Electric Circuits and Equipment for Passenger Rolling Stock

Version 1.0
Issued Date: 26 June 2014
Effective Date: 26 June 2014

Important Warning

This document is one of a set of standards developed solely and specifically for use on the rail network owned or managed by the NSW Government and its agencies. It is not suitable for any other purpose. You must not use or adapt it or rely upon it in any way unless you are authorised in writing to do so by a relevant NSW Government agency.

If this document forms part of a contract with, or is a condition of approval by, a NSW Government agency, use of the document is subject to the terms of the contract or approval.

This document may not be current. Current standards are available for download from the Asset Standards Authority website at www.asa.transport.nsw.gov.au

© State of NSW through Transport for NSW
### Standard Approval

**Owner:** M Uhlig, Lead Rolling Stock Engineer  
**Authorised by:** D. Spiteri, Chief Rail Engineer  
**Approved by:** J. Modrouvanos, Director Asset Standards Authority on behalf of the ASA Configuration Control Board

### Document Control

**Version**  
1.0  
**Summary of Change**  
First issue

For queries regarding this document, please contact:

standards@asa.transport.nsw.gov.au  
www.asa.transport.nsw.gov.au

© State of NSW through Transport for NSW
Preface

The Asset Standards Authority (ASA) develops, controls, maintains, and publishes standards and documentation for transport assets for New South Wales, using expertise from the engineering functions of the ASA and industry.

The ASA publications include the network and asset standards for NSW Rail Assets.

This document has been developed from existing RailCorp standards and specifications and has been issued by the ASA to provide the requirements for the conditions of operation, design, construction, components, materials and finishes and testing of electronic equipment supplied for passenger rolling stock.

This document supersedes RailCorp standard FE 117 Electric Circuits and Equipment for Passenger Rolling Stock.

Foreword

This standard forms part of a suite of passenger rolling stock electrical standards and should be read in conjunction with those related standards. These include the standards listed below:

- T HR RS 01701 ST Mounting and Installation of Electric Equipment for Passenger Rolling Stock
- T HR RS 00164 ST Electrical Cable for Passenger Rolling Stock
- T HR RS 0126 ST Electronic Equipment Supplied for Passenger Rolling Stock
Table of contents

1. Introduction .......................................................................................................................................5
2. Purpose ..............................................................................................................................................5
   2.1 Scope ..................................................................................................................................5
   2.2 Application .........................................................................................................................5
3. Reference documents.......................................................................................................................6
4. Terms and definitions .....................................................................................................................7
5. Operating environment.....................................................................................................................8
6. General electric circuits and equipment requirements.................................................................8
   6.1 General materials requirements.......................................................................................9
7. Fire protection requirements ...........................................................................................................9
8. Circuit diagrams ................................................................................................................................9
9. Circuits and earthing ......................................................................................................................10
   9.1 Alternating current circuit protection ............................................................................10
   9.2 Direct current circuit protection.....................................................................................10
   9.3 Earthing ............................................................................................................................11
   9.4 Colour coding and marking of cables ...........................................................................11
10. Auxiliary contacts ........................................................................................................................12
11. Power contactors and arc control devices ................................................................................12
12. Coils and windings of small inductances and transformers ....................................................12
13. Cable connectors and plug-in components .................................................................................13
14. Calibrated devices........................................................................................................................13
15. Low voltage, extra low voltage switches and push buttons ......................................................13
16. Circuit breakers ...............................................................................................................................14
   16.1 Circuit breakers on general purpose outlets .................................................................14
17. Fuses ................................................................................................................................................14
   17.1 Low voltage and extra low voltage fuses ......................................................................14
   17.2 High voltage fuses .........................................................................................................14
18. High voltage or heavy current resistors .......................................................................................15
19. Light current resistors ....................................................................................................................15
20. Capacitors ........................................................................................................................................15
21. Electrical measuring instruments .................................................................................................15
   21.1 Instrument accuracy .........................................................................................................15
1. **Introduction**

This document provides the minimum performance requirements and recommendations for the electric circuits and electric/ electro-pneumatic components for TfNSW passenger rolling stock. It covers the mechanical, electrical and fire performance requirements of these items.

