





























































- 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, calculated from type testing, and the maximum acceptable response time, for each of the braking systems.
- f) The minimum acceptable mean deceleration rates at speed for the vehicle at tare mass shall be nominated by the manufacturer and may not be less than those required to meet the requirements of 1.3.4, for service brakes and 1.4.3 for secondary brakes and 1.6.4 for automatic brakes.
- g) The minimum acceptable peak deceleration rates at speed for the vehicle at tare mass, calculated from type testing, and the maximum acceptable response time, for each of the braking systems.
- h) The maximum gross vehicle mass.
- i) The maximum gross unbraked towing capacity.
- j) 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 table 2 for an example of a compliance plate.*

*Table 2 Compliance plate example*

Braking system compliance plate	
Approval /certification No.	
Manufacturer	
Date of manufacture	
Approval/certification drawing	
Max. (vehicle) gross mass	

Max. (trailer) gross mass				
<b>Minimum acceptable brake performance for in-service testing</b>				
	At speed (km/hr)	Mean deceleration rate (m/s <sup>2</sup> )	Peak Deceleration rate (m/s <sup>2</sup> )	Response time (s)
<b>Service brakes</b>				
<b>Secondary brakes</b>				
<b>Automatic brakes</b>				
<b>Maximum holding grade (%)</b>				
<b>Parking brakes</b>				

## 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 table 2 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.

# 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 TRG.
- 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 D, E and I and the test results reported.

All type testing shall (excluding locomotives) be carried out within 10% or 2km/hr (whichever is the greater) of the maximum attainable speed for the particular loaded test condition.

### 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.

### 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 F.

### 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.

As a minimum, dynamic braking of the mobile plant shall be carried out annually using the formula below.

Mean brake decelerations shall not decrease by more than 125% from those results obtained from the type test result unless the manufacturer has carried out further brake testing to confirm a larger variance is safe to use.

$$a_{\text{brake-test}} = (a_{\text{safe-nett}} + g(D-T)) \left( \frac{m_{GVM}}{m_{\text{actual}}} \right)$$

$$s = \left( \frac{v^2}{25.9 [a_{\text{safe-nett}} + g(D-T)]} \right) \left( \frac{m_{\text{actual}}}{m_{GVM}} \right)$$

Where

$$\left( \frac{m_{GVM}}{m_{\text{actual}}} \right) = \text{ratio of gross vehicle mass to actual mass of the machine} = 1 \text{ for type testing}$$

$m_{GVM}$  = gross vehicle mass of the machine

$m_{\text{actual}}$  = actual mass of the machine being tested

The minimum values for  $a_{\text{safe-nett}}$  when the machine is being operated in service are:

- i. Service brake application = 0.60 m/s<sup>2</sup>

- ii. Secondary brake application = 0.30 m/s<sup>2</sup>

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

#### 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.*

## 4. Documentation

### 4.1. General

The designer of the braking system must keep records of the design to fulfil the duties of a designer, to provide ongoing support for the design and provide necessary information to manufacturers, persons conducting testing, end users and regulatory authorities.

Braking system design records should include but, not limited to:

- 1) A description of the intended purpose of the design.
- 2) Limitations of use of the design.
- 3) Circumstances the design should or must not be used.
- 4) Detailed drawings and Bills of materials.
- 5) Calculation, analysis, testing and examination reports.
- 6) Compliance assessment reports.
- 7) Design verification reports.
- 8) Arrangement drawings and schematic diagrams.
- 9) Commissioning checklists or inspection and test plans (ITPs).
- 10) Safety critical checks, settings and adjustments.
- 11) Parts and servicing information.
- 12) Maintenance and repair information.
- 13) Performance data.
- 14) Purchaser information.

Much of the above mentioned will be required in the preparation and support of an application for design registration of transport braking systems.



