Electrical Technical Reference for the Approval of Power Winding Systems

MDG 2005

Produced by
Mine Safety Operations branch
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Department of Primary Industries

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NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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DISCLAIMER

FOREWORD

The NSW DPI has a vision for electrical engineering safety, that vision is:

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

Electrical engineering safety encompasses:

1. Prevention of electric shock and burns,
    - Prevention of electrocution,
    - Prevention of injury or death from electric shock,
    - Prevention of electrical burns, including electrically induced radiation burns,
2. Prevention of electrical arcing and surface temperatures that have sufficient energy to ignite gas and/or dust,
3. Prevention of fires caused by the malfunction of electrical equipment, and
4. Prevention of injury and death from unintended operation, failure to stop or failure to operate, of electrically powered or controlled equipment.

Underpinning the vision and the definition of electrical engineering safety is a philosophy of operation, which is:

- Based on RISK MANAGEMENT, requiring FIT FOR PURPOSE EQUIPMENT, COMPETENT PEOPLE AND PROCESSES / PROCEDURES, all supported by MANAGEMENT SYSTEMS, throughout the LIFE CYCLE of the mine. For risk reduction consideration, the layers of protection must be independent, verifiable, dependable, and designed for the mitigation of the specific risk
- Ownership of safety rests with the mine owners/operators and equipment manufacturers/suppliers.
- The way we do things must contribute to changing the safety culture of the industry so that industry accepts ownership of safety.
- Everything mines do must provide for a level of risk less than or equal to the current risk.
- Information is provided in advisory terms, not as a “must do it this way”.
- Be prepared to take appropriate actions against stakeholders not complying with safety legislation.

This document is consistent with the above philosophy of operation and is a key element in realising the vision and achieving point 4 of the definition of electrical engineering safety. Current coal mines legislation is consistent with this philosophy, in particular Clause 58, Coal Mines (Underground) Regulation 1999 recognises the high risk nature of mine winders, hence, legislation requires that the Chief Inspector of Coal Mines approve powered winding systems. The purpose of this document is to facilitate the approval of powered winding systems as required by Clause 58, Coal Mines (Underground) Regulation 1999 and to assist mine operators to maintain powered winding systems in a safe state.

The 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.

R Regan

Director, Mine Safety Operations

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SCOPE AND DEFINITIONS

1.1 Reference Documents

1.1.1 Australian Standards

The following Australian Standards should be used as reference material for this document;

AS1318	Colours-Safety Marking	
AS3785	Underground Mining – Shaft Equipment	
	AS3785.1	Part 1: Overwind Safety Catch Systems
	AS3785.4	Part 4: Conveyances for Vertical Shafts
	AS3785.8	Part 8: Personnel Conveyances in other than Vertical Shafts
AS4360	Risk Management	
AS61508	Functional safety of electrical/electronic/programmable electronic safety-related systems	
	AS61508.1	Part 1: General requirements
	AS61508.2	Part 2: Requirements for electrical/electronic/ programmable electronic safety-related systems
	AS61508.3	Part 3: Software requirements
	AS61508.4	Part 4: Definitions and abbreviations
	AS61508.5	Part 5: Examples of methods for the determination of safety integrity levels
	AS61508.6	Guidelines on the Application of AS61508 parts 2 & 3
	AS61508.7	Overview of Techniques and measures
AS1736	Lifts	Lifts, Escalators and moving walks
AS4024	Safeguarding of machinery	
	AS4024.1	Part 1: General principles

1.1.2 Centers for Disease Control (CDC)

National Institute for Occupational Safety and Health (NIOSH) information circular " Programmable Electronic Mining Systems: Best Practice Recommendations (In Nine Parts).

Available from (WWW.CDC.GOV/NIOSH/PUBLISTD.HMTL)

1.1.3 Coal Mines Regulation Act, 1982

1.1.4 Coal Mines (Underground) regulation 1999

1.1.5 Department of Mineral Resources MDG 33 – "Drum Winders"

1.1.6 Occupational Health and Safety Act 2000

1.1.7 Risk Management

Department of Mineral Resources MDG 1010 – “Risk Management Handbook for Mining Industry”

1.1.8 Safe Man Riding

Safe Man Riding in Mines parts 1A and 1B, parts 2A and 2B being the first and second report of the National Committee for Safety of Man riding in shafts and Unwalkable Outlets.

1.2 Scope

1.2.1 The Document

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 approval.

Previous legislation.

1.2.1.1 Clause 7 of the Coal Mines Regulation Act (Shafts and Roadways – Underground Mines) regulation 1984, required that a mechanically operated winding apparatus or mechanically operated rope haulage apparatus used at a mine for transporting persons through any shaft or roadway be approved by the Chief Inspector.

1.2.1.2 Clause 9(1) and Clause 11 of the Coal Mines Regulation Act (Shafts and Roadways – Underground Mines) Regulation 1984, required that conveyances used at coal mines for transporting persons through a shaft or roadway, be of a type which has been approved for the purpose by the Chief Inspector.

1.2.1.3 Clause 6(6) of the Coal Mines Regulation (Approval of Items) Regulation by way of notice required that all slope drift rope haulage systems be approved by the Chief Inspector.

Current legislation.

1.2.1.4 Part 3 Transport, Division 3 Powered winding systems, Clause 58, of the Coal Mines (Underground) Regulation 1999 requires that a powered winding system must not be used at a mine unless it is approved.

General information

1.2.1.5 Mine operators must ensure that the powered winding system complies fully with the requirements of the CMRA 1982, OH&S Act 2000, the applicable parts of OH&S Regulation 2001 and all clauses of the Underground Regulation 1999.

1.2.1.6 This document is not intended to restrict innovative design. Where specific values or test procedures are required in addition to, or as alternatives to those included in this document, advice should be sought from Inspectors of Electrical Engineering, Mine Safety Operations of the Department of Mineral Resources.

