T HR RS 11001 ST

Standard

Electric Passenger Rolling Stock Onboard Main Power Supply System – 1500 V dc

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Standard governance

Owner: Lead Rolling Stock Engineer, Asset Standards Authority

Authoriser: Chief Engineer Rail, Asset Standards Authority

Approver: Executive Director, Asset Standards Authority on behalf of ASA Configuration Control Board

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For queries regarding this document,
please email the ASA at
standards@transport.nsw.gov.au
or visit www.asa.transport.nsw.gov.au

Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance-based to create opportunities for innovation and improve access to a broader competitive supply chain.

This document provides the requirements for the electrical onboard main power supply for heavy rail passenger rolling stock and aims to ensure the reliability, availability, maintainability, and safety of such systems. Historically these requirements were specified in technical performance specifications for each new fleet type under procurement. The ASA have captured and reviewed critical requirements of past technical performance specifications and have standardised the requirements in this standard. To allow suppliers the freedom to innovate, the requirements are performance based and where possible are non-prescriptive.

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1. Introduction

The electric passenger rolling stock's onboard main power supply system collects current from the overhead power supply using the pantographs, and returns the current to the running rails using the wheel-sets and axle-earthing units. The onboard main power supply system provides the power from the overhead power supply system to the traction and auxiliary power supply system through the high-speed circuit breakers and line switches. The onboard main power supply system provides isolation, fault current limiting, and protective and functional earthing functions to facilitate in the safe operation and maintenance of the electric passenger rolling stock.

The onboard main power supply system's functions include the following:

- interface with the TfNSW heavy rail overhead power supply system
- protection of the TfNSW heavy rail signalling system from 50 Hz current signals
- provide safety systems for the protection of operations and maintenance personnel
- provide normal and abnormal operation isolation of the train from the overhead power supply system
- provide high-speed fault current detection and fault current limiting to protect the train and the overhead power supply system
- provide protection from overhead power supply abnormal voltages and atmospheric voltage discharges

2. Purpose

The purpose of this document is to specify the requirements of the onboard main power supply system for new electric passenger rolling stock for TfNSW.

This document aims to help ensure the reliability, availability, maintainability, and safety of the TfNSW rail network and new passenger rolling stock fleets.

This standard points to international, national, and TfNSW standards as normative references, and seeks to ensure that the functional performance of the onboard main power supply system of new electric passenger fleet for TfNSW is equal to or better than the performance of existing electric passenger fleet.

2.1. Scope

This standard details the minimum requirements of the onboard main power supply system for TfNSW electric passenger rolling stock.

The scope of the onboard main power supply system includes the following:

- the current collecting device, for example, the pantograph
- the high-tension protective components, including the high-speed circuit breakers and surge arresters
- the high-tension current return and earthing arrangement path to the running rails via the wheel-sets
- the high-tension isolation switching elements for the traction and auxiliary systems
- the 50 Hz current signal detection and protection system for the TfNSW heavy rail network signalling system

2.2. Application

This standard applies to new TfNSW electric passenger rolling stock fleet and to rolling stock fleet where significant modification of the onboard main power supply system is to be undertaken.

Contracts and tenders for new or modified electric passenger rolling stock released before the standard's effective date are exempt from the requirements of this standard unless otherwise directed by the TfNSW contract administrator.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards

EN 50153 Railway Applications - Rolling Stock - Protective Provisions Relating to Electrical Hazards

EN 50526-1 Railway applications - Fixed installations - D.C. surge arresters and voltage limiting devices - Part 1: Surge arresters

IEC 60077 Railway applications – Electric Equipment for Rolling Stock

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 61373 Railway Applications - Rolling Stock Equipment - Shock and Vibration Tests

I.S. EN 50128 Railway Applications - Communication, Signalling and Processing Systems - Software for Railway Control and Protection Systems

Transport for NSW standards

T HR EL 90002 ST Heavy Rail Traction System - Voltage Ratings

T HR EL 90003 ST Heavy Rail Traction System – Current Ratings of 1500 V dc Equipment

T HR RS 00117 ST Electric Circuits and Equipment for Passenger Rolling Stock

T HR RS 00164 ST Cable for Passenger Rolling Stock

T HR RS 00850 ST RSU Appendix E - Rolling stock 1500 V dc overhead power supply interface requirements

T HR RS 01701 ST Mounting and Installation of Electrical Equipment

T HR RS 11119 ST Passenger Rolling Stock 1500 V dc Overhead Power Supply Interface Requirements

