embraces a **System Safety Approach,** applying the **Hierarchy of Risk Controls** and the **Risk Reduction Precedence,** and fostering a **Positive Safety Culture.**

Satisfactory electrical engineering safety has to be achieved in the context of the mining industry's increasing electricity consumption and its use of electrical technology, with resulting increases in size (power rating) and complexity. With this comes a changing risk profile. To adequately manage the safety risks posed by electrical equipment and technology the hazards, risks and risk controls need to be thoroughly understood. This understanding must be at an engineering level, so electrical engineers within the management structure of coal or mining operations will be responsible for development, periodic review and day to day implementation of the Electrical Engineering Safety aspects of a powered winding system.

This document is one of a series dealing with powered winding systems. These documents are consistent with the above philosophy of operation and are a key element in realising the vision and points 4 and 5 for electrical engineering safety listed above.

The documents in the series are:

EES008.1 Design of Powered Winding Systems - Electrical Engineering Safety – General Requirements & Registration
EES008.2 Design of Powered Winding Systems - Electrical Engineering Safety – Definitions and types of winders
EES008.3 Design of Powered Winding Systems - Electrical Engineering Safety – a prescriptive approach
EES008.4 Design of Powered Winding Systems - Electrical Engineering Safety – a Functional Safety approach
EES008.5 Life-Cycle Management of Powered Winding Systems - Electrical Engineering Safety Requirements

Current legislation is consistent with this philosophy. In particular Clauses 107 and 113 of the *Occupational Health and Safety Regulation 2001* recognise the high risk nature of mine winders, so legislation requires that the Director General design register and item register powered winding systems.

The purpose of this document is to facilitate, within an electrical engineering safety context, the design registration of powered winding systems and to assist coal and mine operators to maintain powered winding systems in a safe state.

Use of this document will:

- Enhance the management of safety risks associated with powered winding systems through good and safe electrical engineering practice
- Contribute significantly toward the prevention of unintended operation of mine winders and preventing any unintended operation from injuring personnel.

Use this technical reference to assess your Powered Winding Systems.

Use this technical reference as an aid to the design of Powered Winding Systems.

This technical reference will be used by Mine Safety Operations to assess powered winding systems for design registration purposes and routine assessment activities.

John Francis Waudby

Senior Inspector of Electrical Engineering – Special Projects

Table of Contents

1. Establishment

1.1 Title

This is the Mining Industry Technical reference – *Electrical Technical Reference for Design of Powered Winding Systems Electrical Engineering Safety – definition and winder types.*

1.2 Purpose

This document is intended to assist designers and manufactures of powered winding systems, including shaft sinking winders, by indicating parameters which will be considered in the assessment for design registration. It will also aid coal and mining operators to obtain item registration. It also provides specific information on the content of any submission for design registration. Full details of how to obtain design registration is given in Guidance Note GNC-005 *NSW DPI Guidance Note – Registration of Plant Designs*.

Note Registration does not limit the responsibility of the designer, manufacturer and operator to ensure that the powered winding system is safe to operate.

This technical reference describes acceptable arrangements that can be tailored to suit the particular needs of an operation. It identifies some control measures relevant to electrical circuitry. It is intended to protect the safety of workers, others in the workplace and property.

1.3 Scope

This technical reference extends to all underground coal and mining operations in NSW that use a powered winding system. This technical reference is intended to provide guidance for any person designing, implementing, managing or reviewing a powered winding system installation.

1.4 Authority

This is an electrical engineering safety technical reference and is recommended by the Mine Safety Operations branch of Industry and Investment NSW.

1.5 Definitions

See Chapter 2.

1.6 Applicable legislation

Occupational Health and Safety Act 2000

Occupational Health and Safety Regulation 2001

Coal Mine Health and Safety Act 2002

Coal Mine Health and Safety Regulation 2006

Mine Health and Safety Act 2004

Mine Health and Safety Regulation 2007

1.7 Referenced Gazette Notices

Gazette Notice for Powered Winding Systems

1.8 Referenced Standards and Guidelines

AS 61508 Series - Functional safety of electrical/electronic/programmable electronic safety-related systems

AS 62061 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems

EES008.1 Design of Powered Winding Systems - Electrical Engineering Safety – General requirements and registration

EES008.3 Design of Powered Winding Systems - Electrical Engineering Safety – a prescriptive approach

EES008.4 Design of Powered Winding Systems - Electrical Engineering Safety – a Functional Safety approach

EES008.5 Life-Cycle Management of Powered Winding Systems - Electrical Engineering Safety Requirements

Guidance Note GNC-005 NSW DPI Guidance Note – Registration of Plant Designs

IEC 60947-5-1 Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices

1.9 Acronyms

AS: Australian Standard

EES: Electrical Engineering Safety

IEC: International Electrotechnical Commission

OH&S: Occupational health and safety

1.10 Who is affected by this Technical Reference?

This Technical Reference is relevant for all operators of coal or mining

operations in New South Wales where there is a powered winding system.

2. Definitions

Note:	Part 4 of AS/IEC 61508 provides a full list of definitions associated with the AS 61508 set of standards.
ALARP	The initials stand for 'As Low As Reasonably Practicable' and mean that as much as reasonably practicable has been done to minimise the risk.
Availability	The probability that the device, equipment or system is operational at any instant in time.
Back-up Over Travel devices	Devices or limits, driven by the winder drum to detect for both over travel and under travel of the conveyance. The devices are driven by the winder drum and operate as 'back up' systems to those of physical over travel devices located on Headframes, Gantries, Shaft and Drift Bottoms.
Back-up Over Travel devices (mechanically driven)	The devices are identified as 'encoders'. They are driven by the winder drum and operate into programmable software and provided 'back up' systems to those of physical over travel devices located on headframes, gantries, shaft and drift bottoms.
Note:	Backup over travel and under travel devices are not substitutes for physical over travel and under travel limit switches (or other devices) located on headframes, gantries, shaft and drift bottoms.
Brake Application / Brake Proving Protection	A device to detect the application of the winder brakes.
Brake Lift Monitoring	A device to detect the lifting of the winder brakes.
Brake Oil Level Monitoring	A device to monitor the level of oil in the oil storage tank(s) of hydraulically operated braking systems.
Brake Oil/ Air Pressure Monitoring	A device to monitor the brake oil/air pressure of oil/air operated braking systems.
Brake Oil / Air Temperature Monitoring	A device to monitor the brake oil/air temperature of oil/air operated braking systems.
Brake Path Contamination	The deposition of water, condensation, oil, other fluids, or other material or fluids on brake paths, so that the brake performance may be compromised.

Brake Temperature Monitoring	A device to monitor the operating temperature of brake materials.
Brake Wear Monitoring	A device to monitor the degree of wear of brake materials.
Beta Factor	Represents the percentage of failures that are due to common causes – and so affect all devices in a redundant set.
Cable Integrity	The design of the cable, protection systems and safety circuits are such that cable faults cannot compromise the SIL capability of the safety function and safety circuit.
Competence	Appropriate competencies are defined as thorough knowledge of winder design features and expertise and experience in testing and auditing of powered winding systems used in mines.
Control EUC	A control EUC is any primary conveyance directly attached to the winder rope(s) and is designed to control the operation of the winder from within the conveyance. For drift winders the EUC may have the ability to mechanically attach other EUC's for transport purposes, but generally the control EUC is always attached to the rope(s) during normal operation of the winder.
Conveyance (EUC)	Any car, carriage, cage, skip, kibble, or stage in which persons, minerals or materials are wound through a shaft/drift or any counterweight. The terms conveyance and EUC are used interchangeably throughout this series of documents.
Conveyance cable tension monitor (Shaft Winders)	A device to monitor tension in any cable which provides power, control and / or communication to an EUC shaft conveyance.
Data / Fibre Cable	Any form of serial or parallel data transfer system utilised to establish communications between the EUC and EUC control system and associated field stations.
Dead Man Control	A control switch (or other similar device) either hand or foot operated, which upon release, automatically returns to the off position and causes the conveyance to be brought safely to rest by application of the winder brakes. Dead man controls are required for the manual operation of any winder and shall be used for the manual control of personal EUC's (conveyances) on drift winders and in some cases for the static and dynamic brake testing facility of any winder.
Depth Indicator	A device showing the position of the conveyance in the drift or shaft.

Design Registration File	This file contains the essential and required information (mechanical and electrical) to obtain design registration. It is a distinct entity within the Powered Winding System Library. It is supplied as part of the design registration application. Information supplied must be in accordance with Guidance Note GNC-005 *NSW DPI Guidance Note – Registration of Plant Designs.*
Design Registration Electrical Engineering Safety File	The Electrical Engineering Safety information supplied as part of the design registration application (refer EES008.1, Chapter 4)
Double Drum Clutch Protection Device	A device or limit switch verifying that a double drum winder clutch is engaged or disengaged.
Drum Pit Flood Alarm	A device to monitor the level of water or other fluids in winder drum pits and raise an alarm before brake paths are contaminated.
Drum Pit Flood Protection	A device to monitor the level of water or other fluids in winder drum pits and causes the conveyance to be brought safely to rest after a drum pit flood alarm and before brake path contamination.
Diagnostic Coverage (DC)	The percentage of failures that are detectable via diagnostic functions.
Electrical / Electronic / Programmable Electronic System (E/E/PES)	A system for control, protection or monitoring based on one or more electrical/electronic programmable electronic (E/E/PE) devices, including all elements of the system, such as power supplies, sensors and other input devices, data highways and other communication paths, and actuators and other output devices.
Emergency Stop	An emergency operation intended to stop a process or a movement that has become hazardous.
Emergency Stop Function	The emergency stop function shall override all other functions and operations. Power to the machine actuators that can cause a hazardous situation(s) shall be removed in accordance with the stop category, the effect of this shall be sustained until it is reset. Reset shall only be possible by manual action at the device where the emergency stop action was initiated. Reset shall not initiate a restart, it shall only permit restart. It shall not be possible to restart the machinery until all emergency stop commands have been reset.
Emergency Stop Device	Manually actuated control device used to initiate an emergency stop function (AS60204.1) The emergency stop shall function either as a stop category 0 or as a stop category 1. The choice of the stop category of the emergency stop depends on the results of the powered winding system risk assessment. The emergency stop device is capable of being activated by a single human action. Push button

	actuators shall be coloured **red**. The types of device for emergency stop device include: push-button operated switch with a palm or mushroom head type; a pull-cord operated switch; a pedal-operated switch without a mechanical guard. The devices shall have direct opening operation (see IEC 60947-5-1 Annex K).
Equipment Under Control (EUC)	Any equipment, machinery, apparatus or plant used for manufacturing, processing, transportation or other activities.
EUC control system	A system which responds to input signals from the process and/or from an operator and generates output signals, causing the EUC to operate in the desired manner.
EUC (CONVEYANCE) Slack Rope Monitoring System	A system used on drift winder conveyances to automatically prevent the dolly car dump brakes from being energised whilst ever slack rope exists in the drift.
EUC Derail switch	A device fitted to the conveyance of drift winders to detect a derailing of the conveyance.
EUC Door / Gate Monitoring	Mechanical and electrical interlocking of any door or gate fitted to conveyances and/or personnel cars of drift winders and all conveyances of shaft winders.
EUC Dump Brakes	Hydraulic lift, spring applied pad type dump brakes fitted to the conveyance of drift winders. In an emergency situation the brake pads engage the rail track and bring the conveyance to safe stop.
EUC Hydraulic Pressure Monitoring	A pressure switch utilised to monitor the hydraulic pressure of dump brakes systems on drift winder conveyances.
EUC Motion Detection Device	A device to detect the motion or lack of motion of the EUC (conveyance) fitted to a conveyance on drift winders.
EUC Overspeed Protection	An overspeed device set to operate at 115%, fitted to drift winder conveyances.
EUC Speed Zone	A zone established to automatically slow down the EUC conveyance to provide a safe approach to the surface and bottom of the shaft and drift winders.
Final Over Travel Protection	A safety device or limit switch located in the headgear of a shaft winder, or located at the end of the track at the gantry of a drift winder, to activate and protect the EUC (and counterweight where applicable) from passing a predetermined point of travel.
Final Under Travel Protection	A safety device or limit at the shaft bottom of a shaft winder, or located at the end of the track at the drift bottom of a drift winder, to activate and protect the EUC (and counterweight where applicable) from

	passing a predetermined point of travel.
Functional Safety	Is that part of overall safety that depends on a system (or equipment) operating correctly in response to its inputs.
Gearbox bearing temperature	A device to monitor gearbox bearing temperatures of gearboxes on drives of shaft and drift winders.
Gearbox oil level monitoring	A device to monitor the oil level of gearboxes on drives of shaft and drift winders.
Gearbox oil temperature	A device to monitor the oil temperature of gearboxes on drives of shaft and drift winders.
Gear Loss / Broken Shaft Protection	A device or devices to monitor a break or differential in speed between the opposite drive end the winder drive motor and the extremity of any device driven by the winder drum.
Hazard	A potential source of harm.
Keps / Chairing Beam Proving Device	A device(s) to monitor that the conveyance of a shaft winder is secured in order to prevent movement of the conveyance caused by rope stretch during loading and unloading operations. Chairing beams are sometimes utilised to secure conveyances of drift winders and for securing conveyances and/or counterweights of shaft winders for the purposes of maintenance and/or repair.
LOPA: Layer of Protection Analysis	A simplified risk assessment method, providing a means of evaluating hazard scenarios and comparing them with risk tolerance criteria, to decide if existing safeguards are adequate.
Load Sensing Device	A device to detect the weight of the conveyance and its load before movement in the drift or shaft. The device generally determines the speed of the winder based on the load measured or prevents the winder from operating if an excessive load is detected.
MCS	Machinery Control System (AS62061 term).
Monkey	A device used on the shaft sinking winders. The monkey sits (by gravity) above the kibble and is secured by the “staging” guide ropes. It assists in stabilising the kibble during ascent and descent. The device is usually fitted with a covering to protect personnel riding in the kibble from falling material. On modern shaft sinking winders, signalling and communication devices are attached to the monkey for ease of operation.
Monkey Separation Device	A switch or other device to monitor the separation distance between the monkey and the kibble.
Motion Detection	A device fitted to all drift winder EUC’s capable of man riding, to detect

