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Preface

This document was prepared by the Braking Systems – Part 1: Locomotive Rolling Stock Development Group, overseen by the ARISO Rolling Stock Standing Committee.

Objective

The objective of this document 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 document describes minimum standards for brake performance, features and compatibility for the braking systems of locomotives.

This document is intended to compliment the rolling stock compliance certification process outlined in AS 7501, including new, modified and heritage locomotives.

Compliance

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

(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.

ARISO Standards address known hazards within the railway industry. Hazards which are addressed by this Standard are listed in Appendix B.

Appendices in ARISO 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 document 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 document.

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Section 1 Scope and general

1.1 Scope

This document applies to locomotives that are:

a) new;

b) modified affecting braking system compliance; and

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

Commentary C1.1-1

Existing locomotives could have braking systems different to this document due to the age of fleets and the previous organisational structures (e.g., fully-integrated state government owned and operated railways). These differences could be a result of design to earlier standards such as previous versions of AS 7510.1, the Railways of Australia manual or legacy standards from prior organizational structures.

It is also recognized that modifications to existing locomotives only affect some requirements and the RSO may deem that full compliance with the requirements of this document not practicable.

Examples of such modifications are a change of end cock, installation of a different handbrake or replacement of a legacy brake valve with an updated/modern version.

The derogation process as defined in AS 7501 is recommended for assessing non-conformances to mandatory requirements where it is deemed not practicable to change the design in order to comply with the requirements.

This scope of this document covers:

d) the design and construction of brake systems including automatic air brake and ECP brake systems with a standard brake pipe pressure of 500 kPa; and

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

Commentary C1.1-2

Some networks do not use the standard brake pipe pressure of 500 kPa (e.g., New Zealand uses 550 kPa, and Pilbara railways use 620 kPa). In such cases, some of the requirements of this document do not apply, but those which do can be applied to such networks as deemed appropriate.

Similarly, the pin numbers for train lines specified in this document are as previously defined in RoA Table 13.5A. While these are mandatory for the NNI, some captive fleets use different pins. Refer to the relevant RIM.

Locomotives and trains that use standard, unmodified AAR pneumatic brake equipment are not covered and should refer to the relevant AAR standards.

The operation of locomotives, considering network safeworking rules and route standards, is not covered.

This document is not specifically intended to cover locomotives used on cane railways or specialist maintenance/rescue locomotives used on unmanned metro systems, but items from this document can be applied to such systems as deemed appropriate by the relevant RSO and/or RIM.

1.2 Normative references

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

- AS 1200:2015, *Pressure equipment*
- AS 1210:2010, *Pressure vessels*
- AS 2435:1992, *Elastomeric hose for railway air brakes*
- AS 2971:2017, *Serially produced pressure vessels*
- AS 61508:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems*
- AS 7451:2023, *Train integrity*
- AS 7470:2024 *Human Factors*
- AS 7501:2019, *Rolling stock compliance certification*
- AS 7503:2023, *Rail vehicle identification and markings*
- AS 7504:2018, *Brake blocks*
- AS 7504.2:2023, *Brake components – Part 2: Brake discs and pads*
- AS 7510.2:2024, *Braking Systems, Part 2: Hauled Rolling Stock*
- AS 7519:2022, Bogie structural requirements
- AS 7520.1:2025, Rolling Stock Body Structural Requirements, Part 1: Locomotive
- AS 7722:2026, *EMC Management*
- AS 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems* (all parts)
- EN 50128:2020, *Railway applications – Communication, signalling and processing systems – Software for railway control and protection systems*
- *Code of Practice – ECP Braking:2017 (ARISO)*

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

1.3 Defined terms and abbreviations

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

1.3.1
AAR
Association of American Railroads

1.3.2
abrasive brake block
trim block
brake block that may be used to remove minor wheel and tread irregularities

1.3.3
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

1.3.4
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

1.3.5
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

1.3.6
automatic brake
continuous brake system for trains or sets that will self-apply in the event of loss of continuity including train or set separation

1.3.7
automatic park brake (APB)
park brake able to self apply in predetermined circumstances without direct human intervention

1.3.8
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

1.3.9
bail off
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

1.3.10
bifurcated brake pipe
one brake pipe that is split into two connection points at the end of the vehicle

1.3.11
brake block
friction element that is forced directly onto the tread of a vehicle wheel for the purpose of braking

1.3.12
brake disc
rotor having one or more co-planar annular friction faces for the engagement of brake pads and means of transmitting rotational forces between itself and the associated axle or drive shaft element

1.3.13
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

1.3.14
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

1.3.15
brake system
braking equipment of a vehicle or a train

1.3.16
brake system pneumatic test point
quick disconnect valve or other type of connection installed within the brake pneumatic system used for testing and/or maintenance of the brake system

1.3.17
braking surface
equipment surface at which vehicle braking may be developed by friction

1.3.18
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

1.3.19
coefficient of friction
ratio of the resultant retarding force produced to the applied brake pad or brake block force (normal to the friction material)

1.3.20
composition brake block
brake block containing non-metallic friction material

1.3.21
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

1.3.22
continuous brake
brake system that is effective continuously along the length of the train

1.3.23
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

1.3.24
control valve
triple valve
distributor valve
control element of the automatic air brake of a vehicle

1.3.25
cut in
driver's brake valve is in a posiiton that allows the application of the service brake

Note 1 to entry: When the driver's brake valve (which may be electronic) is set to cut in, it may be used to apply the service brake. when cut out, as is normally the case for trailing locomotives in a multiple unit consist, it will not apply in the service range, however, moving the handle to emergency will cause an emergency application.

1.3.26
cut out
driver's brake valve is in a posiiton that does not allow service braking and the service-range handle movements can not apply the brake

1.3.27
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

1.3.28

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

1.3.29
dynamic brake
rheostatic brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of traction motors to generate electrical energy while braking

1.3.30
electronically controlled pneumatic (ECP)
term to describe electronically controlled brake equipment that complies with AAR standards

1.3.31
emergency application
An application of the automatic brake initiated by venting the brake pipe and resulting in brake cylinder pressure no less than full service

1.3.32
EOT
end-of-train device

1.3.33
electro-pneumatic (EP)
air brake equipment incorporating principal function control by electromagnetically operated valves but not electronically controlled in the manner of ECP brakes

1.3.34
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

Note 1 to entry: 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.

1.3.35
friction element
sacrificial pad or block that is forced onto a braking surface to develop a braking force by friction

1.3.36
full service
application of the automatic air brake resulting from service braking to the extent that the maximum normal rate of retardation is achieved

1.3.37
function check
brake checking in the field performed for the purpose of confirming the serviceability of the brake system of a vehicle or vehicles

1.3.38
graduated application
brake system that allows the gradual application of the brakes

1.3.39
graduated release
brake system that allows the gradual release of the brakes as distinct from a direct release system

1.3.40
handbrake
park brake operated by manual effort via a wheel or lever

1.3.41
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

1.3.42
independent release (actuating) pipe
conduit of the air brake system of a locomotive that conveys the bail off signal

1.3.43
lead
brake valve is active for control-pipe charging

Note 1 to entry: When the driver's brake valve (which may be electronic) is set to Lead, moving the independent handle forward will admit air to the control pipe and apply brakes. In a multiple unit consist, the leading locomotive is usually set to Lead.

1.3.44
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

1.3.45
main reservoir equalising pipe
conduit of the air brake system of a locomotive or set that conveys compressed air for air brakes and auxiliary equipment between coupled locomotives or vehicles of a set and, where applicable, for auxiliary equipment of connected hauled vehicles

1.3.46
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

1.3.47
minimum reduction
pre-determined reduction of brake pipe pressure below the standard brake pipe pressure that will cause the minimum controllable application of the automatic air brake

Note 1 to entry: ECP brake systems utilize a pre-determined percentage of ECP brake application sent down the train line electronically. For ECP brake systems, the brake pipe pressure is not reduced to apply brakes on the train unless during emulation mode or when an emergency application is performed.

1.3.48
modified rolling stock affecting braking system compliance
rolling stock altered in such a way that the declared braking system compliance status for one or more requirements or recommendation clauses in this document is as a consequence affected

1.3.49
multiple unit control
full functional operation of more than one coupled vehicle from a single driving station

1.3.50
National Network for Interoperability (NNI)

Interstate network formerly known as the DIRN

1.3.51
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

1.3.52
powered park brake
park brake that can be remote-controlled by a train driver

1.3.53
regenerative brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of traction motors to generate electrical energy that is fed into the off-train supply system or to an on-train energy storage system

1.3.54
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

1.3.55
relay valve
pneumatic device that permits a pilot signal to control brake system compressed air

1.3.56
rail infrastructure manager (RIM)
As defined by Rail Safety National Law.

1.3.57
rolling stock operator (RSO)
As defined by Rail Safety National Law.

1.3.58
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

1.3.59
service braking
normal manipulation of the stopping brake during train running

1.3.60
single car test
brake testing performed to confirm the correct operation of the brake system of a single vehicle

1.3.61
spring park brake
park brake that is applied by spring force and released by compressed air or hydraulic force

1.3.62
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

Note 1 to entry: Typically 500 kPa except in NZ and Pilbara networks.

1.3.63
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

1.3.64
trail
locomotive brake valve is in a position that does not allow it to apply the independent (locomotive-only) brake

Note 1 to entry: When the driver's brake valve (which may be electronic) is set to Trail, moving the independent handle will not apply brakes. However, in a multiple unit consist, a locomotive in trail will respond to the control pipe pressure and apply its brakes.

1.3.65
two pipe brake system
automatic brake system that has a brake pipe and a main reservoir pipe that is connected to the supply reservoir of a relayed brake system

Note 1 to entry: Typically used on trains operating on long descending grades.