1.2.1.7 When specified "shall" means the requirement is mandatory if required under existing legislation or as determined by the Chief Inspector. When specified "should" means the requirement is recommended.

1.2.1.8 Unless otherwise specified the appropriate Australian Standards shall apply.

1.2.1.9 Where reference is made to a design standard, the current published version shall be used. Where the intent of the design standard generates a substantive difference with this Code, the advice of an Inspector of Electrical Engineering, Mine Safety Operations of the Department of Mineral Resources, should be sought.

1.2.1.10 This document does not in any way negate the requirements of the Coal Mines (Underground) Regulation 1999, Coal Mines (General) Regulation 1999 nor the Occupational Health and Safety Act, 2001.

1.3 Approval Procedures

1.3.1 Requirements

In order to gain approval for an existing powered winding system, new design, modification to existing design, replacement or change to original approval, a formal written application to the Chief Inspector is required.

Clause 58 of the Coal Mines (Underground) Regulation 1999 requires that powered winding systems be approved. The implications of this are that many of the winders approved pursuant to the 1984 regulations will need to be assessed for approval pursuant to clause 58. Those winders approved as powered winding systems under the 1984 regulations are considered to be approved for the purposes of clause 58. In summary if approval documents issued pursuant to the 1984 regulations do NOT mention a **"powered winding system"** then those winders will need to be re-assessed for approval as a **"powered winding system"** pursuant to clause 58.

1.3.2 New or Existing Winders

Whilst primarily intended for use with new powered winding systems, these documents, where applicable, will be used as an integral part of the application and assessment process for approval of variations to existing approved powered winding systems.

A variation to an existing approval shall exist when:

- A component of the winding system is replaced by a "non like" component
- The "Philosophy of Operation" of the winding system is changed.

1.3.3 Approval Application

Final approval shall be by the Chief Inspector of Coal Mines, who may:

(a) Inspect the installation and examine test records, specifications, drawings and design calculations and request that such documentation be audited by an independent competent person if required, and

(b) Be present at any or all of the commissioning and impose any further tests as deemed necessary. Any application for primary or supplementary approval must be supported by a credible risk assessment report. The risk assessment should be based on the document AS4360 – Risk Management and MDG 1010 "Risk Management Handbook."
In general, the Risk Assessment will cover situations or areas where there are no codes or standards or where variations to codes or standards are required.
This document may be used as an aid in identifying hazards, but should not be solely relied on for that purpose. Information as detailed in MDG 1010 shall be supplied. A third party independent facilitator shall undertake this risk assessment.

1.3.3.1 The application should contain an electrical general arrangement drawing, detailing major components (controller, switchgear, prime mover etc.) from the power source to the prime mover.

1.3.3.2 The application should contain an electrical block diagram outlining the primary and secondary safety circuits.

1.3.3.3 The application should contain a brief statement of compliance, variation, or reason for non-compliance with each clause in this document.

1.3.3.4 The application should contain results of tests and a statement of compliance with all requirements in accordance with Australian or other relevant standards, codes, or methods used.

1.3.3.5 The application should contain any further information, calculations, drawings or other documentation considered appropriate in supporting the application.

1.3.3.6 Full details covering electrical and control aspects will be required including those as may be detailed by other documents, guidelines, codes and standards.

1.3.3.7 A Failure Modes and Effects Analysis shall be provided for all critical safety functions. A third party independent facilitator shall undertake the Failure Modes and Effects Analysis.

1.3.3.8 A copy of the commissioning program as referred to in Section 7.

1.3.3.9 Results of the commissioning that demonstrate compliance with this "Technical Reference " document.

1.3.3.10 A Safety File shall be provided covering aspects as outlined in the NIOSH "Programmable Electronic Mining Systems Best

Practices". A "proof of safety" that the system and its operation meet the appropriate level of safety for the intended operation. The Safety File shall be kept for the life of the Winder in accordance with the NIOSH recommendations.

1.3.3.11 A Radio Frequency Control File shall be provided identifying all radio frequencies used at the winder location complete with supporting documentation as to the possible effects of RF transmission contamination.

1.3.4 Scope of Approval

On satisfactory assessment by the Chief Inspector of Coal Mines, an approval will be issued.
The approval will conform with the requirements specified in MDG 3001 "Applicants Guide to Obtaining an Approval", and with regard to electrical aspects will specify :-

- Mine
- Specific Powered Winding System
- Drawings identifying the Powered Winding System
- Conditions as the Chief Inspector of Coal Mines sees fit.

1.3.5 Expiry of Approval

The approval will expire after 5 years, unless a full audit as specified in this technical reference manual is submitted to the Chief Inspector of Coal Mines.

1.4 Definitions

1.4.1 A 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.

1.4.2 A Winder

A winder is 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.

1.4.3 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.

1.4.4 Control EUC

A control EUC is any primary conveyance directly attached to the winder rope. This EUC may have the ability to mechanically attach other EUC's for transport purposes, but generally the control EUC is always attached during normal operation of the winder.

1.4.5 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.

1.4.6 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.

1.4.7 Equipment Under Control (EUC)

Any equipment, machinery, apparatus or plant used for manufacturing, process, transportation or other activities.

1.4.8 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.

1.4.9 Powered Winding System

A Powered Winding System is identified by and includes the following:

Control Systems

Equipment Under Control

Implementation of Safety Integrity Levels

Management of Functional Safety

Motive force and Drive train

Protection Systems

Safety Systems

Signalling systems

<u>It does not include the following:</u>

Competency

Examination and Testing schemes

Maintenance schemes

Rails

Roofs and sides

Training

Transport rules

1.4.10 Quick Stop

A device such as a Push button which activates the emergency braking system of the winder, but due to its transmission method to the EUC control system can not be considered an Emergency Stop Button.

1.4.11 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.

1.4.12 Safety Integrity

The probability of a safety-related system satisfactorily performing the required safety function under all the stated conditions within a stated period of time.

