
Handbook for approval assessment of transport braking systems on free-steered vehicles in underground coal mines

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PREFACE

This Handbook is primarily intended for the use of Officers of the Department of Mineral Resources and Assessors involved in the approval of Transport Braking Systems. The information contained within the handbook is also a valuable tool for manufacturers, service/maintenance organisations, users and others concerned with the safe operation of Transport Braking Systems on free-steered vehicles when operated in underground coal mines.

All mineworkers rely on free-steered, diesel powered, vehicles for safe transport to and from the workplace and for their day to day work underground. The proper design, testing and maintenance of braking systems on these vehicles is essential to minimise the risk of injury to all mineworkers. The Handbook has been prepared to assist in maintaining the safety of personnel and vehicles.

The Handbook specifies the requirements for the design, installation, testing and maintenance of braking systems fitted to free-steered vehicles in underground coal mines for the purposes of approval assessment.

Note In New South Wales, braking systems are required to be approved under the requirements of clause 61(1)(b) of the Coal Mines (Underground) Regulation 1999. This Handbook will assist in the processes of approval.

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FOREWORD

Various Australian Standards and the relevant statutory requirements lay down standard criteria for the design and performance of braking systems fitted to on-road and off-road vehicles. This Handbook includes provisions of those Standards and Handbooks and applies them to the underground mining industry.

The Handbook is not exhaustive in the coverage of Transport Braking Systems, but is intended to include those areas of concern to achieve a high safety standard. The focus has been placed on performance and design utilising acceptable standards and historical safety information.

Manufacturers, Service Organisations and the Users of free-steered vehicles have a 'duty of care' under the provisions of Occupational Health & Safety Legislation to ensure the safe operation of braking systems. The Handbook will assist in meeting those obligations.

It is essential for the manufacturer and user that hazards associated with the Transport Braking System be assessed and controlled with appropriate treatments. Risk management techniques shall be employed as per AS4360 "Risk Management", MDG 1010 "Risk Management Handbook for the Mining Industry" or other appropriate standard. Occupational health and safety aspects shall be considered during this process as per AS4801 "Occupational Health and Safety Management Systems" and the Occupational Health and Safety Act.

This Handbook supersedes the provisions of MDG1 and MDG9 in respect of braking systems only.

ACKNOWLEDGMENT

This document was prepared at the request of the Department of Mineral Resources, New South Wales and various stakeholders in the industry.

The participation of the members of the editorial committee is noted and appreciated.

The edition of the Handbook dated February 2001 is the first edition of this document. As required from time to time the document shall be reviewed to reflect current safety expectations. Comments on any aspect of this Handbook should be submitted in writing to:

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HANDBOOK FOR THE DESIGN, INSTALLATION, TESTING AND MAINTENANCE OF BRAKING SYSTEMS ON FREE-STEERED VEHICLES IN UNDERGROUND COAL MINES

SECTION 1 DESIGN AND CONSTRUCTION

1.1.0 SCOPE

This Handbook is produced as an assessment document to assist those persons involved with Transport Braking System approvals for free steered vehicles pursuant to clause 61 (1)(b) of Coal Mines (Underground) Regulation 1999. This clause states:-

“Transport must not be operated at a mine unless it is approved with respect to its braking systems.”

Note Clause 61 (1)(b) of Coal Mines (Underground Regulation) 1999, employs the word ‘transport’, see definition at 1.3.8.

As transport braking system can be classified as a safety critical item, any **electrical** transport braking system shall be designed in accordance with AS/NZS 61508 parts 1,3,4 & 5 “Functional Safety of Electrical / Electronic / Programmable Electronic Safety - Related Systems”.

It would be expected that any assessment carried out for approval purposes would use this document as a compliance document supplying information as detailed in section 4. Documentation providing evidence of OH&S and Electrical obligations shall be provided.

1.2.0 REFERENCED DOCUMENTS

The following documents are referenced in this Handbook.

MSHA, 30 CFR part 75.	Braking Performance - underground vehicles
CAN/CSA-M424.3-M90	Braking Performance, Rubber tyred self-propelled underground mining machinery.
AS1180.10B	Determination of Combustion Propagation characteristics of a horizontal oriented specimen of hose using surface ignition.
AS1210	Pressure Vessels
AS2660	Hose & hose Assemblies - Air/Water - for Underground Coal Mines.
AS2958.1	Earth Moving Machinery - Safety Part 1 : Wheeled Machines - Brakes
AS2971	Serially produced pressure vessels
AS3584	Diesel engine systems for underground coal mines.
AS3791	Hydraulic hose
SAEJ10	Automotive and off-highway air brake reservoir performance and identification requirements
ISO6805	Rubber hose and hose assemblies for underground mining, wire reinforced types for coal mining - specification.

BS7201

Hydraulic accumulators

1.3.0 DEFINITIONS

1.3.1 Vehicle

A free-steered vehicle, having a maximum speed of more than 4 km/hr, not operating on rails, powered by a diesel engine system or batteries and/or electric motors and driven by wheels or tracks, used for the transportation, handling or manipulation of personnel and/or equipment and/or material.

Does not include machines or equipment fitted with tracks or wheels for the purpose of relocation but which do not perform their normal function while moving.

Notes

(a) *The speed limit is derived from MSHA, 30 CFR part 75.*

(b) *The Statutory Authority may define vehicles requiring approval to this Handbook in greater detail.*

(c) *Vehicles having a maximum achievable speed of less than 4 km/Hr require approval in NSW by the Statutory Authority. A risk assessment, based on the applicable clauses of this Handbook is required for any application for the approval of such vehicles.*

1.3.2 Brake System

1.3.2.1 *Service brakes* – (see 1.5)

a system used to stop and momentarily hold a vehicle.

1.3.2.2 *Secondary brakes* – (see 1.6)

a system applied by the operator in the event of a failure of the service brakes.

1.3.2.3 *Parking brakes* – (see 1.7)

used to prevent movement of a stationary vehicle for prolonged periods.

1.3.2.4 *Automatic brakes* – (see 1.8)

which apply automatically. (see 1.8.5)

1.3.3 Light metal

Aluminium, magnesium, titanium or an alloy containing an aggregate of more than 15% by mass of aluminium, magnesium and titanium, or an alloy containing an aggregate of more than 6% by mass of magnesium and titanium.

1.3.4 Mean deceleration, (a)

Average rate of change of the speed of the vehicle from the instant the brake control actuation begins until a full stop is achieved.

Mean deceleration may be determined from the formula;

$$a = \frac{v^2}{2s}$$

where

a is the mean deceleration, in metres per second squared;

v is the speed of the vehicle immediately prior to the brake control being activated, in metres per second;

s is the stopping distance in metres.

1.3.5 Statutory authority

The Government department or authority that administers safety and health legislation pertaining to coal mines within which the approved/certified braking system will operate.

1.3.6 Tare Mass

The tare mass of a vehicle including the heaviest combination of cab, canopy and protective structures (ROPS/FOPS). It also includes components, mountings and equipment which are approved by the vehicle manufacturer, one 85kg operator, full fuel, water, oil and lubricant tanks.

For materials, equipment/stores transporters and LHD's the vehicle shall be fitted with the heaviest combination of attachments recommended by the manufacturer. The attachments shall not be loaded.

