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Preface

This standard was prepared by the Braking systems – Part 2: Hauled rolling stock Development Group, overseen by the RISSB Rolling Stock Standing Committee.

Objective

The objective of this Standard is to provide safety benefits in that proper braking performance contributes to the prevention of collisions or derailments of railway rolling stock by providing controls for known hazards.

This standard describes minimum standards for brake performance, features and compatibility for the braking systems of hauled Freight and Passenger Rolling Stock.

This Standard is intended to compliment the rolling stock compliance certification process outlined in AS 7501, including all vehicle types such as new, modified and heritage rolling stock.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints – provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix C.

Appendices in RISSB Standards may be designated either “normative” or “informative”. A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary C *Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Section 1 Introduction

1.1 Purpose

The purpose of this Standard is to describe the requirements for brake performance, features and compatibility for the braking systems of hauled freight and passenger rolling stock.

1.2 Scope

This Standard applies to hauled freight and passenger rolling stock that is:

a) new;

b) modified rolling stock; or

c) is to operate in a network in which it has not previously operated.

This scope of this Standard covers:

d) the design and construction of brake systems including automatic air brake and ECP brake systems; and

e) the maintenance of the brake systems including automatic air brake and ECP brake systems.

Locomotives and trains that use standard unmodified AAR pneumatic brake equipment are not covered.

The operation of rolling stock, including network safeworking rules and route standards, is not covered.

This Standard is not specifically intended to cover rolling stock used on light rail, cane railway and monorail networks, but items from this Standard may be applied to such systems as deemed appropriate by the relevant RIM.

1.3 Normative references

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

- AS 1200, *Pressure equipment*
- AS 1210, *Pressure vessels*
- AS 2435, *Elastomeric hose for railway air brakes*
- AS 2971, *Serially produced pressure vessels*
- AS 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems*
- AS 7504, *Brake blocks*
- AS 7504.2, *Brake components – Part 2: Brake discs and pads*
- AS 7507, *Rolling stock outlines*
- AS 7510.6, *Railway rolling stock – Braking systems – Part 6: Train*
- AAR S400, *Brake equipment – Installation specifications*
- AAR S401, *Brake design requirements*
- *AAR Manual of standards and recommended practices – Section E: Brakes and brake equipment*
- *AAR Manual of standards and recommended practices – Section E - II: Electronically controlled brake systems*
- EN 50128, *Railway applications – Communication, signalling and processing systems – Software for railway control and protection systems*

- *Code of Practice – ECP Braking (RISSB)*
- *Field manual of the AAR interchange rules*

NOTE:
Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.4 Defined terms and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.4.1
abrasive brake block (trim block)
brake block that may be used to remove minor wheel and tread irregularities

1.4.2
accelerated application valve
pneumatic device connected to the brake pipe which can sense brake pipe pressure drop and that will vent controlled amounts of brake pipe compressed air to atmosphere to aid the development of service brake applications and so to reduce stopping distances

1.4.3
accelerated release reservoir
automatic air brake reservoir, on a vehicle having a control valve incorporating the accelerated release feature, in which is stored compressed air for the assistance of brake pipe recharging during the operation of that feature

1.4.4
articulated vehicle
a vehicle comprising of two or more sections, where adjacent sections are supported by and can pivot about a shared bogie and may incorporate a shared brake control system

1.4.5
automatic air brake
brake that automatically applies throughout a train when the brake pipe pressure is reduced and releases when the brake pipe pressure is restored

1.4.6
automatic brake
continuous brake system for trains that will self-apply in the event of loss of continuity (including train separation)

1.4.7
automatic park brake
APB
park brake able to self-apply in predetermined circumstances without direct human intervention

1.4.8
auxiliary reservoir
automatic air brake reservoir on a vehicle in which is stored compressed air as the primary source specific to that vehicle for a non-relayed brake system or the compressed air that provides the pilot signal for a relayed brake system

1.4.9
bail off
term to describe the action of manipulating the controls of a locomotive to bring about the independent release on that locomotive and on all others in multiple unit operation with it of an automatic air brake application without causing the release of an application of the automatic air brake on hauled vehicles

1.4.10
brake block
friction element that is forced directly onto the tread of a vehicle wheel for the purpose of braking

1.4.11
brake cylinder
hydraulic or compressed air device that generates brake force in a brake system

1.4.12
brake disc
rotor having one or more co-planar annular friction faces for the engagement of brake pads and means of transmitting rotation between itself and the associated axle or drive shaft element

1.4.13
brake pad
friction pad that interfaces with the brake disc via a brake calliper to slow the rolling stock down by the use of friction when the brakes are applied

1.4.14
brake pipe
automatic air brake system conduit that is installed throughout the length of a train for the delivery of brake system compressed air and in which pressure signals for brake system control may be delivered

1.4.15
brake system
braking equipment of a vehicle or a train

1.4.16
braking surface
equipment surface at which vehicle braking may be developed by friction

1.4.17
coefficient of adhesion
force attempting to move an axle along the track divided by the vertical force on the rail due to the axle load mass

1.4.18
coefficient of friction
ratio of the resultant retarding force produced to the applied brake pad force (normal to the friction material)

1.4.19
composition brake block
brake block containing non-metallic friction material

1.4.20
continuity
continuous connection and the operability of the brake system of a train on all vehicles from the front of the train to its rear

1.4.21
continuous brake
brake system that is effective continuously along the length of the train

1.4.22
control pipe
conduit of the air brake system of a locomotive that conveys the control signal for the locomotive independent brake and for the straight air brakes of connected hauled vehicles

1.4.23
control valve (alternatively triple valve or distributor valve)
control element of the automatic air brake of a vehicle

1.4.24
direct release
only applicable to the automatic air brake system where it can only be released in a single step as distinct from many steps in a graduated release system

1.4.25
dummy volume
automatic air brake reservoir on a vehicle which provides the reference volume for the pilot signal for a relayed brake system

1.4.26
dynamic (or rheostatic) brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of traction motors to generate electrical energy that is dissipated on board

1.4.27
electronically controlled pneumatic
ECP
term to describe electronically controlled brake equipment that complies with AAR Standards

1.4.28
emergency application
application of an automatic air brake that is propagated at a higher rate than the normal rate of a service application and that may result in a rate of retardation that is higher than the normal rate of a service application and not less

1.4.29
electro-pneumatic
EP
term to describe air brake equipment incorporating principal function control by electromagnetically operated valves but not electronically controlled in the manner of ECP brakes

1.4.30
equalising reservoir
automatic air brake reservoir on self-propelled rolling stock in which is stored compressed air at a reference pressure for replication in the brake pipe. Also a reservoir that accepts compressed air from an empty/load valve in the empty condition to reduce the brake cylinder pressure and therefore the braking force applied to prevent skidding

1.4.31
equivalent deceleration
is the mean deceleration with respect to the braking distance, once the brake force has been applied (i.e. it excludes the delay time of the braking system), as defined in the standard EN 14531-1

1.4.32
friction element
sacrificial pad or block that is forced onto a braking surface to develop a braking force by friction

1.4.33
full service
application of the automatic air brake resulting from service braking to the extent that the maximum normal rate of retardation is achieved

1.4.34
function check
brake checking in the field performed for the purpose of confirming the serviceability of the brake system of a vehicle or vehicles

1.4.35
graduated application
brake system that allows the gradual application of the brakes

1.4.36
graduated release
brake system that allows the gradual release of the brakes as distinct from a direct release system

1.4.37
handbrake
park brake operated by manual effort via a wheel or lever

1.4.38
holding brake
in an EP brake system, the application of a predetermined braking effort for emergency purposes or for parking or securing a train

1.4.39
independent brake
straight air brake that is for the primary purpose of holding one or more vehicles stationary and that is operated via the control pipe

1.4.40
independent release (actuating) pipe
conduit of the air brake system of a locomotive that conveys the bail off signal

1.4.41
main reservoir
one or more interconnected compressed air reservoirs supplied directly by one or more air compressors as a primary source of compressed air for a vehicle air brake system and often for additional purposes

1.4.42
main reservoir equalising pipe
conduit of the air brake system of a locomotive or train that conveys compressed air for air brakes and auxiliary equipment between coupled locomotives or vehicles of a train and where applicable, for auxiliary equipment of connected hauled vehicles

1.4.43
main reservoir pipe
vehicle through pipe having flexible end connections to permit the supply of compressed air to that vehicle and others attached to it from the main reservoirs of an attached locomotive

1.4.44
modified rolling stock
rolling stock altered in such a way that the declared compliance status for one or more requirement or recommendation clauses in the standards compliance register is as a consequence affected

1.4.45
multi-pack vehicle
semi-permanently or permanently coupled vehicles connected by a drawbar which may incorporate a shared brake control system

1.4.46
multiple unit control
full functional operation of more than one coupled vehicle from a single driving station

1.4.47
net braking ratio
NBR
quotient of the sum of the actual braking forces (net of brake rigging losses), referred as normal forces at the wheel treads of a vehicle, and its weight

1.4.48
park brake
braking equipment arranged to enable an individual vehicle to be secured at rest without reliance upon the stopping brake

1.4.49
powered park brake
park brake that can be remotely controlled by a train driver

1.4.50
relayed brake
arrangement of the automatic air brake installation within a vehicle that incorporates a relay valve and a supplementary reservoir to increase the amount of brake system compressed air that may be controlled by a single control valve

1.4.51
relay valve
pneumatic device that permits a pilot signal to control brake system compressed air

1.4.52
RIM
rail infrastructure manager

1.4.53
rolling stock outline
a generic term for the three-dimensional size of a railway vehicle including its movements that consists of three specific parts, the static outline, basic kinematic outline and swept kinematic outline. Refer to AS 7507

1.4.54
RSO
rolling stock operator

1.4.55
service application
application of the stopping brake that is propagated within a train at a normal rate that is pre-determined and that results in a normal rate of retardation according to driver demand

1.4.56
service braking
normal manipulation of the stopping brake during train running

1.4.57
single car test
brake testing performed to confirm the correct operation of the brake system of a single vehicle

1.4.58
spring park brake
park brake that is applied by spring force and released by compressed air or hydraulic force

1.4.59
standard brake pipe pressure
network specified maximum brake pipe pressure to which an automatic air brake is to be initially charged for normal train operation (typically 500 kPa is adopted for locomotive hauled operations)

1.4.60
static brake test
brake test performed on a vehicle or train whilst it is stationary

1.4.61
straight air brake
non-automatic air brake

1.4.62
stopping brake
braking equipment used for stopping a train in running

1.4.63

supplementary/supply reservoir

compressed air reservoir on a vehicle that is the source of air pressure for the brake cylinders on EP systems, relayed brake systems and ECP brake systems

1.4.64

two pipe brake system

an automatic brake system that has a main reservoir pipe that is connected to the supply reservoir of a relayed brake system. Typically used on trains operating on long descending grades. Vehicles fitted with a bifurcated brake pipe are not classified as two pipe

1.4.65

vehicle

a means of transportation or, specifically, an item of rolling stock (e.g., a locomotive, a carriage or a wagon)

1.4.66

vent valve

a pneumatic device connected to the brake pipe which can sense rapid brake pipe pressure drop and that will vent brake pipe air to atmosphere when the rate of pressure drop rises to a pre-determined level

General rail industry terms and definitions are maintained in the RISSB Glossary. Refer to: https://www.rissb.com.au/products/glossary/

Section 2 Air brake system

2.1 General

The pneumatic energy required to operate the brakes on each vehicle shall be stored on the vehicle or an adjacent vehicle in the case of drawbar connected multi-pack vehicles or articulated vehicles.

