



Mining—Winding equipment

Part 2: Braking systems



AS 4730.2:2018

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- Engineers Australia
- Minerals Council of Australia
- Mining Electrical and Mining Mechanical Engineering Society
- NSW Department of Industry, Skills and Regional Development

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Part 2: Braking systems

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Preface

This Standard was prepared by the Standards Australia Committee ME-018, Mining Equipment.

The objective of this Standard is to assist designers, manufacturers and managers of winder braking systems, including shaft sinking winder braking systems, by providing control measures for the purpose of protecting the safety of people in the workplace and property.

This Standard is Part 2 of a new series of Standards for mine winding equipment. This series comprises the following:

AS 4730.1, *Mining — Winding equipment, Part 1: Winder control systems*

AS 4730.2, *Mining — Winding equipment, Part 2: Braking systems* (this Standard)

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The term “informative” has been used in this Standard to define the application of the appendix to which it applies. An “informative” appendix is only for information and guidance.

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Australian Standard®

Mining—Winding equipment

Part 2: Braking systems

Section 1 Scope and general

1.1 Scope

This Standard specifies requirements for systems used for service and safety braking functions on drum and friction winder drum assemblies, used for moving persons, minerals or materials in vertical and inclined shafts in mines.

NOTE [Appendix E](#) describes typical hazardous events that can arise during the operation of winding systems, and the associated actions that may be used to address the hazards.

This Standard applies to all powered winding systems, whether vertical or inclined, where the travel distance is more than 40 m, and to powered winding systems carrying more than two people if the travel distance is less than 40 m.

This Standard does not cover retardation provided by the drive system.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents for informative purposes are listed in the Bibliography.

AS 2671, *Hydraulic fluid power — General requirements for systems (ISO 4413:1998, MOD)*

AS 2788, *Pneumatic fluid power — General requirements for systems (ISO 4414:1998, MOD)*

AS 3791, *Hydraulic hose*

AS 3990, *Mechanical equipment — Steelwork*

AS 4100, *Steel structures*

AS 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems (all parts)*

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

AS IEC 61511, *Functional safety — Safety instrumented systems for the process industry sector (all parts)*

AS/NZS 4024.1503, *Safety of machinery, Part 1503: Safety-related parts of control systems — General principles for design*

1.3 Terms and definitions

For the purpose of this Standard the following terms and definitions apply.

1.3.1**abnormal condition**

condition that needs to be actioned to prevent either injury to personnel or damage to equipment

Note 1 to entry: This may be determined by industry experience, user experience or risk assessment. Examples of such conditions include operation outside the defined speed and distance requirements, conveyance door not secured, unauthorized shaft access, shaft obstruction and slack rope.

1.3.2**brake channel**

system consisting of the minimum set of components able to independently apply force to a brake path or paths. i.e. a brake control system and a mechanical brake

1.3.3**brake control system**

electrical, pneumatic, hydraulic or combination of any; that interprets commands from the winder control system and converts these commands to control the force of the mechanical brake acting on the brake path

1.3.4**brake force**

force applied to the brake path normally by a combination of spring force (or dead weight) and a counteracting fluid pressure

1.3.5**brake load**

equivalent load referred to the rope centre resulting from the brake torque

1.3.6**brake path**

machined surface affixed or integral to the winder drum, to which the mechanical brake(s) applies a friction force

1.3.7**brake torque**

torque acting on the drum resulting from the brake force applied to the brake path and the brake coefficient of friction

1.3.8**braking system**

system that when commanded by the winder control system, will apply a torque to the drum allowing the winder to be brought to or remain at rest. It is the complete system encompassing brake control system, mechanical brakes, brake channels and brake paths

Note 1 to entry: See [Figure 2.1](#).

1.3.9**bypass**

risk assessed manually initiated function to defeat an individual control or safety function

1.3.10**closed-loop braking system**

braking system which has feedback typically from drum speed to adjust braking torque during braking to ensure that a regulated deceleration is achieved irrespective of direction of travel, loading condition and actual friction co-efficient

1.3.11**clutch**

mechanical device that engages and disengages power transmission from the drum shaft to the drum

1.3.12**constant brake force system**

braking system that applies a constant brake force during safety braking irrespective of speed and direction of travel of the conveyance

Note 1 to entry: Deceleration will consequently vary depending on direction of travel, loading condition and actual friction co-efficient.