1.4.13 Safety Integrity Level (SIL)

A discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions.

1.4.14 Safety-related system

A designated system that both

- 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.

2 Safety-Related Circuits

All Powered Winder systems shall be provided with two safety circuits, “Primary” and “Secondary”. These circuits shall perform the following functions.

2.1 Primary Safety Circuit

The primary safety circuit is designed to operate independently to that of the secondary safety circuit. The Safety Integrity levels for each safety function in the primary safety circuit shall be level two. See Appendix C (ref AS61508.1)

The operation and or failure of any function within the primary safety circuit shall initiate the EUC control system emergency braking.

In the event that any of the devices connected into the primary safety circuit have operated and brought the EUC to rest, the EUC control system cannot be operated until an authorised person has investigated the cause of the stoppage and has carried out the necessary remedial action before manually resetting the primary safety circuit in the EUC control system. The manual reset circuit shall have a Safety Integrity Level of Two, See Appendix C (ref AS61508.1), to minimize the risk of the reset defeating the primary safety circuit during normal operation.

All cabling between transducers and the EUC Control system shall be provided with short circuit and lead breakage (open circuit) monitoring.

The following is a list of subsystems operating within the Primary Safety Circuit:-
Cable Integrity
Data/Fibre Cabling
  a) *Communication Error Check Monitoring*
  b) *Communication Failure/Loss Monitoring*
Emergency Stop Facilities
EUC Derail switch
EUC Door/Gate Monitoring
EUC Hydraulic Pressure
Gear Loss Protection
Over Speed Protection
Over Travel Protection
Quick Stop Facilities

Radio Control

a) *Data Error Check Monitoring (Watch Dog)*
b) *RF Carrier Loss Monitoring (Carrier Detect)*

2.2 Secondary Safety Circuit

The secondary safety circuit is essentially provided for all other routine stopping devices located within the EUC control system. The Safety Integrity Levels for each safety function in the secondary safety circuit shall be at least level one. See Appendix C (ref AS61508.1).

The operation and or failure of any function within the secondary safety circuit shall bring the EUC to a controlled stop.

In the event that any of the devices connected into the secondary safety circuit have operated and brought the EUC to rest, the EUC control system can be operated in a manner that will allow the automatic reset of the device or devices. If the automatic reset circuit malfunctions, it shall not defeat any portion of the secondary safety circuit.

The following is a list of subsystems operating within the Secondary Safety Circuit:-
Brake Wear/Lift Protection
Drift Profile
Gearbox/Drive Monitoring
Hydraulic Unit Protection
Safe Coiling Protection
Motion Detection
Slack Rope Protection
Winder Drum Pit Protection

3 Safety-Related Devices

(Refer to section 4 for devices related to communications)

3.1 Brake Wear/Lift Protection

To monitor correct brake operation, all brakes (or brake calipers) shall be fitted with devices to monitor brake lift and brake wear.

This device shall be located in the secondary safety circuit.

3.2 Drift Flashing Lights

To ensure the safe operation of the EUC and equipment transported into and out of the mine, all drifts shall be fitted with drift flashing lights at a distance no greater than 100 metres throughout the length of the drift. These lights shall operate continually whilst the EUC's are in motion. The lights shall be positioned such that persons can observe at least one light from any point in the drift.

3.3 Drift Profile

To ensure the safe operation of the EUC and equipment transported into and out of the mine, all drifts shall be fitted with profile monitoring. This profile monitoring shall address the following requirements:

(a) Surface/Portal monitoring to detect equipment or loads that are outside the accepted profile of the drift.

(b) At designated Underground loading points where equipment can be attached to the EUC for transportation into or out of the mine, monitoring to detect equipment or loads that are outside the accepted profile of the drift.

Operation of these monitoring devices shall stop the EUC from any further movement in the selected direction. The EUC may only be returned to the point of loading, until the cause of stoppage is addressed.

The failure of any of these devices shall inhibit the EUC from operating.

The operation of these devices shall be located in the secondary safety circuit.

NOTE
Due to the "Procedural" aspects of this activity, special attention shall be directed toward competency of operators in "returning to the point of loading". Particular attention shall be paid to this activity in the risk assessment in relation to isolation and access, as the operator will need to inspect both load and drift to determine the cause of being out of profile.

3.4 Emergency Stop Facilities

Emergency stop buttons are to be provided at all call stations, the winder house and the gantry and where considered necessary (ref AS4024)

All Man riding EUC's are to be provided with a Quick Stop Button.

This device shall be located in the primary safety circuit.

3.5 EUC Flashing Lights

All man riding EUC's shall be fitted with flashing lights which shall operate continually whilst the EUC's are in motion. Consideration shall be given to the operation of the flashing lights at the same time as the pre start alarm.

3.6 Gearbox/Drive Monitoring

Gearbox/Drive monitoring is recommended for automatic EUC control systems. Sensors should be installed to monitor:

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

This device shall be located in the secondary safety circuit.

3.7 Gear Loss Protection

A safety device shall be fitted to the winder drum monitoring the drive mechanism of any limits or switches operating in the primary safety circuit.

This device shall be located in the primary safety circuit.

3.8 Hydraulic Unit Protection

The brake control circuit shall allow the EUC to complete its cycle, but not recommence a new cycle if any of the following occurs:

(a) Low hydraulic oil level
(b) Low system pressure
(c) High oil temperature alarm

This device shall be located in the secondary safety circuit.

3.9 Load Sensing

To ensure the safe operation of the EUC and equipment transported into and out of the mine, risk assessment shall be undertaken to determine the need for utilizing load sensing, allowing the automatic selection of winder speeds for the load attached. Justification for any decision must be clearly documented and entered in the safety file.

3.10 Over Speed Protection

3.10.1 Drift EUC Over speed Protection

A safety device shall be located on the drift EUC to activate the primary safety circuit in the event of an over speed of 115% of the maximum design speed of the winder.