1.3.66
venting device
vent valve
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 ARISO Glossary. Refer to:
https://www.ariso.org.au/glossary/

Section 2 Air brake system

2.1 General

Any non-conformance(s) to the requirements of this document shall be assessed in accordance with the derogation process of AS 7501:2019

The brake system should include a pneumatic system that is compatible in operation and function with the 26 L system fitted to pre-existing locomotives used in current operations.

Brake systems and brake system components shall be proven to be safe and reliable in operation.

Novel (i.e. non-proven) designs of brake systems and/or brake system components, if utilized, shall be assessed in accordance with AS 7501:2019

The compressed air required to operate the brake system of a locomotive and its train shall be stored on the locomotive.

The air brake system on each locomotive shall provide for at least one emergency application to be effective when following the release of any automatic brake application.

Except for brake pipe headstock isolation, no operating mode or isolation of any system/component on the locomotive shall impede an emergency application of the train brakes in any way.

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

The air supply to the brake system shall be arranged as shown in Appendix Figure A-10 so that air in the No.2 reservoir is reserved and cannot be drained to supply auxiliary systems.

Regardless of the failure experienced, the system shall fail to a safe condition.

There shall be positive prevention of loss of locomotive independent brake and automatic air brake functions in the event of uncontrolled discharge of compressed air from the main reservoir equalizing pipe.

There shall be positive prevention of loss of locomotive automatic air brake function in the event of uncontrolled discharge of compressed air from the control pipe.

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

Each brake controller shall be fitted with a cut-off valve for isolation and performance of leakage tests.

The following shall be in accordance with AS 7503:2023:

a) the colour of cut-out or isolating cock handles;

b) the colour of all identifying embossed letters on air brake equipment; and

c) the marking of the point of attachment of the manual air brake release.

The locomotive shall have a brake pipe air flow metering system that both audibly and visually indicates to the driver when compressed air is being supplied to the train.

For a single locomotive, the air flow metering system shall indicate a warning of air flow when the brake pipe on the locomotive is allowed to exhaust via a 5.6 mm to 5.8 mm diameter orifice. With an electronically controlled air flow metering system, warning shall commence within the range 27 L/s to 29 L/s.

The standard brake pipe pressure for locomotives shall be 500 kPa ±7 kPa.

The standard brake pipe pressure shall not be adjustable by the driver during normal operations.

Commentary *C2.1-1*

During some specialized operations (e.g., recovery or movement of not operational trainsets), the brake pipe pressure could be adjusted to allow brake operation on the trainset that could have different operating pressures.

Interlocks shall prevent traction power being applied until available compressed air is adequate for braking.

An emergency application by the driver shall automatically interrupt traction power.

The traction power shall be interrupted when the brake pipe pressure falls below set pressure between 250 kPa and 330 kPa.

Locomotives shall be fitted with two (2) vent valves, one connected as close as practicable to each end of the brake pipe. Vent valves shall not be fitted with isolating valves, but functionality may be provided to disable the vent valve in the event of vent valve failure in service so that the train may complete its trip.

Commentary *C2.1-2*

Disabling of vent valves in the event of vent valve fault and thus brake pipe venting, typically requires the crew or a maintainer to plug the exhaust port of the vent valve using hand tools.

The vent valves shall have been proven in service.

It shall be possible to apply traction power with a service, independent or parking brake application to assist the control of trains on gradients.

Commentary *C2.1-3*

To avoid roll back on rising gradients during train starting and to control train slack.

The accuracy of air pressure displays associated with the air brake system shall be corrected if found to be in error by ±7 kPa.

Air pressures nominated in this document which do not include a tolerance or are described as nominal shall have a tolerance of ±15 kPa.

Commentary *C2.1-4*

Some RSOs and RIMs can 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 document 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 *C2.1-5*

The ambient temperatures of the Australian natural environment for the operation of trains can range from -12°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.

Design load cases including mountings for brake system body mounted equipment shall be in accordance with AS 7520.1:2025

Design load cases including mountings for bogie mounted brake system equipment shall be in accordance with AS 7519:2022

The management of electromagnetic compatibility shall be in accordance with AS 7722:2026

Quick disconnect brake system pneumatic test points (if fitted) should be in accordance with AAR S-4020

The layout of controls and displays shall be in accordance with AS 7470:2024, Section 9.6.

2.2 Brake system pipework

2.2.1 General

Metallic pipework should be secured to the locomotive in accordance with AAR S-400

All pipework shall be orientated, secured and supported to minimize the potential for rubbing, chaffing, twisting and to avoid water traps.

The location of pneumatic control equipment relative to the height of the air pipes (e.g., brake pipe, main reservoir pipe, etc.) shall be evaluated in the integrated design of the brake system so that control valves and other pneumatic valves are not installed at the lowest point in the pneumatic system.

Commentary C2.2.1

Low points in the brake pneumatic system can collect water typically resulting from water vapour in the air supply (e.g., brake pipe, main reservoir pipe, etc.) and condensing. This can lead to faults with the braking pneumatic equipment and result in additional maintenance requirements.

2.2.2 Brake pipe pipework

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

The brake pipe material shall 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.

Bifurcation of the brake pipe should be achieved by a Y-connector fitted into the main brake pipe.

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

2.2.3 Other brake system pipework

The size of the main reservoir pipe (if fitted) and its fittings shall be 25 mm nominal bore or equivalent.

The size of the brake cylinder pipe should be 20 mm nominal bore or equivalent.

Pipes or tubing of other appropriate materials (if fitted) shall be sized to function with an equivalent flow rate as a metallic nominal bore pipe.

The operating pressure capability of the pipe material and size being used shall exceed that of the pressure normally expected in that part of the brake system.

The cross-sectional area of brake system piping should not be restricted by the application of fittings, bends 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 applied in positions below axle centrelines.

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

Locomotives 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

Emergency cocks shall be fitted to locomotives, accessible by the crew, or as defined by the RSO.

Opening the emergency cock shall exhaust the brake pipe resulting in an emergency application of the train brakes.

The emergency cock shall remain in the application position until manually closed.

The operating handle of the emergency brake pipe cock shall be red and contrasted to the surrounding housing and equipment.

The emergency cock should be accessible from all seating positions, including when seats are rotated.

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, the vent valves:

a) activate on the locomotive that the emergency cock has been opened;

b) activate on the locomotives adjacent to the locomotive that the emergency cock has been opened; and

c) if fitted, activate on the vehicles in the train.

2.5 Compressed air reservoirs

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

Unless specified in this document, compressed air storage reservoirs shall comply with AS 1210:2010, AS 2971:2017 or recognized equivalent standards for a minimum design pressure of 1,000 kPa.

AS 1200:2010 shall be used to provide guidance regarding recognized equivalent standards.

Main reservoir compressed air storage reservoirs should be of steel construction.

The quantity of compressed air stored on a locomotive in the main reservoirs shall not be less than 800 L.

The interconnection of main reservoirs on a locomotive shall be in accordance with those shown in Appendix Figure A-10 of Appendix A.

The main reservoir compressed air system shall be provided with suitable filtration equipment to ensure that the transfer of any foreign matter, water or oil into the system is kept to a practical minimum and that all pneumatic equipment will operate with reliability.

Unless integrated into the compressor, air drying equipment shall be fitted at the outlet of the main reservoir that first receives supply from the air compressor.

The main reservoir safety valves shall be set according to the relevant requirements of AS 1210:2010

Safety valves shall have sufficient discharge flow capacity to retain main reservoir pressure no greater than the reservoir design pressure with the compressor pumping continuously at full speed.

Each compressed air storage reservoir shall be fitted with means for draining accumulated water.

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

Drain cocks should not be fitted to supplementary/supply reservoirs.

2.6 Air compressors

One or more air compressors should be provided that are capable of fully charging the locomotive brake system within 3 min.

The air compressor governor should be set to maintain a main reservoir pressure of 750 kPa to 850 kPa. If a higher pressure setting is used, the MREQ pressure should not exceed 850 kPa when coupled to other locomotives with the standard range.

If the main reservoir equalizing pipe circuit is ruptured, the compressors shall be capable of maintaining the minimum main reservoir pressure while saturating flow through an 8 mm choke between the main reservoir and main reservoir equalizing pipe circuit.

Locomotives may include functionality to modify the main reservoir equalizing pipe pressure for compatibility of operation with other rolling stock.

The operation of the air compressors of locomotives running as a multiple unit shall be synchronized to pump by energization of train line 22 (CC).

The synchronisation logic should ensure that no locomotive in the consist is starved of main reservoir air due to other locomotives unloading all the compressors.

2.7 Pneumatic couplings and cocks between vehicles

2.7.1 General

Pneumatic couplings between locomotives and hauled 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 shall be arranged to avoid damage to or kinking of flexible hoses.

Locomotives shall be fitted with pneumatic couplings that are compatible with those of all other locomotives and hauled vehicles in use on that network as specified by the RIM.

Pneumatic couplings between locomotives in a multiple consist and between locomotives and hauled vehicles in a train, shall only be able to be connected to another coupling of the same type and size.

Commentary C2.7.1-1

This size requirement for couplings is so that it is not possible to deliberately or accidently connect to the wrong air system.

End cocks shall be vented on the coupling side to permit stored compressed air to be vented prior to disconnection.

Commentary C2.7.1-2

Examples for typical standard gauge locomotives pneumatic coupling positionings are shown in Appendix Figure A-1 and Appendix Figure A-2 of Appendix A.

An example for typical narrow gauge locomotive pneumatic coupling positionings is shown in Appendix Figure A-3 of Appendix A.

