

TRANSPORT FOR NSW (TfNSW)

TfNSW SPECIFICATION D&C TS914

MOTORWAY SYSTEMS - ELECTRICAL POWER SUPPLY AND DISTRIBUTION SYSTEM

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REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 0	Global	First issue as “OMCS Requirements – Electrical Power Supply and Distribution System”, based on non-D&C Specification TS914 Ed 1/Rev 1. Specification reorganised and reworded to improve clarity.	A/GM, CS (J Staugas)	14.06.17
Ed 1/Rev 1	2.1 5.8	Spec title changed. Clauses rearranged and reworded to improve clarity. Material and IP rating requirements for HV enclosures and LV enclosures relocated to Annex F. HV enclosures and LV enclosures to comply with Annex F added. Reference to D&C TS931 for LV main switchboard requirements. Reference to D&C TS932 for tunnel and underpass electrical services works added. Update of minimum required duration of UPS power. Circumstances for use of alternative power sources clarified. Consolidating EPSD system design requirements for tunnels, long underpasses and roadways New clause on Roadway and Other Buildings.	DCS	10.06.20
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		References to “RMS Representative” changed to “Principal”.		



MOTORWAY SYSTEMS - ELECTRICAL POWER SUPPLY AND DISTRIBUTION SYSTEM

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VERSION FOR: DATE:

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FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW D&C TS914 Edition 1 Revision 1.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

- Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.
- Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

TfNSW SPECIFICATION D&C TS914

MOTORWAY SYSTEMS - ELECTRICAL POWER SUPPLY AND DISTRIBUTION SYSTEM

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for electrical power supply and distribution (EPSD) system for tunnel equipment and electrical infrastructure along motorways, to provide safe operating conditions for the full range of operational requirements, including emergencies.

This Specification is applicable to the tunnels, long underpasses and roadways on Motorways.

Power over Ethernet requirements are stated in Specification TfNSW D&C TS915.

1.2 RELATED SPECIFICATIONS

This Specification is a Level 2 document which forms part of the suite of TfNSW specification documents for the Motorway Systems (see figure below). Other documents within the suite are:

Level 1

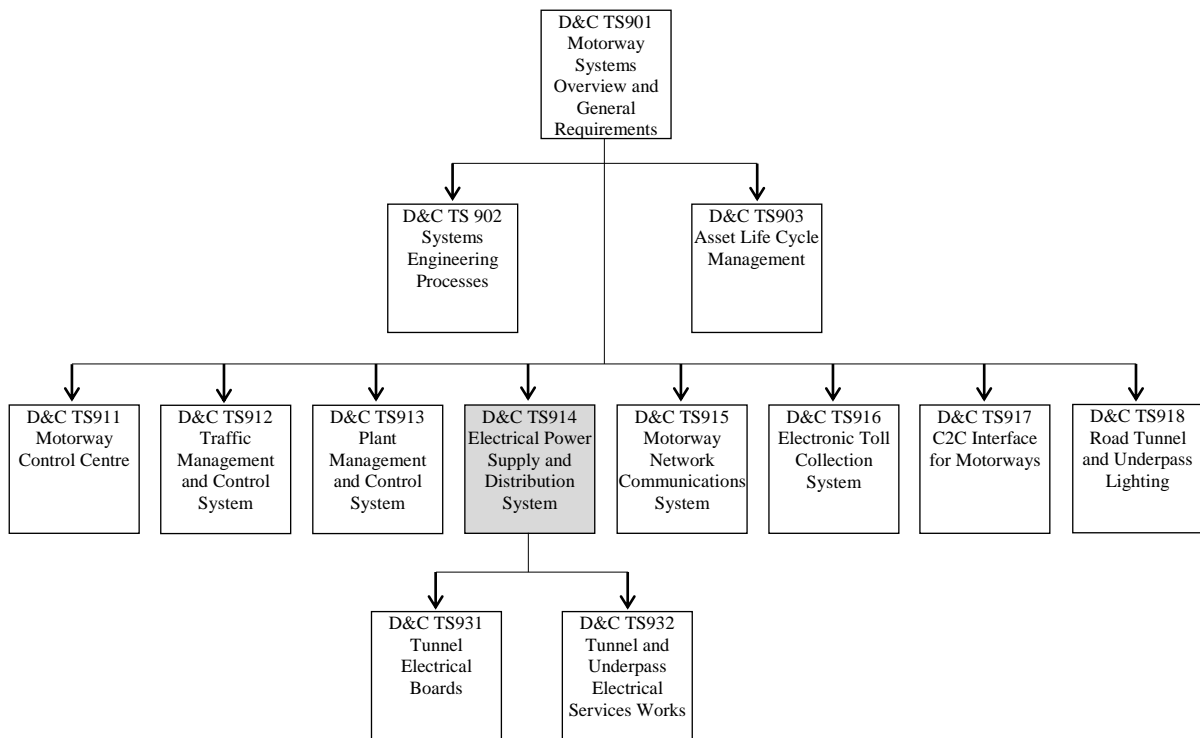
- D&C TS901 “Motorway Systems Overview and General Requirements”;