For vehicles designed to haul un-braked trailers, the tare mass shall include the unladen mass of the trailer.

1.3.7 Testing authority

A body acceptable to the statutory authority to carry out the assessments and tests herein. (normally a nationally accredited testing authority)

Notes (a) Such bodies should be traceable to the Joint Accreditation System of Australia and New Zealand (JAS-ANZ), which has been established for the purpose of accrediting testing laboratories, to undertake testing. NATA registered laboratories meet this requirement.

(b) Approved Competent Persons (Mechanical) may be acceptable Testing Authorities in New South Wales.

1.3.8 Transport

Transport means; a locomotive, rubber tyred or 'caterpillar' tracked vehicle (including a shuttle car) propelled by electrical or mechanical means and used for the purpose of transporting persons, materials, coal or stone, whether by carrying, towing or otherwise

Note The following vehicles are required to have approved types of braking systems. Shuttle car, Hauler-electric (battery), Load-Haul-Dump, Shearer Carrier, Chock Carrier, Personnel Transporter, Grader/Dozer, Skid-Steered Loader.

1.3.9 Vehicle Mass (gross)

The operating mass of a vehicle including the heaviest combination of cab, canopy and protective structures (ROPS/FOPS). It also includes components, mountings and equipment which are approved by the vehicle manufacturer, an 85kg operator, full fuel, water, oil and lubricant tanks.

For personnel carriers, a mass equivalent to the designed maximum number of persons multiplied by 85 kg shall be added.

For materials, equipment/stores transporters and LHD's the vehicle shall be loaded to its' maximum rated payload at the specified axle distribution.

For vehicles designed to haul un-braked trailers, the operating mass shall include the mass of the trailer and the maximum rated load of the trailer.

1.3.10 Normative, Informative

Are defined as per Australian Standards.

1.4.0 DESIGN

1.4.1 *General*

Vehicles shall be fitted with;
a service brake system, complying with Clause 1.5;
a secondary brake system, complying with Clause 1.6;
a parking brake system, complying with 1.7; and
an automatic brake system, complying with 1.8 .

1.4.2 *Brake Independence*

The braking systems shall be sufficiently independent so that failure of one system will not prevent the operation of the other systems.

1.4.3 *No. of wheels braked*

Vehicles having a designed maximum operating speed of more than 15 kph, when performing their designed function, shall have the brakes operating on at least four wheels or two tracks for tracked vehicles.

a) For Service Brakes on vehicles which operate at speeds greater than 15 kph when performing their designed application shall have independent brake assemblies, mechanically connected to and as close as practicable to the wheel hubs or track drive hubs.

b) For Service Brakes on vehicles having a transit speed of more than 15 kph but which are normally operated at a speed less than 15 kph when being used for their designed application may have a lesser number of brake assemblies providing that the brakes are permanently interconnected through the drive line components including the vehicle transmission or transfer gearbox.

c) For Secondary, Parking and Automatic Brakes, the permanent interconnection of the brake unit(s) through the drive line components including the vehicle transmission or transfer gearbox, meets this requirement.

1.4.4 *Holding ability*

All brake systems shall be capable of holding the vehicle on a 25% grade in both the forward and reverse direction with the vehicle loaded to 110% of vehicle mass.

or,

The manufacturer may instruct the testing authority to test the vehicle on an increased grade in both the forward and reverse direction with the vehicle loaded to vehicle mass.

In addition, the service brake system shall be demonstrated to hold the vehicle on grade for not less than five minutes, with one application of the brake.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$F = \text{SIN}(\text{Grade}) \times M \times 9.81$ where

F = pulling force on the machine in Newtons
Grade = the maximum operating grade in degrees
M = 1.1 X vehicle mass in kg (See 1.3.9)

NOTE This test exceeds the requirements of CAN/CSA-M424.3-M90. This Standard is commonly accepted for metalliferous mining applications in many countries.

1.4.5 *Common components*

The brake systems may include common components provided that the other requirements for each individual brake contained in this Handbook are satisfied and in the event of the failure of any single component, the braking system shall provide vehicle stopping capacity meeting the requirements of 1.6.4.

1.4.6 *Fail to safety*

At least the automatic and park brake systems shall fail to safety. Brakes applied by compression springs, on the release of fluid pressure, satisfy this requirement.

1.4.7 *Anti-locking*

All braking systems should be designed to eliminate, or minimise, as far as practicable, the locking of wheels during brake application.

1.4.8 *Stored Pressure Systems*

Power assisted braking shall be capable of operation in the event of engine failure to enable the vehicle to be brought safely to rest. For brakes operated by stored pressure systems, the capacity of the stored pressure shall permit at least five applications of the service brakes, after the engine has stopped.

If stored pressure is used to apply the service braking system, then the system shall be fitted with a warning device that activates before the system pressure drops below the greater of 50% of the manufacturers specified maximum operating pressure level or the pressure required to meet the secondary braking requirements. The warning device shall readily attract the operator's attention by providing a continuous visual and audible warning. Gauges indicating pressure or vacuum do not meet this requirement.

or

The automatic brakes shall be applied at the pressure determined to meet the secondary brake performance requirements. (see 1.6.4)

1.4.9 *Pressure Gauges*

Hydraulic or pneumatic, pressure applied, braking systems shall include a pressure gauge clearly marked to indicate the minimum safe brake operating pressure. The gauge shall be easily visible from the operator's seat.

Hydraulic or pneumatic, pressure released (fail-to-safety), braking systems shall include a pressure gauge or a low pressure indicator, clearly marked to indicate the minimum brake release pressure. The gauge or indicator shall be easily visible from the operator's position.

1.4.10 *Enclosure*

Mechanical braking assemblies shall be totally enclosed.

NOTE: Liquid cooled brakes are preferred.

1.4.11 *Surface Temperatures*

Mechanical brake assemblies shall be designed to limit surface temperature to a maximum of 150 degrees Centigrade under conditions of normal duty cycle operation when tested to the requirements of Appendix D.

1.4.12 *Wear Indication*

A clearly identifiable means of monitoring brake wear and the safe adjustment range should be provided.

1.4.13 *Asbestos*

Brakes shall not include any asbestos material.

1.4.14 *Ancillary components*

Interlocks, valves, logic components, associated mechanical devices shall be engineered, so as to minimise as far as practicable any accidental application, failure or release of any brake, by reason of system, design or component failure.

Notes (a) Examples of avoidable design or component failure include;

The design of door hinges with excessive clearance, where doors are interlocked to braking systems.

(b) The use of pilot operated valves or devices, where direct operated valves are practicable.

1.4.15 *Cables*

Wire cables shall not be used to apply any part of a braking system.

1.4.16 *Fluid Power Systems*

(a) Accumulators

Hydraulic accumulators shall be certified in compliance with Australian Standard AS1210 or British Standard BS7201.

Where a hydraulic system incorporates an accumulator the attachment to the accumulator shall be by means of a minimal length adaptor and flexible hose.

Fittings shall be located or otherwise guarded to provide mechanical protection.

A manual bleed valve shall be fitted to allow pressure relief for maintenance. Fluid should return to tank.

Accumulators shall be securely installed.