The quantity of compressed air stored in the brake reservoirs on a vehicle should be sufficient to enable at least one emergency application of its automatic air brake to be effective including when following a service application.

There shall be a safe system for discharging stored compressed air.

The brake system shall be protected from any auxiliary system that interfaces with the brake system (including auxiliary systems that connect directly to the brake pipe) so that the brake system efficiency and safe operation is not affected.

Provision shall be made to enable the brake system on a vehicle to be isolated with no interference to the through brake pipe.

All cut-out or isolating cock handles, excluding those of emergency cocks, shall have white handles.

External park brake wheels and levers shall be in a contrasting colour to their surroundings (e.g., white).

All identifying embossed letters on air brake equipment should be painted in a contrasting colour to aid legibility.

The standard brake pipe pressure for hauled rolling stock shall be 500 kPa.

Hauled rolling stock should be compatible for operation with locomotives with a nominal brake pipe pressure of 500 kPa up to 620 kPa.

Commentary *C2.1-1*

Note that some networks operate with brake pipe pressures which deviate from the standard brake pipe pressure of 500 kPa.

An inverted “U” or the word "Release" shall be painted on each side of the vehicle underframe at the point of attachment of the manual air brake release.

The accuracy of air pressure displays associated with the air brake system shall be corrected if found to be in error by in excess of +/-15 kPa.

Air pressures nominated in this Standard which do not include a tolerance or are described as nominal shall have a tolerance of +/-21 kPa.

Commentary *C2.1-2*

Note that some networks may require a more accurate tolerance than defined above for air pressure displays and/or standard tolerance for air pressures.

Diameters or nominal bore sizes of pneumatic equipment defined in this Standard which do not include a tolerance or are described as nominal should have a tolerance of +/- 1 mm.

The brake system shall be able to operate effectively as intended under the full range of environmental conditions that can be expected in the route/area of operation.

Commentary *C2.1-3*

The ambient temperatures of the Australian natural environment for the operation of trains can range from -10° C to +55° C. The Australian climate can produce conditions including relative humidity of 100 % at 25° C, heavy rain, hail, frost, dew and fine dust.

2.2 Brake pipework

The size of the brake pipe and its fittings shall be 32 mm nominal bore.

The size of the main reservoir pipe and its fittings shall be 25 mm nominal bore.

The brake pipe material should be metal.

The minimum brake pipe bend radius should be 300 mm.

The cross-sectional area of brake system piping should not be restricted by the application of fittings or from other causes.

2.3 Brake rigging

Spring loaded type brake rigging pin securing devices such as ‘R’ clips, grip clips, or lynch pins shall not be installed in locations below axle centrelines.

Below axle centrelines, split cotter pins shall be applied to secure brake rigging pins.

Vehicles shall be fitted with safety straps, or brake rigging otherwise retained, to contain all pin-connected body and bogie mounted brake equipment such that the effect of component failures do not cause exceedance of the rolling stock outline if a single pin connection fails.

2.4 Emergency cocks – Hauled passenger vehicles

Emergency cocks shall be fitted to hauled passenger vehicles, accessible by on board rail traffic crew, or as defined by the RSO.

An emergency cock shall enable the brake pipe to be exhausted in an emergency situation resulting in an emergency application of the train brakes. The operating handle of the emergency brake pipe cock shall be red.

The emergency cock and the pipework connecting it to the brake pipe should have nominal bore of at least 25 mm.

The air flow capacity of the emergency cock and pipe work should ensure that even with the driver's brake valve feeding the brake pipe:

a) if the passenger car is located adjacent to a hauling locomotive, then the vent valve on that locomotive activates when the emergency cock is opened, and

b) an alarm level flow is provided to the driver to signal opening of the emergency cock when the passenger car is located anywhere in the train.

2.5 Compressed air reservoirs

Applicable state and federal legislation for registration of compressed air storage reservoirs must be complied with.

Compressed air storage reservoirs shall comply with AS 1210, AS 2971, or recognized equivalent standards.

AS 1200 shall be used to provide guidance regarding recognized equivalent standards.

Each compressed air storage reservoir shall be fitted with threaded drain bung plugs or other means for draining accumulated water.

Drain cocks shall not be fitted to auxiliary reservoirs, dummy volumes or brake cylinders.

Drain cocks may be fitted to supplementary/supply reservoirs. If fitted, the air supply shall be protected for brake application.

If fitted, drain cocks should be locked/latched to prevent accidental activation from in-train forces, vibrations and/or being struck by foreign objects.

2.6 Pneumatic couplings between vehicles

2.6.1 General

With the exception of vehicles coupled together with fixed drawbars, articulated vehicles or multi-pack vehicles, pneumatic couplings between vehicles shall be designed to provide connections that are secure but easily parted without damage in the event of train or locomotive separation.

Pneumatic couplings between vehicles shall be arranged to avoid damage to or kinking of flexible hoses.

All hauled rolling stock shall be fitted with pneumatic couplings that are compatible with those of all other rolling stock in use on that network.

All hauled rolling stock should be fitted with brake pipe pneumatic couplings as detailed in Appendix A.

Alternative pneumatic couplings may be used which are compatible with other vehicles operating within the route/area of operation.

Pneumatic couplings between vehicles shall be arranged to permit stored compressed air to be vented prior to disconnection.

For single or bifurcated brake pipe, or installations that have a main reservoir or other air pipe/s fitted, the coupling/s installed at the end of a vehicle shall be positioned to ensure each brake line can connect to the same brake line via end hoses on the adjacent rolling stock that it shall operate with.

Where bifurcated brake pipes are fitted, the "Y" connection to the main brake pipe, shall ensure that no air flow restrictions result.

Commentary *C2.6.1-1*

Figures A.1 and A.2 of Appendix A provide guidance on typical coupling locations.

Bifurcated brake pipes are typically required where a single brake pipe connection between wagons with standard hoses may cause uncoupling of the hoses on tight curves. This is normally only required on long wagons.

For vehicles with bifurcated braking systems, the brake pipe and main reservoir pipe end cocks should be clearly labelled in a contrasting colour to their surroundings for identification purposes.

The additional volume associated with brake pipe bifurcation shall be kept to a minimum and shall be incorporated into the brake system design.

Pneumatic couplings between vehicles shall be configured to ensure that only the same type of pneumatic pipe can be connected to the same type of pneumatic pipe on the adjacent vehicle.

Commentary *C2.6.1*

Coupling hoses and end fittings shall be unique to the type of pneumatic pipe to eliminate the possibility of incompatible pneumatic pipes being connect (i.e. only brake pipe can connect to brake pipe, main reservoir pipe to main reservoir pipe, etc).

2.6.2 Brake pipe end cock

Brake pipe compressed air end cocks shall:

(a) be ball type cocks;

(b) be of size 32 mm nominal bore;

(c) have a means of ensuring the handle remains in position when open and closed;

(d) vent the hose when the cock is closed;

(e) be equipped with curved handles; and

(f) be closed in the up/vertical position.

Commentary *C2.6.2*

Figure A.3 of Appendix A provides an example of a typical brake pipe end cock configuration.

2.6.3 Other end cocks

Where fitted, compressed air end cocks for main reservoir, control pipe and independent release pipe coupling hoses shall:

(a) be ball type cocks;

(b) be of at least 19 mm nominal bore for main reservoir cocks;

(c) be of at least 12 mm nominal bore for control pipe and independent release pipe cocks;

(d) have spring loaded or latching handles to prevent accidental operation;

(e) latch in the open position;

(f) be readily accessible to ground staff during coupling and uncoupling;

(g) be equipped with straight or curved handles;

(h) be open when the handle is pointing along the pipe; and

(i) vent the hose when the cock is closed.

2.6.4 Coupling hose components

Brake system coupling compressed air hoses shall comply with the requirements of AS 2435 or international equivalent.

The internal diameter of elastomeric hose for brake system coupling compressed air hoses for:

(a) the brake pipe shall be 35 mm;

(b) the main reservoir should be 29 mm; and

(c) the control pipe shall be 12 mm.

Coupling heads for brake system coupling compressed air hoses shall incorporate orifices of minimum size as follows:

(d) 32 mm for brake pipe;

(e) 17 mm for main reservoir; and

(f) 9.5 mm for control pipe.

Brake Pipe coupling compressed air hose head details shall be in accordance with Appendix Figure A-4, Appendix Figure A-5, Appendix Figure A-6, and Appendix Figure A-7 of Appendix A.

Provision shall be made to secure coupling hoses by the use of dummy couplings or receptacles.

Section 3 Automatic air brake

3.1 General

Every vehicle, articulated vehicle or multi-pack vehicle shall be fitted with an automatic air brake.

The automatic air brake control system shall provide for graduated application of the automatic air brake.

The automatic air brake control system shall provide for direct release or graduated release of the automatic air brake.

Commentary *C3.1-1*

Automatic air brake control systems fitted with graduated release are normally limited to a train length of 30 vehicles or less.

The automatic air brake control system shall permit an emergency application of the stopping brake at any time when in running.

Hauled vehicles in dedicated unit trains may be equipped with AAR emergency devices such as AAR vent valves.

Commentary *C3.1-2*

Vent valves assist with the propagation of an emergency brake signal by rapidly exhausting the brake pipe locally on the vehicle.

Control valves in use in Australia/New Zealand may not have an emergency vent portion and so the spacing requirements shown in AAR S-400 and S-401 would not apply.

Vent valves shall not induce undesired emergency (UDE) brake applications on the vehicle.

The vent valve shall be listed in the field manual of the AAR interchange rules.

The vent valve where possible should be installed in accordance with AAR S-400 and S-401 including:

(a) be mounted on the opposite end of the vehicle from the control valve, or on a multi-pack vehicle with shared control valve on the vehicle without a control valve;

(b) at least 4.5 m from the control valve branch pipe tee;

(c) at least 1.5 m from the wagon brake pipe end cock; and

(d) where a branch pipe from the brake pipe to the vent valve is used it should be of 25 mm nominal bore pipe or hose and no more than 0.76 m in length.

Each vehicle shall be fitted with a control valve (or its brake system shall be connected to a control valve) arranged to respond to braking commands transmitted via the brake pipe. Articulated vehicle or multi-pack vehicles may have more than one control valve.

The control valve should be of the diaphragm type.

The control valve shall be suitable for all train lengths and configurations they will be operated in.

The suitability of a control valve for a given train length and configuration shall be proven by functional testing.

For train configurations with different types of controls valves installed in the same train consist (e.g., control valves from different suppliers that may have different attribute timings as described in section 3.3.1), interoperability shall be proven by functional testing considering the train configuration and operating route.

Commentary *C3.1-3*

Suitability of a control valve is closely related to the following:

1. The ability to propagate a minimum brake application signal throughout whole train consist;
2. the ability to fully release of a minimum brake application throughout whole train consist; and
3. ensuring uniform charging and recharging of a whole train consist.

The three (3) items listed above are very important to safe train handling and avoidance of train runaways, sticking brakes, wheel damage, track damage and derailments.

