



**NSW  
Resources  
Regulator**

**TECHNICAL REFERENCE GUIDE**

# **POWERED WINDING SYSTEMS**

Part 5: Winder control systems



**Document control**

Published by NSW Resources Regulator

Title: Technical reference guide: Powered winding systems – Part 5: Winding control systems (replaces MDG 2005 and draft MDG 33.6)

First published: January 2020

Authorised by: Chief Inspector, NSW Resources Regulator

CM9 reference: DOC18/938821

**AMENDMENT SCHEDULE**

Date	Version	Amendment
January 2020	1	Original version  Supersedes MDG 33 (1998), MDG 12 (1992), MDG 26 (1999) and MDG 2005 (2003). Reflects 2020 NSW WHS legislative framework. Developed in consideration of current Australian standards, international standards, the EES008 series and industry feedback from the 2011 consultation process for draft MDG 33 (1-7) series.

© State of New South Wales through Department of Planning, Industry and Environment 2020. You may copy, distribute, display, download and otherwise freely deal with this publication for any purpose, provided that you attribute the Department of Planning, Industry and Environment as the owner. However, you must obtain permission if you wish to charge others for access to the publication (other than at cost); include the publication in advertising or a product for sale; modify the publication; or republish the publication on a website. You may freely link to the publication on a departmental website.

Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (September 2019) and may not be accurate, current or complete. The State of New South Wales (including the NSW Department of Planning, Industry and Environment), the author and the publisher take no responsibility, and will accept no liability, for the accuracy, currency, reliability or correctness of any information included in the document (including material provided by third parties). Readers should make their own inquiries and rely on their own advice when making decisions related to material contained in this publication.

DOC18/938821

# Contents

- 1. Introduction ..... 7
  - 1.1. Scope and application ..... 7
  - 1.2. References ..... 8
  - 1.3. Abbreviations and definitions ..... 8
- 2. Design - Performance requirements ..... 9
  - 2.1. General ..... 9
  - 2.2. Essential safety requirements ..... 9
  - 2.3. Essential functional requirements ..... 10
- 3. Design - general control system requirements ..... 11
  - 3.1. General ..... 11
  - 3.2. Hardware requirements ..... 11
  - 3.3. Operational control functions ..... 12
  - 3.4. Safety functions ..... 12
    - 3.4.1. New powered winding systems ..... 13
    - 3.4.2. Modification of existing powered winding systems ..... 13
  - 3.5. Stop categories ..... 14
  - 3.6. Programmable electronic systems ..... 15
- 4. Design – independent safety circuit requirements ..... 16
  - 4.1. General ..... 16
  - 4.2. Ultimate safety circuit elements ..... 16
    - 4.2.1. General requirements ..... 16
    - 4.2.2. Requirements for ALL types of winders ..... 17
    - 4.2.3. Additional requirements for double drum winders ..... 17
    - 4.2.4. Additional requirements for shaft sinking winders ..... 17
    - 4.2.5. Friction winders ..... 17
    - 4.2.6. Drift winders ..... 18
  - 4.3. Primary safety circuit elements ..... 18

4.3.1. General requirements .....	18
4.3.2. Requirements for ALL winder designs .....	18
4.3.3. Additional requirements for ALL shaft winders .....	19
4.3.4. Additional requirements for double drum winders fitted with a clutch .....	20
4.3.5. Additional requirements for double drum winders without a clutch .....	20
4.3.6. Additional requirements for friction winders .....	20
4.3.7. Additional requirements for material winders .....	20
4.3.8. Additional requirements for drift winders.....	21
4.3.9. Additional requirements for shaft sinking winders.....	21
4.4. Secondary safety circuit elements.....	22
4.4.1. General requirements .....	22
4.4.2. Requirements for ALL winder designs .....	22
4.4.3. Additional requirements for friction winders, single rope drum shaft winders, single rope rack and pinion hoists and double drum winders fitted with or without a clutch.....	23
4.4.4. Additional requirements for drift drum winders .....	23
4.4.5. Additional requirements for shaft sinking winders.....	24
5. Design – Description of safety functions.....	25
5.1. General.....	25
5.2. Brake systems .....	25
5.2.1. Mechanical brake systems.....	25
5.2.2. Electrical braking systems.....	26
5.3. Hold-to-run control .....	26
5.4. Door/gate interlocking – shaft winders.....	27
5.4.1. General .....	27
5.4.2. Collar and shaft entries.....	27
5.4.3. Conveyances.....	27
5.4.4. Material winder tubs/skips.....	28
5.5. Door/gate interlocking – drift winders.....	28
5.6. Double drum shaft winders fitted with a clutch .....	28

5.7. Shaft and drift profile monitoring .....	29
5.8. Emergency stop facilities – including hand-operated.....	29
5.9. Flashing lights (drift winders) .....	30
5.9.1. General .....	30
5.9.2. Conveyance flashing lights.....	30
5.10. Gearbox/drive monitoring.....	31
5.11. Gear loss protection .....	31
5.12. Indicators .....	31
5.12.1. Depth indicators .....	31
5.12.2. Load current/torque .....	32
5.12.3. Winder speed .....	32
5.13. Keps (chairs, catches, dogs or keeps) .....	32
5.14. Load sensing.....	32
5.15. Winder overspeed devices .....	33
5.15.1. General.....	33
5.15.2. Winder speed profile deviation .....	33
5.15.3. Winder drums.....	33
5.15.4. Winder motors .....	33
5.16. Over travel devices.....	33
5.16.1. Ultimate over and under travel limits.....	33
5.16.2. Primary over travel and under travel limits .....	34
5.16.3. ‘Normal stop’ over and under travel limits.....	35
5.16.4. Over and under travel ‘back out’ devices and procedures .....	35
5.17. Torque-sensing circuit .....	35
5.18. Plat gates.....	36
5.19. Quick stop facilities .....	36
5.20. Radio frequency (R/F) links .....	36
5.21. Data transfer .....	37
5.22. Safety circuit cabling .....	37

5.23. Safe coiling protection – double drum, single rope shaft and drift winders.....	38
5.24. Safety monitoring for drift winder conveyance.....	38
5.24.1. Conveyance door/gate monitoring.....	38
5.24.2. Conveyance dump brake system operation and protection .....	38
5.24.3. Conveyance derail switch .....	39
5.24.4. Conveyance motion detection device.....	39
5.24.5. Conveyance overspeed.....	39
5.25. Conveyance slow down speed zones .....	39
5.26. Shaft or drift obstruction protection.....	40
5.27. Signalling and communication systems.....	40
5.27.1. Signalling systems for all mine winders .....	40
5.27.2. Signalling systems for manually operated mine winders including shaft sinking winders – additional requirements.....	41
5.27.3. Voice communication systems .....	41
5.28. Single point suspension of shaft cables supplying electrical and communication services to conveyances – over tension protection .....	42
5.29. Slack rope protection .....	42
5.29.1. General.....	42
5.29.2. Drift winders.....	42
5.29.3. Shaft winders.....	43
5.30. Tail rope protection (friction – Koepe winders).....	43
5.31. Warning devices – prestart warning.....	44
5.32. Winder controls .....	44
5.33. Winder drum pit protection .....	44
5.34. Winder sump protection .....	45
5.35. Winder guide rope tension protection – counterweights .....	45
6. Design – commissioning.....	46
6.1. Commissioning program .....	46
6.2. Personnel .....	46

6.3. Records .....	46
7. Maintenance.....	48
7.1. Outcomes.....	48
7.2. Maintenance program .....	48
7.3. Personnel .....	49
7.4. Records .....	49
7.5. Proof testing.....	49
7.6. Routine testing.....	50
7.6.1. General .....	50
7.6.2. Brake testing.....	50
7.6.3. Overspeed testing.....	50
7.6.4. Over travel/under travel testing.....	50
7.6.5. Ultimate safety circuit testing.....	50
7.6.6. Primary safety circuit testing .....	51
7.6.7. Secondary safety circuit testing.....	51
7.6.8. Programming verification .....	51
Appendix A - references .....	52
Australian standards .....	52
International Standards .....	56

# 1. Introduction

## 1.1. Scope and application

Part 5 of the *Technical reference guide: Powered winding systems* series:

- provides guidance on eliminating or minimising risks associated with winder control systems, and
- identifies the essential safety and functional requirements that must be included in the design of control systems for the safe operation of a PWS.

As outlined in the table below, Part 5 applies to the control systems on all mine winders.

WINDER TYPE	APPLICATION OF TRG: POWERED WINDING SYSTEMS				
	Part 1: General requirements	Part 2: Drift winders	Part 3: Vertical shaft winders (drum, friction, shaft sinking and emergency winders)	Part 4: Ropes	Part 5: Control systems
Drift	☑	☑		☑	☑
Vertical shaft drum	☑		☑	☑	☑
Friction (koepe)	☑		☑	☑	☑
Shaft sinking	☑		☑	☑	☑
Emergency	☑		☑	☑	☑

Part 5 should be used by designers, manufacturers, owners and end users with consideration to:

- designing new PWS
- verifying new PWS



- applying for design registration of a PWS
- altering an existing PWS
- carrying out five yearly audits of a PWS
- reviewing PWS designs following an incident, and
- altering, maintaining or repairing PWS.