1.3.13**conveyance**

any car, carriage, cage, skip, kibble or stage in which personnel or material is conveyed in a shaft. A counterweight is also considered to be a conveyance

1.3.14**critical component**

any component, the failure of which will reduce the braking capacity of the braking system by 50 % or more

1.3.15**critical head rope tension ratio**

limiting value of dynamic head rope tension ratio at which slip between the rope and the driving friction winder drum occurs

1.3.16**drum winder**

winder in which a winding rope coils on and off the drum during winding

1.3.17**dynamic head rope tension ratio**

ratio of head rope tensions on either side of the driving friction winder drum during acceleration or retardation

1.3.18**emergency stop device**

manually actuated control device used to initiate an emergency stop function

[SOURCE: IEC 60204-1:2016, 3.1.21]

1.3.19**emergency stop function**

function intended to stop all hazardous motion in an emergency situation

1.3.20**fatigue reserve factor**

ratio of the allowable stress range to the stress range under actual dynamic load conditions

Note 1 to entry: The allowable stress range is based on the endurance limit of the material and takes into account both stress range and the mean stress.

1.3.21**friction winder**

winder in which the driving force is transmitted to all winding rope(s) by friction between the drive drum and the rope(s)

1.3.22**functional safety**

that part of the overall safety relating to the winder and its control and braking systems that depends on the correct functioning of safety systems and other risk reduction measures

1.3.23**hazard**

potential source of harm

1.3.24**hazardous event**

event that may result in harm

1.3.25**maximum static out-of-balance suspended load**

maximum difference between the suspended load on each side of the drum calculated on the basis of rated loads

Note 1 to entry: For single drum winders it is the maximum suspended load.

1.3.26**mechanical brake**

mechanical device that applies a friction force to a brake path

1.3.27**normal operation**

use of the winder within its design parameters and intended operating modes

Note 1 to entry: Maintenance and testing functions are considered to be normal operation, however, during these conditions simulated faults may be introduced.

1.3.28**open-loop braking system**

braking system that does not utilise drum speed feedback during safety braking. The preselected brake force may be set according to payload and direction of travel

1.3.29**over speed**

any speed of the conveyance outside the designated speed/distance envelope

1.3.30**over travel**

any position of the conveyance outside the designated limits of travel for normal winding operations

1.3.31**powered winding system**

any mechanical device powered by air, electricity, internal combustion, water, or hydraulic power or operated by a force of gravity designed for the purpose of lifting or lowering persons or materials to or from different levels within the underground mine and/or to the surface of the mine by means of a rope or chain attached to a conveyance

1.3.32**response time**

elapsed time from receipt of the brake apply signal from the winder control system to the contact of the mechanical brake onto the brake path

1.3.33**risk**

combination of the probability of the occurrence of harm and the severity of that harm

1.3.34**safe state**

condition within the design limitation of the winding system which, as determined by risk assessment, reduces risk to a tolerable level

Note 1 to entry: Examples of safe state include the following:

- (a) Brought to a stop by the immediate initiation of the safety braking function.
- (b) Brought to a controlled stop.

- (c) Operated at a reduced speed.
- (d) Operated in a certain direction.
- (e) Operated until the end of the current winding sequence, at which time further operation is prohibited by the control system.
- (f) Prevented from moving by the control system if the winder is already stationary.

1.3.35

safety braking function

braking function used to bring a conveyance safely to rest, and hold at rest, in the event of detection of an abnormal condition

Note 1 to entry: A safety braking function is often characterized by a higher integrity level and a lower expected use than a service braking function.

1.3.36

safety system

electrical, electronic, programmable electronic system, mechanical device, or combination of any, that implements safety functions of the mine winding equipment

1.3.37

service braking function

braking function used to bring a conveyance safely to rest and hold at rest during normal operation. This may be automatically or manually applied

1.3.38

shall

indicates that a statement is mandatory

1.3.39

should

indicates a recommendation

1.3.40

speed/distance envelope

area bounded by zero speed and the maximum safe speed of the conveyance for each given position in the shaft

1.3.41

static brake safety factor

brake load/static out of balance load

1.3.42

static design factor

ratio between the ultimate failure load of a component in the particular manner of likely failure and the maximum static loading to which it may be subjected in service

1.3.43

static head rope tension ratio

ratio of static head rope tensions on either side of the friction winder drum

1.3.44

suspended load

load imposed onto the drum by the rope(s) including the loads due to suspended rope mass, conveyance mass, attachment mass and payload

1.3.45

thermal capacity

maximum temperature that the brake components are able to withstand before braking function deteriorates

1.3.46**tolerable risk**

risk that is accepted in a given context based on the current values of society

1.3.47**unclutched**

state in which the drum is disengaged from the drum shaft and free to rotate

1.3.48**winder**

machine used for raising and lowering conveyances in a mine shaft by means of a winding rope or ropes

1.3.49**winder control system**

system that carries out the necessary functions for control and safe operation of mine winding equipment.

