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Data entry – draft starts next page

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Preface

This standard was prepared by the ECP Brakes Development Group, overseen by the ARISO Rolling Stock Standing Committee.

Objective

The objective of this Standard is to describe the configuration and operation of trains that are fitted with electronically controlled pneumatic (ECP) brakes for use in the Australian rail industry.

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’.

Using this Standard

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.

ARISO Standards identify known hazards relevant to the railway industry. Appendix A provides a non-exhaustive list of hazards relevant to the scope of this Standard.

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.

Table of Contents

Tables

Section 1 Scope and general

1.1 Scope

This document is applicable to locomotive hauled trains that are equipped with ECP brakes as described in AAR S-4200:2014.

The practices described are recommended but not mandatory for captive unit train operations or for operations where rolling stock operators, vehicles or locomotives do not interchange across functional boundaries.

The primary focus of this document does not include the use of distributed power however the use of this equipment is discussed.

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 3000:2018, *Wiring Rules*
- AS 7510.2:2024, *Braking Systems – Part 2: Hauled Rolling Stock*
- AS 7510.6:2026, *Braking Systems – Part 6: Trains*
- AAR Standard RP-505:2001, *Typical 26-L Type Brake Equipment Piping Diagrams for Locomotives*
- AAR Standard S-401:2020, *Brake System Requirements*
- AAR Standard S-4200:2014, *Electronically Controlled Pneumatic (ECP) Cable-Based Brake Systems - Performance Requirements*
- AAR Standard S-4230:2014, *Intratrain Communication Specification for Cable-Based Freight Train Control Systems*
- AAR Standard S-4260:2008, *ECP Brake and Wire Distributed Power Interoperability Test Procedures*

NOTE:

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

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

1.3.3
brake pipe
pipe connecting the brake pipe to the air brake equipment on rolling stock

1.3.4
captive unit train operations
train operations where rakes of wagons do multiple return trips as a complete unit

Note 1 to entry: These rakes of wagons are shunted infrequently and rarely travel outside a defined area of operation.

1.3.5
car control device (CCD)
electronic control device that is part of the ECP brake control system

Note 1 to entry: The car control device replaces the function of the conventional pneumatic service and emergency portions during electronic braking and provides for electronically controlled service and emergency applications.

1.3.6
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

1.3.7
conventional air brake system
automatic air brake (non-ECP) where a reduction in brake pipe pressure applies brake cylinder pressure

1.3.8
crosstalk
unwanted coupling of ECP communications between two nearby trains

1.3.9
distributed power
system for control of locomotive power distributed in a train which uses either a radio-based or a cable-based communication medium for the transmission of control signals between groups of locomotives

1.3.10
driving diagnostics
indicating system that provides the driver with information and warnings from the ECP system and air pressures in the pneumatic system

1.3.11
electronic air brake (EAB)
locomotive equipment that electronically controls the locomotive air brake system and can also control the conventional air brakes of connected vehicles

1.3.12
electronically controlled pneumatic (ECP)
electronically controlled brake equipment of a type similar to that described in the AAR S-4200 standards

1.3.13
emergency application
automatic air brake application that is propagated faster than a service application and produces an equal or higher rate of retardation than service applications

1.3.14
emulator CCD
CCD capable of emulating a pneumatic control valve while in a conventionally braked train

1.3.15
EOT
end-of-train

1.3.16
end of train marker (EoTM)
device, including taillights, fitted to the trailing end of the last vehicle of a rail traffic consist to indicate the end of the consist

1.3.17
end-of-train (EOT) device
device connected to the train line at the end of trains fitted with ECP brakes that contains a means of communicating with the HEU, a brake pipe pressure transducer and a battery

Note 1 to entry: An ECP equipped locomotive can also act as an EOT device.

1.3.18
head end unit (HEU)
control device within the locomotive for operating the ECP brake system

1.3.19
main reservoir
one or more interconnected compressed air reservoirs supplied directly by one or more air compressors as a primary source of stored energy for an air brake system and often for additional purposes

1.3.20
net braking ratio (NBR)
quotient of the sum of the actual braking forces (net of brake rigging frictional losses) referred as normal forces at the wheel treads of a vehicle, and its weight

1.3.21
rolling stock operator (RSO)
As defined in Rail Safety National Law.