Device	motion of the EUC. Failure of this device to detect motion shall cause the EUC (conveyance) to stop. The device also assists in the detection of slack rope and hence reduces the possibility of developing kinks in the winder rope.
MTBF	Mean Time Between Failures = MTTF + MTTR.
MTTF	Mean Time To Fail – is the operational uptime between start-up/repair and the next failure.
MTTR	Mean Time To Repair – is the time taken to find ***and*** repair the failure.
Over speed devices	Devices installed on the winder prime mover/motor winder drum and EUC conveyances of drift winders to detect an over speed of 110%, 112% and 115% respectively of the nominal speed of the winder.
Over Travel Device	A safety device or limit switch located in the headgear or shaft bottom of a shaft winder, or located at the end of the track at the gantry or drift bottom of a drift winder, to activate and protect the EUC (and counterweight where applicable) from passing a predetermined point of travel.
Personnel Transport	Any EUC that is used for the transport of one or more persons at any time within the duty-cycle or life-cycle of the powered winding system. The term also refers to purpose designed, personal transport carriers which are attached to the conveyance of drift winders.
PES	Programmable Electronic System.
PFD	Probability of Failure on Demand - used for 'low demand mode'.
PFH	Probability of Failure per Hour– used for 'high demand or continuous mode'.
Plat	A term used for a shaft entry.
Plat Gate	A device utilised to bridge a gap that exists between the conveyance and a shaft entry to provide safe access for personnel to enter and leave the conveyance. The gate is designed in such a manner that personnel are protected from the danger of exposure to open sections of the shaft.
Plat Gate Monitoring	Electrical interlocking to monitor the opening or closing of any mine winder plat gate. This also includes mechanical interlocking monitored by the electrical control system through separate electrical interlocks to ensure that the mechanical interlocks are engaged.
PLC	Programmable Logic Controller
Powered Winding System	A gazette notice defines a powered winding system as: "For the purpose of clause Cl 3(1) 'of the *Coal Mine Health and Safety Regulation 2006* a 'powered winding system' means any mechanical

winch or hoist powered by air, electricity, internal combustion, water, or hydraulic power or operated by a force of gravity designed for the purpose of lifting or lowering persons or heavy materials to or from different levels within the underground mine and/or to the surface of the mine by means of a cable or chain attached to a skip, cage, bucket, or other type of conveyance. The powered winding system includes the; energy supply, winding apparatus, winch control circuitry, cable or chain, conveyance and supporting structure. The term does not include any: manually operated winch or mechanical light portable winch, such as portable hand air winches, chain blocks, or the like, designed for lifting small materials and not people, or winch which holds a current design registration number pursuant to the *Occupational Health and Safety Act 2001* Chapter 5, Division 3, Subdivision 1 'Registration of plant design', provided the winch is being used in accordance with the design registration conditions and for the purpose that is was designed for.

Note: This is not an exhaustive list of types of winding systems. Some systems not mentioned may or may not be included in this definition.

Powered Winding System Library

A collection of all the information relating to the powered winding system that is required for life-cycle management of the winder. It provides a continual traceable history from concept to disposal. The library can be stored as hard copy or electronic copy or both. Within the library should be a 'Design Registration File', this contains the essential and required information (mechanical and electrical) to obtain design registration, a sub-section of the Registration File is the 'Design Registration Electrical Engineering Safety File'. Where programmable systems are used, it is essential that a 'Winder Software File' is established, this particular file will contain ***all*** software changes that are made. It also contains a Radio Frequency Control File where RF systems are used as part of the winder. Alternative terms may be used for the 'Winder Library' such as 'Full Technical File' or 'Safety File'. The 'Winder Library' will in turn be an essential component of the operations Occupational Health and Safety Management System (OHSMS). For example the OHSMS may set the tolerable and ALARP risk levels, specify the hazard identification and risk analysis approach that is used within the powered winding system acquisition process. The 'Winder Library' will have clear linkages to the OHSMS in addition to the information generated specifically for the powered winding system.

Primary Safety Circuit

The Primary Safety Circuit is a safety circuit containing all the safety critical devices of the powered winding system. An initiation or failure of any of the safety critical devices shall cause an emergency stop of the powered winding system. The Safety Integrity level of each safety function in the primary safety circuit shall be level two.

Quick Stop Drift Winders

A quick stop is a controlled stop of the EUC conveyance and is designed to stop at a rate where the occurrence of slack is minimised to a safe value. A device to initiate a quick stop such as a push button activates the emergency braking system of the winder, but due to its transmission method to the EUC control system cannot be considered

	an Emergency Stop Button.
Radio Control	A method whereby control signals to and from the EUC and associated control stations are connected via any form of radio frequency link.
Radio Frequency (RF)	A method of transferring voice, data and video information from a transmitting device to a receiving device via a medium that requires no mechanical or electrical connections.
Radio Frequency Control File	Information identifying all radio frequencies used at the winder location, complete with supporting documentation as to the possible effects of RF transmission contamination. This is part of the Powered Winding System Library.
Random failure	Failure occurring at a random time, which results from one or more of the possible degradation mechanisms in the hardware. **Note:** Failures of equipment comprising many components occur at predictable rates but at unpredictable (i.e. random) times.
Reliability	The probability that a device, equipment or system is operational for a specific time period without failure.
Risk	Combination of the probability of the occurrence of harm and the severity of that harm.
Rope Creep Detection Device	A device required on drum friction winders to detect and correct relative movement between the winder rope(s) and the winder drum, thus re-establishing the correct position of the conveyance within the shaft relative to physical devices and other devices driven by the winder drum.
Rope slip device	A device required on drum friction winders to detect slippage of the rope(s) on the winder drum.
Safety Audit	An audit of the safety requirements of all of the electrical equipment and documentation of the powered winding system. It is conducted every 5 years, give or take 6 months, and verified as acceptable by a qualified electrical engineer.
Safety Circuit	A circuit which detects abnormal conditions. It shall be arranged so as to cause the winding apparatus to be brought to rest, prevent it from being moved and/or indicate the nature of the abnormal occurrence. A safety circuit shall not be dependent upon single line components for functions essential to safety and shall be protected against electrical faults.
Safe Coiling Monitor	A device to ensure that the winder rope coils safely on the winder drum and does not ‘climb up’ the rope flange or pile up on the winder drum. The device also assists in monitoring slack rope and is fitted to all winder drums with the exception of friction (Koepe) winders.
Safety Function	A function that is implemented by a safety related system, which is

(SF)	intended to maintain a safe state in respect of a specific hazardous event. A function which is intended to achieve or maintain the EUC in a safe state.
Safety Integrity	The probability of a safety-related system satisfactorily performing the required safety functions under all the stated conditions within a stated period of time. **Note:** Safety integrity comprises software safety integrity (when a PES is involved) and hardware safety integrity.
Safety Integrity Level (SIL)	A discrete level (range is from 1 to 4) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE SRS, where SIL 4 has the highest level and SIL1 the lowest. **Note:** This concept is focussed on achieving a level of risk reduction that provides tolerable risk in terms of a corporate risk matrix.
Safety-related Control Function (SRFC)	Refers to an individual protective loop in the safety system. There are potentially many SRCFs in each SRECS.
Safety-related Electrical Control System (SRECS)	The AS62061 equivalent of an E/E/PE SRS.
Safety-related system	A designated system that implements the required safety functions necessary to achieve or maintain a safe state for the EUC and is intended to achieve, on its own or with other safety-related systems, technology safety-related systems or external risk reduction facilities, the necessary safety integrity for the required safety functions. Basically it is any system (or equipment) whose failure may lead to death or injury.
SRS	Safety Requirements Specification.
Secondary Safety Circuit	The secondary safety circuit is designed to operate the service braking system and bring the EUC (conveyance) safely to rest. The Safety Integrity level of each safety function in the secondary safety circuit shall be level one.
Shaft / Drift Obstruction Monitoring	A device or devices to monitor the position of a structure deliberately installed in a shaft or drift for the purposes of inspection repair or maintenance.
Shaft / Drift Profile Monitoring	A device installed at all entrances to a shaft or drift to monitor the maximum permissible dimensions of any load taken in or out of a shaft or drift.
Shaft Entry Door / Gate Monitoring	Electrical interlocking to monitor the opening or closing any mine winder shaft entry gate or door. This also includes mechanical interlocking monitored by the electrical control system.

Slack Rope Device	A device installed on drift and shaft winders to detect the occurrence of a slack rope condition.
Stage Location Proving Device	A device to monitor the location of any movable staging in a shaft.
Stage Tilt Device	A device to detect the tilting of any staging located in a shaft. The tilting is detected before it reaches a hazardous angle of inclination.
Stop category 0	Stopping by immediate removal of power to the machine actuators (Refer AS60204.1) i.e. an uncontrolled stop.
Stop category 1	A controlled stop (Refer AS60204.1) with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved. The hazardous situation is brought under control as quickly as possible without creating other hazards.
System	A set of elements which interact according to a design, where an element of a system can be another system, called a subsystem, which may be a controlling system or a controlled system and includes hardware and software.
Systematic failure	(From AS/IEC61508 Part 4) Failure related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors.
Tail / Balance Rope Wander Switches	A minimum of two devices for each tail/balance rope is required to detect any movement likely to damage the rope or ropes in either the vertical or horizontal planes.
Test Interval	Refers to the manual functional test interval to discover undetected failures.
Torque Sensing Device	A device to detect that sufficient motor torque is available prior to the release of the winder brakes. The purpose is to prevent the possibility of 'freewheeling' of the winder.
Ultimate Over Travel Limit (Optional)	A safety device or limit switch located in the headgear for a shaft winder and end of track at the gantry of a drift winder, to activate and protect the EUC (and counterweight where applicable) from passing a predetermined point of travel. The device is located at a point after the over travel limit in the primary safety circuit.
Ultimate Safety Circuit (Optional)	The ultimate safety circuit is designed to operate independently to that of the primary safety circuit and in an emergency operates as a 'back up' stopping system to that of the primary safety circuit.
Ultimate Under Travel Limit	A safety device or limit switch located at the shaft bottom of a shaft winder and at drift bottom of a drift winder, to activate and protect the

(Optional)	EUC (and counterweight where applicable) from passing a predetermined point of travel. The device is located at a point after the under travel limit located in the primary safety circuit.
Winder	Apparatus in which EUC's are raised and lowered by means of a rope attached directly to the EUC, and winding onto or over a cylindrical drum, or drums; or a rack and pinion system.
Winder Drum Over Speed Device	A device driven by the winder drum to detect an over speed of 110% of the nominal speed of the winder.
Winder Motor / Motive Force (hydraulic / pneumatic) Over Speed Device	A device driven by the winder motor shaft to detect an over speed of 112% of the nominal speed of the winder.
Winder Speed Profile Monitoring	A device to detect an over speed of the winder during periods of acceleration, constant speed and deceleration. Usually set at 5% of the nominal speed profile of the winder.
Winder Types	2.104.1 Double Drum Winder – Shaft - Not Fitted with a Clutch 2.104.2 Double Drum Winder – Shaft - Fitted with a Clutch, 2.104.3 Drift Winder – Single Rope. 2.104.4 Friction Winder – Shaft – Bulk Material. 2.104.5 Friction Winder – Shaft – Men and Materials. 2.104.6 Raise Climbing Winder – Rack and Pinion, 2.104.7 Shaft Sinking Winder, 2.104.8 Shaft Winder – Single Rope.

