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T HR RS 00850 ST

Standard

RSU Appendix E – Rolling Stock 1500 V DC Overhead Power Supply Interface Requirements

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1.0	19 December 2014	First issue
2.0	27 June 2019	Second issue Incorporation of TN 023: 2018 affecting Section 5.1
3.0	24 February 2020	Third issue New Section 5.3 on PCMS requirements
1.0	03 March 2025	First issue as TS 04070 superseding T HR RS 00850 ST version 3.0. Version number recommended in line with new designation. Changes include an amendment of the dimensional characteristics of pantograph profiles and updating of references.

Preface

This standard is the first issue as TS 04070 and supersedes T HR RS 00850 ST *RSU Appendix E – Rolling Stock 1500 V DC Overhead Power Supply Interface Requirements*, version 3.0.

This document sets the requirements for rolling stock that interface with the 1500 V dc overhead power supply on the TfNSW metropolitan heavy rail network.

The changes in this document's content to previous content include the following:

- A review of and update to referenced standards
- Amendment of Section 7.2.3.

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1 Scope

This standard specifies requirements and provides guidelines for the electrical interface between the overhead power supply and the vehicle-based systems and components of the TfNSW metropolitan heavy rail network.

Information about the existing electrical and mechanical infrastructure for the metropolitan heavy rail network is outlined in Sections 5 and 6 respectively.

This document provides requirements for:

- collection of current (power) via the pantograph
- electricity management on trains
- information to be made available before new equipment is to be added to the TfNSW metropolitan heavy rail network.

This document does not cover requirements for return of electricity from the train system to the electricity grid.

2 Application

This document applies to the 1500 V dc electrical traction system used on the TfNSW metropolitan heavy rail network. The network consists of the fixed components that enable power to be supplied to trains for traction and auxiliary supply. It may also accept power back to the network when regenerated by the train. Refer to the TS TOC 1 Manual which defines the area associated with the network.

The electrical interface is the interaction of the traction supply with the vehicle-based systems and components. The correct operation of the power supply system can only be determined when the electrical and mechanical interface factors influencing design are known. It is important to note the factors that influence the design of the electrical interface. These factors include the following:

- magnitude of electrical load – stationary and moving, including the type of train, the current required for powering, the current required for auxiliaries, the number of trains operating (that is, the timetable), and the speed of operation
- traction system capacity, including fault levels, protection types, and rate of rise of current
- train mounted equipment, including protection, in-rush current, and input filter characteristics.

The mechanical interface is the complete pantograph, including horns, and the catenary and contact wire that deals with the ability to transfer the required power across the interface.

Factors that influence the design of the mechanical interface include the following:

- movement of the OHW, including contact wire stagger, ambient temperature and crosswind
- characteristics of the pantograph
- characteristics of the collectors on the pantograph
- the number of pantographs on a train, and their spacing.

3 Referenced 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 50119 *Railway applications – Fixed installations – Electric traction overhead contact lines*

EN 50367 *Railway applications – Fixed installations and rolling stock – Criteria to achieve technical compatibility between pantographs and overhead contact line*

Transport for NSW standards

TS 03744 (EP 00 00 00 13 SP) *Electrical Power Equipment – Design Ranges of Ambient Conditions*

TS 03739 (T HR EL 00001 TI) *RailCorp Electrical System General Description*

TS 03800 (T HR EL 08007 ST) *Overhead Wiring Construction and Commissioning*

TS 03802 (T HR EL 08009 ST) *Designations of Overhead Wiring Conductor Systems*

TS 03803 (T HR EL 08010 ST) *Overhead Wiring Conductor System Selection*

TS 03804 (T HR EL 08011 ST) *Overhead Wiring Maintenance Standard*

TS 03805 (T HR EL 08012 ST) *Overhead Wiring Standards for Design and Construction*

TS 03869 *Lightning Protection and Insulation Coordination*

TS 03872 (T HR EL 90002 ST) *Heavy Rail Traction System – Voltage Ratings*

TS 03873 (T HR EL 90003 ST) *Heavy Rail Traction System – Current Ratings of 1500 V dc Equipment*

TS 04003 (T MU RS 17002 ST) *Prohibited and Restricted Materials*

TS 04072 (T HR RS 00870 ST) *RSU Appendix G – Drawings*

TS TOC 1 *Train Operating Conditions (TOC) Manual – General Instructions*

Transport for NSW drawings

CV0131343 *Standard Pantograph Profiles – Suburban/Interurban and Locomotive Rolling Stock* (published in TS 04072 *RSU Appendix G – Drawings*)

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document.