## 1.2. References

Refer to **Appendix A** for a list of Australian and International Standards referred to in this series.

**Note:** All Standards referred to in this series relate to the 2019 revision of the Standard, as amended from time to time.

## 1.3. Abbreviations and definitions

For the purposes of Part 5 '*Winder control systems*', the abbreviations and definitions in *Reference guide: Powered Winding Systems – Part 1: General requirements* apply.

## 2. Design — Performance requirements

### 2.1. General

PWS must be designed to achieve the essential safety requirements and the functional requirements detailed below.

PWS must achieve the essential safety requirements through the application of functional safety principals to identify all hazards associated with the proposed winding application and to develop appropriate risk controls that will achieve a tolerable level of risk.

When identifying risks associated with the PWS, the design risk assessment should give consideration to all intended uses and reasonably foreseeable misuse of the winding system.

**Note:** Section 5 '*Design – Description of safety functions*' provides guidance to the types of safety functions that should be considered during the design risk assessment and control identification processes to achieve a safe PWS.

The outcome(s) of the design risk assessment must be maintained in the plant safety file.

### 2.2. Essential safety requirements

PWS must be designed and constructed to protect people against harm to their health, safety and welfare through the elimination or minimisation of risks throughout the lifecycle of the PWS.

Essential safety requirements include, but are not limited to:

- preventing injury to people from sources of electrical energy, including:
  - prevention of electrocution
  - prevention of injury or death from electric shock
  - prevention of electrical burns, including electrically induced radiation burns
- preventing unintended operation of plant, including:
  - failure to stop, or
  - failure to operate as commanded, and
- providing electrical and mechanical safeguards for electrical, mechanical and other hazards with a probability of failure appropriate to the degree of risk posed by the hazard.

## 2.3. Essential functional requirements

The conveyance must operate within pre-defined:

- travel limits
- speed limits
- acceleration and deceleration limits.

The conveyance must be brought safely to rest when the conveyance operates outside the predefined:

- travel limits
- speed limits
- acceleration and deceleration limits.

The conveyance must be capable of being automatically brought safely to rest in an emergency.

The conveyance must not be able to be moved while people are entering or leaving the conveyance.

For vertical shafts, the conveyance must only be capable of access or egress at predefined locations during normal operation.

All conveyances must be provided with facilities that allow for access or egress in emergency situations at any location.

The conveyance must have facilities that provide for signalling, operating and communicating to:

- the winder control system
- the winder operator where manual control facilities are provided
- locations that are used for access to and egress from the conveyance
- other locations identified through the design risk assessment processes.

No part of a person's body must be permitted to protrude from the conveyance during travel, or to signal, operate controls or communicate to the winder control system, winder operator or other locations.

Facilities must be provided that prevent oversize loads being transported in the drift or shaft.

In the event of any safety-related device, feature, component, circuit or the like failing in such a manner that it becomes incapable of operating on demand, the conveyance must be automatically brought safely to rest.

## 3. Design — general control system requirements

### 3.1. General

The control functions of the winder should be separate and independent to the safety functions of the winding system where possible. Safety functions that are provided as a backup to another safety function such as primary overtravel and ultimate overtravel limits must operate independently of each other.

The design risk assessment and in particular a failure modes effects and criticality analysis (FMECA) should identify safety function components, the required stopping category and clearly define the interface between electrical and mechanical components.

### 3.2. Hardware requirements

Mechanically actuated position switches should be actuated in the positive mode. Refer to AS 4024.1.

Hardware must be suitable for the environment in which it is to operate. This should include resistance to corrosive liquids, ingress of dust and the ability to withstand impact damage. Refer to AS 60529 for guidance in degrees of protection provided by enclosures.

Additional measures must be implemented to prevent or detect failure where magnetic and proximity-type safety switches are used.

Electrical circuits associated with control and safety functions must be designed so they are able to detect abnormal conditions such as an open circuit or a short circuit that may initiate unintended operation, or inhibit shut down, of the associated functions. This includes the control signals to and from the conveyance and associated control systems, including call stations.

Where a fault condition is not self-revealing, additional means of detection must be provided to identify the fault condition and initiate appropriate automatic actions to ensure the safety of the PWS.

Redundancy and diversity should be used to avoid, where possible, common cause failure of safety functions.

The power supply to field devices for control and safety circuits should not exceed extra low voltage.

### 3.3. Operational control functions

Operational control functions are those functions that relate to the normal operation of the PWS. These control functions must be designed using a risk-based safety approach.

The functional requirements identified in clause 2.3 '*Essential functional requirements*' must be achieved.

Winder control systems should have facilities that enable the calling and sending of a conveyance. The location of these facilities is dependent on the operational requirements of the mine.

Visual and audible signalling systems must be provided at all shaft/drift entry points and within all conveyances.

Manuals controls associated with winder motion must be provided with a 'hold-to-run device' facility.

The failure of any control function to perform in the designed manner must bring the PWS to a stop.

Any fault condition that prevents the winder from performing the commanded instruction or causes the winder to be brought to a stop as a result of an unexpected condition must be displayed and automatically recorded.

### 3.4. Safety functions

Safety functions are those that are intended to identify abnormal conditions or actions associated with the winder and initiate appropriate control actions to bring the winder to a safe state.

The essential safety outcomes identified in clause 2.2 '*Essential safety requirements*' above must be achieved.

Each safety function, when operated, must bring the PWS to a stop.

Any activation of a safety device must annunciate through alarms (visible and audible). The activation should be automatically logged.

All activations of safety functions must cause the trip or the alarm to be latched.

The facility for resetting of any function that has tripped and requires manual reset must be provided with the capability to restrict access to the reset facility.

Operation of the reset facility must not over-ride a protection trip.

The loss of power to the PWS, or parts thereof, should not cause or enable the latch to be reset.

Testing and verification for the validation of risk reduction functions must be by, or under the supervision of, an independent certified functional safety expert (CFSE), or in the case of hard-wired systems, an independent competent electrical engineer.

### 3.4.1. New powered winding systems

Safety functions of new PWS must be designed using a full functional safety approach in accordance with the processes identified in the AS 61508 series of Standards or AS 62061.

All elements identified in Section 5 '*Design – description of safety functions*' and the required stop category (refer clause 3.5 '*Stop categories*') for each of these elements in the 'independent safety circuits' identified in Section 4 '*Design – independent safety circuit requirements*' must be considered during the risk identification process and when selecting appropriate safety related control functions and the required stop category.

**Note:** This requirement is to ensure that the risks that were controlled by the protection functions that were required for winders designed to MDG 2005, and were implemented due to significant incidents that resulted in multiple injuries and fatalities, are not overlooked in future winder designs.

Each safety function must bring the PWS to a stop when operated. The method used for stopping must be in accordance with the nominated stop category for that function. Stop categories are defined in clause 3.5 '*Stop categories*'.

The required stop category must be determined based on the risk to be controlled and the suitability of each stop function to effectively control that risk.

For non-electrical components, such as brake system hydraulic and mechanical components, as well as simple items such as limit switch striker arms, etc, that form parts of the safety related control systems, performance levels (PLs) should be used, as detailed in AS/NZS 4024.1503.

Designs should include the capability to undertake proof testing without code forcing, lifting of wires or bridging. Testing processes should be implemented in such a way that faults are readily revealed to the person undertaking the testing. These processes should be automated where possible.

### 3.4.2. Modification of existing powered winding systems

Any modification made to a control function or a safety function of the PWS, whether hardware or software, must be in accordance with the requirements of a documented change management system.

Where new risk controls are added to the control or safety functions, or modifications are made to a significant portion of one or more safety circuits, the modifications must be done in accordance with the

full functional safety approach as per clause 3.4.1 'New powered winding systems'. Requirements detailed in AS 61508.1 in relation to modification and retrofit should be followed.

There must not be a reduction of safety of any of the existing safety functions of the PWS.

If the winder design is based on independent safety circuits, the modification of a safety function must not reduce the level of safety provided by the safety circuit that the function relates to. Section 4 'Design – independent safety circuit requirements' details the safety functions associated with each safety circuit.

Safety functions may be designed using independent layers of protection and proven in use components or by safety-rated components to achieve the required level of risk reduction.

The commissioning and verification process for the modifications must demonstrate that the modifications achieve the desired effect without unintended impact on any other system or function.

Refer to the following for guidance:

- AS 61508 series of standards
- AS 61511 series of standards
- AS 62061.

**Note:** Uncontrolled modifications to winder control system software can result in catastrophic failure of the PWS.

### 3.5. Stop categories

Stopping of the winder must be achieved in accordance with the following categories:

- **Stop category 0** must bring the winder to an immediate stop by the removal of drive torque from the PWS and the application of the braking system.

**Note:** Removal of drive torque may be achieved by features such as the opening of a supply circuit breaker or by use of the 'safe torque off' feature of a variable speed drive. Whatever method is chosen must achieve the required safety integrity level (SIL) specification for the function that is initiating the removal of drive torque.