2. **Purpose**

This standard details the requirements which must be met by equipment manufacturers who wish to supply equipment for use on TfNSW passenger rolling stock.

This standard aims to ensure the reliability, availability, maintainability and safety of the electric circuit and electric/ electro-pneumatic equipment used in passenger rolling stock.

2.1 **Scope**

This standard covers the following; electric circuits and electric and electro-pneumatic components for passenger rolling stock:

- traction and auxiliary power and control circuits and their components
- communication and auxiliary control circuits and their components
- electric components such as switches, push buttons, circuit breakers and fuses
- electro-pneumatic and electro-magnetic devices such as magnetic valves and high speed circuit breakers

2.2 **Application**

This standard shall apply to new passenger rolling stock and the refurbishment or modifications of existing rolling stock assets. Pending a direction otherwise from the TfNSW contract administrator (or applicable equivalent), contracts and tenders for new or modified passenger rolling stock released before the standard effective date shall be exempt from the requirements of this standard.
3. Reference documents

The following standards are referenced as specific requirements or were consulted in the development of this document:

**Australian standards**

AS 1102 Graphical Symbols for Electrotechnology

**International standards**

BS 6853 Code of practice for fire precautions in the design and construction of passenger trains

EN 50121-3-1 Railway Applications - Electromagnetic Compatibility - Part 3-1: Rolling Stock - Train and Complete Vehicle

EN 50121-3-2 Railway Applications - Electromagnetic Compatibility - Part 3-2: Rolling Stock - Apparatus

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

EN 50163 Railway Applications – Supply voltages of traction systems

EN 50343 Railway Applications – Rolling Stock – Rules for Installation of Cables

IEC 60034-1 Rotating electrical machines – Part 1: Rating and performance

IEC 60051-1 Direct acting indicating analogue electrical measuring instruments and their accessories

IEC 60077-1 Railway Applications – Electric Equipment for Rolling Stock – General Service conditions and general rules


IEC 60077-3 Railway Applications – Electrotechnical components – Rules for DC circuit-breakers

IEC 60077-4 Railway Applications – Electrotechnical components – Rules for AC circuit-breakers

IEC 60077-5 Railway Applications – Electric equipment for rolling stock – Electrotechnical components – Rules for HV fuses

IEC 60349-2 Electrical traction – Rotating electrical machines for rail and road vehicles – Electronic converter-fed alternating current motors

IEC 61373 Railway Applications – Rolling stock equipment – Shock and vibration tests
4. Terms and definitions

The following definitions apply in this document:

**ac** alternating current

**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

**authority** the allocation of responsibility which allows you to act

**auxiliary contact** a contact in a circuit, up to and including low voltage, which is not fitted with arc suppression devices.

**dc** direct current

**enclosure** a closed space in which equipment or terminal boxes are mounted.

**heavy currents** are currents in excess of 30 A.

**HRC** high rupture current

**light currents** currents of 30 amps or less.

**power contact** is a contact not covered by the definition of auxiliary contact.

**RCD** residual current device

**terminal** is a fixed point to which a conductor can be attached.

**termination** device fixed to a cable or other conductor to enable it to be attached to a terminal.

**terminal box** an enclosure containing terminals.

**voltage classification** aligned with EN 50153 clause 4.1. Described in Table 1

<table>
<thead>
<tr>
<th>TfNSW Definition</th>
<th>Band</th>
<th>Nominal voltage ($U_n$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ac V</td>
</tr>
<tr>
<td>extra low voltage</td>
<td>I</td>
<td>$U \leq 25$</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>$25 &lt; U \leq 50$</td>
</tr>
<tr>
<td>low voltage</td>
<td>III</td>
<td>$50 &lt; U \leq 1000$</td>
</tr>
<tr>
<td>high voltage</td>
<td>IV</td>
<td>$U &gt; 1000$</td>
</tr>
</tbody>
</table>
5. Operating environment

The vehicles operate in suburban and outer suburban areas which include tunnels and elevated track.

The operating and design categories shall be approved by the authorised TfNSW contract representative prior to the applying of the requirements of BS 6853 - Code of practice for fire precautions in the design and construction of passenger trains.

Related topic:
Fire protection; section 7

6. General electric circuits and equipment requirements

The following requirements are paramount and are overriding on all clauses of this standard.