A guard shall be installed between accumulators and any personnel within a vehicle. The structure of the vehicle may meet this requirement.

(b) Air Compressors

Air compressors shall be of a liquid cooled type in accordance with AS3584.

(c) Fluid reservoirs

Liquid reservoirs shall be fitted with a robust filler cap that is rated for the maximum pressure in the reservoir system. The cap shall effectively seal the tank from any leakage and be positioned to minimise impact damage in the event of a vehicle collision.

Reservoirs designed to operate at atmospheric pressure may include caps designed for breathing, provided that they include a labyrinth or similar feature to limit spillage.

Filler caps should be self closing.

(d) Hoses

Flexible hoses shall be compatible with the fluid used, maximum system pressure and temperature.

The hose factor of safety shall be a minimum of 4 to 1 based on hose burst pressure to maximum working pressure.

Hydraulic hose shall comply with the provisions of AS3791. The requirements for flame resistance shall be in accordance with testing to AS1180.10B and acceptance to AS2660 or alternately satisfy Schedule 2G of the US Bureau of Mines or comply with type 1 or 3 hose specifications as listed in ISO 6805.

The use of nylon, polyurethane, PVC or similar plastic piping for pneumatic braking control systems will be acceptable only in cases where loss of pressure within these systems cause the system to fail to safety. All such piping shall be adequately protected and shielded from contact with hot and /or sharp surfaces.

Air hoses shall be in accordance with AS2660 unless specified otherwise.

Where hoses are directly attached to a compressor delivery port, they shall be PTFE, steel wire reinforced, braided construction.

(e) Pressure vessels

All pressure vessels of capacity greater than 30 litres shall comply with AS1210 - Unfired Pressure Vessels.

Pressure vessels having a capacity of 30 litres or less which do not comply with AS1210 shall comply with at least one of the following

AS2971 Serially Produced Pressure Vessels

SAE.J10 Automotive and Off - Highway Air Brake Reservoir

Performance and Identification Requirements.

A drain line with a manual valve shall be provided to drain the lowest point of all air receivers. This line and valve should be suitably protected against damage.

(f) Filters

Fluid filters shall be fitted to remove contaminants from the fluid system.

1.4.17 *Control Forces*

Control forces shall not be greater than those quoted in TABLE 1 when achieving the stopping distances required in 1.5.5 (Service Brakes), 1.6.4 (Secondary Brakes) and 1.8.5 (Automatic Brakes).

TABLE 1 CONTROL FORCE	
Method of activation	Maximum control force N
Finger grasp	20
Hand grasp:	
Upwards	400
Downwards	300
Fore-aft	300
Sideways	300
Foot pedal:	
End pivoted	700
Centre pivoted	350

1.5. SERVICE BRAKES

1.5.1 Brake system recovery

For service brake systems which are pressure applied, with the pressure source operating at maximum capacity, the brake application pressure shall be measured near a brake. The service brake system shall be capable of delivering 70% of the pressure measured during the first brake application, after the service brakes have been applied as follows.

(a) For any vehicle with a design speed greater than 15 kph, 20 times at a rate of six applications per minute.

(b) For any vehicle with a design speed less than 15 kph, 12 times at a rate of four applications per minute.

Notes

For a diesel engine powered vehicle, where the pressure source is an engine driven air compressor or hydraulic pump, "operating at maximum capacity" would normally mean at flight rpm.

For systems where the pressure source may be employed for other applications (eg, power steering) then the capacity of the system may need to be tested with flow being diverted to the other application to ensure sufficient safe capacity for brake system recovery.

Pressure systems where the pressure is decreased to apply the brakes (reverse modulation), meet this requirement.

1.5.2 Hydrostatic Braking

1.5.2.1 The only service brake system

Hydrostatic service braking systems are permitted as the only service brake system for skid steer, tracked or other vehicles having a maximum designed road speed of less than 10 kph provided dual traction/braking circuits are used so that the failure of one circuit, including the bursting of a hose, will not prevent the other circuit from acting as a brake.

or

Hydrostatic service brake systems are permitted as the only service brake system for skid steer, tracked or other vehicles having a maximum designed road speed of greater than 10 kph, provided that the failure of any part of the system, including the breaking of a hose applies the automatic brakes.

1.5.2.2 Combined with other systems

Vehicles fitted with both hydrostatic and mechanical (friction) brakes, designed to operate together, shall meet the performance requirements of 1.5.5 for either the hydrostatic braking system or the mechanical friction brake system when operated singularly. The other system must meet the minimum performance requirement of 1.6.4. Mechanical (friction) service brakes are preferred.

1.5.3 Response time

Service braking systems shall be constructed so that the response time between initiation and commencement of braking does not exceed 0.7 seconds (excludes human response time). The braking is considered to have commenced at a deceleration rate of 0.1 g.

Note $g = \text{acceleration due to gravity} = 9.81 \text{ mtrs/sec}^2$

1.5.4 Stopping distance

The service brakes shall bring the vehicle loaded at its vehicle mass (see 1.3.9) to rest from maximum achievable speed in both directions of travel in the distance calculated from the following formula, when tested under the conditions nominated in Appendix B & C.

For vehicles < 32000 kg

$$S_d = \frac{v^2}{68} + \frac{v^2}{124} \left(\frac{M}{32000} \right) + C$$

For vehicles \geq 32000 kg

$$S_d = \frac{v^2}{44} + C$$

Where S_d = Stopping distance in metres
 v = Speed in Kph
 M = Vehicle mass in kg (See 1.3.9)
 V_{max} = The maximum achievable vehicle speed
 C = Correction factor, applied as follows
 (a) For vehicles with a maximum level surface speed of not less than 32 kph, $C = 0$
 (b) For vehicles with a maximum level surface speed of less than 32 kph, $C = 0.1(32 - V_{max})$

Notes

- (a) The above formula is derived from AS2958.1
- (b) Manufacturers should design for and achieve stopping distances significantly shorter than the maximums determined from the above formula to ensure a satisfactory service life of systems after normal wear.
- (c) Where variations of stopping distances occur under test conditions because of variations in speed or conditions, then mathematical modelling may be employed to demonstrate compliance.

1.5.5 Heat and fade

The service brake system when tested under the conditions specified in Clause 1.5.5, shall be capable of stopping the vehicle five times at intervals between successive stops of not more than 20 min and provided that the entire test shall be completed in 40 mins. The stopping distance of any stop shall not be more than 125% of the stopping distance of the first stop.

The surface temperature of the service brakes shall not exceed 150⁰ C when tested to the requirements of Appendix D.

Note

125% derived from ISO3450.

1.6. SECONDARY BRAKE

1.6.1 Operation

The secondary brake system may apply automatically on the loss of service brake system pressure or be manually applied by the operator.

1.6.3 Response time

Secondary braking systems shall be so constructed that the response time between initiation and commencement of braking does not exceed 1.0 seconds (excludes human response time). The braking is considered to have commenced at a deceleration rate of 0.1 g.

1.6.4 Stopping distance

The secondary brakes shall bring the vehicle loaded to its vehicle mass (see 1.3.9) to rest from maximum achievable speed in both directions of travel in the distance calculated from the following formula, when tested under the conditions nominated in Appendix B & C.

