Government of South Australia
Department for Infrastructure and Transport

Public Transport Standard: Electrical Infrastructure Engineering – Design

Asset Management

CS5-DOC-003511

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1. Introduction

This standard specifies the requirements for the design of Electrical Infrastructure and Lighting Systems for railway stations and other infrastructure on the Adelaide Metropolitan Passenger Transport networks.

2. Purpose

The purpose of this Standard is to outline the design requirements for the Electrical Infrastructure, Lighting Systems and Pit & Conduit systems at the station precinct.

3. Scope

This Standard applies to all projects and to contractor organisations designing, constructing, or maintaining electrical infrastructure associated with rail passenger stations and tram or bus stops for the metropolitan transportation networks.

4. Related Documents and Drawings

DOCUMENT NAME	DOCUMENT NUMBER
Typical Single Line Diagram for an Electrified Railway Station	004-A2-12-115
Standard Drawing – Stations – Lighting Control Requirements – Functional Diagram	CS4-DRG-359802
Standard Drawing – Tram Stops – Isolated Power and Lighting – Typical Schematic Diagram	CS2-DRG-365211
Standard Drawing – Pedestrian Crossings – Lighting Control Requirements – Functional Diagram.	TC4-DRG-200014
Standard Drawing – System Electrical – Small Indoor Distribution Board with DALI Control – Layout and Equipment Details	CS5-DRG-365195
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Standard Drawing – System Electrical – Tilt-Down Camera (Joint Use) Poles, 7m & 8.5m Height – General Arrangement	CS4-DRG-362575
Standard Drawing – Isolation Transformer – 230V : 230V, 15kVA – Typical Arrangement	TP4-DRG-004185
Station Precinct Lighting 8.5 m and 5.5 m Lighting and Joint use CCTV and Light Pole, Pile footing and Anchor Details – for information	S7071, sheet 27
Standard Drawing – Stations Electrical Services – Lighting Pole Internal Wiring – Equipment Arrangement	CS4-DRG-350285
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Typical Electrical Arrangement for a Neighbourhood Rail Station	004-A2-11-033
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Seaford Line – Goodwood Underpass – Maintenance Lights Remote Control – Circuit Diagram	CS1-DRG-350295

Standard Drawing – Bicycle Enclosure – Card Reader Circuit Diagram	CS5-DRG-350182
Standard Platform Details – General Assembly of Cage & Mirror	735-A1-10-197
Standard Platform Details – Recessed Enclosure for Power Outlet in DTEI Mirror Pole	735-A2-11-029
Standard Platform Details – Typical Installation and Footing for Mirror Poles	735-A3-10-164
Electrical and Mechanical Clearances for the 25 kV Electrified Train Network	TP1-DOC-000389
Public Transport Standard: Earthing & Bonding (was AR-PW-PM-SPE-00129002, D Part 061)	TP4-DOC-003507
Guidelines for the Protective Provisions Relating to Electrical Earthing and Bonding for the Adelaide Metro Electrified Rail Network (commonly referred to as the E&B Guidelines)	AR-EL-STD-0102
Guidelines for Low Voltage Electrical Earthing and Bonding for the Adelaide Metro Tram Network	TP2-DOC-002020
Public Transport Standard: Security Systems (was AR-PW-PM-SPE-00129015, D Part 075)	PI5-DOC-003512
Public Transport Standard: Passenger Information Systems for Rail (was AR-PW-PM-SPE-00129016, D Part 076)	PI1-DOC-003513
Public Transport Standard: Equipment Room – Engineering – Design (was AR-PW-PM-SPE-00129017, D Part 077)	CE5-DOC-003514
Public Transport Standard: Design – Stations – Toilet Facilities (was AR-PW-PM-SPE-00129008, D Part 067)	CS1-DOC-003510
Lifts for Public Transport Infrastructure	CS1-DOC-002336
Supply and Installation of Conduits and Pits	RD-EL-C3
Pit and Conduit Standard for Signalling and Communication Cables	PTS-MS-10-SG-STD-00000094
Road Lighting Design	RD-EL-D1
Conduit Design for Road Lighting, Traffic Signals and ITS	RD-EL-D3

5. References

- *AS/CA S009 Installation Requirements for Customer Cabling (Wiring Rules)*
- *AS 1158 Lighting for Roads and Public Spaces (Set)*
- *AS 1680 Interior and Workspace Lighting*
- *AS 1735.2 Lifts, escalators and moving walks – Passenger and goods lifts – Electric*
- *AS 1742.3 Manual of uniform traffic control devices – Traffic control for works on roads*
- *AS 2293.1 Emergency escape lighting and exit signs for buildings – system design, installation and operation*
- *AS 2648.1 Underground marking tape – Non-detectable tape*
- *AS 3000 Electrical Installations (Wiring Rules)*
- *AS 3008.1.1 Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and Including 0.6/1 kV – Typical Australian Installation Conditions*
- *AS 3013 Electrical Installations – Classification of the fire and mechanical performance of wiring system elements*
- *AS 3084 Telecommunications installations – Telecommunications pathways and spaces for commercial buildings*
- *AS 3100 General Requirements for Electrical Equipment*
- *AS 3996 Access Covers and Grates*
- *AS 4312 Atmospheric Corrosivity Zones in Australia*
- *AS 60076.11 Power Transformers – Dry-type Power Transformers*
- *AS 61558.1 Safety of Power Transformers, Power Supplies, Reactors and Similar Products*
- *AS 61558.2.4 Safety of Power Transformers, Power Supplies, Reactors and Similar Products. Requirements and Tests for Isolation Transformers and Power Supply Units incorporating Transformers.*

- *AS/NZS CISPR15 Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment*
- *AS4282 Control of Obstructive Effects of Outdoor Lighting*
- *DSAPT Disability Standards for Accessible Public Transport*
- *IEC 62386 Digital Addressable Lighting Interface (DALI) (Set)*
- *TS 085 – 2006 Trenching and Conduit Standard for Underground Cable Networks – South Australian Power Networks (SAPN)*
- *TS 087 – 2005 Construction Standard (SAPN)*
- *TS 100 – 2006 Electrical Design Standard (SAPN)*
- *TS 102 – 2005 Easement Standard (SAPN)*
- *TS 105 – 2007 Testing Standard (SAPN)*
- *WEBB Lighting Report, 2004 Queensland Rail Network – Lighting of Station Environment to Comply with Disability*

6. Application

Railways have ‘stations’, while tramways and buses have ‘stops’. Throughout this document the term ‘station’ is used for convenience, but all requirements herein, unless specifically noted, apply equally to:

- heavy rail stations on the Adelaide Metropolitan Rail Network (AMPRN);
- tram Stopes on the AMPRN’s tram network,
- bus Infrastructure (interchanges, car parks, the O’Bahn, etc.) and
- other public transport infrastructure as required (for example, underpasses and car parks).

The term “L1” is used herein to denote a lighting circuit that remains on all night, while “L2” denotes a lighting circuit that turns off (or dims) at night between the last evening service and the first morning service (‘ALBF’).

7. General

The design works for station projects must include, but are not limited to, the following items:

- new mains power supply connection or existing mains power supply upgrade;
- electrical infrastructure;
- lighting system;
- consideration of future works; and
- design works necessary to isolate the 25 kV or 600 V traction return from the incoming utility supply Multiple Earth Neutral (MEN) and to prevent circulating or traction fault current in the neutral of station supplies.

  ***Note**:* A neutral connection to traction earth is required within the electrified railway or tram environment to limit touch potential from the power supply protective earth to traction earthed metalwork. At the boundary of the rail alignment, power supply protective earthed objects such as lighting masts could be within touch distance of MEN earthed objects and the supply to these objects needs to be isolated from traction earth.

8. Design Requirements – Reticulation

8.1. SAPN Supply Point

The Contractor must design the power loading for the station and organise any SAPN upgrade required to the electrical supply point and associated infrastructure to meet the power demands of the new or upgraded station, plus a 20% minimum factor for future increases.

Sites incorporating large pumping stations will require two separate supplies—refer to section 9.9.9 below.

8.2. Site, Platforms and Structures

The Department’s standard pits and conduits must be utilised on site wherever practicable. Conduit routes must comply with the following:

- utility services required to traverse the rail corridor at a site with an overpass must be via the overpass structure;
- utility services required to traverse the rail corridor at a site without an overpass must be via undertrack conduits in accordance with *PTS-MS-10-SG-STD-00000094 – Pit and Conduit Standard for Signalling and Communication Cables*.
- a minimum distance of 300mm must be maintained between structure footings and conduit trenches;
- conduit for shelter luminaires must be reticulated in the cavity of the Alucobond station sign—refer drawing *No. S7071*, sheet 22;
- With the exception of the fourth dot-point above, all electrical cables and conduits must be concealed within the shelter structural framework—fabrication and construction techniques must be co-ordinated to accommodate this requirement;
- Where conduits cannot be practically concealed within the structure, cabling may be fixed to the exterior of the structure within a galvanised conduit in a continuous run to a minimum height of 3 metres with the prior approval of the Department; and
- All shelter cable entries require access to the concealed cables. Access covers must comprise flush cover plates as shown on drawing *624-A3-11-315 Details of Conduit Entry into Shelter Columns or Poles*. Covers must be fixed with M6 anti-vandal metal-thread fixings (larger size bolts must not be used).

8.3. Enclosed Areas

Enclosed areas include the Common Equipment Room (CER), bicycle enclosure, toilet facilities and waiting rooms.

Conduits from a pit adjacent to the enclosed area must penetrate through the floor slab. Conduits must be installed within wall cavities and ceiling space (where available) to provide simple cable access to enclosed areas.

8.4. Co-ordination

- The Contractor must co-ordinate the electrical services design with the design requirements of:
  - *TP4-DOC-003507 – Public Transport Standard: Earthing and Bonding on electrified train or tram territory;*
  - *PI5-DOC-003512 – Security System; and*
  - *PI1-DOC-003513 – Passenger Information System for Rail; or*
  - *PI6-DOC-003515 – Passenger Information System for Trams and Buses;*
- Early investigation of existing power supply requirements must be undertaken to determine if existing supply is satisfactory for new demands. The Contractor must allow for all requirements to connect new power demands to existing power supply. The Electricity Supply Authority must be notified of the installation of an isolation transformer down-stream of the service point for their information and consideration in the network analysis; and
- Where practical, lighting may share 'joint-use' (camera) poles with CCTV cameras, refer to *PI5-DOC-003512 – Security System* for camera pole requirements.

8.5. Labelling

All equipment must be labelled using a standard approved naming convention. The Contractor must allocate appropriate designations for transformers, switchboards, cables, circuits, light poles and camera poles. Labels must correspond to the terminology and identifying number of the respective item. Labels must be in English, legible, permanent, and robust, and must comply with the requirements of *AS 3100: General Requirements for Electrical Equipment* as a minimum.

9. Design Requirements – Electrical Infrastructure

9.1. Power Distribution Network

- The power distribution network must provide power supply to the station precinct as required.

- For new and large sites, the power supply must be a 400 V, 3 phase, 50 Hz system and the designed electrical network must be capable of supporting this system. For small, upgraded train or tram sites, it may be possible to retain (and upgrade) the existing single-phase supply.
- The maximum electrical power demand of the station must be calculated in accordance with *AS 3000: Electrical Installations (Wiring Rules).*
- A minimum of 30% spare capacity must be allowed for future or unknown loads/demands.
- The power distribution network will include all or part of the following components in quantities as required:
  - Power Transformer;
  - Main Switchboard (referred to as the MSB);
  - Isolation Transformer;
  - Main (isolated) Distribution Board (referred to as the MDB);
  - Sub-Distribution Boards (referred to as DB2 – DBn);
  - Cabling including consumer mains cables and sub-main cables;
  - Sub-circuits and associated cabling and wiring;
  - Cable pits, conduits, and ducts;
  - Power Monitoring System; and
  - Earthing System.
- All aspects of a train station or tram stop's electrical system must be designed and installed strictly in accordance with *TP4-DOC-003507 – Public Transport Standard: Earthing and Bonding* and with reference to either drawing *004-A2-12-115 Typical Single Line Diagram for an Electrified Railway Station* or *CS2-DRG-365211 Tram Stops – Isolated Power and Lighting – Typical Schematic Diagram.*

9.2. Power Transformer

- Large public transport sites may require their own supply transformer. Power transformers must be in accordance with the Electricity Supply Authority's specification.
- On rail sites, the power transformer must be placed outside the Over-Head Contact Line Zone and Pantograph Zone (OHCLZPZ) and at least 2.5 m away from any structure that is bonded to the Common Bonded Earth of the AMPRN.
- The transformer must be earthed such that the earthing system impedance (with the traction earth bond disconnected) must comply with *AS 3000*: *Electrical Installations (Wiring Rules)*, Clause 5.7.4.
- Refer to the Earthing and Bonding (E&B) Guidelines, noting that the sheaths of incoming HV supply cables are required to be gapped, in compliance with the Guidelines, if a 2.5 metre separation from structures to the Common Bonded Earth cannot be achieved.