This device shall be located in the primary safety circuit.

3.10.2 Drum Over speed Protection

A safety device shall be located on the winder drum to activate the primary safety circuit in the event of a speed difference of 10%, between desired speed and actual speed of the drum.

This device shall be located in the primary safety circuit.

3.10.3 Motor Over speed Protection

A safety device shall be located on the winder motor to activate the primary safety circuit in the event of a proportional speed difference of 10%, between the drum speed and motor speed. This device shall also trip in the event of a speed difference of 12%, between desired speed and actual speed of the motor.

This device shall be located in the primary safety circuit.

3.11 Over Travel Protection

3.11.1 End of Track Limits (Ultimate over travel)

All winders shall be fitted with a suitable ultimate over travel switch in the headgear (for a shaft winder) or end of track (Top end of track for a Drift winder).

These devices shall be operated by the EUC, shall withdraw power from the EUC control system, and apply the emergency brakes.

This device shall be located in the primary safety circuit.

3.11.2 End of Travel Limits (Primary over travel)

A safety device shall be installed to activate the primary safety circuit and protect the EUC from passing a predetermined point of travel. These devices should be activated before the end of track limits.

These devices shall be located in the primary safety circuit.

3.12 Pre-start Warning

To ensure the safe operation of the EUC and equipment transported into and out of the mine, all EUC control systems shall be fitted with pre-start warning alarms. These alarms shall be sounded prior to any movement of the EUC. The alarm shall operate for sufficient time allowing persons to avoid any danger. The length of time shall be determined by risk assessment and will need to consider all possible scenarios of operation of the winding system.

These alarms shall be located in the winder house, at all points within the drift or shaft where routine work is carried out, and where persons embark or disembark from the EUC.

An alarm shall also sound from the EUC prior to any movement of the EUC.

3.13 Quick Stop Facilities

All Man riding EUC's are to be provided with a Quick Stop Button.

This device shall be located in the primary safety circuit.

3.14 Safe Coiling Protection

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

This device shall be located in the secondary safety circuit.

3.15 Safety Monitoring for Man Riding EUC's

3.15.1 EUC Derail switch

All man riding EUC's operating on a drift winder shall have a device fitted to detect derailing of the EUC.

The operation of this device shall be located in the primary safety circuit.

3.15.2 EUC Door/Gate Monitoring

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

(a) EUC's fitted with doors shall be monitored as closed and locked before the EUC control system can be operated.

(b) Platform gate doors shall be monitored as closed and locked before the EUC control system can be operated.

The failure of any of these devices shall cause the EUC to stop.

The operation of these devices shall be located in the primary safety circuit.

NOTE

Mines shall conduct a Risk Assessment to demonstrate that man riding EUC's without doors, are safe to operate, and do not require doors.

3.15.3 EUC Hydraulic Pressure

All man riding EUC's that have a hydraulically operated braking circuit shall have a device fitted to monitor the pressure.

The failure of this device to detect minimum pressure shall cause the EUC to stop.

The operation of this device shall be located in the primary safety circuit.

3.15.4 Motion Detection

All control EUC's capable of man riding, operating on a drift winder shall have a device fitted to detect motion of the EUC. This device shall detect the uncontrolled loss of motion of the EUC due to means other than the EUC control system.

The failure of this device to detect motion shall cause the EUC to stop.

The operation of this device shall be located in the secondary safety circuit.

3.16 Slack Rope Protection

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

This device shall prevent no more than a calculated value of two metres of slack rope being developed at any point throughout the length of travel, prior to the operation of the primary safety circuit.

Refer: Appendix B. (Slack rope conditions in Drifts)

This device shall be located in the secondary safety circuit.

NOTE
Due to the "Procedural" aspects of this activity, special attention shall be directed toward competency of operators in controlling the outbye direction of the winder to remove slack rope. Particular attention shall be paid to this activity in the risk assessment in relation to isolation and access, as the operator will need to inspect the rails and rope for possible causes of the slack rope condition.

3.17 Torque Sensing Circuit

To ensure the safe operation of the EUC and equipment transported into and out of the mine, risk assessment shall be undertaken to determine the need for utilizing torque sensing circuitry of the motor, before allowing the primary brakes on the winder to be released. Justification for any decision must be clearly documented and entered in the safety file

3.18 Winder Drum Pit Protection

Any pit required to house the winding drum and brake path shall be adequately drained and protected with a monitoring device. This device shall operate before the brake path (disk) becomes contaminated.

This device shall be located in the secondary safety circuit.

4 Signaling and Communication System

All man riding EUC's operating on winders, shall be provided with a suitable means to:

a) Give audible and visual signals to; and

b) Receive audible and/or visual signals from; and

c) Communicate by speech with

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

4.1 Hard Wired Control System

Where the control signals to and from the EUC and associated control systems and control stations are connected via cabling, the following requirements shall be provided.

A single electrical fault shall not cause the EUC to move. (eg Short Circuit, Open Circuit, High Resistance, Earth Fault)

4.1.1 Cable Integrity

All cabling between the EUC and the EUC Control system associated with the primary safety circuit shall have a SIL of 2.

4.1.2 Data/Fibre Cable

Where communications are established between the EUC, EUC Control system and any associated field stations or devices via any form of serial or parallel data transfer, the communication method shall be monitored and provide the following: (ref NIOSH Safety File)

a) Communication Error Check Monitoring

b) Communication Failure/Loss Monitoring

The failure or operation of any of these devices shall stop the EUC, and/or prevent the EUC from running.

The operation of this device shall be located in the primary safety circuit.

4.2 Radio Control System

In the case, where the control signals to and from the EUC and associated control stations are connected via any form of RF Link the following requirements shall be provided.

a) RF Carrier Loss Monitoring (Carrier Detect)

b) Data Error Check Monitoring (Watch Dog)

The failure or operation of any of these devices shall stop the EUC, and/or prevent the EUC from running.