3. Winder characteristics

3.1 Winder types

Modern powered winding control systems utilise encoders coupled with pre-programmed software thereby reducing the number of driven components required. However, conventional principles of control system design are still applied.

Note: Shaft designers are reminded that the design of shafts utilising sumps is discouraged. It is desired that self draining shaft bottoms be provided. There have been several instances of people being drowned when lowered into water filled sumps. Refer to Figure 13.

Typical winder house facilities are shown in Figure 14.

3.1.1 Double Drum Winder – Shaft – Not Fitted with a clutch

A Powered Winding System installed in a single shaft, comprising two winding drums directly coupled together.

The winder configuration can consist of two man riding cages or one man riding cage with a counterweight, or one material tub with a counterweight or two material tubs.

Where a material tub or tubs is/are used, one tub is fitted with man riding facilities for the purpose of shaft inspection and/or second means of egress.

There may or may not be a tail or balance rope connected between the two shaft EUC's, and fixed guides or rope guides will be utilised for the EUC's.

Winder controls within the conveyance are provided by radio frequency and/or data transmission which includes communication systems. However some systems utilise a trailing cable attached to the underside of the conveyance to supply these functions.

Some systems are capable of carrying 150 men – usually in a double cage arrangement.

Note: Currently there are no operational winders of this design installed in NSW.

3.1.2 Double Drum Winder – Shaft – Fitted with a clutch (see figures 1 and 2)

A Powered Winding System installed in a single shaft, comprising two winding drums coupled together through a clutch. The drive shaft to one drum can be disconnected and the disconnected drum locked in position thus permitting the other drum to be operated independently to that of the locked drum.

The winder configuration can consist of two man riding cages or one man riding cage with a counterweight. This type of winder is not generally used for material winding.

There may or may not be a tail or balance rope(s) connected between the two shaft EUC's, and fixed guides or rope guides will be will be utilised for the EUC's.

Winder controls within the conveyance are provided by radio frequency and/or data transmission which also includes communication systems, however some systems utilise a trailing cable attached to the underside of the conveyance to supply these functions.

Some systems are capable of carrying 150 men – usually in a double cage arrangement.

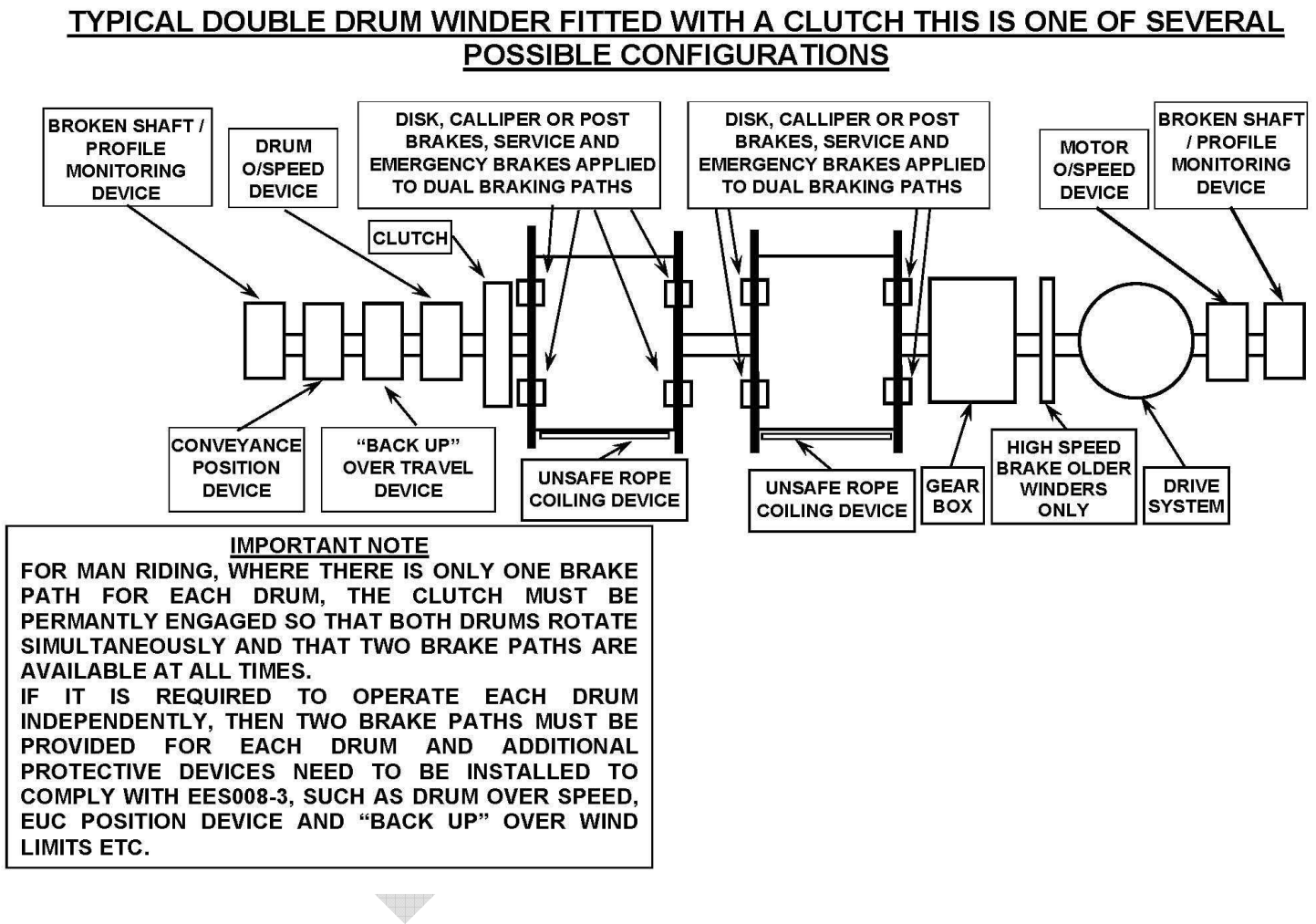
Double Drum Winder

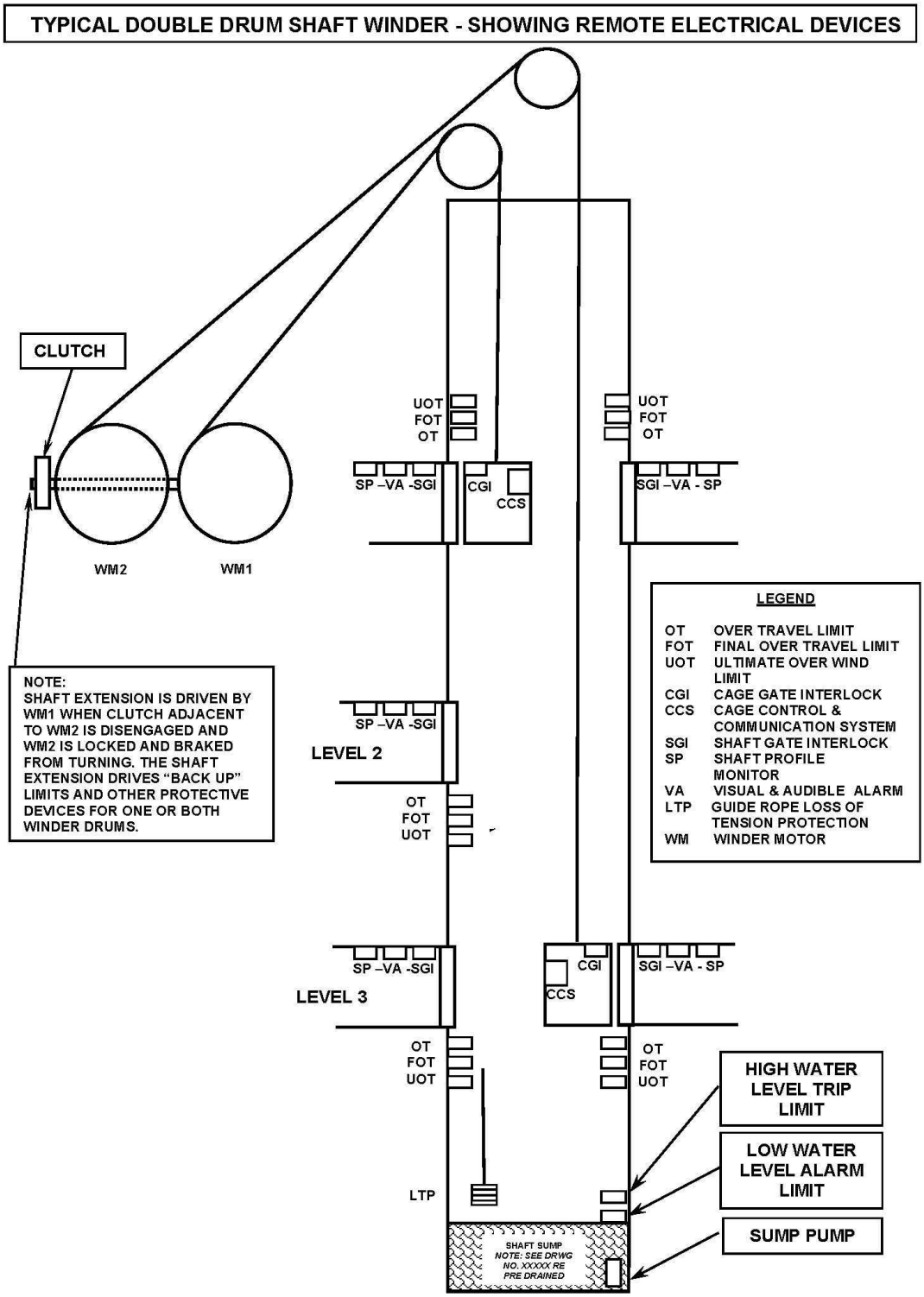
For man riding, where there is only one brake path for each drum, the clutch must be permanently engaged so that both drums rotate simultaneously and that two brake paths are available at all times.

Note:

If it is required to operate each drum independently, then two brake paths must be provided for each drum and additional protective devices need to be installed to comply with EES008-3, such as drum over speed, EUC position device and 'back up' over wind limits etc.

Figure 1:


TYPICAL DOUBLE DRUM WINDER FITTED WITH A CLUTCH THIS IS ONE OF SEVERAL POSSIBLE CONFIGURATIONS
BROKEN SHAFT / PROFILE MONITORING DEVICE
DRUM O/SPEED DEVICE
DISK, CALLIPER OR POST BRAKES, SERVICE AND EMERGENCY BRAKES APPLIED TO DUAL BRAKING PATHS
DISK, CALLIPER OR POST BRAKES, SERVICE AND EMERGENCY BRAKES APPLIED TO DUAL BRAKING PATHS
MOTOR O/SPEED DEVICE
BROKEN SHAFT / PROFILE MONITORING DEVICE
CLUTCH
CONVEYANCE POSITION DEVICE
"BACK UP" OVER TRAVEL DEVICE
UNSAFE ROPE COILING DEVICE
UNSAFE ROPE COILING DEVICE
GEAR BOX
HIGH SPEED BRAKE OLDER WINDERS ONLY
DRIVE SYSTEM
IMPORTANT NOTE
FOR MAN RIDING, WHERE THERE IS ONLY ONE BRAKE PATH FOR EACH DRUM, THE CLUTCH MUST BE PERMANTLY ENGAGED SO THAT BOTH DRUMS ROTATE SIMULTANEOUSLY AND THAT TWO BRAKE PATHS ARE AVAILABLE AT ALL TIMES.
IF IT IS REQUIRED TO OPERATE EACH DRUM INDEPENDENTLY, THEN TWO BRAKE PATHS MUST BE PROVIDED FOR EACH DRUM AND ADDITIONAL PROTECTIVE DEVICES NEED TO BE INSTALLED TO COMPLY WITH EES008-3, SUCH AS DRUM OVER SPEED, EUC POSITION DEVICE AND "BACK UP" OVER WIND LIMITS ETC.


TYPICAL DOUBLE DRUM SHAFT WINDER - SHOWING REMOTE ELECTRICAL DEVICES
CLUTCH
WM2
WM1
NOTE:
SHAFT EXTENSION IS DRIVEN BY WM1 WHEN CLUTCH ADJACENT TO WM2 IS DISENGAGED AND WM2 IS LOCKED AND BRAKED FROM TURNING. THE SHAFT EXTENSION DRIVES "BACK UP" LIMITS AND OTHER PROTECTIVE DEVICES FOR ONE OR BOTH WINDER DRUMS.
UOT
FOT
OT
SP –VA -SGI
CGI
CCS
SGI –VA - SP
LEVEL 2
LEVEL 3
LTP
SHAFT SUMP
NOTE: SEE DRWG NO. XXXXX RE PRE DRAINED
HIGH WATER LEVEL TRIP LIMIT
LOW WATER LEVEL ALARM LIMIT
SUMP PUMP
LEGEND
OT OVER TRAVEL LIMIT
FOT FINAL OVER TRAVEL LIMIT
UOT ULTIMATE OVER WIND LIMIT
CGI CAGE GATE INTERLOCK
CCS CAGE CONTROL & COMMUNICATION SYSTEM
SGI SHAFT GATE INTERLOCK
SP SHAFT PROFILE MONITOR
VA VISUAL & AUDIBLE ALARM
LTP GUIDE ROPE LOSS OF TENSION PROTECTION
WM WINDER MOTOR

3.1.3 Drift Winder – Single Rope (see figures 3, 4, 5 and 6)

A Powered Winding System installed in a single drift, usually installed in coal mines at a gradient of approximately 1 in 3¼.

