Australian Rail Track Corporation Ltd

Discipline
Engineering Standard

Category
Rolling Stock

Specification for 1500V DC Traction Supply

WOS 01.E

Applicability

ARTC Network wide	
New South Wales	✓
Western Jurisdiction	
Victoria	

Primary Source
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WOS 01.E – Specification for 1500V DC Traction Supply

E[1] Introduction

E1.1 The Australian Rail Track Corporation 1500V dc electrical traction system consists of the fixed components that enable power to be supplied to trains for traction and auxiliary supply. The purpose of the system is to supply electric power to rolling stock for traction and auxiliaries. It may also accept power back to the network when regenerated by the train.

E1.2 The electrical interface is the interaction of the traction supply with the vehicle based systems and components.

Influencing Factors:

- Magnitude of electrical load – stationary and moving, including: the type of train, the current required for powering, the current required for auxiliaries, the numbers of trains operating. ie the timetable, the speed of operation.
- Traction system capacity including: fault levels, protection types, rate of rise of current,
- Train mounted equipment including: protection, in-rush current,

E1.3 The mechanical interface is the pantograph complete (including horns) and the catenary/contact wire and deals with the ability to transfer the required power across the interface.

Influencing Factors:

- Movement of the OHW
- Characteristics of the pantograph
- Characteristics of the collectors on the pantograph
- The numbers of pantographs on a train, their spacing.

E1.4 The correct operation of the power supply system can only be determined when all these factors are known.

E[2] References

IEC RECOMMENDATION Publication 494:- Rules for pantographs of electric rolling stock.
TS 3802 Standard Structure Gauge - 1987
TS 3803 Minimum Structure Gauge - 1987
RAC standards:
EP 90 20 00 01 SP - 1500V dc equipment current ratings
EP 90 20 00 02 SP - 1500V system voltage ratings.
EP 08 00 00 16 SP - Designation of OHW Conductor Systems
Drawing 305 - 981 Pantograph Controlling Dimensions

E[3] Electrical system

This section describes the ‘quality’ and performance parameters of the power supply provided to trains.

E3.1 Supply

The 1500 Volt DC overhead traction system is fed from substations supplied from the 50 Hz AC system of New South Wales grid.

Silicon diode rectifiers are used to covert the ac voltage to dc. Six and 12 pulse rectification is used. Substations are fitted with shunt harmonic filters tuned to 150, 300, 600, 900 and/or Hz depending upon the harmonics produced.

Failure of one or more diode can result in 50Hz voltages appearing on the 1500V dc. Ratings of the rectifiers range from 2000 kW to 5000 kW (continuous).

Voltages

The voltage conditions are as under:-

Nominal no-load voltage at substation:	1600 V
Typical Substation voltage variation:	1500-1750V
Typical lowest voltage at train (depends on other factors):	1100V
Maximum regenerated voltage allowable at train:	2050V

For further information see EP 90 20 00 02 SP - 1500V system voltage ratings.

E3.2 Protection

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

Circuit breaker steady state setting 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 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.

E3.3 Fault levels

	Maximum fault	Minimum fault
Prospective fault 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 (max)	15 ms	150 ms
Max let through current	30,000 A	3000 A

For further information see specification, EP 90 20 00 01 SP – “1500V dc equipment current ratings”

E3.4 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 trains, however there is no guarantee that the traction system will be receptive at any time.

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

E3.5 Surge diverters and transients

Transient voltages ranging between 3000 and 5000 volts have been measured between contact wire and rail, when testing high speed circuit breakers for clearing DC faults.

Substations and Sectioning Huts are fitted with surge diverters with a breakdown voltage of 2100V. For this reason, train regenerated voltages must not exceed 2050V.

E[4] Mechanical Interface

This section describes the Overhead wiring parameters.

E4.1 General

In general the catenary - contact system has total cross section area ranging from 452 mm^2 to 689 mm^2.

See specification EP 08 00 00 16 SP – “Designation of OHW Conductor Systems”, for a full description of OHW types.

The contact wire is hard drawn copper, cadmium/copper alloy or tin/copper alloy, of 137 or 193 mm^2 cross sectional area when new.

E4.2 Contact wire position

Under the worst condition of high temperature and cross wind the maximum displacement of the contact wire from the superelevated centre line is 450 mm.

The contact wire heights above rail are:-

- Maximum contact wire height 5800 mm
- Nominal contact wire height 5200 mm
- Minimum contact wire height 4520 mm

Ramp rates in the order of 1 in 150 can be encountered in the system. The worst ramp rate permitted ie 1 is to (3 times the km/hr of maximum track speed).

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. The converging situation is more severe than the diverging situation, the pantograph forces being 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 magnitude and frequency of forces induced in pantographs by the contact wire and its components are currently unquantified.

E[5] Pantograph requirements

This section sets out the parameters required of all pantographs to be approved to run on the RIC 1500V dc system.