Offers of materials, equipment or circuitry that do not comply with these general requirements shall be accompanied by a statement of non-compliance setting out which features do not comply and the reason for the non-compliance and shall be conditional on the approval of a concession to the requirements of this standard by ASA.

This specification shall be read in conjunction with TfNSW standards:

- T HR RS 00164 ST Passenger Rolling Stock Electrical Cable
- T HR RS 01701 ST Mounting and Installation of Electric Equipment

All equipment shall comply with relevant Australian Standard, International Standard or TfNSW Standard. Reference to any standard implies reference to the latest issue at time of tender. Nothing in this clause shall prevent the offering of equipment to other standards, but, in each case, copies of the proposed standard or specification, in English, shall be submitted for approval.

All passenger rolling stock electrical circuits and equipment shall comply with the relevant sections of one or more of the following standards:

- EN 50121-3-1 Railway Applications - Electromagnetic Compatibility - Part 3-1: Rolling Stock - Train and Complete Vehicle
- EN 50121-3-2 Railway Applications - Electromagnetic Compatibility - Part 3-2: Rolling Stock - Apparatus
- EN 50153 Railway Applications – Rolling Stock – Protective Provisions Relating to Electrical Hazards
- EN 50163 Railway Applications. Supply Voltages of Traction Systems
- IEC 60077-1 Railway Applications – Electric Equipment for Rolling Stock – General Service Conditions and General Rules
All materials and equipment shall be suitable for use in the rolling stock environment of New South Wales and remain suitable without attention for use in that environment for a minimum of six years of service, from placing in service, unless otherwise specified in the contract specification. Variance to this period shall specifically be approved in writing via a concession to this standard.

6.1 General materials requirements

Asbestos shall not be used in any form.

Wearing parts shall not contain lead or carcinogenic agents.

7. Fire protection requirements

All new equipment shall comply with the fire protection requirements and recommendations of BS 6853 in its design, material selection and testing. All design categories and operating conditions shall be as per documented in this standard.

8. Circuit diagrams

Major electrical systems and equipment shall be accompanied by a technical manual that includes functional systems diagrams, as well as 'point to point' systems diagrams and detailed descriptions of operation for the purpose of assessment, maintenance, fault finding and future modification activities. In such cases a technical maintenance plan shall also be provided which meets the requirements of engineering standard ESI 0021. These documents, including all notes and symbols, must all be in English.

Circuit diagrams shall be clear and easy to interpret and comply with AS 1102 Graphic Symbols for Electrotechnology or IEC 60617 Graphic Symbols for Diagrams.

The interlocks, contacts and controlled equipment of any device shall be shown or clearly identifiable by reference to only one drawing.

A legend shall be available for all component symbols.

An electrical circuit diagrams package shall be supplied in an editable CAD and searchable PDF electronic format along with a bounded hard copy.

An abbreviations table shall be available to define all abbreviations.

An index showing the drawing zone location of all numbered circuit link/wire and circuit components shall be available.
9. **Circuits and earthing**

Train batteries shall have switches installed in positive side and shall be fused on the positive and negative sides.

Train batteries shall have switches installed in positive and negative rails.

Batteries shall be protected by HRC fuses in both the positive and negative rail.

All dc and single phase circuits shall have one pole of each device connected directly to the negative or neutral line, with no switches, fuses or contacts.

The practice of de-energizing devices by short-circuiting the operating coil is not permitted.

Use of economy resistors or separate pull-in and holding coils for contactor, solenoids or similar devices are not acceptable.

Each circuit function shall be protected by an individual circuit breaker, which shall be clearly and unambiguously labelled.

Where regular switching by hand is anticipated, separate switches shall be provided.

Circuit breakers shall not be used for where regular switching by hand is anticipated.

9.1 **Alternating current circuit protection**

Protection and isolation of ac circuits up to and including low voltage shall be by magnetic circuit breakers backed up by power source circuit breakers.

Sources of ac shall have the neutral earthed and a ganged circuit breaker in each phase.

Proof of adequate protection of the power source by this circuit breaker shall be provided; that is both the machine characteristic and circuit breaker characteristic shall be consistent.

The loading of each phase of three phase power sources shall be within 5% of each other.