2.7.2 Brake pipe end cock

Brake pipe end cocks shall be mounted in front of the locomotive headstock face (i.e. cow catcher). If an additional brake pipe cock is fitted behind the headstock face, it shall be secured in the open position (e.g., lock or lock wire).

Commentary C2.7.2-1

The requirement for the position of brake pipe end cocks is to enable brake pipe isolation if the front brake pipe cock is impacted (e.g., animal strikes).

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 or closed;

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

(e) be equipped with curved handles;

(f) be closed in the vertical position perpendicular to the brake pipe; and

(g) be standardized within each fleet that the vehicle operates.

Commentary C2.7.2-2

Appendix Figure A-4 of Appendix A provides an example of a typical brake pipe end cock.

2.7.3 Other end cocks

Main reservoir, control pipe and independent release pipe cocks shall be fitted at each end of the locomotive. These cocks may be mounted behind the headstock face (cow catcher).

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

(a) be ball type cocks;

(b) be of a size 25 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 handles;

(h) be open when the handle is inline with the pipe; and

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

2.7.4 Other pneumatic system cocks

(j) For other pneumatic cocks not specified in Clauses 2.7.2 or Clause 2.7.3, the isolating cocks should be designed such that their handles are at right angles to the direction of flow through the valve body when closed and parallel to the direction of flow when open.

(k) Pneumatic cocks specified in this Clause 2.7.4 shall have spring loaded or latching handles to prevent accidental operation.

2.7.5 Coupling hose components

Brake system coupling compressed air hoses shall comply with the requirements of AS 2435:1992, RSO specifications or equivalent international standards.

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;

(c) the control pipe shall be 12 mm; and

(d) the independent release pipe shall be 12 mm.

The coupling head sizes for brake system coupling compressed air hoses shall be as follows:

(e) 32 mm for brake pipe;

(f) 25 mm for main reservoir;

(g) 19 mm for control pipe; and

(h) 12 mm for independent release pipe.

For each pipe, the coupling head shall be unique so that it is only possible to connect with the same type of coupling head.

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

(i) 32 mm for brake pipe;

(j) 17 mm for main reservoir;

(k) 9.5 mm for control pipe;

(l) 7 mm for independent release pipe.

Commentary C2.7.5

The dimensions refenced in this Clause 2.7.5 are the closest metric equivalent to the actual dimension which in most cases is in imperial measurement (e.g., 32 mm = 1¼”).

Brake pipe coupling compressed air hose head details shall be in accordance with Appendix Figure A-5, Appendix Figure A-6, Appendix Figure A-7, Appendix Figure A-8 and Appendix Figure A-9 of Appendix A.

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

Receptacles, if fitted, shall be arranged to prevent dust and water ingress into the coupling/hose.

2.8 Dead engine device

Each locomotive shall be equipped with a dead engine device.

The dead engine device shall allow the locomotive to be towed as a brake pipe only vehicle with functioning automatic train brakes.

All connections between main reservoir and brake pipe shall be protected by:

(a) an appropriately located and clearly identified cut-out cock;

(b) a spring-loaded check valve; and

(c) a strainer.

The cut-out cock shall be latched (or indented) in both positions, and each position shall be clearly labelled.

When operating as a dead engine, the brake cylinder pressure of the locomotive should be limited to match the performance of other hauled vehicles.

Commentary C2.8-1

AS 7510.2 uses an average deceleration rate of a hauled vehicle of 0.45 ms^2.

Section 3 Automatic air brake

3.1 General

Every locomotive shall be fitted with an automatic air brake.

Driver control of the brake system shall be provided for at each driving position.

The arrangement of power and brake controllers (with regard to left- or right-hand or singular operation) shall be similar to other vehicles in the intended operation.

It shall not be possible to cut in the brake controller on two driving positions within a single locomotive simultaneously.

Service brake applications and releases shall only be possible from the driving position where the brake controller is cut in.

Movement of any automatic brake controller to the emergency position shall result in an emergency brake application regardless of brake controller cut-in/cut-out state.

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

No fault, failure or operating mode of the air brake system (pneumatic or electro-pneumatic) shall inhibit the initiation of an emergency application via the automatic brake handle.

The brake controller shall be arranged so that in the normal direction of travel the brake is:

(a) applied when the handle is moved forwards/away from the driver; and

(b) released when the brake handle is moved backwards/towards the driver.

This clause does not prohibit the operation of a locomotive with a fixed driving station in the opposite direction to that which it was designed, provided that:

(c) the operation of the locomotive in the opposite direction to which it was designed is either unplanned, or for short distances during shunting operations;

(d) the locomotive is restored to its normal direction of travel at the next facility with capacity to do so; and

(e) the brake controller is ergonomically located to permit the driver to adequately control the locomotive/train.

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 of the automatic air brake.

The automatic air brake control system may provide an option for graduated release of the automatic air brake.

The automatic air brake of a locomotive shall incorporate a control valve arranged to respond to braking commands transmitted via the brake pipe.

A control valve should be of the diaphragm type.

The automatic air brake maximum design brake cylinder pressure for purposes of service braking should be between 350 kPa and 380 kPa when the standard brake pipe pressure is 500 kPa.

A means shall be provided to manually release the brake cylinder pressure and inhibit further application of the friction brakes on the isolated bogie in the event of a failure as follows:

(f) there shall be an individual isolating cock for each bogie;

(g) the isolation of the bogie shall be detectable by the driver;

(h) the isolating cock shall be visible to authorized users;

(i) the isolating cock shall be clearly labelled to indicate the function.

3.2 Functions

The automatic air brake controller shall have the following functional positions:

When the handle is moved to release, the brake pipe shall charge to the standard brake pipe pressure.

When the handle is moved to minimum reduction, pressure in the brake pipe shall reduce to a value that is nominally 10% below the standard brake pipe pressure.

When the handle is moved to full service, pressure in the brake pipe shall reduce to a value that is between 150 kPa and 165 kPa below the standard brake pipe pressure when the standard brake pipe pressure is 500 kPa.

Commentary C3.2-1

In ECP mode, the brake pipe pressure does not change as above, but the brake command signal is transmitted electronically.

When the handle is moved to emergency, the pressure in the brake pipe shall reduce to atmospheric pressure at a rate sufficient to activate vent valves within 1 s.

The handle position for emergency shall be distinctly separate from and positioned beyond all service application positions.

3.3 Pressures, timings and travels

The automatic air brake control valve should have the following attributes:

(a) a pressure differential between 9 kPa and 12.5 kPa;

(b) not apply during 60 s with the brake pipe volume isolated and choked to reduce from 500 kPa to 350 kPa in 93 s;

(c) apply within 60 s with a rate of brake pipe reduction which is determined with the brake pipe volume isolated and choked to reduce from 500 kPa to 350 kPa in 36 s; and

(d) release within 60 s with a rate of brake pipe pressure rise which is determined with the brake pipe volume isolated and choked to charge from 140 kPa to 170 kPa in 80 s.

The following automatic brake system timings apply for single locomotive units:

(e) when the automatic air brake handle is moved to full service, brake pipe pressure should fall from 500 kPa to 350 kPa in 3.5 s to 6 s;

(f) when the handle is moved to full service or emergency, brake cylinder pressure should rise from zero to 80% of full pressure in 5 s to 10 s;

(g) when the handle is moved to emergency, brake pipe pressure should fall from 500 kPa to 30 kPa within 2 s;

(h) when the handle is moved to emergency, equalising reservoir (where fitted, or its equivalent) pressure should fall to atmospheric pressure;

(i) when the handle is moved to release following a full service or emergency application, brake cylinder pressure should fall from full pressure to 30 kPa in 6 s to 9 s; and

(j) when the handle is moved to release following a full service application, equalising reservoir (where fitted, or its equivalent) pressure and brake pipe pressure should rise from 350 kPa to 500 kPa within 3 s.

The following maximum leakage rates should apply to locomotives in service:

(k) main reservoir system leakage: 35 kPa over 5 min;

(l) control pipe and brake cylinder leakage: 30 kPa over 5 min;

(m) independent release pipe leakage: 20 kPa over 3 min;

(n) equalising reservoir leakage: No indication of leakage over 5 min; and

(o) brake pipe leakage: 20 kPa over 5 min with feed (BV) cut out

A locomotive shall be capable of maintaining train brake pipe pressure at the demanded value despite train brake pipe leakage equivalent to that which would cause a pressure drop of 50 kPa per minute from the standard brake pipe pressure.

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

3.4 Measurements

Timings should be taken from the movement of pressure gauge pointers and not from brake controller movement.

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

3.5 Performance

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

Maximum stopping distances for a light locomotive (no vehicle attached) for a full service application of the automatic air brake should be as shown in Table 3-1. For tread brakes, verification tests should be conducted after the brake blocks have bedded in, and any machining marks on the tread have worn smooth.

Table 3-1 Maximum Stopping Distances – Level Grade, Dry Rail

Initial Speed (km/h)	Maximum Stopping Distance (m)
20	50
40	150
60	280
80	460
100	680
115	872
120	940
140	1,240

The stopping distance table was calculated from the following:

(a) theoretical brake ratio 30%;

(b) brake system efficiency 85%;

(c) brake block coefficient of friction 0.3; and

(d) linear brake cylinder build-up time 0 kPa to 350 kPa in 6 s.

Unless wheel slide protection is provided, the service 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. A guide to the selection of friction coefficient with NBR may be found in Appendix Table A-10.

Measured characteristics for the actual friction elements under consideration should be used for braking calculations, as coefficient of friction greatly affects stopping performance.

The brake performance shall be possible for any condition of brake block wear or wheel size, and be possible for a wheel tread start temperature of between 60°C and 80°C.