9.3. Main Switchboard

- All of SAPTA's public transport assets require a metered supply.
- The switchboard which houses the Retailer's metering device will be referred to as the Main Switchboard (MSB).
- The MSB must supply power to Distribution Boards (if any) and may also incorporate sub-circuits for lighting and power as suitable. On electrified traction territory, often the MSB's role is solely to feed the isolation transformer, however it may also feed non-isolated loads such as a carpark, as indicated on drawing *004-A2-12-115*.
- The MSB is usually outdoors and is usually made up of a minimum of two separate compartments:
  - A metering section for the Retailer's meter and Main Switch (Meter Isolator) and, possibly, the Service Fuses. The lock for this compartment must be keyed to SAPTA's 'K9800CM'.

  - A distribution section to supply power to Distribution Boards (if any) along with any local sub-circuits for lighting and power as suitable. This compartment must be keyed to 'K9800'.
- For low-demand sites (for example, tram stops), install the isolation transformer in a separate compartment within the MSB. Drawing *CS1-DRG-363217* shows an example.
- The MSB must be able to cater for the maximum power demand plus a minimum of 30% additional capacity.
- All MSBs must be provided with a white Communications conduit. Refer to Section 9.8 below.

9.3.1. MSB Location and Construction

- The MSB is usually an outdoor, free-standing, pad-mounted cubicle. Alternatively, suitably small boards can be mounted onto the outside wall of an Equipment Room.
- It must be located such the Retailer's staff (agents) can access the metering compartment without needing to enter the rail corridor.
- Outdoor switchboards must be of heavy-duty sheet steel construction (or powder-coated stainless steel if located in a coastal area that may be regarded as Category C4 to *AS 4312*: *Atmospheric Corrosivity Zones in Australia*) and:
  - Have 3-point locking on doors equal to or taller than 500mm;
  - Be fitted with heavy-duty 'swing handles' (Select Lock or equivalent) that can accept either a C4 pin tumbler lock or a padlock. Locks must be keyed to the Department's standards, as above;
  - Have their compliance/rating plates mounted inside;
  - Be labelled externally using aluminium or stainless-steel labels laser cut fully through;
  - Have their fixings located inside the galvanised plinth;
  - Be fitted with vents (passive cooling);
  - Be fitted with fans and 5-sided heat-shields if the enclosure contains lighting control or other electronic equipment;
  - Have an internal switched light; and
  - Be coloured mid-grey or to the project's specification.
- A typical small MSB is shown on drawing *004-A1-80-524.*

9.4. Isolation Transformer

- The purpose of an isolation transformer is to isolate the SAPN power network from the rail Mains supply. The transformer is normally located within the rail corridor and must be no less than six metres from the MSB and the SAPN MEN earth stake.
- The isolation transformer(s) must comply with the manufacturing and installation requirements set out in Appendix 1. Drawing *TP4-DRG-004185* provides detail for the manufacture of small (15 kVA) transformers and guidance for larger units.
- All wiring associated with the transformer must be double insulated and primary and secondary cables/wiring must be physically segregated. By way of example, they must not share the same conduit or terminal box.

9.5. Main Distribution Board

- There will be a distribution switchboard 'downstream' from the MSB, which will be referred to as the Main Distribution Board (MDB). On electrified traction rail territory, the MDB will be fed from the isolation transformer.
- The MDB will contain the main lighting and power sub-circuits and also must have provision to house the DALI lighting control system.
- The MDB must be installed inside the equipment room so that the lighting control electronics benefit from the air-conditioned environment.

- The MDB must provide a minimum of 30% spare capacity.
- An indoor cabinet must:
  - Be of medium-duty sheet steel construction, and;
  - Have side-by-side doors with one door housing distribution and the other containing only lighting control;
  - Have the control electronics mounted at an ergonomic height;
  - Have a socket outlet (GPO);
  - Have 3-point locking on doors taller than 600mm;
  - Have flush-mounted door handles (Kiroo A/HF8V Series or similar);
  - Be ventilated;
  - Be coloured orange; and
  - The lighting control equipment must have two colours of wiring duct installed with one colour being white (communications).
- A typical small MDB is shown on drawing *CS5-DRG-365195*.

9.6. Sub-Distribution Boards

- The station may have Sub-Distribution Boards (DB2 to DBn) as required, unless the MDB is relatively close to the loads.
- The number of sub-circuits crossing rail or tram tracks must be kept to a minimum; as such SDBs must be mounted on that side of the track that has the least number of consumers and loads.
- The SDB must be provided with a lighting 'Test' button and a DALI network port for the connection of a local laptop computer for maintenance purposes. It must not be necessary to open the board's internal escutcheon to access the port. A socket outlet (GPO) must be provided adjacent to the port. The port and power outlet may either be both external to the board or both internal.
- Note that a separate isolation transformer with an independent secondary connection to traction earth is required for SDB's in excess of 500m from the MSB. Refer to the E&B Guidelines.

9.7. Surge Protection

- For large installations, both the MSB and the MDB must be provided with a surge arrestor device. For small installations, it may be sufficient to protect only the MDB or, in some cases, only the circuit feeding the control electronics.
- Units must preferably be protected by a low-impedance circuit breaker (Novaris type SCB or equivalent) or a HRC fuse.
- Surge arrestors must be fitted with segregated, normally-closed alarm output terminals. The alarm output will be ELV and must be isolated from the mains circuits by a minimum of 4 kV. It must be fed to an input of the DALI lighting control and arranged to be remotely monitoring by the MERLINS application.
  Note: Designers are reminded that, on electrified rail territory, the MSB's alarm signal will need to cross the 'isolation boundary' and so will need to be transmitted over optical fibre. (Relays or contactors are not considered to provide sufficient segregation.)

9.8. Power Monitoring System

- A stand-alone 'Power Logic' Power Monitoring System (PMS) must be provided.
- The PMS must have the facility to be connected to a Central Monitoring System located in a remote location via the communications system. All metering devices within the switchboards except for the Electricity Supply Authority meter must be connected to the PMS. The PMS cables must be reticulated through communications conduits. Co-ordination with other communications system cables is required for conduit allocation.

9.9. Sub-Circuits

- The Contractor must specify each sub-circuit on the switchboard's single line diagram and allocate supply phases to each circuit to balance the load across the

phases. In three-phase lighting sub-circuits, only one phase must enter the pole and be connected to the luminaire.

- Below is a list of sub-circuits (comprising of protective devices, conduit runs and cables) for stations.

9.9.1. Lighting

Lighting circuits include but are not limited to:

- Platforms;
- Shelters;
- Bus Interchanges;
- Lifts, Stairs and Overpasses;
- Primary access and access paths;
- Bicycle Enclosure;
- Equipment Room;
- Car Parks; and
- Subways.

9.9.2. Power outlets including Shelter and Bicycle Enclosure General Purpose Outlets

- IP 56 outdoor rated 15 A, 250 V switched power outlets must be provided every 40 m of sheltered platform, mounted with a height of 1900–2000 mm above the finished platform surface.
- The outlets must be recessed into a shelter column, flushed to the exterior, fitted with a padlock-able cover and locked with an “M” padlock which must not be located on an access path to avoid injury. The general-purpose outlet must be installed with its face perpendicular to the track.
- One secured IP 56 outdoor rated 15 A 250 V switched power outlet must be provided on a structural column within the Bicycle Enclosure at a height of 1900–2000 mm above finished floor level and secured with an ‘M” padlock.

9.9.3. Heated Mirrors

- Heated mirrors must be installed wherever driver mirrors are required as per *CS1-DOC-003508 – Public Transport Standard: Design – Stations – Platforms* Clause 6.7, “Train Driver’s Platform Sighting Mirrors”.
- A socket output (GPO) must be provided on each mirror gantry. It must be mounted on the same side of the gantry pole as the mirror and be recessed into the pole as per drawing *735-A2-11-029*. It must be weatherproof to IP66 and incorporate double-pole automatic switching (Clipsal 56SO310A or equivalent). The mirror outlets must be on a discrete circuit(s) controlled by the lighting control system to allow the mirror heaters to be controlled as follows:
  - A Humidity & Temperature Transducer (Vaisala HMT330 series or equivalent), together with its associated Radiation Shield, must be provided and its sensor must be installed at the same height as the mirrors (or within 500mm lower). It must be interfaced to the lighting control system via RS-232 data communications (or equivalent). Power to the mirrors must be controlled using an algorithm based on train services (as for the lighting control) and a measurement of when the ambient temperature is approaching the dew-point temperature. This difference must be user programmable (typically set to 2°C).
- Note that heated mirrors (or any light fittings) within the Overhead Contact Line Zone and Pantograph Zone (OHCLZPZ) are required to be bonded to traction earth and thus the protective earth conductor must

not be terminated to prevent traction fault current flowing in this conductor to the SDB/MDB—refer to the E&B Guidelines.

- Unless otherwise specified in the Project CSTR, Heated Drivers' Platform Mirrors will be supplied by the Department. They will be manufactured to drawing *735-A1-10-197* and will be installed and aligned by the staff of SAPTA's maintenance contractor.
- Drawing *735-A3-10-164* details a typical mirror pole and its positioning.

9.9.4. Alucobond Sign-trough Lighting

- Aluminium composite troughs are incorporated into new station shelters. The station name is routed into the trough and back-lit with a LED 'linear' batten. Its portion of the trough should be covered to prevent light spill.
- This light should be fed from the shelter's L1 circuit.

9.9.5. Commercial Advertising Signs and Vending Machines

- Third-party advertising signs or vending machines may be supplied from the Department's switchboards under commercial agreement. Both types of load must be fed from multiple, dedicated, RCD protected circuits to ensure that a fault does not cause any of the Department's apparatus to lose power.
- A dedicated switched socket outlet should be provided for each vending machine. The socket should be auto-switched and of the type that accepts a threaded (locking) plug and the plug should be threaded to avoid inadvertent disconnection. To mitigate vandalism, the socket outlet and plug should be housed in a metal enclosure mounted above the machine.
- The wiring for lighting of signs must have a clear point of delineation so that the sign's maintenance staff can isolate its power without the need to gain access to the switchboard. The delineation is typically a weather-proof, double-pole isolator mounted on the back of the sign.
- Vending machines should be located:
  - with their back against a wall to deter vandalism (also CPTED);
  - outside of pedestrian walkways;
  - as close as practicable to a mains power source; and
  - in an area monitored by CCTV.

9.9.6. Facility Circuits

Equipment Room – Where an equipment room is specified at a station, it must be air conditioned and include lighting, dedicated outlets and general-purpose outlets in accordance with CE5-DOC-003514 – *Public Transport Standard: Equipment Room*.

Stand Alone Toilet Facility – A separate circuit (usually 32A) is required for those stations where a unisex self-contained toilet (Exeloo) is provided. Refer to document *CS1-DOC-003510 – Public Transport Standard: Toilet Facilities*.

Security System – Refer to *PI5-DOC-003512 – Public Transport Standard: Security Systems*.

Passenger Information System – Refer to *PI1-DOC-003513 – Public Transport Standard: Passenger Information Systems for Rail*.

Bicycle Enclosure – These require three circuits for: a 15A GPO (refer to section 9.9.2 above), lighting and power for a card reader ('validator'). This requires power and communications conduits – refer to drawing *CS5-DRG-350182 – Bicycle Enclosure, Card Reader Circuit Diagram*.

9.9.7. Lifts

A lift isolating switch must be installed at each lift controller. The current rating of the switch should be co-ordinated with the lifts' specialist sub-

contractor. Refer to specification *CS1-DOC-002336 – Lifts for Public Transport Infrastructure.*

9.9.8. Pedestrian Underpasses

- With reference to Tables 7.4.1 (Luminaires for Station Precincts) and 7.4.2 (Luminaire Selection), the luminaires in subways must be 'Type C'. The lights in subways are exposed to extreme vandalism, so the 600mm versions are preferred over the 1200mm versions, since they appear to be more resistant to impacts.
- For a subway that traverses two 2 tracks, a minimum of five fittings must be of the battery-backed type.
- Small sump pumps are located at stations with pedestrian subways. The pump must have its own circuit. All pumping faults are to be remotely monitored by SAPTA's maintenance contractor and their specialist sub-contractor.

9.9.9. Large Pumping Stations

Large sump pumping systems are associated with 'lowered' stations and underpasses (for example, at Bowden and the Goodwood Dive).

Such pumping stations must:

- have redundant pumps;
- have redundant power transformers fed from separate SAPN feeders;
- have an Automatic Transfer Switch (ATS) feeding the pump switchboard;
- have a terminal enclosure for the connection of a generator set; and
- a pump control system that allows pumping faults to be remotely monitored by SAPTA's maintenance contractor and their specialist sub-contractor.

It is preferable that the supply for an adjacent station is also fed from the output of the ATS (that is, the Pump MSB is also the station's MSB).