Level 2

- D&C TS902 “Systems Engineering Processes”;
- D&C TS911 “Motorway Systems - Motorway Control Centre”;
- D&C TS912 “Motorway Systems - Traffic Management and Control System”;
- D&C TS913 “Motorway Systems - Plant Management and Control System”;
- D&C TS915 “Motorway Systems - Motorway Network Communications System”;
- D&C TS916 “Motorway Systems - Electronic Toll Collection System”;
- D&C TS917 “Motorway Systems - C2C Interface for Motorways”;
- D&C TS918 “Motorway Systems - Road Tunnel and Underpass Lighting”;

Level 3

- D&C TS931 “Tunnel Electrical Boards”;
- D&C TS932 “Tunnel and Underpass Electrical Services Works”.



1.3 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.3.1 (Not Used)

1.3.2 (Not Used)

1.3.3 Schedules of HOLD POINTS and Identified Records

The schedules in Annexure TS914/C list the **HOLD POINTS** that must be observed. Refer to Specification TfNSW D&C Q6 for the definition of **HOLD POINTS**.

The records listed in Annexure TS914/C are **Identified Records** for the purposes of TfNSW D&C Q6 Annexure Q/E.

1.3.4 (Not Used)

1.3.5 (Not Used)

1.3.6 Referenced Documents

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 2350). For convenience, the full titles are given in Annexure TS914/M.

1.4 DEFINITIONS AND ACRONYMS

1.4.1 Definitions

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

Electricity Supply Authority	The Electricity Distributor within whose distribution area the electrical installation is situated or where the installation work is carried out.
Firm power supply	The grade of power supply which is derived from a connection within the Electricity Supply Authority zone substation. This is where there are N components of each type forming the power supply connection and that connection will maintain the rated capacity of power supply with (N-1) components in service.

1.4.2 Acronyms

The following acronyms apply to this Specification:

AC	Alternating current
CCTV	Closed circuit television
C2C	Centre to Centre
DC	Direct current
EPSD	Electrical power supply and distribution
HV	High voltage
IEC	International Electrotechnical Commission
ITS	Intelligent transport system
LED	Light emitting diode
LV	Low voltage
MCC	Motorway Control Centre
MNCS	Motorway Network Communications System
OMCS	Operations Management and Control System
PMCS	Plant Monitoring and Control System
PVC	Polyvinyl chloride
TMCS	Traffic Management and Control System
SPD	Surge protection device
SWTC	Project Deed Scope of Works and Technical Criteria
UPS	Uninterruptible power supply
VMS	Variable message sign(s)

2 EPSD SYSTEM DESIGN – GENERAL

2.1 DESIGN CRITERIA

- (a) The design of the EPSD system for tunnels, long underpasses and roadways must be in accordance with the specific requirements of the Project Deed Scope of Works and Technical Criteria (SWTC) and the requirements of relevant Authorities, and must take into consideration the power requirements of all equipment connected along the Motorway.

- (b) Except where otherwise required by this Specification, the following design codes must be used where applicable:
 - (i) TfNSW Specifications;
 - (ii) Australian Standards;
 - (iii) PIARC publications (produced by the Permanent International Association of Road Congresses).
- (c) The design of electrical components must comply with the standards of the relevant Electricity Supply Authority and AS/NZS 3000.
- (d) For tunnels and long underpasses, the design of electrical components must also comply with Specifications TfNSW D&C TS931 and TfNSW D&C TS932.
- (e) For roadways power system:
 - (i) The power distribution cableway design must comply with Specification TfNSW D&C R155.
 - (ii) The design of electrical components must comply with the standards of the relevant Electricity Supply Authority and AS/NZS 3000.
- (f) All voltage drop calculations must be based on a maximum voltage drop under the maximum expected load from any operational condition, including Incident conditions of 4% calculated from either the Electricity Supply Authority LV point of connection or the LV terminals of the relevant Motorway substation transformer, whichever is applicable, to any point in the installation. Cable sizes must be selected to suit.
- (g) The design of the electrical services power supply and reticulation must ensure that correct voltage levels are maintained to all connected equipment.

2.2 COMPATIBILITY

- (a) The EPSD system must be compatible with the existing computer systems, equipment and communication networks used in the TfNSW OMCS.

2.3 CAPACITY AND REDUNDANCY

- (a) The EPSD system must be designed with adequate redundancy to ensure that failure of any part of the EPSD system does not adversely impact the operation of the Motorway, and to allow maintenance to be performed on any part of the EPSD system, without affecting the normal operation and traffic capacity of the tunnel.
- (b) Redundancy requirements do not apply when there is planned or unplanned maintenance on a redundant part of the EPSD system.
- (c) The EPSD system must include all cableway infrastructure throughout the Motorway required for the power distribution on the Motorway.