The Powered Winding system comprises a single rope single drum winder attached to a track mounted EUC conveyance (often called a “Dolly Car”). The conveyance is designed to carry up to 30 men and can have additional man transports attached.

Refer to Figure 5 for typical dolly car arrangements.

The conveyance is also designed to attach rolling stock for the movement of heavy machinery and materials in and out of the mine.

The Powered Winding System is automatically or semi automatically controlled from the conveyance via radio frequency and/or data transmission which includes communication systems. The conveyance is usually provided with a ‘call’ function.

Single rope drift winder conveyance entering a drift

Single rope drift winder drum

Figure 3: Drift Winder - Single Rope.

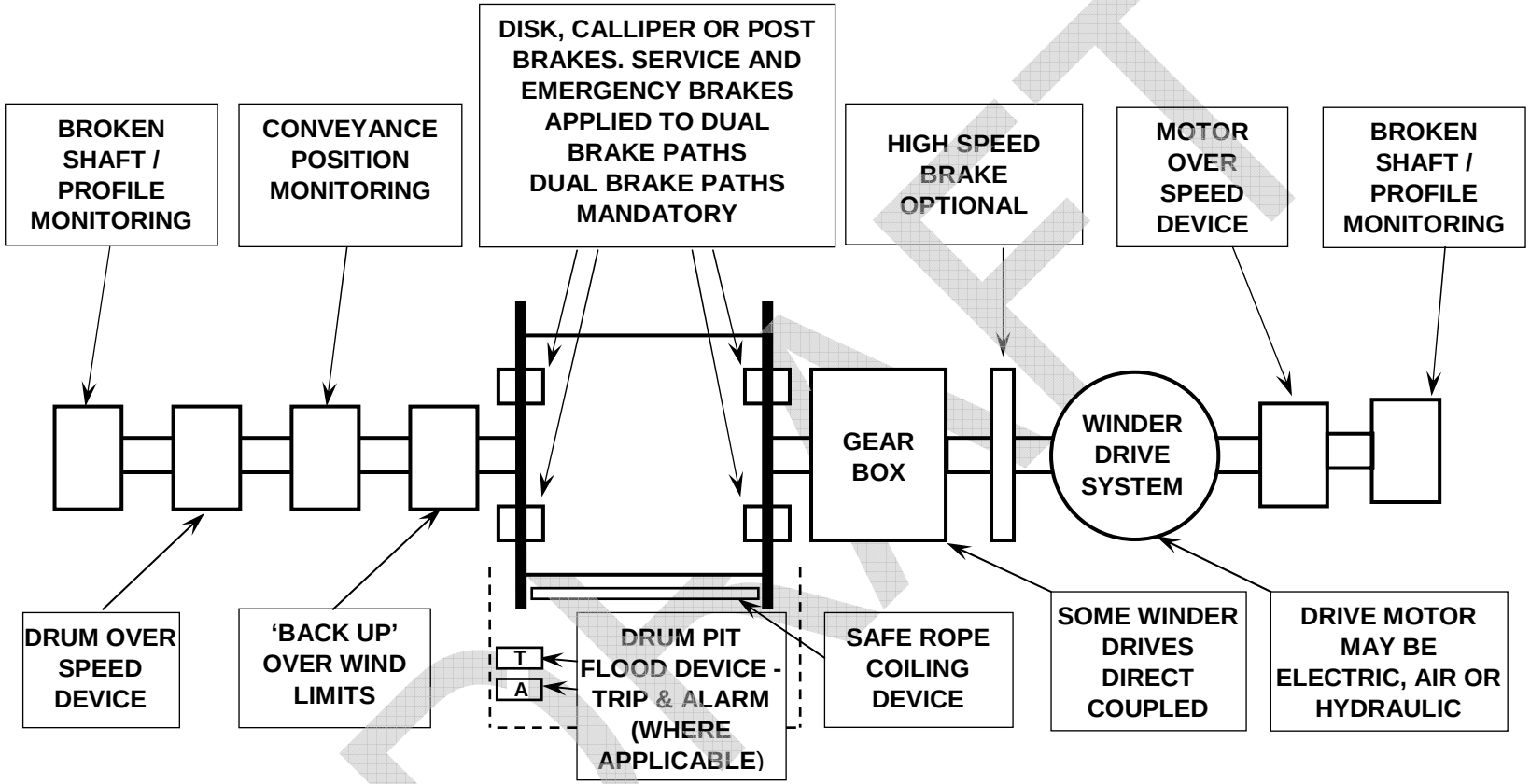


Figure 4:

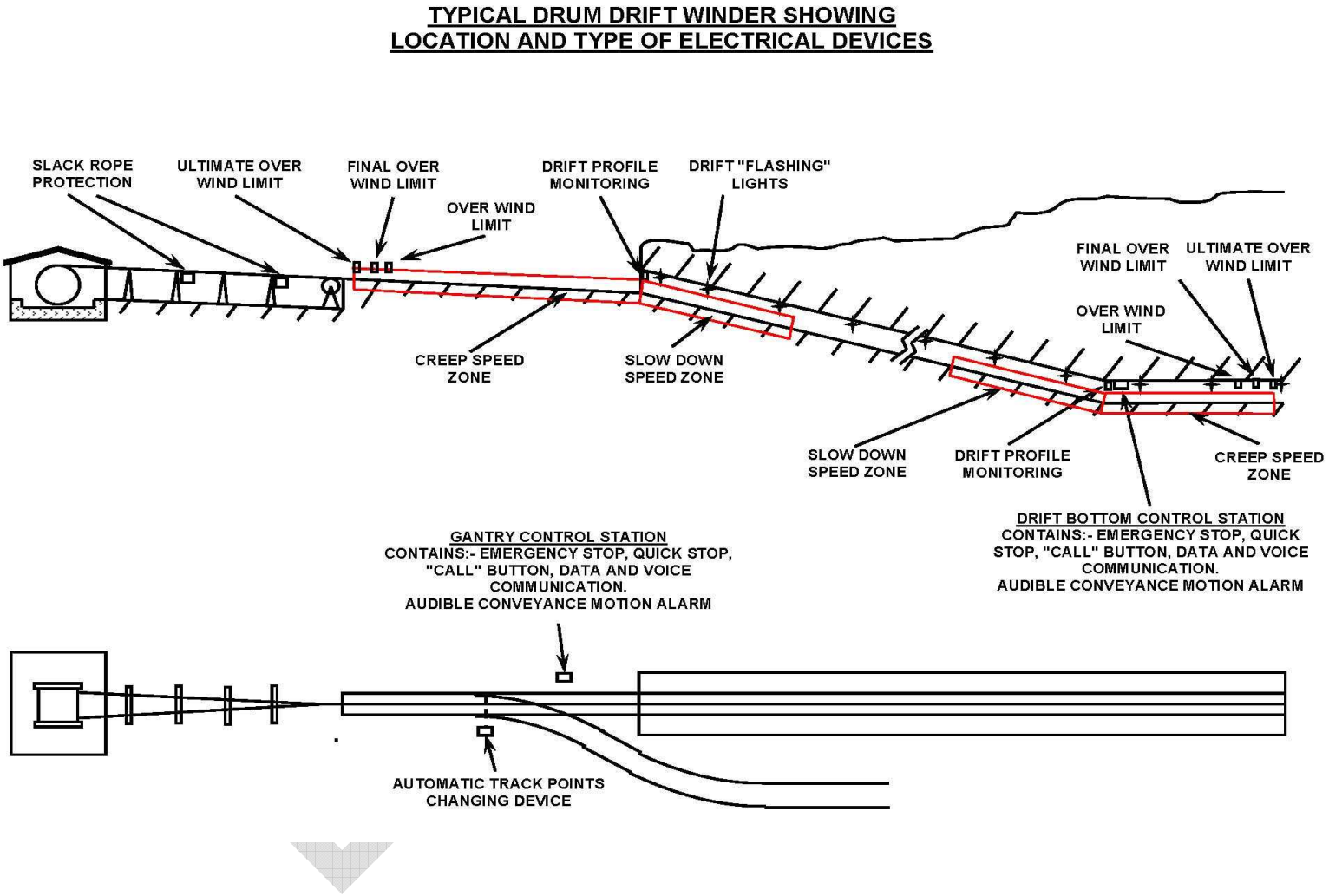

TYPICAL DRUM DRIFT WINDER SHOWING
LOCATION AND TYPE OF ELECTRICAL DEVICES
SLACK ROPE PROTECTION
ULTIMATE OVER WIND LIMIT
FINAL OVER WIND LIMIT
OVER WIND LIMIT
DRIFT PROFILE MONITORING
DRIFT "FLASHING" LIGHTS
CREEP SPEED ZONE
SLOW DOWN SPEED ZONE
FINAL OVER WIND LIMIT
ULTIMATE OVER WIND LIMIT
OVER WIND LIMIT
SLOW DOWN SPEED ZONE
DRIFT PROFILE MONITORING
CREEP SPEED ZONE
DRIFT BOTTOM CONTROL STATION
CONTAINS:- EMERGENCY STOP, QUICK STOP, "CALL" BUTTON, DATA AND VOICE COMMUNICATION.
AUDIBLE CONVEYANCE MOTION ALARM
GANTRY CONTROL STATION
CONTAINS:- EMERGENCY STOP, QUICK STOP, "CALL" BUTTON, DATA AND VOICE COMMUNICATION.
AUDIBLE CONVEYANCE MOTION ALARM
AUTOMATIC TRACK POINTS CHANGING DEVICE

Figure 5: Typical Electrical Devices Used On Conveyance (Dolly Car) of Drift Winders – Side elevation view.