- **Stop category 1** must bring the winder to a stop in a controlled manner that retains drive torque to the winder drive system and enables the drive motor to bring the conveyance to a standstill as quickly as possible while minimising slack rope conditions on a drum winder or rope slip on a friction winder.
- **Stop category 2** must bring the winder to a normal stop.

**Note:** These categories are consistent with stop categories as defined in AS/NZS 4024.1204.

### 3.6. Programmable electronic systems

The speed of processing information within the processor and between remote racks or external devices must be at a rate that does not present a risk to the operation of the conveyance and the PWS.

All safety-related software must be self-monitoring.

Where software forms part of a safety circuit, it must be designed, developed, tested and verified in accordance with the processes identified in AS 61508.3 or AS 62061.

Provision must be made for the routine verification of the programming. The winder safety management system should provide for routine verification checks to be performed at:

- a predetermined frequency for the detection of unauthorised change, and
- the occurrence of a trigger event.



## 4. Design — independent safety circuit requirements

### 4.1. General

Where a winder has been designed using the independent safety circuits approach, the winder must include at least two independent safety circuits.

Each of the safety circuits includes functions that detect failures in the winder control system or that backup other safety circuit functions to achieve the required level of risk reduction.

The ultimate safety circuit must operate independently to the winder control systems and to the primary and the secondary circuits. That is, there should be no commonality of the hardware or software components that make up each of the safety circuits, where possible.

The primary and secondary safety circuits should be independent of each other and the winder control system, where possible.

**Note:** As both the primary and the secondary safety circuits use common components of the drive system to bring the winder to a standstill, they cannot achieve a high level of independence as is achieved with the ultimate safety circuit.

The time response required of the safety function to bring the winder to a safe state determines if the function should be located in the primary safety circuit or in the secondary safety circuit.

This section identifies which safety functions must be included in each of the safety circuits and the stop category (refer clause 3.5 'Stop categories') required to be assigned to that safety circuit. The list is not exhaustive and additional protective devices and functions may be necessary. This will be dependent on each specific winder design.

### 4.2. Ultimate safety circuit elements

#### 4.2.1. General requirements

The safety integrity level (SIL) specification of the ultimate safety circuit must be at least SIL2.

The operation or failure of any function within the ultimate safety circuit must initiate a category 0 stop of the PWS.

The reset facility for the ultimate safety circuit must be provided with the capability to restrict access to the reset facility.

**Note:** In the event that any of the devices connected into the ultimate safety circuit has operated and brought the PWS to rest, the winder control system should not be reset until an authorised person has investigated the cause of the stoppage and has carried out the necessary remedial action before manually resetting the ultimate safety circuit.

The reset circuit must not over-ride or defeat any safety function that forms part of the ultimate safety circuit during normal operation, or reduce the SIL specification of the safety circuit.

Where there is a demand on the primary safety circuit and the winder is not brought to a controlled stop, the ultimate safety circuit must be activated.

### 4.2.2. Requirements for ALL types of winders

All winders must be fitted with the following safety functions:

- failure/loss of control of electric, hydraulic or pneumatic power source
- failure to operate of the primary safety circuit
- ultimate over travel limit
- ultimate under travel limit
- gear loss/broken shaft
- winder motor/motive force (hydraulic/pneumatic) over speed.

### 4.2.3. Additional requirements for double drum winders

A separate ultimate over travel limit and an ultimate under travel limit must be provided for each conveyance.

### 4.2.4. Additional requirements for shaft sinking winders

Shaft sinking winders must have ultimate over travel limits and ultimate under travel limits for both the kibble/conveyance and the stage.

### 4.2.5. Friction winders

All friction (Koepe) winders must have ultimate over travel devices fitted for the conveyance and for the second conveyance/counterweight.

The conveyance ultimate over travel should be fitted in the head frame.

The ultimate over travel device for the second conveyance/counterweight should be fitted in the opposite side of the headframe.

### 4.2.6. Drift winders

All drift winders must have a physical ultimate over travel device fitted on the gantry.

An ultimate under travel device should be fitted. This may be a physical limit at the drift bottom or a limit driven by the winder drum.

## 4.3. Primary safety circuit elements

### 4.3.1. General requirements

The SIL specification of each safety function in the primary safety circuit must be at least SIL2.

An initiation or failure of any of the primary safety circuit devices must initiate a minimum of a category 1 stop of the PWS.

The reset facility for the primary safety circuit must be fitted with the capability to restrict access to the reset facility.

**Note:** In the event that any of the devices connected into the primary safety circuit operate, the winder must be inhibited from further operation 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.

The reset circuit must not over-ride or defeat any safety function that forms part of the primary safety circuit during normal operation, or reduce the SIL specification of the safety circuit.

Where there is a demand on the secondary safety circuit and the winder is not brought to a controlled stop, the primary safety circuit must be activated.

### 4.3.2. Requirements for ALL winder designs

All winders must be provided with the following safety functions:

- brake system protection – application and release

**Note:** Where the monitored brake fault condition is not considered to present an immediate safety demand, then this monitored condition may be in the secondary safety circuit

- communication error check
- communication failure/loss

- data error check monitoring (watch dog)
- R/F carrier/data detect
- emergency stop facilities
- failure to operate of the secondary safety circuit
- primary over travel limit
- primary under travel limit
- high level drum pit flooding
- excess load
- shaft/drift obstruction
- signal confirmation failure
- slack rope
- winder drum overspeed
- winder speed profile deviation

### 4.3.3. Additional requirements for ALL shaft winders

The following safety functions must also be provided for all shaft winders, additional to the requirements of clause 4.3.2 '*Requirements for ALL winder designs*' above:

- door gate monitoring/interlocking – conveyance
- door gate monitoring/interlocking – shaft entry
- guide rope counterweight loss of tension protection (where there is a risk of build-up of material under the counterweight(s))
- keps/chairing beams proving device (where applicable)
- plat extension monitoring / interlocking (where applicable).

#### 4.3.4. Additional requirements for double drum winders fitted with a clutch

The following safety functions must also be provided for all double drum winders fitted with a clutch, additional to the requirements of clause 4.3.2 'Requirements for ALL winder designs' above:

- de-clutch interlocking

**Note:** Man riding is only permitted where two separate brake systems are provided. This may be achieved with the drums coupled together

- separate primary over travel limit and primary under travel limits must be provided for each conveyance, and
- single drum de-clutch protection device.

#### 4.3.5. Additional requirements for double drum winders without a clutch

All double drum winders without a clutch must be fitted with primary over travel limit protection in the headframe for each conveyance/counterweight and a primary under travel limit at shaft bottom.

#### 4.3.6. Additional requirements for friction winders

The following safety functions must be provided for friction winders, additional to the requirements of clause 4.3.2 'Requirements for ALL winder designs':

- rope creep device
- tail rope wander/protection device.

#### 4.3.7. Additional requirements for material winders

The following safety functions must also be provided for material winders, additional to the requirements of clause 4.3.2 'Requirements for ALL winder designs':

- Flask and tub gate/chute securing/interlocking systems

**Note:** For the purposes of man riding systems on material winders, flask and tub gate/chute securing / interlocking systems should be SIL 2.

### 4.3.8. Additional requirements for drift winders

The following safety functions must also be provided for all drift winders, additional to the requirements of clause 4.3.2 '*Requirements for ALL winder designs*':

- conveyance dump brakes application
- conveyance derail switch
- conveyance door/gate monitoring (where doors are fitted)
- conveyance hydraulic pressure loss
- conveyance loss of motion detection
- conveyance over speed protection
- conveyance emergency stop facility
- winder slack rope protection.

### 4.3.9. Additional requirements for shaft sinking winders

The following safety functions must also be provided for all shaft sinking winders, additional to the requirements of clause 4.3.2 '*Requirements for ALL winder designs*':

- brake system protection, both application and release, for each of the kibble/conveyance and staging winch drums
- declutch interlocking (where applicable)
- emergency stop facilities for each of the kibble/conveyance and staging winch drums
- primary over travel limits and primary under travel limits for both the kibble/conveyance and the stage where the end of travel position varies between the two modes of transport
- gear loss/broken shaft protection, for each of the kibble/conveyance and staging winch drums
- excess load for each of the kibble/conveyance and staging winch drums
- radio control for each of the kibble/conveyance and staging winch drums
- signal confirmation facility for each of the kibble/conveyance and staging winch drums

- single drum de-clutch protection device (where applicable)
- slack rope device for each of the kibble/conveyance and staging winch drums
- stage location proving device
- stage tilt device
- winder drum over speed device for both the kibble/conveyance and staging winches
- winder speed profile monitoring, for both the kibble/conveyance and staging winches
- collar doors closed interlocking.

## 4.4. Secondary safety circuit elements

### 4.4.1. General requirements

The secondary safety circuit must be designed to operate independently to that of the ultimate safety circuit and the primary safety circuit.

The SIL specification of the secondary safety circuit must be at least SIL1.

The initiation or failure of any safety function within the secondary safety circuit must initiate a minimum of a category 2 stop of the PWS.

Some of the safety functions that relate to the conveyance may be provided with an automatic reset, or a manual reset within the conveyance, to allow for trip resetting once the conveyance has come to a stop and the fault that initiated the stop corrected.