1.3.22
overlay brake system
brake system capable of operation in either a conventionally or electronically braked train

1.3.23
pneumatic backup
system required on each vehicle to apply emergency brake cylinder pressure in the event of a vented brake pipe which also assists in propagating pneumatic signals through the brake pipe

1.3.24
pneumatic emergency
brake application in response to venting the brake pipe

1.3.25
power supply controller (PSC)
power supply which provides 24 V and 230 V DC to the train line

1.3.26
private network
rail network that is privately owned and constructed that operates in an isolated or closed condition

Note 1 to entry: Private networks exist in the Pilbara (AAR style) and in other isolated locations in Australia.

1.3.27
service braking
normal manipulation of the brake during train running

1.3.28
single car test
brake testing performed to confirm the correct operation of the brake system of a vehicle or set of vehicles fitted with a single set of brake control equipment

1.3.29
shared networks
rail networks formerly owned by government railways which form the bulk of the interstate and intrastate networks in Australia

1.3.30
rail infrastructure manager (RIM)
As defined in Rail Safety National Law.

1.3.31
train brake command (TBC)
level of brake application for electronically controlled brake systems expressed as a percentage from 0% to 100% of full service braking force

Note 1 to entry: For ECP emergency brake, TBC is 120% - step change, not graduated.

1.3.32
train line
two-conductor electric cable spanning the train that carries both train line power (to operate all CCDs and EOT devices) and the communications network signals between the locomotive(s) and the vehicles on the train

1.3.33
wired distributed power (WDP)
control of locomotives distributed throughout a train using cable-based intratrain communication, as per AAR S-4250 clause 3.0

General rail industry terms and definitions are maintained in the ARISO Glossary. Refer to:
https://www.ariso.org.au/glossary/

Section 2 Brake system basic requirements

2.1 Introduction

The intent of this document is to ensure interoperability of rolling stock by complying with the AAR standards. However, some specific areas where divergence is allowed will be described in the clauses which follow. Specific areas to note are:

(a) brake pipe and brake cylinder pressure (see Clause 3.4);

(b) the type of cable connector (see Section 4); and

(c) requirements to prevent uncontrolled movement when ending ECP (see Section 7).

2.2 ECP train components

A train with an ECP (electronically controlled pneumatic) brake system shall have the following components:

(a) A CCD (car control device) on each wagon which responds to electronic signals via a train line from the HEU (head end unit) in the lead locomotive to provide graduated application and graduated release of braking.

(b) A continuous brake pipe which is used to provide a constant supply of air to the reservoirs, and which also provides an emergency pneumatic brake function.

(c) A train line which is a two-conductor electric cable spanning from the locomotive to the end of the train that carries both communications network signals and power to operate all CCDs and EOT devices.

(d) A compatible EOT device fitted at the rear of the train to ensure integrity of the networked signal when in run mode.

A trailing ECP equipped locomotive may function as an EOT device.

An EOT device is not required in switch mode. Switch mode is a restricted mode with speed limited to 32 km/h to allow moving and marshalling of single cars and consists. Extended movements outside yards shall not be undertaken in switch mode without an EOT, as the batteries can become fully discharged in the absence of train-line power.

2.3 Automatic response

In the event of a train line separation, the ECP brake system shall detect the discontinuity of the train line and shall apply an ECP emergency.

Loss of brake pipe pressure shall trigger a pneumatic emergency on the locomotive and wagons via emergency application devices (e.g., vent valves/emergency portions).

The locomotive HEU shall make an ECP emergency application if commanded by either the brake controller handle or an ECP fault. In the case of an integrated EAB controller, a pneumatic emergency shall also apply when the handle is moved to emergency.

2.4 Intra-train compatibility

The CCD on each vehicle making up the train shall be compatible with the requirements of AAR S-4200:2014.

All braking equipment shall be compatible with the requirements of AAR S-4230:2014. The interoperability test procedures for these trains shall be consistent with the relevant scope of AAR S-4260:2008.

