Transport Asset Standards Authority

T HR SS 80001 ST

Standard

Infrastructure Lighting

Version 3.0

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Standard governance

Owner:	Lead Stations and Buildings Engineer, Asset Standards Authority
Authoriser:	Chief Engineer, Asset Standards Authority
Approver:	Executive Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

Version	Summary of changes
1.0	First issued 01 November 2016.
2.0	Second issue 28 September 2017. Changes from the previous version include clarification to existing requirements and introduction of new requirements for substations, sectioning huts and level crossings.
3.0	The changes from the previous version include updates to requirements related to T HR SS 80002 ST *Low Voltage Electrical Installations* and T MU SY 20001 ST *Surface Transport Fixed Infrastructure Physical Security Standard.*

Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the *ASA Charter*, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW's governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW's process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW's Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW's Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This standard provides requirements for lighting on the TfNSW heavy rail network and guidance on the appropriate application of those requirements at different locations within the network.

This standard is the third issue. The changes from the previous version include updates to requirements related to T HR SS 80002 ST *Low Voltage Electrical Installations* and T MU SY 20001 ST *Surface Transport Fixed Infrastructure Physical Security Standard.*

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1. Introduction

Adequate lighting is a prerequisite to creating safe and comfortable environments. To carry out rail operations in compliance of legislative and Transport for NSW (TfNSW) requirements, adequate lighting is required for all rail facilities.

Stations and stops are the primary interface between commuters and the transport system. The quality of natural and artificial lighting influences passengers' perception of safety, cleanliness and level of service. Good lighting contributes to properly defining the transport system facilities in line with corporate branding practice and accentuating features that attract patrons to stations, associated public spaces and retail areas. Adequate lighting makes it easier to navigate an area, promotes full use of the available facilities and is a deterrent to crime.

TfNSW aims to provide safe and ergonomic transport solutions that satisfy NSW's legislative and regulatory requirements in dependable and efficient ways. The resulting approach promotes the use of environmentally and socially responsible lighting solutions.

2. Purpose

This standard provides requirements for lighting on the TfNSW heavy rail network and provides guidance on the appropriate application of those requirements at different locations within the network.

This standard defines practical, economic and technical lighting requirements that provide for safe travel, comfortable use and efficient operation of the rail transport system. This standard aims to achieve the following objectives:

- facilitate optimal visual conditions for operation and maintenance
- ensure compliance with relevant legislative requirements and regulations, TfNSW and Australian and international standards
- minimise pollution and depletion of natural resources, reduce energy consumption and carbon footprint, and promote the image of TfNSW as a socially and environmentally responsible public service provider
- attain the best possible commercial results through appropriate design, equipment life cycle evaluation and resultant cost-benefit analysis

2.1. Scope

This standard covers requirements for internal and external lighting, including daylight, artificial lighting and a combination thereof, during the normal operation of the network.

This standard does not cover emergency lighting, rolling stock lighting or lighting for signalling systems.

2.2. Application

This standard applies to all stages of the lighting asset's life cycle including planning, design, construction, operation, maintenance and decommissioning.

This standard applies to all new installations including upgrades and additions or changes to existing installations.

This standard shall be read and applied in conjunction with the relevant standards and T HR SS 80003 ST *Infrastructure Emergency Lighting*.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards

IEC 62262 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

IES LM-63 Standard File Format for Electronic Transfer of Photometric Data

Australian standards

AS 1428.1 Design for access and mobility Part 1: General requirements for access – New building work

AS 1428.2–1992 Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities

AS 1798 Lighting poles and bracket arms – Recommended dimensions

AS 4282 Control of the obtrusive effects of outdoor lighting

AS 4806.2 Closed circuit television (CCTV) Part 2: Application guidelines

AS 60529 Degrees of protection provided by enclosures (IP Code)

AS/CA S009 Installation requirements for customer cabling (Wiring rules)

AS/NZS 1158.1.1 Lighting for roads and public spaces Part 1.1: Vehicular traffic (Category V) lighting - Performance and installation design requirements

AS/NZS 1158.1.2:2010 Lighting for roads and public spaces Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance

AS/NZS 1158.1.3 Lighting for roads and public spaces Part 1.3: Vehicular traffic (Category V) lighting - Guide to design, installation, operation and maintenance