For vehicles < 32000 kg

$$S_d = \frac{v^2}{39} + \frac{v^2}{130} \left(\frac{M}{32000} \right) + C$$

For vehicles ≥ 32000 kg

$$S_d = \frac{v^2}{30} + C$$

Where S_d = Stopping distance in metres

v = Speed in Kph

M = Machine operating mass in kg (See 1.3.9)

V_{max} = Maximum achievable vehicle speed

C = Correction factor, applied as follows

(a) For vehicles with a maximum level surface speed of not less than 32 kph, $C = 0$

(b) For vehicles with a maximum level surface speed of less than 32 kph, $C = 0.1(32 - V_{max})$

Notes

(a) *The above formula is derived from AS2958.1*

(b) *Manufacturers should design for and achieve stopping distances significantly shorter than the maximums determined from the above formula to ensure a satisfactory service life of systems after normal wear.*

(c) *Where variations of stopping distances occur under test conditions because of variations in speed or conditions, then mathematical modelling may be employed to demonstrate compliance.*

1.6.5 *Severity*

To ensure minimal risk of injury to personnel within the vehicle, the maximum deceleration rate should not exceed 0.7 g.

1.6.6 *Hydrostatic Systems*

Secondary braking systems shall not utilise hydrostatic braking.

1.6.7 *Controls*

The secondary brake control shall be clearly identified and readily accessible to the operator

1.7 PARKING BRAKE

1.7.1 *Operation*

The parking brake system shall apply automatically on the loss of parking brake system pressure (fail to safety).

1.7.3 *Common components*

The parking braking system may use common components that also form part of other braking systems, provided that the requirements of Clause 1.4.2 are met.

1.7.5 *Hydrostatic Systems*

Parking brake systems shall not utilise hydrostatic braking.

1.7.6 *Control button*

The parking brake control shall be a red button, ≥ 40 mm in diameter, readily visible which is pushed to apply the brakes. This button shall be located in a position readily accessible to the operator.

Once applied, the brake may only be released by the manual resetting of the brake button (pull). The system shall be arranged so that it cannot be released unless immediate reapplication is possible from the operator's position.

Once applied, the park brake shall not be capable of being released by the operation of controls governing any other function of the vehicle.

Where a control system includes more than one operating button, then all buttons must meet the requirements of this clause.

Personnel carrying vehicles having more than one passenger compartment, shall be fitted with brake operating control buttons in each compartment.

1.7.7 *Interlocking*

An effective interlock shall be fitted to prevent the vehicle being driven with the park brake applied.

Notes (a) A brake providing more braking effort than the maximum tractive effort meets this requirement.

(b) An interlock disabling the transmission may meet this requirement.

1.8 AUTOMATIC BRAKES

1.8.1 Operation

The automatic brake system shall fail to safety.

1.8.2 Common components

The automatic braking system may use common components that also form part of other braking systems, provided that the requirements of Clause 1.4.2 are met.

1.8.3 Hydrostatic Systems

Automatic brake systems shall not utilise hydrostatic braking.

1.8.4 Stopping distance

The automatic brake shall bring the vehicle loaded to its vehicle mass (see 1.3.8) to rest from maximum achievable speed in both directions of travel in the distance calculated from the following formula, when tested under the conditions nominated in Appendix B & C.

For vehicles < 32000 kg

$$S_d = \frac{v^2}{39} + \frac{v^2}{130} \left(\frac{M}{32000} \right) + C$$

For vehicles \geq 32000 kg

$$S_d = \frac{v^2}{30} + C$$

Where S_d = Stopping distance in metres

v = Speed in Kph

V_{max} = Maximum achievable vehicle speed

M = Vehicle mass in kilograms (refer 1.3.9)

C = Correction factor, applied as follows

(a) For vehicles with a maximum level surface speed of not less than 32 kph, $C = 0$

(b) For vehicles with a maximum level surface speed of less than 32 kph, $C = 0.1(32 - V_{max})$

Notes

(a) *The above formula is derived from AS2958.1*

(b) *Manufacturers should design for and achieve stopping distances significantly shorter than the maximums determined from the above formula to ensure a satisfactory service life of systems after normal wear.*

(c) *Where variations of stopping distances occur under test conditions because of variations in speed or conditions, then mathematical modelling may be employed to demonstrate compliance.*

1.8.5 *Control*

Automatic brakes shall apply;

- a) Whenever the operator leaves the driving position, and
- b) Whenever the engine is stopped by the operator, and
- c) Whenever the engine stops for any reason. (eg, the operation of the automatic engine protection system)

Once applied, the brake may only be released by the manual resetting of the brake.

1.8.6 *Response time*

Automatic braking systems shall be constructed so that the response time between initiation and commencement of braking does not exceed 1.0 seconds (excludes human response time) for 1.8.5 (a) & (b). The braking is considered to have commenced at a deceleration rate of 0.1 g.

For an engine stoppage as 1.8.5.(c), the response time should not exceed 2.0 seconds from the time the engine ceases rotation.

or,

If the transmission drives the engine while ever the vehicle is moving then the response time between initiation and commencement of braking shall not exceed 3.0 seconds (excludes human response time)

Note $g = \text{acceleration due to gravity} = 9.81 \text{ mtrs/sec}^2$

1.8.7 *Interlocking*

An effective interlock shall be fitted to prevent the vehicle being driven with the automatic brake applied.

Notes (a) A brake providing more braking effort than the tractive effort meets this requirement.

(a) An interlock disabling the transmission may meet this requirement.

SECTION 2 MARKING

2.1 PLATES & LABELS

Labels shall not be manufactured from light metal. Labels shall be permanently fixed and indelibly marked. Engraved or etched and filled stainless steel labels are preferred.

2.2 COMPLIANCE PLATE

A plate giving the following information shall be permanently affixed to each free-steered vehicle in an easily seen position.

- (a) The Braking System Approval/Certification number
- (b) The name of the manufacturer of the braking system
- (c) The date of manufacture of the braking system
- (d) The drawing number, issue number and date of the schematic and arrangement drawing(s)
- (e) The minimum acceptable mean deceleration rates at speed for the vehicle at tare mass (see 1.3.6), calculated from type testing, and the maximum acceptable response time, for each of the braking systems.
The minimum acceptable mean deceleration rates at speed for the vehicle at tare mass (see 1.3.6) shall be nominated by the manufacturer and may not be less than those required to meet the requirements of 1.5.5, for service brakes and 1.6.4 for secondary brakes and 1.8.4 for automatic brakes.
- (f) The minimum acceptable peak deceleration rates at speed for the vehicle at tare mass (see 1.3.6), calculated from type testing, and the maximum acceptable response time, for each of the braking systems.
- (g) The maximum Gross Vehicle Mass (see 1.3.9).
- (h) The maximum gross unbraked towing capacity.
- (i) The maximum holding grade for the Parking Brakes.

Notes.

(a) The information required above may be included on a general vehicle compliance plate.

(b) See Fig 1 for an example of a compliance plate.

FIGURE 1.

