

Technical Note - TN 033: 2017

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Subject: Update to T HR RS 10001 ST *Electric Auxiliary Power Supply and Battery System for Passenger Rolling Stock* – clarification of battery capacity, emergency load duration and sharing

This technical note is issued by the Asset Standards Authority (ASA) as an update to T HR RS 10001 ST *Electric Auxiliary Power Supply and Battery System for Passenger Rolling Stock*, version 2.0.

The reason for this change is to ensure that the requirements for battery capacity and emergency load duration is understood and to clarify that load shedding is permitted to enable the battery system to meet the emergency load durations.

Delete the existing Section 6.3 *Battery capacity and emergency load duration* and replace with the following:

6.3 Battery capacity and emergency load duration

The battery system at 80% state of charge shall have sufficient charge capacity to power the train's emergency loads as specified in Table 2 and Table 3 over the full operating life of the energy storage system.

The battery system shall have excess capacity to start the train, with the pantographs in the lowered position, after providing emergency power for the durations specified in Table 2 and Table 3.

If the control circuit and the lighting circuit have distinct battery banks, a method of temporarily powering the control circuit from the lighting circuit battery banks that automatically isolates the control battery banks shall be available. This is to start the train if the control battery banks are depleted.

The battery system shall be able to continue to provide emergency power, beyond the specified minimum durations in Table 2 and Table 3, up to the point of reaching the state of charge necessary to start the train.

A load-shedding schedule may be used to ensure that the control circuit emergency load durations detailed in Table 2 and Table 3 can be achieved. Precedence should be given to power high priority train systems for the required duration, for example, emergency lighting, voice radio, and the ability to restart the train.

Table 2 – Control circuit emergency load

System to be maintained	Minimum duration
Video surveillance systems	1.5 hours after loss of OHW power
Door control and release	4 hours after loss of OHW power
Train radio equipment, PA and Intercom	4 hours after loss of OHW power
Train controls	4 hours after loss of OHW power
Fire detection system	4 hours after loss of OHW power
Event recorder	4 hours after loss of OHW power

Table 3 – Lighting and ventilation emergency load

System to be maintained	Minimum duration
Emergency ventilation	1.5 hours; refer to ASA standard 'T HR RS 08001 ST Interior Climate Comfort for Passenger Rolling Stock'
Emergency lighting	3 hours after loss of OHW power; refer to EN13272, at lighting luminance levels specified in 'T HR RS 12001 ST Interior and Exterior Lighting for Passenger Rolling Stock'
Marker lights on end vehicles of the train	3 days after loss of OHW power

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Technical Note - TN 078: 2015

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Subject: **Provisional update to T HR RS 10001 ST *Electric Auxiliary Power Supply and Battery System for Passenger Rolling Stock***

1. Purpose

To expand the types of energy storage device for the battery system that can be used on new passenger rolling stock, requirements in T HR RS 10001 ST, Version 2.0 are to be provisionally amended. This is to ensure that existing battery types, in wide use in the railway industry in NSW and overseas, are not inadvertently excluded due to the wording of the requirements.

An environmental impact assessment requirement for the energy storage device will also be added to cover the disposal and recycling at end-of-life.

2. Changes

The following requirements in Section 6.4 'Energy storage device requirements' will be changed as per the following table:

From:	To:
contained in a non-spill case such that no fluids can spill if the batteries are handled or transported in any orientation	contained in a non-spill case such that no fluids can spill if the energy storage device is handled or transported
not require refilling of fluids over the operating life of the batteries	use technology that minimises or eliminates fluid top up
not release gas or vapour during normal operation	not cause a build-up of released gas or vapour within the train that can cause a safety risk

From:	To:
New requirement	An environmental impact assessment covering the life cycle of the energy storage device shall be included. This assessment shall cover the end-of-life recycling and disposal plan for the energy storage device.