3 TUNNEL POWER SYSTEM

3.1 ELECTRICITY SUPPLY

- (a) The Contractor must make arrangements with the relevant Electricity Supply Authority for the provision of two firm and secure permanent high voltage (HV) power supplies to the tunnel substation(s).
- (b) Supply to the tunnel substation(s) must be in accordance with the following:
 - (i) Supply must be by connection to the Electricity Supply Authority's power distribution system for the area.
 - (ii) Supply must be by provision of multiple feeders from separate zone supply substations or from separate HV sections of a transmission or sub-transmission substation. Each feeder must be capable of supplying the total load requirements of the particular tunnel substation.
 - (iii) Automatic changeover facilities must be provided within the low voltage (LV) network and arranged in such a manner that the transfer of load from one feeder to another does not adversely impact on the electricity supply HV network or the electrical integrity of the system. Automatic changeover equipment must have independent backup battery supply to enable changeover during mains failure.
 - (iv) Feeders must be installed in separate ductlines, physically isolated from one another such that failure of one feeder will not affect the others. Ductlines must generally be encased in concrete.
 - (v) Separation of pilot and inter-trip wiring must be maintained in accordance with the Electricity Supply Authority requirements. Such cables must be physically isolated from the feeders so that any major disruption or failure of a feeder cable will not impact on the pilot and inter-trip control wiring.
 - (vi) All equipment of the EPSD system must be designed such that they can be safely accessed and isolated for maintenance, to minimise tunnel closures or other impacts on tunnel operation.

3.2 HIGH VOLTAGE DISTRIBUTION

- (a) HV distribution must be in accordance with the following:
 - (i) Each substation must be supplied from the two separate incoming supplies. Each supply must be connected to its respective HV switchgear.
 - (ii) In all instances, HV substations must be separated from each tunnel carriageway by a barrier of at least FRL ---/240/240 fire rating. The HV supply along one carriageway must be separated from the HV supply along the other carriageway by a barrier of the same FRL.
 - (iii) HV switchgear must be provided for complete protection and control of incoming HV supplies, HV supply reticulation within the tunnels, transformers and ring feeder connections.
 - (iv) HV circuit breakers must comply with the standards of the relevant Electricity Supply Authorities, AS 62271.200 (all parts) and AS 62271.100. Circuit breakers selected must be of make and model that is commonly used, and available for procurement in Australia.

- (v) Multiple transformers must be provided in each tunnel substation to allow for redundancy and to carry the full load during failure or maintenance. The transformers must be separated from each other by a barrier of at least FRL ---/240/240 fire rating.

The substation(s) supplying power to ventilation plant, essential services and lighting must have sufficient rated transformer capacity to continuously supply 120% of the full design load with any one transformer out of operation.

The changeover mechanism to transfer the transformer source must be located on the downstream main low voltage switchboard that automatically transfers supply, upon failure of one source, to the other transformer.

Transformers must comply with Electricity Supply Authority requirements, AS 2374 and AS 60076. Where dry type transformers are supplied, the requirement of AS 3953 must be followed. Transformers located underground must be of the encapsulated dry type.

- (vi) The locations of the substations must ensure that correct voltage levels are maintained throughout the tunnels for all services. Automatic tap-changing facilities must be provided to maintain voltage levels within specified tolerances, if the Contractor's power supply design analysis indicates that tap-changing facilities are necessary.
- (vii) The material and ingress protection rating for HV enclosures/equipment must comply with Annexure TS914/F.

HOLD POINT

Process Held:	Connection for provision of two firm and secure permanent HV power supplies to each tunnel substation.
Submission Details:	Drawings, design reports, engineering data, and Electricity Supply Authority approval to connect HV power supplies.
Release of Hold Point:	The Nominated Authority will consider the submitted documents prior to authorising the release of the Hold Point.

3.3 LOW VOLTAGE DISTRIBUTION

- (a) LV distribution must be in accordance with the following:
 - (i) Modular design metal clad switchboards (including switchgear) for the protection and control of LV supplies must be provided to all tunnel lighting systems, control and management systems, ventilation, pumping, fire protection, surveillance systems, communication systems, the Motorway Control Centre (MCC), administration/maintenance and plant buildings, general lighting, power and air conditioning equipment.
 - (ii) All equipment, including lighting and emergency systems, must be protected against voltage fluctuations induced from any source.
 - (iii) The Mains Transient Voltage must be determined from the Overvoltage Category and the AC mains supply voltage in accordance with Table 2J of AS 60950.1. For equipment supplied from an AC mains supply, the Mains Transient Voltage for Overvoltage Category II must be greater than 2.5 kV.
 - (iv) Equipment that may be subject to transient overvoltages that exceed those for its design Overvoltage Category must have the installation designed to provide additional protection external to the equipment.

- (v) Adjacent distribution boards must be fed from separate supplies with a minimum of two supplies required for each portion of tunnel. A minimum of two switchboards or distribution board pairs must service each portion of tunnel. Each switchboard must typically supply 50% of the load for that portion. The supply to the second switchboard, or distribution board pair, must be from the alternate electrical power supply.

Switchboards and distribution boards and their construction must be of the topology that allows for any single switchboard to be taken out of service without compromise to tunnel operations or resilience required.