A communications conduit must be installed between the Pump MSB, the Pump Switchboard and the Equipment Room for future monitoring of the ATS, PMS and pump status.

9.9.10. Track Maintenance or Incident Lighting

Critical areas of rail or track must have incident/maintenance lighting provided. Such areas include underpasses and viaducts.

- Rail Underpasses
  - (i) Lights must be provided on both sides of the tunnel and must be spaced to provide a minimum value of average horizontal illuminance ($E_{H\,AV}$) at floor level (rail fastenings) of 160 lux (with a target of 200 lux) and a Uniformity (= $E_{H\,MIN}/E_{H\,AV}$) of 0.5.
  - (ii) Similar levels of lighting must be provided over the storm-water sump(s) if this is located in the underpass.
  - (iii) The lights must be remotely controlled using a system providing on/off control from a (mobile) phone. The controller must be a 'Remote Lighting Controller', type RLC-01, manufactured by Worktrax Pty Ltd. (The Department's drawing *CS1-DRG-350295* refers.) The unit must be located adjacent to the lighting supply's switchboard and a 'Manual Override' (Test) switch must be provided as per the drawing.
- Viaducts
  - (i) Where no other lighting is present, it must be provided over the walkways to permit safe egress by passengers in the event of an

incident. The illumination should exceed the horizontal requirements of Category PA2 to *AS 1158.3.1*.

(ii) Local controls for the lighting must be provided along the length of each walkway and spaced 100–150 m apart. Each control point must provide on/off control of all the lights.

(iii) The lights must be remotely controlled using a system providing on/off control from a (mobile) phone, as above.

10. Design Requirements – Various

10.1. Equipment Rooms – General

1. Refer to *CE5-DOC-003514 – Public Transport Standard: Equipment Room*.
2. Cables entering the equipment room via conduits must be routed to their final destinations via a system of cable trays. (Refer to section 10.3 below.)

10.2. Equipment Rooms – Below Ground Level

Where a station's Equipment Room is below natural ground level, it will be necessary to protect some cable pits against flooding by:

1. The incorporation of a pit drainage system, with a sump pump if necessary.
2. The installation of electronic (capacitive) proximity water sensors. The pit sensors must be wired to a Water Sensor Monitoring Unit in the equipment room. This facility must transmit these "water detection" alarms to the pump's controller for transmission via its telemetry system.
3. Relevant pits must have an 80mm silt trap.

10.3. Cable Trays

1. Cable trays must be installed as per the manufacturer's specifications.
2. All trays must be properly earthed as per *AS 3000* and be provided with proper segregation if required.
3. Cable trays must be powder coated to reduce sharp edges and identify services:
   a) Electrical cable trays must be powder-coated Orange.
   b) Comms cable trays must be powder-coated White.
   c) Special purpose trays must be Yellow.

10.4. Cable Trunking

Cable trunking must contain earthed segregated compartments if required to house more than one service.

10.5. General Design Principles

1. There should be only one Mains supply point for a site. It is preferred to have long cable runs than to have multiple MSBs and retailer meters.
2. The Department's usual lighting control is to provide L2 circuits so that approximately half the site lighting turns off, or dims down to 50%, after hours (where practicable).
3. On new installations, this L2 function is supplemented by movement detectors which temporarily restore the lighting to full brightness and also send an alarm to the Department's security monitoring centre.
4. There are 'exception days' where L2 lighting circuits must stay on all night at train stations and tram stops. Currently, there are two exception days: New Year's Eve and Anzac Day.
5. Carparks are usually arranged to be an L2 area.

10.6. Other Design Elements

- Where a time clock function is required at an installation without C-Bus or DALI control, the time clock must be a GPS unit, manufactured by Theben and complete with GPS antenna. It must be installed as per drawing *CS1-DRG-360129*. It must be programmed to handle daylight saving changeovers and, if appropriate, to have 'exception days' as described in section 10.5 above.

- Most basic 'neighbourhood' train stations and tram stops have electrical systems based on drawing *004-A2-11-033*.
  Note: As shown on the drawing, the Department's usual arrangement is to have lighting controlled by a PE Cell and to have the L2 function performed by a time clock 'in series with' the PE Cell. Control circuit arrangements with a PE Cell and time switch 'in parallel' are not required.
- Where a timer function is required at an installation without C-Bus or DALI control (for example, Emergency Lighting test timer), the timer must be a Clipsal type 31VETR3 digital unit.
  Note: The unit's LED indicator should be configured to be 'on' during the timing period.

11. Design Requirements – Lighting System

11.1. General

The lighting system must include all or part of the following elements as required:

- Light poles;
- Luminaires complete with their accessories and wiring; and
- Lighting control system.

Note: The supply to lighting masts at the edge of the railway or tram alignment close to MEN earthed metalwork requires a power supply which is not earthed to the traction return system and must be supplied from a direct utility MEN supply or through an isolation transformer, with the secondary neutral independently earthed, from the traction earthed railway supply. Refer to the Earthing and Bonding Guidelines.

The following areas must be illuminated in accordance with Tables 11.3.1, 11.3.2 and 11.3.3 (Required Lighting Levels) below:

- Primary access and other paths;
- Platforms – both open and under cover;
- PIS screens and static timetabling;
- Ramps;
- Equipment room (where provided);
- Emergency Help Phones;
- Information Displays;
- Toilet facilities;
- Lifts, stairs, and overpasses;
- Adjacent bus interchanges and Kiss 'n' Ride zones;
- Car parking and bicycle facilities;
- Vending machines; and
- Pedestrian subways.

The Contractor must provide a complete and functional lighting system for the operational requirements of the site and the safety of customers at all hours of the day. It must be co-ordinated with the Security System design to ensure appropriate lighting levels are provided in the necessary locations to meet the system's functional requirements.

The lighting system must be designed to:

- Minimise glare to both customers and to train and tram drivers;
  Note: Batten ('linear') luminaires should in general be mounted facing downwards. The use of 'linear' fittings facing outwards on walls should be avoided and care should be taken with the use of up-tilt for pole-mounted luminaires. (Refer to drawing *CS4-DRG-350377.)*
- Include a maintenance factor dependent on the type of luminaire as follows:
  (i) LED with regulated ('constant') output: 0.90;
  (ii) LED: 0.85;

(iii) T5: 0.8;
(iv) Other: State the assumption used.

- Provide a minimal number of luminaires while meeting the light level requirements indicated in Tables 11.3.1, 11.3.2 and 11.3.3 (Required Lighting Levels) below;
- Ensure light spill to neighbouring properties is minimised and does not exceed the levels prescribed in the standards and in accordance with *AS4282: Control of obstructive effects of outdoor lighting;*
- In a rail or tram environment, consider maintainability in an electrified traction environment by avoiding placing elements that require maintenance within the electrification clearance zone as described in the Department's specification *TP1-DOC-000389 – Electrical and Mechanical Clearances for the 25 kV Electrified Train Network;*
- Ensure light fitting locations are co-ordinated with CCTV cameras and selected to optimise CCTV images for the target light level whilst avoiding glare caused by light fittings appearing in the close in field of view of cameras;
- Ensure all access path lighting is pole mounted;
- Ensure all side platforms have light poles located at the back of the platform;
- Ensure adequate light levels around Emergency Telephone locations; and
- Ensure that any structure does not impact signal sighting.

11.2. Lighting Design

- The lighting/electrical design must divide the station precinct into logical areas and each such area must be serviced by multiple single-phase circuits with luminaires spread/spaced evenly between the circuits. The failure of one circuit breaker should cause an even reduction in illumination across an area, and it must not be possible for the tripping of one breaker to put an entire area into complete darkness. Three-phase lighting circuits/breakers must not be used.
- It is expected that lighting levels will be "over-designed" such that they can be dimmed down to the required values during commissioning.
- The lighting design should make use of the SAPTA's lighting assets only—the contribution of any adjacent 'third-party' lights (for example, council) must not be relied upon.
  Exception*:* tram stops in the Central Business District.
- The design must avoid shadows and/or complex ground patterns which can be created on paths, stairs or ramps from the effects of fences and solid walls. This can be especially problematic for stations built below the natural ground level. The use of accurate 3D modelling is essential.
- The lighting calculations must be carried out using one of the following software packages: AGi32, Dialux, Perfect Lite or Relux.
- Prior to commencement of design the designer must investigate the area surrounding the site to determine if any lighting or electrical elements that fall outside the scope of work are impacted by the new works. The Department must be informed should any of these elements be found to be non-compliant to current regulations and standards.

At each Design Stage Review the designer must submit a lighting design report incorporating the following data as a minimum:

- Design parameters and assumptions including limitations;
- Luminaire and light pole arrangement, co-ordinated with CCTV camera locations, including the use of joint use poles;
- Isolux contours for lighting levels across the Station Precinct and extending to the nearest residential boundary; and
- A tabulated summary table, with headings as per Tables 11.3.1, 11.3.2 and 11.3.3 of the designed light levels for all the station elements.

11.3. Required Lighting Levels

It is essential that light levels in various areas of the station precinct meet the DSAPT requirements in Tables 11.3.1, 11.3.2 and 11.3.3 below.

11.3.1. Enclosed Stations and Tram Stops

STATION ELEMENT	AVERAGE HORIZONTAL ILLUMINANCE	MINIMUM HORIZONTAL ILLUMINANCE	MINIMUM VERTICAL ILLUMINANCE (NOTE 1)	UNIFORMITY	UNIFORMITY
	$\overline{E}_H\ (lux)$	$E_{ph}\ (lux)$	$E_{pv}\ (lux)$	$U_1 = \frac{E_{min}}{\overline{E}_H}$	$U_{E2} = \frac{E_{max}}{\overline{E}_H}$
General areas	160			0.5	
Passenger Information Displays (excluding monitors) and Static Signage	200	–		0.5	–
Sheltered entrances, primary access paths, stairs, ramps and overpasses	150	–		0.5	–
Sheltered platforms	160	–		0.5	–
Yellow line at platform edge – sheltered platform	–	150		–	–
Yellow line at platform edge – Fully enclosed platform	–	150	–	–	–

Table 11.3.1 – Required Lighting Levels for an Enclosed Station

11.3.2. Open Stations and Tram Stops

An open station means a station—or those portions of a station—which are essentially open to the sky. The platform may contain ticket offices, covered canopies (shelters), etc.

STATION ELEMENT	AVERAGE HORIZONTAL ILLUMINANCE	MINIMUM HORIZONTAL ILLUMINANCE	MINIMUM VERTICAL ILLUMINANCE (NOTE 1)	UNIFORMITY	UNIFORMITY
	$\overline{E}_H\ (lux)$	$E_{ph}\ (lux)$	$E_{pv}\ (lux)$	$U_1 = \frac{E_{min}}{\overline{E}_H}$	$U_{E2} = \frac{E_{max}}{\overline{E}_H}$
General areas	42	21	14	–	7
Under shelter and covered areas (on open platforms)	160			0.5	–
Yellow line at platform edge – open areas of platform	–	30	–	–	–
Yellow line at platform edge – adjacent to shelters	–	150 (Note 2)		–	–
Emergency Help Phones	200	–	–	–	–
Enclosed areas, including but not limited to Toilet Facilities, equipment rooms and bicycle enclosures	200	–	–	0.5	–
Access paths, ramps, stairs and overpasses	42	21	14	–	–
Pedestrian Subways	200 (Note 3)			0.5	

STATION ELEMENT	AVERAGE HORIZONTAL ILLUMINANCE	MINIMUM HORIZONTAL ILLUMINANCE	MINIMUM VERTICAL ILLUMINANCE (NOTE 1)	UNIFORMITY	UNIFORMITY
	$\overline{E}_H\ (lux)$	$E_{ph}\ (lux)$	$E_{pv}\ (lux)$	$U_1 = \frac{E_{min}}{\overline{E}_H}$	$U_{E2} = \frac{E_{max}}{\overline{E}_H}$
Other paths, ramps, stairs, and overpasses	14	4	4	–	
Any other area	As per AS 1158 and AS 1680				

Table 11.3.2 – Required Lighting Levels for an Open Station

11.3.3. Other Areas

STATION ELEMENTS	AVERAGE HORIZONTAL ILLUMINANCE	MINIMUM HORIZONTAL ILLUMINANCE	MINIMUM VERTICAL ILLUMINANCE (NOTE 1)	UNIFORMITY	UNIFORMITY
	$\overline{E}_H\ (lux)$	$E_{ph}\ (lux)$	$E_{pv}\ (lux)$	$U_1 = \frac{E_{min}}{\overline{E}_H}$	$U_{E2} = \frac{E_{max}}{\overline{E}_H}$
CAR PARKS					
Accessible (Cat PCD in accordance with AS 1158)	35	14	7	–	10
Standard (Cat PC1 in accordance with AS 1158)	14	3	3	–	1
BUS INTERCHANGES					
Bus or integrated Bus and Rail Interchanges — sheltered areas	160	–	–	0.5	–
Separate Bus Shelters within the Station Precinct	As per the requirements of DSAPT				
Bus lane roadways	As per AS 1158 Category ‘V’ requirements				
PEDESTRIAN RAIL CROSSINGS					
Rail or tram corridor and rail crossing	42	21 (Note 4)	14	–	–
OTHER					
Bicycle, and shared bicycle and other access paths within the boundary of the Station Precinct that access the station from the public road network	In accordance with AS 1158 PR1(h) and PR3(v) levels, except where a higher luminance is required under DSAPT for accessibility.				