The reset circuit must not over-ride or defeat any safety function that forms part of the secondary safety circuit during normal operation, or reduce the SIL specification of the safety circuit.

If an automatic reset circuit malfunctions, it must not defeat any portion of the secondary safety circuit. The manual reset facility for the secondary safety circuit must be fitted with the capability to restrict access to the reset facility.

### 4.4.2. Requirements for ALL winder designs

All winders must be fitted with the following safety functions:

- air/hydraulic unit protection

- brake wear/lift protection
- hold-to-run controls (for manual operations)
- gearbox/drive condition monitoring
- low level drum pit flood protection alarm (where applicable)
- normal stop over travel (for automatic winders)
- normal stop under travel (for automatic winders)
- safe coiling protection
- shaft/drift profile monitoring
- hold-to-run device released (for manual operation, with winder in motion)
- stuck button protection, including stuck hold-to-run device.

#### **4.4.3. Additional requirements for friction winders, single rope drum shaft winders, single rope rack and pinion hoists and double drum winders fitted with or without a clutch**

The following safety functions must also be provided for all shaft winders, except shaft sinking winders, additional to the requirements of clause 4.4.2 *'Requirements for ALL winder designs'* above:

- low level guide rope counterweight loss of tension protection alarm (where applicable)
- winder sump protection (where applicable).

#### **4.4.4. Additional requirements for drift drum winders**

The following safety functions must also be provided for all drift winders, additional to the requirements of clause 4.4.2 *'Requirements for ALL winder designs'* above:

- automatic shunting points device
- conveyance motion detection device.



#### 4.4.5. Additional requirements for shaft sinking winders

The following safety functions must also be provided for all shaft sinking winders, additional to the requirements of clause 4.4.2 '*Requirements for ALL winder designs*' above:

- multiple winder interlocking, where there is more than one PWS used in the same shaft (e.g. staging and kibble/conveyance winches). The system must be designed so that when one PWS is in use, the other PWS cannot be used in any other alternate mode.
- shaft collar interlocking: must be provided to ensure that when personnel are riding in the conveyance, stone tipping systems cannot be operated and the shaft collar is completely covered to prevent loose materials from falling down the shaft.
- tipping chute interlocking: must be provided to ensure that when personnel are to enter and ride in the conveyance, the winder drive system cannot operate unless tipping chutes are clear of the conveyance.

## 5. Design — description of safety functions

### 5.1. General

This section describes the operational requirements of various safety functions used within PWS safety functions.

### 5.2. Brake systems

#### 5.2.1. Mechanical brake systems

##### 5.2.1.1. General

Where it is determined that an abnormal brake condition requires immediate action, then the winder safety system must initiate a category 1 stop utilising the remaining (redundant but still intact) braking components.

Where the abnormal brake condition is not considered to present an immediate safety risk, then this abnormal condition may initiate a category 2 stop. The winder may also be permitted to complete the current winder prior to initiating the category 2 stop.

**Note:** Depending on the nature of the brake fault condition and the design of the electrical drive system, it may be determined that the drive torque should be maintained to the winder drum, with the winder at stand still, until the fault has been investigated and the fault rectified.

##### 5.2.1.2. Brake monitoring

The braking system must be designed to monitor for dangerous conditions and should be fitted with devices to monitor brake release (lift), brake release failure, brake application (set), brake application failure, brake wear, brake temperature, broken brake linkages and where applicable brake counterweight operation.

Where counterweights are used for brake application (external drum and post brakes), a means to monitor brake pressure is adequate should be provided.

### 5.2.1.3. Brake path contamination

The deposition of water condensation or other contaminations may affect the efficiency of brake paths. The design risk assessment must take into account sudden changes in atmospheric temperature and humidity. Reference should be made to historical data relating to these changes.

Engineering solutions must be developed and implemented to prevent the contamination of brake paths.

### 5.2.1.4. Brake testing

All PWS should be fitted with facilities to carry out dynamic and static brake testing. The test facilities should be designed to be of key or push button operation and requiring no other manual alteration to the winder control system to perform these tests.

The key or push button should return to the normal operating position upon release. Failure of the key or push button to return to the normal operating position should prevent normal operation of the winder.

### 5.2.1.5. Hydraulic brake unit protection

The brake unit control circuit may allow the winder to complete its cycle, but not recommence a new cycle where any of the following occurs:

- high oil temperature alarm
- low hydraulic oil level
- low hydraulic system pressure.

## 5.2.2. Electrical braking systems

Electric braking, either regenerative or dynamic, must be provided on all electrically driven winders. Electric braking should be retained until it is proven that the mechanical brakes have been effectively applied as per stop category 1 and stop category 2 requirements (refer clause 3.5 'Stop categories').

## 5.3. Hold-to-run control

Hold-to-run controls are often referred to as deadman controls.

Hold-to-run devices, such as a joy stick, must be provided for the manual operation of any winder including the manual control of personnel conveyances on drift winders.

The hold-to-run device must return to the off/stop position when released by the operator.

Release of the hold-to-run device while the winder is still in motion should cause a category 2 stop of the winder.

Hold-to-run controls must be used where static and dynamic brake tests are performed with manual control.

**Note:** Automatic 'push button tests' do not require a hold-to-run facility.

## 5.4. Door/gate interlocking – shaft winders

### 5.4.1. General

All conveyances should be totally enclosed.

### 5.4.2. Collar and shaft entries

All collar and shaft entry positions/landings must be fitted with doors/gates, electrically and mechanically interlocked as closed and locked before the winder control system can be operated.

The shaft entry door/gates must be designed in such a manner that the door/gates cannot be opened unless the conveyance is positioned at the respective landing.

### 5.4.3. Conveyances

All conveyances must be fitted with doors/gates, electrically and mechanically interlocked as closed and locked before the winder control system can be operated.

**Note:** The term 'closed and locked', means that the mechanical interlocking devices must be separately monitored as engaged (locked) by an interlock device.

The conveyance door/gates must be designed in such a manner so that the door/gates cannot be opened unless the conveyance is positioned at a landing and cannot be opened while the conveyance is in motion.

The interlock monitoring device must operate independently to that of the door/gate electrical interlocks and must cause a stop of the winder in the event of loss of integrity of the mechanical interlock system.

Failure of any of the above electrical facilities must cause the conveyance to stop.

The winder control system must be designed so that a person within the conveyance is not required to reach outside of the conveyance to access conveyance controls once the door/gates are closed and locked.

#### 5.4.4. Material winder tubs/skips

Where man riding facilities are fitted to material winder tubs/skips, the requirements of clause 5.4.2 '*Collar and shaft entries*' and clause 5.4.3 '*Conveyances*' must apply.

In addition, flask and tub gate/chutes must be fitted with locking systems to prevent material falling onto the man riding facility when the facilities are in use. The locking systems must be interlocked with the winder control system to prevent the movement of the winder unless the gates are secured and locked.

### 5.5. Door/gate interlocking – drift winders

Where the design risk assessment process has determined there is a risk to the safety of people riding in the conveyance, the conveyance must be fitted with doors.

Where fitted, the doors must be monitored as closed and locked before the winder control system can be operated.

Operation of any of these devices while the conveyance is in motion must cause the conveyance to be brought to a controlled stop as quickly as possible.

The failure of any of these devices must cause the conveyance to stop.

### 5.6. Double drum shaft winders fitted with a clutch

The clutch for a double drum winder must be interlocked with the braking system of the de-clutched drum in such a manner that the clutch cannot be disengaged without the brakes being applied and that the applied brakes cannot be released without the clutch being engaged.

Where both drums of a clutched double drum winder are required to provide the necessary two independent braking systems for the purposes of man riding, the clutch interlocking system must only enable man riding when the clutch is engaged.

A double drum winder with clutch must have the position of the clutch indicated.

Where the clutch of a double drum winder is disengaged without the brake for the de-clutched drum being applied, or where the brake is released without the clutch being engaged, the brakes must be applied immediately.

## 5.7. Shaft and drift profile monitoring

To ensure the safe operation of the conveyance and equipment transported into and out of the mine, all drifts and shafts that carry materials or equipment must be fitted with load profile monitoring. This profile monitoring must detect equipment or loads that are outside the accepted profile of the drift or shaft and must be provided at the following locations:

- designated underground loading points
- shaft or drift access points where equipment can be attached to or loaded inside of the conveyance for transportation into or out of the mine
- surface – portal/ or shaft entry.

Operation of these monitoring devices must be ‘fail to safety’ concept in design and must stop the conveyance from any further movement in the selected direction. The conveyance may only be returned to the point of loading after the cause of the stoppage has been addressed.

## 5.8. Emergency stop facilities – including hand-operated

Emergency stop devices must comply with the requirements of 4024.1604.

Emergency stop devices must be designed so the stop control cannot be adversely affected by electrical or electronic circuit malfunction.

Emergency stop switches must be provided at the following locations:

- within the winder house
- at all loading and unloading points
- at all shaft entry points
- at all call stations
- within all conveyances
- within arm’s reach of any winder driver
- within arm’s reach of any static and dynamic brake testing facility, and
- wherever else is identified within the design risk assessment as being necessary.