Sample network stopping distance requirements for trains in general and additional data for several networks are provided in AS 7510.6

3.6 Driving diagnostics

The brake system shall incorporate instruments that indicate to the driver main reservoir, brake pipe, equalising reservoir, brake cylinder pressures in kPa and brake pipe air flow.

A visual brake cylinder pressure warning shall be provided by energising train line 14 (BW), set to cut in at 40 kPa and to cut out at 10 kPa.

Section 4 Dynamic brake

4.1 General

Locomotives that incorporate an electrical drive system should be equipped with a dynamic brake.

It shall be possible to cut-out and isolate the dynamic brake without affecting the safety, efficiency or control of the other brake systems on the locomotive or train.

The dynamic brake shall be interlocked with the stopping brake so as to prevent simultaneous application of both brakes.

A brake cylinder pressure of 100 kPa or greater (such as from an application of the independent brake) should cause the interruption of dynamic brake action.

The locomotive may reduce the dynamic brake proportionally to the independent brake application.

The locomotive brake system should ensure that, in the event of a service application of the locomotive automatic air brake, an application of the dynamic brake should take precedence, except in the event of an emergency application, then air braking shall take precedence.

Commentary C4-1

It is noted that some RSOs not operating on the NNI follow AAR S-5018 practice, where the dynamic brake is not cut out by an emergency application.

Section 5 Brake force application

5.1 General

Friction elements on a locomotive 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 7504:2018

Brake discs and pads (if fitted) shall comply with AS 7504.2:2023

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 accommodating relative movement between brake gear and running gear.

The design of the braking system shall ensure brake blocks do not overhang the outer edge of the wheel rim.

For tread brake applications, the design of the braking system shall maximize the contact between the brake block and the wheel.

5.2 Composite brake blocks and brake disc pads

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

Commentary C5.2

WARNING: SATISFACTORY PERFORMANCE ON A DYNAMOMETER DOES NOT GUARANTEE SATISFACTORY PERFORMANCE IN SERVICE.

5.3 Brake discs

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

5.4 Cast iron brake blocks

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

Section 6 Calculation of braking system performance

6.1 Stopping brake

Brake performance should be assessed by calculations during the design phase and when changes to the braking system are proposed. In some cases, this assessment can reduce the amount of testing required to verify braking performance. EN 14531-1 contains suggested methodologies for assessing brake performance.

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

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

6.2 Park brake

Park brake holding performance shall be assessed for locomotives in the fully provisioned condition.

6.3 Coefficient of friction

Measurements of friction element dynamic and static coefficients of friction are used for stopping brake and park brake calculations, respectively.

The determination of friction element dynamic coefficient of friction should be based on testing from at least two (2) initial speeds and, for each initial speed, for at least two (2) values of friction element application force.

Brake block dynamic and static coefficient of friction should be determined by one of the following methods:

(a) testing on a dynamometer in compliance with AAR Specification M-926;

(b) testing on a dynamometer where the coefficient of friction measurements using an AAR-approved brake block have been compared with the results of the same brake block on an AAR-approved dynamometer; or

(c) rolling stock physical stopping and haul testing.

Brake disc pad dynamic coefficient of friction should be determined by one of the following methods:

(d) testing on a friction test bench in compliance with UIC Code 541-3;

(e) testing on a friction test bench where the coefficient of friction measurements using a UIC-approved disc pad have been compared with the results of the same pad on a UIC-approved friction test bench; or

(f) rolling stock physical stopping testing.

Brake disc pad static coefficient of friction should be determined by one of the following methods:

(g) adopting the nominal values in UIC Code 544-1 where suitable; or

(h) rolling stock physical haul testing.

Section 7 Park brake

7.1 General

Each locomotive shall be equipped with at least one park brake that complies with sections 7.2, 7.3 or 7.4.

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

The park brake shall hold the locomotive stationary on a 1:30 gradient under all conditions of loading of the uncoupled locomotive.

The park brake shall be able to maintain the required braking forces indefinitely.

For its intended operation, a park brake should not be reliant upon the coefficient of adhesion exceeding 0.085 between the wheel and rail.

Commentary C7.1

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

7.2 Manual park brake

The manual force to apply a park brake shall not exceed 420 N applied tangentially at the rim of a handbrake wheel or alternatively at the end of the operating lever. An internal mechanism shall lock the application.

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

7.3 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 shall not cause the maximum designed brake force to be exceeded, for example, when brake cylinder pressure is also applied.

When a powered park brake is applied from any driving position, train line 25 of the standard 27-pin multiple unit jumper shall be energized and when released, train line 26 shall be energized so that there will be an application or release of each powered park brake throughout a set of coupled locomotives.

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

A powered park brake should be able to be applied by manual means.

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

The command status of a powered park brake shall be indicated near the park brake operating controls at each driving position.

7.4 Automatic park brake

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

If an APB equipped locomotive has its pneumatic brake system isolated and this results in the APB being disabled (with no manual park brake fitted), the locomotive may be deemed to have an inoperative park brake.

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 locomotive 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 locomotive to be held stationary while recharging the reservoirs from an emergency application.

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

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

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

The park brake holding force shall not fall below the standard minimum, or such that is required to hold the locomotive 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 8 Validation of braking function and performance

8.1 General

Locomotive 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 by the RSO.

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

8.2 Static brake type & routine tests

8.2.1 General

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

(a) introduction to service of a previously untested locomotive;

(b) a new type or build of locomotive is to be introduced to service;

(c) modification of a locomotive such as to affect braking performance; or

(d) modification of the brake system of a locomotive.

8.2.2 Requirements

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

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

A static brake type test conducted on a locomotive 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.

8.2.3 Static brake type test

8.2.3.1 General

It is recommended that brake force tests be carried out and documented to verify the design criteria.

A static brake type test should determine:

(a) net braking ratio, or the required braking force to achieve the required braking performance from measurements of actual braking forces with full service brake cylinder pressure;

(b) independent brake net braking ratio from measurement of actual braking forces at the set independent 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 or appropriate pull force test may be conducted to demonstrate compliance

8.2.3.2 Tests with Brake Rigging

The following instructions are for locomotives with conventional brake rigging, and not for package brake units.

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.

8.2.4 Static brake routine test

The brake system of all locomotives shall be tested as follows:

(a) All brake valve positions are checked for correct function.

(b) The brakes apply and release (i.e. the brake blocks/brake disc pads are forced onto the wheels/discs and then released).

(c) The main reservoir, equalizing reservoir, brake pipe and brake cylinder pressures are according to Clause 3.3 of this document for each brake application and release.

(d) The brake application and release timings are according to Clause 3.3 of this document.

(e) All air leakage is according to Clause 3.3 of this document.

(f) All pressure switches and interlocks associated with the brake system operate according to Clause 3.3 of this document.

(g) The park brake applies and releases according to Section 7 of this document.

8.3 Braking performance type test

Braking performance type tests shall be carried out on one or more locomotives of a production run as specified by the RSO to ensure that:

(a) the brake system functions as specified;

(b) all brake system component parts meet their specifications; and

(c) the braking performance specifications are met.

The braking performance type test shall include:

(d) a stopping distance testing; and

(e) a park brake holding test.

The braking performance type test should also include testing to validate the independent brake holding capacity with the intended train mass on the steepest gradient.

8.4 Scheduled static brake tests

8.4.1 Reason for Conducting Scheduled Brake Tests

A scheduled static brake test is typically conducted:

(a) prior to a locomotive entering service;

(b) when required by the maintenance schedule; and/or

(c) if a brake system fault is suspected.

8.4.2 Requirements

A scheduled static brake test shall be carried out to the operator's procedures checking the following:

a) That main reservoir, equalising reservoir, brake pipe and brake cylinder pressures for each brake application and release are acceptable.

b) All air leakage is within specification.

c) The brake cylinder piston strokes are acceptable.

d) The brake block thicknesses are acceptable.

8.4.3 Multiple light locomotives

Light locomotives coupled in multiple units shall be considered to be a train for inspection purposes.

RSOs shall have procedures to ensure all air hoses and cables pertaining to the brake system are correctly coupled prior to the locomotives entering service.

8.5 Single car test

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

Commentary C8.5-1

A single car test is typically performed on a locomotive:

1. if it has not previously entered service;
2. if required by the maintenance schedule;
3. after replacement of any pneumatically operated control equipment;
4. if a brake system fault is suspected; or
5. it is typically not used as a lead locomotive.

A single car test conducted on a locomotive shall confirm that:

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

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

A single car test shall be carried out as described in AS 7510.2:2024

Section 9 Independent brake

9.1 General

Locomotives shall be equipped with an independent brake.

The independent brake controller operating handle of a locomotive shall be separate from the corresponding automatic air brake controller operating handle.

The operating handles of the independent brake controller and the automatic air brake control should be distinct to allow the operator to identify and differentiate each control by touch alone, without the need for visual confirmation.

A brake system shall have a brake bail off feature that permits the release of the automatic air brake of the locomotive and attached locomotives without affecting an existing application of the automatic brake throughout other attached vehicles.

Commentary C9.1

The bail off feature for the independent brake is typically activated by moving the independent brake handle perpendicular to the normal direction of operation (e.g., pushing down or sideways dependent on the type and orientation of brake handle controller).

When the bail off feature is deactivated during an emergency brake application, the locomotive shall recover the brake cylinder pressure.

The pressure of the control pipe (also known as the No. 3 pipe) shall be 350 kPa for a full independent brake application.

If required for holding on a grade, the brake cylinder pressure may be increased above the control pipe pressure. However, the risk of wheel flats should be considered if the required adhesion is greater than 0.08.

Brake cylinder pressure applied via the independent brake valve shall be maintained against leakage.

The independent brake shall be able to be set to either lead or trail to allow multiple unit operation with coupled locomotives.