Table 11.3.3 – Required Lighting Levels for Other Areas of the Station Precinct

Note 1: Vertical illuminance is measured in a vertical plane at a height of 1.5m above finished floor level as required by AS 1158: Lighting for Roads and Public Spaces Set. Refer to Appendix 2 for clarification regarding the calculation of vertical lighting levels on train and tram platforms.

Note 2: The covered areas are deemed by the Department to be “enclosed”.

Note 3: With regard to clauses 9.9.8 and 11.1 above, because of the extreme vandalism and grime experienced in subways, a very low maintenance factor should be assumed.

Note 4: Applies at the corridor boundaries only.

11.4. Luminaires

Luminaire selection must meet the following criteria:

- Meet Australian Standards including without limitation *AS 3000:* Electrical Installations (Wiring Rules) and *AS/NZS CISPR 15*: Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment (EMC compliance).
  ***Note**: Documentary evidence of compliance to AS/NZS CISPR 15 is required.*
- Be of the Solid-State Lighting (SSL or LED) type.
- Fit for purpose and robust in construction;
- Minimum IP rating of IP55 for exterior locations (including covered spaces);
- Very good horizontal cut-off (*AS 1158.3.1*, type 5 or better);
- Very good rear cut-off;
- Minimise life cycle cost;
- Be readily available, easily maintained and replaced;
- An expected design life of 15 years;
- Energy efficient (low wattage and high output).
- 4000°K nominal Correlated Colour Temperature
- High power factor >0.9;
- Availability of a NATA (or equivalent) LM-63 tested and approved report with electronic photometric data in IESNA format. (Luminaires for *AS 1158*: *Lighting for Roads and Public Spaces Set,* Category 'V' designs should include electronic photometric data in CIE format.);
- Minimum 5-year warranty;
- The diffuser of batten ('linear') luminaires must not be fastened by clips; and
- The body of external batten luminaires must be metal (for UV and vandal resistance).

All luminaires must be safely accessible for maintenance purposes by ladder or mobile work platform. The mass of the luminaire must not exceed that which can be safely handled whilst working on a ladder or mobile work platform.

Luminaires on platform shelters must be integrated with the structure ensuring the following:

- Provide good quality and uniformity of light;
- Be concealed, protected or mounted to avoid vandalism;
- Be easily accessible for maintenance;
- Meet the architectural intent; and
- Limit light spill to adjacent precincts or residences.

TYPE	SPECIFICATION	EXAMPLES
A	Compliant with Australian road lighting standards; LED luminaire (with Constant Light Output over life preferred); Fitted with DALI dimmable ballast; Robust die-cast aluminium body; LEDs and reflectors shielded from angles above 90° elevation; IP 65 minimum; Simple access.	Versalux Smart LED Aldridge LED LRL LED (Note 1) Sylvania IZYLUM EVO
B	LED luminaire (with Constant Light Output over life preferred); Fitted with DALI dimmable ballast; Robust die-cast aluminium body; LEDs and reflectors shielded from angles above 90° elevation; IP 65 minimum; Simple access.	Versalux Smart LED WE-EF LRL NXT (Note 1) Thorn ISARO PRO

C	Surface-mount LED 'linear' luminaire with integral DALI dimmable ballast; Highly vandal resistant — certified to IK10++ (50 Joules) impact rating; High performance, total system 110 Lm/W minimum; Projected life 50,000Hrs (L70); 5 mm, UV stabilised, polycarbonate lens; IP55 minimum with metal body; Locking system or stainless-steel security fasteners; '1200' mm and '600' mm options; Option for integral maintained DALI emergency function; Sealed rear fixing points.	Thorn Gladiator (Notes 2 & 3) Versalux Enduralux
D	Surface-mount LED 'linear' luminaire with integral DALI dimmable ballast; Vandal resistant — certified to IK10 impact rating; High performance, total system 120 Lm/W minimum; Projected life 50,000Hrs (L90); IP56 minimum with metal body; Stainless-steel security fasteners; '1200' mm and '600' mm options; Option for integral maintained DALI emergency function.	SAL Commercial Grandlux (Note 3)
E	Optional recessed or surface-mount LED 'linear' luminaire with integral DALI dimmable ballast and various length options; Projected life >100,000Hrs (L70); Polarised electrical connectors between sections; Vandal resistant — certified to IK10+ impact rating; IP66 minimum; Option for integral maintained emergency function.	Xero XTI-DPTI-OCR
F	Surface-mount LED luminaire with integral DALI dimmable ballast and diffused refractor optics; Vandal resistant — certified to IK10+ impact rating; Option for maintained DALI emergency function (external IK10 battery box) and security locking screw; High performance, total system 115 Lm/W minimum; IP65 minimum; Suitable for low to medium mounting heights.	Versalux AURA

Table 11.4.1 – Luminaries for Public Transport Projects

Note 1: *LRL NXT units must be fitted with blanking plates instead of a NEMA socket.*

Note 2: *Thorn Gladiators must be supplied with the 'high-brightness' and 'SP' (security options.*

Note 3: *Type C luminaires are recommended for low-height applications while Type D is recommended for higher mounting situations.*

Any proposed alternatives must be type-approved by the Department's specialist DALI contractor to ensure full compatibility of their control gear with the requirements of the Department's control system and must be approved by Rail Asset Management.

Table 11.4.2 below indicates the luminaire selection for various public transport applications:

STATION ELEMENT	LUMINAIRE TYPE
Open Car Parks	A
Open Platforms	B
Open Areas other than Platforms and Car Parks	A
Covered Areas, Enclosed Areas, Indoor Areas	C or D

Pedestrian Subways and similar enclosed areas (refer 9.9.8 above)	C
Tram stop shelters	E
Covered car parks	F
Equipment Rooms	DALI LED batten
Cleaners' Rooms, etc	LED batten

Table 11.4.2 – Luminaire Selection

11.5. Lighting Amenity

The lighting design should take a "whole of Journey" approach, considering the paths that people will take to access the public transport facility in all weather and at all times of day.

The addition of architectural lighting in the public transport precinct should be considered.

11.6. Control Gear

All lighting must be fitted with Digital Addressable Lighting Interface (DALI) dimmable drivers, offered with a warranty no less than five years.

This requirement includes any non-standard or architectural lighting that may be incorporated into the station precinct.

11.7. Battery-backed (Emergency) Lighting

Emergency luminaires must be provided throughout the installation on platforms and indoor areas. The provision and installation of emergency lighting must be in accordance with *AS 2293.1*: *Emergency Escape Lighting and Exit Signs for Buildings – System Design, Installation and Operation*.

Under loss-of-power conditions, an average lighting level of 1–2 lux must be provided under train and tram shelters, in station overpasses and subways, over stairs, etc. Lighting levels according to *AS 2293.1* must be provided in premises.

Permanently illuminated EXIT luminaires must be provided where required for safe evacuation of the precinct.

The battery packs must be of best contemporary, long-life technology Lithium-Ion or better type, taking into account the effects of temperature.

The lighting control system must provide for routine, automated testing and remote fault reporting for all battery-backed lights. For non-DALI sites, a local manual emergency lighting test facility in accordance with *AS 2293.1* and clause 10.6 herein must be provided.

All battery-backed fittings must be:

- Wired in the 'maintained' mode (that is, luminaires must be switched normally as required, forming part of the illumination calculation for their respective area and, in the event of mains failure, the required light source must remain energised by the internal battery pack);
- Generally located in the row of fittings closest to the yellow line edge of the platform;
- Spaced as evenly as practicable; and
- Be suitable for automated DALI testing—that is, they must have two DALI addresses.

11.8. UPS System for Battery-Backed Lighting

With the Department's prior approval, an Uninterruptable Power Supply (UPS) system may be used to provide the emergency lighting function, as an alternative to individual batteries.

The UPS must be an Eaton 9PX Series with optional network card.

11.9. Light Poles

11.9.1. Type of Light Poles for Roads, Interchanges or Open Carparks

These light poles may be medium-duty, octagonal, fixed, base-plate mounted poles with a maximum outreach of 4.5 m. Standard poles are 7 m (9 m with outreach), 8.5 m (10.5 m with outreach) and 10 m (12m with outreach) high galvanised 'impact absorbing' poles. However, the tilt-down poles in section 11.9.2 are preferred for use in open car parks.

These poles must not be used for joint VSS (CCTV) and lighting purposes unless they meet the rigidity criteria stated in *PI5-DOC-003517 – Security Specification*, Appendix 1 and are approved by the Department.

Footing details are available from the Department's website (refer to the "lighting" subsection).

11.9.2. Type of Light Poles for Station or Tram Stop Precincts

Poles for use within the station precinct (for example, platforms, access paths, ramps and pedestrian crossings) are usually 6 m tall. Lighting poles must be of the tilt-down ('see-saw') type and comply with the requirements of drawing CS4-DRG-362572.

Likewise, camera or joint-use (that is, lights and cameras) poles must comply with the requirements of drawing CS4-DRG-362573.

Tilt-down lighting or camera poles of 7 m or 8.5m height are preferred for use in open car parks and must comply with drawing *CS4-DRG-362574* (light poles) or *CS4-DRG-362575* (camera poles).

Outreach arms must generally be in accordance with standard drawing *CS4-DRG-350286*. Standard spigots and adaptors may be used with a minimum arm length of 300 mm. It will usually be appropriate for LED luminaires on platforms and elsewhere in the station precinct to have zero up-tilt.

Where lighting poles for pedestrian ramps are not located on the ramp itself, they must have their base-plates at the same height as the ramp surface by being mounted on up-stands that are engineered for the purpose and are cosmetically attractive. The preferred solution is to use square polymer-concrete pit risers (ACO Polycrete Pty. Ltd. 'Cablemate' or equivalent). Poles for pedestrian mazes must not tilt into the corridor and, at active crossings, must not interfere with the RX-12 'red man' sign's pole.

At train and tram stops, light and camera poles must be mounted on square plinths encompassing the pole's base-plate. The plinth must provide 30 % luminance contrast with the surroundings (for example, by being painted yellow). Light poles in the rail corridor or elsewhere must not be mounted on plinths.

Poles must not have their base-plates or fixings covered.

11.9.3. Signs Attached to Poles

Signage must be fixed to tilt-down poles in such a way as to not prevent the pole from tilting.

11.10. Lighting Control

11.10.1. Test Facility for Non-DALI Stations

'Legacy' stations that are not fitted with DALI controls must have a lighting 'Test' circuit installed.

A user must be able to over-ride the PE cell and time clock (if fitted) in order to test the lights. This circuit must incorporate a timer so that it automatically reverts to normal operation after a period of two hours. Refer to wiring diagram *004-A2-11-033*.

11.10.2. Lighting Control Strategy

Dimming must be incorporated in the lighting design for the site. For train and tram use, the precinct's dimming levels must be determined during the commissioning phase to ensure that the lux levels required for all station elements as indicated in Tables 11.3.1, 11.3.2 and 11.3.3 above are achieved.

Lighting in the station precinct must be split over staggered multiple circuits to ensure that tripping of circuit breakers will not cause total black out in any area.

Each pole-mounted luminaire must be individually protected by a 4–6A circuit breaker in the pole. Each sub-circuit of pole lighting must be protected by a 100 mA RCBO/RCD in the switchboard.

The control system must include a push-button control at stations with T5 fluorescent lighting to activate a 100-hour timer to cause the tubes to 'burn in' without any dimming following a relamping exercise.

A single DALI line is capable of operating 64 devices, however all lines must be limited to between 55 and 60 devices to allow for future expansion.

11.10.3. Photo Electric Cell

At DALI sites, switching of the lighting circuits must be controlled by means of a photo-electric light sensor (PE Cell) mounted outdoors, either on a structure, or an adjacent light pole away from direct sun light and protected from other light sources including oncoming vehicles and train lights. The unit must be an analogue unit connected to the lighting control system. It must be installed in a location close to the lighting control system interface to minimise wiring. The PE Cell must be activated when the ambient lighting level drops below a programmed threshold (42 lux). The PE Cell is to be a DALI or C-Bus type.

For non-DALI sites, it is preferred to have only one PE Cell controlling the entire precinct's lighting—multiple PE Cells must be avoided. Various systems are in use by the Department to transmit the PE Cell's signal over optical fibre on electrified traction territory—refer to drawing *CS1-DRG-350145* as an example.

Where no building is available, the PE Cell must be mounted at height, usually on the (tilt-down) pole closest to the lighting switchboard.