All locomotives in an ECP train shall be fitted with two brake pipe vent valves, one at each end, as shown in AAR Recommended Practice RP-505:2001 to ensure the propagation of the pneumatic backup signal in the brake pipe.

2.5 Inter-vehicle compatibility

The CCD on each vehicle making up the train shall apply and release brakes as commanded by the HEU on the lead locomotive.

Empty/load devices (where fitted) shall provide a reduced service brake pressure when empty.

The brake cylinder pressure shall be proportional to the TBC percentage between minimum and maximum in accordance with AAR S-4200:2014.

The type approval process for new vehicles shall include interoperability testing to demonstrate compatibility prior to their introduction to service unless the ECP hardware and software version are identical to another vehicle already in service with demonstrated compatibility.

2.6 Driving diagnostics

The cab screen display on locomotives shall show the information, warnings and indications specified in AAR S-4200:2014 in addition to main reservoir pressure, brake pipe pressure and brake pipe air flow.

2.7 Crosstalk

Each ECP installation shall have unique network addresses for HEUs, CCDs, PSCs and EOTs to mitigate the effects of crosstalk. When a train is sequenced, the driver shall check for notifications of non-crosstalk compliant software on any vehicle. Any vehicle found to be non-compliant shall be made compliant by a software update or by replacing the non-compliant hardware at the earliest opportunity, and in the interim shall be isolated and by-passed.

The programmable vehicle ID shall be unique and sufficient to readily identify the vehicle in ECP fault logs.

Fault logs shall be examined frequently to check for instances of vehicles causing crosstalk.

RSOs shall regularly maintain and test their ECP trains in accordance with OEM recommendations to minimize instances of crosstalk. Mitigation steps shall be taken when crosstalk occurs.

The following parameters shall be tested after a crosstalk report and during scheduled maintenance:

Table 1 Crosstalk Investigation and Scheduled Maintenance Test Parameters

TL resistance per vehicle	Recommended	Fail
Continuity	<0.5 Ω	>1.5 Ω
Insulation	>500 MΩ	<149 MΩ
Earth continuity	0.01–0.5 Ω	> 0.5 Ω

2.8 Stopping distance performance

Braking performance, including stopping distance performance of the train, shall be in accordance with the requirements of AS 7510.6:2026, noting that ECP trains are not subject to the same length limits as conventionally braked trains.

Section 3 Automatic brake control system

3.1 General

Every train in operation shall be equipped with an automatic brake that has continuity and provides consistent, repeatable brake performance during train running.

Wagons with ECP only shall not run in trains with conventional braking except under special conditions for purposes such as recovery using the emulation feature, if battery charge is sufficient for the journey length. The safety of such a move shall be assessed.

On new locomotives, the EAB control handle shall be used for both pneumatic and ECP brake control.

When retrofitting ECP to existing locomotives fitted with only pneumatic brake controls, a separate ECP brake control device may be provided for the driver to operate the ECP brake.

3.2 Brake system and control

The installation of an ECP brake system on a locomotive or train shall be in conformance with the current requirements of the *AAR Manual of Standards and Recommended Practices*, Section E-II and this document.

Circuit protection for ECP equipment on locomotives and test equipment shall comply with AS 3000:2018.

3.3 Inter-train compatibility of braking systems for trains

3.3.1 Vehicles in normal network operation

The communications protocol for all trains that are fitted with an ECP brake system shall comply with AAR S-4230:2014.

Where rolling stock from more than one owner is to operate under ECP in a train, all equipment shall have been demonstrated to be compatible in accordance with AAR S-4260:2008 by maintaining records of all software and hardware versions fitted to the RSO's vehicles.

New train configurations shall be type tested to validate brake system performance.

Compatibility testing for ECP and WDP operations shall include the tests listed in AAR S-4260:2008 unless the ECP (and WDP) hardware and software versions are identical to other vehicles already in service with demonstrated compatibility.

All vehicles in a train shall have the same brake pipe settings, as described in Clause 3.4.