Emergency stop switches located within any conveyance must, when operated, cause the winder to stop at any position in the shaft or drift.

**Note:** The winder control system should be inhibited from being operated until an authorised person has investigated the reason for operation of the emergency stop and has carried out the necessary remedial action before manually resetting the winder control system.

Initiation of any emergency stop switch must cause the winder to be automatically brought to a stop, irrespective of any actions by a winder operator.

**Note:** It is essential that the emergency stopping function of any circuit is not impaired in any way by a program malfunction, equipment failure or application of software overrides.

## 5.9. Flashing lights (drift winders)

### 5.9.1. General

To ensure the safe operation of the conveyance and equipment transported into and out of the mine, all drifts must be fitted with flashing lights.

These lights must operate whenever the conveyance is in motion.

The lights must be positioned so that people can observe at least one light from any point in the drift.

### 5.9.2. Conveyance flashing lights

All personnel transport conveyances operating in a drift must be fitted with flashing lights that must operate continually while the conveyances are in motion. Consideration should be given to the operation of the flashing lights at the same time as the pre-start alarm. The conveyance flashing lights are additional to the prestart alarm.

The conveyance flashing lights must be readily seen and be of a different colour and operating frequency to that of the fixed flashing lights in the drift.

The conveyance flashing lights should also be of differing colours on either end of the control conveyance to visually indicate the travelling direction of the control conveyance.

When any additional personnel transport conveyances are connected to the control conveyance, the most inbye conveyance must be fitted with a flashing light operating at the same colour and frequency to that of the inbye flashing light fitted to the control conveyance.

## 5.10. Gearbox/drive monitoring

Gearbox/drive monitoring should be provided for winder control systems. Real time sensors should be installed to monitor the following items:

- bearing vibration
- high bearing temperature
- high lubricating oil temperature
- low lubricating oil level.

## 5.11. Gear loss protection

A gear loss protection system should be fitted to monitor the complete winder drive system from the non-drive end of the drive motor to the end of the gear train driven by the winder drum. This includes the gear train that incorporates overspeed protection, back up overwind limits, conveyance position indicator drive system, encoders and other safety-related devices, winder drum position and speed.

The design risk assessment and an engineering assessment should determine the allowable limits of differences between the winder drum speed monitoring and the drive motor speed monitoring device. This should operate at no greater than 15% speed differential and immediately initiate a category 0 stop.

## 5.12. Indicators

### 5.12.1. Depth indicators

Every winder should be provided with a depth indicator that accurately shows the position of the conveyance in the shaft or drift. The location of each shaft/drift entry should be clearly marked on the depth indicator. The depth indicator may be analogue or digital. Where there are two conveyances associated with a winder, the location of each conveyance should be shown on the indicator.

Double drum winders with a clutch should have a separate depth indicator for each conveyance. Each depth indicator, including the monitoring and operating apparatus of double drum winders fitted with a clutch, should be synchronised with the position of its respective conveyance in the shaft.



### 5.12.2. Load current/torque

Every electrically driven winder should be provided with instrumentation showing the load current or torque of the motor.

### 5.12.3. Winder speed

Every winder should be provided with a speed indicator graduated in metres per second.

## 5.13. Keps (chairs, catches, dogs or keeps)

The device and the control system should be designed so that the Keps cannot be engaged until the conveyance is stationary and located in position and that the engaged Keps cannot be withdrawn while the weight of the conveyance is resting on them, i.e. the winder has taken up the stretch in the rope(s). This prevents any sudden drop or rise of the conveyance upon withdrawal.

## 5.14. Load sensing

Consideration should be given to the inclusion of automatic load sensing of the conveyance and associated loads to enable automatic selection of the correct speed for the load being carried.

Where automatic load sensing is used, the default setting for the winder should be for maximum load settings when no signal is present from the load sensing device.

#### Note:

1. In order to ensure the safe operation of the conveyance and equipment transported into and out of the mine, and where PWSs are designed to carry both personnel and heavy materials on different occasions, the design risk assessment should determine the engineering requirements, including load sensing, to automatically predetermine the speed of the winder for the intended load attached to the conveyance.
2. The design risk assessment should also address procedures for safely transporting heavy machinery in and out of the shaft or drift.
3. The outcome(s) of the design risk assessment should be maintained in the plant safety file. Any deviation from the above requirements should be shown to provide an equivalent level of safety.

## 5.15. Winder overspeed devices

### 5.15.1. General

Operation of winder drum or winder motor overspeed devices signifies a loss of control of the drive system.

Overspeed detected by either of these overspeed devices should bring the winder to a stop.

### 5.15.2. Winder speed profile deviation

The PWS will have a speed profile that determines the actually operating speed in all parts of the shaft or drift. Deviation of the winder speed away from the speed profile, where not specifically commanded, should cause the winder to be brought to a safe state.

This deviation detection is typically set at +/- 5% of nominal speed throughout the wind, although this deviation may increase when winders are operating in or close to creep speed.

### 5.15.3. Winder drums

All winder drums should be provided with an overspeed device fitted to the non-driven end of the winder drum and set to operate at 110 % of the nominated winder speed.

### 5.15.4. Winder motors

All winder motors should be provided with an overspeed device fitted to the non-drive end of the winder prime mover and set to operate at 112% of the nominated winder speed.

## 5.16. Over travel devices

### 5.16.1. Ultimate over and under travel limits

#### 5.16.1.1. General

Each ultimate over and ultimate under travel limit should be provided with a mechanical and electrical latching system capable only of being manually reset at the location of the device and should operate in such a manner as to prevent the winder from being moved in until the cause of the event has been determined.

These devices should be operated by the conveyance (and counterweight where applicable) and should operate in the ultimate safety circuit and cause removal of drive torque from the winder drive and apply the emergency brakes.

The position of the ultimate over travel limit should allow for system inertia and should allow for the conveyance (and counterweight where applicable), to be brought safely to rest without striking end of travel structural buffers or stops.

The physical ultimate over travel and under travel limits should be backed up by duplicated limits driven by the winder drum. This may be achieved by use of hard-wired limits or by absolute position encoders.

#### **5.16.1.2. Double drum and single rope shaft winders**

Double drum and single rope shaft winders should have at least two physical over travel devices fitted in the head frame and at least two physical under travel devices fitted at shaft bottom to prevent an over/under travel condition from occurring.

#### **5.16.1.3. Friction winders**

Friction (Koepe) winders should have at least two physical over travel devices fitted in the head frame and have at least two physical under travel devices fitted in the opposite side of the headframe for cage/cage and/or cage/counterweight combinations.

#### **5.16.1.4. Drift winders**

Drift winders should have at least two physical over travel devices fitted on the gantry and at least two physical under travel devices fitted to prevent an under travel condition from occurring at the drift bottom.

### **5.16.2. Primary over travel and under travel limits**

Winders should be fitted with a suitable primary over travel and primary under travel physical devices. These should be located in the headgear and shaft bottom (for a shaft winder) and end of track (gantry) and track bottom (for a drift winder). Under travel limits for drift bottom may be operated using hunting tooth limits or absolute position encoders driven by the winder drum.

**Note:** Hunting tooth limits and absolute position encoders are protected against loss of drive through the gear loss protection.

The position of the primary over travel and under travel limit devices should allow for system inertia and should allow for the conveyance (and counterweight where applicable), to be brought safely to rest without entering the zone of protection of the ultimate over and under travel limits.

Upon initiation of the primary over travel or primary under travel limit, each device should mechanically and electrically latch in such a manner as to prevent the winder from being operated in either direction.

These devices should be operated by the conveyance and counterweight where applicable.

Where absolute position encoders form part of the winder control system, consideration should be given to use of this information to act as a back up to the hardwired primary travel limits.

### 5.16.3. 'Normal stop' over and under travel limits

All predefined normal stopping locations form part of the control system functions of an automatic winder.

A failure to stop at a predefined location must cause the winder to be brought safely to rest. This over or under travel must be defined for each of the predetermined stopping locations within a shaft or drift. It must not be dependent on the conveyance travelling the full distance of the shaft or drift before the fault is identified as an over travel or under travel condition.

For shaft/drift top and bottom, this protection must bring the winder to rest prior to activation of the primary over travel or under travel protection.

These normal stop over travel or under travel limits may be physical devices or may be software driven in conjunction with absolute position encoders driven by the winder drum.

### 5.16.4. Over and under travel 'back out' devices and procedures

Provision should be made to 'back out' from any over or under travel condition.

The manually operated switch or device used for the 'back out' procedure should be designed as 'spring return to off' upon release.

**Note:** Procedures should be established whereby an authorised person should investigate the cause of the over travel condition and should only allow operation of the 'back out' system until the conveyance is returned to within the normal travel limits for the winder.

The 'back out' system should only permit the winder to be operated in the opposite direction to that of the initiation of the detecting device or limit switch.

## 5.17. Torque-sensing circuit

A torque-sensing detection circuit should be provided to confirm that the drive system is developing torque before allowing the mechanical brakes on the winder to be released. The torque sensing is

critical to ensure that torque is available to control the load attached to the winder rope and prevent any possibility of a runaway occurring due to a 'free wheeling' situation.