11.10.4. Motion Detectors

Motion detectors must be placed in order to cover the entire platform and main access points to the station. Long distance, outdoor rated, robust motion detectors must be used outdoors. Motion detectors must be ADPRO PRO E Series beam detectors.
Note: The ADPRO movement detectors are specialised items, and the electrical sub-contractor should allow for them to be mounted and calibrated by the security sub-contractor and integrated into the alarm system.

Dimming of the luminaires must be triggered by the controller's time clock function for certain hours of the day and full light levels must be restored instantly for a programmed period (normally 15 minutes) as soon as a movement is detected by motion detectors.

11.11. Lighting Control System – Details

11.11.1. General

The programmable lighting control system for the precinct must be DALI with a Clipsal C-Bus 'front-end' or equivalent approved by the Department. It must incorporate both a C-Bus 'logic engine' (Network Automation Controller, NAC), a DALI controller unit(s) and a DALI power supply/line driver unit(s).

11.11.2. Introduction

The scope of work for the lighting control system is based upon maximum flexibility and maximum control. It provides an individually addressable DALI digital lighting system that can typically be reconfigured without the need to rewire, while providing control and status down to an individual ballast, transformer or emergency inverter.

The lighting control system is to be a multi-master DALI (Digital Addressable Lighting Interface) system with DALI Electronic Control Gear (DALI ECG) in all light fittings, emergency lights and exit signs controlled by multi-master DALI Electronic Control Devices (DALI ECD) throughout the interior space. The lighting controllers, ballasts, transformers, drivers, emergency inverters and other electronic control gear and electronic control devices are to fully comply with the DALI Standard (IEC 62386) enabling equipment from multiple manufacturers to be used in the system.

Where possible all electronic control gear must comply with version 1 of the DALI Standard in order to provide manufacturer, serial number and other related data held in DALI memory.

DALI Lines are to be linked on an Ethernet network to provide computer control, configuration, monitoring and analysis

The lighting system must provide a manual test facility and an emergency override capability. Reference must be made to standard drawings *CS4-DRG-359802* and *TC4-DRG-200014*, and their dimming times noted.

The lighting controls are to utilise rail or tramway timetable schedules, occupancy/movement sensors, light sensor, switches and temperature sensors to control the lighting.

The Line Controllers are to automatically monitor the status of all ballasts and emergency fittings on the DALI Lines and to provide the tools to identify and replace ballast and lamp failures.

The Contractor is to engage a qualified Clipsal Platinum Partner trained in DALI and C-Bus to install, program and commission the system.

11.11.3. System Description

The lighting control system must consist of multiple DALI Lines linked to form an arrangement using intelligent control units connected on an Ethernet network. Part of the station's local network may need to be isolated using optical fibre.

The system is designed as a distributed control system where all DALI Line Controllers, Switches, Sensors, Input Modules and other DALI Electronic Control Devices must co-exist enabling devices from different manufacturers to be mixed and matched to provide maximum flexibility now and in the future.

All Electronic Control Devices must be multi-master devices with collision detection and must not interfere with each other on the DALI line.

The system is to be capable of incorporating a range of multi-master DALI Electronic Control Devices (ECDs) including those shown in the list below. These should include, but not be limited to, wall and ceiling controls, switches, occupancy sensors and light level sensors:

- DALI control units
- DCDALIO Advanced Input Modules
- DCDAL3xM Switches and key input units
- DCDALMS360 Multi-Sensors with Auxiliary Input
- Group Controllers
- Room Controllers
- Partition Controllers
- LCD Controllers and Touch Panels

Single master control devices are not acceptable as they do not provide the flexibility required for the system.

11.11.4. Wiring and Installation

All light fittings are to be wired in compliance with the DALI Standard and local electrical regulations.

A single DALI Line has the following constraints:

- The maximum number of addressable DALI Electronic Control Gears is 64 (devices that take a DALI short address such as ballasts, transformers, emergency lighting units, etc.)
- The DALI voltage range at the DALI Power Supply must be between 11.5V and 22.5V; with a typical value of 16V.

⚠ **THIS DALI VOLTAGE MUST BE CONSIDERED TO BE LV MAINS AS IT HAS THE CAPABILITY OF GOING TO 240V AT ANY TIME.**

- The voltage-drop over the length of the DALI control wires is not to exceed 2V.
- The maximum permitted line current is 250mA.
- The sum of the current consumptions of all the DALI units from the DALI Line must not exceed the nominal current of the DALI power supply used.

Emergency luminaires and Exit signs must be connected to the nearest DALI Line and be powered by the DALI active conductor to minimise cabling and installation costs.

11.11.5. DALI Line Controllers

The DCBMx-1608 Line Controllers (or equivalent approved by the Department) are required to link the distributed DALI Lines onto an Ethernet network to provide a site-wide DALI system. The Line Controllers provide configuration, monitoring, control, reporting and maintenance functions.

The Line Controllers are to operate independently and must continue to process local inputs and schedules when disconnected from the Ethernet network. The Line Controllers must not be reliant on a server or other control system in order to operate.

The Line Controllers must provide local intelligence and features including:

- Integrated real time clock with automatic daylight savings adjustment and leap-year correction.
- Integrated sunrise/sunset support based on site location (latitude and longitude).
- Automatic Time Schedules to control groups for scheduled occupancy with support for active periods and holiday exceptions.
- 16 multi-function digital inputs for pushbuttons and sensors, including occupancy sensors and daylight sensors, and for integration with other building services such as access control and security panels.
- 4 input profiles to provide tailored input configurations for different periods of the day including office hours and after-hours.
- 8 digital outputs for additional control and interlocking to external equipment such as fans and blinds.
- Up to 32 configurable sequences for override sequences, mood and effect lighting.
- Up to 32 configurable command lists for advanced control and effects.
- Support one or two DALI Lines (up to 64 or 128 DALI ECG's).
- Zone control whereby groups on different DALI Lines are controlled together as one entity.
- An in-built web server for status and error reporting of DALI Line, ballast and lamp failures. The status must include lamp hours.
- DALI Emergency testing and reports.
- Local processing. In the event of network failure or disconnection from the Ethernet network the Line Controller is to continue to run automatic time schedules and sequences and process inputs independently.
- Computer monitoring and configuration. The Line Controller must allow configuration, monitoring and analysis from computers on the Ethernet network.
- Computer control. The Line Controller must allow occupants to control their local lighting using their computers on the network (local laptop access).
- The ability to have their real time clock remotely set from the network.

In order to separate mains voltage from extra-low voltage and Ethernet cabling, DCBMx-1608 Line Controllers are to be located in the switchboard separate from their associated DALI line power supplies.

The specialist DALI sub-contractor must set up each Line Controller's IP address from the department's master list.

1. **Line Controller Inputs and Input Profiles**
   The DCBMx-1608 Line Controller inputs are required to provide manual control through the use of switches and pushbuttons, and occupancy control using motion detectors and light sensors. The inputs may also be

used for integration with lift controllers, fire panels, security panels, access control systems and Building Management Systems (BMSs).

The Line Controller must provide:

(i) 16 multi-function digital inputs for use with switches, push-buttons, occupancy sensors, light sensors etc.

(ii) Multi-group functionality so that one input can control multiple DALI Groups. An input is not to be limited to a single group.

(iii) Dynamic Input Profiles that enable an input to operate differently for Normal-hours and After-hours operation.

An example of uses for this functionality is:

- After Hours Occupancy Sensor
  Daylight Hours: disabled
  After Hours: 15-minute Override Sequence

2. **Automatic Time Schedules**

In order to cater for scheduled occupancy of the station, the Line Controllers must include an integrated real-time clock and automatic schedule control.

The Line Controller must provide:

(i) An integrated real-time clock to allow automatic time schedules to be run independently of the Ethernet network.

(ii) The real-time clock is to provide automatic daylight savings adjustment and leap year correction.

(iii) Sunrise/sunset support based on site location. Schedules are to be provided with a configurable offset to allow lighting to be controlled relative to dusk and dawn.
For example, sunrise + 20 minutes;
sunset - 30 minutes.

(iv) Active Periods where a timer can be configured to fire only within a defined date range.
For example, from 1st June to 31st August 2023;
from 1st June to 31st August every year.

(v) Custom time schedules are to be configured for an absolute time.
For example, Office open, Monday to Friday at 8:30am;
Cleaners' lights, Thursdays at 8:00pm and for Special Services.

(vi) Repeat timers.
For example, Run façade lighting sequence every 30 minutes from 7pm until 11pm.

(vii) Time schedules must be able to be configured to include or exclude holiday periods. Holiday periods are to be configurable for one or more days and are to be able to be selected as perpetual.
For example, 31st December, every year.

(viii) Scheduled actions are to include all DALI direct (arc) levels (for example, 80%), DALI indirect commands (for example, GOTO MAXIMUM, RECALL SCENE2), Sequences (for example, 50%, 5 minutes 25%, 0.5 mins OFF) and Command Lists.

(ix) Configuration of the time schedules is to be completed from a computer over the Ethernet network.

3. **Sequences**

Control sequences are required to provide multi-step override timers and mood and effect lighting. Examples of uses for sequences include:

(i) Override sequence: 30 mins 75%, 5 mins 50%, 5 mins 25%, 5 mins OFF.

(ii) Delayed exit button: Goto 50%, 5 mins MINIMUM, 5 mins OFF.
(iii) Façade colour mixing: variations in red, green and blue over time.
(iv) Mood lighting: SCENE1, 20 sec SCENE2, 30 sec SCENE3, 40 sec SCENE4.

The Line Controllers are to be able to store 32 sequences of up to 8 steps where each step consists of a configurable time delay and action. Longer sequences are to be achieved by linking sequences.

Sequences are to be activated by a Time Schedule, from an Input or by Computer via the Ethernet network.

Configuration of the sequences is to be completed from a computer over the Ethernet network.

4. **Command Lists**

Command Lists are required to provide a series of actions to different groups in response to a timer or input. An example of a command list is to provide a structured shutdown of all lighting when the building is secured.

The Line Controllers are to be able to store 32 Command Lists of up to 8 steps where each step consists of a target ballast, group or zone, a configurable time delay and an action. Longer command lists are to be achieved by linking command lists.

Command Lists are to be activated by a Time Schedule, from an Input or by Computer/PDA/Touch Screen via the Ethernet network.

Configuration of the Command Lists is to be completed from a computer over the Ethernet network.

5. **Computer Control**

It is a requirement of the Line Controller to accept commands from computers connected to the Ethernet network. This provision is to be provided by a desktop applet that provides the user with full control of their lighting. The applet is to include a slider with full dimming capabilities plus buttons with the following functions: Maximum, Minimum, Off, Scene 1 to 16, Previous, Favourite 1 to 4.

The group of ballasts to be controlled is to be configurable.

6. **Status and Error Information**

The Line Controllers are to monitor the connected DALI Lines and are to provide status and error information for DALI Lines, ballasts and lamps.

The status and error information is to be available on web pages served by the integrated webserver in the Line Controller. This means that only a web-browser is required by maintenance or operations staff to monitor the system.

The Line Controller is to monitor and track lamp hours for connected luminaires and emergency fittings. If the DALI ballast does not support lamp hours then the Line Controller is to provide the tracking.

7. **Maintenance and Ballast Replacement**

The Line Controller is to monitor the connected DALI Lines and is to provide status and error information for DALI Lines, ballasts and lamps. The maintenance software is to identify a faulty ballast and address and reconfigure the replacement ballast with a simple point and click operation.

All group, scene and configuration settings are to be restored to the DALI ballast.

(i) **Occupancy Sensor Interface**
The DALI occupancy sensor interface is used to control a group of ballasts depending on the occupancy of an area as determined by occupancy sensors. The interface is to operate with one or more sensors that provide a contact closure output, including Adpro PRO E Series sensors.

The group of ballasts to be controlled is to be configurable allowing the space to be reconfigured or modified without changing the fixture wiring.

The lighting level activated when the sensor detects a change in occupancy is to be configurable to match the use of the space.

(ii) **Light Sensor Interface**
The DALI light sensor interface is used to control the level of a group of ballasts depending on the light level of an area as determined by a light sensor. The light sensor interface is typically used to control a group of ballasts adjacent to a row of windows.

The group of ballasts to be controlled is to be configurable allowing the space to be reconfigured or modified without changing the fixture wiring.

When the group is on the light level is raised or lowered depending on whether the light level determined by the light sensor is above or below the setpoint.

(iii) **DALI Relay and Output Modules**
The DALI Relay or Output Modules are required to provide ON/OFF control for non-dimmable loads such as fixed output electronic ballasts, incandescent lamps, fans and motors. The modules are to accept DALI commands over the DALI Line allowing modules to be placed adjacent to the load to be controlled.

The DALI Relay or Output Modules are to be provided as indicated on the accompanying drawings.

Where it is necessary to control lighting with relay outputs (and optional associated contactors), preference should be given to operating them in the ‘normally-closed’ mode—that is, a fail-safe arrangement where the control system turns ‘on’ the contactors in order to hold off the lights.