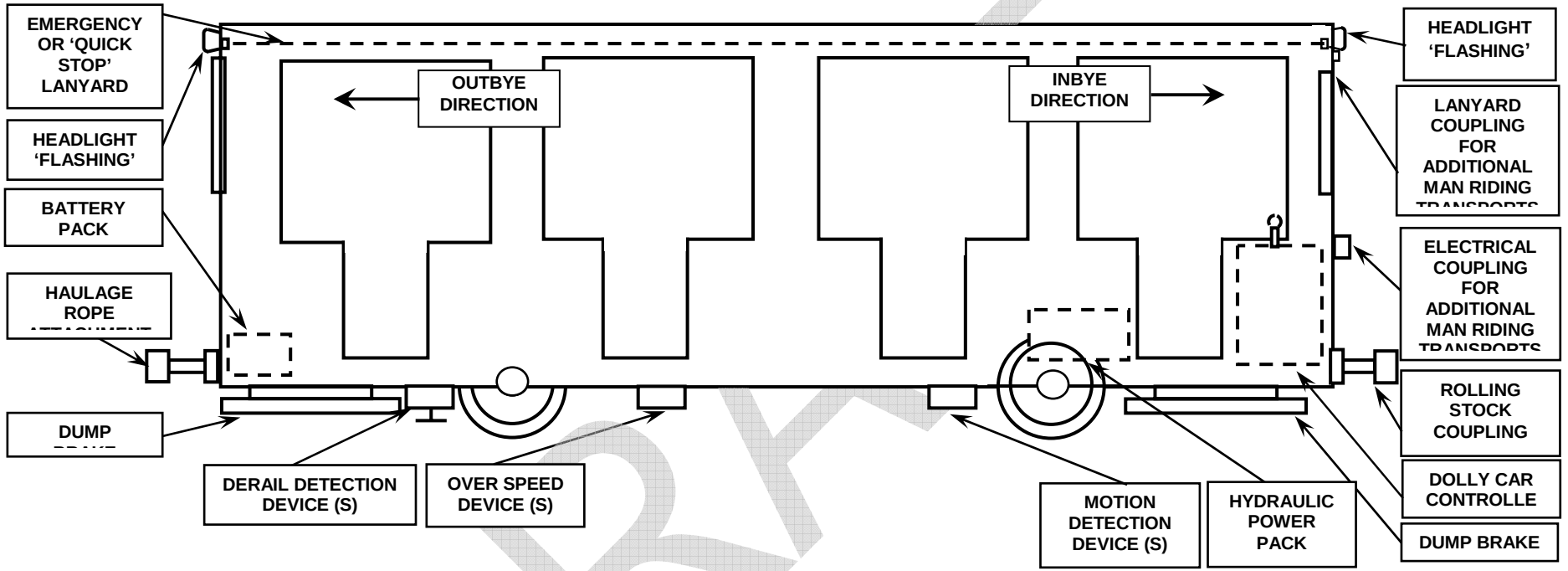
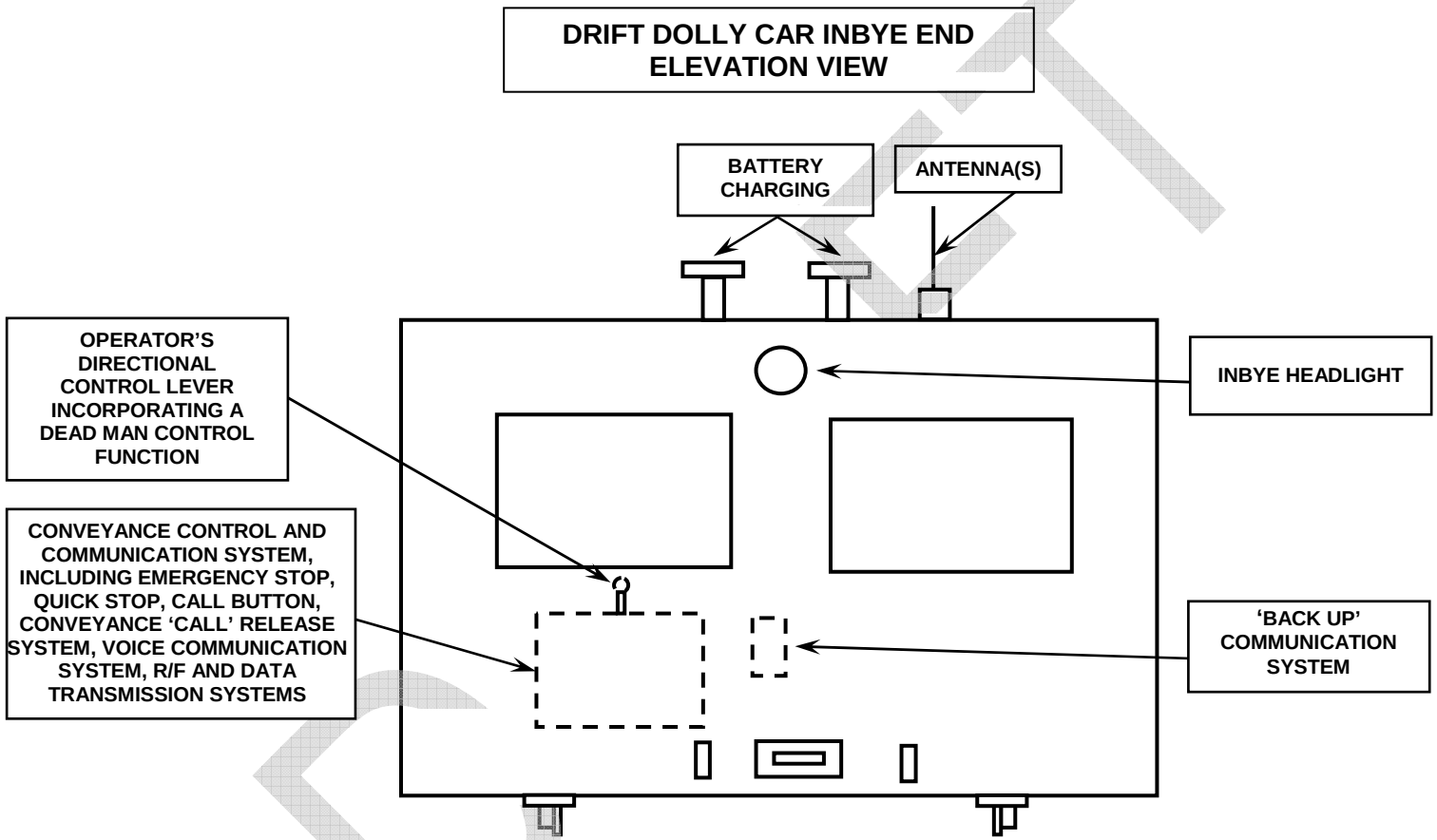


Figure 6: Typical Controller Used On Conveyance (Dolly Car) of Drift Winders – End elevation view.



3.1.4 Friction Winder – Shaft – Bulk Material (see figures 7 and 8)

A Powered Winding System installed in a single shaft, comprising a single winding drum. It is often referred to as a Koepe Winder.

The winder drive system is generally tower mounted, however some are ground mounted.

The winding system comprises two to six ropes attached to the EUC conveyances. The number of ropes is dependent on the payload and depth required.

The principle of operation is that the ropes are taken over the winder drum with a half lap, thus relying on the friction between the ropes and the drum to drive the load.

The Powered Winding System normally comprises two tubs attached to each end of the winding ropes with a payload from 2 to 30 tonnes of material.

At least one material tub is fitted with man riding facilities for the purpose of shaft inspection and/or second means of egress.

One or two balance (tail) ropes are attached to the bottom of each of material tubs and fixed guides or rope guides are utilised for the EUC's.

Loading and unloading facilities are provided at the shaft bottom and in the headframe.

Winder controls within the conveyance fitted with man riding facilities are provided by radio frequency and/or data transmission which also includes communication systems.

Refer to Figure 5 and Figure 6 in Section 3.1.5

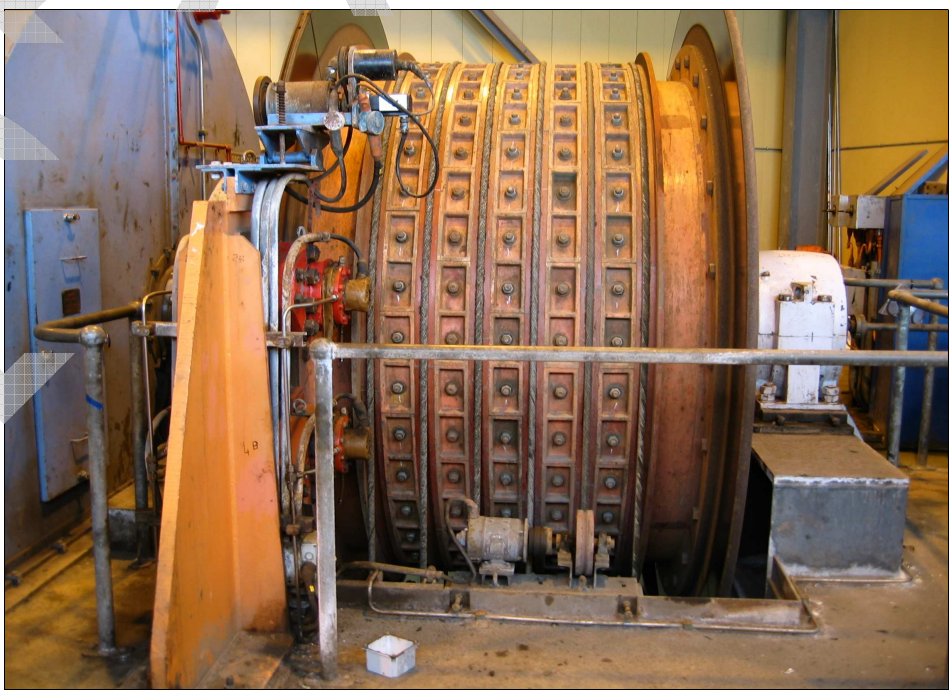
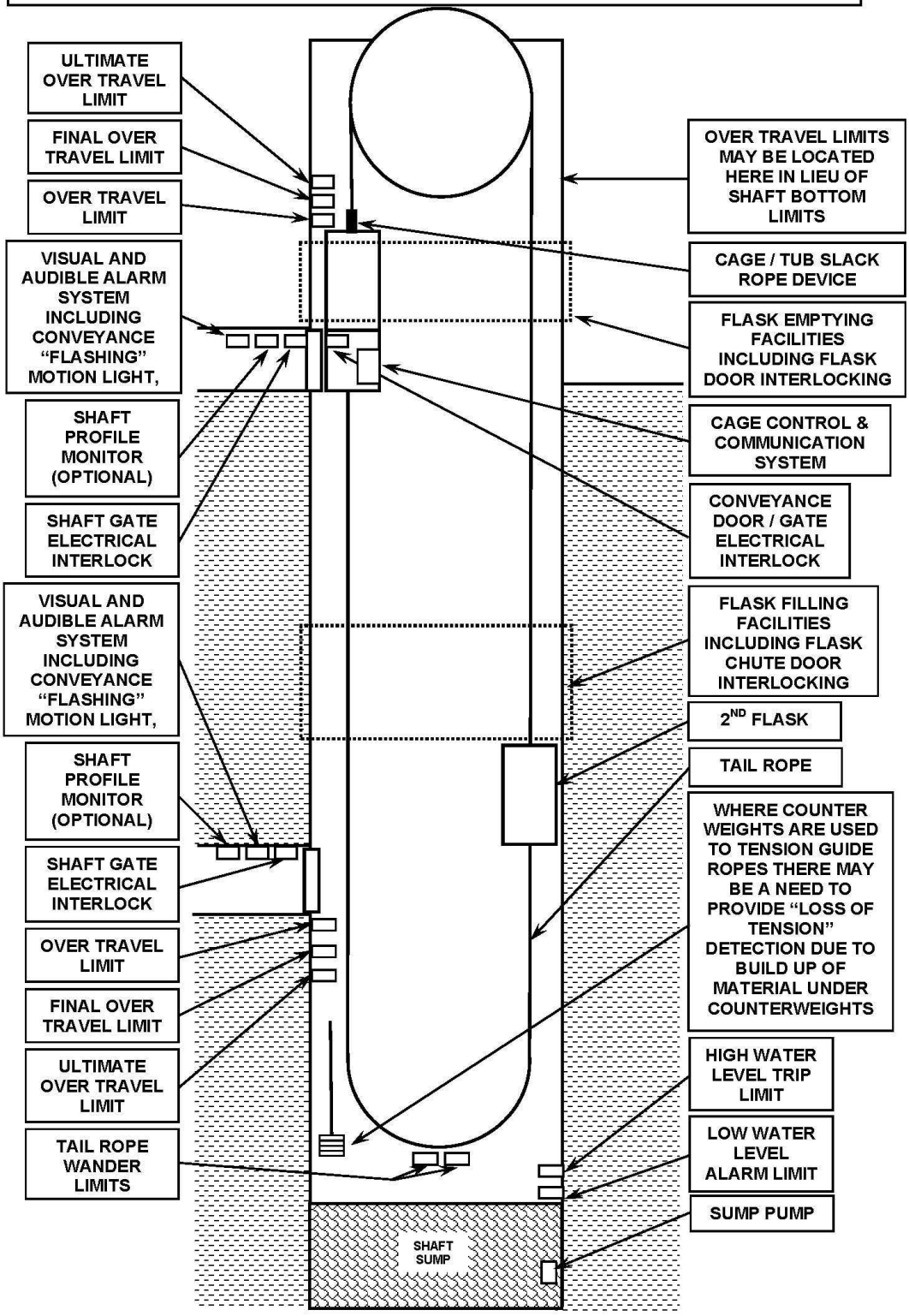


Figure 7 – Bulk Friction Winder for Materials Handling and Man Riding

TYPICAL BULK FRICTION WINDER WITH PROVISION FOR MAN RIDING SHOWING REMOTE ELECTRICAL DEVICES



Bulk Friction Winder Headframe

3.1.5 Friction Winder – Shaft – Men and materials (see figures 8 and 9).

The winding system comprises two to six ropes attached to the EUC conveyances. The number of ropes depends on the payload and depth required.

The principle of operation is that the ropes are taken over the winder drum with a half lap, thus relying on the friction between the ropes and the drum to drive the load.

The Powered Winding System can consist of either one men and materials conveyance and counterweight individually fitted to either end of the winding ropes or two men and materials conveyances fitted to either end of the winding ropes

Some systems are capable of carrying 150 men – usually in a double cage arrangement.

One or two balance (tail) ropes are attached to the bottom of each of the men conveyances.

Winder controls within the conveyance are provided mostly by radio frequency and/or data transmission which also includes communication systems, however some systems utilise a trailing cable attached to the underside of the conveyance to supply these functions.

Refer to Figure 5 in 3.1.3 and to Figure 7 following.

Friction Winder tower – men and materials

Friction winder drum – men and materials

Figure 8: Typical Friction Shaft Winder Drive System Showing Electrical Devices.