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Standard

Electric Auxiliary Power Supply and Battery System for Passenger Rolling Stock

Version 2.0

Issued Date: 19 December 2014

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Standard governance

Owner: Lead Engineer Rolling Stock, Asset Standards Authority
Authoriser: Chief Engineer Rail, Asset Standards Authority
Approver: Director, Asset Standards Authority on behalf of ASA Configuration Control Board

Document history

Version	Summary of change
1.0	First issue
2.0	<p>Second issue</p> <p>Following sections amended:</p> <ul style="list-style-type: none">Section 6.2 – Deleted the following content: The battery management system shall connect to a non-proprietary commercial ethernet network to enable communication with the train management system and condition monitoring system. Refer TfNSW's T HR TE 41001 ST <i>Packet switched networks</i>.Section 6.4 – Deleted the following content: The contractor shall provide a whole of life cost report to the TfNSW contract administrator that details the cost of replacement, corrective maintenance, preventative maintenance, and operating cost of the battery type and battery management and charging system. The whole of life cost report shall be in accordance with T MU AM 01001 ST <i>Life Cycle Costing</i>.

For queries regarding this document,
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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. 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 electrical auxiliary power supply and battery system for heavy rail passenger rolling stock and aims to ensure the reliability, availability, maintainability, and safety of such systems.

This standard is developed by the ASA Chief Engineer Rail and has been reviewed by TfNSW and industry.

This is a second issue.

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1. Introduction

The electrical auxiliary power supply (EAPS) system covers the equipment that converts the train's main power supply input voltage to voltages for the train's auxiliary systems such as the climate control system, train control and lighting circuits.

The battery system covers the equipment that stores and provides emergency power to maintain power to essential auxiliary systems when the main power supply is not available.

The requirements in this standard are based on international standards and local performance criteria that are currently met by existing TfNSW passenger rolling stock fleet.

2. Purpose

This document provides the minimum performance requirements and recommendations for the electrical auxiliary power supply and battery systems for TfNSW passenger rolling stock. Requirements for EAPS and battery systems were previously included in contract technical performance specifications for rolling stock procurement programs.

This standard aims to ensure the reliability, availability, maintainability, and safety of the electrical auxiliary power supply and battery systems used in passenger rolling stock in NSW.

This standard also seeks to reduce the whole of life cost of the battery system.

2.1. Scope

This document covers the requirements of the auxiliary power supply and backup power supply system for electric passenger rolling stock operating on TfNSW's heavy rail network.

This document shall be used in conjunction with the technical specification for compliance for new rolling stock.

2.2. Application

This standard applies to the design or procurement of new electric heavy rail passenger rolling stock and may be used for the redesign of existing rolling stock assets that undergo a refurbishment or modification program, as directed by the TfNSW contract administrator.

3. Reference documents

International standards

IEC 61287 Railway Applications - Power converters installed on board rolling stock

IEC 60146 Semiconductor converters - General requirements and line commutated converters

EN 50155 Railway Applications - Electronic Equipment Used on Rolling Stock

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

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

IEN 13272 Railway Applications - Electrical Lighting for Rolling Stock in Public Transport Systems

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

Australian standards

AS/NZS 3112 Approval and test specification - Plugs and socket-outlets

AS 61000.3.100 Electromagnetic compatibility (EMC) - Limits - Steady state voltage limits in public electricity systems

Transport for NSW standards

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

T HR RS 01701 ST Mounting and Installation of Electrical Equipment

T HR RS 12001 ST Interior and Exterior Lighting for Passenger Rolling Stock

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

T HR RS 08001 ST Interior Climate Comfort for Passenger Rolling Stock

Drawings

Title: "Carriage Inspection Shed 415 Volt Train Supply Main Switchboard Arrangement and Control Diagram", EDMS Number: EL0012182, Original SRA Drawing Number: C83656

4. Terms and definitions

The following terms and definitions apply in this document:

ac alternating current

battery an individual self-contained energy storage device

battery bank a group of individual batteries connected in series or parallel to achieve the required voltage

control circuits all circuits related to the control of train systems and auxiliary equipments

depth of discharge a complement of state of charge; a measure in percentage the level of discharge, for example, 0% = full, 100% = empty

dc direct current

EAPS electrical auxiliary power supply

EAPS module the main electrical auxiliary power supply component containing its inverter and converter circuits

general power outlet electrical power socket for Australian domestic and industrial appliances

GPO general power outlet

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

OHW overhead wiring

overhead wiring equipment of the power supply infrastructure for electric rolling stock

state of charge a complement of depth of discharge; a measure in percentage the level of charge, for example, 0% = empty, 100% = full

state of health a measure in percentage of the condition of the battery or battery bank compared to its ideal or new specified condition

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

vehicle refers to an individual railway vehicle

voltage classification aligned with EN 50153 clause 4.1. This is described in Table 1.