AMB Asset Management Branch

DCCB direct current circuit breaker

HSCB high-speed circuit breaker

OHW overhead wiring

PCMS pantograph condition monitoring system

SH sectioning hut

SS substation

TfNSW Transport for NSW

5 Existing electrical infrastructure system

5.1 General

The main elements of existing electrical infrastructure on the TfNSW metropolitan heavy rail network that trains shall be required to interface with include the following:

- traction power supply
- protection systems for OHW
- specified fault levels and ratings
- a capacity for power regeneration
- surge arresters and transients.

Sections 5.2 through 5.6 summarise relevant information about these elements and advise references for relevant requirements.

5.2 Supply

TS 03739 provides general background to electrical infrastructure and assets located within the Sydney metropolitan rail area.

The existing dc traction system is nominally 1500 V dc. This 1500 V dc traction supply is provided to the OHW from traction substations and is obtained by transforming and rectifying the incoming high voltage (33 kV or 66 kV) obtained from the high voltage ac distribution network.

Silicon diode rectifiers are used to convert the ac voltage to dc. Six pulse and twelve pulse rectification is used.

Failure of one or more diodes can result in 50 Hz voltages appearing on the 1500 V dc.

Ratings of the rectifiers range from 4000 kW to 5000 kW continuous.

The ratings of rectifiers are specified within TS 03873.

Shunt harmonic filters are connected to the 1500 V busbar at the majority of traction substations. These harmonic filters are tuned to 600 Hz and 1200 Hz.

The voltage conditions are as specified in TS 03872.

5.3 Protection

OHW protective devices are sensitive to both current amplitude and rate of rise of current.

Circuit breaker steady state settings are typically 3 kA to 6 kA. OHW sections are usually fed from both ends. DCCB trip levels are sensitive to rate of rise of current. Rates of rise that are less than 60 kA/s have no effect on the trip level. Above this rate of rise, the trip level decreases to 60% of the steady state setting, at 500 kA/s.

Delta I relays are installed on most feeders as a backup to the dc circuit breakers. They are intended to detect limited arcing faults. They are usually set at 2 kA or above.

5.4 Fault levels

Table 1 provides some fault levels and current ratings specified on the 1500 V dc traction power supply system. For further information and relevant requirements, refer to TS 03873.

Table 1 - Fault levels

Description	Maximum fault	Minimum fault
Prospective fault current level at train	75,000 A	3000 A
Corresponding circuit time constant	12 ms	25 ms
Rate of rise of current	6,000,000 A/s	120,000 A/s
SS/SH fault clearing time (maximum)	15 ms	150 ms
Maximum let through current	30,000 A	3000 A

5.5 Regeneration

The traction system is capable of accepting power from regenerating trains only when there are other trains capable of using the regenerated energy. This is usually the case for multiple unit train operation; however, this does not guarantee that the traction system will be receptive at any time.

A small number of substations are equipped with energy dissipating resistances to dissipate energy regenerated by trains, when no other train loads are nearby.

Train current limits are specified in TS 03873.

5.6 Surge arresters and transients

Transient voltages ranging between 3000 V and 5000 V have been measured between contact wire and rail, when testing HSCBs for clearing dc faults.

Surge arresters are installed at locations that include substations, sectioning huts and rail connecting switches. Refer to TS 03869 for specifications and information.

6 Mechanical infrastructure

6.1 General

Sections 6.2 through 6.3 summarise relevant information mechanical infrastructure for rolling stock and advise references for relevant requirements.

Trains shall interface with the OHW parameters including contact wire position heights and gradients, and vertical, horizontal, and lateral forces, and system contact wire tension.

Various combinations of catenary contact systems are applied on the NSW electrified network.

The catenary contact systems, including their cross-sectional areas, are as detailed in TS 03802.

The contact wire material is specified in TS 03802.

6.2 Contact wire position

Under the worst condition of high temperature and cross wind, the design maximum displacement of the contact wire from the superelevated centre line is specified in TS 03805.

The contact wire heights above rail are specified in TS 03805.

The worst contact wire gradient is specified in TS 03805 and in TS 03800.

The maintenance trigger for in service OHW is specified in TS 03804.

The running surface of the contact wire contains mechanical discontinuities which can subject pantographs to vertical forces and horizontal forces in the direction of the pantograph travel. These forces are generally attributed to the following contact wire characteristics and components:

- splices
- section insulators
- kinks.