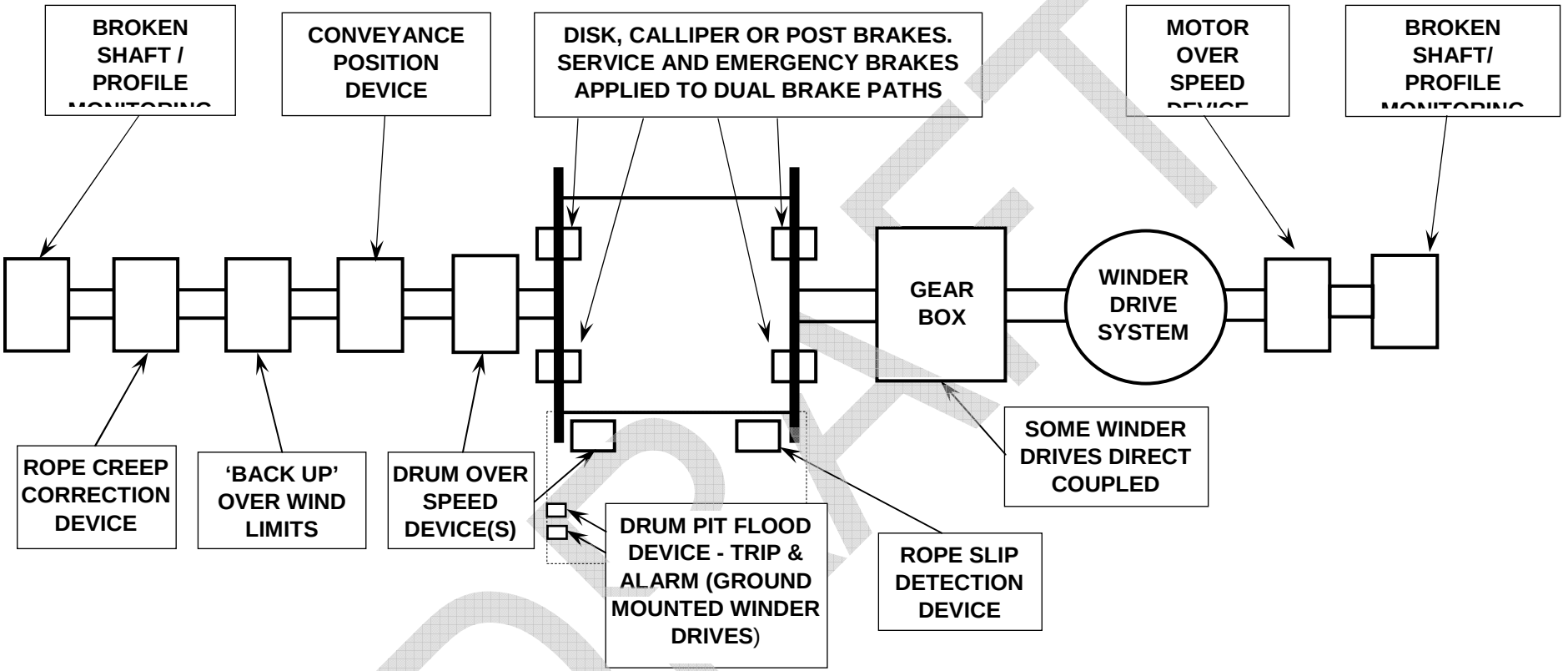
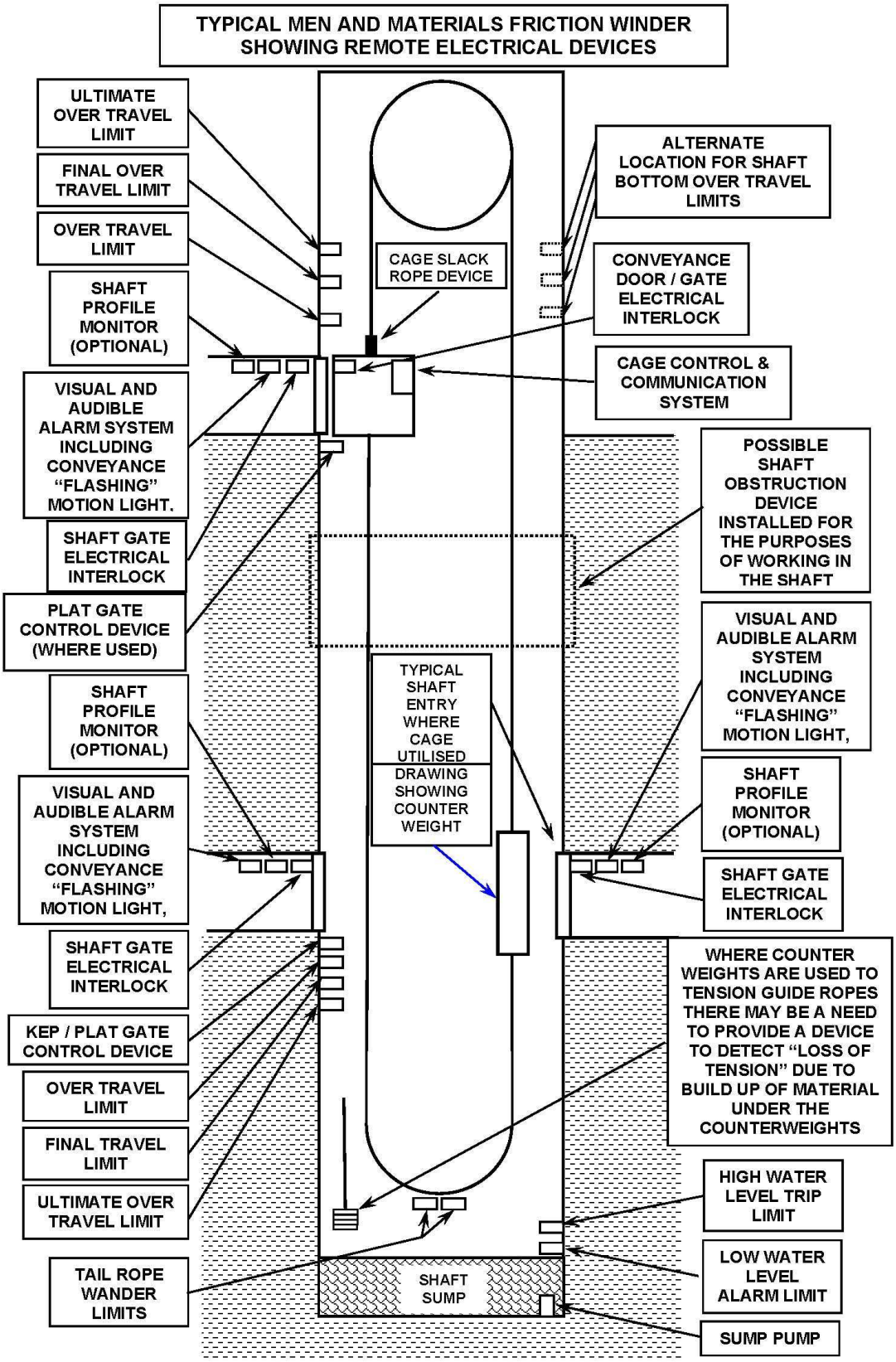


Figure 9: Typical Men and Materials Friction Winder


TYPICAL MEN AND MATERIALS FRICTION WINDER SHOWING REMOTE ELECTRICAL DEVICES
ULTIMATE OVER TRAVEL LIMIT
FINAL OVER TRAVEL LIMIT
OVER TRAVEL LIMIT
SHAFT PROFILE MONITOR (OPTIONAL)
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT.
SHAFT GATE ELECTRICAL INTERLOCK
PLAT GATE CONTROL DEVICE (WHERE USED)
SHAFT PROFILE MONITOR (OPTIONAL)
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT,
SHAFT GATE ELECTRICAL INTERLOCK
KEP / PLAT GATE CONTROL DEVICE
OVER TRAVEL LIMIT
FINAL TRAVEL LIMIT
ULTIMATE OVER TRAVEL LIMIT
TAIL ROPE WANDER LIMITS
CAGE SLACK ROPE DEVICE
ALTERNATE LOCATION FOR SHAFT BOTTOM OVER TRAVEL LIMITS
CONVEYANCE DOOR / GATE ELECTRICAL INTERLOCK
CAGE CONTROL & COMMUNICATION SYSTEM
POSSIBLE SHAFT OBSTRUCTION DEVICE INSTALLED FOR THE PURPOSES OF WORKING IN THE SHAFT
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT,
SHAFT PROFILE MONITOR (OPTIONAL)
SHAFT GATE ELECTRICAL INTERLOCK
TYPICAL SHAFT ENTRY WHERE CAGE UTILISED
DRAWING SHOWING COUNTER WEIGHT
WHERE COUNTER WEIGHTS ARE USED TO TENSION GUIDE ROPES THERE MAY BE A NEED TO PROVIDE A DEVICE TO DETECT "LOSS OF TENSION" DUE TO BUILD UP OF MATERIAL UNDER THE COUNTERWEIGHTS
HIGH WATER LEVEL TRIP LIMIT
LOW WATER LEVEL ALARM LIMIT
SUMP PUMP
SHAFT SUMP

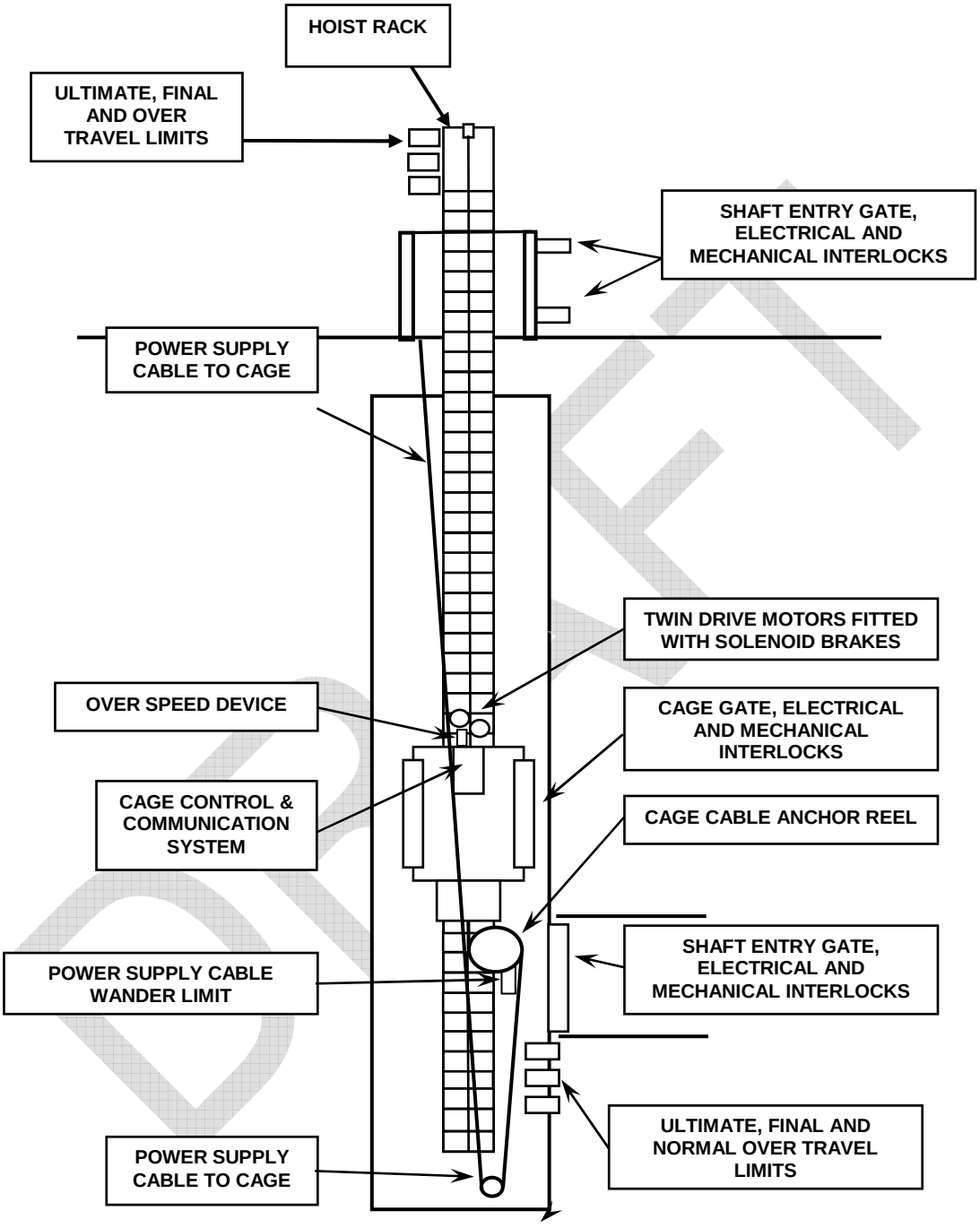
3.1.6 Raise Climbing Winder – Rack and pinion (see figure 10).