9.2 Pressures and timings

The following brake system timings apply for single locomotive units:

(a) During a full application of the independent brake, brake cylinder pressure should rise from 0 kPa to 280 kPa in no more than 3 s; and

(b) During a full release of the independent brake, brake cylinder pressure should fall from 300 kPa to 30 kPa in no more than 5 s.

Section 10 ECP brake system

The installation of an ECP brake system on a locomotive shall be in conformance with all applicable requirements of the AAR manual of standards as modified by *RISSB Code of Practice - ECP Braking*.

NOTE:

RISSB Code of Practice - ECP Braking is scheduled to be replaced by AS 7510.7:2027

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 *RISSB Code of Practice - ECP Braking*.

All locomotives fitted for ECP shall have vent valves as per Clause 2.1.

Locomotives may use the ECP cable to provide digital connection for multiple unit communications.

Section 11 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 (all parts) or in accordance with EN 50128:2020, or an alternative internationally recognized auditable standard that is specific to railway braking or to railway safety systems.

Section 12 Maintenance

12.1 General

Requirements for train inspection including qualifications for personnel shall be in accordance with AS 7451:2023

RSOs shall 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 and data derived from in-service experience and testing to ensure the brake performance as per this document is maintained throughout the vehicle life.

RSO's shall ensure that personnel including contracted organisations engaged to overhaul and/or repair brake equipment are suitably qualified and trained in the necessary competencies to perform these tasks.

Where applicable, these tasks shall include testing of equipment on a test rack to ensure correct operation.

12.2 Function checks – Serviceability

A locomotive brake system routine function check shall be undertaken to confirm serviceability when brake system components are replaced and reconnected on a locomotive 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.

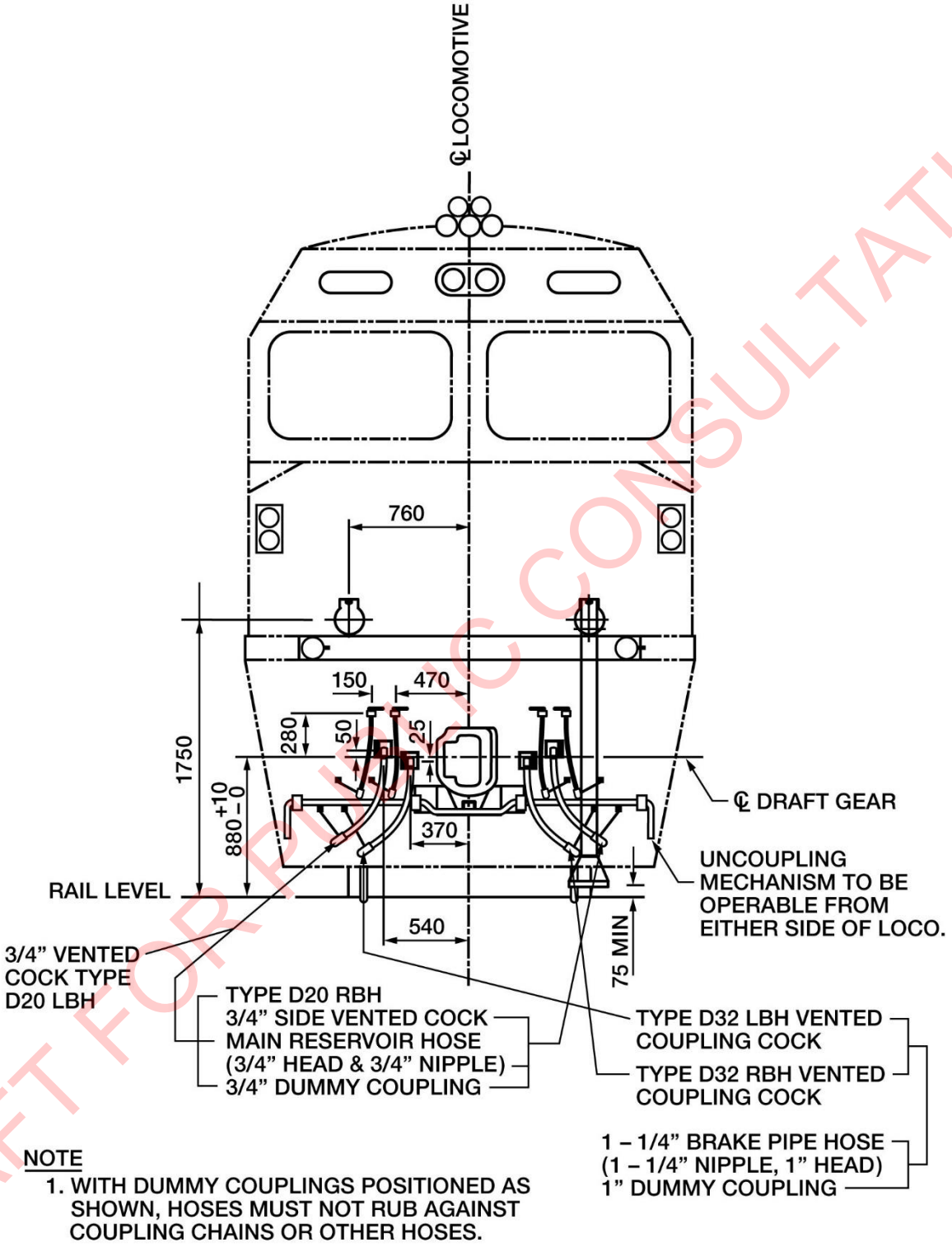
12.3 Abrasive brake blocks

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

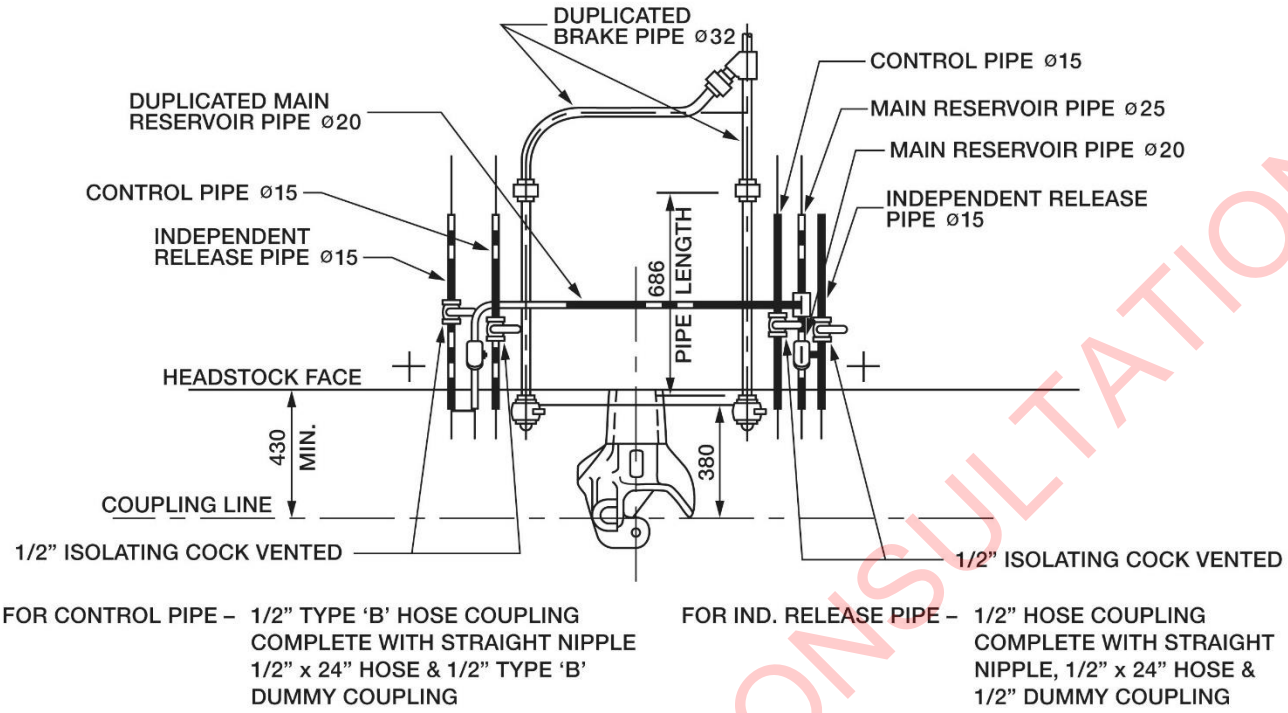
Abrasive brake blocks should have a thin coating of abrasive material over conventional brake block material or an insert of abrasive material.

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.