Distribution boards may have a single source of supply where the services fed from that distribution board are interleaved with that from the adjacent distribution board such that loss of a single distribution board does not affect the ability of the tunnel to operate normally.
- (vi) Automatic transfer of load between transformers in each substation must be provided to eliminate shutdown in case of transformer failure or supply failure. Interlocked withdrawable main circuit breakers must be provided in each main switchboard for automatic transfer of load.
- (vii) LV switchboards must comply with TfNSW D&C TS931.
- (viii) All LV switchboards must be fitted with a multifunction power analyser to monitor measurements such as Power Factor, voltage, and power readings.
- (ix) Circuit breakers must be provided for the protection and control of all outgoing submains to lighting and mechanical services distribution boards.
- (x) The material and ingress protection rating for LV enclosures, including control panels and switchgears, must comply with Annexure TS914/F.

3.4 SYSTEM PROTECTION

- (a) System protection must be in accordance with the following:
 - (i) Main incoming supply protection relays must be of modular type and sourced from suppliers with recognised and established technical support facilities. These relays must be type approved by the Electricity Supply Authority.
 - (ii) All protection relays must be multi-function industrial processor based with choices of inverse time current characteristics, definite time ranges and other relevant parameters. These relays must be monitored by OMCS and must provide visual and audible alarms.
 - (iii) Relay settings must be coordinated by the Contractor with the Electricity Supply Authority to achieve correct time current grading in the power system.

3.5 POWER FACTOR CORRECTION

- (a) Power Factor Correction must be supplied in accordance with the requirements of the Electricity Supply Authority for maintenance of Power Factor in the electrical power supply at a minimum of 0.9 under all conditions. Attention must be given to voltage levels as capacitor banks are switched in and out.

3.6 HARMONICS

- (a) Facilities must be provided to meet the requirements of the Electricity Supply Authority for limiting the effect of harmonics impressed on the power supply system by the tunnel electrical loads.

3.7 STANDBY GENERATORS

- (a) Where dual tunnel mains supply feeders are unavailable due to the existing electricity supply arrangement in the area, diesel prime generators must be provided in lieu of one of the mains feeders.
- (b) The standby generator supplied must:
 - (i) be designed and located for ease of access and maintenance;
 - (ii) be fully housed, with the housing structure design consistent with the urban design and surrounding features, and comply with the specified noise abatement requirements. The housing must be secured and monitored for unauthorised entry;
 - (iii) be suitably rated to take the full load of the essential tunnel electrical systems UPS controlled systems (refer Clause 3.8), tunnel base lighting, fire protection systems, tunnel warning and emergency equipment;
 - (iv) be designed for full power immediately upon start-up;
 - (v) be provided with a “load bank” for maintenance and “exercise”;
 - (vi) be designed for automatic start-up in the event of a mains power failure;
 - (vii) be provided with fuel storage for at least 4 hours operation under full load;
 - (viii) if located within or adjacent to any part of the tunnel, be housed in a fire rated structure and comply with the fire safety requirements for tunnel plant and equipment;
 - (ix) be provided with fuel spillage containment measures;
 - (x) provide comprehensive monitoring and alarm information to the tunnel PMCS, including fuel level, running, fail to start, amp load, and all generator fault conditions.

3.8 UNINTERRUPTIBLE POWER SUPPLY SYSTEM

- (a) Uninterruptible power supply (UPS) systems must be in accordance with the following:
 - (i) A network of UPS systems, including batteries, must be provided to supply essential loads.
 - (ii) UPS must be provided to fire detection and protection systems if a loss of power supply could render the fire detection and protection systems inoperable, and, in the event of a fire, would result in damage to components of equipment in tunnel, or adversely impact the safe operations of the tunnel.
 - (iii) The UPS system must include automatic static bypass transfer of essential loads in case of a UPS system fault, including overload, and automatic recovery on fault clearance. The UPS system must also be provided with maintenance bypass switching facilities.
 - (iv) The UPS system must provide facilities for automatic detection of faulty and failing batteries within banks of batteries in the UPS. Detection of faulty individual batteries must raise an alarm in the OMCS fault management systems.
 - (v) UPS must be provided for illuminated exit signage, emergency lighting and illuminated directional exit signage in accordance with AS/NZS 2293.
 - (vi) The minimum duration that UPS is required to provide power supply to support the operation of the tunnel system is specified in Table TS914.1.
 - (vii) The Contractor must calculate the heat rise during power loss, and if the temperature inside enclosures or equipment rooms is likely to exceed the equipment maximum temperature limits, the enclosure cooling fans or room air conditioners must also be

backed up by UPS to ensure that the equipment will operate during the required autonomy time.