11.11.6. Documentation

The specialist DALI sub-contractor must produce the Department’s standard schematic diagram and a Technical Maintenance Plan.

11.11.7. System Safety

The control system must be wired with full and obvious segregation between its ELV and LV sections. The ELV portion must form a Compliant Telecommunications System and a telecommunications Certificate of Compliance must be delivered. By way of example, ducting of different widths must be used for LV and ELV wiring and the ELV (communication) ducts must be white.

11.11.8. Remote System Monitoring

The system must be fully integrated with the Department's existing remote lighting monitoring and control software program ("MERLINS"). The specialist sub-contractor must allow to make all changes necessary to the monitoring software system in order to add an additional station and to facilitate the remote testing and monitoring of the battery-backed lighting.

11.12. Luminaire Installation

Luminaires must be installed to their manufacturers' instructions and their mounting must ensure that their IP rating is not compromised from the rear.

Water or insect ingress from behind or otherwise must be prevented and will be regarded as a defect. Circular cable must be used where necessary to ensure that the sealing of luminaires is not compromised by the inappropriate use of flat TPS cables.

Shelter luminaires must be installed behind the platform's white line.

Every luminaire must be identified with the circuit breaker from which it is supplied and the relevant DALI address. This labelling must be provided immediately adjacent to the light fitting and lettering height must be selected so that it can be read by a person standing underneath. It may be stencilled or be engraved labels with externally rated high-performance adhesive. Pole mounted lights must be labelled at the gear tray. Long rows of batten luminaires may be labelled at every tenth unit. This information is required on the as-built drawings.
***Note**: the labelling must not be fixed to the light fittings.*

12. 230/400 V and 110 V Electrical Power Cabling and Conduits

12.1. Cabling – General

1. All cables used throughout the installation must be of Australian manufacture and comply with *AS 3000* and all relevant Standards stated in Appendix A of *AS 3000*.
2. All cables must be double insulated, including those entering the isolation transformer and light poles.
3. For consumer mains and sub-main cables, single-core or multi-core cables with copper conductor and Cross-linked Polyethylene (XLPE) X-90 insulation and PVC sheath must be used.
4. Cable must use multi-stranded soft drawn copper conductors.
5. All PVC insulated and PVC sheathed cables must use a minimum of V-75 insulation, unless otherwise specified.
6. Where required to have a fire resistance level, mains cabling in lift shafts must comply with Category WS52 of *AS 3013*: Electrical Installations – Classification of the fire and mechanical performance of wiring system elements, as required in AS 1735.2: Lifts, escalators and moving walks – Passenger and goods lifts – Electric.
7. Cables must be selected in accordance with *AS 3008.1.1*: *Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and including 0.6/1 kV – Typical Australian Installation Conditions*. The following must be considered in cable selection:
   a) Circuit nominal current as per *AS 3008.1.1*;
   b) Permissible voltage drop as per *AS 3000*;
   c) Fault loop impedance as per *AS 3000*; and
   d) Short circuit current as per *AS 3008.1.1*.
8. A common neutral may be used for two or more circuits providing that conditions stated in Clause 2.2.1.3 of *AS 3000* apply.

12.2. Cabling in Tunnels and Underground Buildings

The cable used in tunnels and underground building areas must be of the LSZH type and comply with all relevant Australian Standards.

12.3. Cables Encased in Concrete

HV or LV cables that are encased in concrete to a depth of less than 300mm, such as bridges, walkways and suspended platforms must have flush identification markers set into the top surface of the concrete to indicate services below. The markers must display:

- Type of service;
- Approximate depth; and
- Direction of service

and must not create a slipping or tripping hazard.

12.4. Cable types and Sizes

All cables and wiring associated with any new electrical circuits must comply with the following:

12.4.1. Underground wiring

- 2-core with insulated earth conductor, not less than 4 mm^2 (7/0.84), 0.6/1 kV, PVC insulated, PVC sheathed; and
- Installed in conduit of minimum size 32 mm.

12.4.2. Above ground wiring

- 2-core with insulated earth conductor, not less than 2.5 mm^2 (7/0.67), 0.6/1 kV, PVC insulated, PVC sheathed; and
- Installed in conduit of minimum size 32 mm.

12.4.3. Inside poles and elsewhere directly to luminaires

- Circular 5-core DALI power cable only. By way of example, Tricab TD818-XXXN/5C2.5BK, Tycab BMX350-23025-BK or equivalent. The requirements of Section 11.12 above must be noted.
- Pole-mounted luminaires must be individually protected and wired generally in accordance with drawing CS4-DRG-350285 *Stations Electrical Services – Lighting Pole Internal Wiring – Equipment Arrangement*.
- The DALI power cable must have the following characteristics:

MARKING	CONDUCTOR TO SIZE	WIRE COLOUR	DESCRIPTION
L	2.5 mm^2	Brown	20A Active Conductor
N	2.5 mm^2	Blue	20A Neutral Conductor
Earth symbol	2.5 mm^2	Green/Yellow	Protective Earth
DA-	1.5 mm^2	Grey (typical)	DALI Control Wire
DA+	1.5 mm^2	White (typical)	DALI Control Wire

12.5. Cable Installation

1. All electrical cables must be installed to AS 3000 and the manufacturer's recommendations.
2. All Telecommunications ELV & LV cables must be installed to AS/ACIF S009 and the manufacturer's recommendations.
3. Unless otherwise specified or unavoidable due to route length or site conditions, cables must be run for their entire route length without intermediate joints. Joints must only be made at equipment terminals.
4. No cable joints must be made below ground level, nor in concealed or inaccessible locations, without prior application to the Department, as follows:
   - the Contractor must provide full details of the exact joining method proposed and must not install the joint until approval is granted by the Department; and

- at each end of any cable that is joined, the Contractor must provide labels stating that the cable is jointed and the approximate location of the joint.

5. All cable joints required due to cable damage during installation, route length or difficult installation conditions must be installed in accordance with manufacturer's recommendations unless otherwise specified. Any enclosures containing joints must be installed at accessible locations and labelled.
6. Cables must be installed so as to avoid damage to insulation or sheathing. Damage to cables must be reported and replaced or repaired as directed by the Department.
7. Where cable access holes pass through metal structures, the holes must be burr free, treated against rust, bushed and sealed to prevent the ingress of moisture and vermin.
8. Cabling extending to the top of poles must be installed with the appropriate cable support at top and bottom.
9. Copper conductors with a nominal area less than 0.75 mm^2 must be terminated by means of a compression-type ferrule of the correct size for the conductor and compressed only by the correct tool.
10. All wiring, cabling and terminations, both within and outside of switchboards and other enclosures, must be performed in a neat and professional manner in accordance with the best current industrial electrical work standards. By way of example, all wiring must be installed in ducting or neatly loomed and supported; cables, terminals, and other elements must be labelled. Adhesive products such as self-adhesive cable-tie mounts must not be used.

12.6. Cable Marking, Protection and Labelling

1. The Contractor must ensure that underground conduits are protected by:
   - Electrical — orange cable marking tape complying with AS 2648.1: Underground marking tape – Non-detectable tape and installed in compliance with AS 3000.
   - Telecommunications — white marking tape in accordance with Australian Standards AS/ACIF S009 & 008.
2. Each end of all cables must be labelled. In addition, all cables must be fitted with a third label immediately adjacent to the point where they enter the equipment room and cables which run underground must be identified in every cable pit by means of stamped, non-ferrous tags or engraved plastic tags clipped around each cable.
3. Cables must be identified in a manner that is permanent and indelible and consistent with the as-built drawing nomenclature. Self-adhesive labels are not acceptable.

12.7. Conduits

12.7.1. General Requirements

- The rail signalling's pit and conduit system must not be used for Mains electrical.
- **No corrugated conduit is to be installed underground** except for the purpose of providing additional sheathing (segregation) in pits. Where awkward or unusual bends are required in order to direct a conduit into a pole or small opening, the Contractor must use "setting" (gentle heating and bending of a PVC conduit while using a metal bending spring to prevent conduit wall collapse).
- Conduits must be laid out in straight lines to avoid unnecessary bends. The maximum permissible bend count for any one conduit run is 180°. (For example, 2 × 45° sweeps and 1 × 90 sweep = 180°.)
- Sweeps must be used in preference to bends.
- Conduits must be cleaned and must be free of dirt and debris.
- For conduits in filled platforms, each platform's pits and conduits must consist of a main 'back-bone' and a number of 'daisy-chained' spurs,

such that an arrangement of ‘redundant loops’ is formed along the platform for each of the Power, Communications and Speaker systems.

- Conduit diameters may be chosen by the Contractor, subject to a minimum of 32mm. For an initial installation, conduits must achieve a fill factor of less than 25% as the ratio of the sum of cable cross sectional areas to the inner cross-sectional area of the conduit. This equates to 50% spare useable capacity.
- In accordance with Master Specification RD-EL-D3, spare conduits must be provided in every trench or under-bore. The electrical spare must be the same size as the largest occupied electrical conduit. The communications spare must be the same size as the largest occupied communications conduit. Where close to a station or other infrastructure, consideration must be given to the installation of a second, smaller conduit for LV communications (PA speakers).
- Notwithstanding AS 3000, in order to avoid confusion with white communications conduits, power conduits must be orange and must not be grey.

12.7.2. Conduits Entering Poles

All conduits entering poles must:

- be spaced from each other so that conduit caps or couplings can be easily fitted to all conduits at the same level.
- extend up from the finished floor level by 100mm (drawing 624-A3-11-315 refers).
- be rigid wall conduit.

If more than one type of service enters a pole, all services with the exception of electrical must be fully segregated from all other services.

12.7.3. Joining Conduits

All underground conduit joints must be prepared with PVC red priming fluid and glued together with PVC solvent cement. Refer to AS/NZS 2032: *Installation of PVC pipe systems*. The conduit to be joined (not bell end) must be cut square to create the strongest join. After glue is applied, the conduits must be pushed firmly together ensuring maximum bell penetration.

Where the conduit enters a pit, the conduit end must be fitted with an “End Collar” (“bell end”).

12.7.4. Conduit Compliance

- All conduit and pit installations, without exception, must require the Contractor to supply a compliance certificate stating that the installation meets all relevant Australian Standards, is fit for purpose and is safe to use.
- For electrical conduits, a Certificate of Compliance (CoC) is required and for communications conduits, a Form TCA1 certificate is required.
- Conduit and pit installation work involving communications conduits must be performed by, or supervised by, persons who are appropriately registered in accordance with the ACMA Cabling Provider Rules.
- If the pit and conduit installation is done by persons under supervision of a Registered Cabler, the Contractor must demonstrate that those persons have received training on the essentials of communications conduit work.
- The certificates must be delivered to the Department as soon as possible after the work is completed.

- It must be noted that a Project must deliver a total of 4 CoCs, as listed in Section 17 below.

12.7.5. Underground Electrical Conduit Cover

Notwithstanding *AS3000*, the cover for electrical conduits (without additional protection) must be a minimum of 600mm and a maximum of 800mm below finished floor/ground level. The conduit must be orange to comply with AS3000 and have a minimum diameter of 32mm.

12.7.6. Underground Communications Conduit Cover

Notwithstanding *AS/CA S009*, the cover for communications conduits (without additional protection) must be a minimum of 450mm and a maximum of 600mm below finished floor/ground level. The conduit must be white (marked “Communications”) to comply with AS/CA S008 and have a minimum diameter of 32mm.
Note: Platforms and walkways are regarded as ‘public footways’.

Marking tape must be installed, complying with the requirements of *AS/CA S008.*

12.7.7. Above Ground or Exposed Conduits

- All wiring in exposed situations (including under suspended-slab platforms without any other protection) must be enclosed in metal conduit up to a minimum height of 3 m above finished floor or ground level. Solid wall galvanised metal conduit must be used, incorporating short lengths of flexible metal conduit (“Anaconda”) where necessary. (Metal Anaconda conduit must not be used in straight lines as a replacement for solid-wall conduit.)
- Fixings must be of stainless-steel material and be provided with two fixing points (not “P-clips”). They must be fitted at a maximum spacing of 600 mm to secure the conduit to the structure. The usual minimum diameter of metal conduit to be used is 32 mm, although 25 mm is preferred.
- Sections of metal conduit can be replaced by a “top-hat section” being a mechanical protection in the form of 1.6 mm hot dipped galvanised section, screw fixed in place at intervals not exceeding 1000 mm and painted to match the surroundings.
- PVC conduits more than 3 m above finished floor or ground level must be UV-resistant.

12.7.8. Front of Station Platforms

- Reticulation along the front of a platform must be regarded as a ‘last resort’.
- 230V mains power must never be run on the front wall of a platform—110 V AC is the maximum voltage permitted. Usually only communications conduits are considered for use in this way.
- The conduits must be metal and as small as practicable to prevent them being used as a foothold by trespassers—32mm is the maximum allowed.
- Fixings must be spaced at a maximum of 500 mm.