The operation of this device shall be located in the primary safety circuit.

4.2.1 Data Error Check Monitoring

Where Data Error Check monitoring (Watch Dog) is employed as part of a Radio Control System the operational time for detection of data error shall be calculated to prevent excessive slack rope being generated, should the EUC fail mechanically.

Refer: Appendix B. (Slack rope conditions in Drifts)

The operation of this device shall be located in the primary safety circuit.

4.2.2 Data Up Date Time

The operational up date time for data transfer via a Radio Control System shall be calculated to prevent excessive slack rope being generated, should the EUC fail mechanically.

Refer: Appendix B. (Slack rope conditions in Drifts)

This time base is to be calculated from input to output.

4.2.3 RF Carrier Loss Monitoring

Where RF Carrier Loss monitoring (Carrier Data) is employed as part of a Radio Control System the operational time for detection of carrier loss shall be calculated to prevent excessive slack rope being generated, should the EUC fail mechanically.

Refer: Appendix B. (Slack rope conditions in Drifts)

The operation of this device shall be located in the primary safety circuit.

4.3 Voice Communication System

All control EUC's capable of man riding shall have an adequate voice communication system fitted.

This system shall provide the ability for two-way voice communication between the operator of the EUC, the EUC winder Control room, call stations associated with the EUC and the operations room (if applicable).

The system shall provide the ability for the operator of the EUC, in the case of an emergency, to establish communications with site personnel if the above locations are unmanned.

5 Programmable Electronic Systems

In the case where any part of the "powered winding system" has programmable electronic components, a competent person or persons, shall perform a Safety Audit of all parts of the programmable electronic system.

Australian Standard 61508 and NOISH documents "Programmable Electronic Mining Systems Best Practices" are reference documents for Programmable Electronic Systems (PES).

The competent person shall address all issues nominated in AS 61508 and NIOSH documents.

The following issues are by no means complete or comprehensive, but should provide a sound starting point for creation of engineering standards :-

- All hardware components of the PES shall be verified as being suitable for the duty to be performed, in the environment in which they are housed.
- The structure, logic, and code of programming shall be verified as safe.
- The speed of processing information within the processor and between remote racks or external devices, is at a rate that does not present a risk to the operation of the EUC. The speed shall be assessed as acceptable by the competent person.
- The system of "Management of Change" for programming of PES shall be structured, and prevent inadvertent and intentional mismanagement of the system.
- The system of "Management of Access" to the program for "fault finding" purposes shall be structured.
- Routine verification of the status of programming, to detect unauthorised change, shall be performed at a predetermined frequency, and at the occurrence of a trigger event.

All data from the safety audit shall be retained in the Safety File.

6 Routine Testing Procedures

All devices associated with the EUC Control that operate the primary safety circuit of the EUC Control shall be statically tested weekly.

All devices associated with the EUC Control that operate the secondary safety circuit of the EUC Control shall be statically tested monthly.

In addition to these tests, the following requirements shall also be met: -

6.1 Brake Testing

All winders shall be fitted with a system that provides for the requirement of brake testing under MDG 33.

This system shall be designed to be of key or push button operation, requiring no other manual alteration to the EUC Control to perform these tests. The key or pushbutton shall return to the normal operating position on release.

6.2 Over Speed Testing

All Over Speed devices shall be dynamically tested biannually and a record of these test results logged.

6.3 Over Travel Testing

All Over Travel devices shall be dynamically tested bimonthly and a record of these test results logged.

6.4 Primary Safety Circuit Testing

The operation of the Primary Safety circuit shall be dynamically tested weekly and a record of these test results logged.

6.5 Testing Records

Testing records shall be retained and finalized for:

(a) Submitting with approval documentation to the Chief Inspector of Coal Mines and;

(b) Recording and filing by the Mine in a record book for such purposes.

Testing records shall define all testing and record the results of such testing of safety equipment, safety equipment settings, operating times of safety equipment, over speed settings, and any other tests relevant to the EUC.

7 Commissioning Procedures

7.1 New, Relocated or Upgraded EUC's

NOTE

For the purpose of this document all shaft sinking winders shall be treated as relocated EUC's

Prior to any commissioning, the Approval Procedures shall have commenced as stated in Section 1.3.

7.1.1 Commissioning Program

A detailed commissioning program shall be prepared prior to commencing final commissioning of the EUC system. This commissioning program shall be reviewed by a person with the appropriate competencies for adequacy.

The commissioning tests detailed in the commissioning program shall be witnessed and/or conducted by a person with the appropriate competencies.

7.1.2 Commissioning

Commissioning shall be carried out by:

(a) A competent Electrical Engineer in co-operation with;

(b) A competent Mechanical Engineer in co-operation with;

(c) The Manufacturer and Purchaser representatives.

The commissioning shall be witnessed by the mine electrical engineer and mine mechanical engineer. The record of the results of the commissioning shall be verified by the mine electrical engineer and mine mechanical engineer.

7.1.3 Commissioning Records

Commissioning records shall be retained and finalized for:

(a) Submitting with approval documentation to the Chief Inspector of Coal Mines and;

(b) Recording and filing by the Purchaser or the Mine, in the safety file.

Commissioning records shall define all testing and record the results of such testing of safety equipment, safety equipment settings, operating times of safety equipment, over speed settings, and any other tests relevant to the EUC, or as required by the Chief Inspector of Coal Mines.

7.2 Existing EUC's

Existing installed EUC's shall be tested:

(a) When EUC maintenance has involved replacement of parts which are components of the primary, secondary, and brake safety circuits or drive system of the EUC;

(b) When components of the system are replaced by "non like" components

(c) When the "Philosophy of Operation" of the winder is changed.

(d) As required by Manager's Rules for the safe operation of the EUC.