Potential issues that can occur due to control valve incompatibility may include:

1. Longer train consist charging and recharging times.
2. Uneven braking forces throughout the train consist.
3. Brake valves not responding to minimum brake application during cycle braking due to uneven charging times.
4. Uninitiated brake release during cycle braking consisting of light brake application and release.

Type testing is required where existing test or service data is not adequate to demonstrate suitability of the proposed configuration, such as for proposed train lengths that are longer than have previously been assured.

The spacing between control valves or other venting devices shall:

(e) be not more than 38 m; or

(f) may be separated by up to 50 m subject to there not being more than 76 m of brake pipe between any three (3) consecutive control valves.

Each control valve shall be fitted with a manual release device which when operated exhausts air pressure to atmosphere in the brake cylinder, auxiliary reservoir and dummy volume, as applicable.

The manual release should have the following attributes:

(g) When operated continuously, brake cylinder air pressure shall be fully exhausted irrespective of the state of brake pipe pressure.

(h) A momentary operation when brake pipe pressure is fully exhausted should cause the brake cylinder, auxiliary reservoir and dummy volume, if applicable, to fully exhaust.

(i) The manual release shall be operable from either side of the vehicle.

The automatic air brake maximum design brake cylinder pressure for purposes of braking should be 350 kPa to 380 kPa for the standard brake pipe pressure of 500 kPa.

The brake system of a hauled vehicle shall be arranged to allow the brake cylinder pressure to reduce over a period of time when the brake application is releasing. The exhaust from each brake cylinder or dummy volume to atmosphere may be via a fixed choke.

The following provisions apply in the case where a vehicle intended for operation as a two pipe brake system:

(j) The auxiliary reservoir and dummy volume shall be sized to equalize at the design maximum brake cylinder pressure.

(k) The supplementary reservoir shall be supplied both from the brake pipe and from the main reservoir pipe.

(l) The supplementary reservoir shall be supplied from the brake pipe via a non-return check valve and choke connected in series.

(m) The size of the choke for the brake pipe supply to the supplementary reservoir should be 1.6 mm.

(n) The supplementary reservoir shall be supplied from a main reservoir pipe via a non-return check valve and choke connected in series.

(o) The size of the choke for the main reservoir supply to the supplementary reservoir should be 2.4 mm.

(p) The programmed maintenance of a vehicle intended for operation in a two pipe brake system shall include testing to ensure that cross leakage of compressed air between the main reservoir pipe and the brake pipe does not occur.

3.2 Functions

The following automatic air brake functions (or their equivalent) of any new or modified rolling stock shall incorporate:

(a) retarded recharge to slow the storage of compressed air on the vehicle when in the forward portion of a train during brake release and charging, in trains of 300 m or greater in length;

(b) brake cylinder pressure maintaining to assist the maintenance of a minimum brake cylinder pressure during a brake application despite possible brake cylinder leakage;

(c) auxiliary reservoir pressure maintaining to aid control valve stability whilst it is in the service lap position;

(d) quick service to locally reduce brake pipe pressure to assist the rapid and substantially uniform rate of propagation of a brake application in a train; and

(e) accelerated release to provide for a rapid rise in brake pipe pressure in order to propagate a brake release signal, when specified for use in trains of greater than 900 m. The accelerated release feature shall be effective in any position within the train up to the maximum length the air brake it is specified for use in.

The following automatic air brake functions (or their equivalent) of any new or modified rolling stock should incorporate:

(f) an initial in shot to produce rapid initial brake cylinder pressure rise;

(g) charging interlock to ensure that the brake control valve will have the stability of operation to remain in the release position throughout the initial charging of a train of length up to 2,250 m; and

(h) reduction ensuring to ensure the occurrence of an initial local reduction of brake pipe pressure of sufficient magnitude to initiate a brake application on the vehicle and to assist the rapid propagation of the brake application throughout a train.

An accelerated application valve, or equivalent, may be connected to the brake pipe to reduce stopping distances during service applications by venting a controlled amount of air from the brake pipe at each control valve throughout the entire service application range and to assist in the development of air brake service applications where brake system signals can be inhibited by brake pipe length or for other reasons.

3.3 Pressures, timings and travels

3.3.1 Control valve attributes

Freight control valves shall have the following attributes:

(a) Be compatible for operation with other rolling stock in service on the RIMs network of operation;

(b) not apply at brake pipe reduction rate lower than 29 kPa/min;

(c) apply within 60 s with a brake pipe reduction rate of 517 kPa to 379 kPa within 29 s and 31 s measured with the brake pipe volume isolated; and

(d) release within 60 s with brake pipe pressure increase at rate of 12 kPa/min.

Freight control valves should have the following attributes:

(e) Apply and release differential between auxiliary reservoir and brake pipe pressures should be between 9 kPa and 13 kPa according to international standards; and

(f) the operating stability should be controlled by air pressure loadings and not by operating friction.

Standard automatic air brake pressures and timings that will be used on new or modified rolling stock, when the standard brake pipe pressure is 500 kPa are:

(g) brake cylinder or dummy volume and auxiliary reservoir equalisation pressure: 350 kPa nominal;

(h) brake cylinder filling time: from 0 kPa to 80% of full pressure for the design brake cylinder piston travel (for reservoir sizing):

(i) freight vehicles: 18 s to 20 s;

(ii) passenger vehicles: 4 s to 10 s;

(i) auxiliary reservoir initial filling time: 0 kPa to 400 kPa in:

(i) freight vehicles: 115 s to 270 s;

(ii) passenger vehicles: 60 s to 70 s;

(j) auxiliary reservoir recharge:

(i) freight vehicles: 240 kPa to 450 kPa in 60 s to 70 s;

(ii) passenger vehicles: 250 kPa to 450 kPa: 20 s to 25 s;

Commentary *C3.3.1-1*

The auxiliary reservoir is typically filled by 2 chokes. One choke is used when the brake pipe/auxiliary reservoir pressure is less than a set pressure and 2 chokes are used when pipe/auxiliary reservoir pressure is greater than a set pressure. The larger pressure differential normally exists towards the back of the train and this assist to balance the charging of the brake systems along the train. As such the auxiliary reservoir recharge time can be variable depending on whether the retarded recharge feature is activated or not. The timings given here are when flow is through one choke.

Testing down to 240 kPa is difficult as normally auxiliary reservoir only reduces to 350 kPa on a train. The ranges above are for when the valve is tested on a test bench.

(k) accelerated release reservoir (if fitted) charging time: 0 kPa to 420 kPa in 95 s to 115 s;

(l) supplementary reservoir (if fitted) initial filling time: 0 kPa to 420 kPa in:

(i) freight vehicles: 90 s to 260 s;

(ii) passenger vehicles: 100 s to 110 s;

(m) brake application minimum rate of propagation: 200 m/s;

(n) brake release minimum rate of propagation: 80 m/s;

(o) for relay valve systems only, brake cylinder inshot capability should be 0 kPa to between 70 kPa and 84 kPa in 1.5 s to 2.0 s following control valve operation;

(p) brake cylinder release time for 350 kPa to 70 kPa:

(i) freight vehicle fitted with a fixed exhaust choke: should be at least 30 s;

(ii) freight vehicle fitted with a fixed exhaust choke: may be 15 s to 20 s for shorter trains or non significant gradient operations; and

(iii) passenger vehicles: 6 s to 15 s; subject to network requirements.

Brake cylinder travel should be regulated by an automatic slack adjuster to maintain the specified travel and friction element clearances irrespective of friction element wear.

Commentary *C3.3.1-2*

Brake cylinder release time: The purpose of using a brake cylinder exhaust choke is to increase the time that a brake application is retained. This can be desirable and contribute to enabling operation of longer trains that are required to stop and restart on a gradient or utilize serial/cycle braking methodologies for descending long gradients. A short retention timing can be desirable where scheduling required frequent train stops and restarts, however priority is typically given to enabling operation of longer trains to operate on long descending gradients. Having inconsistent choke timing throughout a train can lead to undesirable over braking of wagons with longer exhaust delays, this most frequently occurs where the HP setting on grade control valves are used. When determining the sizing of chokes on wagons the train capability requirements and fleet standardization should be assessed as part of the design process.

Pressures and timings: The standard automatic air brake pressures and timings shown in 3.3.1 reflect a type of control valve fitted to hauled rolling stock. Other types of commercially available control valves installed on hauled rolling stock which deviate from some of the timings shown, e.g., 3.3.1 (i) to 3.3.1(j), have demonstrated to be interoperable with other control valves. Interoperability of unproven control valves that deviate from the standard pressures and timings shown in 3.1.1 may be acceptable for operation subject to demonstration of interoperability with other control valves in the train consist or limited to operating in dedicated train consists.

If fitted, manually set grade control equipment timings for freight vehicles are nominally 350 kPa to 70 kPa:

(q) in position Ex - 15 s to 20 s;

(r) in position IP - 55 s (70 s for relayed brake); and

(s) in position HP - 105 s (150 s for relayed brake), retaining 50 kPa to 70 kPa for more than 5 min.

3.3.2 Measurements

Timings should be taken from the first pressure change (e.g., movement of pressure gauge pointers) and not from brake controller movement.

Readings should be taken from calibrated pressure gauges and not from screen displays to avoid screen display time lag.

Section 4 Brake force application

4.1 General

Friction elements on a hauled vehicle shall transmit stopping brake forces to the tread of each wheel or to brake discs securely connected to each wheelset.

Brake blocks shall comply with AS 7504.

Brake discs and pads shall comply with AS 7504.2.

During any normal braking, temperatures reached by a friction element and the associated wheel or disc shall not affect the structural integrity of the braking surfaces of either.

The mechanism that applies the brake force shall be capable of sustaining all loadings that can arise during normal train operations whilst providing the freedom necessary to accommodate relative movement between brake gear and running gear.

The outer edge of a composition brake block should be restrained from overhanging the outer edge of the rim of the wheel during braking.

Brake blocks shall be restrained from contacting wheel flanges during braking.

Brake blocks when new should conform to the cross-sectional tread contours of new wheels.

Noise emissions from friction elements during braking should conform to the RIMs requirements.

4.2 Composition brake blocks and brake disc pads

Composition brake blocks and brake disc pads should have performance characteristics as specified by the RSO, AS 7504 and AS 7504.2 respectively.

Commentary *C4.2*

It is recognized that composition brake blocks and brake disc pads that perform satisfactorily on a dynamometer might not perform satisfactorily in service.

RSOs shall develop procedures when introducing new brake blocks and brake disc pad types to ensure satisfactory performance of brake blocks or brake disc pads with respect to:

(a) train stopping distances comply with the requirements of the RIM;

(b) acceptable brake block and brake disc pad life;

(c) acceptable performance under drag braking conditions;

(d) brake blocks and brake disc pads do not produce offensive odours;

(e) compliance with legislative noise requirements;

(f) brake blocks and brake disc pads do not contribute to wheel damage such as excessive wear, grooving, shelling, spalling, thermal cracking or any other detrimental effects on wheel tread surfaces and brake disc surfaces; and

(g) brake blocks and brake disc pads do not produce sparks, fire banding or hot spots on wheels and brake discs.

The introduction of new brake blocks and brake disc pads should be supported by an approval and testing process.

4.3 Brake discs

Brake discs shall comply with AS 7504.2.

The design of brake discs shall incorporate the braking forces, centrifugal forces, localized and bulk thermal inputs and inertial loads from track irregularities.