12.7.9. Draw-Cords

- Draw-cords must be provided in all conduits. Polypropylene yellow/blue draw rope with a minimum diameter of 4mm must be used. Existing ropes that are used to pull cables may have become brittle over time and must not be re-used.
- Any cables pulled though conduits (regardless of whether these are new or existing conduits) must have another draw-wire pulled through with

them, so that a draw-wire remains in every conduit at the completion of the works. Ropes must be tied off at both ends.

- All empty conduits must be capped at both ends.

13. Cable Pits

13.1. Existing Pits

- Existing Departmental standard conduits and pits must be re-used unless otherwise specified in the Project's CSTR.
- Before re-using the pit and conduit system, it must be inspected and made compliant to all relevant standards. If compliance is not possible, the pit and conduit system must not be used.
- Electrical and communications conduits must not terminate in the same pit unless it is fitted with a segregation wall.
- All existing pits must be permanently labelled identifying the service contained within.

13.2. New Pits

Conduits and pits must be installed in accordance with:

- *AS/AC S009 & 008* Telecommunications Standards.
- *AS 3084: Telecommunications installations – Telecommunications pathways and spaces for commercial buildings*.
- *AS3000*: *Electrical Standards*.
- The Department's Master Specification RD-EL-C3 *Supply and Installation of Conduits and Pits*.

All pits shall have drain holes installed. Where no suitable drainage point is located near the pit(s), it must be provided with an engineered soakage facility.

13.2.1. Pit Location and Security

- In locations subject to pedestrian traffic (platforms, pathways, etc.), the Contractor must employ an arrangement that incorporates the use of a concrete in-filled cover ("Gatic") or equivalent. The cover must:
  (i) be a minimum "Class B" type.
  (ii) be installed within the frame and finished to the surrounding platform level in order to minimise tripping hazards.
  (iii) have minimal gap between the lid and the frame.
  (iv) be easy to open with use of the correct lifting equipment by two people.
  (v) be large enough to comfortably cover three pits, being Electrical, Comms ELV and Comms LV (refer to drawing 004-A3-11-336 for details.).
- The pits located underneath Gatic covers must be fitted with labelled lids and gaskets and they do not need to be locked.
- In locations not subject to pedestrian or other traffic (for example, in the rail corridor or garden areas), the Contractor must install a lockable pit, fitted with a D-bolt and with provision for a padlock.
- All pits with metal covers must be permanently labelled with the SA Government roundel, identifying the pit as SAPTA's and the service that it contains.
- Pits must not be installed:
  (i) next to waterways
  (ii) on roadways
  (iii) in natural depressions or on sloping surfaces (allowing water to run into the pit)
  (iv) in areas that are difficult to access
  (v) within Earth Potential Rise (EPR) zones.

14. Earthworks, Trenching, Boring and Concrete Works

The Contractor must undertake all trenching (or boring) and other earthworks in such a manner that:

- The work complies with the requirements of the *PTS-MS-10-SG-STD-00000094 – PTS Pits and Conduits Standard*;
- The work complies with the requirements of *AS 3000, AS 4799* and *AS/CA S008* and *S009*;
- All trenches done in the rail corridor must employ a vacuum excavation method only.
- All open trenches, uneven surfaces, holes or other hazards must be isolated by the erection of temporary barriers, fencing or other means, supplied by the Contractor and compliant with *AS 1742.3: Manual of uniform traffic control devices – Traffic control for works on roads*;
- No trench or other excavation on pedestrian walkways or platforms must be left uncovered overnight.

14.1. Vandal Resistance

All fittings, mounting brackets and arrangements must be designed to be vandal resistant.

14.2. Mechanical Protection

- All housings, fittings, mounting brackets and arrangements must be dust and weather resistant to at least IP55 rating level.
- All equipment installed must be suitable to withstand the prevailing environmental conditions. For example, boxes, etc. should be stainless steel at stations near the sea.
- All steel brackets, pipes, tubes, etc., together with their associated fixings, supplied as part of the works and intended for use out of doors must be hot dip galvanised or made from stainless steel, unless otherwise approved.
- The exposed thread of all metal conduits must be treated with zinc-rich paint.

14.3. Commissioning and Interruption of Services

The Contractor must ensure that the works undertaken by or under supervision of the Contractor are conducted so that electrical supply to the Station Precinct must be maintained at all times except by prior arrangement with the Department. Prior to any interruption of supply a minimum of 24 hours' notice is required.

Electrical supply to lighting on site may only be interrupted during daylight hours.

15. Drawings

New design drawings must be prepared in colour and showing conduits, cable trays, etc. as follows:

- Electrical: Orange;
- ELV Communications: Purple or similar;
- LV Communications: Light blue or similar.

16. Test Plan

The Contractor's test plan must include tests to demonstrate the correct installation and/or function of each element of the system, including tests associated with the following:

- Earthing and Bonding requirements for electrified railways or tramways, as per Standard *TP4-DOC-003507 – Earthing and Bonding*.
- Inspection of quality of workmanship for physical installation works.
- Demonstration that as-built documentation matches the installation.
- Validation of the lighting control software program.

17. Records

The following records must be provided to the Department:

- Any changes to the original design;
- Layout arrangement of transformers, switchboards and distribution boards;
- Shop drawings of light poles and their mounting bases;
- Shop drawing of isolation transformers indicating details of mounting dimensions, connection points, earthing arrangement, mass and enclosure construction and finish;
    - Shop drawings of distribution boards showing the following:
    - Types, model numbers and ratings of assemblies;
    - Component details, functional units and transient protection;
    - Detailed dimensions;
    - Shipping sections, general arrangement, plan view, front elevations and cross-section of each compartment;
    - Projections from the assembly that may affect clearances or inadvertent operation, such as handles, knobs, arcing-fault venting flaps and withdrawable components;
    - Fault level and rated short circuit capacity characteristics;
    - IP rating;
    - Fixing details for floor or wall mounting;
    - Front and back equipment connections and top and bottom cable entries;
    - Door swings;
    - External and internal paint colours and paint systems;
    - Quantity, brand name, type and rating of control and protection equipment;
    - Construction and plinth details, ventilation openings, internal arcing-fault venting and gland plate details;
    - Terminal block layouts and control circuit identification;
    - Single line power and circuit diagrams;
    - Details of cables routes within assemblies;
    - Busbar arrangements, links and supports, spacing between busbar phases and spacing between assemblies, the enclosure and other equipment and clearances to earthed metals;
    - Dimensions of busbars and interconnecting cables in sufficient detail for calculations to be performed;
    - Form of separation and details of shrouding of terminals;
    - Labels and engraving schedules;
    - Shop drawings of concrete plinths;
- Report for any alternative design solution. The report must incorporate reasons, calculations, risk assessment, assumptions (if any), sketches and shop drawings for the alternative solution;
- Samples of equipment, where possible, along with the manufacturer's technical literature;
- Operation and Maintenance Manuals of all installed systems. The manuals must be supplied in native and PDF formats. The manuals must include the following:
    - General description of the installation;
    - Technical description of the systems installed, written to ensure that the Department's staff fully understand the scope and facilities provided. It must identify function, normal operating characteristics, limiting conditions and emergency operation;
    - Technical description of operation mode of the systems installed;
    - Manufacturers' technical literature for equipment installed or assembled specifically for the project, excluding irrelevant matter. Each product data sheet must be marked to clearly identify specific products and component parts used in the installation, and data applicable to the installation;
    - Supplements to product data to illustrate relations of component parts;
    - Safe starting up, running in, operating and shutting down procedures for systems installed; It must include logical step-by-step sequence of instructions for each procedure;
    - Control sequences and flow diagrams for systems installed;

- Legend for colour-coded services;
- Schedules of fixed and variable equipment settings established during commissioning and maintenance, including a list of all metering devices connected to the Central Monitoring System and their settings;
- Schedule of normal consumable items, local sources of supply, and expected replacement intervals. It must include lubricant and lubrication schedules for equipment;
- Instructions for use of tools and testing equipment;
- Emergency procedures, including telephone numbers for emergency services, and procedures for fault finding;
- Material safety data sheets (MSDS);
- Copies of test certificates for the installation and equipment used in the installation;
- Test reports;
- Switchgear and control-gear assembly circuit schedules including electrical service characteristics, controls and communications;
- Maintenance procedures and program, relating to installed systems and equipment. It must indicate dates of service visits, state contact telephone numbers of service operators and describe arrangements for emergency calls;
- 'As Installed' drawings showing dimensions, types and location of the services in relation to permanent site features and other underground services. Drawings must also show the spatial relationship to building structure and other services. All changes made during commissioning and the maintenance period must be included. Drawings must be supplied in native AutoCAD® and PDF formats (other drawing formats are not acceptable);
- Certificates of Compliance. A minimum of four certificates are required:
  - An electrical CoC covering the (empty) pit and conduit work;
  - A Telecommunications CoC (Form TCA1); covering the (empty) pit and conduit work (unless communications work was not involved);
  - An electrical CoC covering all the electrical work undertaken (installation or modification);
  - A Telecommunications CoC (Form TCA1) covering all the communications work undertaken (installation or modification) if applicable.
- Site commissioning software configuration files, and source files for all as-built site documentation of the Programmable Lighting Control System—hard-copy to be installed and issued on a USB flash drive.

- Circuit breakers settings along with final connected loads;
- Evidence of discrimination between Electricity Supply Authority service protection device and main incoming switch;
- Schematic diagram of power monitoring system along with relevant information and equipment technical literature;
- Test results for Ohmic resistance of installed earth electrodes;
- Calculations showing earth fault-loop impedance conforms to the requirements of *AS3000*, Clause 5.7.4.
- Technical data sheets for luminaires, lamps and control gear (including power factor correction equipment if not integral);
- Lighting control system schematic and settings including test results demonstrating compliance with luminance levels in Section 11.3 above; and
- Operational Training.

APPENDIX 1 – ISOLATION TRANSFORMER REQUIREMENTS

A1.1 General Requirements

The isolation transformer must be provided to isolate the railway traction supply earthing system from the local Electricity Supply Authority earthing Multiple-Earthed-Neutral system where low voltage supplies are required. The transformer must be located on the rail corridor property unless specified otherwise in the Project CSTR. The minimum separation required between SAPN Distribution Substation and isolation transformer earthing grids is 3m however a greater separation may be required if the SAPN earthing grid is extensive. Refer to the E&B Guidelines AR-EL-STD-0102 (train) or TP2-DOC-002020 (tram) for transformers installed within the railway corridor and also for cases in which the transformer has to be installed outside the railway environment.

The transformer must be earthed such that the earthing system impedance (with the traction earth bond disconnected) must comply with AS 3000, Clause 5.7.4.

Note that a railway-owned HV supply transformer can provide the functionality of an isolation transformer. In this case, the traction earthed railway supply may then result in simultaneous contact between traction earthed objects such as station lighting masts on the boundary of the railway alignment and MEN earthed objects which are closer than 2.5 m, for example, street lighting masts. In this case an isolation transformer is required to isolate this supply from traction earth. The secondary of the isolation transformer must be connected to an independent earthing system.

A second isolation transformer is required for all sub circuits in excess of 500 m to contain the touch potential between the local traction earth and that extended from the traction earth connection at the main transformer—refer to the E&B Guidelines.

A1.2 Specifications

The isolation transformer must comply with the requirements of *AS 61558.1*: *Safety of Power Transformers, Power Supplies, Reactors and Similar Products* and *AS 61558.2.4*: *Safety of Power Transformers, Power Supplies, Reactors and Similar Products*. Particular requirements and tests for isolation transformers and power supply units incorporating transformers, *AS 60076.11*: *Power Transformers - Dry-type Power Transformers*, document *TP4-DOC-003507 – Earthing & Bonding* and the additional specific requirements of this document. The transformer must be suitable for continuous operation at nameplate rating under the environmental conditions specified in Table A1 (a) below:

CONDITION	REQUIREMENT
Minimum degree of protection	IP 55
Maximum ambient temperature	50°C
Minimum ambient temperature	-5°C
Maximum altitude	1000 m above sea level
Maximum relative humidity	95%
Maximum solar radiation intensity	1.1 kW/m²

Table A1 (a) – Environmental Conditions

The isolation transformer electrical characteristics must conform to Table A1 (b) below:

CHARACTERISTIC	REQUIREMENT
Rated power	As required. Standard sizes (kVA): 3.6, 10, 15, 25, 40, 63, 80, 100, 125, 160, 200, 315 & 400 (Preferred sizes are underlined.)
Power system	3-phase, 50 Hz
Nominal primary voltage	400V phase-to-phase

Nominal secondary voltage	400V phase-to-phase 230 V phase-to-neutral sinusoidal
Primary-to-Secondary ratio	1 : 1
Tapping	Transformers must be provided with tapping 5% above and below the nominal input voltage in 2.5% steps. Tappings must be arranged so as to be suitable to be altered by off-circuit bolted links.
Vector group	Dyn11
Windings	Separate primary and secondary windings with earthed screen interposed between the windings.