## 4.2. Arrangement drawings and schematic diagrams

Arrangement drawings and circuit diagrams should include:

- a) all part numbers or component specifications
- b) hose, pipe or tube sizes where length or bore size may affect performance of the system
- c) the maximum vehicle mass 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 appendix E service brake system performance)
- e) a written description of the operation of the braking systems.

## 4.3. Maintenance, inspection and testing information

Maintenance, inspection and testing information should include:

- 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

## 4.4. Purchaser information

The braking system manufacturer should supply, or may be required to supply the following to each purchaser of a braking system:

- a) Information regarding the intended use and limitations of use of the design.
- b) Notice of registration – transport braking system.
- c) Arrangement drawings and schematic circuit diagrams.
- d) A certificate of conformance for the braking system to the notice of registration signed by an authorised representative of the design registration holder including any supporting routine test requirements.
- e) Plant safety file including any relevant serial numbers of safety critical components and test certificates (e.g. hose pressure test certificates, pressure vessel certificates etc).
- f) Details of maintenance and operational requirements, specifications and any other drawings required to maintain the braking system in compliance with this TRG or designers and manufacturers duties.
- g) Parts manuals, service manuals and other product related information.

## Appendices

### Appendix A – References

#### Definitions

For the purpose of this TRG, the following definitions apply;

Automatic brakes	Brakes which apply automatically.
Braking system	Includes all components which combine to stop or hold the transport.
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.
Mean deceleration, (a)	<p>Average rate of change of the speed of the vehicle from the instant the brake control actuation begins until a full stop is achieved.</p> <p>Mean deceleration may be determined from the formula;</p> $a = \frac{v^2}{2s}$ <p>Where:</p> <p>a - is the mean deceleration, in metres per second squared.</p> <p>v - is the speed of the vehicle immediately prior to the brake control being activated, in metres per second.</p> <p>s - is the stopping distance in metres.</p>
Mobile plant	<p>Means plant capable of being driven, moved or relocated under its own power and includes track mounted machines which travel at slow speeds.</p> <p>Vehicle may be taken as reference to mobile plant.</p>

Parking brakes	Used to prevent movement of a stationary vehicle for prolonged periods.
Secondary brakes	A system applied by the operator in the event of a failure of the service brakes.
Service brakes	A system used to stop and momentarily hold a vehicle.
Tare Mass	<p>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 120kg operator, full fuel, water, oil and lubricant tanks.</p> <p>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.</p> <p>For vehicles designed to haul un-braked trailers, the tare mass shall include the unladen mass of the trailer.</p>
Transport	<p>Transport means mobile plant used for the purpose of transporting persons, materials, coal or stone, whether by carrying, towing or otherwise and includes:</p> <p>(a) a locomotive, or</p> <p>(b) a rubber tyred or tracked vehicles (including a shuttle car) propelled by electrical and/or mechanical means.</p> <p>Note : The following plant is required to have design registered braking systems: Locomotive, shuttle car, Hauler-electric (battery), Load-Haul-Dump, Shearer Carrier, Chock Carrier, Personnel Transporter, Grader/Dozer, Skid-Steered Loader.</p> <p>Note: The plant which do not require transport braking registration is plant which does not carry a person or materials and does not perform its primary function while moving such as:</p>

	Continuous miners, mobile bolting machines, breaker line supports, feeder breakers etc.
Vehicle	<p>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.</p> <p>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.</p>
Vehicle Mass (gross)	<p>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 120kg operator, full fuel, water, oil and lubricant tanks.</p> <p>For personnel carriers, a mass equivalent to the designed maximum number of persons multiplied by 120 kg shall be added.</p> <p>For materials, equipment/stores transporters and LHD's the vehicle shall be loaded to its' maximum rated payload at the specified axle distribution.</p> <p>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.</p>

## Abbreviations

AS	Australian Standards
AS/NZS	Australian / New Zealand Standard
Km/h	Kilometres per hour
TRG	Technical reference guide
WHS	Work, Health and Safety

Max.	Maximum
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## Relevant Australian Standards