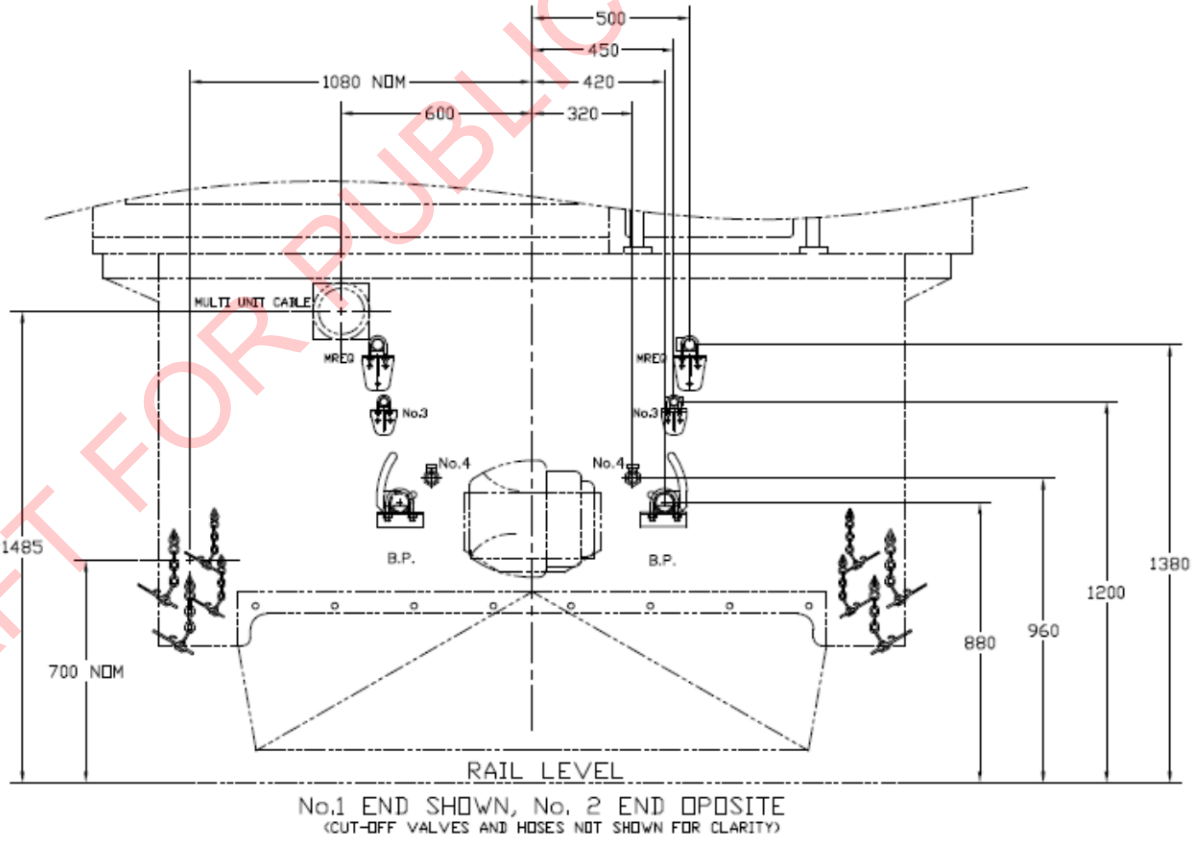
Appendix A Diagrams (Normative)



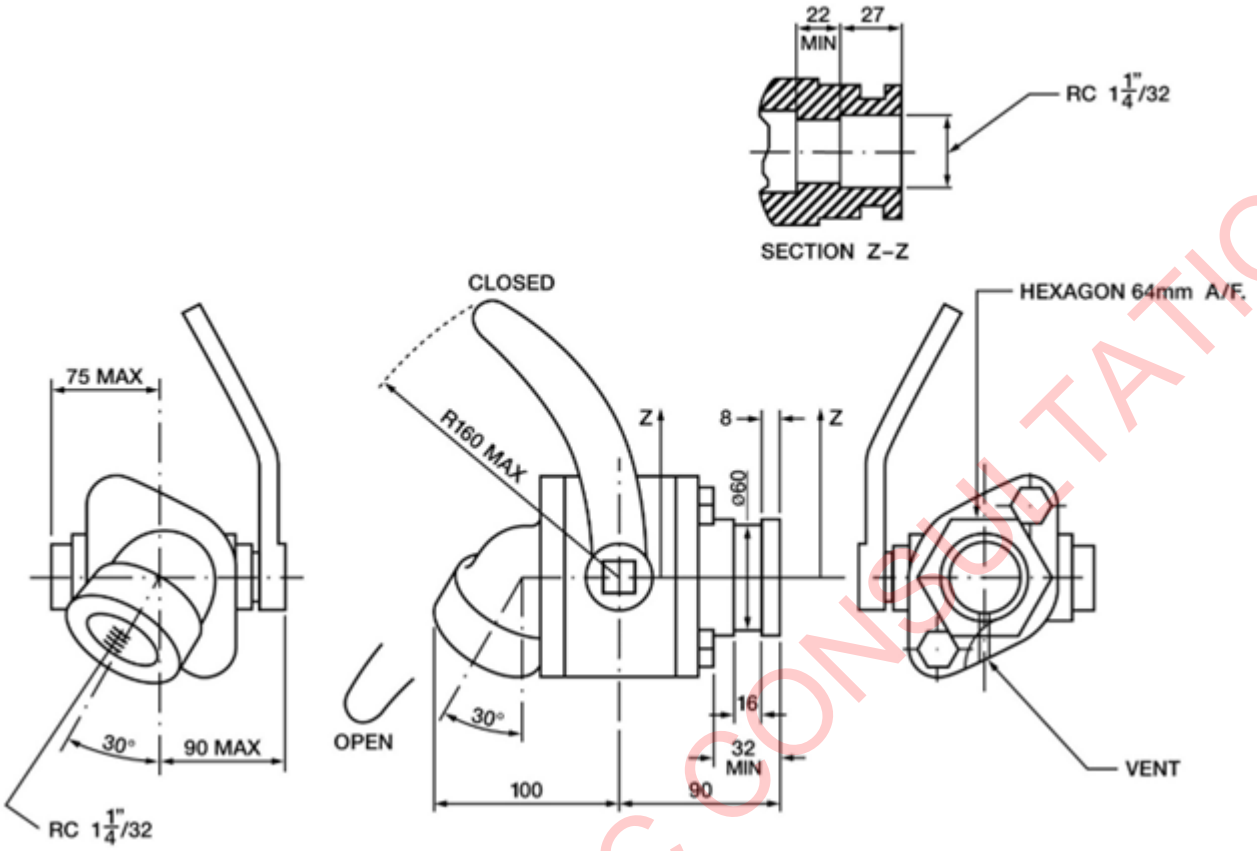
Appendix Figure A-1 Example standard gauge brake system coupling cock nominal locations



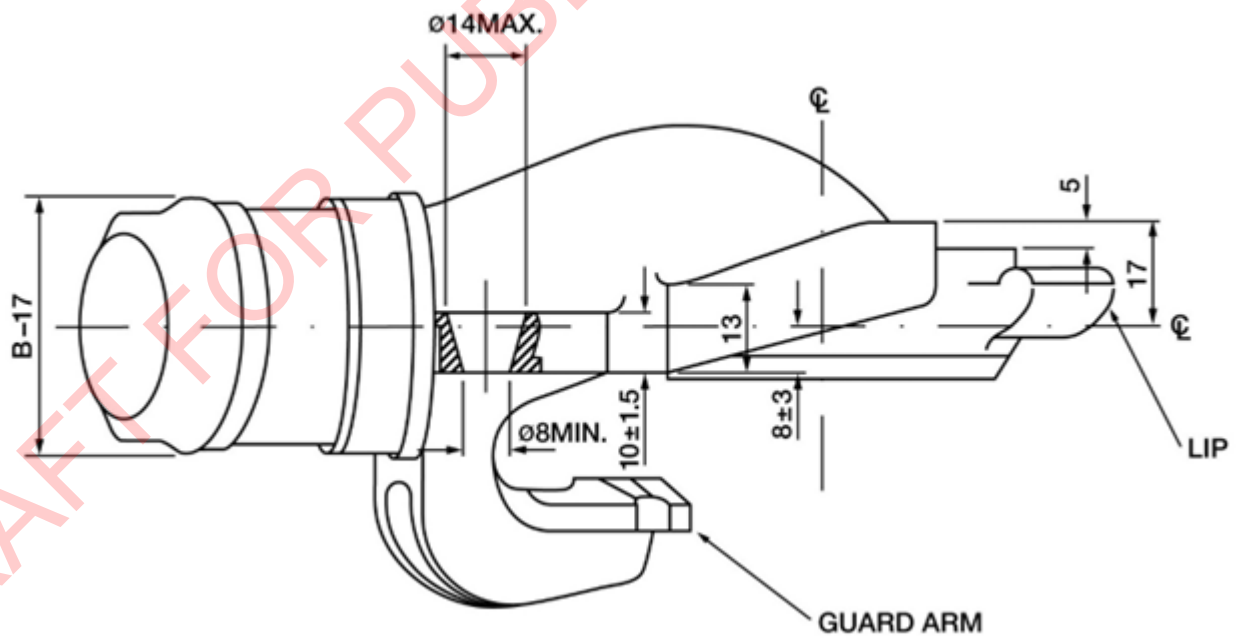
Appendix Figure A-2 Example standard gauge brake system coupling cock nominal locations 2



Appendix Figure A-3 Example narrow gauge brake system coupling cock nominal locations