AS/NZS 1158.2 Lighting for roads and public spaces Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting

AS/NZS 1158.3.1 Lighting for roads and public spaces Part 3.1: Pedestrian area (Category P) lighting - Performance and installation design requirements

AS/NZS 1158.4 Lighting for roads and public spaces Part 4: Lighting at pedestrian crossings

AS/NZS 1680.0 Interior lighting Part 0: Safe movement

AS/NZS 1680.1:2006 Interior and workplace lighting Part 1: General principles and recommendations

AS/NZS 1680.2.1 Interior and workplace lighting Part 2.1: Specific applications – Circulation spaces and other general areas

AS/NZS 1680.2.2 Interior and workplace lighting Part 2.2: Specific applications – Office and screen-based tasks

AS/NZS 1680.2.3 Interior and workplace lighting Part 2.3: Specific applications - Educational and training facilities

AS/NZS 1680.2.4 Interior lighting Part 2.4: Industrial tasks and processes

AS/NZS 1680.3 Interior lighting Part 3: Measurement, calculation and presentation of photometric data

AS/NZS 1680.4 Interior lighting Part 4: Maintenance of electric lighting systems

AS/NZS 1680.5 Interior and workplace lighting Part 5: Outdoor workplace lighting

AS/NZS 2053 (all parts) Conduits and fittings for electrical installations

AS/NZS 2053.1 Conduits and fittings for electrical installations Part 1: General requirements

AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)

AS/NZS 4677 Steel utility services poles

AS/NZS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous article

AS/NZS 4792 Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process

AS/NZS 60079.10.1 Explosive atmospheres Part 10.1: Classification of areas—Explosive gas atmospheres (IEC 60079-10-1, Ed.1.0 (2008) MOD).

AS/NZS 61000 (all parts) Electromagnetic compatibility (EMC)

AS/NZS 61000.3.2 Electromagnetic compatibility (EMC) Part 3.2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

AS/NZS CISPR 15:2011 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment [CISPR 15, Ed.7.2 (2009) MOD]

SA/SNZ TS 1158.6:2015 Lighting for roads and public spaces Part 6: Luminaires–Performance

Transport for NSW standards

EP 00 00 00 15 SP Common Requirements for Electric Power Equipment

EP 17 00 00 11 SP Low Voltage Isolating Transformer

EP 03 00 00 01 TI Rectifier Transformer & Rectifier Characteristics

ESB 000 Introduction

ESB 001 Design Context and Process

ESB 002 Design Principles

ESB 003 Station Functional Spaces

ESB 004 Station Services and Systems

T HR EL 08001 ST Safety Screens and Barriers for 1500 V OHW Equipment

T HR SS 80002 ST Low Voltage Electrical Installations

T HR SS 80003 ST Infrastructure Emergency Lighting

T MU AM 01001 ST Life Cycle Costing

T MU AM 01003 ST Development of Technical Maintenance Plans

T MU AM 04001 PL TfNSW Configuration Management Plan

T MU HF 00001 ST Human Factors Integration – General Requirements

T MU MD 20001 ST System Safety Standard for New or Altered Assets

T MU SS 90001 ST Safe Pedestrian Surfaces

T MU SY 10001 ST Public Transport Closed Circuit Television (CCTV) Functional Requirements Standard

T MU SY 20001 ST Surface Transport Fixed Infrastructure Physical Security Standard

TS 10753 Assurance and Governance Plan Requirements

Transport for NSW standard drawings

EL0003997 Railway Station Lighting, lighting pole for Type 3f & 3g lighting column – Details

EL0003933 Railway Station Lighting, Platform Lighting Column Type 3g – General Arrangement

EL0008945 Railway Station Lighting Platform Standard, Single or Double Arm Support Details

EL0002759 Station Lighting: Typical Arrangement Details for Platform Lighting Columns (Platform Standards)

EL0005172 Station low voltage electrical services general information

EL0204559 Staff Access, Backup Lighting, A/C & HWU

Legislation

Disability Discrimination Act 1992

Disability Standards for Accessible Public Transport 2002

Heritage Act 1977

Work Health and Safety Act 2011

Work Health and Safety Regulation 2011

Other reference documents

Heritage Office, Department of Planning 2006, Photographic Recording of Heritage Items Using Film or Digital Capture