These Powered Winding Systems are utilised in mines for the purpose of a second means of egress and/or for the carriage of light materials. They consist of a single rack secured to the shaft side and an EUC conveyance provided with two pinion drive motors each fitted with a solenoid operated disc brake. It can be designed to carry up to 30 men. Power for the drive motors, conveyance control and communication systems is obtained via a trailing cable attached to the underside of the conveyance.

Rack and pinion raise climbing winder

Raise climbing winder conveyance with trailing cable

Figure 10: Typical Rack and Pinion Hoist Showing Remote Electrical Devices.



3.1.7 Shaft Sinking Winder (see figure 11).

These Powered Winding Systems are usually mobile and are moved from site to site. They are used for sinking new shafts or for carrying out repairs, modifications or maintenance to existing shafts. They are generally, but not limited to, a single rope drum winder.

The most common configuration is for a single rope winder fitted with a conveyance or a kibble (for removing material), coupled with a 'staging' or working platform driven by a separate winding drum or drums.

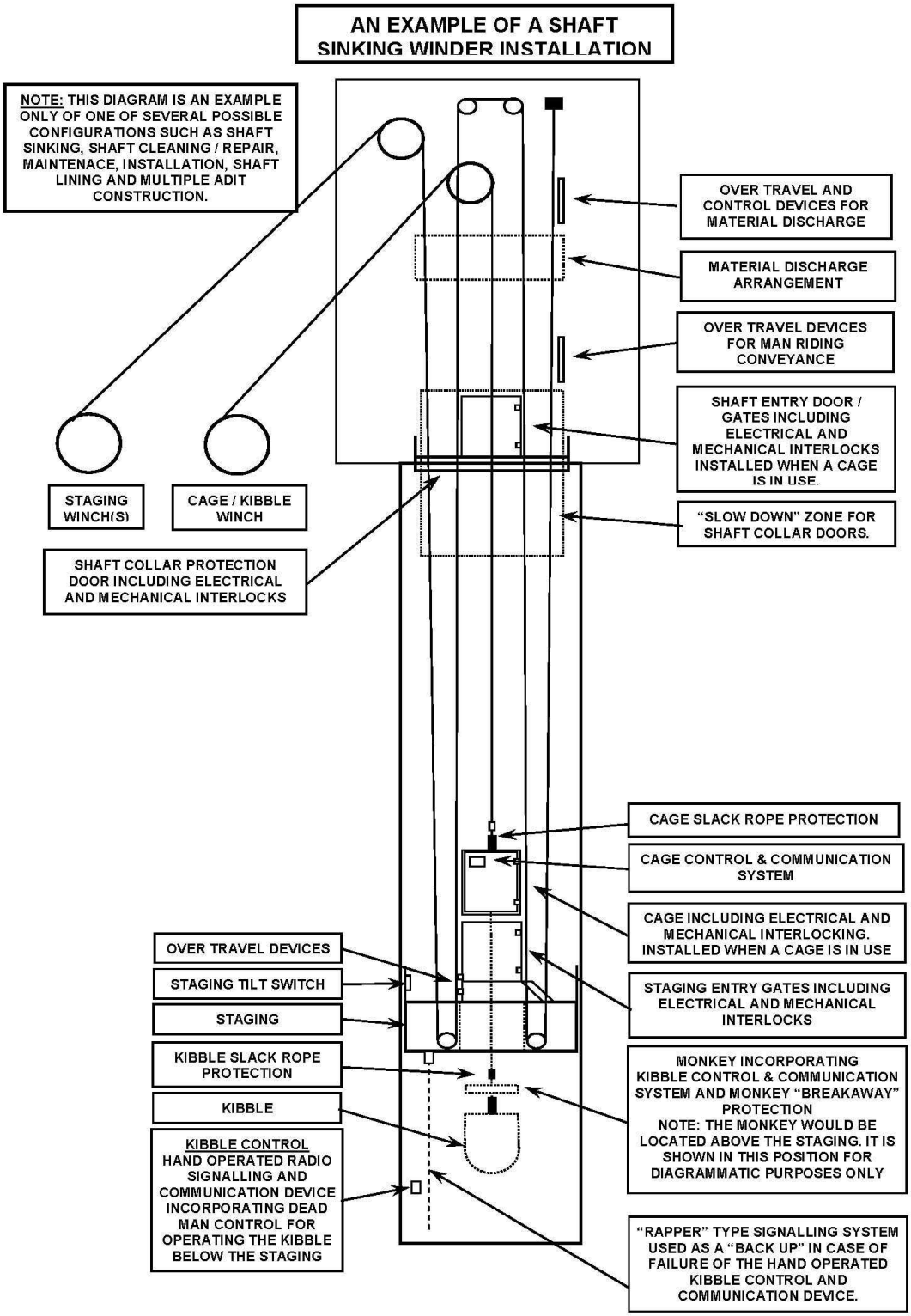
It is customary for the cage/kibble to utilise the ropes supporting and operating the 'staging' as guide ropes. Provision is made on the surface for the discharge of material from the kibble.

Winder controls within the conveyance or kibble are provided mostly by radio frequency and/or data transmission including communication systems.

Shaft sinking winder

Cable drum of mobile shaft sinking winder

Figure 11:


AN EXAMPLE OF A SHAFT SINKING WINDER INSTALLATION
NOTE: THIS DIAGRAM IS AN EXAMPLE ONLY OF ONE OF SEVERAL POSSIBLE CONFIGURATIONS SUCH AS SHAFT SINKING, SHAFT CLEANING / REPAIR, MAINTENACE, INSTALLATION, SHAFT LINING AND MULTIPLE ADIT CONSTRUCTION.
OVER TRAVEL AND CONTROL DEVICES FOR MATERIAL DISCHARGE
MATERIAL DISCHARGE ARRANGEMENT
OVER TRAVEL DEVICES FOR MAN RIDING CONVEYANCE
SHAFT ENTRY DOOR / GATES INCLUDING ELECTRICAL AND MECHANICAL INTERLOCKS INSTALLED WHEN A CAGE IS IN USE.
"SLOW DOWN" ZONE FOR SHAFT COLLAR DOORS.
STAGING WINCH(S)
CAGE / KIBBLE WINCH
SHAFT COLLAR PROTECTION DOOR INCLUDING ELECTRICAL AND MECHANICAL INTERLOCKS
CAGE SLACK ROPE PROTECTION
CAGE CONTROL & COMMUNICATION SYSTEM
CAGE INCLUDING ELECTRICAL AND MECHANICAL INTERLOCKING. INSTALLED WHEN A CAGE IS IN USE
STAGING ENTRY GATES INCLUDING ELECTRICAL AND MECHANICAL INTERLOCKS
OVER TRAVEL DEVICES
STAGING TILT SWITCH
STAGING
KIBBLE SLACK ROPE PROTECTION
KIBBLE
KIBBLE CONTROL HAND OPERATED RADIO SIGNALLING AND COMMUNICATION DEVICE INCORPORATING DEAD MAN CONTROL FOR OPERATING THE KIBBLE BELOW THE STAGING
MONKEY INCORPORATING KIBBLE CONTROL & COMMUNICATION SYSTEM AND MONKEY "BREAKAWAY" PROTECTION
NOTE: THE MONKEY WOULD BE LOCATED ABOVE THE STAGING. IT IS SHOWN IN THIS POSITION FOR DIAGRAMMATIC PURPOSES ONLY
"RAPPER" TYPE SIGNALLING SYSTEM USED AS A "BACK UP" IN CASE OF FAILURE OF THE HAND OPERATED KIBBLE CONTROL AND COMMUNICATION DEVICE.

3.1.8 Shaft Winder – Single Rope (see figures 12 and 13)

A Powered Winding System installed in a shaft, comprising a single rope single drum winder attached to a conveyance. The conveyance can be designed to operate as a man only or men and materials configuration and can carry up to 150 men (double cage) and is often utilised as a second means of egress. Fixed or rope guides are used for the EUC conveyance.

The Powered Winding System is controlled from within the conveyance via radio frequency and/or data transmission which includes communication systems. Control and communication systems are sometimes supplied via a trailing cable attached to the underside of the conveyance. The Winding Systems are sometimes provided with a 'call' function.

Single rope shaft winder

Drum of single rope shaft winder

Figure 12: Typical Drum Drift Winder and Single Rope Shaft Winder Drive System Showing Electrical Devices.

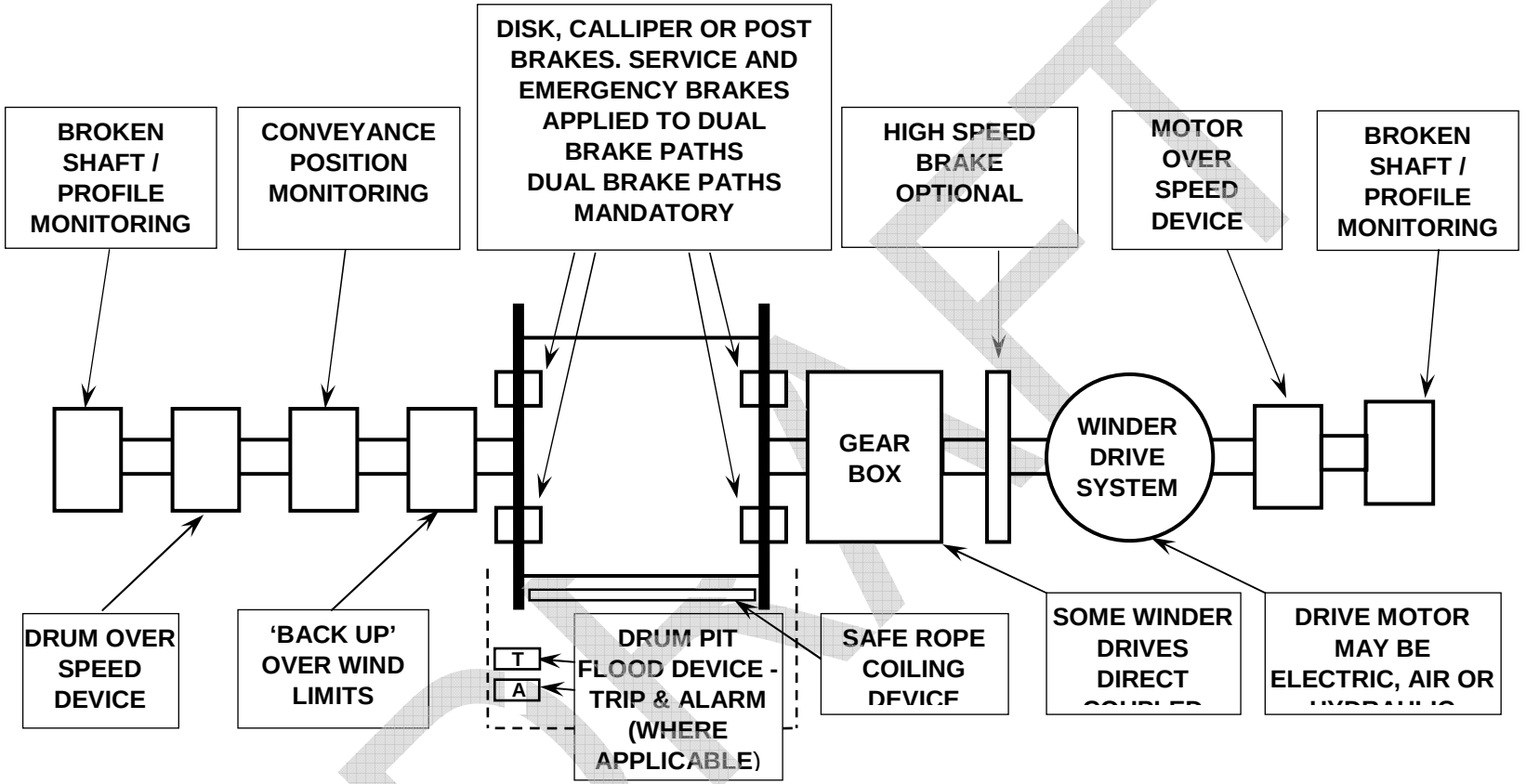
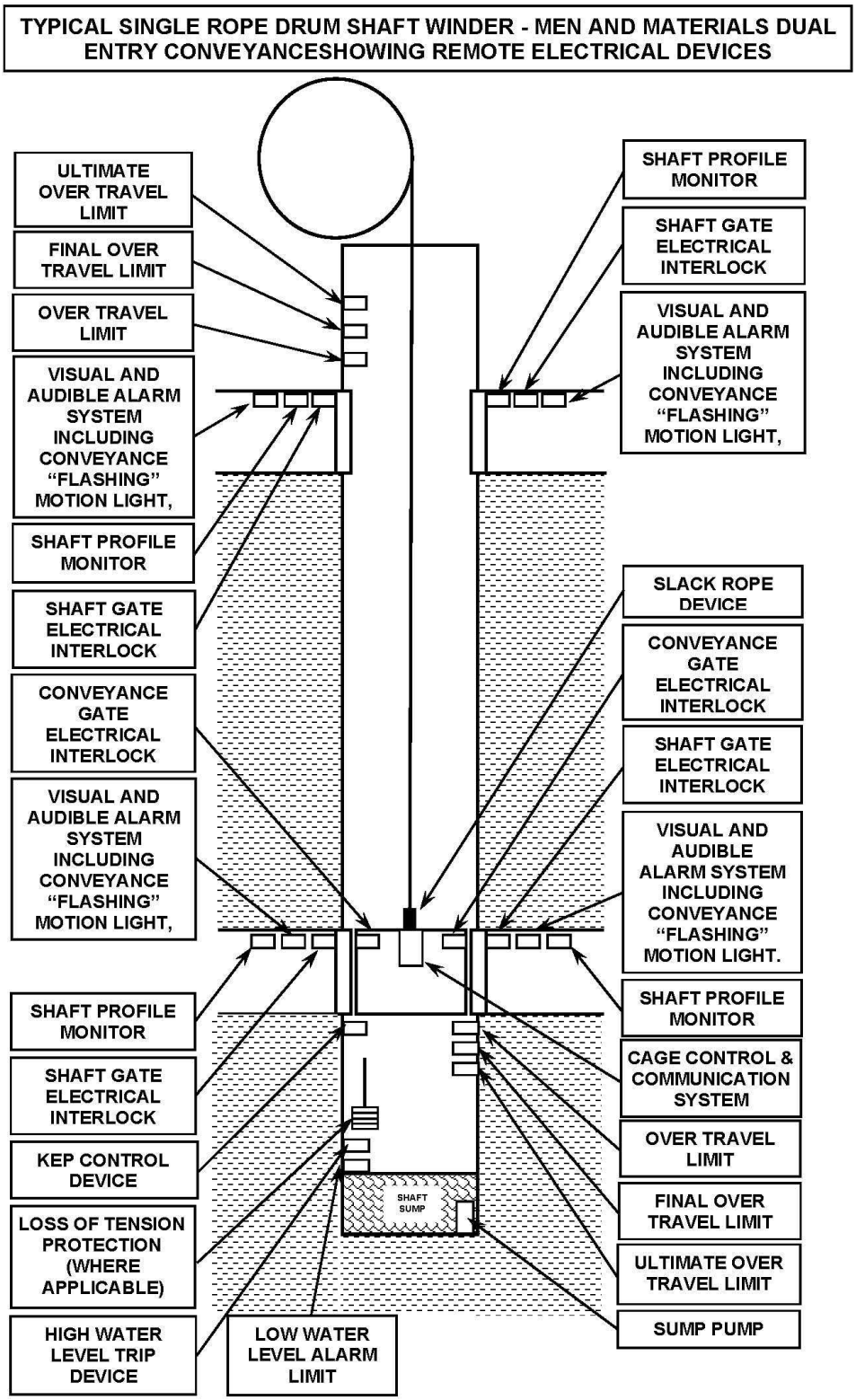