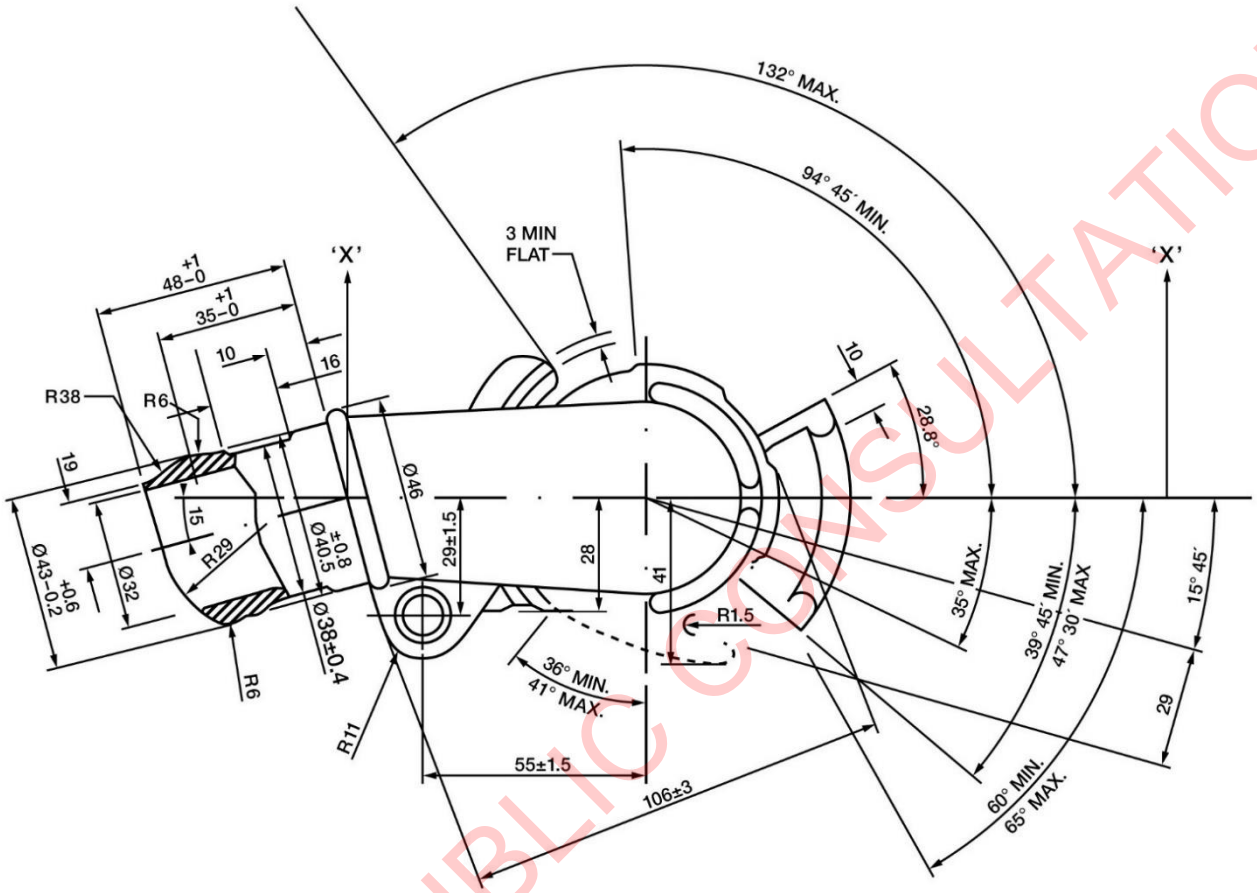


Appendix Figure A-4 Example brake pipe coupling cock

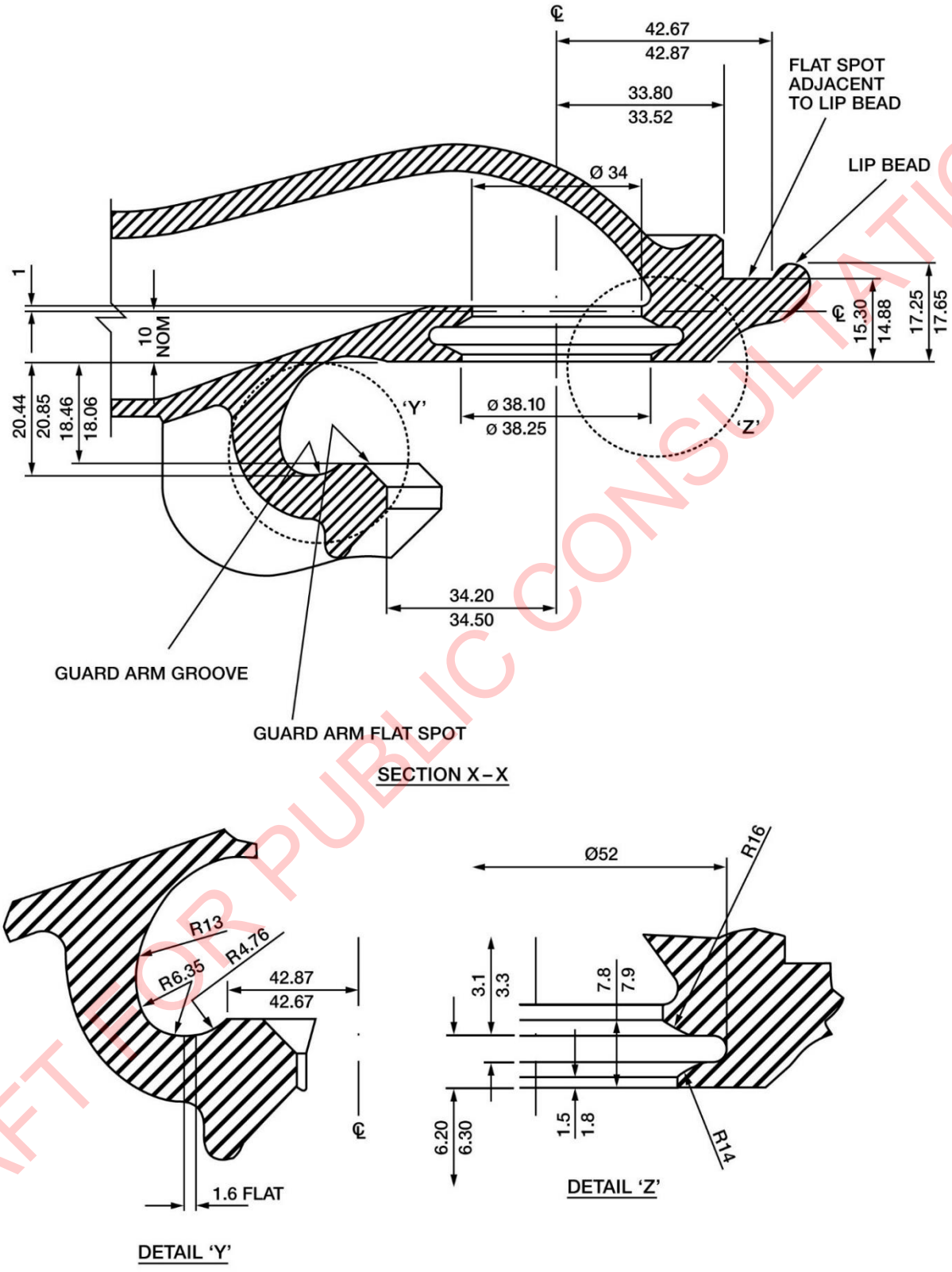


Appendix Figure A-5 Brake pipe coupling hose head

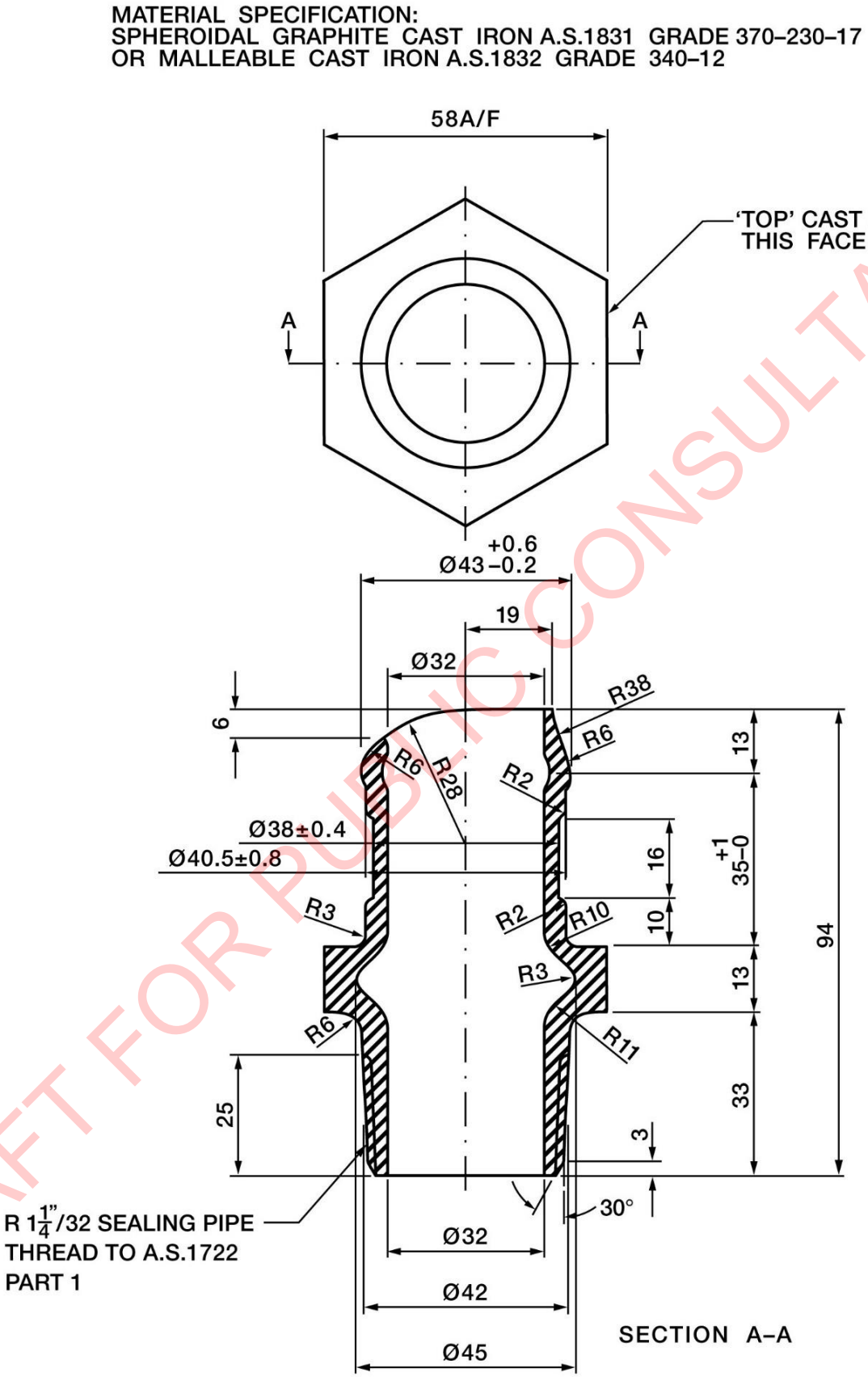
(PINLESS TYPE WITH EYE)