BRAKING SYSTEM COMPLIANCE PLATE				
Approval/Cert. No.				
Manufacturer				
Date of manufacture				
Approval/certification Drawing				
Max (Vehicle) gross mass				
Max (Trailer) gross mass				
Minimum Acceptable Brake Performance for In-Service Testing				
	At speed (km/hr)	Mean Deceleration rate (m/s²)	Peak Deceleration rate (m/s²)	Response time (s)
Service Brakes				
Secondary Brakes				
Automatic Brakes				
Maximum holding grade (%)				
Parking Brakes				

2.3 SPECIFICATION PLATE

A plate giving the following information should be permanently affixed to each free-steered vehicle in an easily seen position.

- (a) Wear indicator location and meaning (if fitted)
- (b) Any special oils used in braking systems
- (c) Any limitations on use or grade

Note

The information required above may be included in a general vehicle compliance plate and/or added to Fig 1 above.

2.4 WARNINGS

Warning labels shall be fitted as required to each braking system or component, in clearly visible locations, to identify hazards which may cause injury to persons.

Example

Labels warning of high hydraulic pressures, stored pressure accumulators and the like.

SECTION 3 TESTING

3.1 TYPE TESTING

The following information for each new type and model of braking systems shall be determined.

- (a) A Statement of compliance or variation to each of the clauses of this Handbook.
- (b) Compliance by audit of the braking systems to the documents, including the approval/certification drawing, provided by the manufacturer.

The following testing shall be undertaken for each new type and model of braking system.

Each system shall be tested to the requirements of Appendix C and Appendix D and the test results reported.

3.2 MODIFIED COMPONENTS

Where a component within the braking systems is modified, the regulatory authority or certifying body, may upon request from the manufacturer, allow the component to be tested individually or may require a complete re-test of the vehicle braking systems.

Whenever a system is installed in any application where differences may occur, the braking system manufacturer shall undertake a complete re-test of the systems to ensure that no adverse changes to performance have occurred.

3.3 ROUTINE TESTING

The integrity of each type tested, approved/certified vehicle braking system shall be confirmed by the braking system manufacturer as complying with the performance established during type testing for approval/certification.

Routine testing shall meet the requirements of Appendix E.

3.4 IN-SERVICE TESTING

In-service testing shall be undertaken by the user of any approved/certified braking system. In-service testing shall be undertaken at intervals no greater than that recommended by the manufacturer of the braking systems.

A guide for the development of in-service testing is provided at Appendix F.

Notes

(a) *Operating hours based, in-service testing is preferred to calendar intervals.*

(b) *Manufacturers and users should develop testing intervals with regard to the operating conditions at each mine. In-service brake testing should be included in the Standards of Engineering Practice for each Mine.*

SECTION 4 DOCUMENTATION

4.1 General

The manufacturer of the braking systems shall prepare and provide documentation to the testing authority, the regulatory authority and the purchaser of the free-steered vehicle which includes the braking systems. This information shall include specifications, drawings, parts information, service information, maintenance information, performance data, settings and adjustments.

4.2 Manufacturer to the testing authority

The manufacturer of the braking system shall supply documents, including the following to the testing authority:

4.2.1 A schematic circuit and arrangement drawing of the braking system which includes:

- (a) All part numbers or a full design specification of each component.
- (b) Hose, pipe or tube sizes where length or bore size may affect performance of the system.
- (c) The maximum vehicle mass (see 1.3.9) and maximum achievable speed of the vehicle for which the braking system has been designed.
- (d) An illustration of the mechanical brakes, noting the highest surface temperature and its' location. (see D6.3 (b)(v))

4.2.2 A written description of the operation of the braking systems.

4.2.3 A maintenance data sheet which includes the manufacturer's recommendations on:

- (a) frequency of in-service testing
- (b) in-service brake testing procedures
- (c) in-service testing performance limits demonstrating the range of safe braking performance.
- (d) adjustment procedures for the braking systems

4.2.4 A letter of request for approval/certification.

4.3 Testing Authority to the manufacturer (post assessment)

The testing authority shall supply documentation to the braking system manufacturer, including

- (a) a detailed compliance report to this Handbook
- (b) actual test measurements, to assist in the auditing of any subsequent units manufactured to the type covered by the compliance report.

Note _____

Additional requirements may be required by the regulatory authority.

4.4 Manufacturer to the purchaser

The braking system manufacturer shall supply to each purchaser of a braking system, the following documentation:

- (a) The schematic circuit drawing (see 4.2).
- (b) A letter of compliance, including the following information:
 - (i) The statement:

THIS FREE-STEERED VEHICLE, BRAKING SYSTEM, COMPLIES WITH THE RELEVANT REQUIREMENTS OF THE BRAKING SYSTEM HANDBOOK, Feb. 2001.
 - (ii) The name and signature of the representative of the manufacturer authorised to issue the letter of compliance.
 - (iii) Name and address of the braking system manufacturer.
 - (iv) Braking system model number.
 - (v) The serial numbers of any relevant system components.
 - (vi) Any relevant statutory approval, certification or test reports.
- (c) Details of maintenance and operational requirements, specifications and any other drawings required to maintain the braking system in compliance with this Handbook.
- (d) A full report on the results of brake performance routine testing (including print-outs from a calibrated brake testing instrument) signed by the senior engineering representative of the applicant in compliance with the requirements of Appendix E of this Handbook.

4.5 Manufacturer to the statutory authority

If required, the manufacturer of the braking system shall supply to the statutory authority:

All of the information required in 4.2, 4.3 and 4.4 above.

4.6 User to Manufacturer

Users of approved braking systems should provide the manufacturer with detailed reports of any faults or defects detected under operating conditions.

APPENDIX A
MEANS OF DEMONSTRATING CONTINUED
COMPLIANCE WITH THIS
HANDBOOK
(Normative)

A1 INTRODUCTION

A manufacturer or supplier has an obligation to ensure that any braking systems supplied as conforming to this Handbook are manufactured to a design that has been type tested and certified/approved as conforming to this Handbook. All further braking systems of the type, if tested in accordance with the Handbook, shall conform to the requirements of the Handbook.

This appendix sets out the following different means by which compliance with this Handbook can be demonstrated by the manufacturer or supplier:

- (a) The use of a product certification scheme eg the certification for electrical explosion protected apparatus.
- (b) Assurance using the acceptability of the supplier's quality system.
- (c) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

A2 SUPPLIER'S QUALITY SYSTEM

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or International Standard for a supplier's quality system or systems, this may provide the necessary confidence that the specified requirements will be met. The quality assurance requirements need to be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Guidance in determining the appropriate quality management system is given in AS/NZS ISO 9000.1-2 and AS/NZS ISO 9004.1.

A3 OTHER MEANS OF ASSESSMENT

If the above methods are considered inappropriate, determination of compliance with the requirements of this Handbook may be assessed from the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform with the full requirements of the Handbook.

APPENDIX B

TYPE TESTING - TEST CONDITIONS

(Normative)

B1 TEST COURSE

B1.1 For deceleration tests

The test course on which braking tests are carried out shall have sufficient length to enable them to be carried out safely.

The grade of the test course-

- (a) at right angles to the direction of travel, shall be not more than three percent from horizontal; and
- (b) in the direction of travel, shall be not more than one percent from the horizontal.

The surface of the test course shall be hard, reasonably smooth and supported by a well compacted base. A sealed, paved surface is preferred. Surface or ground moisture may be present to the extent that it does not adversely affect braking performance.