E5.1 General

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

The pantograph must remain in continuous electrical contact with the contact wire at speed up to 160 kms/hr and the contact wire rising or falling at grades of 1 in 200 with respect to the track line

The pantograph shall pass the wearing test outlined below.

The pantograph shall be capable of rising to its full height in 15 seconds or less.

The pantograph shall be capable of falling from its full height to its folded position in 2 seconds or less from the initiating operation.

In the event of the pantograph becoming damaged or broken and returning to the collapsed position its parts should not foul the overhead.

In the event of the pantograph exceeding 120% of the 5800 mm height above the rail the pantograph is to automatically go to the collapsed position.

In the event of any collector strip becoming dislodged from the pantograph, the pantograph shall automatically lower.

Pantographs shall be adjustable for upwards thrust between 80 N and 130 N and be set at the minimum thrust consistent with achieving the dynamic performance herein listed.

The horizontal drag of the pantograph on the contact wire shall not exceed 20 N from zero to 160 kms/hr.

The total upward thrust shall not increase by more than 60 N at any speed of the train up to 160 km/hr and subject to non train generated winds up to 100 km/hr from any direction.

The worst case collector strip wear shall not increase the forces on the OHW by more than 5% over the unworn case.

Pantographs on electric multiple unit trains shall be placed so that when the cars are arranged in a four (4) car consist, there shall be a of minimum of 20 metres between pantographs.

E5.2 Wearing tests

The pantograph contact material shall have life of 25000 km/strip or greater and shall not cause wear to the contact wire in excess of that of the carbon strips used by the SRA in 1996.

E5.3 Heating effect on contact wire of stationary train loads

Current drawn by a stationary train can cause localised heating of the contact wire. To ensure that this does not reduce the tensile strength of the contact wire, the current shall not cause the maximum *temperature rise* of the contact wire to exceed 150°C.

This temperature shall not be exceeded for the case of only one carbon collector strip contacting a single, new, 137mm^2 contact wire, with the nominal upward pressure of the pantograph.

E[6] Train equipment

This section sets out the requirements of the train-borne equipment to be approved for operation on the RAC 1500V dc system.

E6. 1 Train dc circuit breaker

Each power car or locomotive shall be fitted with a dc circuit breaker to detect and clear faults on the car/loco. This dccb should ideally clear any fault before the substation and sectioning huts dccbs operate. It is acknowledged that discrimination of some faults – especially those close to substations, my not be possible. The data provided in section E3 shall be used to determine the requirements of the train dccb.

E6.2 Auxiliary in-rush current

As described in section E3.2, dccb trip levels depend on the rate of rise of current. Raising all the train pantographs simultaneously, or closing an open SS/SH dccb onto a line with one or more stationary trains, must not cause sufficient inrush current to trip the SS/SH dccb.

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 amps/second. This inrush may be repeated at half second intervals. (eg raising one pantograph may cause the above inrush, and it is then acceptable for another similar event to occur 0.5 seconds later. If four pantographs are raised simultaneously, then the max current must not exceed 1000A or the actual startup of each car’s auxiliary load must be staggered by 0.5 s.)

E[7] Information to be provided to ARTC

The following information shall be provided to the Australian Rail Track Corporation for any new type of equipment, before being introduced onto the network.

Magnitude of electrical load – stationary, moving and regenerating, including: The type of train, the current required for powering, the current required for auxiliaries, the magnitude of any step current and its rate of rise, the numbers of trains operating. ie the timetable, the speed of operation.

Train mounted equipment including: protection, in-rush current,

The pantograph contact material shall be offered for approval. Details as to construction, material type, wear characteristics and usage either in State Rail or elsewhere, shall be submitted.

E[8] Informative section

This information is provided to allow prospective offerers of equipment to be better informed as to the RAC 1500V dc traction system.

The greatest distance between substations is approximately 15km on two (2) track section with two (2) intermediate sectioning huts (tie stations). Average distance is 9km with one (1) intermediate sectioning hut.

Four (4) different substation rectifier transformer connection arrangements are used these being.

(a) Centre tapped double star (half wave)
(b) Quad zigzag (half wave)
(c) Parallel star (full wave)
(d) Star - delta series bridge (full wave)

Track feeders are protected with high speed circuit breakers as follows:-

(a) Mitsubishi BHF 30 46%
(b) BTH RJR 712 36%
(c) Ansaldo IRA 1BM 1520 13%
(d) TH, GEC, ASC older types (expected to be replaced with a few years) 5%

Delta I relays, Tsuda Type FE23A are used in conjunction with the circuit breakers.

Relay setting of 1.5 kA, 2.5 kA and 3 kA are used at present, in a system with a time constant of approximately 20ms.

Metal oxide surge diverters are to meet these characteristics:-

Nominal voltage 1500 V

Maximum system voltage 2100 V

Minimum critical operating voltage 2800 V

Maximum residual voltage:-

5.0 kV crest at 2.5 kA
5.3 kV crest at 5 kA
5.7 kV crest at 10 kA
6.2 kV crest at 20 kA

wave shape **8** x **20** micro second.