Table TS914.1 – UPS Requirements

Load Type	Equipment Type	Minimum Duration
Essential loads	(a) Communications and monitoring equipment (b) Control systems/controllers (c) Computer and safety facilities (d) Signage (excluding emergency egress signage) (e) Tunnel warning and emergency equipment (f) Emergency power outlets (g) Closed circuit television (CCTV) cameras	30 minutes
Emergency lighting Emergency egress signage	(a) Illuminated exit sign (b) Illuminated directional exit sign (c) Emergency lighting (or minimum 10% of carriageway lighting)	As per AS/NZS 2293 requirements
Radio services	(a) Radio communication Services: Operations and Maintenance Radio, Government Radio Network, Police UHF, TfNSW UHF, Mobile	90 minutes
MCC and DRS loads	(a) All critical MCC and DRS systems, including fire detection and protection systems, but excluding fire pumps for tunnel and MCC	4 hours

3.9 ELECTRICAL INSTALLATION

- (a) Electrical installation must be in accordance with the following:
- (i) The installation of electrical components must comply with the standards of the relevant Electricity Supply Authority, AS/NZS 3000 and TfNSW D&C TS931 and TfNSW D&C TS932.
 - (ii) Conduits, cable fastening and support devices, cubicles, trunking, cable tray, junction boxes, metal work and cabling must comply with TfNSW D&C TS932. Fire resistance of these components must achieve the system requirements set out in items (v) and (vi) of this Clause.
 - (iii) Cabling, junction boxes and elements supporting the cabling and junction boxes that are exposed to the carriageway must have a fire rating of two hours.
 - (iv) PVC conduits are acceptable where such conduits are encased in concrete with sufficient cover to attain the required fire rating.
 - (v) Electrical installation must be protected to a fire protection classification level of WS52W, in accordance with AS/NZS 3013. This is not required for electrical installation in equipment rooms or outside tunnel carriageways where the installation is protected within fire rated structures for minimum of two hours at 450°C.
 - (vi) The provisions of this Clause apply to all electrical installation in tunnels, including but not limited to power, electrical control, instrumentation, communications and fibre optic systems.

3.10 BUILDINGS, SUBSTATIONS AND EQUIPMENT ROOMS

- (a) Buildings, substations and equipment rooms must be in accordance with the following:
- (i) They must be finished to a condition which prevents generation of dust and particles within the room. Concrete floors must be coated with a durable polyurethane finish or approved equivalent finish to seal the floor surface. Doors in the closed position must provide effective air flow sealing.
 - (ii) They must be sealed against water ingress through walls, ceilings, floors and cable access ducting.
 - (iii) A drainage scheme must be provided for any substation, which will provide protection from any potential water ingress. The drainage scheme must be connected to the tunnel drainage network. Any drainage scheme must include protection to prevent potential backflow due to downstream flooding of the drainage systems.
 - (iv) They must comply with the requirements of AS/NZS 3000 and AS 2067 and have environmental controls to ensure that durability of the equipment is not affected by the atmosphere or tunnel environment, including ingress prevention of contaminated and vitiated tunnel carriageway air.
 - (v) In all instances, LV main switchboards and their incoming power supply must be separated from each tunnel carriageway by a barrier of at least FRL ---/240/240 fire rating.
 - (vi) They must be designed to:
 - provide adequate temperature control management by means of efficient, redundant air-conditioning systems;
 - prevent the effects of hydrocarbon soot build up on conductors;
 - limit the amount of dust build-up in the equipment room by ensuring a positive pressurisation level relative to the carriageway;
 - support maintenance routines specific to underground installations.
 - (vii) Where heat generated by the equipment in substations and electrical equipment rooms is greater than the heat dissipated naturally to the surrounding, appropriate mechanical cooling must be provided to maintain the actual temperature within the manufacturer's recommended working temperature limits. Mechanical cooling must not induce dust particles in the air. Air intake from tunnel must not be used for cooling purpose.
 - (viii) Alternative power sources (e.g. solar) may be used for non-essential equipment in buildings located outside tunnels, provided that this alternative power source still allows the OMCS to achieve its required availability for its functions. Use of alternative power sources must comply with Clause 5.4.

4 LONG UNDERPASS POWER SYSTEM

4.1 ELECTRICITY SUPPLY

- (a) The Contractor must make arrangements with the relevant Electricity Supply Authority for the provision of a firm and secure permanent LV power supply to the long underpass substation(s).
- (b) Supply to each long underpass substation must be provided in accordance with the following:
- (i) Supply must be by connection to the Electricity Supply Authority's power distribution system in the area.

- (ii) Supply must be by provision of multiple power supply feeders from two separate and physically isolated power supplies, which have a firm rating. Each feeder must be capable of supplying the total load requirements of the long underpass electrical services.
- (iii) An automatic changeover facility must be provided within the main switchboard network and arranged in such a manner that the transfer of load from one feeder to another does not adversely impact on the electricity supply network or the electrical integrity of the system.

4.2 LOW VOLTAGE DISTRIBUTION

- (a) LV distribution must be in accordance with the following:
 - (i) Modular design metal clad switchboards (including switchgear) for the protection and control of LV supplies must be provided to all long underpass lighting systems, control and management systems, ventilation, pumping, surveillance systems, communication systems, general lighting, and power.
 - (ii) All equipment, including lighting and emergency systems, must be protected against voltage fluctuations induced from any source.
 - (iii) The Mains Transient Voltage must be determined from the Overvoltage Category and the AC mains supply voltage in accordance with Table 2J of AS 60950.1. For equipment supplied from an AC mains supply, the Mains Transient Voltage for Overvoltage Category II must be greater than 2.5 kV.
 - (iv) Equipment that may be subject to transient overvoltages that exceed those for its design Overvoltage Category must have the installation designed to provide additional protection external to the equipment.
 - (v) Adjacent distribution boards must be fed from separate supplies with a minimum of two supplies required for each portion of the long underpass.
 - (vi) LV main switchboard must comply with TfNSW D&C TS931.
 - (vii) Circuit breakers must be provided for the protection and control of all outgoing submains to lighting and mechanical distribution boards.
 - (viii) The material and ingress protection rating for LV enclosures, including control panels and switchgears, must comply with Annexure TS914/F.