T HR SC 00006 ST Rolling Stock Signalling Interface Requirements

T MU RS 17001 ST Environmental Conditions for Rolling Stock

4. Terms and definitions

The following terms and definitions apply in this document:

approval process whereby an authorised person certifies that engineering outputs have been verified as meeting input specifications and requirements, and that the engineering output has been completed in accordance with relevant regulations and standards, prior to progressing to the next stage

current-limiting circuit breaker circuit-breaker with a break-time short enough to prevent the short-circuit current reaching its otherwise attainable peak value

dc direct current

DCCB dc circuit breaker

direct over-current release over-current release directly energised by the current in the main circuit of the circuit breaker

DRTC double rail track circuits

earthing refers to protective earthing and rolling stock functional earthing. Protective earthing within the rolling stock includes equipotential bonding of exposed conductive parts to prevent electric shocks and to enable the operation of overcurrent protection devices. Rolling stock functional earthing prevents the flow of current through the vehicle body and structures in normal operation. The rolling stock earth connects to the running rails via the axle-earthing units. The running rails connect to the substations' earthing system via earthing contactors that closes when the voltage difference between the running rails and the ground earth exceeds a dangerous limit.

high-speed circuit breaker a mechanical switching device used to detect, interrupt, and limit prospective electrical fault currents to prevent damage

HSCB high-speed circuit breaker

line-switch a mechanical switching device use to isolate the traction system including interrupting its normal operating current

Lockout-tagout (LOTO) safety procedure used in industry to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work

Lockout-tagout device a device to facilitate a LOTO safety procedure

main power supply the equipment for collection, isolation, and control of current from the overhead wiring electrical supply infrastructure and the return system to the rails

OHW overhead wire

pantograph the interface between the rolling stock and the OHW system. It is a device, located on top of electric powered vehicles, which collects power from the overhead contact wire by means of a sliding contact shoe.

prospective current current that would flow in the circuit if the circuit breaker were replaced by a conductor of negligible impedance

SIL Safety Integrity Level as defined in I.S. EN 50128 *Railway Applications - Communication, Signalling and Processing Systems - Software for Railway Control and Protection Systems*

SRTC single rail track circuits

surge arrester device designed to protect the electrical apparatus from high transient over-voltages and to limit the duration and frequently the amplitude of the follow-on current

train refers to a configuration of one or more railway vehicles that can operate on a rail network

tripping operation opening operation of a circuit breaker initiated by a release

5. General requirements

The onboard main power supply system and equipment shall comply with the following standards:

- EN 50153 *Railway Applications - Rolling Stock – Protective Provisions Relating to Electrical Hazards*
- T HR RS 00117 ST *Electric Circuits and Equipment for Passenger Rolling Stock*
- T HR RS 00164 ST *Cable for Passenger Rolling Stock*
- T HR RS 01701 ST *Mounting and Installation of Electrical Equipment*
- T HR SC 00006 ST *Rolling Stock Signalling Interface Requirements*

- T HR RS 11119 ST *Passenger Rolling Stock 1500 V dc Overhead Power Supply Interface Requirements*
- T HR RS 00850 ST *RSU Appendix E - Rolling stock 1500 V dc overhead power supply interface requirements*

6. Onboard main power supply system requirements

The onboard main power supply system shall demonstrate compatibility with the Transport for NSW heavy rail overhead power supply system.

The onboard main power supply system shall demonstrate compatibility with the Transport for NSW heavy rail signalling system and shall comply with the requirements of T HR SC 00006 ST.

The onboard main power supply system shall use protective switchgear in the form of high-speed circuit breakers (HSCBs) to detect, interrupt, and limit prospective fault currents.

The onboard main power supply system shall use switchgear in the form of line-switches to make and break normal operation traction currents and provide isolation of the traction system from the 1500 V dc supply.

The onboard main power supply system shall have provision for an earth-switch system or equivalent system, which is lockable with a lockout-tagout device, to protect maintenance personnel against the application of power by any means to the train's high-tension circuits during maintenance work. This provision shall facilitate the lowering and isolation of all pantographs and the application of a secure earthing connection to the high-tension circuits on the load side of the main HSCB.

The onboard main power supply system shall facilitate remote isolation of the traction and auxiliary power supply system from the 1500 V dc supply from the driver's cabin.

The onboard main power supply system shall provide protection to onboard equipment against overhead power supply under-voltage and over-voltage.