Table A1 (b) – Electrical Characteristics of Three-Phase Transformers

The isolation transformer must be designed with Class H insulation and natural air (NA) cooling. Transformers must have a maximum winding temperature rise of 115°C above a 50°C ambient temperature when mounted in their enclosure. The entire transformer core and coil assembly must be impregnated with Class H varnish and baked in accordance with the varnish manufacturer's specifications.

The isolation transformers must be of double wound isolation type and must incorporate an electrostatic earth screen of a minimum 0.5 mm thickness. The earth screen must be terminated to a separate terminal marked "Screen".

The transformer windings must be constructed of copper and mounted on a core of high-grade grain-oriented silicon electrical steel. The windings must be securely fixed to the core to prevent movement. Winding end turns must be positively secured.

The transformer core and coil assembly must be mounted in the enclosure on insulators suitable for the insulation levels specified in Table A1(c) below. The entire core and coil assembly must be insulated from the enclosure and must be mounted using high tensile fasteners.

The transformer must be constructed to *AS 61558.2.4* using uniform insulation. Short duration power frequency testing to be performed on the isolation transformer must be in accordance with the table below:

TEST	**VOLTAGE**	**MINIMUM INSULATION RESISTANCE AT 500 V DC**
Primary to earthed secondary and enclosure, with core and screen floating	5 kV AC RMS for 60 seconds	100 MΩ
Secondary to earthed primary and enclosure, with core and screen floating	5 kV AC RMS for 60 seconds	100 MΩ
Screen to earthed primary, secondary, and enclosure with core floating	2.5 kV AC RMS for 60 seconds	10 MΩ
Core to earthed primary, secondary, with enclosure and screen floating	5 kV AC RMS for 60 seconds	10 MΩ
Core to earthed enclosure with primary, secondary and screen floating	5 kV AC RMS for 60 seconds	10 MΩ
Screen to earthed core and enclosure with primary and secondary floating	5 kV AC RMS for 60 seconds	100 MΩ

Table A1 (c) – Insulation Requirements

The transformer must be subjected to a separate source induced over-potential test at twice rated voltage and two times rated frequency for a minimum of 5 minutes in accordance with *AS 61558.1*. Note the frequency can be increased and the duration reduced in accordance with Clause 18.4 of *AS 61558.1.*

The transformer must be mounted in a weatherproof enclosure with IP 55 rating constructed of metal incorporating mounting holes and provision for lifting by forklift or similar.

The enclosure must be designed to minimize external dimensions whilst providing maximum surface area for cooling purposes. Ventilation by means of filtered grills must be provided for air flow within the enclosure. Transformers must be rated for operation without fan cooling.

All external surfaces of the enclosure must be designed to withstand the impact of a test to IK10 (this is a 20N force, applied with a 5kg mass falling from a 400mm height) without exposing live parts.

All primary, secondary and screen termination must be made of nickel-plated brass or stainless-steel studs, or pre-drilled copper flags. All winding terminations must be brought out to terminals or studs mounted in IP 56 termination enclosures mounted on the outside of the main transformer enclosure. Tappings may be located in these termination boxes or inside the transformer main enclosure. An earth stud must be provided within the transformer main enclosure.

Enclosures must be made of galvanised steel. The finish must be UV-stabilised powder coat paint and the colour must be “Transformer Grey” or to the project’s specification. In marine-type environments, Grade 316 stainless steel (powder coated) must be used.

All removable covers must be securely fixed in place with internal hex tamper-proof vandal-resistant stainless-steel fasteners.

Primary, secondary and screen terminals must be located in separate termination enclosures or shrouded and separated such that it is not possible to bridge the primary and secondary windings unless disconnected from the primary supply. Cabling from the terminals to the transformer core and coil assembly must be double insulated and primary and secondary cables must be physically segregated.

Each termination enclosure must be fitted with two engraved labels with red letters on a white background and must read “DANGER xxx VOLTS” where xxx is the line voltage of the winding. The primary and secondary termination enclosures must be fitted with an additional similar label which must read: “WARNING – ISOLATE POWER BEFORE REMOVING THIS COVER”. All labels must comply with *AS 3100*.

The position of the termination enclosures must be such as to ensure that primary and secondary conductors are segregated. The terminals must be shrouded or made inaccessible by barriers such that primary and secondary terminals cannot be bridged.

Rating plates must comply with *AS60076*: Power Transformers and *AS3100* and must be of corrosion resistant metal. Rating plates must be engraved and mounted on the outside of the transformer enclosure. Tapping labels must be located adjacent to the tapping links.

The transformers must be routine tested in accordance with *AS 61558.1, AS 60076.11* and Table A1(c) “Insulation Requirements”.

The first of each new design must also be temperature rise type tested. Test reports must be provided with the transformer supplied and submitted to the Department.

Drawing *TP4-DRG-004185* Isolation Transformer, 230V:230V 15kVA, Typical Arrangement details the requirements for a small isolating transformer (as used for

neighbourhood stations). It also must be followed as a guideline for the manufacture of larger units.

APPENDIX 2 – EXPLANATORY NOTES ON THE CALCULATION OF VERTICAL ILLUMINATION LEVELS

When Vertical Illumination calculations are requested, numerous questions can arise in the mind of the lighting designer as to locations of calculation points and the direction(s) of the illuminance to be calculated. Horizontal Illumination calculations are typically less confusing, as they are usually performed either at ground or 'task' level on a grid of points. AS 1680: *Interior and Workspace Lighting* guides towards horizontal planes with uniform grid spacing of either 200 mm or 500 mm (depending on room size and shape), whereas AS 1158 states that calculation points can be up to five metres apart in many instances.

Of AS 1680 and AS 1158, AS 1158 is the only standard which explicitly describes and illustrates the placement of vertical calculation points (including spacing, extremities and directions), ensuring that designers can provide results that can be meaningfully compared from one system to another without 'interpretation' of the Standard clouding the situation.

With reference to Figure A2, vertical illumination on open platform areas should be calculated as follows:

- For the purposes of this section, the term 'platform' means the structure designed to allow travellers to enter or exit a train on a single rail line. If the structure is an 'island platform' servicing two rail lines (one either side), a set of vertical calculations must be made for each half of the platform area;
- Vertical Illumination calculations must be performed at a height of 1.5 m above each platform floor level;
- For both straight and curved platforms, vertical illuminance calculations must be performed along two lines for each platform. The first line must be above the platform edge. The second line must be set halfway between the platform edge and the back of the platform area;
- The first and last set of calculation points must be set 7.5 m in from the respective platform ends;
- For open stations, vertical illumination calculation points must not be required underneath covered platform areas;
- The spacing between calculation points on each line must be no more than 5 m;
- Vertical Illuminance calculations must be performed in two opposing directions, aiming towards the platform ends. Where the platform is curved, the direction of the calculation point 'light meters' must be at a tangent to the curve at the centre of the platform.

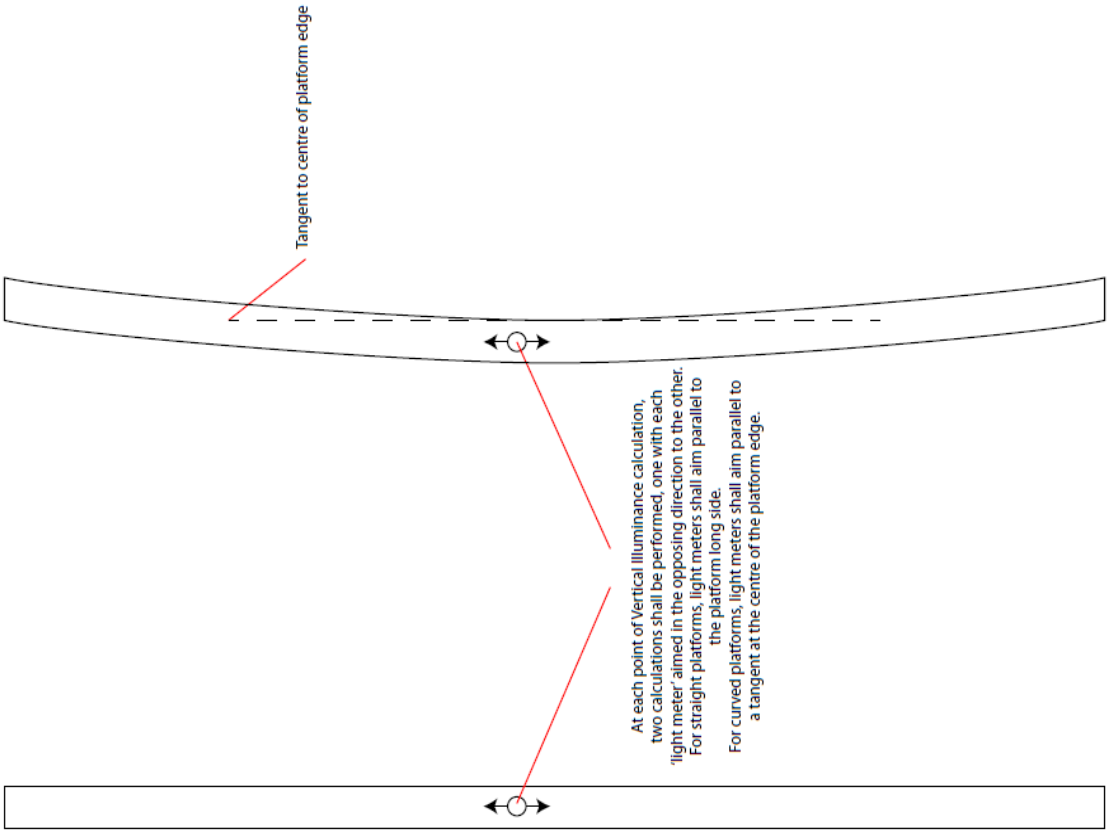

Fig 2

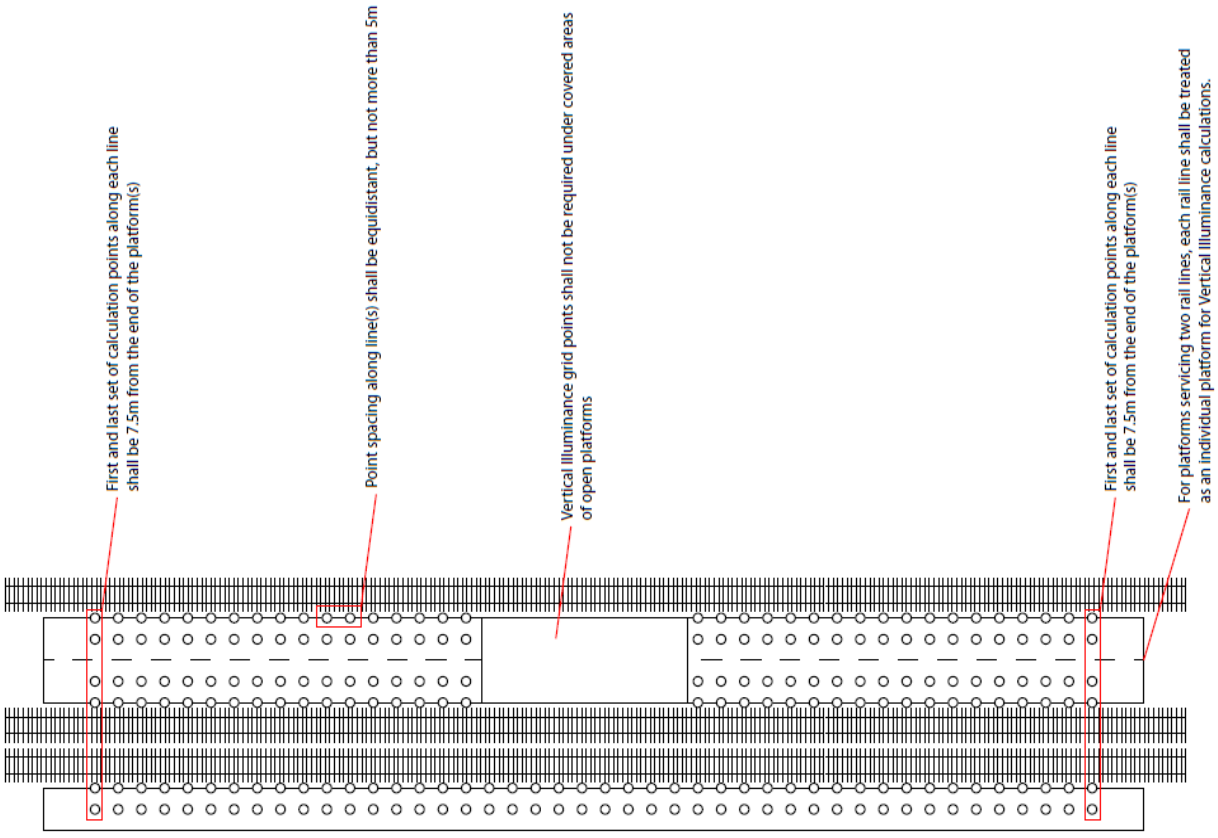

Fig 1

Figure A2