4.4 Cast iron brake blocks

New vehicle designs should not require the use of cast iron brake blocks.

Section 5 Braking system stopping and holding performance

5.1 General

The stopping brake of a vehicle shall be designed for operational compatibility with the stopping brakes of all other attached vehicles.

RIMs may specify the maximum stopping distances for various classes of train, with samples provided in AS 7510.6 and RSOs should observe such requirements.

Braking performance including the stopping distance performance of a vehicle shall be compatible with the performance requirements of each route of each network in which the vehicle is to operate.

Braking system stopping performance shall be determined using the net braking ratio method or alternatively, if specified by the RIM, using the equivalent deceleration method.

Commentary *C5.1-1*

Historically the stopping distance performance of rolling stock has been prescribed indirectly by specifying a minimum total braking force to be achieved at the friction elements for a standard friction element (brake block), the net braking ratio. Alternatively, some RIMs may specify the minimum equivalent deceleration method for determining stopping performance.

Where an RSO uses a standard type of brake friction block or pad on their rolling stock fleet, measured characteristics of the friction elements shall be provided by the RSO.

The use of measured characteristics (e.g., test data) for the actual friction elements that will be installed on the rolling stock should be used for braking calculations, given the sensitivity of stopping performance to friction element coefficient of friction for different speeds, axle load and brake block forces.

Brake block or brake pad dynamic and static coefficients of friction should be determined based on testing in accordance with the methods defined in AS 7504 or AS 7504.2 respectively.

Commentary *C5.1-2*

Dependent on the test data available for the brake friction block or pad, the average brake block or pad friction over the operating speed range of the vehicle may be used.

If the net braking ratio is not met, it shall be demonstrated that the required stopping distances are met.

The automatic air brake should not be designed to achieve a braking force at the rail that necessitates a coefficient of adhesion between the wheel and rail in excess of 0.08, unless a wheel slide protection system is used.

5.2 Net braking ratio method

When the brake system of new or modified rolling stock is designed to utilize brake blocks these should be high friction composition brake blocks.

The automatic air brake of a vehicle fitted with high friction composition brake blocks shall be designed to achieve a net braking ratio of at least 13% with a brake pipe pressure reduction of 150 kPa.

Commentary *C5.2*

Some RIMs may require greater than the mandatory minimum of 13% net braking ratio for particular train types and/or operating routes. RSOs shall comply with the RIM requirements for the route/area of operation.

The automatic air brake of a vehicle fitted with high friction composition brake blocks shall be designed to achieve a net braking ratio of 30% or less when in the empty condition with emergency brake cylinder pressure.

The automatic air brake of a vehicle fitted with low or intermediate friction composition brake blocks or cast iron brake blocks shall be designed to achieve a maximum net braking ratio of 55% when empty and a minimum of 28% (except 20% for medium friction brake blocks) when fully loaded.

Table 1 – Net Braking Ratio - Summary of Values

Brake Block Type	Loading Condition	Net Braking Ratio
High friction	Fully loaded	0.13 minimum
	Empty	0.30 maximum
Medium friction	Fully loaded	0.2 minimum
	Empty	0.55 maximum
Low friction	Fully loaded	0.28 minimum
	Empty	0.55 maximum

5.3 Equivalent deceleration method

On level dry rail, a vehicle stopping from line speed under full braking resulting from an emergency application of the stopping brake should be capable of a minimum equivalent deceleration of 0.45 m/s² in all load conditions (equivalent deceleration does not include any braking delay time such as can be associated with driver reaction, system response and brake cylinder filling).

Commentary *C5.3-1*

The minimum deceleration should be the greater of the value defined in this Standard, or the deceleration required to fulfil the stopping distance and performance requirements of every route of each network in which the vehicle is to operate. In some specific circumstances, it may be necessary to utilize a minimum equivalent deceleration of less than 0.45 m/s², as measured on level dry rail, however this would be subject to approval by the applicable RIMs. Minimum deceleration rates on the order of 0.40 m/s² or less, as measured on level dry rail, can result in an inability to operate trains on 1:30 gradients.

The use of measured characteristics for the actual friction elements should be used for braking calculations, given the sensitivity of stopping performance to friction element coefficient of friction.

Where the braking characteristics including the friction element dynamic friction coefficient are known, the stopping distance should be calculated with a proven methodology, such as defined in Appendix B of this Standard.

Commentary *C5.3-2*

In order to fulfil the required minimum deceleration and/or stopping distance requirements, the brake block dynamic friction coefficient shall be incorporated for a given net brake ratio. For example, for high friction blocks, a dynamic friction coefficient of at least 0.35 is required in order to achieve an equivalent deceleration of at least 0.45 m/s² if the net braking ratio is the minimum value of 0.13. Refer to Appendix B for further information in relation to deceleration performance for a given net braking ratio and brake block dynamic friction coefficient.

5.4 Stopping brake

The effect of wheelset rotational inertia should be included when assessing stopping performance.

The effect of rolling resistance shall not be included when assessing stopping performance.

Stopping performance assessments for braking systems incorporating disc brakes shall be based on new wheel diameters.

Where a stopping distances requirement does not specify whether the braking mode is service or emergency then the assessment should be for service applications of the stopping brake.

Commentary *C5.4*

EN 14531-1 contains suggested methodologies for assessing stopping brake performance.

Appendix B includes some applicable formulas and examples based on standard EN 14531-1.

Section 6 Park brake

6.1 General

Each vehicle, articulated vehicle or multi-unit vehicle shall be equipped with at least one park brake that complies with Sections 6.2, 6.3 or 6.4.

The park brake shall hold the vehicle, articulated vehicle or multi-unit vehicle stationary on a 1:30 gradient, or as otherwise defined by the RIM, under all conditions of loading of the uncoupled vehicle, articulated vehicle or multi-unit vehicle.

For its intended operation a park brake should not be reliant upon the coefficient of adhesion exceeding 0.085 between the wheel and rail. The park brake shall be able to maintain the required braking forces indefinitely.

Commentary *C6.1-1*

The coefficient of adhesion of 0.085 allows for a minimum of 40% of axles to have park brakes applied on a vehicle.

The park brake of a vehicle shall be designed to achieve a minimum net braking ratio when fully loaded of 28% when fitted with low friction composition brake blocks, 20% with medium friction brake blocks or 13% when fitted with high friction composition brake blocks or with cast iron brake blocks.

If the minimum park brake net brake ratios are not met, holding on the maximum gradient shall be demonstrated. The park brake net braking ratio, or holding force, shall not fall below the standard minimum, or such that is required to hold the vehicle stationary on the maximum gradient as defined by the RIM under all conditions of loading.

The effect of wind force shall not be included when assessing park brake performance.

The effect of rolling resistance shall not be included when assessing park brake performance.

Park brake holding performance shall be assessed for vehicles in the fully loaded condition.

Commentary *C6.1-2*

EN 14531-1 contains suggested methodologies for assessing park brake holding performance.

During park brake net braking ratio brake force testing, rapping of the pins shall not be allowed.

6.2 Manual park brake

A manually applied park brake on a vehicle shall be applied and held in order to achieve the required braking forces with a manual force not exceeding 420 N, applied tangentially at the rim of a handbrake wheel or alternatively at the end of the operating lever.

A minimum clearance of 75 mm shall be maintained around the operating lever or handbrake wheel, including spider, pawl handle and release lever.

6.3 Powered park brake

The force to apply a powered park brake is normally via a spring (with pneumatic release) but other methods of providing a braking force may be used (e.g., electro/hydraulic or electro/mechanical).

The application of a powered park brake should not cause the designed brake ratio, or maximum designed brake force, of a vehicle to be exceeded at any time.

A powered park brake shall be able to be released by manual means.

A powered park brake shall apply a constant park brake force without requiring human effort to determine the application force.

Vehicles incorporating park brakes that are power operated but not automatic shall be treated as if fitted with manual park brakes with regard to brake retention testing.

6.4 Automatic park brake (APB)

A brake system incorporating an APB shall be capable of achieving the required braking forces indefinitely without human intervention once it has been applied.

The APB should be applied automatically if the brake pipe is exhausted for any reason.

If the APBs are activated by brake pipe, they shall only apply when the brake pipe reduces below typical service brake pressure.

The application of an APB should not cause the designed upper limit for the brake ratio of a vehicle to be exceeded at any time.

An APB shall be able to be released by manual means.

An APB shall apply a constant park brake force without requiring human effort to determine the application force.

The APB system shall allow the vehicle to be held stationary while re-charging the reservoirs from an emergency application.

If the vehicle is not automatically held stationary, some other means shall be available to hold the vehicle stationary to allow full re-charging of the reservoirs from an emergency application.

The APB should not release until the vehicle is held stationary by some other means.

If the APB can be released without the vehicle being held stationary, the RSO shall ensure there is some other means to hold the vehicle stationary while the APBs are released.

The park brake net braking ratio, or holding force, shall not fall below the standard minimum, or such that is required to hold the vehicle stationary on the maximum gradient as defined by the RIM under all conditions of loading during any transition from an application of the automatic brake to an application of an associated APB after it has been armed.

Section 7 Validation of braking function and performance

7.1 General

Vehicle brake system function and performance shall be validated by testing including type testing.

The results of brake system function and performance tests shall be recorded and the documentation retained for reference.

RSOs shall specify and manage the implementation of in-service brake system function and performance testing of vehicle brakes.

7.2 Static brake type & routine tests

Commentary *C7.2*

A static brake type test and static brake routine tests are typically conducted in any of the following circumstances:

1. Introduction to service of a previously untested vehicle;
2. a new type or build of Vehicle is to be introduced to service;
3. modification of a vehicle such as to affect braking performance;
4. modification of the brake system of a vehicle; or
5. change to the rated load carrying capacity of a vehicle.

7.2.1 Requirements

Static brake type tests shall be carried out on one or more vehicles of a production run as specified by the RSO.

Static brake routine tests shall be carried out on all vehicles of a production run.

A static brake type test conducted on a vehicle shall establish whether its brake system will function and perform as specified when placed in service.

A static brake type test of a park brake shall confirm function and static performance.

Corrective action followed by retesting shall be carried out if train brake system function or static performance specifications are not met.

7.2.2 Static brake type test

A static brake type test shall validate vehicle brake system function and static performance and confirm:

(a) net braking ratio, or the required braking force to achieve the calculated deceleration rate, in the loaded condition from measurements of actual braking forces with full service brake cylinder pressure;

(b) net braking ratio, or the required braking force to achieve the calculated deceleration rate, in the empty condition from measurements of actual braking forces with emergency brake cylinder pressure; and

(c) park brake net braking ratio, or the required braking force to achieve the required parking brake holding force, from measurement of actual braking forces and comparison of them with in-service limits of acceptance. Alternatively, a grade holding test may be conducted to demonstrate compliance.

During net braking ratio brake force testing, all connection pins or other friction points shall be rapped in the direction normal to the applied force. Rapping shall begin at the connection nearest to the brake cylinder and progress through all rigging connection points and friction points. The process shall be

repeated until brake forces are stable. Rapping of the pins shall be undertaken using a 1 kg to 1.3 kg hammer with a handle length of no more than 450 mm. Rapping shall not be performed in a manner that can artificially increase or reduce the brake forces.

During park brake net braking ratio brake force testing, rapping of the pins shall not be permitted.