Heritage Office 1998, How to Prepare Archival Records of Heritage Items

Office of Environment and Heritage January 2005, State Agency Heritage Guide – Management of Heritage Assets by NSW Government Agencies, publication number HO05/01

SMS-06-GD-0268 Working around Electrical Equipment

The Australian Building Codes Board, National Construction Code, Volume one

4. Terms and definitions

The following terms and definitions apply in this document:

ARA Australasian Railway Association

ASA Asset Standards Authority

BMCS building management control system

CCT correlated colour temperature

CCTV closed circuit television

CDM ceramic metal halide

CM configuration management

CPTED crime prevention through environmental design

CRI colour rendering index

DDA Disability Discrimination Act 1992

DSAPT Disability Standards for Accessible Public Transport 2002

EMC electromagnetic compatibility

HID high intensity discharge

HV high voltage

IK code coding system to indicate the degree of protection provided by an enclosure against harmful external mechanical impacts (IEC 62262)

illuminance the luminous flux arriving at a surface, divided by the area of the illuminated surface: Unit: lux (lx). Symbol: E. NOTE: 1 lx = 1 lm/m2

- horizontal illuminance (Eh) is the value of illuminance on a designated horizontal plane or at level ground
- vertical illuminance (Ev) is the value of illuminance on a designated vertical plane typically at a height of 1.5 m above ground (AS/NZS 1680.0)

IP Code a coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection (AS 60529)

IRCS isolating and rail connecting switch

LCS lighting control system

LED light-emitting diode

LSZH low smoke zero halogen

luminaire equipment that houses the lamp(s) and directs the light in desired directions. It includes items necessary for fixing, protecting and operating the lamp(s) (AS/NZS 1680.0)

luminance the physical quantity corresponding to the brightness of a surface (e.g. a lamp, luminaire, sky or reflecting material) in a specified direction. It is the luminous intensity of an area of the surface, divided by that area. Unit: candela per square metre (cd/m2). Symbol: L (AS/NZS 1680.0)

maintained illuminance the defined level below which the average illuminance on any surface is not allowed to fall. It is the minimum illuminance at which maintenance operations, such as replacing lamps and cleaning the luminaires, windows, roof lights and room surfaces are to be carried out (AS/NZS 1680.1)

NCC National Construction Code

TfNSW Transport for NSW

5. Technical requirements

The requirements of this standard are in addition to the requirements of the relevant standards which cater for specific circumstances unique to the railway environment and other Transport for NSW (TfNSW) needs.

If alterations or additions are undertaken for any reason, the selection of luminaires shall ensure visual consistency throughout the space.

Where a project affects more than 50% of the existing lights of a particular type, then the whole number of those lights shall be replaced and repositioned as necessary to comply with all aspects of this standard. The lighting levels achieved shall comply with the requirements of this standard.

5.1. Building elements

A close correlation exists between architectural design and lighting. Different requirements need to be balanced to achieve the optimum solution for each individual location. The lighting requirements for each individual location need to be considered on a case-by-case basis.

Considerations for lighting design include the height, size and shape of rooms and spaces, including surfaces, colours, patterns, textures and resultant light reflectance.

The arrangement and location of light fixtures and their mounting height shall be determined by the area function, layout, environmental and maintenance factors. Lighting locations shall be coordinated with building elements and other equipment such as structural elements, cable paths, public announcement speakers, fire detectors and other similar building elements.

Refer to the following standards for background information on building elements:

- ESB 000 *Introduction*
- ESB 001 *Design Context and Process*
- ESB 002 *Design Principles*
- ESB 003 *Station Functional Spaces*
- ESB 004 *Station Services and Systems*

5.1.1. Surface colour and reflectance

Colours and textures of interior surfaces (such as ceilings, walls and floors) are a major contributor to the perception of a space, and the users' safety, comfort and wayfinding abilities. The use of lightly toned surfaces with controlled reflectance adds to the sense of openness and space, promotes orientation, visual interest and improves lighting uniformity. Dark colours and surfaces with low reflectance reduce the ability to light up spaces with reflected light and contribute to the perception of low illumination.