Note It is the intent that the test course should provide a co-efficient of adhesion of ≥ 0.95 .

B1.2 For holding tests

A ramp having a 25% grade and surface meeting the requirements of B1.1 above.

or

Equipment to provide sufficient pulling force and a calibrated tension gauge.

B2 VEHICLE

Any burnishing of brakes (i.e. conditioning of frictional surfaces before testing), (which is permissible) shall comply with the manufacturer's recommendations.

The physical parameters that affect braking (e.g. tyre size, tyre pressure and brake adjustment) shall comply with the manufacturer's recommendations. Where manual adjustments are made during tests, all tests prior to the adjustments being made shall be repeated.

B3 OPERATION

Any precautions given by the manufacturer shall be observed.

At the commencement of any test, operating fluids (e.g. engine oil and transmission oil) shall be at normal operating temperatures.

Blades, buckets, dozers and other equipment shall be carried in the transport position recommended by the manufacturer.

Any manually selected gear ratio shall be suitable for the speed of the vehicle just prior to the brake test.

The power train may be disengaged just prior to completing the stop.

B4 TEST REPORT

As transparency of testing is of great importance, test report should have a full description of testing including any applicable descriptive drawings and plans. The test report shall include the following:

- (a) The name of the testing authority.
- (b) Descriptions of the components/assemblies/vehicle tested.
- (c) A statement that the Test Course meets the requirements of this Appendix.

APPENDIX C

TYPE TESTING - PERFORMANCE

(Normative)

C1 SCOPE

This appendix sets out the procedure for the type testing of braking systems to determine that the performance meets the requirements of this Handbook.

C2 TESTING AUTHORITY

Braking systems and documents (see Section 4) shall be provided to the testing authority. The braking systems shall be installed and operational in the free-steered vehicle for which they were designed.

C3 PRINCIPLE

The tests simulate the braking systems being operated under conditions from which an assurance of safe operation conforming to this Handbook may be determined.

C4 APPARATUS

The testing shall be carried out with instruments meeting the requirements of Appendix G.

C5 ACCURACY

The calibration of all measuring instruments shall be traceable to national/international Standards and should be controlled through an accredited Quality Management System to AS/NZS ISO 9002. (min)

C6 PROCEDURE

C6.1 Normalisation

The free-steered vehicle, loaded to its vehicle mass, shall be operated over a range of speeds and loads for a sufficient length of time to ensure that operational stabilisation has occurred and that the temperature of oils, hydraulic fluids and the like have reached normal operating temperatures.

C6.2 Burnishing

The burnishing (conditioning) of the brakes before testing is permissible. The burnishing procedures indicated in manuals for the vehicle shall be verified with the manufacturer.

C6.3 Information to be recorded

For each test, measure and record;

- (i) The stopping distance (m)
- (ii) The speed immediately prior to the application of the brakes (km/hr)
- (iii) The maximum deceleration rate (m/s^2)
- (iv) The mean deceleration rate (m/s^2)
- (v) The response time between the application of the brakes and the beginning of retardation. The beginning of retardation is considered to be 0.1 g.

- (vi) The operating force applied to the pedal/button/lever by the operator. (N)

- (vii) Evidence that the minimum stopping distances are achieved with operating forces less than the maximums nominated (see Table 1)

C6.4 Service Brake System - Performance

(a) Forward (at vehicle mass)

Drive the vehicle, loaded to its vehicle mass, on a test course meeting the requirements of Appendix B at the maximum attainable speed in the forward direction. Apply the service brakes. Test.

Test five times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table C1.

(b) Reverse (at vehicle mass)

Drive the vehicle, loaded to its vehicle mass, on a test course meeting the requirements of Appendix B at the maximum attainable speed in the reverse direction. Apply the service brakes. Test.

Test five times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table C1.

(c) Forward (at tare mass)

Drive the vehicle, with minimum load (tare), on a test course meeting the requirements of Appendix B at the maximum attainable speed in the forward direction. Apply the service brakes. Test

Test five times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table C1.

(d) Reverse (at tare mass)

Drive the vehicle on a test course, with minimum load (tare), meeting the requirements of Appendix B at the maximum attainable speed in the reverse direction. Apply the service brakes. Test

Test five times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table C1.

(e) Holding

At vehicle mass (see 1.3.9), drive the vehicle onto a ramp or slope having a grade $\geq 25\%$. Apply the service brakes. Ensure that the brakes hold the vehicle for a period of not less than 5 mins without any further application or re-application of the brakes.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN Grade} \times M \times 9.81 \text{ where}$$

F = pulling force on the machine in Newtons
Grade = the maximum operating grade in degrees
M = 1.1 X Machine operating mass in kg

C6.5 Secondary brake

Repeat the tests nominated in C6.4 (a) & (c) above. Record the results in Table C1.

Note The secondary brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

C6.6 Automatic Brake

(a) Repeat the tests nominated in C6.4 (a) & (c) above. Record the results in Table C1.

Note The automatic brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

(b) Drive the vehicle onto a ramp or slope have a grade $\geq 25\%$. Apply the automatic brakes. Ensure that the brake holds the vehicle.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN Grade} \times M \times 9.81 \quad \text{where}$$

F = pulling force on the machine in Newtons
Grade = the maximum operating grade in degrees
M = 1.1 X Machine operating mass in kg

(c) Confirm that each of the possible methods of automatic initiation of the automatic brake meets the requirements of 1.8.5 and 1.8.6 for operation and response time.

Note Pressure gauges or other indicators of correct brake operation may be employed for this test.

C6.7 Parking brake

Drive the vehicle at 110% of vehicle mass (see 1.3.9) onto a ramp or slope having a grade $\geq 25\%$. Apply the park brakes. Ensure that the brake holds the vehicle.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN Grade} \times M \times 9.81 \quad \text{where}$$

F = pulling force on the machine in Newtons
Grade = the maximum operating grade in degrees
M = 1.1 X Machine operating mass in kg

Ensure that the Parking Brake holds the vehicle for a minimum period of 5 mins.

Note The parking brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

TABLE C1

BRAKING SYSTEM TEST RESULTS

Manufacturer						
Date of test						
Drawing Ref.						
Name & model of free-steered vehicle						
Brake Performance	Stop Dist. (m)	At speed (km/hr)	Max Decel. rate (m/s²)	Mean Decel. rate (m/s²)	Response time (s)	Operating force (N)
Service Brakes – Fwd (at veh. mass)						
Service Brakes – Rev (at veh. mass)						
Service Brakes – Fwd (at tare mass)						
Service Brakes – Rev (at tare mass)						
Secondary Brakes (at veh. mass)						
Secondary Brakes (at tare mass)						
Automatic Brakes (at veh. mass)						
Automatic Brakes (at tare mass)						

Brakes – Holding Ability

Method of test	Grade (%), or	Force (N)
Service, Holds 5 mins ?		
Auto, Holds ?		

Park, Hold 5 mins

C7 TEST REPORT

The test report shall include the following:

- (a) The name of the testing authority.
- (b) Descriptions of the components/assemblies/vehicle tested, including;
 - Burnishing procedure (if any)
 - Tyres fitted during test (specification)
 - Any other information considered relevant by the testing authority which may have affected the test results.
- (c) The tests carried out.
- (d) The test results.
- (e) A statement as to whether or not the tests carried out satisfy this Appendix.