4.3 POWER FACTOR CORRECTION

- (a) Power Factor Correction must be supplied in accordance with the requirements of the Electricity Supply Authority for maintenance of Power Factor in the electrical power supply at a minimum of 0.9 under all conditions. Attention must be given to voltage levels as capacitor banks are switched in and out.

4.4 STANDBY EMERGENCY POWER

- (a) Standby emergency power must be provided for the security of essential loads in the event of incoming mains power failure. This must include either:
 - (i) diesel powered standby generators which will automatically start up upon detection of mains failure and run until mains power is restored.

or

 - (ii) UPS with battery backup to maintain essential loads without a break to operational and safety systems for a limited time;

- (b) Automatic start standby generating equipment must be provided where there are loads beyond the capacity of the UPS such as drainage pumps, fire safety systems and ventilation plant which need to be operated under mains failure conditions to maintain the security of the long underpass infrastructure and systems.

4.5 ELECTRICAL INSTALLATION

- (a) Long underpass electrical installation must be in accordance with the following:
 - (i) The installation of electrical components must comply with the standards of the relevant Electricity Supply Authority, AS/NZS 3000, TfNSW D&C TS931 and TfNSW D&C TS932.
 - (ii) Conduits, cable fastening and support devices, cubicles, trunking, cable tray boxes, metal work and cabling must comply with TfNSW D&C TS932.
 - (iii) Cabling, junction boxes and elements supporting the cabling junction boxes must have a fire rating of two hours.
 - (iv) PVC conduits are acceptable where such conduits are encased in concrete with sufficient cover to attain the required fire rating.
 - (v) Electrical installation must be protected to the level of WS52W in accordance with AS/NZS 3013 against damage by the operation of fire protection systems, by spillage, by cleaning operations or by any other form of water ingress or mechanical damage.
 - (vi) The provisions of this Clause above apply to all electrical installations in long underpasses, including but not limited to power, electrical control, instrumentation, communications and fibre optic systems.

5 ROADWAYS POWER SYSTEM

5.1 ELECTRICITY SUPPLY

- (a) The Contractor must make arrangements with the relevant Electricity Supply Authority for the provision of a secure permanent LV power supply along the roadway to provide power to one or more Main Distribution Points.
- (b) Supply to the roadway Main Distribution Points must be provided by any one of the following:
 - (i) connection to the Electricity Supply Authority's power distribution system in the area;
 - (ii) attachment to the nominated Points of Supply;
 - (iii) alternative power sources, in the event that electrical power supply is not available for remote sites (refer Clause 5.4).

5.2 LOW VOLTAGE DISTRIBUTION

- (a) LV distribution must be in accordance with the following:
 - (i) Modular design metal clad switchboards (including switchgear) for the protection and control of LV supplies must be provided to all roadway lighting systems, control and management systems, surveillance systems, communication systems, the Motorway Control Centre (MCC), administration/maintenance buildings, general lighting, power and air conditioning equipment.

- (ii) All equipment, including lighting and electrical equipment, must be protected against voltage fluctuations induced from any source.
- (iii) The Mains Transient Voltage must be determined from the Overvoltage Category and the AC mains supply voltage in accordance with Table 2J of AS 60950.1. For equipment supplied from an AC mains supply, the Mains Transient Voltage for Overvoltage Category II must be greater than 2.5 kV.
- (iv) Equipment that may be subject to transient overvoltages that exceed those for its design Overvoltage Category must have the installation designed to provide additional protection of the installation external to the equipment.
- (v) Lightning protection must be provided for all roadside equipment and structures in accordance with AS 1768. The risk for losses due to lightning, the tolerable risk R_a , must be less than 10^{-3} for loss of service to the public, which represents the tolerable probability of that loss occurring over the period of a year.
- (vi) Lightning protection for local installations must be provided at the main switchboard with Primary and Secondary protection stages incorporating Surge Protection Devices (SPDs) with series impedance and low pass filters.
- (vii) The use of SPDs must be provided with coordinated Primary and Secondary protection of supply where long distance distribution of electrical power is involved, in order to take advantage of the distance between the main switchboard, sub-distribution boards, and final load circuits by providing coordinated Primary and Secondary protection.
- (viii) LV switchboards must comply with AS/NZS 61439.2 requirements for Form 3b verification test.
- (ix) Circuit breakers must be provided for the protection and control of all outgoing submains to all roadway lighting systems, control and management systems, surveillance systems, communication systems, general lighting, and power distribution boards.
- (x) All LV enclosures, including control panels and switchgears, must comply with Annexure TS914/F and Specification TfNSW TSI-SP-012.
- (xi) Roadside equipment housings with a switchboard that is not fed from the Motorway/Tunnel substation will be regarded as a separate electrical installation for earthing and isolation purposes under AS/NZS 3000, incorporating a main switch and Multiple Earth Neutral (MEN) connection and earth electrode.