Table 1 - Voltage classification

TfNSW definition	Band	Nominal voltage (U_n) ac (V)	Nominal voltage (U_n) dc (V)
extra low voltage	I	$U \leq 25$	$U \leq 60$
extra low voltage	II	$25 < U \leq 50$	$60 < U \leq 120$
low voltage	III	$50 < U \leq 1000$	$120 < U \leq 1500$
high voltage	IV	$U > 1000$	$U > 1500$

5. Electrical auxiliary power supply system

The EAPS system provides power to systems essential to train operation including control circuits and the climate control system.

The electrical auxiliary power supply (EAPS) system shall comply with IEC 61287 *Railway Applications - Power converters installed on board rolling stock*, IEC 60146 *Semiconductor converters - General requirements and line commutated converters*, and EN 50155 *Railway Applications - Electronic Equipment Used on Rolling Stock*.

The EAPS shall comply with T HR RS 00117 ST *Electric Circuits and Equipment for Passenger Rolling Stock*.

The EAPS electronics enclosures and cable connectors shall be IP rated in accordance with IEC 60529. The rating shall include the effects of exposure to jets of water from rain up to the maximum train speed and train wash plant water jets. The rating of equipment mounted inside hatches shall consider protection from water exposure that could occur in the event of failure of the hatch, or sealing.

The insulated high tension negative or neutral of the EAPS dc input side shall be kept separate from the insulated negative or neutral circuits of the EAPS output, except where these effectively are connected via the axle earth return brush connections of the train.

For 1500 V dc operation, the EAPS system shall integrate with the whole train to comply with T HR RS 00850 ST *Minimum Operating Standards for Rolling Stock - RSU Appendix E - Specification for 1500 V dc Traction Supply*.

The EAPS system shall be disconnected from the main power supply system in fault or failure conditions.

It shall be possible, from the driver's cabin, to reset individual EAPS and isolate individual EAPS modules from the main power supply.

The EAPS system shall include a safety system that lets maintenance personnel safely work on the input side and output side of the EAPS. A lockable isolation and earthing system shall be provided on the input and output side to provide maintenance personnel protection against any application of power in all configurations, including any application of power from emergency backup feeds from other EAPS modules or from the fixed shore power supply.

5.1. EAPS protection

All EAPS extra low voltage and low voltage circuits shall be protected by individual circuit breakers, except where fuse protection is required.

Circuit breakers shall protect associated equipment and cabling from abnormal currents.

There shall be galvanic isolation between all EAPS outputs and the main power supply, except for earth back to axle earth return connections.

In the event of a fault or abnormal condition, the EAPS shall not cause degradation to the train's external interfaces, overhead wire, or signalling infrastructure. The equipment shall provide protection to cover a full range of credible failures and abnormal conditions.

A loss of EAPS output that is not a result of variation of main power supply, for example, OHW under-voltage or over-voltage, shall generate a fault indication to the driver.

The EAPS three-phase output shall be protected by over-current detection and contactors.

Inter-vehicle connectors carrying EAPS supply voltages greater than extra low voltage band II shall be interlocked so that power is not present at the electrical contacts prior to the connectors being connected or immediately prior to the connectors being disconnected.

The EAPS shall automatically protect itself from failure in the event of an induction motor failure of any type.

All operational EAPS modules in a train shall automatically reset upon restoration of the interrupted main power supply.

5.2. EAPS voltages

The control circuit voltage and lighting circuit voltage shall be extra-low voltage band II.

The frequency of the EAPS ac output shall be maintained within ± 1.0 Hz of the nominal value under all operating conditions.

Note: The following voltages are typical in existing TfNSW rolling stock fleet and maintenance centres:

- 110 V dc to 120 V dc for control circuits and related auxiliary equipment – extra low voltage band II
- 110 V dc to 120 V dc lighting and ventilation circuit – extra low voltage band II
- 400 V ac to 415 V ac, 50 Hz, for three-phase climate control modules and battery charger systems
- 240 V ac, 50 Hz, single-phase for headlights, other auxiliary systems and general power outlets

- 120 V dc shore fixed power supply
- 415 V ac, 50 Hz, three-phase shore fixed power supply

The neutral of the EAPS three-phase output shall be earthed and load balanced to minimise neutral return current.

The total harmonic distortion of the EAPS ac output shall be less than 10%.