Testing shall be carried out by person's authorised by the Mine Manager or his/her representative, as competent and authorised to perform such testing.

8 Safety Audits

8.1 Safety Audit Purpose

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

8.2 Safety Audit Procedures

8.2.1 General

All EUC system's, shall be audited at five yearly intervals + or – 6 months.

8.2.2 Safety Audit

The external audit shall be carried out by competent persons. For auditing purposes a competent person is a person with a thorough knowledge of winder design features and expertise and experience in testing and auditing of powered winding systems used in mines.

8.2.3 Structure

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

8.2.3.1 Review Approvals

Review approvals for the EUC system, including supplementary approvals.

8.2.3.2 Review Design

Review design calculations, drawings, and specifications.

NOTE
For ongoing audits these documents may require only sighting if a previous audit indicates that the documents have been examined and are acceptable.

8.2.3.3 Review PES

Review the structure, logic and code of any programmable electronic system (PES).

8.2.3.4 Safety Devices

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

8.2.3.5 Static and Dynamic Testing

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

8.2.3.6 Records

Verify that records are kept correctly for the following:

(a) Brake Testing

(b) Static Safety Device Testing

(c) Dynamic Safety Device Testing

(d) Primary Safety Circuit Testing

(e) Maintenance Program Results

(f) Safety File

(g) Radio Frequency Control File

8.3 Safety Audit Results

8.3.1 Safety Issue

Any safety issue found during the audit, and needing attention, should be resolved with the Mine Manager and his/her representatives, and/or EUC system owner in the case of a shaft sinking contract.

8.3.2 Perceived Hazard

If a difference of opinion arises as to the requirement of a safety device or the consequence of a perceived hazard, that cannot be resolved, then the auditor shall include this on the final report to the mine. If the audit is part of an approval application the matter shall be brought to the attention of the Chief Inspector of Mines.

8.3.3 Report

To complete the audit, the auditor shall conclude the report with attachments that will clearly indicate the safety condition of the EUC system. The auditor will give a copy of the report to the Mine Manager, Mine Mechanical Engineer and Mine Electrical Engineer.

8.3.4 Approval Validity

Failure by the Mine Manager or owner to have a safety audit on a EUC system under his/her control completed, and any non-conformances that may effect the safety of the powered winding system rectified, renders the powered winding system approval invalid.

9 Appendix A

Maintenance Program

A Maintenance program shall be prepared and implemented and be an integral part of the mine's maintenance management system and/or mine safety management system.

A detailed Maintenance program should be prepared prior to commencing operation of the powered winding system. This maintenance program shall be reviewed by a person with the appropriate competencies for adequacy.

The maintenance program shall identify those tests to be witnessed and/or conducted by a person with the appropriate competencies.

Maintenance Work

Maintenance shall be carried out by:

(a) A person or persons authorised by the mine manager or his/her representative, as competent and authorised to perform such maintenance.

(b) The Manufacture/Installer of the EUC system.

Maintenance Records

Maintenance records shall define all maintenance performed and record the results of such maintenance of safety equipment, safety equipment settings, brake settings, and any other maintenance performed relevant to the EUC system.

All maintenance carried out on EUC's shall be entered into a book or some secure and readily accessible electronic media, kept specifically for this purpose.

It is important that the Safety File for the powered winding system reference these maintenance records

10 Appendix B

Slack rope Conditions

Slack rope conditions in drifts
(A paper presented to the DMR Mechanical Safety Seminar – March 2000)
(by Les Melane)

Rope life is usually related to fatigue effects or maintenance problems that can be predicted or are indicated such that advanced warning of impending problems can be anticipated in time for a solution to be implemented, eg. A rope change. The prediction of rope problems and the replacement of the rope is an established practice, and the instances of actual rope failure due to fatigue, wear, corrosion or misuse are rare if normal precautions are taken. The requirements of MDG26 covers these normal precautions.

The other side of failures, not only with respect to rope but to all components subjected to fatigue loading, are the strength failures. This type of failure can be sudden and devastating. The damage and consequences caused by a strength failure can be terminal.

One of the worst conditions which can cause a strength failure in the winding system is that of slack rope. This has an effect on any single line component in the winding system, ie., the rope, rope capping, rope socket, rope to drum attachment, and in the case of vertical winders, the attachments and pins.

Causes of slack rope can be divided into that caused by operational methods, which can be eliminated by various risk removal processes such as hazop studies, work procedures and operator training, and those caused by what can be called maintenance system failures.

1 Maintenance system failures – Slack rope

1.01 Emergency brake application in the outbye direction.

The case here is the emergency stop at full speed and full man load near the top of the drift on the steepest slope.

The trip occurs, an emergency stop is initiated, winder power is removed from the winder motor and the emergency winder brakes are activated. The winder drum is brought to a halt in a short time. This happens at maximum winder speed. Because of the inertia of the train, it continues to run on, creating slack rope. Eventually, due principally to gravity, the train stops, runs back, and comes to a jarring stop. The rope, which at the top of the drift is at its shortest, absorbs the energy created by the fall-back, and imparts a solid jolt to the train occupants often causing injury.

This problem could be averted by attention to brake maintenance. The conditions prevalent for a slack rope condition can only be detected by periodic maintenance of the hydraulic brake unit and periodic brake testing. For drift winders brakes should always be set to maintain the minimum deceleration rate allowed by the guidelines, i.e., for the maximum man load of $1 m/s^2$ at the worst condition (maximum rope out on maximum slope). If this philosophy is maintained it is unlikely that slack rope will be created.

Example 1:

For an 80 Tonne drift haulage, the system inertia without the EOR load is a calculated 598330 Kgm^2 at the drum. The maximum man EOR load at any time is 32 Tonnes. Brakes are set to give a stopping distance of 8 metres or 1 m/s^2 in the in-bye direction. What is the effect if an outbye emergency stop is performed with this brake setting?