9.2 **Direct current circuit protection**

Protection and isolation of dc circuits up to and including low voltage shall be by magnetic circuit breakers backed up by power source fuses, with the exception of motor circuits where HRC fuses shall be used for motors rated at more than 1 kW.
9.3 Earthing

Protective earthing shall comply with EN 50153.

Separate insulated earthing bars shall be provided for the high, low and extra low voltage circuits on each car.

Each circuit shall have a separate insulated wire connecting the negative or neutral to a separate bolted terminal on the respective bars. The ac and dc circuits, or circuits of different voltages, connected to the same earthing bar, shall be arranged in groups of like circuits.

Low voltage and extra low voltage earthing bars shall be directly bonded to the car body.

The high voltage earth return circuits shall be arranged in a manner that avoids the possibility of leakage paths through wheel set bearings and stray ac signal induced currents elsewhere.

Earthing bars for high voltage circuits shall be connected to rail by two separate paths that are insulated from the car bodies of the train up to the earth return brushes on the wheel sets. These two separate paths shall go to wheel sets on separate bogies in the same car. The high voltage earth return cabling shall not have direct electrical connections with the car body or bogie frames apart from the wheel set earth return brushes.

The car body shall be earthed directly to earth return brushes on the wheel sets by at least two separate paths. These two separate paths shall go to wheel sets on separate bogies and these paths shall be independent from the high voltage earthing paths. Intermediate electrical connections to bogies are not permitted.

Bogie frames and bogie-mounted traction motor frames may share common electrical connections to earth return brushes on the wheel sets.

Earthing connections shall be made onto surfaces suitably prepared to provide adequate earthing continuity that is cleared of surface contaminants such as oils or paint.

Special earthing arrangements for electronic equipment where required, shall be submitted to the authorised TfNSW contract representative for approval.

The use of unearthed circuits shall require a concession to this standard.

9.4 Colour coding and marking of cables

The colour coding and marking of cables shall be in accordance with;

**T HR RS 00164 ST** *Passenger Rolling Stock Electrical Cable*.

Three-phase cables shall be numbered in the 100, 200 and 300 series.
10. **Auxiliary contacts**

An auxiliary contact is a contact in a circuit, up to and including low voltage, which is not fitted with arc suppression devices.

Auxiliary equipment that use contacts such as control voltage contactors, relays, master controllers and manual switches should use silver contacts with a self-cleaning action as a method of prolonging contact life.

Condensation of moisture inside the contact enclosure shall be prevented.

Auxiliary contacts should be positioned so as to ensure isolation of creepage from high voltage circuits.

11. **Power contactors and arc control devices**

All power contactors shall be fitted with contact tips, securely fixed to their support and arranged for easy removal without further dismantling.

Contact screws of size M8 or larger shall not be provided with screw driver slots.

Current shall be taken from moving contacts by flexible shunts having crimped end connections, with flared ends to avoid abrasion of the shunt.

Shunts shall be supported and restrained so as to prevent damage due to movement and or vibration.

Passage of current through springs or bearings shall be prevented.

Contacts shall be protected against corrosion.

Power Contacts shall have a wiping action to avoid contact arcing causing deterioration of contact surfaces.

Blow-out coils shall be connected to the positive side of the contacts.

All arc chute components have adequate resistance to erosion and burning from the arcs to which they may be subjected.

12. **Coils and windings of small inductances and transformers**

All coils shall be continuously rated and mechanically suitable for the railway environment.

Encapsulated coils shall be suitable for a temperature in service of up to 150° C. Where the maximum temperature in service will exceed this figure the coil details shall be submitted to the authorised TfNSW contract representative for approval.

Insulated coils shall be fully impregnated to prevent the ingress of fluids.
The coil conductor and its insulation system shall have mechanical protection to prevent any chafing or movement damage caused by normal installation, removal or storage conditions.

Connections to coils shall be to terminals securely fixed to the coil body or adjacent to the coil body so that rewiring is unnecessary on coil replacement.