5.3. Fixed shore power supply interface

A three-phase, 415 V ac, 50 Hz fixed shore power supply socket is available at existing TfNSW passenger rolling stock maintenance centres to provide external power to the train's EAPS. The shore supply circuit is detailed in drawing C83656 *Carriage Inspection Shed 415Volt Train Supply Main Switchboard Arrangement and Control Diagram*. An interlocking system ensures that the power from the shore supply circuit is not present at the end of the shore supply jumper prior to connection to the vehicle.

The EAPS shall interface with the fixed shore power supply circuit detailed in drawing C83656, which includes the interlocking circuit, operating voltage, and maximum circuit breaker ratings.

The EAPS shall be interlocked with the shore supply and the main power supply interface to prevent both systems simultaneously connecting to the train.

The shore supply connection points on the train shall not be energised from any onboard power source including the EAPS.

The EAPS's shore supply interface shall be interlocked with the traction system to stop the traction system from moving the train while the train is connected to the fixed shore power supply.

5.4. EAPS redundancy

The EAPS system shall continue to operate normally through interruptions of input power from one of the OHW current collecting devices supplying the train for up to 15 seconds.

The EAPS system shall provide a level of redundancy such that the failure of one EAPS module in a train will not affect the operation of the train. Any other EAPS modules in the train shall be configured so that they can provide power to the following train circuits and systems:

- control circuits and related equipment
- safety systems, including fire and smoke detectors
- communication systems
- lighting circuits
- battery charger

- video surveillance systems
- event recorders

The EAPS system shall provide a redundant power supply to the climate control system in each vehicle such that the loss of one EAPS module in the train will not result in the complete loss of climate control capacity in any vehicle of the train. Refer to ASA standard T HR RS 08001 ST *Interior Climate Comfort for Passenger Rolling Stock*.

5.5. General power outlets

General power outlets (GPOs) shall comply with the requirements of EN 50153 *Railway Applications - Rolling Stock - Protective Provisions Relating to Electrical Hazards* to prevent electric shocks.

The GPOs shall comply with AS/NZS 3112 *Approval and test specification - Plugs and socket-outlets* and AS 61000.3.100 *Electromagnetic compatibility (EMC) - Limits - Steady state voltage limits in public electricity systems*. The frequency of the public electricity system in Australia is 50 Hz.

GPOs for devices used while a train is in operation, for example, ovens and cash registers, and for maintenance, for example, vacuum cleaners, shall have a maximum power rating of 2400 W.

GPOs intended for passenger use and distributed throughout passenger areas shall limit the power to each GPO to that necessary to operate and simultaneously charge a portable personal computer. The power-limiting system shall be self-resetting and shall remove power before any damage can occur. Reset shall occur after the over-power condition has been removed.

GPOs intended for passenger use shall have a robust childproof cover or a system that ensures power is not available at the socket if an appliance plug has not been fully inserted.

6. Battery systems

A battery system provides backup power to systems critical to safety such as passenger minimum lighting, ventilation, train control, and communication systems when the EAPS power is not available. The battery system includes the individual batteries or energy storage devices, and the battery management and charging system.

Battery systems shall provide backup power to all train systems to maintain the operational safety profile of the train in the absence of EAPS output power.

The battery systems shall maintain power to the emergency lighting and ventilation systems in all vehicles of the train in all credible emergency situations including train separation incidents.

Battery systems shall comply with T HR RS 00117 ST *Electric Circuits and Equipment for Passenger Rolling Stock* and T HR RS 01701 ST *Mounting and Installation of Electrical Equipment*.

All electronic components of the battery systems shall comply with EN 50155.

The battery systems electronics enclosures and cable connectors shall be IP rated in accordance with IEC 60529. The rating shall include the effects of exposure to jets of water from rain up to the maximum train speed and train wash plant water jets. The rating of equipment mounted inside hatches shall consider protection from water exposure that could occur in the event of failure of the hatch or sealing.

The output of all battery banks shall be fitted with an isolation switch that is accessible from within the vehicle.

Both negative and positive poles of all battery banks shall be protected by a fuse that is accessible from within the vehicle. Spare fuses shall be within one meter of the installed fuse and shall be on a fuse holder identical to the active fuse holder.

6.1. Battery systems mechanical requirements

The battery system's batteries shall be mechanically secured to protect against dislodgement during a vehicle derailment or roll-over.