AS1210	Pressure Vessels
AS2971	Serially produced pressure vessels
AS3584	Diesel engine systems for underground coal mines.
AS/NZS 4024.1201	Safety of machinery - General principles for design - Risk assessment and risk reduction
AS/NZS 4024.1302	Safety of machinery - Risk assessment - Reduction of risks to health from hazardous substances emitted by machinery - Principles and specifications for machinery manufacturers
AS4024.1501	Safety of machinery - Design of safety related parts of control systems - General principles for design
AS4024.1502	Safety of machinery - Design of safety related parts of control systems
AS61508.1	Functional safety of electrical/electronic/programmable electronic safety-related systems - General requirements
AS61508.2	Functional safety of electrical/electronic/programmable electronic safety-related systems -Requirements for electrical/electronic/programmable electronic safety-related systems
AS61508.3	Functional safety of electrical/electronic/programmable electronic safety-related systems - Software requirements
AS61508.4	Functional safety of electrical/electronic/programmable electronic safety-related systems - Definitions and abbreviations

AS61508.5	Functional safety of electrical/electronic/programmable electronic safety-related systems - Examples of methods for the determination of safety integrity levels
AS/NZS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
AS/NZS ISO 9000	Quality management systems - Fundamentals and vocabulary
AS/NZS ISO 9001	Quality management systems - Requirements
AS/NZS ISO 9004	Quality management - Quality of an organization - Guidance to achieve sustained success

## International Standards

MSHA, 30 CFR part 75	Braking Performance - underground vehicles
CAN/CSA-M424.3-M90	Braking Performance, Rubber tyred self-propelled underground mining machinery.
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.

## Appendix B Means of demonstrating continued compliance with this TRG

### Introduction

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

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

- a) The use of a product certification scheme e.g. 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.

### 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 9001 and AS/NZS 9000.

### 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 C Type testing – test conditions (normative)

### Test course

#### 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  $\geq 0.95$ .*

#### For holding tests

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

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

### 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.

### 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.

## 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 test organisation and key personnel involved .
- b) descriptions of the components/assemblies/vehicle tested.
- c) a statement that the test course meets the requirements of this appendix.

## Appendix D Type testing – Performance (normative)

### Scope

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

### Principle

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

### Apparatus

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

### 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 9001.

### Procedure

#### 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.

#### 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.

#### 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<sup>2</sup>)

- iv. The mean deceleration rate (m/s<sup>2</sup>)
- 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)

## 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 C at the maximum attainable speed in the forward direction. Apply the servicebrakes. 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 3.

(b) **Reverse (at vehicle mass)**

Drive the vehicle, loaded to its vehicle mass, on a test course meeting the requirements of Appendix C at the maximum attainable speed in the reverse direction. Apply the servicebrakes. 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 3.

(c) **Forward (at tare mass)**

Drive the vehicle, with minimum load (tare), on a test course meeting the requirements of Appendix C at the maximum attainable speed in the forward direction. Apply the servicebrakes. 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 3.

(d) **Reverse (at tare mass)**

Drive the vehicle on a test course, with minimum load (tare), meeting the requirements of Appendix C at the maximum attainable speed in the reverse direction. Apply the servicebrakes. 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 3.

(e) **Holding**

At vehicle mass, drive the vehicle onto a ramp or slope having a grade  $\geq 25\%$ . Apply the servicebrakes. 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:

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

F = pulling force on the machine in Newtons

Grade = the maximum operating grade in degrees

M = 1.1 X Machine operating mass in kg

## Secondary brake

Repeat the tests nominated in service brake system – performance (a) & (c) above. Record the results in Table 3.

*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.*

## Automatic brake

Repeat the tests nominated in service brake system – performance (a) & (c) above. Record the results in Table 3.

*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.*

- (a) 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 C. The pulling force shall be applied horizontally near to the ground. The force required shall be calculated as follows:

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

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

- (b) Confirm that each of the possible methods of automatic initiation of the automatic brake meets the requirements of 1.6.5 and 1.6.6 for operation and response time.