To ensure an efficient installation, the ceilings and walls of all public spaces should have surface reflectance values as follows:

- a minimum of 0.8 for ceilings
- a minimum of 0.5 for walls
- a minimum of 0.2 for floors

Numerous other factors such as branding, signage and advertising, interaction with green and red safety colours, long term maintenance properties and cleanability of surfaces will affect lighting.

5.1.2. Walking surfaces

Prevailing weather conditions, the type of walking surface, level of crowding and crowd behaviour can affect a person's ability to see safety hazards. Lighting shall be designed to assist individual perception of walking surfaces and wayfinding cues to prevent falls and similar accidents. Refer to T MU SS 90001 ST *Safe Pedestrian Surfaces* for design requirements for walking surfaces.

5.1.3. Luminance contrast

Low contrast can cause difficulty in distinguishing objects from the background. Using contrasting colours for objects and the background will aid proper object recognition, improve visibility, provide assistance and decrease the risk of accidents. It is necessary to ensure adequate contrast between adjacent building elements such as edges of steps, the door and adjacent wall.

Luminance contrast between the relevant elements of a building shall comply with AS 1428.1 *Design for access and mobility Part 1: General requirements for access–New building work*.

5.2. Lighting hierarchy

Major elements of a space are recognised through differences in horizontal and vertical illumination. Station public lighting shall emphasise station safety-critical areas such as platform edges, vertical circulation areas (such as stairs, escalators and lifts), and obstacles to traffic flows (such as ticket gates). The lighting of public areas of a station shall be organised according to the following hierarchy:

i. station safety-critical areas

ii. general passenger circulation and waiting areas

iii. staff, operational areas, plant and maintenance, and other infrastructure areas

The exterior illumination of the station entry and adjacent areas shall comply with the TfNSW corporate branding approach as part of integrated design.

Prominent architectural features, facade and landscape lighting require individual attention so that the lighting design is developed to complement the architectural design intent and crime prevention through environmental design (CPTED) principles. Both interior and exterior lighting fixtures shall be integrated into architectural elements and be concealed as far as is practicable.

Only approved light fittings shall be used (see Section 5.10).

5.3. Natural light

Natural light is the preferred light source to illuminate a space and shall be used wherever appropriate to reduce the amount of energy used by artificial lighting.

As daylight illuminance can reach up to 100,000 lx, direct sunlight can at times be undesirable. While the linear nature of a railway may dictate a specific building orientation, UVA and UVB radiation, glare and excessive solar heat gains need to be controlled by design.

The architectural design of a space shall be complemented by appropriate solar shading to facilitate daylight harvesting, prevent visual discomfort and limit heat gains into the space.

Passive daylight harvesting collects sunlight through static elements (such as windows, glass doors, skylights and light tubes) and reflects the collected daylight deeper inside the space using light shelves or similar techniques.

Active harvesting collects sunlight with the aid of automated mechanical devices that increase the efficiency of light collection.

Manual or automatic (with manual override) glare control devices may be used to limit glare related to natural light. For transport transient spaces, the design target should be able to achieve illuminance levels between 300 lx and 5000 lx on the floor area where daylight harvesting is used.

5.4. Artificial light

Artificial lighting shall be provided when available natural light is not sufficient to provide legislatively compliant, ergonomic, functional and safe levels of lighting.

5.4.1. Light distribution

In the public spaces of railway infrastructure, it is necessary to not only have an adequate level of illumination but also for that illumination to be distributed evenly, for example, along the platform yellow line.

To ensure the uniformity of illumination, the selection of luminaires shall be based on the following:

- luminaire light distribution characteristics
- space characteristics
- luminaires location, mounting height and spacing

Trees and vegetation at external lighting locations can affect lighting. The lighting design shall ensure proper light distribution throughout the lifetime of the installation at external locations where trees and vegetation are present.

5.4.2. Colour temperature of articial light sources

Light sources with a correlated colour temperature (CCT) value of 4000 K (neutral white) shall be used at the following locations:

- offices
- control rooms and equipment rooms
- station platforms
- tunnels
- underpasses
- viaducts
- stabling yards
- access roads
- car parks
- plant and maintenance areas
- areas in the track vicinity

Light sources with a CCT value of 3000 K (warm white) may be used in public areas that are not listed above.