The onboard main power supply system shall provide protection to onboard equipment against electrical surges due to atmospheric voltage discharges and overhead power supply system switching actions.

The onboard main power supply system shall provide a redundant high-tension current return and earthing arrangement to the running rails.

The onboard main power supply configuration shall ensure supply of power to the minimum number of traction modules, required to enable the train to continue service or reach the nearest maintenance centre, after a loss of power from a pantograph due to damage or failure. Refer to

the following information regarding the available main power supply redundancy on existing passenger fleet in NSW.

The onboard main power supply configuration shall ensure supply of power to the auxiliary power supply modules during momentary loss of power from a pantograph due to pantograph bounce or the pantograph's HSCB tripping. The momentary loss of power may extend up to 15 minutes or up to the nominal time required to isolate likely high-tension faults to enable a successful reset of the pantograph's HSCB. Refer to the following information regarding the available main power supply redundancy on existing passenger fleet in NSW.

For information:

Modern EMU passenger trains operating on the TfNSW network use two or more pantographs per operational train. Each pantograph provides power to a set of traction and auxiliary power modules. In the event of an onboard main power supply power loss due to pantograph bounce, pantograph failure or damage, or a HSCB tripping, only the connected traction module(s) are directly affected and the train may be able to continue passenger service or return to the nearest maintenance centre using the remaining operating pantograph(s) and traction modules(s). For the auxiliary power supply, a high-tension electrical link provides a temporary power supply to the affected auxiliary power modules from an adjacent pantograph for up to 15 minutes. This ensures uninterrupted auxiliary power for the main lighting and air-conditioning system for up to 15 minutes.

6.1. Pantographs

For compatibility with the TfNSW OHW traction supply system, the pantograph shall comply with the following TfNSW standards:

- T HR RS 11119 ST *Passenger Rolling Stock 1500 V dc Overhead Power Supply Interface Requirements*
- T HR RS 00850 ST *RSU Appendix E - Rolling stock 1500 V dc overhead power supply interface requirements*

6.2. High-speed circuit breakers and line-switches

HSCBs and line-switches type testing shall comply with IEC 60077-3 and IEC 61373.

HSCBs and line-switches operational frequency rating, as per IEC 60077-3, shall be 'C3'.

HSCBs shall primarily use natural cooling with any other type of cooling to be supplemental.

The unprotected cable connection between HSCBs and the electrical supply shall be as short and as direct as possible.

HSCBs shall primarily use direct over-current release.

Parallel connection with HSCBs and line-switches shall be limited to detection and control equipment.

HSCBs and line-switches shall have the provision to be monitored remotely though the train operating system or equivalent.

The main power supply HSCB's performance characteristic and configuration shall ensure discrimination with respect to the overhead power supply dc circuit breakers (DCCBs) to ensure the HSCB can quickly detect, break and limit onboard electrical fault currents before the fault can trip the overhead power supply DCCBs. Refer to the information below regarding the overhead power supply DCCBs.

For information:

The operating characteristic of the substation DCCBs is contained in the TfNSW Standard T HR RS 00850 ST RSU Appendix E - Rolling stock 1500 V dc overhead power supply interface requirements.

The voltage and current ratings for the major elements of the overhead power supply system are given in TfNSW Standards T HR EL 90002 ST Heavy Rail Traction System - Voltage Ratings and T HR EL 90003 ST Heavy Rail Traction System – Current Ratings of 1500 V dc Equipment, respectively.

The main power supply HSCB system shall provision for protection against excessive automatic and manual HSCB reset.

The HSCB electrical rating and characteristics shall ensure a service life comparable to the service life of HSCB's on existing passenger rolling stock operating on the TfNSW heavy rail network. Refer to the following information on HSCBs on existing fleet:

For information:

The specification for the naturally cooled HSCBs on existing passenger trains operating on the TfNSW heavy rail network require the HSCBs to undergo type testing to demonstrate continued operation after a series of test that simulate operation under prospective fault currents. The test based on the withdrawn British Standards BS 2618 uses the prospective fault currents and source inductance settings in Table 1*.*

Experience with the HSCBs on the Tangara fleet over the past 25 years indicates reliable operation of over 6 years.