A failure to develop torque should result in a category 0 stop being initiated.

## 5.18. Plat gates

Where plat gates are used, they should be electrically and mechanically interlocked in the manner described in clause 5.4.1 '*General*' and form part of the conveyance/shaft entry electrical and mechanical interlocking system.

The plat gate should not be able to be opened unless the conveyance is correctly positioned at the plat so that no person is exposed to open sections of the shaft when the plat gate is opened, thereby providing safe access and egress for people. Correct positioning of the conveyance includes engagement with deployable plats where used.

Where a deployable plat is used, the movement of the conveyance must be inhibited until the plat is fully retracted, unless the conveyance must be moved to enable retraction of the plat. In this case only movement of the conveyance that enables the retraction of the plat must be permitted.

Plat gates are also sometimes designed to provide the function of a Kep in that it secures the conveyance, preventing slack rope from occurring during loading and unloading operations. In this instance and in addition to the requirements of this clause, the system should be designed in a manner described in clause 5.13 '*Keps (chairs, catches, dogs or keeps)*'.

## 5.19. Quick stop facilities

Quick stop facilities now form part of the emergency stop facilities of the winding system. Refer to clause 5.8 '*Emergency stop facilities – including hand operated*'.

## 5.20. Radio frequency (R/F) links

In the case where control signals (e.g. raise, lower etc) to and from the conveyance and associated control stations are connected via any form of R/F link, the following protection should be provided:

- R/F carrier/data detection monitoring
- R/F must not be used for ultimate safety circuits
- loss of R/F (carrier/data detect) should cause the conveyance to be brought safely to rest

- loss of R/F associated with safety functions must cause the conveyance to be brought safely to rest.
- where data error check monitoring (watch dog) is employed on conveyances, the radio control system operational time for detection of data error should be calculated to prevent excessive slack rope being generated at the conveyance for protection associated with functions such as conveyance over speed, slack rope or emergency stop operation, dolly car motion detection or dolly car dump brake operation.

**Note:** Depending on speed of the dolly car and the data transmission system in use, it may be possible to permit multiple retries of the data transmission prior to initiation of the winder stop. These data transmission retries should be recorded.

## 5.21. Data transfer

Where communications are established between the conveyance, the winder control system and any associated field stations or devices, via any communications protocol, the communication method should be monitored and provide for the following:

- communication failure/loss
- data error check monitoring (watch dog).

Where data transmission systems are used with a conveyance, the control system operational time for detection of data error should be calculated to prevent excessive slack rope being generated at the conveyance for protection functions such as dolly car motion detection or dump brake operation or a cage slack rope.

**Note:** Depending on speed of the conveyance and the data transmission system in use, it may be possible to permit multiple retries of the transmission before initiation of the winder stop. Where there is an abnormal increase in data transmission retries, these should be automatically logged and alarms raised.

## 5.22. Safety circuit cabling

Where control devices forming part of any safety circuit are connected via cabling, either electrical or optical fibre, the following requirements should be complied with:

- a single electrical fault should not cause the conveyance to move unexpectedly or fail to stop. (typical faults are: short circuit, open circuit, high resistance and earth fault)
- where the safety circuit cabling is associated with a safety function, the safety function must register as faulty and initiate the appropriate stopping category for the affected function.

## 5.23. Safe coiling protection – double drum, single rope shaft and drift winders

A device should be fitted to the winder drum to detect 'unsafe coiling' of the winder rope.

Upon detection of any unsafe coiling, the winder should be stopped.

## 5.24. Safety monitoring for drift winder conveyance

### 5.24.1. Conveyance door/gate monitoring

The PWS design risk assessment should include the assessment of risk to people when riding in the conveyance.

Where it has been determined there is a risk to the safety of people riding in the conveyance, the conveyance should be fitted with doors.

Doors fitted to conveyances should be monitored as closed and locked before the winder control system can be operated.

### 5.24.2. Conveyance dump brake system operation and protection

#### 5.24.2.1. General

The conveyance dump brake system of the drift winder is critical to safety. The mechanical components of the braking system should be monitored for dangerous conditions.

The full range of dump brake system protection requirements should be determined by an engineering assessment.

#### 5.24.2.2. Release of conveyance dump brakes

The drift winder control system should be designed in such a manner so as to automatically prevent the lifting of the conveyance dump brakes clear of the track by operation of the hydraulic system, until all slack rope has been taken up by the winder drum.

#### 5.24.2.3. Conveyance hydraulic brake pressure

All personnel transport conveyances that have a hydraulically operated dump brake release circuit should have a device fitted to monitor the hydraulic pressure.

The failure of this device to detect minimum pressure for safe release of brakes should initiate a category 1 stop.

### 5.24.3. Conveyance derail switch

Personnel conveyances operating on a drum drift winder should have a device fitted to detect derailing of the conveyance.

### 5.24.4. Conveyance motion detection device

Conveyances should have a device fitted to detect loss of motion of the conveyance.

**Note:** This device will assist in the detection of slack rope and hence reduce the possibility of developing kinks in the winder rope.

Detection of a loss of motion of the conveyance should cause the winder drive system to stop and prevent any further inbye movement. The winder control system should only allow outbye movement until motion has been detected. This prevents slack rope from developing and enables the removal of slack rope that has developed. Once motion has been detected, inbye movement of the conveyance can be allowed. This permits the conveyance to be returned to the surface for repair if no motion is detected whilst travelling outbye.

Conveyance speed should be restricted while travelling with no motion detection signal.

This device may be reset at the conveyance to allow outbye motion only.

### 5.24.5. Conveyance overspeed

Drift winder conveyances should be provided with an overspeed device that is set to operate at 115% of the nominated winder speed.

Activation of this device should cause operation of the conveyance dump brake system and the winder braking system.

**Note:** The overspeed device, coupled with the conveyance motion detection device causes operation to the dump brakes in the case of a rope break.

## 5.25. Conveyance slow down speed zones

Slow down zones must be incorporated in the speed profile of the PWS.

For drift winders, the winder control system should reduce speed of the conveyance as it approaches the surface of the mine. Slow down zones should also apply at any auto-stop locations within the drift



including the bottom of a drift where drift grades may be reduced and at rail shunts and turns in the drift.

This is to prevent over run of the winder rope by the conveyance as the winder drum slows down and to reduce the effects of deceleration on occupants of the conveyance and on the PWS itself.

**Note:**

1. The grade of a drift is reduced on the surface gantry to allow for safer working and access/egress to the conveyance. With the reduced grade, gravity has a reduced deceleration effect on the conveyance and so the speed of the winder must be reduced. The reduced speed reduces the stopping distance for the conveyance and reduces the likelihood of rope over-run that can result in a 'whipping' effect when the conveyance runs backwards.
2. For a conveyance travelling to the surface, if the winder drum slows down faster than the conveyance, a slack rope condition will develop. The conveyance will roll backwards until the slack rope is taken up. This effect has caused serious injury to people in the past.

For shaft winders, slow down zones should be used at both the top and bottom of shafts and at plats at different levels in the shaft to control deceleration forces on conveyance occupants when lowering and to prevent the conveyance over running the rope during deceleration on raise.

## 5.26. Shaft or drift obstruction protection

Any deliberate obstruction placed in a shaft or drift that is deployed for maintenance or unloading of equipment should have its position monitored by a safety device or devices. The winder control circuitry should ensure that the conveyance cannot unintentionally make contact with an obstruction.

## 5.27. Signalling and communication systems

### 5.27.1. Signalling systems for all mine winders

All personnel transport conveyances operating on PWSs, should be provided with a suitable means to:

- give audible and visual signals to
- receive audible and/or visual signals from, and
- communicate by speech

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

Where a failure of the audible or visual signalling systems is detected, alarms should be initiated. The design risk assessment should give consideration to the limiting of winder operations, and any additional controls required to be implemented, until the warning systems have been repaired.

### 5.27.2. Signalling systems for manually operated mine winders including shaft sinking winders – additional requirements

These requirements do not apply to automatic winders with provision for manual operation provided that the existing visual and audible signalling systems are used.

In addition to the requirements of clause 5.27.1 *'Signalling systems for all mine winders'* signalling systems installed on all manually operated mine winders should be provided with a signal confirmation system whereby 'signals sent' from shaft entry levels, cage, or staging are automatically compared (using a monitoring system) with those 'signals returned' by the winder operator.

Any discrepancy detected between signals sent and signals returned should prevent the winder from moving independent to that of the winder operator.

Visual and audible alarms should warn the winder operator of the occurrence of a signal discrepancy.

It is strongly recommended that 'rapper'/'knocker' type signalling systems not be used because of the risk of inadvertent operation of the signalling system by falling material and/or loss of all or part of the signal line.

Where 'rapper'/'knocker' signalling systems are used, the system should be designed with 'fail to safety' concepts in that a break or slackening of the signal line, should cause the winder to stop.

'Rapper'/'knocker' signalling systems may be used as a back up to existing signalling systems for use in an emergency.

Where more than one signalling system is installed i.e. conveyance and staging etc, an interlocking system should be established whereby only one signalling system can be used at any one time.

The operation of each signalling event should be recorded.