5.3 POWER FACTOR CORRECTION

- (a) Power Factor Correction must be supplied in accordance with the requirements of the Electricity Supply Authority for maintenance of Power Factor in the electrical power supply at a minimum of 0.9 under all conditions. Attention must be given to voltage levels as capacitor banks are switched in and out.

5.4 ALTERNATIVE POWER SOURCES

- (a) Alternative power sources may be used to provide power to non-critical Motorway and MCC electrical infrastructure or where there is no electrical power supply from the grid available (e.g. remote sites). Use of alternative power sources requires approval from the Principal.
- (b) A power selection matrix must be prepared to assess the suitability of an alternative supply to each remote roadway installation substation, taking into account the time of day and duration of the maximum and minimum power requirements. The environmental factors at each remote location must be incorporated into the design to determine the most effective energy source for the system.

- (c) Alternative power options include:
- (i) Stand-alone generator sets driven by diesel, petrol or LPG powered motors in critical situations where clusters of equipment are located in remote locations. Such generators must be provided with a secured weather-proof housing/cabin for maintenance purposes. Remote monitoring of the generator sets via the OMCS must be provided.
 - (ii) Solar power supply where the equipment is located with an unobstructed view of the sky primarily in northerly direction.
 - (iii) Wind driven generator to provide supplemental power for small clusters of equipment, and in situations where such equipment must be located in the open.
 - (iv) Primary storage batteries or hybrid charging systems incorporating UPS or DC system battery banks.

5.5 BATTERY BACKUP AND UNINTERRUPTIBLE POWER SUPPLY SYSTEMS

- (a) Battery backup and UPS systems must be in accordance with the following:
- (i) A network of monitored battery backup or UPS systems, including batteries, must be provided to supply loads for the backup times as listed in Table TS914.2.

Table TS914.2 – Equipment Battery Backup and UPS Systems Backup Time

Equipment Type	Backup Time (hr)
Tolling	12
Controller for VMS/ISLUS	12
Emergency Telephones	12
Traffic Monitoring Units	12
CCTV	12
OMCS Equipment	12
UHF Radio Services Equipment	4
Emergency Lighting	2
MNCS Equipment	12
All other equipment	1

The battery backup system calculations must be carried out for each electrical distribution cabinets depending on the type and power consumption of the equipment supplied. Dedicated battery backup systems may be considered to cater for the variance in the backup time.

- (ii) The UPS system, if used, must include automatic static bypass transfer of essential loads in case of a UPS system fault, including overload, and automatic recovery on fault clearance. The UPS system must also be provided with maintenance bypass switching facilities.
- (iii) The UPS system must provide facilities for automatic detection of faulty and failing batteries within banks of batteries in the UPS. When faulty batteries are detected, an alarm must be raised in the fault management systems in the OMCS.

5.6 ELECTRICAL INSTALLATION

- (a) Roadways electrical installation must be in accordance with the following:
 - (i) The power distribution cableway installation must comply with TfNSW D&C R155.
 - (ii) The installation of electrical components must comply with the standards of the relevant Electricity Supply Authority and AS/NZS 3000.
 - (iii) Conduits, cable fastening and support devices, cubicles, trunking, cable tray boxes, metal work and cabling must be designed to withstand the outdoor environment.
 - (iv) All cables must be colour coded for the appropriate phase as per AS/NZS 3000 and must be fitted with permanent labels at the point of connection in the switchboard identifying the destination and circuit number.
 - (v) Circuit protection devices must be fully coordinated to achieve complete discrimination so that, in the event of a fault, there is no interruption to upstream supplies to earth circuits.
 - (vi) Traffic control Intelligent Transport System (ITS) equipment must be connected to a different main switch as that for lighting. The traffic control ITS power circuit must be provided with a warning “not to be turned off” attached next to the switch.
 - (vii) All electrical switchboard doors must be fitted with a three point locking system.
 - (viii) The provisions of this Clause above apply to all electrical installations along the roadway, including but not limited to power, electrical control, instrumentation, communications and fibre optic systems.

5.7 ROADSIDE TRAFFIC MANAGEMENT INFRASTRUCTURE

5.7.1 Traffic Management and Control Systems

- (a) The roadways power system must cover all the locations on the Motorway and meet the power requirements of all Traffic Management and Control System (TMCS) equipment, including, but not limited to:
 - (i) MNCS hubs;
 - (ii) roadside controller systems;
 - (iii) Motorway CCTV management systems;
 - (iv) vehicle detectors (traffic monitoring units) producing flow, speed and occupancy data for various types of vehicles;
 - (v) UHF radios services.