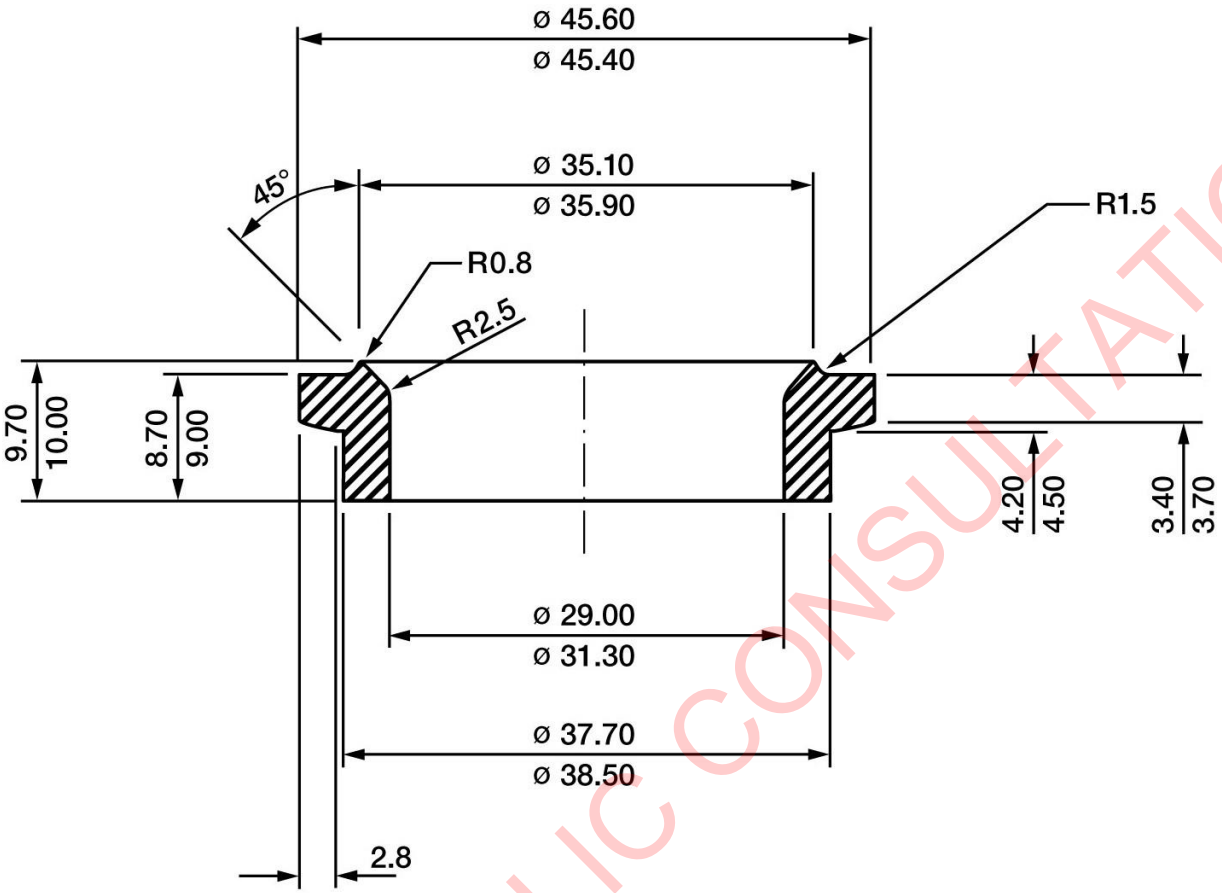
Appendix Figure A-6 Brake pipe coupling hose head



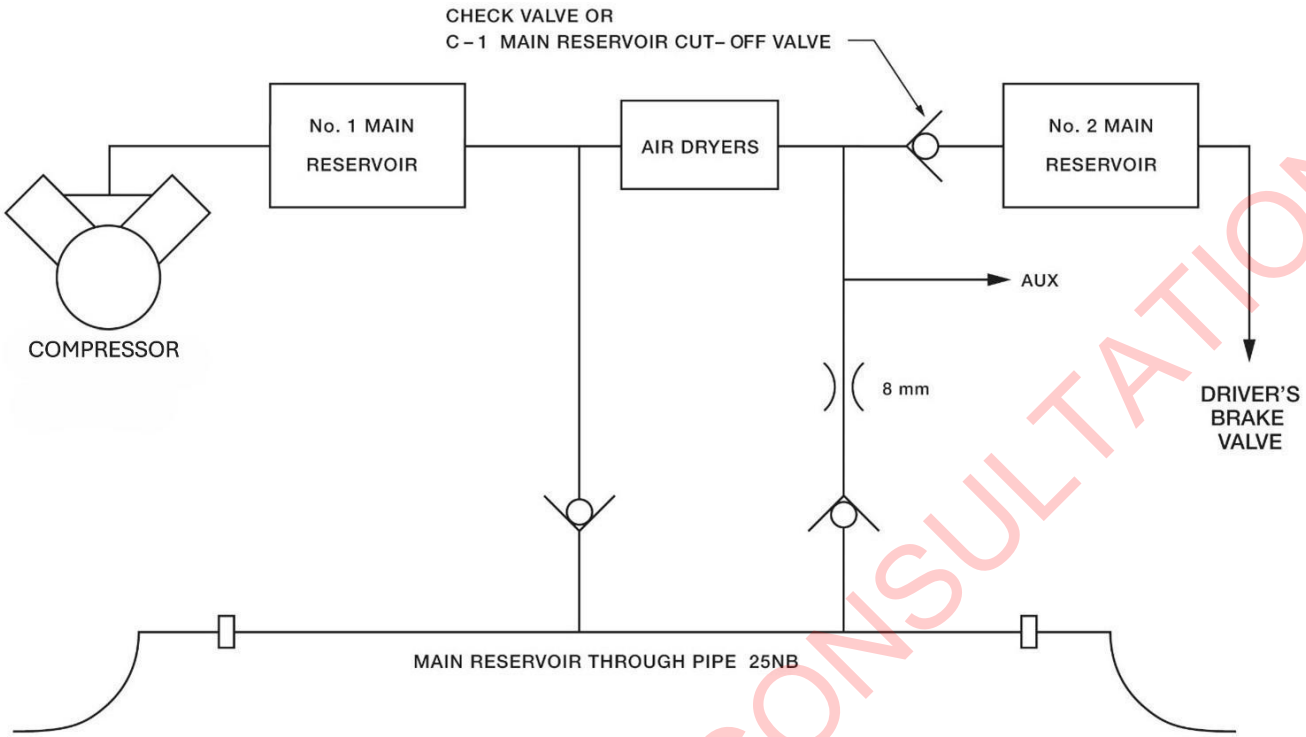
Appendix Figure A-7 Dimensions of brake pipe coupling hose head



Appendix Figure A-8 Brake pipe coupling hose nipple



Appendix Figure A-9 Brake pipe coupling hose head seal



Appendix Figure A-10 Main reservoir arrangement

Appendix Table A-1 Relationship between vehicle Net Brake Ratio (NBR %), brake block/pad co-efficient of friction (μ) and the Equivalent Deceleration (m/s²) 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

<0.7	Not acceptable if 4.5 s brake delay assumed for light engine. Vehicle deceleration is too low and may not meet the light Engine stopping distance requirements. That is, assuming a light engine brake delay is 4.5 s, 0.7 m/s/s deceleration rate is required to meet the 100 km/h stopping distance requirement of 680 m.
0.7 to 0.75	Not acceptable if 6 sec brake delay assumed for light Engine. Vehicle deceleration is too low and may not meet the light Engine stopping distance requirements. That is, assuming a light engine brake delay is 6 seconds, 0.75 m/s/s deceleration rate is required to meet the 100 km/h stopping distance requirement of 680 m.
0.75 to 0.80	Recommended range of deceleration, NBR and brake block coefficient of friction for locomotive light engine to comply with minimum performance requirements of Section 3.5.
0.8 to 1.0	Not recommended but optional for operators to accept risk of wheel damage for locomotives requiring adhesion greater than 0.08 during maximum braking effort.
>1.0	Not acceptable. Vehicle deceleration is too high. Required adhesion above 0.1, range may be suitable for special applications where wheel slide protection is fitted to specialized locomotives.

NOTE 1:
Equivalent Deceleration (m/s^2) 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.
NOTE 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.
NOTE 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 $0.25 < \mu \leq 0.52$

NOTE 4:
The traditional NBR for locomotive service brake fitted with HF brake blocks is between 30% and 35% but is highly dependant on selecting the correct coefficient of friction in the HF range.

Appendix B 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

Bibliography (Informative)

- AS 4292, Railway Safety Management
- AS 7510.6, Railway Rolling Stock - Braking Systems - Part 6: Train
- BS EN 14531-1, Railway Applications - Methods for Calculation of Stopping Distances, Slowing Distances and Immobilisation Braking - Part 1: General Algorithms
- BS EN 14531-6, Railway Applications - Methods for Calculation of Stopping and Slowing Distances and Immobilisation Braking - Part 6: Step by Step Calculations for Train Sets or Single Vehicles
- 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
- AAR S-4020, *Brake cylinder pressure measurement taps*
- *UIC Leaflet 541-3, 8th edition (April 2017)*