In the **in-bye** direction (neglecting friction), the brakes must hold the load and decelerate the complete system. In the **out-bye** direction, additional braking effort available to stop the winder is derived from two sources; the decrease in system inertia due to the End of Rope Load and the decrease in the requirement to Hold the Load. These decreases will increase the available capacity provided by the brakes to stop the winder.

For the winder, the inertia due to the 32 Tonne man load = $32000 \times (3.966/2)^2$
= 125833 Kgm^2

Total system Inertia = 598330 + 125833

= 724163 Kgm^2

EOR man load inertia contribution = 125833/724163
= .1737 or 17.37%

In respect of the torque to hold the load

Total braking effort = 1*a* + Fr
= 724163 x 0.50429 + 32 x 9.81 x Sin 15.9454 x 3.966/2
= 365185.57 + 171014.86
= 536200 Nm

EOR man load torque contribution = 171014/536200
= 0.32 or 32%

Thus the Total contribution by the 32 tonne load to brake effort = 32 + 17.37
= 49.32%

Since brake torque effort is linear in respect to the deceleration rate ($T = I\alpha$) then for braking in the outbye direction the deceleration rate will increase by 49.32% since at this point in time the brakes do not see the EOR load inertia, nor the torque required to hold the load.

Deceleration rate (outbye) = 1 x 1.4932
= 1.432 m/s^2

On the 1 in 3.5 slope, the EOR man load will decelerate at G x Sin β
= 9.81 x Sin 15.9454
= 2.69 m/s^2 > 1.432

Therefore, at this brake setting, the 32 Tonne man load will no over-run the rope.

From the brake tests, the minimum man load (10 Tonnes) stopping distance was measured as 6.6 metres

Deceleration = $4^2/(2 \times 6.6)$
= 1.21 m/s^2

Using the same method above, the total contribution of the 10 Tonne EOR load is 18.2%

The expected deceleration rate in the out-bye direction
= 1.21 x 1.182
= 1.43 m/s^2 same as full load

1.02. Jamming of EOR loads in shafts, guides or drifts

Incidents of this type have happened several times whereby the EOR load has jammed in the shaft or shaft guides, which has created slack rope. The EOR load then falls, either by itself or with the aid of played out rope which sits on the cage/skip. Versions of the incidents vary, often with dire results.

With drift winders carrying EOR loads of up to 108 Tonnes, the energy created by such a hang-up and drop can be enormous. Happening at the top of the drift, the rope energy absorption properties are minimal, and rope breaking loads are reached within a short distance of around 4 to 6 metres in the event of a free fall. Such an event would not only cause damage to equipment and the drift, but could cause fatalities. For automatic winders, slack rope detection is difficult to achieve at lower levels.

For drift haulages, the load envelope is not restricted, i.e., the load can exceed the confines of the flat-top dimensions. In order to restrict the load to within the parameters established by the mine, load profile frames are often located at the top and bottom of the drift. Loads which will not fit through the frame do not proceed up or down the drift. Clearance in the drift must be maintained to statutory requirements. Sometimes the frames are electronically operated beams. Cutting the beam will stop the haulage.

Added to the problem of oversized loads is that of the undersized drift. This occurs when drift movement causes the drift profile to change over the length of the drift. Over time, this movement can be hard to observe. Drift movements can be found at any point along the drift length. Drift dimensions should be checked periodically. A simple way to check the drift is to mount an oversize profile frame to a flat-top or car (with the correct clearance to the profile frames at drift top and bottom) and traverse the drift. Any interference with the frame by the drift profile should be corrected. This check interval should be determined by the Colliery (suggested 6 monthly but dependent on drift conditions and movement) and results recorded in the mine records.

1.03. Clearances in drifts

For drifts and roadways, the CMR act states:
Clause 63 (2a) “sufficient horizontal and vertical clearances are to be maintained so as to prevent a transport operator or any part of any transport, any conveyance attached to transport or any load coming into contact with the roof and sides of a roadway, and
Clause 63 (2b) “if persons are required to travel along a roadway in which transport operates, sufficient clearance between the transport, any conveyance attached to the transport or any load is to be maintained to allow it to pass safely or, if such clearance is impracticable, a means to enable persons to safely take refuge when transport passes is to be provided”.

It is proposed that for drifts with man hole refuges the minimum clearance in the drift for material loads should be 150mm. The minimum clearance for non-enclosed man riding conveyances should be 400mm. The minimum clearance for enclosed (doors fitted) conveyances should be 150mm.

Example 2:

For the 80 Tonne EOR load haulage.

Case 1

Assume the load jams in the drift in the outbye direction. Assume the jam is instantaneous. What speed will break the rope?
Assume rope grade of 1860Mpa, a rope metallic area of 1380mm^2, and Modulus of Elasticity E of 103 Gpa, and length of rope of 140 metres.

The energy absorption capacity of the rope

$$= \frac{\sigma_y^2 \times A \times L}{2 \times E}$$

$$= \frac{(0.67 \times 1860)^2 \times 1380 \times 140000}{2 \times 103 \times 10^3}$$

$$= 1456516 \times 10^3 \text{ Nmm}$$
$$= 1456516 \text{ Nm}$$

When the load jams, the rope will see the energy load due to the rotating system inertia plus the energy due to motor torque. Assume a slope load equivalent at motor of 216.27 kN.

$$I\omega^2/2 \quad +mV^2/2 \quad = \text{Energy absorbed by rope}$$

Or

$$\underline{598330 \times (V \times .50429)^2} + ½ \times (216270/9.81 \times V^2 \qquad = 1456516$$

2

V = 4.08m/s

Note: The standard haulage speed is 4 m/s. The rope strength of 1860 Mpa may drop in service by 10%. It is difficult to see how an instantaneous jamming of the load could occur. But the exercise shows that if a sudden jam did occur, the effects could be significant.