The colours of light sources located in the same space shall not be mixed.

There are no light colour restrictions, other than alignment with the TfNSW branding approach, for a building exterior elevation or facade, landscape, public art installations and decorative lighting. However, in each case, a location-specific design shall be prepared by a competent lighting designer, coordinated with and approved by the stakeholders.

Existing installations shall continue to operate until the end of the lamp's life.

5.4.3. Colour stability

The colour of light emitted by a lamp will change over time as the lamp ages, especially towards the end of the lamp's rated life. Original lamps can appear to be a different colour than those that have been newly installed, which may create visual inconsistency.

Colour-stable lamps shall be used. Refer to Section 5.10 for requirements.

5.4.4. Colour rendering index

Light sources with a minimum colour rendering index (CRI) value of 80 shall be used, except for special lighting (designed to provide coloured lighting for effect), decorative lamps and fixtures, and landscape lighting.

5.4.5. Light loss

The amount of light emitted by a lamp (luminous flux) decreases with the lamp's age. The lamp's ability to maintain its luminous flux over the lamp life is called lumen maintenance.

The rate of change is different for different light sources, although in general it is accelerated once the lamp has been in use for longer than 60% of its rated life. The lamp lumen maintenance shall be accounted for to ensure adequate lighting conditions at the end of the lamp's life. Adequate lamp lumen maintenance will be achieved by utilising the lighting technologies selected in accordance with Section 5.10.

The light loss factor predicts the extent of the light loss over time and the lighting system performance towards the end of its economic lifetime. Light loss can be attributed to the following:

- maintenance factors such as luminaire dirt depreciation and room surface dirt depreciation
- equipment factors related to lamp lumen depreciation
- ballast factors (or driver and 'lamp' factors for LED lighting)
- ambient temperature effects on heat extraction from the luminaire
- effect of increased or decreased installation voltage on long-term performance of the lighting installation components

The light loss factor shall be correctly accounted for during the lighting design process.

For further information on selection and application of maintenance factors, refer to AS/NZS 1158.3.1 *Lighting for roads and public spaces Part 3.1: Pedestrian area (Category P) lighting—Performance and installation design requirements*.

5.4.6. Energy efficiency

Energy efficient light sources and luminaires with a high light output ratio shall be used.

One of the steps in minimising energy use is to avoid over-specifying and aim to provide as closely as possible the illuminance and quality of light required for each task or specific area.

Whilst the maintained lighting levels shall not be less than the minimum values specified in Section 7 of this standard, lighting levels in excess of 1.2 times the minimum indicated values are not recommended.

Groups of lights shall be effectively controlled relative to their location, either by manual or automatic switching on and off, or dimming according to the usage pattern requirements of the space and available daylight.

The requirements in Section J of the National Construction Code (NCC), volume one, shall be applied to all lighting installations. The following requirements also apply:

- light sources that have light source efficacy of 85 lm/W or greater shall be used for internal lighting (light source efficacy is an indication of the efficiency of the conversion of electrical energy to visible light by a light source, calculated as the product of initial lamp lumens divided by the lamp wattage)
- light sources that have light source efficacy of 80 lm/W or greater shall be used for external lighting
- illumination power density shall not exceed 90% of the limits set in Section J6 of the NCC, volume one
- high frequency electronic ballasts with reduced losses (class A2 ballast) shall be used for fluorescent lamps
- electronic ballasts compliant with Table 5.1 of SA/SNZ TS 1158.6:2015 *Lighting for roads and public spaces Part 6: Luminaires Performance* shall be used for high intensity discharge (HID) lighting

Light fixtures shall comply with the following requirements:

- have power factor of 0.90 or higher
- have individual harmonics limited to the values defined in AS/NZS 61000.3.2 *Electromagnetic compatibility (EMC) Part 3.2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*
- where required, utilise a blocking inductor in accordance with the requirements of SA/SNZ TS 1158.6
- electromagnetic capability (EMC) requirements detailed in AS/NZS 61000 (all parts) *Electromagnetic compatibility (EMC)* and AS/NZS CISPR 15:2011 *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment (CISPR 15, Ed.7.2 (2009) MOD)* shall be met

5.5. Lighting for human comfort

Lighting shall accentuate specific hazards and locations that can adversely affect the safety of users in the space. A risk assessment addressing the impact of different physical aspects of the space on the provision of adequate lighting shall be included as part of the overall safety in design process.