5.7.2 Driver Advisory and Traffic Lane Control Devices

- (a) The roadways power system must cover all locations on the Motorway and meet the power requirements of all Driver Advisory and Traffic Lane Control Devices equipment, including, but not limited to:
 - (i) VMS;
 - (ii) variable speed limit signs (VSLS) / integrated speed limit and lane usage signs (ISLUS);
 - (iii) lane use signals;
 - (iv) movable physical barriers;
 - (v) movable medians;

- (vi) changeable message signs (CMS).

5.8 ROADWAY AND OTHER BUILDINGS

- (a) The installation of electrical components must be in accordance with AS/NZS 3000 and the standards required by the relevant Electricity Supply Authority
- (b) Roadways MCC, depots and other buildings can utilise HV or LV power supplies from the local Electricity Supply Authority.
- (c) UPS systems must be installed in accordance with Clause 5.5.
- (d) If a secure dedicated HV or LV supply authority power arrangement is not utilised, then a generator complete with automatic change over must be installed to maintain power to the MCC in case of power outages for extended periods.
- (e) Alternative power sources (e.g. solar system) may be utilised for non-essential buildings and amenities loads (e.g. hot water systems, decorative lighting).
- (f) Other buildings which are ancillary to Motorway operations (e.g. Operations and maintenance office facility, storage facility) must comply with this Clause.

6 LIGHTING

- (a) In addition to relevant roadside traffic management infrastructure requirements elsewhere in the SWTC and the electrical installation requirements in this Specification, the lighting design and installation for tunnels and long underpasses must comply with AS/NZS 1158 and TfNSW D&C TS918.
- (b) For roadways, the lighting design and installation must comply with the requirements stated in the preceding paragraph except that, for AS/NZS 1158, it must comply with category V3.

ANNEXURES TS914/A AND TS914/B – (NOT USED)

ANNEXURE TS914/C – SCHEDULES OF HOLD POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.3.3.

C1 SCHEDULE OF HOLD POINTS

Clause	Description
3.2	Connection for provision of two firm and secure permanent high voltage power supplies to each tunnel substation.

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TfNSW D&C Q6 Annexure Q/E.

Clause	Description of Identified Record
3.2	Drawings, design reports, engineering data, and Electricity Supply Authority approval to connect power supplies for tunnels, long underpasses, and roadways.

ANNEXURES TS914/D TO TS914/E– (NOT USED)

ANNEXURE TS914/F – MATERIAL AND INGRESS PROTECTION RATING FOR ENCLOSURES

All enclosures, including control panels, switchgears (HV and LV) and transformers, must comply with Table TS914/F.1 as a minimum for their specified locations:

Table TS914/F.1 – Material Type and Ingress Protection Rating For Enclosures

Location	Material Type	Ingress Protection (Minimum)
Inside environmentally controlled equipment rooms	Steel or Stainless Steel 316	IP 41
Outside Equipment Rooms within Tunnel	Stainless Steel 316	IP 65
Roadways	Stainless Steel 316	IP 65

ANNEXURES TS914/G TO TS914/L – (NOT USED)

ANNEXURE TS914/M – REFERENCED DOCUMENTS

Refer to Clause 1.3.6.

TfNSW Specifications

TfNSW D&C Q6	Quality Management System (Type 6)
TfNSW D&C R155	Design and Construction of Underground Cableways
TfNSW D&C TS901	Motorway Systems Overview and General Requirements
TfNSW D&C TS902	Systems Engineering Processes
TfNSW D&C TS911	Motorway Systems - Motorway Control Centre
TfNSW D&C TS912	Motorway Systems - Traffic Management and Control System
TfNSW D&C TS913	Motorway Systems - Plant Management and Control System
TfNSW D&C TS915	Motorway Systems - Motorway Network Communications System
TfNSW D&C TS916	Motorway Systems - Electronic Toll Collection System
TfNSW D&C TS917	Motorway Systems - C2C Interface for Motorways
TfNSW D&C TS918	Motorway Systems - Road Tunnel and Underpass Lighting
TfNSW D&C TS931	Tunnel Electrical Boards
TfNSW D&C TS932	Tunnel and Underpass Electrical Services Works
TfNSW TSI-SP-012	General Requirements for Roadside Equipment Housings

Australian Standards

AS/NZS 1158	Lighting for roads and public spaces
AS 1768	Lightning protection
AS 2067	Substations and high voltage installations exceeding 1 kV a.c.
AS/NZS 2293	Emergency lighting and exit signs for buildings
AS 2374	Power transformers - Minimum Energy Performance Standard (MEPS) requirements for distribution transformers
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand wiring rules)
AS/NZS 3013	Electrical installations - Classification of the fire and mechanical performance of wiring system elements
AS 3953	Loading guide for dry-type power transformers
AS 60076	Power transformers
AS 60950.1	Information technology equipment - Safety - General requirements
AS/NZS 61439.2	Low-voltage switchgear and controlgear assemblies - Power switchgear and controlgear assemblies (IEC 61439-2, MOD)
AS 62271	High-voltage switchgear and controlgear

AS 62271.100	High-voltage alternating-current circuit-breakers (IEC 62271-100, MOD)
AS 62271.200	A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV (IEC 62271-200, MOD)