APPENDIX D

TYPE TESTING - TEMPERATURE

(normative)

D1 SCOPE

This Appendix sets out the procedure for the type testing of braking systems for surface temperature and the effects of temperature on brake performance.

D2 TESTING AUTHORITY

Braking systems and documents (see Section 4) shall be provided to the testing authority. The braking systems shall be installed and operational in the free-steered vehicle for which they were designed.

D3 PRINCIPLE

The tests simulate the braking systems being operated under conditions from which an assurance of safe operation conforming to this Handbook may be determined.

D4 APPARATUS

The testing shall be carried out with instruments meeting the requirements of Appendix G.

D5 ACCURACY

The calibration of all measuring instruments shall be traceable to national/international Standards and should be controlled through an accredited Quality Management System to AS/NZS ISO 9002.

D6 PROCEDURE

D6.1 Normalisation

The free-steered vehicle, loaded to its vehicle mass, shall be operated over a range of speeds and loads for a sufficient length of time to ensure that operational stabilisation has occurred and that the temperature of oils, hydraulic fluids and the like have reached normal operating temperatures.

D6.2 Burnishing

The burnishing (conditioning) of the brakes before testing is permissible. The burnishing procedures indicated in manuals for the vehicle shall be verified with the manufacturer.

D6.3 Service Brake System - Performance

- (a) For a vehicle designed to be driven primarily in the forward direction, drive the vehicle, loaded to 110% of vehicle mass, on a test course, meeting the requirements of Appendix B at the maximum attainable speed in the forward direction. Apply the service brakes.

Test five times at intervals between successive stops of not more than 20 min and provided that the entire test shall be completed in 40 mins.

For vehicles designed to operate equally in both forward and reverse directions, the tests shall be repeated for the reverse direction.

- (b) Measure and record:
 - (i) The stopping distance (m)
 - (ii) The speed immediately prior to the application of the brakes (km/hr)
 - (iii) The maximum deceleration rate (m/s^2)
 - (iv) The mean deceleration rate (m/s^2)
 - (v) The highest surface temperature of any part of the braking system. The location of the highest surface temperatures shall be described and added to arrangement drawing(s). ($^{\circ}\text{C}$) (see 4.2.1)
 - (vi) The ambient temperature ($^{\circ}\text{C}$)

Record the test results at Table D1.

Optical thermal imaging systems should be employed for the measurement of temperatures, providing the instrument is:

- (a) Calibrated
- (b) Corrected for colour temperature

The stopping distance of any stop shall not be more than 125% of the stopping distance of the shortest stop.

The highest surface temperature of the service brakes shall not exceed 150°C .

TABLE D1

BRAKING SYSTEM TEST RESULTS					
Manufacturer					
Date of test					
Approval/cert.n Drawing					
Name & model of free-steered vehicle					
Ambient temp.					
BRAKE PERFORMANCE	Stop Dist. (m)	At speed (km/hr)	Decel. rate (max) (m/s²)	Decel. rate (mean) (m/s²)	Highest surface temp. °C
Test 1					
Location of highest temp					
Test 2					
Location of highest temp					
Test 3					
Location of highest temp					
Test 4					
Location of highest temp					
Test 5					
Location of highest temp					

D7 TEST REPORT

The test report shall include the following:

- (a) The name of the testing authority.
- (b) Descriptions of the components/assemblies/vehicle tested, including;
 - Burnishing procedure (if any)
 - Tyres fitted during test (specification)
 - Any other information considered relevant by the testing authority which may have affected the test results.

- (c) The tests carried out.
- (d) The test results.
- (e) A statement as to whether or not the tests carried out satisfy this Appendix.

APPENDIX E

ROUTINE TESTING

(normative)

E1 SCOPE

This Appendix sets out the procedure for the routine testing of serially produced approved/certified braking systems as installed in free-steered vehicles.

E2 PRINCIPLE

The tests indicate that serially produced braking systems provide performance indication within an acceptable tolerance of the results measured by the testing authority during type testing. The tests indicate that the configuration and function of brake controls conform to the design approved/certified.

E3 APPARATUS

The testing should be carried out with instruments meeting the requirements of Appendix G.

E4 ACCURACY

The calibration of all measuring instruments shall be traceable to national/international Standards and should be controlled through an accredited Quality Management System to AS/NZS ISO 9002.

E5 PROCEDURE

E5.1 Normalisation

The free-steered vehicle, at tare mass, shall be operated over a range of speeds and loads for a sufficient length of time to ensure that operational stabilisation has occurred and that the temperature of oils, hydraulic fluids and the like have reached normal operating temperatures.

E5.2 Burnishing

The burnishing (conditioning) of the brakes before testing is permissible. The burnishing procedures indicated in manuals for the vehicle shall be verified with the manufacturer.

E5.3 Service Brake Testing

(a) Forward (at tare mass)

Drive the vehicle, with minimum load (tare), on a test course meeting the requirements of Appendix B at the maximum attainable speed in the forward direction. Apply the service brakes. Test

Test three times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table E1.

(b) Reverse (at tare mass)

Drive the vehicle on a test course, with minimum load (tare), meeting the requirements of Appendix B at the maximum attainable speed in the reverse direction. Apply the service brakes. Test

Test three times with not more than 20 mins between each test. Record the results applying to the longest recorded stopping distance in Table E1.

(c) Holding

Drive the vehicle at vehicle mass (see 1.3.9) onto a ramp or slope having a grade $\geq 25\%$. Apply the service brakes. Ensure that the brakes hold the vehicle for a period of not less than 5 mins without any further application or re-application of the brakes.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN}(\text{Grade}) \times M \times 9.81 \quad \text{where}$$

F = pulling force on the machine in Newtons

Grade = the maximum operating grade in degrees

M = 1.1 X Machine operating mass in kg

E5.4 Secondary brake Testing

Repeat the tests nominated in E5.3 (a) & (c) above. Record the results in Table E1.

Note The secondary brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

E5.5 Automatic Brake Testing

(a) Repeat the tests nominated in E5.3 (a) & (c) above. Record the results in Table E1.

Note The automatic brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

(b) Drive the vehicle onto a ramp or slope having a grade $\geq 25\%$. Apply the automatic brakes. Ensure that the brake holds the vehicle.

or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN}(\text{Grade}) \times M \times 9.81 \quad \text{where}$$

F = pulling force on the machine in Newtons

Grade = the maximum operating grade in degrees

M = 1.1 X Machine operating mass in kg

E5.6 Parking brake Testing

Drive the vehicle at vehicle mass (see 1.3.9) onto a ramp or slope have a grade $\geq 25\%$. Apply the park brakes. Ensure that the brake holds the vehicle.
or,

If the above requirement is impractical for test purposes, then the following alternative may be employed. Apply a pulling force to the vehicle with the brake set and with the transmission in neutral under test conditions meeting the requirements of Appendix B. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

$$F = \text{SIN}(\text{Grade}) \times M \times 9.81 \quad \text{where}$$

F = pulling force on the machine in Newtons

Grade = the maximum operating grade in degrees

M = 1.1 X Machine operating mass in kg

Note The parking brake may be combined in function and/or components with other braking systems in which case, performance must comply with the requirements nominated for each of the systems.