### 5.27.3. Voice communication systems

All conveyances capable of personnel transport should have an effective voice communication system installed.

The system should provide the ability for two-way voice communication between the operator of the conveyance, the winder control room, call stations associated with the PWS and an operations/control room (if applicable).

If the above locations are unmanned, the system should provide the ability for the operator of the conveyance, in the case of an emergency, to establish communication with site personnel at other identified areas where people are present.

A 'back up' voice communication system should be provided in the event of failure of the primary communication system.

The 'back up' voice communication system should be capable of operating totally independent to that of the primary system.

Procedures should be developed for the use of both the primary voice communication system and the 'back up' voice communication system.

## **5.28. Single point suspension of shaft cables supplying electrical and communication services to conveyances – over tension protection**

Detection of the over-tension of single point suspension cage cables should be provided.

This detection device should operate before the tension applied to the cable exceeds the safe working load/strain of the cable.

Where the device incorporates a shear pin, a secondary means of support to prevent the cable falling into the shaft should be installed. The shear pin should be monitored and an alarm and trip activated when the shear pin operates.

## **5.29. Slack rope protection**

### **5.29.1. General**

For all winder types, a safety device should be installed to ensure that in the event of slack rope being detected, the conveyance will stop.

### **5.29.2. Drift winders**

In the case of drift winders, the slack rope control system should prevent no more than a calculated value of two metres of slack rope being developed at any point throughout the length of travel following the operation of the conveyance quick stop function.

In the event of the occurrence of a slack rope condition and the winder is brought to a stop, the winder control system design should only permit the winder to be driven in the outbye direction, while the slack in the rope is taken up.

Where the conveyance dump brakes have operated, procedures should be developed and implemented to specifically address the dangers arising out of energising the dump brake system in order to lift the dump brakes clear of the track. An engineering solution should be developed and implemented to automatically prevent the dump brakes being energised (released) while the slack rope condition exists.

Due to the 'procedural' aspects of this activity, attention should be directed toward competency of operators in controlling the outbye direction of the winder to remove slack rope. Attention should be paid to this activity in the design 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.

### 5.29.3. Shaft winders

The slack rope device should detect the occurrence of a slack rope condition in the event of a 'hang up' in the shaft by the cage, tub or counterweight and in the case of shaft sinking winders the tub, kibble, cage and staging (where applicable).

**Note:** The slack rope detection device is usually attached to a rope immediately above the conveyance.

Where winders are manually operated and where automatic winders are placed in the manual mode, the initiation of the emergency braking system following the detection of a slack rope condition must be independent to that of the winder operator.

An engineering solution and associated procedures should be developed and implemented to minimise the occurrence of a slack rope condition, with particular reference to the nature and type of devices and procedures employed to remove slack in the rope.

Due to the 'procedural' aspects of this activity, attention should be directed toward competency of operators in controlling the direction of the winder to remove slack rope. Attention should be paid to this activity in the design risk assessment in relation to isolation and access, as people will need to inspect the shaft, cage, tub kibble or counterweight for possible causes of the slack rope condition and for possible damage to the conveyance, fixed guides or rope guides.

## 5.30. Tail rope protection (friction – Koepe winders)

Safety devices should be fitted to detect entanglement or twisting of tail ropes in a shaft winding system. The devices should detect unacceptable vertical and horizontal movement of the ropes(s).

## 5.31. Warning devices – prestart warning

All winder control systems should be fitted with prestart warning alarms.

These alarms should be sounded before any movement of the conveyance. The alarm should operate for sufficient time to allow people to avoid any danger. The length of time should be determined during the design risk assessment and will need to consider all possible scenarios of operation of the PWS.

These alarms should be in the winder house, at all points within the drift or shaft where routine work is carried out, and where people embark or disembark from the conveyance.

An alarm should also sound from the conveyance before any movement of the conveyance.

Where more than one PWS is installed adjacently in a single shaft or drift, pre-start warning alarms should be of a different colour and tone respectively.

## 5.32. Winder controls

Winder controls at shaft or drift entry points should be positioned in such a location as to prevent operation from within the conveyance.

The winder control system should be designed to only permit operation of the winder from within the conveyance where people have entered the conveyance and only when shaft entry and conveyance door/gates are closed, locked and proven locked. Where plat gates/doors are fitted, the plat gates/doors must also be raised or disengaged and locked and proven locked.

The interlocking of shaft entry gates/doors, conveyance gates/doors and plat gates/doors should be designed to operate independently to that of any winder operator so that the conveyance cannot be moved unless shaft entry and conveyance door/gates are closed, locked and proven locked and where plat gates/doors are fitted, the plat gates/doors are raised or disengaged, locked and proven locked. Where plat gates are mechanically interlocked, conveyance motion must be limited to motion that enables the conveyance to be disengaged from the plat.

## 5.33. Winder drum pit protection

It is recommended that any winder drum and associated brake paths are not housed in a pit or sump, however any pit required to house the winding drum and brake paths should be adequately drained and protected with a monitoring device. This device should operate before the brake path (disk) becomes contaminated.

Separate alarm and trip functions should be provided.

### **5.34. Winder sump protection**

Any blind or undrained shaft sump at a shaft bottom that is required to house the winder tail ropes and guides/guide ropes should be protected with monitoring devices to detect falling material and rising water that may cause damage to any winder mechanical or electrical equipment. This device should operate before the components become contaminated.

Separate alarm and trip functions should be provided.

### **5.35. Winder guide rope tension protection – counterweights**

Where winder guide ropes are tensioned by counterweights and there is a possibility of build-up of material under the counterweights, a protective device should be installed to stop the winder before the occurrence of unacceptable loss of tension of the guide ropes.

## 6. Design — commissioning

### 6.1. Commissioning program

Commissioning of plant is undertaken to confirm that the control functions and the safety functions of the plant perform their intended function in the manner in which the design risk assessment intended them to perform.

A detailed commissioning program should be prepared by the designer or the manufacturer before beginning the final commissioning of the PWS.

The commissioning must verify the correct operation of all elements of the control functions and the safety functions associated with the PWS.

A commissioning program must be developed and implemented:

- for new installations
- for relocated installations
- when maintenance of the PWS has involved replacement of parts or components of safety related circuits
- when the 'philosophy of operation' of the winder, or parts thereof, have changed from the commissioned design.

**Note:** The replacement of components of the system with 'non like' components is a modification. All parts of the design affected by this change must be assessed in accordance with documented change management processes.

### 6.2. Personnel

The commissioning program should be reviewed by an independent, competent person.

The commissioning should be witnessed by a competent electrical engineer and a competent mechanical engineer with experience in the operation of PWS.

### 6.3. Records

Commissioning records should define all testing and record the results of such testing of the control functions and safety functions of the PWS. This includes all control and safety function settings,

operating times of safety functions of the PWS. This should also include any other tests relevant to the PWS.

The commissioning records should show that all aspects of the winder operation and safety functions operated in accordance with the designs.

The results of the commissioning should be verified by the statutory electrical engineer and the statutory mechanical engineer.

Commissioning records should be kept in the plant safety file.



## 7. Maintenance

### 7.1. Outcomes

All parts of a PWS should be maintained to ensure that:

- safe operation is not impaired by interference, damage, ageing or wear
- it is capable of operating to the limits specified in its design
- regulations are complied with
- all safety features and warning devices are functioning correctly.

**Note:** This will be an integral part of maintaining the SIL and will require the identification of safety-related functions and systems.

### 7.2. Maintenance program

A detailed maintenance program should be prepared before beginning operation of the PWS.

Elements to be considered in developing and implementing a maintenance program include inspection and testing activities, and the frequencies of these activities.

The procedures for inspection, testing, maintenance and repair activities should be developed and periodically reviewed by the designer or manufacturer or, if the designer and manufacturer are not available, these should be developed by a competent person.

The maintenance program should identify the appropriate competencies of the people that will undertake the maintenance activities, or supervise those people that are undertaking the maintenance activities.

The maintenance program should be reviewed by a competent person, independent of the person who developed the program prior to implementation.

Where the PWS has been damaged to the extent that its safe operation is impaired and the risk to health or safety is increased a competent person should assess the damage and provides advice on:

- the nature of the damage.
- whether it is able to be repaired and, if so, what repairs should be carried out to minimise risks to health and safety.

All repairs should be carried out to keep the PWS within its design limits.

## 7.3. Personnel

Maintenance activities should be carried out by a person or people that have had relevant training and have been assessed as competent and authorised to perform such maintenance activities.

**Note:** This may include the manufacturer/installer of the PWS as well as mine personnel.

## 7.4. Records

A record should be kept of all inspections and tests made, including routine and proof tests, along with any other maintenance carried out on the PWS.

Testing records should define all testing and record the results of such testing of control and safety functions, control and safety function settings, operating times, and any other tests relevant to verify correct operation of the PWS.

The following information should be recorded:

- name of the person who made the inspection or carried out the test or maintenance
- date on which, or dates over which, the inspection was made or the test or maintenance was carried out
- result or outcome of the inspection, test or maintenance
- date by which the next inspection and test should be carried out.