Table 1 – HSCB prospective current and source inductance settings used to test existing TfNSW fleet

Prospective test current setting	*3000 A*	*6000 A*	*14000 A*

Source inductance	*25 mH*	*10 mH*	*4 mH*
Min. open voltage	*1650 V*	*1650 V*	*1650 V*

6.3. Over-voltage and under-voltage protection

The main power supply system shall detect over-voltage and under-voltage of the overhead power supply system, as per T HR EL 90002 ST, and provide the necessary protection for onboard equipment and circuits including isolation from the overhead power supply while the condition exists.

If applicable, the main power supply shall isolate the traction system from the 1500 V dc supply if the traction system's regenerative braking current causes the voltage at the pantograph to exceed the voltage limit specified in T HR EL 90002 ST.

6.4. Surge arrester

The surge arrester rating shall be suited to provide protection against the atmospheric voltage discharge intensities and frequency of strikes expected in NSW as detailed in T MU RS 17001 ST *Environmental Conditions for Rolling Stock*, 'Lightning' section.

The surge arrester shall provide protection to the onboard equipment from arching voltages of the onboard HSCB and overhead power supply system's DCCB during electrical fault clearing. The arching voltages of the DCCBs can exceed 3000 V for a few tens of milliseconds as per T HR EL 90002 ST.

The surge arrester shall not degrade due to the TfNSW heavy rail overhead power supply system's highest non-permanent voltage as specified in T HR EL 90002 ST.

The surge arrester shall be located in close proximity to the pantograph with the high-tension connections as short and as straight as possible.

The surge arresters shall not have the potential for uncontained shattering which can result in the ejection of porcelain, or other material, shards from the train and cause injury.

The surge arresters shall be functionally type tested in accordance with EN 50526-1 *Railway applications - Fixed installations - D.C. surge arresters and voltage limiting devices - Part 1: Surge arresters*, or equivalent internationally recognised standard for non-linear, metal-oxide surge arresters with no spark gaps that covers that test the following:

- operating duty
- accelerated ageing
- weather ageing
- operation in high humidity

- resistance to UV degradation
- resistance to degradation from exposure to pantograph sparking
- overload test
- vibration and shock testing in accordance with IEC 61373

6.5. High-tension current return and earthing arrangement

For information:

The TfNSW overhead power supply system uses the running rails as the current-return to the substations. The running rails connect to the substation's earthing system via an earthing contactor that closes when the voltage difference between the rail and the ground earth exceeds a dangerous limit.

The high-tension current return arrangement shall effectively conduct the return current to the running rails at all operating speeds up to the maximum test speed.

The earthing arrangement shall effectively conduct fault currents from the earthing bus bars, electrical equipment metal enclosures, and vehicle body and bogie structures to the running rails at all operating speeds up to the maximum test speed.

The earthing arrangement shall provide functional earthing to prevent the flow of current through the vehicle body in normal operation.

High-tension return current, other than fault-current, shall not conduct through the vehicle body.

The high-tension current return arrangement and the earthing arrangement shall each use a minimum of two redundant paths to the running rails via axle-earthing units that are on different bogies of the vehicle. The redundant paths shall ensure a path to the running rail when up to one bogie derails from the rail.

Current shall not flow through any non-insulated bearings including wheel set bearings of the train.

Access to the electrical connection points of the axle-earthing units shall permit periodical electrical resistance testing between the axle-earthing unit and the wheels.

6.6. Earth-switch system

For information only:

The A-Set (Waratah) Fleet operating on the TfNSW network uses an underframe-mounted earth-switch with the earth-switch handle accessible at rail level. The earth-switch arrangement when in the 'earth' position uses interlocks to open the HSCB before lowering the pantographs and connecting the load-side of the HSCB to the running rails via the axle-earthing units.

To protect against accidental access to high-tension voltages due to accidental or inadvertent dislodgement of the earth-switch enclosure panels, protective interlock switches will trip the HSCBs when any enclosure panels are dislodged.

The earth-switch shall have an operating handle that is accessible from rail level.

The earth-switch operating handle shall have two positions, a 'normal' and an 'earth' position or equivalent.

If applicable, remote operation of the earth-switch shall use a redundant hardwired system or an equivalent SIL rated system that protects against false indication of earth-switch operational status.

The earth-switch operating handle shall be lockable by maintenance personnel using a secure lockout-tagout device.