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

### Parking brake

Drive the vehicle at 110% of vehicle mass 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:

$F = \text{SIN Grade} \times M \times 9.81$  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 3 Braking system test results

<b>Braking system test results</b>						
<b>Manufacturer</b>						
<b>Date of test</b>						
<b>Drawing reference</b>						
<b>Name &amp; model of vehicle</b>						
<b>Brake Performance</b>	<b>Stop Distance. (m)</b>	<b>At speed (km/hr)</b>	<b>Max Decel. rate(m/s<sup>2</sup>)</b>	<b>Mean Decel. rate(m/s<sup>2</sup>)</b>	<b>Response time (s)</b>	<b>Operating force (N)</b>
<b>Service brakes – forward (at vehicle mass)</b>						
<b>Service brakes – reverse (at vehicle mass)</b>						
<b>Service brakes – forward (at tare mass)</b>						
<b>Service brakes – reverse (at tare mass)</b>						
<b>Secondary brakes (at vehicle mass)</b>						

<b>Secondary brakes (at tare mass)</b>						
<b>Automatic brakes (at vehicle mass)</b>						
<b>Automatic brakes (at tare mass)</b>						
<b>Brakes – holding ability</b>						
<b>Method of test</b>	<b>Grade (%), or</b>		<b>Force (N)</b>			
<b>Service, holds 5 minutes?</b>						
<b>Auto, holds?</b>						
<b>Park, hold 5 minutes?</b>						

## **Test report**

The test report shall include the following:

- a) The name of the test organisation.
- b) Descriptions of the components/assemblies/vehicle tested, including;
  - i. Burnishing procedure (if any)
  - ii. Tyres fitted during test (specification)
  - iii. Any other information considered relevant by the test organisation 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 type testing – temperature (normative)

### 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.

### Principle

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

### Apparatus

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

### 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 9001.

### Procedure

#### 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.

#### 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.

#### 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 C 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 minutes and provided that the entire test shall be completed in 40 minutes.

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). ( $^{\circ}C$ ) (see 4.2.1)
  - vi. The ambient temperature ( $^{\circ}C$ )

Record the test results at Table 4.

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  $150^{\circ}C$ .





















## Appendix I locomotives brake performance verification

The performance of all brake systems shall be verified by both calculations and by practical tests as follows.

### Calculations should include those leading to:

- 1) available braking force assuming an adhesion coefficient of 0.17
- 2) maximum possible adhesive braking force - best conditions
- 3) maximum possible braking force that the brakes can apply.

### Practical tests

These tests require use of a suitable automatic device to monitor brake response time and to coordinate this with actual loco retardation relative to the track. This requires the use of a separate non braked wheel applied to the track but supported by the loco to ensure that any skidding is catered for.

Test results will include:

- 1) Brake system response time from each driver's compartment and also for tandem operation.
- 2) Average deceleration.
- 3) Maximum deceleration.
- 4) Operation of the interlock which prevents a loco being driven with the brakes applied.
- 5) Operation of the automatic brake systems where fitted.
- 6) Maximum surface temperature of brakes (for oil immersed type brakes only) NOTE this may require a non-braked load to be applied to increase the load on the braking system.
- 7) Number of effective brake operations that can be achieved from any stored energy system, where fitted.
- 8) Ability of brake system to defeat the maximum tractive effort of the loco (requires temporary defeat of interlock).
- 9) All brake tests are to be conducted with and without the sanders operating.
- 10) Level track is preferred but results can be corrected if necessary, to allow for some grade.
- 11) Tests should be conducted with both the loco loaded and unloaded.
- 12) Check to ensure that operation of the service brake doesn't interfere with the operation of the dump brake.
- 13) Brake tests should be conducted in both directions and repeated. The suggested number of operations is at least 3 service, 3 dump brake tests and 1 deadman brake test in each direction.
- 14) Variations to this test procedure are permitted subject approval by the Resources Regulator.