Figure 13:


TYPICAL SINGLE ROPE DRUM SHAFT WINDER - MEN AND MATERIALS DUAL ENTRY CONVEYANCESHOWING REMOTE ELECTRICAL DEVICES
ULTIMATE OVER TRAVEL LIMIT
FINAL OVER TRAVEL LIMIT
OVER TRAVEL LIMIT
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT,
SHAFT PROFILE MONITOR
SHAFT GATE ELECTRICAL INTERLOCK
CONVEYANCE GATE ELECTRICAL INTERLOCK
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT,
SHAFT PROFILE MONITOR
SHAFT GATE ELECTRICAL INTERLOCK
KEP CONTROL DEVICE
LOSS OF TENSION PROTECTION (WHERE APPLICABLE)
HIGH WATER LEVEL TRIP DEVICE
LOW WATER LEVEL ALARM LIMIT
SHAFT SUMP
SHAFT PROFILE MONITOR
SHAFT GATE ELECTRICAL INTERLOCK
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT,
SLACK ROPE DEVICE
CONVEYANCE GATE ELECTRICAL INTERLOCK
SHAFT GATE ELECTRICAL INTERLOCK
VISUAL AND AUDIBLE ALARM SYSTEM INCLUDING CONVEYANCE "FLASHING" MOTION LIGHT.
SHAFT PROFILE MONITOR
CAGE CONTROL & COMMUNICATION SYSTEM
OVER TRAVEL LIMIT
FINAL OVER TRAVEL LIMIT
ULTIMATE OVER TRAVEL LIMIT
SUMP PUMP

3.2 Winder Drive Systems

Ward Leonard, thyristor, vvvf, squirrel cage induction motor, slipring induction motor, hydraulic, air.

3.3 Winder Brake Types

Disc, drum, calliper, pressure applied spring back up calliper. Post, suspended post, parallel motion – all should be fail to safety and are spring or counterweight applied.

Band brakes shall not be used.

3.4 Winder Brake Operating Mediums

Hydraulic, air, electro magnetic thrustor.

Figure 14: Shaft bottom arrangement.

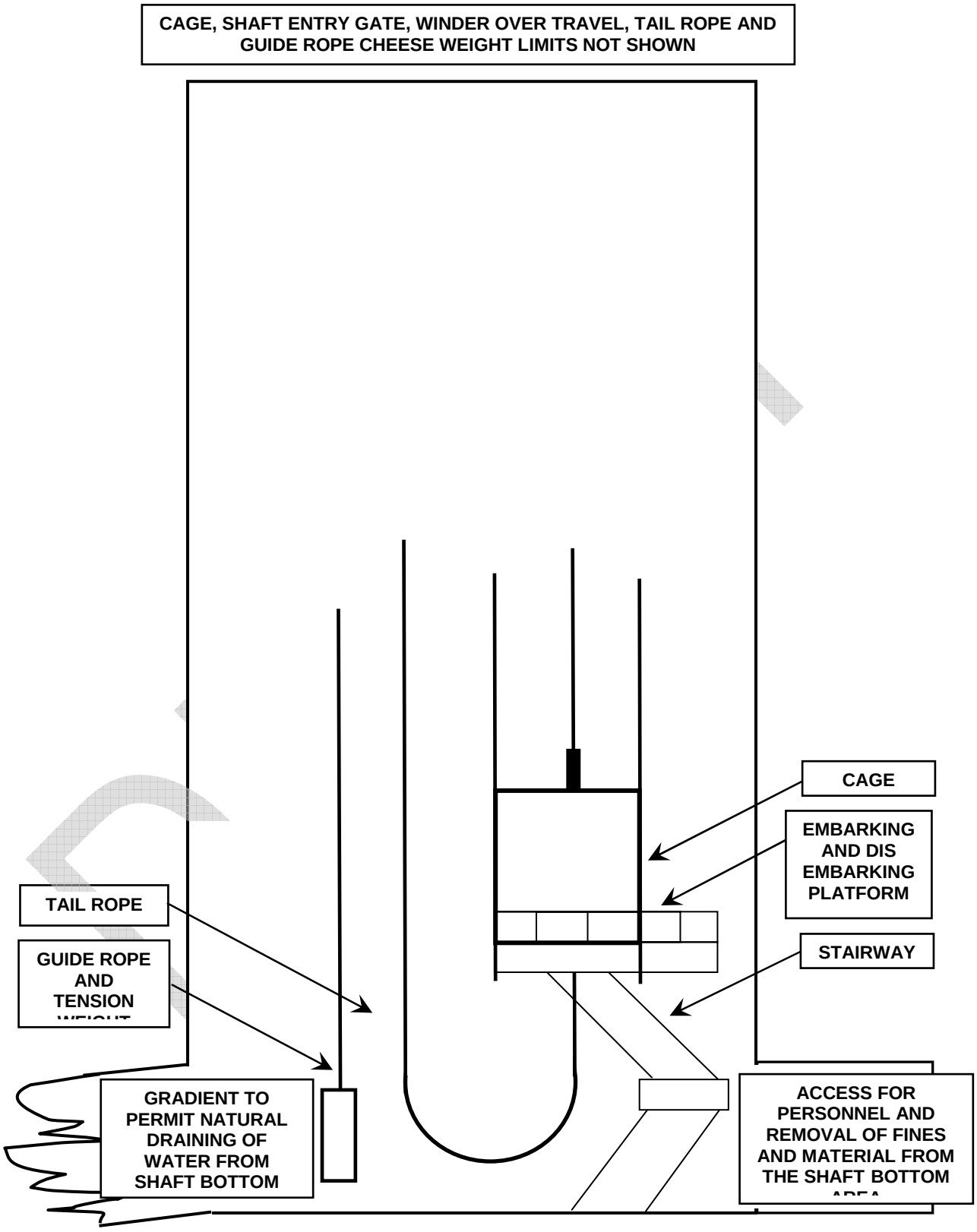
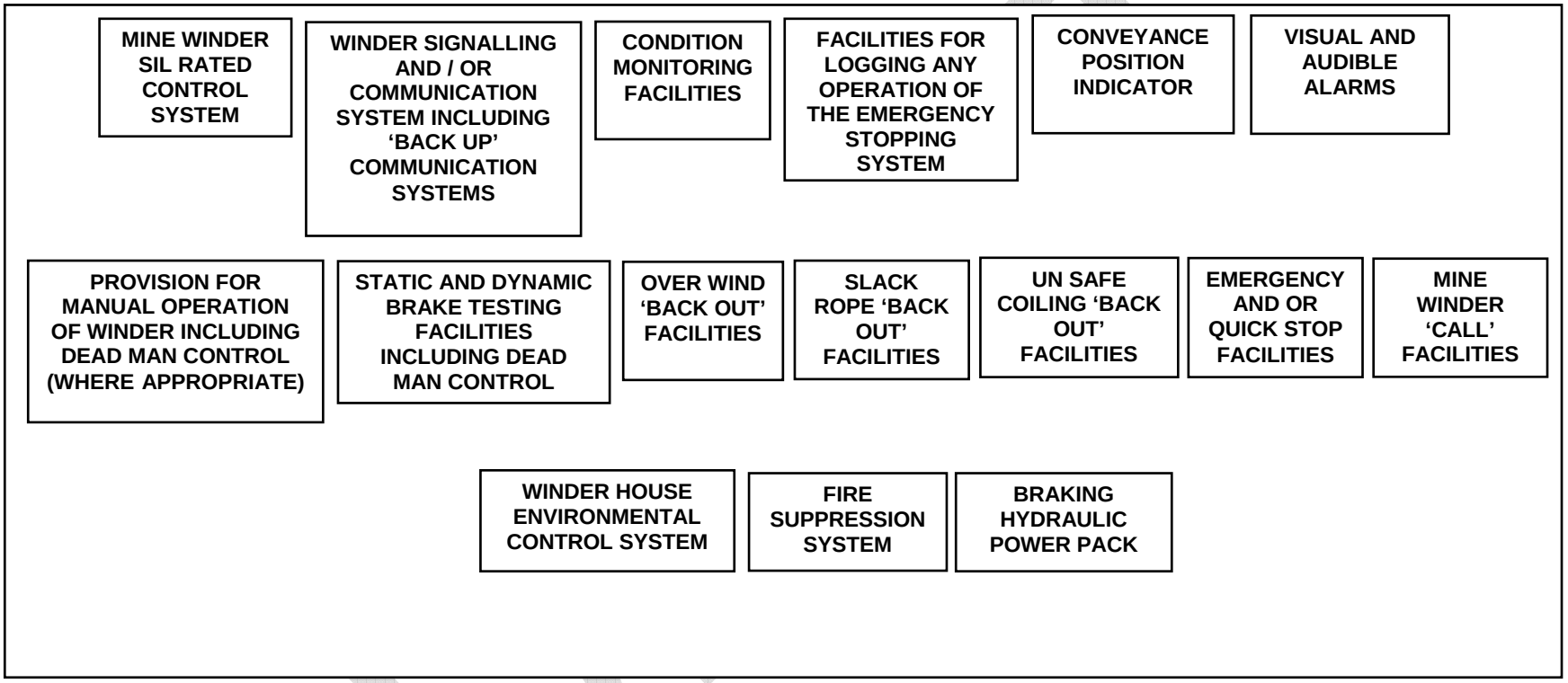


Figure 15: Mine Winder House – Typical Facilities.



4. Appendices

Feedback Sheet

Your comment on this Technical Reference is essential for its review and improvement.

Please make a copy of this Feedback Sheet and send your comments to:

The Senior Inspector of Electrical Engineering
Mine Safety Operations
Industry and Investment NSW
PO Box 344
Hunter Region Mail Centre NSW 2310
Phone: (02) 4931 6641
Fax: (02) 4931 6790

How did you use (or intend to use) this Guideline?	
What did you find most useful about the Guideline?	
What did you find least useful about the Guideline?	
Do you have any suggestions to improve the Guideline?	

Thank you for completing and returning the Feedback Sheet.

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