Diverging and converging contact wire can also subject pantographs to lateral forces at right angles to the direction of pantograph travel. The lateral forces are caused by the pantograph horns striking the contact wires. Generally, such wires would not contact the pantograph horn more than 200 mm below the top running surface of the pantograph. Because the pantograph forces are a function of vehicle speed, the difference in wire heights, the angle of incidence of wire on the pantograph horn and the pantograph pressure, the converging situation is more severe than the diverging situation.

6.3 Contact wire tension

The contact wire tension is influenced by the type of conductor systems used in the design and variations in the ambient temperatures under which they operate.

The range of conductor systems and the design contact wire tension at the design temperature for each system is specified in TS 03802.

The ranges of ambient conditions within which OHW equipment used on the high voltage and traction networks is designed to operate is specified in TS 03744.

The allowable contact wire tension change for regulated OHW is specified in TS 03805.

7 Pantograph requirements

7.1 General

Smooth reliable operation of electric trains requires continuous electrical contact between the pantograph current collection device and the contact wire.

If the pantograph or carbon collector strip becomes damaged or broken resulting in the pantograph returning to the collapsed position, its parts shall not foul or cause damage to the overhead system.

Pantographs on electric multiple unit trains shall be placed so that when the cars are arranged in a train, a minimum of 20 m shall be maintained between any two pantographs to avoid excessive upward thrust by pantographs on to the OHW.

In the case of electric locomotive operations, the maximum number of pantographs that can be raised for any catenary contact systems, as detailed in TS 03802, is given in TS 03803.

7.2 Performance characteristics of the pantograph

7.2.1 General

The pantograph shall remain in continuous electrical contact with the contact wire at any speed up to the maximum operating speed plus any design over speed (typically 10%), as specified in the vehicle's train performance specification, and the contact wire rising or falling gradients as referenced in TS 03805.

The pantograph design shall take into account the dynamic lateral movement caused by track geometrical deviation and train body movement as detailed in TS 03805.

The pantograph shall be capable of rising to its unrestricted full height in 8 s or less under static conditions.

The pantograph shall be capable of falling from its full height to a position within the applicable rolling stock outline, excluding the area designated for the pantograph, within 3 s of the initiating operation.

The pantograph shall be fitted with an automatic drop device that causes the pantograph to lower automatically following any failure of the collector head. Such failures shall include, but are not limited to, the following:

- if the pantograph exceeds 6000 mm height above the rail, then the pantograph shall automatically return to the collapsed position
- pantographs shall have a minimum unrestricted free height of 6000 mm above railhead level on level track when any height limit function is disabled.

7.2.2 Physical characteristics

Pantographs have physical characteristic requirements regarding positioning, movement, dimensions, drag, and resistance to damage.

Pantographs shall be adjustable for upwards static thrust as tabled in TS 03805. Pantographs shall also be set at the minimum thrust consistent with achieving the required dynamic performance.

Where a supplier proposes to use alternative system settings, an assessment of dynamic performance shall be provided by the supplier, if requested by the purchaser.

When in the lowered position, all parts of the pantograph shall fit within the applicable rolling stock outline.

7.2.3 Dimensional characteristics

The drawings in CV0131343 provide dimensioned pantograph profiles for existing trains operating on the TfNSW metropolitan heavy rail network.

Alternative profiles may be used. Where alternative profiles are used, compliance to TS 03805 and TS 03804 shall be demonstrated to the purchaser.

> Note: The design of some particular types of section insulators used in some areas on the TfNSW metropolitan heavy rail network precludes the use of bowed pantograph profiles. Only flat pantograph profiles are compatible.

7.2.4 Pantograph current draw

The maximum current drawn by a pantograph shall not exceed limits imposed by the traction supply infrastructure.

The current draw of a stationary train drawing current from the OHW to supply auxiliary loads for extended periods shall comply with the requirements of EN 50119. The ability for the pantograph to meet this performance requirement shall be tested in accordance with EN 50367 to achieve free access.

The OHW temperature at the point of contact with any single pantograph, when subjected to the maximum current drawn by a stationary train, under any operating condition, shall not exceed 110 C for 30 minutes and shall not exceed 90 C thereafter, as indicated in Figure 1.