The testing and maintenance records should be retained in the plant safety file. Alternatively the safety file may make reference to the testing and maintenance records.

## 7.5. Proof testing

To maintain safety integrity, special tests (called proof tests) are required. These tests are designed to detect dangerous hidden failures so that repairs can be carried out to restore the system to the 'as designed' functionality, for example the E-stop operational test described above might not necessarily detect a failed component in a redundant channel.

Proof testing must be undertaken in accordance with the time intervals and the procedures nominated by the designer to ensure that the assigned safety integrity levels are maintained for each of the

specified safety functions. These are additional and more detailed and thorough than the tests identified in the routine testing section above.

## 7.6. Routine testing

### 7.6.1. General

Time intervals for undertaking routine testing should be nominated by the designer of the PWS. These routine test intervals should be determined in conjunction with the requirements for proof testing.

Where routine test intervals have not been nominated, the intervals detailed in the following sections should be used.

### 7.6.2. Brake testing

Brake testing should be done in accordance with Part 1 of this series '*General requirements*'.

### 7.6.3. Overspeed testing

All over speed devices should be dynamically tested six monthly and a record of these test results logged.

### 7.6.4. Over travel/under travel testing

All over/under travel devices should be dynamically tested monthly and a record of these test results logged.

Special precautions should be taken when testing the ultimate and primary over/under travel devices in order to prevent excessive travel of the conveyance in the event of failure of the device under test.

### 7.6.5. Ultimate safety circuit testing

All devices associated with the winder control that operate the ultimate safety circuit of the winder should be statically tested monthly.

The operation of the ultimate safety circuit should be dynamically tested monthly and a record of these test results logged.

### **7.6.6. Primary safety circuit testing**

All devices associated with the winder control that operate the primary safety circuit of the winder should be statically tested weekly.

The operation of the primary safety circuit should be dynamically tested weekly and a record of these test results logged.

### **7.6.7. Secondary safety circuit testing**

All devices associated with the winder control that operate the secondary safety circuit of the winder should be statically tested weekly.

The operation of the secondary safety circuit should be dynamically tested weekly and a record of these test results logged.

### **7.6.8. Programming verification**

Routine verification of the status of programming, to detect unauthorised change, should be performed at a predetermined frequency, and at the occurrence of a trigger event.

This should be done throughout the life of the PWS.

## Appendix A — references

All Standards listed below refer to the current revision of the standard, as revised from time-to-time.

### Australian standards

AS 1065	AS 1065 Non-destructive testing - Ultrasonic testing of carbon and low alloy steel forgings
AS 1085.1	AS 1085.1 Railway track material – Steel rails
AS 1085.2	AS 1085.2 Railway track material - Fishplates
AS 1085.3	AS 1085.3 Railway track material - Sleeper plates
AS 1085.4	AS 1085.4 Railway track material - Fishbolts and nuts
AS 1085.7	AS 1085.7 Railway track material - Spring washers
AS 1085.8	AS 1085.8 Railway track material - Dogspikes
AS 1085.10	AS 1085.10 Railway track material - Rail anchors
AS 1085.12	AS 1085.12 Railway track material - Insulated joint assemblies
AS 1085.13	AS 1085.13 Railway track material - Spring fastening spikes for sleeper plates
AS 1085.14	AS 1085.14 Railway track material - Prestressed concrete sleepers
AS 1085.17	AS 1085.17 Railway track material - Steel sleepers
AS 1085.18	AS 1085.18 Railway track material - Screw spikes and threaded inserts
AS 1085.19	AS 1085.19 Railway track material - Resilient fastening assemblies
AS 1085.20	AS 1085.20 Railway track material - Welding of steel rail
AS 1085.21	AS 1085.21 Railway track material - Turnouts, switches and crossings
AS/NZS 1170.0	AS/NZS 1170.0 Structural design actions - General principles
AS 1171-1998	AS 1171 Non-destructive testing - Magnetic particle testing of ferromagnetic products, components and structures
AS 1210-2010	AS 1210 Pressure vessels

AS 1403	AS 1403 Design of rotating steel shafts
AS 1554.1	AS 1554.1 Structural steel welding –Welding of steel structures
AS/NZS 1554.4	AS/NZS 1554.4 Structural steel welding - Welding of high strength quenched and tempered steels
AS/NZS 1554.5	AS/NZS 1554.5 Structural steel welding - Welding of steel structures subject to high levels of fatigue loading
AS 1657	AS 1657 Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS 1670.1	AS 1670.1 Fire detection, warning, control and intercom systems - System design, installation and commissioning - Fire
AS 1710	AS 1710 Non-destructive testing - Ultrasonic testing of carbon and low alloy steel plate and universal sections - Test methods and quality classification
AS 1735.2	AS 1735.2 Lifts, escalators and moving walks - Passenger and goods lifts – Electric
AS 2574	AS 2574 Non-destructive testing - Ultrasonic testing of ferritic steel castings
AS 2671	AS 2671 Hydraulic fluid power - General requirements for systems (ISO 4413, MOD)
AS 2759	AS 2759 Steel wire rope - Use, operation and maintenance
AS 2788	AS 2788 Pneumatic fluid power - General requirements for systems (ISO 4414, MOD)
AS 3507.2	AS 3507.2 Non-destructive testing - Radiographic determination of quality of ferrous castings
AS 3569	AS 3569 Steel wire ropes - Product specification
AS 3600	AS 3600 Concrete structures

AS 3637.1	AS 3637.1 Underground mining - Winding suspension equipment - General requirements
AS 3637.2	AS 3637.2 Underground mining - Winding suspension equipment - Detaching hooks
AS 3637.3	AS 3637.3 Underground mining - Winding suspension equipment - Rope cappings
AS 3637.4	AS 3637.4 Underground mining - Winding suspension equipment - Drawbars and connecting links
AS 3637.5	AS 3637.5 Underground mining - Winding suspension equipment - Rope swivels and swivel hooks
AS 3637.6	AS 3637.6 Underground mining - Winding suspension equipment - Shackles and chains
AS 3751	AS 3751 Underground mining - Slope haulage - Couplings, drawbars, and safety chains
AS 3785.1	AS 3785.1 Underground mining - Shaft equipment - Shaft overwind safety catch system
AS 3785.2	AS 3785.2 Underground mining - Shaft equipment - Shaft winding arresting systems
AS 3785.3	AS 3785.3 Underground mining - Shaft equipment - Drum winding gripper systems
AS/NZS 3785.4	AS/NZS 3785.4 Underground mining - Shaft equipment - Conveyances for vertical shafts
AS 3785.5	AS 3785.5 Underground mining - Shaft equipment - Headframes
AS/NZS 3785.6	AS/NZS 3785.6 Underground mining - Shaft equipment - Fixed guides, rope guides and rubbing ropes for conveyances
AS 3785.7	AS 3785.7 Underground mining - Shaft equipment - Sheaves

AS/NZS 3785.8	AS/NZS 3785.8 Underground mining - Shaft equipment - Conveyances for inclined shafts
AS 3990	AS 3990 Mechanical equipment - Steelwork
AS 4024	AS 4024 safety of machinery series of standards
AS 4024.1	AS 4024.1 Series Safety of Machinery (all sub-Parts as applicable)
AS/NZS 4024.1204	Safety of machinery – Electrical equipment of machines - General requirements (IEC 60204-1:2016 (ED. 6.0) MOD)
AS 4024.1503	Safety of machinery- Safety-related parts of control systems—General principles for design’
AS 4024.1604	Safety of machinery - Design of controls, interlocks and guarding— Emergency stop—Principles for design
AS 4100	AS 4100 Steel structures
AS 4730.2	AS 4730.2 Mining - Winding equipment - Braking systems
AS/NZS 4812	AS/NZS 4812 Non-destructive examination and discard criteria for wire ropes in mine winding systems
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS 61508 Series	Functional safety of electrical/electronic/programmable electronic safety-related systems
AS 61511	AS 61511 series of standards ‘Functional safety – Safety instrumented systems for the process industry sector’
AS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS/NZS ISO 9001	AS/NZS ISO 9001 Quality Management Systems - Requirements
AS ISO 31000	AS ISO 31000 Risk management - Guidelines



## International Standards

ISO 286-1	ISO 286-1 : Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 1: Basis of tolerances, deviations and fits
BS 7608	BS 7608 Guide to fatigue design and assessment of steel products
ISO Guide 73	ISO Guide 73 Risk management - Vocabulary
ISO 4309	ISO 4309 Cranes - Wire ropes - Care and maintenance, inspection and discard
ISO 4413	ISO 4413 Hydraulic fluid power - General rules and safety requirements for systems and their components
ISO 4414	ISO 4414 Pneumatic fluid power - General rules and safety requirements for systems and their components
IEC 31010	IEC 31010 Ed. 2.0 (Bilingual 2009) Risk management - Risk assessment techniques
ISO 12100	ISO 12100 Safety of machinery – General principles for design – Risk assessment and risk reduction
Other Reference	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.
SABS 0293	Condition assessment of steel wire ropes on mine winders code of practice
ASTM E1571 – 11(2016)e1	Standard Practice for Electromagnetic Examination of Ferromagnetic Steel Wire Rope