Where vehicles with an overlay brake system are operated in a train, an ECP brake application shall not actuate the pneumatic brakes on adjacent wagons by causing a localized drop in brake pipe pressure, leading to dragging brakes.

If the RSO intends to use emulation mode, they shall demonstrate that the vehicles can be safely moved in accordance with a procedure which states the maximum limits of the train operation (consist length, speed and duration). Vehicles fitted with an emulator CCD shall not be marshalled as the last vehicles in a train of conventional air-braked vehicles.

3.3.2 Vehicles carrying out a single transit of a network

Where a vehicle does not conform to the standard communication protocol under the conditions described above, and is required to transit once over a network, the RSO should demonstrate that either:

(a) ECP brake settings, software and hardware control are in place that establish that the systems used are fully compatible with other ECP traffic operating on the network; or

(b) sufficient safety control is in place to ensure the train can transit the network without safety or reliability issues and that appropriate first response and train rescue preparations have been put in place.

3.4 Inter-train compatibility and intra-train compatibility

The items below affect compatibility:

(a) Brake pipe pressure for operation on shared networks shall be in accordance with AS 7510.1:2026. On private networks, the brake pipe pressure used in AAR S-4200:2014 and S-401:2020 may be used.

(b) Locomotives shall be configured such that adjustment of the fully charged brake pipe pressure shall only be available through maintenance screens. The driver shall not have access to adjust this pressure setting under normal operating conditions.

(c) Maximum brake cylinder pressure for full service shall be in accordance with AS 7510.2:2024 on shared networks.

(d) Minimum service brake cylinder pressure shall be at least 10% of the full-service value.

(e) Vehicle brake cylinder fill and exhaust rates shall be as per AAR S-4200:2014.

(f) Emergency application – The propagation rate shall be as per AAR S-4200:2014 and AAR S-401:2020 and emergency brake cylinder pressure shall be 15–20% higher than the full service pressure.

(g) The NBR, when loaded, shall provide the minimum deceleration rate in accordance with AS 7510.2:2024 for vehicles on shared networks.

(h) On shared networks, load compensation shall be automatic, with CCDs programmed for the presence of an empty/load device.

(i) Mixing vehicles with and without mechanical empty/load devices on a train can lead to incorrect brake cylinder pressures on some vehicles. If mixing vehicles, the RSO shall assess whether the correct braking levels will be applied and ensure operational procedures will give correct operation.

(j) Where automatic load compensation equipment is fitted, it shall be designed appropriately for the vehicle and its operational requirements.

(k) On private networks where empty/load devices are not fitted, and an empty/loaded train signal is sent from the HEU, the load status shall be displayed to the driver at all times, and the RSO shall follow a documented procedure to ensure the train has the correct load setting.

Section 4 Brake system couplings between vehicles

Train line couplings between vehicles shall ensure continuity of the ECP brake through the train.

Train line couplings should be compatible within a train of ECP equipped rolling stock. Where the coupling used cannot physically couple to the AAR S-4210 coupling, adapter cables may be used.

The connectors shall be designed to connect securely but part without damage in the event of train separation.

Brake system couplings between vehicles shall be arranged so that movement between vehicles, or the impact from falling objects, does not damage or kink flexible hoses or cables.

Locomotives for use on shared networks shall be fitted with brake system couplings or cables that are compatible with those of all other rolling stock in use on that network, either directly or by use of an adapter coupling.

Commentary *C4*

The majority of rolling stock on shared networks are fitted with a proprietary coupling which requires an adapter to couple to an AAR S-4210 coupling.

ECP end connections shall be located nominally in accordance with Section 9 of AAR S-4210:2014 as applicable to the wagon structure. Where this is not practicable, the connections shall be positioned such that they can be coupled to compliant vehicles using a standard-length inter-car connector.

ECP connections shall be arranged to prevent chaffing against other connections or vehicle structures. ECP connections shall also accommodate all relative vehicle movements encountered when negotiating curves.

Where interoperability with other vehicles is not required, the RSO may use non-standard terminal locations to give improved or safer access for coupling and uncoupling.

Lanyards shall be located to ensure there is no load on the cable when parting.