E5.7 Information to be recorded

For each test, the measure and record;

- (ii) The speed immediately prior to the application of the brakes (km/hr)
- (iv) The mean deceleration rate (m/s^2)
- (v) The response time between the application of the brakes and the beginning of retardation. The beginning of retardation is considered to be 0.1 g.
- (vi) The operating force applied to the pedal/button/lever by the operator. (N)

E6 TEST REPORT

The test report shall include the following:

- (a) The name of the organisation undertaking the testing, and the name of the person responsible for the testing.
- (b) Descriptions of the components/assemblies/vehicle tested, including;
 - The serial No. of the vehicle
 - The date of manufacture and the date of test (may be the same)
 - Burnishing procedure (if any)
 - Tyres fitted during test (specification)
 - Any other information considered relevant by the testing authority which may have effected the test results.
- (c) The tests carried out.

- (d) The test results.
- (e) A statement as to whether or not the tests carried out satisfy this Appendix.

APPENDIX F

IN-SERVICE TESTING PROCEDURE

(Informative)

F1 SCOPE

This Appendix sets out a procedure for evaluating and monitoring the performance of braking systems fitted to free-steered vehicles, in service. This procedure is a guide only.

Operators of vehicles with approved/certified braking systems should develop unique maintenance and testing procedures within their maintenance management systems to ensure the safe and effective continued operation of braking systems.

Note Users should develop maintenance management systems in consultation with the manufacturer.

F2 PRINCIPLE

The tests simulate the braking systems being operated under conditions from which an assurance of safe operation conforming to this Handbook may be determined.

The test results are compared to the manufacturer's recommendations as noted on the Compliance Plate. (see 2.2, Fig. 1)

F3 APPARATUS

The testing should be carried out with instruments meeting the requirements of Appendix G.

F4 ACCURACY

The calibration of all measuring instruments should be traceable to national/international Standards and should be controlled through an accredited Quality Management System to AS/NZS ISO 9002.

F5 PERFORMANCE

F5.1 Information to be recorded

For each test, measure and record;

- (i) The speed immediately prior to the application of the brakes (km/hr)
- (ii) The mean deceleration rate (m/s^2)
- (iii) The peak deceleration rate (m/s^2)
- (iv) The response time between the application of the brakes and the beginning of retardation. The beginning of retardation is considered to be 0.1 g.
- (v) The operating force applied to the pedal/button/lever by the operator. (N)

Note The peak deceleration rate is an indicator of the ability of brakes to hold on a grade. A rate of less than 2.8 m/s^2 indicates that the brakes may not hold on a 25% grade.

F5.2 Service brakes

a) Service brakes shall be tested while the vehicle is unladen, at tare mass, (see 1.3.6) and travelling on a surface and grades as close as practicable to the requirements of Appendix B. at the recommended testing speed for the vehicle, subject to a maximum of 30 km/h. Retarders or hydrostatic systems may be used during the test.

Tests should be repeated a minimum of three times and the lowest deceleration rate recorded.

Note Where a test course is not available, meeting the requirements of Appendix B, then operators should select a test course for in-service testing which will be maintained and consistent for long periods. The results from the same test course may then be used to indicate performance trends which may then be employed within the maintenance management system to predict service/repair requirements. Testing should always be done in the same direction of travel on the test course.

The mean deceleration rate shall not be less than that recommended by the manufacturer and included on the Compliance Label. (see 2.2 Fig. 1)

Note Decreases in the mean deceleration rate for subsequent in-service tests will indicate a reduction of service brake performance and a requirement for maintenance, service, adjustment or repair.

F5.3 Secondary and Automatic brakes

Secondary braking systems shall be tested in accordance with the manufacturer's specification.

F5.4 Park brakes

Parking brakes shall be capable of holding the vehicle stationary in a fully loaded condition on the steepest grade that it will encounter in both the forward and the reverse directions, subject to a minimum incline of 25%.

NOTES:

(a) *This test should not submit the operator or observers to any danger.*

(b) *The test can be a live test or a stall test that will apply an equivalent braking force.*

F6 TEST REPORT

The test report shall include the following:

- (a) The name of the organisation undertaking the testing, and the name of the person responsible for the testing.
- (b) Descriptions of the components/assemblies/vehicle tested.
- (c) The tests carried out.
- (d) The test results.
- (e) A statement as to whether or not the tests carried out satisfy this Appendix.

APPENDIX G
SPECIFICATION OF TEST INSTRUMENTS
(Normative)

G1 SCOPE

This appendix sets out the performance requirements for instruments used in the measurement of brake performance parameters.

G2 BRAKE TESTING INSTRUMENT

Any brake testing instrument employed to demonstrate compliance with this Handbook shall be calibrated.

Accuracy	± 1.5% g
Repeatability	± 2.0% g
Range	0 - 140% g (g = 9.81 m/s ²)
Pedal force transducer	0 - 2000 N
Calibration	± 0.1% g

G3 GENERAL INSTRUMENTATION In general terms, the permissible deviations of instruments/sensors/transducers, when combined with power supplies and converters, for engine related parameters shall be as shown in Table G1 (based on ISO 8178-1 : 1996.08.15):

TABLE G1

No.	Item	Permissible deviation	
		based on max values	Repeatability
1	Mass	+/- 2 %	+/- 1 %
2	Power	+/- 4 % (calc)	+/- 2 %
3	Temp (surface)	+/- 2 K	+/- 0.5 K
4	Force	+/- 4%	+/- 2%
5	Oil temp	+/- 2 K	+/- 0.5 K
6	Ambient temperature	+/- 2 K	+/- 1 K
7	Atmospheric pressure	+/- 1 %	+/- 0.5 %
8	Relative humidity	+/- 2 %	+/- 0.5 %

APPENDIX H
DOCUMENTS REFERENCED
IN THE
PREPARATION OF THIS HANDBOOK
(informative)

H1 SCOPE

This appendix lists the documents referenced by the committee in the preparation of this Handbook.

H2 LIST

MDG1	Handbook Issue A; Rev 1; File M86/0349 Free-steered vehicles in underground coal mines
CMRA 1999	Coal Mines (Underground) Regulation 1999
AS 2958.1 1995	Earth-moving machinery - Safety Part 1 : Wheeled Machines - Brakes
SAE J843	Brake system, Road Test Code
SAE J1329	Minimum performance criteria for braking systems for specialised rubber-tyred, self-propelled underground mining machines.
Title 49, Vol 5 Parts 400 - 999	Code of federal regulations (US) Hydraulic and electric braking systems
E/ECE/324	Uniform provisions concerning the approval of passenger cars Reg 13 with regard to braking.
CAN/CSA- M424.3-M90	Braking performance - Rubber tyred self propelled underground mining machinery.
ISO 3450	Earth moving machinery - Braking Systems of rubber-tyred machines- Systems and performance requirements and test procedures.
SABS 1589.1994	Braking performance of trackless underground mining vehicles, LHD's and Dump Trucks.
Dept. Minerals (NSW) Compendium	