By placing the earth-switch handle to the 'earth' position from the 'normal' position, the earth switch using redundant switch interlocks or equivalent shall cause the following sequence:

- application of an interlock to force the HSCBs to open and to remain in the open position
- application of an interlock to force the train's pantographs to lower and to remain in the lowered position
- application of an earthing connection to high-tension circuits on the load side of the HSCB

Placing the earth-switch handle to the 'normal' position from the 'earth' position shall cause the following sequence:

- removal of the earthing connection to the high-tension circuit
- removal of the interlock that forces the pantograph to remain in the lowered position
- removal of the interlock that forces the HSCB to remain in the open position

The earth-switch and its switching elements rating shall conduct the calculated maximum 'let-through' current of the onboard HSCB and any residual charge electric charge from any inductive and capacitive elements of the high-tension circuits without affecting the operational life of the earth-switch.

The earth-switch system shall discharge any residual electric charge held in any inductive and capacitive components of the high-tension circuits to protect maintenance personnel.

The earth-switch design, where applicable, shall protect against inadvertent access to high-tension voltages due to dislodgment of any earth-switch enclosure panels.

The earth-switch enclosure(s) shall be IP rated in accordance with IEC 60529 *Degrees of protection provided by enclosures (IP Code)*, and shall take into consideration, where applicable, potential exposure to jets of water from train wash plants and driving through rain at up to the maximum train speed.

6.7. Electrical clearances

The free-air electrical clearance distance between any energised part of the main power supply and any parts electrically bonded to the vehicle body shall comply with the requirements in the following standards:

- T HR RS 01701 ST Mounting and Installation of Electrical Equipment
- T HR RS 11119 ST Passenger Rolling Stock 1500 V dc Overhead Power Supply Interface Requirements

6.8. Train current limits

The onboard main power supply system shall be compatible with the train current limits specified in T HR EL 90003 ST.

To facilitate stable operation on electrically weak regions of the TfNSW heavy rail overhead power supply system, the onboard main power supply system shall be compatible with the automatic train current regulation and maximum train power limiting functionality specified in T HR EL 90003 ST.

For information only:

To achieve stable operation in electrically weak power regions of the TfNSW overhead power supply network, the A-Sets (Waratah) fleet utilise two methods to limit the maximum train current. The first type uses a configurable 'contact line voltage versus maximum train current curve' which is configured to decrease the maximum train current limit with a decreasing contact line voltage. The second use a configurable maximum train current limiting base on the overhead power supply region the train is operating on to provide a targeted current limiting for electrically weak regions. The system uses a configurable look up table to determine the maximum train current limit for specific electrically weak overhead power supply regions.

6.9. 50 Hz current detection system

A 50 Hz current detection system shall detect harmful levels of 50 Hz current returning to the running rails where it can interfere with or cause a 'Wrong Side' failure of the TfNSW heavy rail network signalling system. The detection system shall detect 50 Hz current exceeding the levels defined in T HR SC 00006 ST. 50 Hz current may originate from the overhead power supply or from onboard traction and auxiliary power supply equipment in failure modes.

Detection of 50 Hz current above the levels defined in T HR SC 00006 ST shall initiate the isolation of the train from the overhead power supply or the isolation of the faulty onboard equipment from the train's onboard main power supply, before the 50 Hz current can interfere with the rail network signalling system.

The 50 Hz detection system shall be compatible with the TfNSW heavy rail network signalling system's single rail track circuits (SRTC) and double rail track circuits (DRTC) defined in T HR SC 00006 ST.

For information:

The signalling system of the TfNSW heavy rail network uses track circuits to detect the presence of a rolling stock using 50 Hz current signal. The signalling system uses both single rail track circuits (SRTC) and double rail track circuits (DRTC). The suburban area of the network uses only the SRTC type.

Under abnormal operating conditions, it may be possible for faulty equipment in either the overhead power supply substation or the train to generate a 50 Hz current signal that if returned to the rail, may cause a 'Wrong Side' failure of the signalling system.

Configuration

The 50 Hz current detection system, for operation outside the suburban area of operation, shall automatically be set to detect 50 Hz current that reaches or exceeds the level and duration defined in the TfNSW standard T HR SC 00006 ST for double rail 50 Hz track circuits.

The 50 Hz current detection system, for operation inside the suburban area of operation, shall automatically be set to detect 50 Hz current that reaches or exceeds the level and duration defined in TfNSW standard T HR SC 00006 ST for single rail 50 Hz track circuits.

The 50 Hz current detection system shall automatically reset when the 50 Hz current falls below the required detection level as per the train's area of operation.

The 50 Hz current detection system shall provide a self-test functionality to ensure correct operation at regular intervals and to inform maintenance personnel of any faults.

The 50 Hz detection system shall indicate to the train driver its operational status.