13. **Cable connectors and plug-in components**

All cable connectors and plug-in components including relays, printed circuit boards, electronic cards or racks shall comply with the following:

- the plug or device shall be adequately and positively secured against working loose by means additional to the friction of the electrical contact
- the plug contacts shall be adequately safe-guarded against failure to make good contact
- incorrect insertion of the plug or device shall be prevented by use of a guide, shield or otherwise
- where non-interchangeable parts have similar plug in components they shall be provided with a means to prevent them being inserted in the wrong position

Circular cable connectors, upon connection, shall produce an audible or otherwise mechanical feedback able to be sensed by the technician to indicate the connector has locked into position.

14. **Calibrated devices**

Calibrated relays or electronic modules shall have their adjusting mechanism securely locked after setting.

15. **Low voltage, extra low voltage switches and push buttons**

Low tension tumbler or rotary switches shall have a quick action mechanism. Switch contacts shall be of the wiper or wiping butt type.

Rotary switches shall be capable of continuous rotation in either direction, and shall have a shaft suitable for the application required to prevent failure between maintenance cycles.

Rotary switches shall have the 'off' position with the operating handle vertical.

Tumbler switches shall have the 'off' position upwards (2 position type) or in the mid position (3 position type) except where otherwise approved.

Push buttons, except where otherwise specified, shall be shrouded and secured from behind. After installation the design shall prevent dismantling from the front by unauthorised persons.
16. **Circuit breakers**

Miniature circuit breakers shall be back connected except where otherwise approved in writing.

Miniature circuit breaker ratings shall be 5 A, 10 A, 16 A, 20 A, 32 A or 40 A, Standard Curve.

In ac circuits above 100 A and up to 400 A, circuit breakers shall be the magnetically tripped type.

The operating lever shall be down in the 'off' or 'tripped' position and the 'off' position shall be clearly marked.

Each circuit breaker shall be labelled with the circuit it protects.

Circuit breakers shall comply with the following standards:

- IEC 60077-3 *Railway Applications – Electrotechnical components – Rules for dc Circuit-Breakers*
- IEC 60077-4 *Railway Applications – Electrotechnical components – Rules for ac Circuit-Breakers*

16.1 **Circuit breakers on general purpose outlets**

All low voltage ac general purpose outlets shall have RCD protection.

17. **Fuses**

Separate requirements exist for the following classes:

- low voltage and extra low voltage fuses
- high voltage fuses

17.1 **Low voltage and extra low voltage fuses**

Low voltage and extra low voltage fuses shall be back-connected.

A fuse tester shall be supplied in the same enclosure as the battery fuses.

Spare fuses of each type shall be mounted in unconnected fuse holders adjacent to each fuse panel, or group of panels in one location. The number of spare fuses of each type at a location shall be equal to the number of fuses of each type divided by three and rounded up.

17.2 **High voltage fuses**


A fuse tester using extra low voltage shall be provided in the same enclosure as the fuse group.

Spare fuses of each type shall be mounted in unconnected fuse holders adjacent to each fuse panel, or group of panels in one location.
18. **High voltage or heavy current resistors**

High voltage or heavy current resistors shall be prevented from shorting out in overload conditions in normal service.

19. **Light current resistors**

Light current resistors greater than 5 W rating shall be of the wire or strip wound type, with the conductor set in vitreous enamel. Where the wire size exceeds 20 SWG the use of vitreous enamel is not mandatory but in all cases the coating, if any, shall not peel off or disintegrate.

The sliders of pre-set resistors shall be adequately locked in position.

Fixed resistors of standard resistance values shall be used, where this is not possible the use of variable resistors shall be subject to a concession to this standard.

The value, rating and tolerance shall be marked on the resistor.

20. **Capacitors**

Electrolytic capacitors shall not be used with single phase capacitor start motors.

Where capacitors are used as part of a surge suppression circuit, the required capacity shall be available at the surge frequency.

Discharge resistors shall not be integral with the capacitors.

21. **Electrical measuring instruments**

All analogue electrical measuring instruments and their accessories shall:

- comply with IEC 60051-1 *Direct acting indicating analogue electrical measuring instruments and their accessories*

- have a true zero and movements suitably damped for railway service

Instruments shall be suitable for mounting in any orientation and on Ferro-magnetic material.

All electrical displays are to be solid state displays.

All instruments and their parts are to be accessible for removal by maintenance staff only.

21.1 **Instrument accuracy**

All instruments shall be accurate to ± 0.75% of full scale or better.