Note 1 to entry: See [Figure 2.1](#)

1.3.50**winder system**

that part of the overall hoisting system consisting of the winder control system, the braking system, the drum and the drive system components

1.4 Risk management

Risk management principles shall be used to manage mine winder braking systems throughout their life cycles. Reference should be made to AS/NZS ISO 31000, IEC/ISO 31010 and ISO Guide 73.

NOTE The designer needs to account for any legislation pertaining to braking systems within the jurisdiction of intended use.

1.5 Safety braking application control

Typically, application of safety braking during emergencies is in accordance with one of the following alternatives:

- (a) Constant brake application force independent of the operating conditions.
- (b) Open-loop controlled braking force, where the force is varied according to load, direction of travel or other operating conditions.
- (c) Closed-loop control in order to —
 - (i) decelerate at a regulated rate irrespective of the direction of travel, loading conditions and actual friction coefficient;
 - (ii) reduce rope oscillations on application of the brake;
 - (iii) decrease the likelihood of rope slip for friction winders; and
 - (iv) limit the deceleration for an ascending load for drum winders.
- (d) A combination of (b) and (c).

During safety brake application using open or closed-loop braking systems, if a component malfunctions which may cause the design deceleration to be compromised, the system should automatically revert to a constant braking force system.

Section 2 Design principles

2.1 General

Winders shall have a braking system that provides service and safety braking functions. The requirements for these functions shall be determined by a risk assessment (see [Clause 2.3](#)).

The control and safety of the winding system is carried out by the winder control system, as set out in AS 4730.1, while this Standard covers the braking system. The relationship between the various elements of the winder control and the braking systems is shown in [Figure 2.1](#).

NOTE Information that may assist in the design of a braking system is listed in [Appendix A](#).

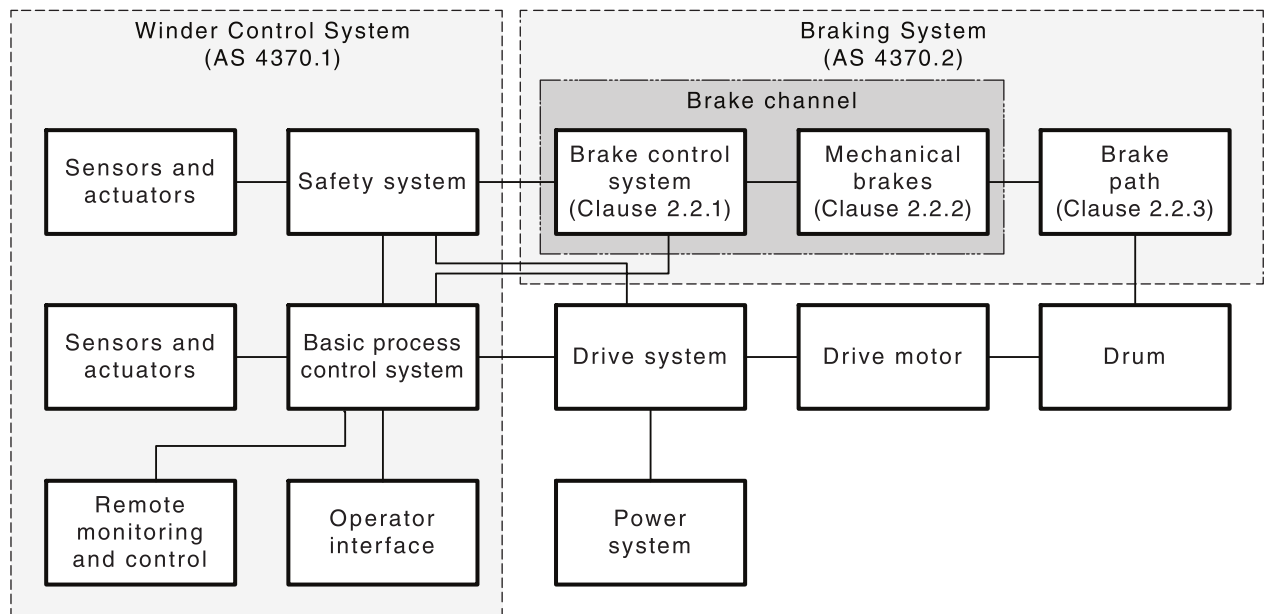


Figure 2.1 — Winder system functional diagram

2.2 Typical functions of winder braking systems

2.2.1 Brake control system

The brake control system typically —

- (a) interfaces with the winder control system and mechanical brakes;
- (b) applies service braking;
- (c) applies safety braking;
- (d) controls braking force (for personnel safety and equipment integrity);
- (e) communicates fault and operational information to the winder control system;
- (f) detects drum speed;
- (g) provides for bypass of selected control functions. Refer to [Clause 7.3\(e\)](#);
- (h) receives instructions from the operator interface;
- (i) displays operational information such as position, speed, current, I/O status, operating mode, fault status, via the operator interface;