The battery system's batteries shall be safely accessible for replacement or maintenance by maintenance personnel.

If the batteries are accessed from within the vehicle, for example if located under the seats, the battery compartment shall be sealed and vented to the outside of the vehicle to prevent any battery vapours or smoke entering the vehicle. The battery compartment and its sealing system shall withstand any battery fire intensity and duration expected from the battery type used.

6.2. Battery management and charging system

A dedicated battery management and charging system shall manage the monitoring, protection, and charging of the batteries to enable the batteries to function for their minimum operating life, as specified in Section 6.4, and provide information to assist maintenance.

The battery management system shall protect the energy storage device or batteries from the following, where applicable:

- over-current while charging and discharging
- over-voltage while charging
- under-voltage while discharging
- over-temperature

The battery charging system shall charge the batteries from an initial 20% state of charge to 80% state of charge within three hours under normal EAPS operation.

Automatic removal or reduction of charging current shall be used to protect the batteries. Optimised charging cycles shall be used to ensure the specified life of the batteries. An example of an optimised charging cycle is 'IUIU' that uses charging characteristics consisting of constant currents and constant voltage phases.

Passive charging systems that permanently connect the battery banks to the auxiliary dc supply shall not be used. These charging systems provide no active overcharge protection or optimised charging characteristics.

If multiple battery banks are connected in parallel to the same auxiliary dc supply, systems shall be used to ensure that the performance of an individual battery bank shall not have detrimental effects on other banks during charging and discharging.

For battery banks with series-connected batteries, where applicable, the charging system shall prevent the batteries from localised undercharging or overcharging.

The battery condition monitoring system should monitor and provide the following information where applicable:

- voltage: total battery bank voltage, individual voltage of each battery in the battery bank
- temperature: average temperature of the battery bank, or temperatures of individual batteries
- state of charge or depth of discharge that indicates the charge level of the battery
- state of health a measurement of the overall condition of the battery
- coolant flow: for air or fluid cooled batteries where applicable
- current in to and out of the battery

6.3. Battery capacity and emergency load duration

The battery system at 80% state of charge shall have sufficient charge capacity to power the train's emergency loads as specified in Table 2 and Table 3 over the full operating life of the energy storage system.

The battery system shall have excess capacity to start the train, with the pantographs in the lowered position, after providing emergency power for the durations specified in Table 2 and Table 3.

If the control circuit and the lighting circuit have distinct battery banks, a method of temporarily powering the control circuit from the lighting circuit battery banks that automatically isolates the control battery banks shall be available. This is to start the train if the control battery banks are depleted.

The battery system shall be able to continue to provide emergency power, beyond the specified minimum durations in Table 2 and Table 3, up to the point of reaching the state of charge necessary to start the train.

Table 2 - Control circuit emergency load

System to be maintained	Minimum duration
Video surveillance systems	1.5 hours after loss of OHW power
Door control and release	4 hours after loss of OHW power
Train radio equipment, PA and Intercom	4 hours after loss of OHW power
Train controls (at full load)	4 hours after loss of OHW power
Fire detection system	4 hours after loss of OHW power
Event recorder	4 hours after loss of OHW power

Table 3 - Lighting and ventilation emergency load

System to be maintained	Minimum duration
Emergency ventilation	1.5 hours; refer to ASA standard ' <i>T HR RS 08001 ST Interior Climate Comfort for Passenger Rolling Stock</i> '
Emergency lighting	3 hours after loss of OHW power; refer to EN13272, at lighting luminance levels specified in ' <i>T HR RS 12001 ST Interior and Exterior Lighting for Passenger Rolling Stock</i> '
Marker lights on end vehicles of the train	3 days after loss of OHW power

6.4. Energy storage device requirements

The energy storage device or battery type shall have the following characteristics:

- contained in a non-spill case such that no fluids can spill if the batteries are handled or transported in any orientation
- not require refilling of fluids over the operating life of the batteries
- not release gas or vapour during normal operation
- operational over the expected ambient temperature range specified for the train
- construction that complies with the shock and vibration requirements of EN 61373 *Railway Applications - Rolling Stock Equipment - Shock and Vibration Tests*, Category 1, Class B, and Sections 8 through to section 10
- proven minimum operating life of five years before replacement or overhaul in rolling stock applications with the selected battery management and charging system