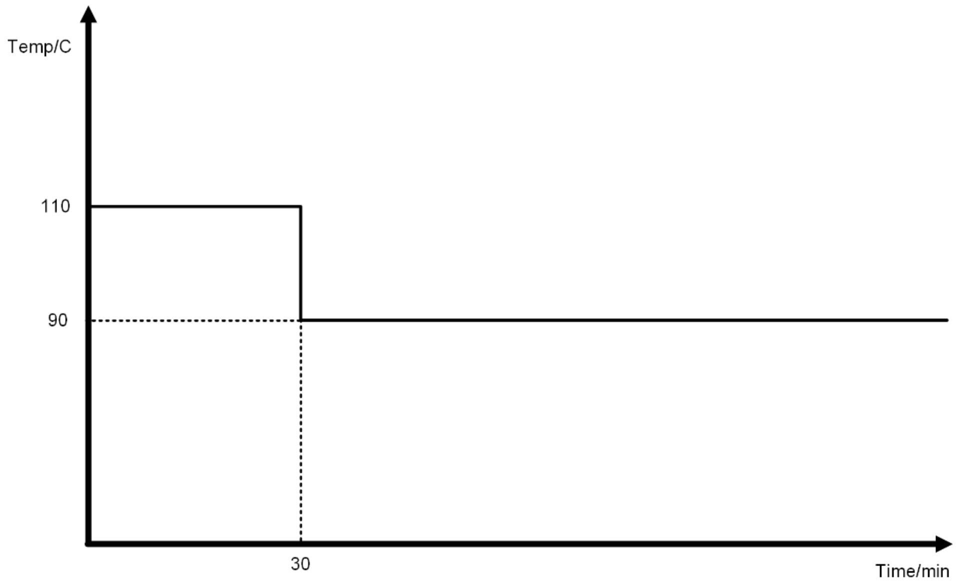

Figure 1 – Maximum OHW temperature at the point of contact with any single pantograph

7.3 Pantograph materials requirements

The material used for the part of the pantograph that makes contact with the OHW has operation, service life, and environmental and safety requirements.

The composition of the contact collector strip material shall be optimised for the vehicle operating characteristics and maximise service life for both the contact collector strip and the contact wire.

The carbon insert shall not include lead or any other prohibited materials, as detailed within TS 04003.

7.4 Pantograph condition monitoring system requirements

PCMS installed on the metropolitan heavy rail network protect the network from damaged or defective pantographs or carbon collector strips which cause overhead infrastructure damage or dewirement incidents. These types of incidents have a significant impact on the safe and reliable operation of the network.

When defective pantographs are identified, alarms are triggered and sent to train control as detailed in TS TOC 1.

To achieve this function, the PCMS is programmed to correctly identify, measure and analyse each unique pantograph head design in operation on the network. The process requires creating a numerical model of the pantograph head (including carbon collector strips and horns) based on drawings and a physical sample in new condition. The model is then entered in PCMS and tested before being released for production use.

Every unique pantograph head design in operation on the network shall be configured for PCMS before commencing operation. Rolling Stock fitted with pantographs operating non-regular services (for example heritage operations) or having pantographs lowered during normal operations (for example mechanised track patrol vehicle) may be exempted, subject to confirmation from the rail infrastructure manager or TfNSW (AMB).

8 Train-borne protection equipment

8.1 Train high-speed circuit breaker

Each power car or locomotive shall be fitted with a HSCB to detect and clear faults. This HSCB should ideally clear any fault before the substation and sectioning hut DCCBs operate. The data provided in Section 5.3 shall be used to determine the requirements of the train HSCB.

8.2 Auxiliary in-rush current

Train equipment shall limit the magnitude of the total in-rush current to 1000 A for any one incidence, with a maximum rate of rise of 60,000 A/s. This in-rush may be repeated at half second intervals.

A high rate of rise of current will trip DCCBs. Raising all the train pantographs simultaneously shall not cause sufficient in-rush current to trip the substation or sectioning hut DCCB.

Train equipment shall limit the magnitude of the total in-rush current such that closing an open substation or sectioning hut DCCB onto a line with one or more stationary trains will not cause sufficient in-rush current to trip the DCCB.

9 Power regeneration requirements

No requirement exists for trains to feed energy back to the grid.

The maximum regeneration voltage shall not exceed the limits stated in TS 03872.

10 Information requirements for new equipment

The following information shall be provided to TfNSW for any new type of equipment, before being introduced onto the TfNSW metropolitan heavy rail network:

- magnitude of electrical load – stationary, powering and regenerating, including:
    - the type of train
    - the number of pantographs
    - the maximum steady state current required for powering on the steepest track grades to be encountered with the heaviest loads
    - the maximum steady state current required for auxiliaries
    - the magnitude of any traction system or auxiliary system step current drawn from the traction supply and its rate of rise
    - the numbers of trains operating (that is, the timetable)
    - the speed of train operation
    - tractive effort versus speed curve.
- pantograph head design (see Section 7.4).