Case 2

Assume that the 80 Tonne maximum EOR load going inbye gets caught, hangs up and then releases. What amount of slack rope and fall will break the rope?

From the above case 1 the energy absorption capacity of the new rope
= 1456516 NM

For the 80 Tonne EOR load on a 1 in 3.5 drift slope

Slope Load = 80 x 9.81 x Sin 15.9454
= 215.60 kN

Assuming no losses to friction and from F = ma

EOR mass acceleration = $215.60 \times 10^3/80000$
= 2.695 m/s^2

From $E = ½ mv^2$	$½ \times 80000 \times V^2$	= 1456516
At rope break	V	= 6.03 metres/sec
From $V = (2as)^{0.5}$	6.03	= $\sqrt{(2 \times 2.695 \times s)}$
Or	Slack rope S	= 6.74 metres

This is for a new rope. The rope strength could be down 10% then S = 5.47 metres

2 Slack rope on the top ramp of Drift Winders

Because of the decrease in slope at the top ramp, slack rope can also be created during an emergency stop initiated while the EOR load is travelling on the top ramp in the outbye direction.

Assume a top ramp slope of 1 in 10 or 5.71 Degrees and an outbye ramp speed of 2 m/s.

In the outbye direction the EOR load will decelerate at G Sin β
= 9.81 x Sin 5.71
= 0.976 m/s^2

The distance to stop from a ramp speed of 2 m/s

S = $V^2/(2 \times a)$
= $2^2/(2 \times .976)$
= 2.079 metres

The total braking effort established from the inbye brake test is 536200 NM. In the outbye direction, this braking effort will effectively increase by 49.32%

Inertia of rotating parts = 598330 Kgm^2

Deceleration of rotating parts from T = 1α

α = (536200 x 1.4932)/598330
= 1.338 Rad/s^2

a = 2.653 m/s_2

S = $2^2/(2 \times 2.653)$

= 0.7538 metres

Calculated slack rope on ramp = 2.049 - .7538
= 1.29 metres

Note: To reduce the slack rope in this case the ramp speed would have to be lowered

$V = \sqrt{(0.7538 \times 2 \times .976)}$
= 1.21 m/s on the 1 in 10 ramp
= maximum on ramp

Summary Note:
The brake application rate above is designed to ensure the minimum deceleration rate allowable for maximum man riding i.e. 1 m/s^2. This allows the man load to be stopped on the maximum drift grade in the outbye direction without over-run and with minimum stress to the system. This establishes the maximum brake effort to be applied. Since the brake application rate has been established, then the stopping distance on the top ramp with a reduced slope can be modified by reducing the ramp speed in the outbye direction. It would appear that this ramp speed should not exceed 1 m/s.

11 Appendix C

Safety Integrity Levels

For the purpose of this Technical Reference the following shall apply for Safety Integrity Levels. (see AS 61508 Part 1 and 4)

AS 61508.4

3.5.12 Mode of Operation

The way in which a safety-related system is intended to be used, with respect to the frequency of demands made upon it.

Low demand mode: where the frequency of demands for operation made on a safety-related system is no greater than one per year or no greater than twice the proof-test frequency.

AS 61508.1

Table 2 – Safety integrity levels: target failure measures for a safety function, allocated to an E/E/PE safety-related system operating in low demand mode of operation.

Safety integrity level	Low demand mode of operation (Average probability of failure to perform its design function on demand)
4	$> 10^{-5}$ to $< 10^{-4}$
3	$> 10^{-4}$ to $< 10^{-3}$
2	$> 10^{-3}$ to $< 10^{-2}$
1	$> 10^{-2}$ to $< 10^{-1}$

Determination of SIL's

For the purpose of this Technical Reference the following shall apply for the determination of Safety Integrity Levels. (see AS 61508 Part 5 Annex D "Determination of Safety Integrity Levels - A qualitative method: Risk Graph)

Examples are given overleaf for primary and secondary safety circuits.

Table 1. Primary Protection Circuit

Safety Devices	Risk Parameter				Derived SIL
	Consequence	Frequency	Possibility of avoidance	Probability of event	
Over Speed	C4	F2	P1	W1	2
Over Travel	C3	F2	P1	W2	2
E/Stop	C3	F2	P1	W2	2
Quick Stop	C3	F2	P1	W2	2
Gear Loss	C3	F2	P1	W2	2
EUC Derail	C3	F2	P1	W2	2
Communication Error Checking	C3	F2	P1	W2	2
Communication Failure/Loss	C3	F2	P1	W2	2
Cable Integrity	C3	F2	P1	W2	2
EUC Door/Gate	C3	F2	P1	W2	2
EUC Hydraulic Pressure	C3	F2	P1	W2	2
Watch Dog	C3	F2	P1	W2	2
Carrier Detect	C3	F2	P1	W2	2

Table 2. Secondary Protection Circuit

Safety Devices	Risk Parameter				Derived SIL
	Consequence	Frequency	Possibility of avoidance	Probability of event	
Brake Wear\Lift	C2	F2	P1	W2	1
Drift Profile	C2	F2	P1	W2	1
Gearbox\Drive Monitoring	C2	F2	P1	W2	1
Hydraulic Unit Protection	C2	F2	P1	W2	1
Safe Coil Protection	C2	F2	P1	W2	1
Motion Detection	C2	F2	P1	W2	1
Slack Rope Protection	C2	F2	P1	W2	1
Winder Drum Pit Protection	C2	F2	P1	W2	1

12 Appendix D

Feedback sheet

Your comment on MDG 2005 will be very helpful in reviewing and improving the document.

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

Senior Inspector of Electrical Engineering
Mine Safety Operations
NSW Department of Primary Industries
PO Box 344 Hunter Region Mail Centre NSW 2310
Fax: 02 4931 6790

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

What do you find most useful about the Guideline?

What do you find least useful?

Do you have any suggested changes to the Guideline?

Thank you for completing and returning this Feedback Sheet.