Lanyards shall support the connector such that its lowest point remains within the rolling stock outline.

Section 5 In-service static brake test for trains with ECP brakes

Trains shall be inspected and tested in accordance with AS 7451:2024 and AS 7510.6:2026 before trains enter service or when vehicles are added or removed.

A continuity test shall be performed after any event which could compromise the integrity of the brake pipe or train lines.

Prior to entering run mode, the ECP system shall be initialized to register all network devices and train conditions in accordance with Section 4.2.3 of AAR S-4200:2014.

An ECP EOTM device is required on all trains operating outside marshalling yards to allow initialisation and ensure train and brake pipe continuity. Switch mode shall not be used outside marshalling yards without the agreement of the relevant RIMs.

A flashing light EOTM shall be fitted to the last vehicle if it is necessary to move a train on the network in switch mode without an ECP EOTM.

Section 6 Static brake test of vehicles fitted with ECP brakes

To verify the vehicle brake system is operating correctly, a static brake test shall be carried out for a vehicle passing through a maintenance location where work has been carried out on the vehicle brake system.

RSOs shall have criteria for the extent of brake testing required to be carried out based on the extent of repair work carried out. In the absence of criteria for the extent of testing, all vehicles with control valves fitted that are rigidly coupled to the vehicle that has been worked on shall be tested for correct operation as a combined unit before returning to service.

Staff conducting automated single car testing shall have a suitable level of electrical safety training and understanding of the electrical aspects of the ECP system before conducting tests.

A single car test in accordance with the brake equipment manufacturer's minimum requirements shall be used to test the brakes on the vehicle after repairs have been carried out to its brake control system. Where possible, the brake pipe length of the vehicle set shall be reduced to that of the vehicle on which the CCD is located. The pneumatic single car test devices used with the ECP test device shall be calibrated annually.

Where one CCD controls brakes on two wagons or platforms which are permanently coupled together, the pneumatic single-car test shall be applied to the pair.

On multi-platform vehicles with two or more CCDs, the vehicle pair shall be tested by isolating the other CCDs and control valves.

Section 7 Ending ECP operation

7.1 Risk of uncommanded movement

The risk of an uncommanded train movement which can occur when the CCDs on all vehicles in a train shut down while the brake pipe is charged shall be mitigated as described in the following clauses.

NOTE: See Appendix B for general information.

7.2 Ending ECP

On private networks where it is required to remove locomotives or the ECP EOT device without dropping brake pipe at a specific location (e.g., an unloading facility), means shall be provided for holding the train after ending ECP in accordance with a documented procedure.

For all other circumstances, the brake pipe shall be vented to give a pneumatic emergency before ending ECP or before the driver leaves the cab to prevent the possibility of a timed shutdown of ECP after 60 min.

The brake pipe shall be vented to give a pneumatic emergency before a train is left standing without a functioning ECP EOT or without power from the locomotive power supply.

When selecting End ECP, the ECP system shall require the driver to confirm such an operation by acknowledging a confirmation message in accordance with the RSO's procedure.

To prevent inadvertent confirmation of the End of ECP operation, the confirmation message(s) shall be acknowledged through a different selection key than that used to select cut-out from the setup menu. This is to prevent accidental double-tapping of the same selection key.

7.3 Securing the train after ending ECP

The train shall be secured using park brakes in a time frame in accordance with procedures for conventional air-braked trains standing on grades after applying a pneumatic emergency.

If ECP brakes cannot be applied, the train shall be held using park brakes or other means before releasing a pneumatic emergency application and beginning to charge the brake pipe.

Where the train or rake of wagons is to be stowed, the park brakes shall be applied or other procedures followed to secure the train in accordance with RSO's instructions.

Section 8 Emergency feature

Both locomotives and other vehicles shall be fitted with air brake equipment that responds to and propagates a rapid drop in brake pipe pressure occurring at any location in the train.

This function shall be provided on hauled vehicles by the arrangement of emergency portions and vent valves in the AAR Manual of Standards and Recommended Practices, Section E, Brakes and Brake Equipment Valves, Specification S-401 as referenced by AAR S-4200:2014.