During the physical testing of a hand operated park brake, a test force of 420 N shall be applied and maintained tangentially at the rim of the handbrake wheel or, alternatively, at the end of the operating lever.

7.2.3 Static brake routine test content

A single car test shall be carried out on all vehicles.

7.3 Braking performance type test

Commentary *C7.3*

Brake performance type tests are not normally required or carried out on individual hauled vehicles.

Train performance testing shall comply with AS 7510.6.

7.4 Single car test

Commentary *C7.4*

A single car test is typically performed on a vehicle:

1. if the vehicle has not previously entered service;
2. if required by the maintenance schedule;
3. after replacement of any pneumatically operated control equipment on the vehicle; or
4. if a brake system fault is suspected.

7.4.1 Requirements

A single car test conducted on a vehicle shall establish whether its brake system achieves the required performance.

A single car test conducted on a vehicle shall include confirmation that:

(a) the vehicle brake system is sufficiently responsive as to operate correctly under service conditions; and

(b) the vehicle brake system maintenance condition is such that it can be expected to continue to perform as intended until the next maintenance service.

7.4.2 Single car testing of a vehicle fitted with the automatic air brake

A single car test for a vehicle fitted with the automatic air brake shall validate the vehicle brake system performance for the following (as applicable):

(a) Brake pipe leakage of new or overhauled Vehicles is no greater than 20 kPa in 15 min;

(b) brake pipe leakage of vehicles in service is no greater than 20 kPa per min;

(c) brake application sensitivity (brake pipe exhaust choke shall reduce brake pipe pressure from 500 kPa to 400 kPa in 35 s to 45 s);

(d) brake release sensitivity (brake pipe charging choke shall increase brake pipe pressure from 300 kPa to 400 kPa in 100 s to 120 s);

Commentary *C7.4.2*

In some applications it may be necessary to use a different brake application and/or release sensitivity chokes based on the required BP reduction performance on a train.

(e) operation of accelerated release (if fitted);

(f) operation of grade control equipment (if fitted);

(g) operation of load compensation equipment (if fitted);

(h) slack adjuster operation;

(i) brake cylinder leakage with brake pipe vented is no greater than 10 kPa in 5 min (note for relayed systems the supplementary reservoir pressure shall be reduced to brake cylinder pressure for this test);

(j) reservoir leak back - the blow of air ceases within 1 min of venting brake pipe to atmosphere;

(k) emergency valve operation (passenger vehicles only);

(l) correct functioning of the brake rigging; and

(m) operation of AAR emergency devices to be tested (if fitted).

A single car test of the brake system of a vehicle fitted with a main reservoir pipe should be conducted without that pipe being connected to the vehicle. The main reservoir pipe shall only be connected to carry out testing of cross leakage of compressed air between the main reservoir pipe and the brake pipe.

Section 8 Independent brake

The range of control pipe pressure for service braking when connected to attached hauled vehicles for holding shall be from 0 kPa to 350 kPa.

Section 9 ECP brake system

The installation of an ECP brake system on a hauled vehicle shall be in conformance with all applicable requirements of the AAR manual of standards as modified by the RISSB ECP code of practice.

The functional properties of ECP brake equipment shall be such that it is interoperable with an ECP brake system that conforms with the requirements of the AAR manual of standards, Section E-II as modified by the RISSB ECP code of practice.

Section 10 Brake system software

Brake system software used in association with a brake system shall be designed, validated and tested to an appropriate safety integrity level (SIL) rating, in accordance with the requirements of AS 61508, or in accordance with EN 50128, or an alternative internationally recognized auditable standard that is specific to railway braking or to railway safety systems.

Section 11 Maintenance

9.1 General

RSOs should ensure the effective implementation of inspections, routine function checks, overhaul procedures and acceptance criteria to maintain specified brake system performance throughout the period between successive services.

The content and periodicity of the inspection, testing and maintenance of brake equipment should be based on the recommendations of the brake equipment manufacturer or data derived from in-service experience and testing.

9.2 Function checks – serviceability

A vehicle brake system routine function check shall be undertaken to confirm serviceability when brake system components are replaced and reconnected on a vehicle following component repair, replacement or disconnection in the field.

The results of brake system function checks shall be recorded and the documentation retained for reference.

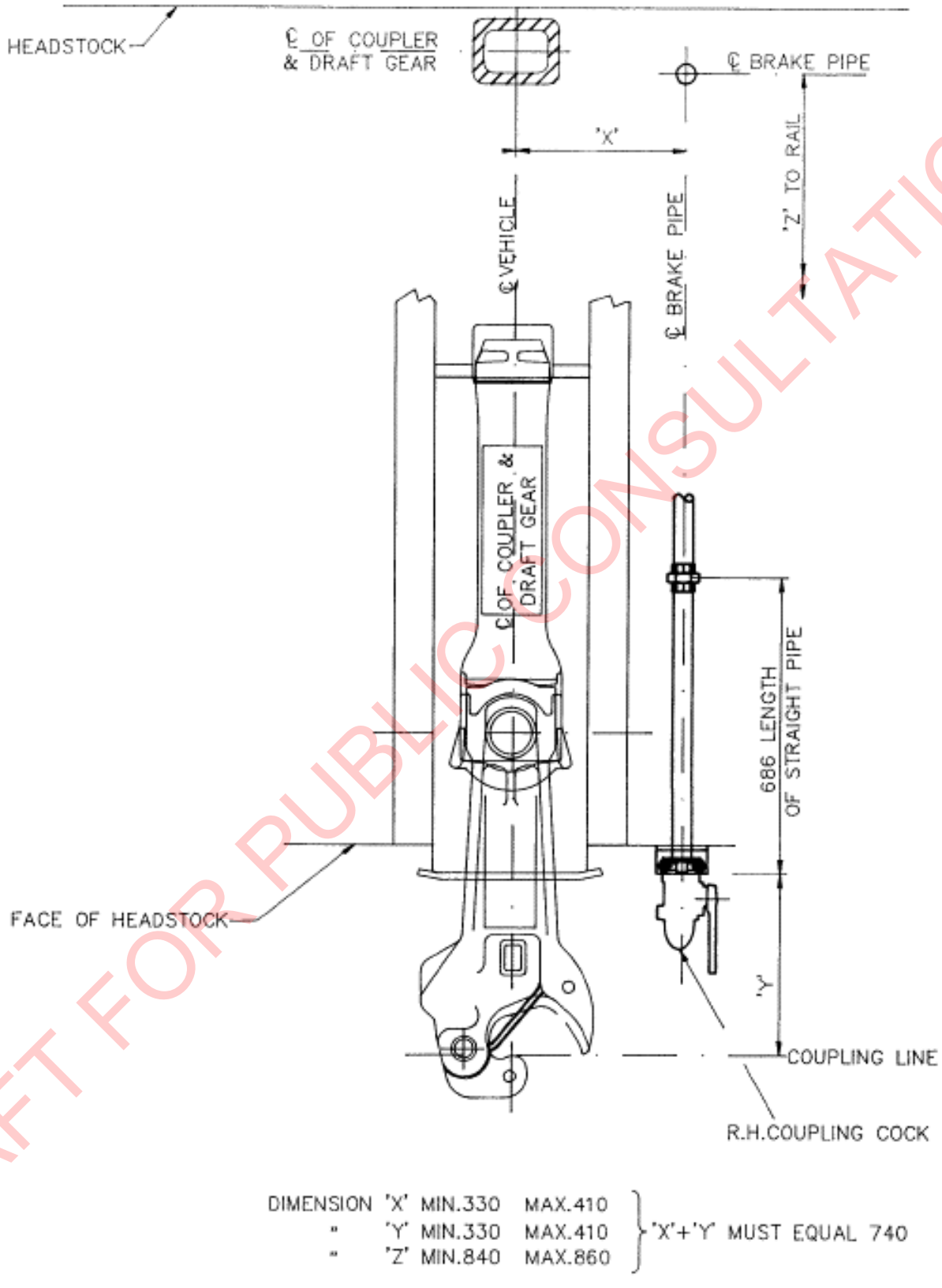
9.3 Abrasive brake blocks

Abrasive brake blocks (trim blocks) may be used to remove minor wheel and tread irregularities.

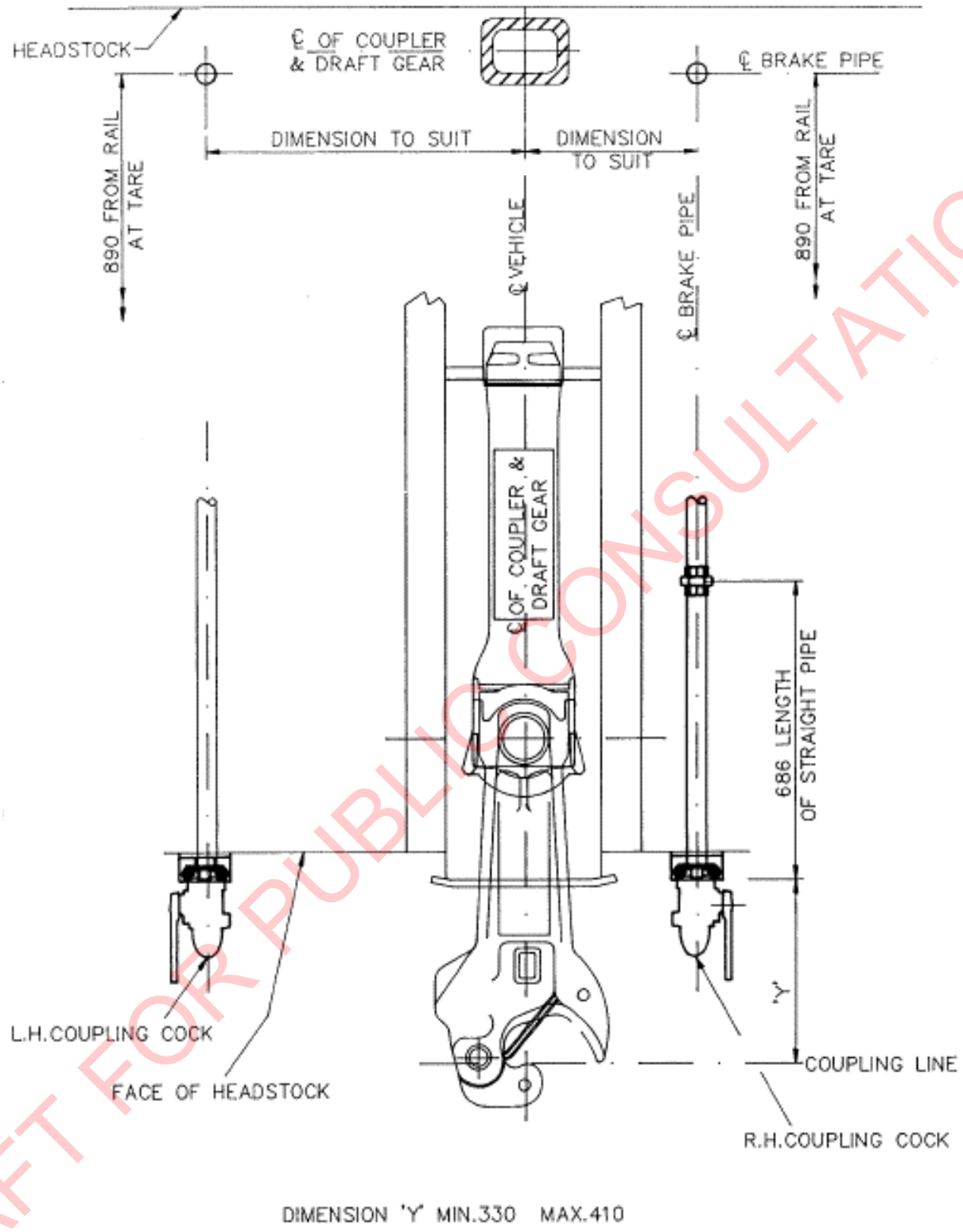
Abrasive brake blocks should have a thin coating of abrasive material over a conventional brake block material or an insert of abrasive material.