Section 9 Distributed power

Where the control system for wire distributed power capability (WDP) uses the allocated bandwidth on the ECP train line, the brake control and WDP systems shall be capable of simultaneous operation without degrading the operation and response of either system.

Performance requirements for all trains fitted with an ECP brake system and WDP shall comply with AAR S-4250:2014. The interoperability test procedures for these trains should comply with AAR S-4260:2008.

Appendix A Hazard Register (Informative)

The following hazards have been sourced from the ARISO hazard register.

Hazard number	Hazard
5.4.1.60	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 - Inadequate rolling stock pre-service testing and commissioning
5.4.1.61	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 - Inadequate rolling stock in-service testing
5.5.1.8	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 - Being unable to release brakes leading to the inability to haul dead trains off the sections
5.5.1.45	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 - Design deficiency causing the inability to operate trains
5.5.1.46	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 - Manufacturing deficiency causing the inability to operate trains
5.5.1.47	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 - Maintenance deficiencies causing the inability to operate trains
5.5.1.48	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 - Operational deficiencies causing the inability to operate trains
5.5.1.49	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 - The absence of (unique) components identification causing the inability to trace or identify (suspected) faulty components
5.10.1.4	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Inadequate braking on down grades
5.10.1.9	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Leaking brake cylinders leading to insufficient brake cylinder pressure

Hazard number	Hazard
5.10.1.19	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Local brake control system mechanical failure e.g., control valve, (Braking system failure)
5.10.1.21	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake control system software 'failure' - (Braking system failure)
5.10.1.23	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Component failure causing a brake controller failure (Braking system failure)
5.10.1.26	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Kinked brake pipe hoses causing a braking signal transmission system failure (Braking system failure)
5.10.1.27	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Damaged or flow-restricted brake piping or hoses causing a braking signal transmission system failure (Braking system failure)
5.10.1.37	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Reservoir being insufficiently recharged before next application causing a brake energy reservoir failure (Braking system failure)
5.10.1.41	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Incompatible braking systems on coupled vehicles (Braking system failure)
5.10.1.49	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Unable to apply emergency brake due to brake controller failure (Braking system failure)
5.11.1.1	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake systems automatically releasing the brakes after a preset time
5.11.1.4	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Hand / park brakes not being applied causing air in brake cylinders to leak off
5.11.1.13	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Insufficient brake cylinder pressure
5.12.1.3	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Incompatible brake systems on vehicles in the train (Brake not released)

Hazard number	Hazard
5.12.1.14	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Brake release propagation too weak
5.12.1.15	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Faulty brake control equipment
5.12.1.16	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Driver mismanagement of brake system
5.13.1.12	Inadequate adhesion - Design Failure, Security Breach and or Vandalism - Vehicle or wheelset over-braked
5.13.1.13	Inadequate adhesion - Design Failure, Security Breach and or Vandalism - Insufficient wheelsets braked on vehicle
5.30.1.3	Excessive dynamic longitudinal train forces - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Load not Secure and or Vandalism - Brake propagation down train too slow

Appendix B Guidance Information – Ending ECP Operation (Informative)

NOTE: The scope of this appendix is to provide guidance information on the application, implementation and adoption of Section 7 of this document.

The CCDs on all vehicles in a train will shut down when a command is received from the HEU (End ECP) or if no HEU beacon is received for one hour. In both cases, if the brake pipe is charged, any ECP application will immediately be released. This creates a risk of rollaway on trains which have ECP without overlay, and the following clauses mitigate this risk.

Bibliography (Informative)

- AAR Standard S-4210, *ECP Cable-Based Brake System Cable, Connectors, and Junction Boxes - Performance Specification*
- AAR Standard S-4220, *ECP Cable-Based Brake DC Power Supply - Performance Specification*
- AAR Standard S-4240, *ECP Brake Equipment - Approval Procedure*
- AAR Standard S-4250, *Performance Requirements for ITC-Controlled Cable-Based Distributed Power Systems*
- AAR Standard S-4270, *ECP Brake System Configuration Management*