As the coefficient of friction of abrasive brake blocks is generally higher than that of the brake block that it will temporarily replace, the RSO should allow for the possible consequences of increased adhesion demand.

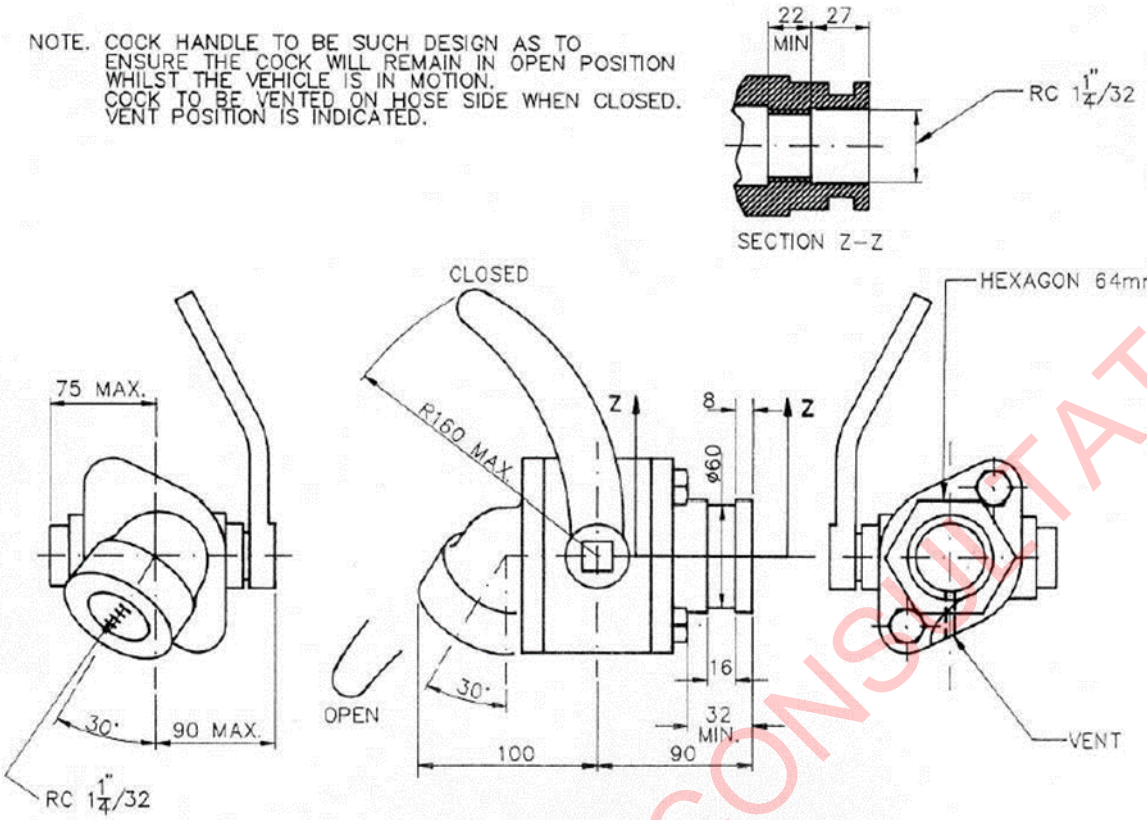
Appendix A Diagrams (Normative)



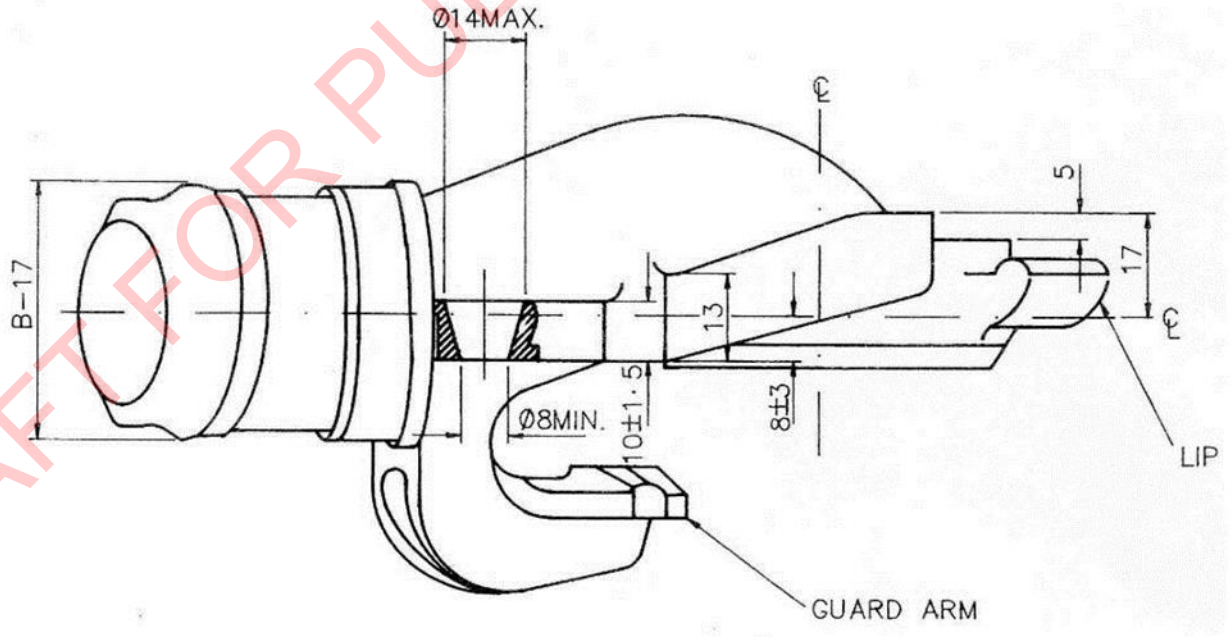
Appendix Figure A-1 – Position of single brake pipe



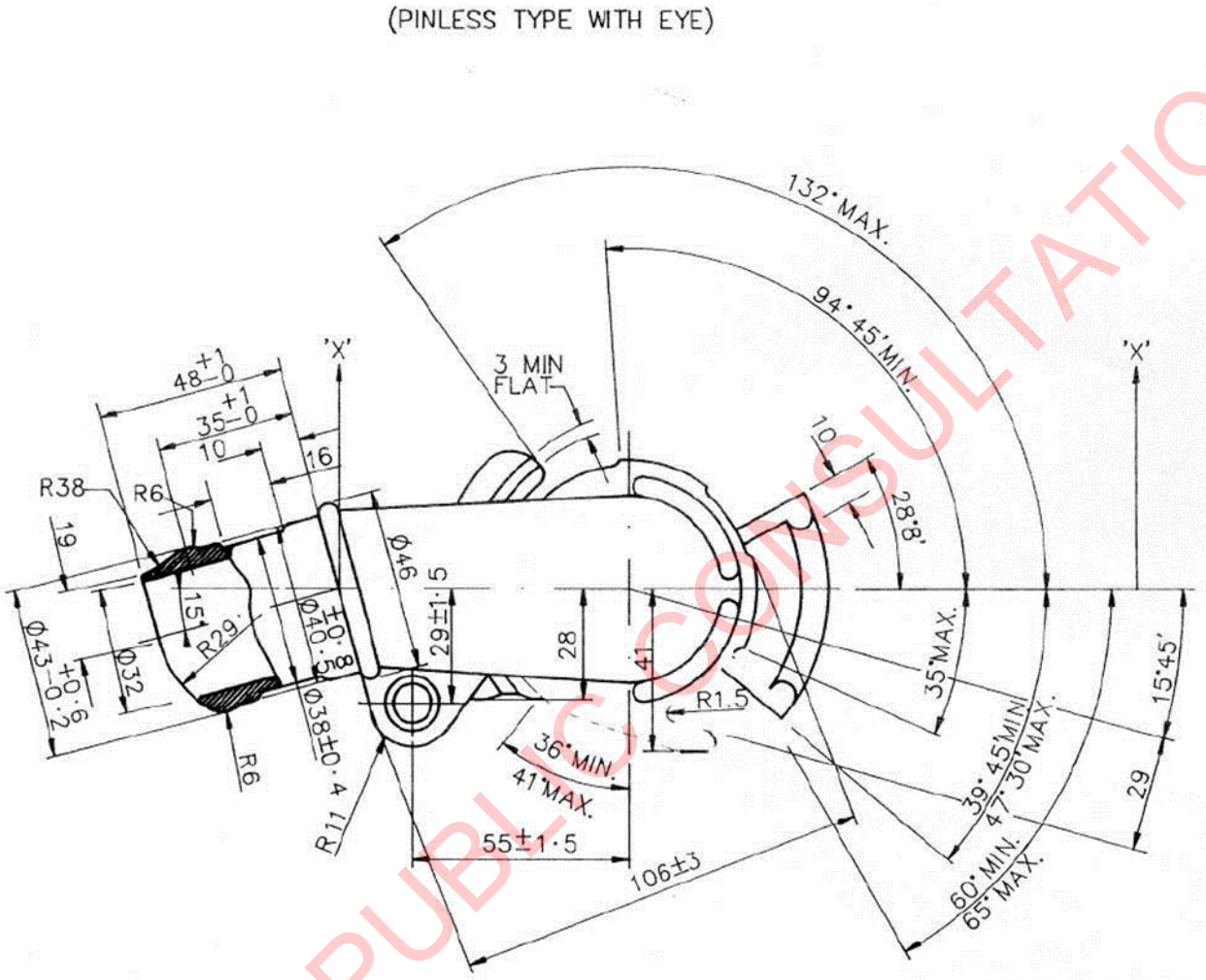
Appendix Figure A-2 – Positions of bifurcated brake pipe branches



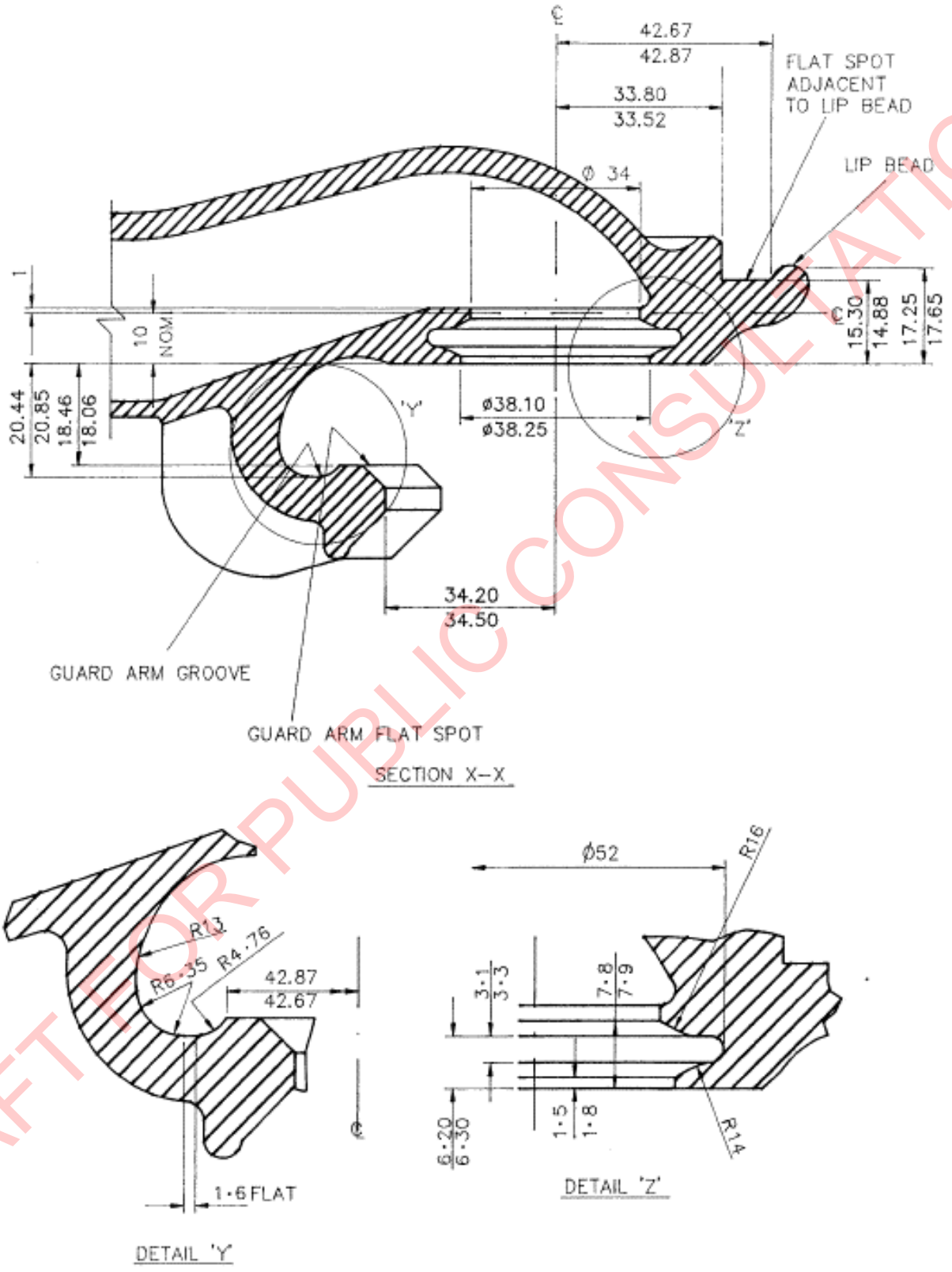
Appendix Figure A-3 – Brake pipe coupling cock



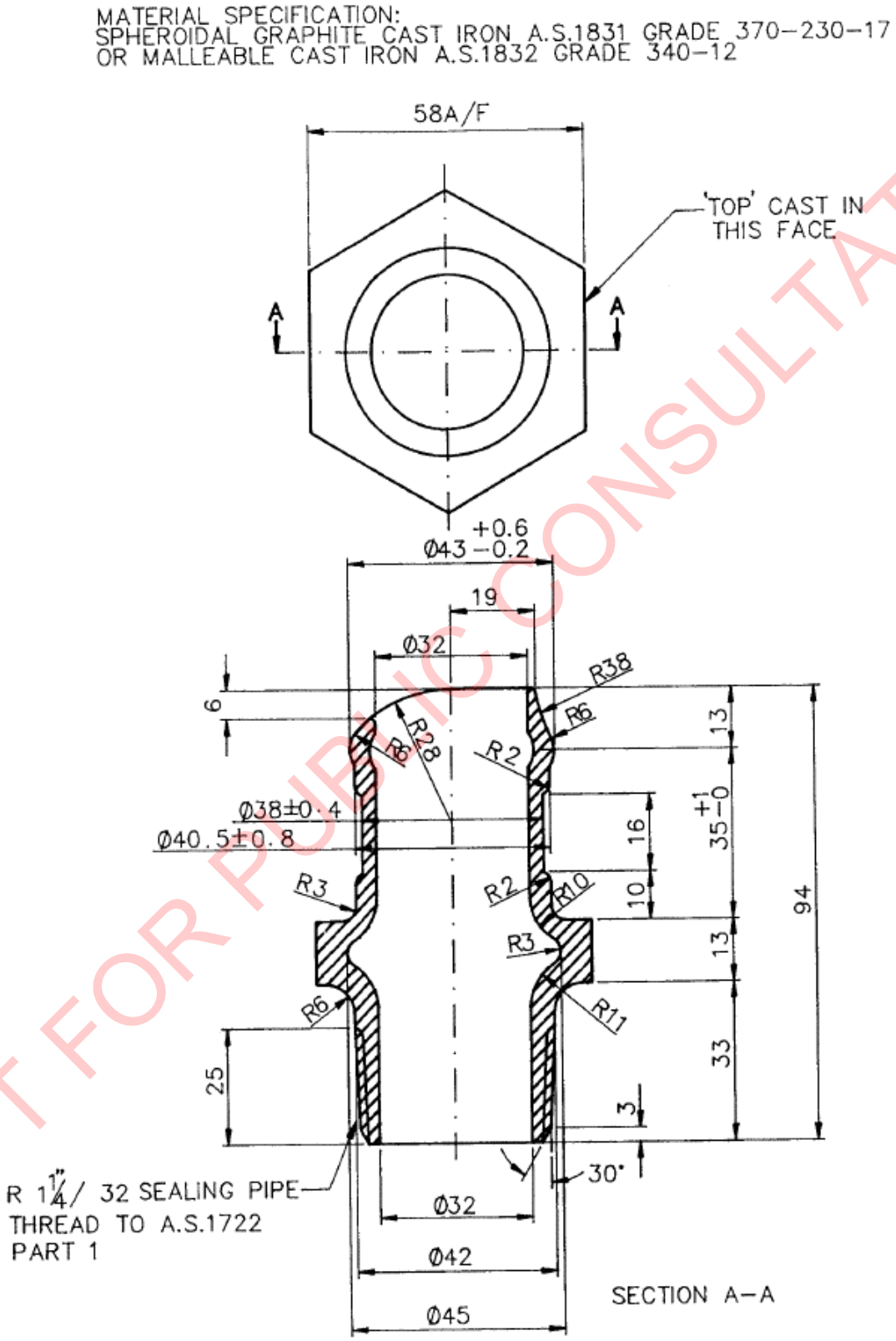
Appendix Figure A-4 – Brake pipe coupling hose head



Appendix Figure A-5 – Brake pipe coupling hose head



Appendix Figure A-6 – Dimensions of brake pipe coupling hose head



Appendix Figure A-7 – Brake pipe coupling hose nipple

Appendix B Example Brake Calculation (Informative)

The following example brake calculation includes methodologies for assessing stopping brake performance based on the standard EN 14531-1 as defined in Section 8 of this standard.

The equivalent deceleration, as used in the standard EN 14531-1, is the mean deceleration with respect to the braking distance once the brake force has been applied (i.e. it excludes delay time of the braking system).

The following suggested calculation methodology can be used to determine the equivalent deceleration when the total braking force and the dynamic friction coefficient of the brake block are known.

It is recognized that brake block suppliers typically provide laboratory test results for brake block average "instantaneous" co-efficient of friction vs speed and brake block force. This data is taken from a braking dynamometer test rig. It is noted that the friction properties of brake blocks can vary dependent upon these factors. In such cases, the example brake calculations below may use the test data provided by the brake block supplier at the full-service brake block force (fully loaded condition) and the estimated maximum operational speed. Alternatively, multiple calculations may be undertaken using different mean dynamic friction coefficient values for different speed ranges and brake block forces. Dependent on the test data available for the brake friction block or pad, the average brake block or pad friction over the range of operating speeds of the vehicle may be used.

Where an RSO uses a standard type of brake friction block or pad on their rolling stock fleet, measured characteristics of the friction elements shall be provided by the RSO.

The rotating mass should be included in the calculation, if known. It may be approximated by a fixed percentage of the static tare mass (e.g., 5 % to 8 % for non-driven axles).

Example calculation methods for a brake block are as follows:

Appendix Equation B-1 – Braking force with single tread brake/block

$$F_B = F_n \times \mu$$

Appendix Equation B-2 – Total vehicle braking force

$$F_{B\_total} = N \times F_B$$

Appendix Equation B-3 – Dynamic mass

$$m_{dyn} = m_{st} + m_{rot}$$

Appendix Equation B-4 – Equivalent deceleration

$$a_e = F_{B\_total} \div m_{dyn}$$

Where

F_B = braking force per brake block (N)
F_{B_total} = total braking force for the complete vehicle (N)
F_n = brake block normal force (N)
μ = mean dynamic friction coefficient of brake block
N = number of brake blocks per vehicle
m_{dyn} = dynamic mass (kg)
m_{st} = static mass (kg)
m_{rot} = rotating mass (kg)
a_e = equivalent deceleration (m/s^2)
NBR = net brake ratio
g = gravity (9.81 m/s^2)

The following formulas show the relationship between NBR and equivalent deceleration. For simplicity the inertial effect of rotating mass is ignored in this formula, however if it is known, both static and rotating mass should be included when calculating the equivalent deceleration, as per the previous formula).

Appendix Equation B-5 – Net brake ratio

$$NBR = F_{B_{total}}/(m_{st} \times g)$$

Appendix Equation B-6 – Equivalent deceleration (Excludes rotating mass)

$$a_e = NBR \times \mu \times g$$

For reference, using the above relationship with an equivalent deceleration of 0.45 m/s^2 which is the minimum defined in this Standard when fully loaded, the following mean dynamic friction coefficients of the brake blocks correspond to the NBR's defined in this Standard:

Appendix Table B-1 – Relationship of NBR to Dynamic Friction Coefficient (Example)

Net braking ratio	Mean dynamic friction coefficient of brake block (μ)
0.13	0.353
0.20	0.229
0.28	0.164

NOTE:
Equivalent deceleration of 0.45 m/s^2 and excluding rotating mass.

As a further reference, using the above relationship with a variable NBR and brake block dynamic friction coefficient, the equivalent deceleration on level track has been calculated. Table 3 highlights ranges which are recommended, not generally accepted or not acceptable, in line with the requirements of this Standard.

Appendix Equation B-7 – Stopping and slowing distance formula (level track)

$$s = v_0 * t_e + \frac{v_0^2}{2 * a_e}$$

Where

S = stopping/slowing distance (m)
t_e = total equivalent response time (s)
v_0 = initial speed (m/s)
a_e = equivalent deceleration (m/s^2)

Appendix Table B-2 – Correlation of Net Brake Ratio, Brake Friction, and Equivalent Deceleration on Level Track

NBR / μ	9%	11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%	33%	35%	37%	39%	41%	43%	45%	47%	49%	51%	53%	55%
0.15	0.13	0.16	0.19	0.22	0.25	0.28	0.31	0.34	0.37	0.40	0.43	0.46	0.49	0.52	0.54	0.57	0.60	0.63	0.66	0.69	0.72	0.75	0.78	0.81
0.16	0.14	0.17	0.20	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.46	0.49	0.52	0.55	0.58	0.61	0.64	0.67	0.71	0.74	0.77	0.80	0.83	0.86
0.17	0.15	0.18	0.22	0.25	0.28	0.32	0.35	0.38	0.42	0.45	0.48	0.52	0.55	0.58	0.62	0.65	0.68	0.72	0.75	0.78	0.82	0.85	0.88	0.92
0.18	0.16	0.19	0.23	0.26	0.30	0.34	0.37	0.41	0.44	0.48	0.51	0.55	0.58	0.62	0.65	0.69	0.72	0.76	0.79	0.83	0.87	0.90	0.94	0.97
0.19	0.17	0.21	0.24	0.28	0.32	0.35	0.39	0.43	0.47	0.50	0.54	0.58	0.62	0.65	0.69	0.73	0.76	0.80	0.84	0.88	0.91	0.95	0.99	1.03
0.20	0.18	0.22	0.26	0.29	0.33	0.37	0.41	0.45	0.49	0.53	0.57	0.61	0.65	0.69	0.73	0.77	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08
0.21	0.19	0.23	0.27	0.31	0.35	0.39	0.43	0.47	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.89	0.93	0.97	1.01	1.05	1.09	1.13
0.22	0.19	0.24	0.28	0.32	0.37	0.41	0.45	0.50	0.54	0.58	0.63	0.67	0.71	0.76	0.80	0.84	0.88	0.93	0.97	1.01	1.06	1.10	1.14	1.19
0.23	0.20	0.25	0.29	0.34	0.38	0.43	0.47	0.52	0.56	0.61	0.65	0.70	0.74	0.79	0.83	0.88	0.93	0.97	1.02	1.06	1.11	1.15	1.20	1.24
0.24	0.21	0.26	0.31	0.35	0.40	0.45	0.49	0.54	0.59	0.64	0.68	0.73	0.78	0.82	0.87	0.92	0.97	1.01	1.06	1.11	1.15	1.20	1.25	1.29
0.25	0.22	0.27	0.32	0.37	0.42	0.47	0.52	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96	1.01	1.05	1.10	1.15	1.20	1.25	1.30	1.35
0.26	0.23	0.28	0.33	0.38	0.43	0.48	0.54	0.59	0.64	0.69	0.74	0.79	0.84	0.89	0.94	0.99	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
0.27	0.24	0.29	0.34	0.40	0.45	0.50	0.56	0.61	0.66	0.72	0.77	0.82	0.87	0.93	0.98	1.03	1.09	1.14	1.19	1.24	1.30	1.35	1.40	1.46
0.28	0.25	0.30	0.36	0.41	0.47	0.52	0.58	0.63	0.69	0.74	0.80	0.85	0.91	0.96	1.02	1.07	1.13	1.18	1.24	1.29	1.35	1.40	1.46	1.51
0.29	0.26	0.31	0.37	0.43	0.48	0.54	0.60	0.65	0.71	0.77	0.83	0.88	0.94	1.00	1.05	1.11	1.17	1.22	1.28	1.34	1.39	1.45	1.51	1.56
0.30	0.26	0.32	0.38	0.44	0.50	0.56	0.62	0.68	0.74	0.79	0.85	0.91	0.97	1.03	1.09	1.15	1.21	1.27	1.32	1.38	1.44	1.50	1.56	1.62
0.31	0.27	0.33	0.40	0.46	0.52	0.58	0.64	0.70	0.76	0.82	0.88	0.94	1.00	1.06	1.13	1.19	1.25	1.31	1.37	1.43	1.49	1.55	1.61	1.67
0.32	0.28	0.35	0.41	0.47	0.53	0.60	0.66	0.72	0.78	0.85	0.91	0.97	1.04	1.10	1.16	1.22	1.29	1.35	1.41	1.48	1.54	1.60	1.66	1.73
0.33	0.29	0.36	0.42	0.49	0.55	0.62	0.68	0.74	0.81	0.87	0.94	1.00	1.07	1.13	1.20	1.26	1.33	1.39	1.46	1.52	1.59	1.65	1.72	1.78
0.34	0.30	0.37	0.43	0.50	0.57	0.63	0.70	0.77	0.83	0.90	0.97	1.03	1.10	1.17	1.23	1.30	1.37	1.43	1.50	1.57	1.63	1.70	1.77	1.83
0.35	0.31	0.38	0.45	0.52	0.58	0.65	0.72	0.79	0.86	0.93	1.00	1.06	1.13	1.20	1.27	1.34	1.41	1.48	1.55	1.61	1.68	1.75	1.82	1.89
0.36	0.32	0.39	0.46	0.53	0.60	0.67	0.74	0.81	0.88	0.95	1.02	1.09	1.17	1.24	1.31	1.38	1.45	1.52	1.59	1.66	1.73	1.80	1.87	1.94
0.37	0.33	0.40	0.47	0.54	0.62	0.69	0.76	0.83	0.91	0.98	1.05	1.13	1.20	1.27	1.34	1.42	1.49	1.56	1.63	1.71	1.78	1.85	1.92	2.00
0.38	0.34	0.41	0.48	0.56	0.63	0.71	0.78	0.86	0.93	1.01	1.08	1.16	1.23	1.30	1.38	1.45	1.53	1.60	1.68	1.75	1.83	1.90	1.98	2.05
0.39	0.34	0.42	0.50	0.57	0.65	0.73	0.80	0.88	0.96	1.03	1.11	1.19	1.26	1.34	1.42	1.49	1.57	1.65	1.72	1.80	1.87	1.95	2.03	2.10
0.40	0.35	0.43	0.51	0.59	0.67	0.75	0.82	0.90	0.98	1.06	1.14	1.22	1.29	1.37	1.45	1.53	1.61	1.69	1.77	1.84	1.92	2.00	2.08	2.16
0.41	0.36	0.44	0.52	0.60	0.68	0.76	0.84	0.93	1.01	1.09	1.17	1.25	1.33	1.41	1.49	1.57	1.65	1.73	1.81	1.89	1.97	2.05	2.13	2.21
0.42	0.37	0.45	0.54	0.62	0.70	0.78	0.87	0.95	1.03	1.11	1.19	1.28	1.36	1.44	1.52	1.61	1.69	1.77	1.85	1.94	2.02	2.10	2.18	2.27
0.43	0.38	0.46	0.55	0.63	0.72	0.80	0.89	0.97	1.05	1.14	1.22	1.31	1.39	1.48	1.56	1.65	1.73	1.81	1.90	1.98	2.07	2.15	2.24	2.32
0.44	0.39	0.47	0.56	0.65	0.73	0.82	0.91	0.99	1.08	1.17	1.25	1.34	1.42	1.51	1.60	1.68	1.77	1.86	1.94	2.03	2.12	2.20	2.29	2.37
0.45	0.40	0.49	0.57	0.66	0.75	0.84	0.93	1.02	1.10	1.19	1.28	1.37	1.46	1.55	1.63	1.72	1.81	1.90	1.99	2.07	2.16	2.25	2.34	2.43

Legend - Deceleration Range

< 0.30	Not acceptable. Vehicle deceleration is too low.
0.30 to 0.39	Special application - not generally accepted. Vehicle may not meet recommended minimum equivalent deceleration rate. Do not use when descending long 1:30 gradients or if design may be used in this operation within the vehicle service life. Deceleration range may be suitable for special applications such as pneumatically braked unit trains that descend gradients no steeper than 1:50 (e.g. heavy haul coal or minerals).
0.40 to 0.44	Special application - not generally accepted. Vehicle may not meet recommended minimum equivalent deceleration rate. Deceleration range may be suitable for special applications such as in unit trains that descend gradients no steeper than 1:40 (e.g. heavy haul coal or minerals).
0.45 to 0.80	Recommended range of deceleration, NBR and brake block co-efficient of friction for general hauled vehicles to comply with minimum performance requirements of Section 3.4.1.
0.80 to 1.40	Special application - not generally accepted. Required adhesion above 0.08, range may be suitable for special applications where wheel slide protection is fitted such as hauled passenger vehicles.
> 1.40	Not acceptable. Vehicle deceleration is too high.

Notes

1. Equivalent Declaration (m/s²) calculated based on **NBR(%) x μ x 9.81**. Rotating mass is excluded, more detailed assessment may be needed where rotating mass is not negligible. Refer to Appendix B.
2. The recommended range is general and does ensure sufficient brake performance on all routes. The designer must consider the minimum performance requirements of every route of each network in which the vehicle is to operate.
3. For the purpose of classification of brake blocks in this Standard;
   - Low Friction block $\mu \leq 0.2$
   - Medium Friction $0.2 < \mu \leq 0.25$
   - High Friction $0.25 < \mu \leq 0.52$

Appendix C Hazard Register (Informative)

Hazard Number	Hazard
5.1	Rolling Stock – Harm to the environment - Derailment or Collision, Human Error, Design Failure, Organisational SMS Failure, Security Breach, Loads not Secure and or Vandalism
5.2	Rolling Stock – Harm to infrastructure by rolling stock - Derailment or Collision, Human Error, Design Failure, Security Breach, Loads not Secure, and or Vandalism
5.3	Rolling Stock – Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism
5.4	Rolling Stock – Harm to Rolling Stock - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism
5.5	Rolling Stock – Harm to Rolling Stock Related Processes – Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism
5.6	Rolling Stock – Out of Control Trains - Human Error, Design Failure, Health Failure, Organisational SMS Failure, Security Breach and or Vandalism
5.7	Rolling Stock – Path Infringement – Derailment or Collision, Human Error, Track Failure, Track Obstructions, Design, Health Failures, Environmental Impact, Security Breach, Load not Secure, Vandalism and or Threat
5.8	Rolling Stock – Collision – Derailment, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism
5.9	Rolling Stock – Signal Passed at Danger – Human Error, Track Failure, Design Failure, Health Failure, Lack of Training and or Vandalism
5.10	Rolling Stock – Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organisational SMS Failure, Security Breach and or Vandalism
5.11	Rolling Stock – Brakes being Inadequate when Stationary – Human Error, Design Failure, Health Failure, Organisational SMS Failure, Security Breach and or Vandalism
5.12	Rolling Stock – Wheel Skidding – Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism
5.16	Rolling Stock – Train protection system failure - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure and or Vandalism

Hazard Number	Hazard
5.18	Rolling Stock – Level crossing collision - Derailment, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure and or Vandalism
5.22	Rolling Stock – Overspeed - Design Failure, Health Failure, Organisational SMS Failure, Load not Secure, Vandalism and or Threat
5.30	Rolling Stock – Excessive dynamic longitudinal train forces - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Load not Secure and or Vandalism
5.32	Rolling Stock – Fire - Derailment or Collision, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism
5.46	Rolling Stock – Excessive acceleration – Human Error, Design Failure, Health Failure, Organisational SMS Failure, Security Breach and or Vandalism
5.50	Rolling Stock – Uncommanded brake applications - Human Error, Design Failure, Health Failure, Security Breach and or Vandalism

Appendix D Bibliography (Informative)

The following referenced documents are used by this Standard for information only:

- AS 7501 *Rolling stock compliance certification*
- EN 14531-1 *Railway applications – Methods for calculation of stopping distances, slowing distances and immobilisation braking – Part 1: General algorithms*