Lighting shall be positioned to not conflict with the train driver's sight lines, view of railway signals and pedestrian flows. The location of light columns and light fittings shall be designed such that safe clearances from overhead traction wiring shall be maintained at all times.

Lighting positioned either in front of or behind railway signals shall not have a negative impact on a train driver's or train guard's ability to interpret and respond to the railway signal.

Lighting conditions required for safe movement of people during the normal use of a building shall meet requirements of AS/NZS 1680.0 *Interior lighting Part 0: Safe movement* and this standard.

Assessment of compliance shall follow the methodology prescribed by AS/NZS 1680.0.

5.5.1. Environmental and human factors

Human factors shall be integrated into the design and development process of new or altered assets in order to minimise risk from the possibility of human-system related issues. The lighting design shall integrate human factors in accordance with the requirements of T MU HF 00001 ST *Human Factors Integration – General Requirements.*

Lighting shall contribute to achieving the goals of safety and high-level ergonomics in ways that have the least adverse effect on the end user and the environment. The use of artificial light sources that mimic natural light, such as artificial skylights, is preferred.

5.5.2. Psychological aspects of light

The lighting design shall take into account the psychological aspects of light.

Direct light from the ceiling in the absence of reflected light can create a visually unpleasant environment. Conversely, directing the light upwards (lighting the ceiling) contributes to creating a perception of volume and lessens the possibility of claustrophobic sensations, especially in subterranean environments.

As most human eye perception concentrates on vertical elements of a space, lighting of walls increases visual comfort and helps to determine safe boundaries of the space. Spaces with low levels of horizontal illumination but with well-lit walls can still feel comfortable.

Colour differentiation can help to alert a person to an increased level of danger. For example, a neutral light colour of 4000 K can be used on platforms and a warmer light colour of 3000 K can be used within the station concourse.

5.5.3. Eye adaption

A gradual transition of light intensity between adjacent spaces and the avoidance of sudden changes in light levels (for example, from above ground spaces to subterranean levels) aids the eye to adapt to prevailing lighting conditions. The rate of change in levels of the average illumination between adjacent spaces shall not exceed 3:1 for all public spaces. Additional requirements apply at specific locations as follows:

- entrances to interior car parks shall comply with Table D1 in AS/NZS 1680.2.1:2008 *Interior and workplace lighting Part 2.1: Specific applications – Circulation spaces and other general areas*
- the difference between the illuminance at a lift car floor and that provided over the landing or lobby area onto which the lift car opens shall not exceed a ratio of 3:1
- lighting of the platform yellow line shall comply with Section 7 of this standard

5.5.4. Horizontal and vertical illumination

Illumination requirements of a space shall be determined by the nature and complexity of the activities that occur in that space. All illumination levels detailed in this standard refer to maintained illuminance levels. Maintained illuminance refers to light levels of a space at other than initial conditions which corresponds to the lowest level of system performance. It considers light loss factors such as lamp lumen depreciation, luminaire dirt depreciation and room surfaces dirt depreciation.

Appropriate levels of lighting (defined by the requirements specified in Section 7) in the horizontal and vertical planes shall be provided. While horizontal illumination is the common focus of most designs (for example, working surfaces, platforms and walkways), vertical illumination is important for facial recognition, lip reading and the reading of wall mounted signs and other information, ticket vending machine information and visibility of wayfinding signs.

Both illuminance and uniformity of illuminance over the designated area shall be achieved to the level specified for the area in accordance with the requirements specified in Section 7.

Uniformity is defined as follows (where U1 refers to the internal uniformity of illumination and U2 refers to the external uniformity of illumination):

- U1 = Emin/Eav
- U2 = Emax/Eav

Respectively, Emax, Emin and Eav represent the maximum, minimum and average values of illumination.

The required lighting uniformity shall be proven through software calculation results.

Refer to Section 7 for common vertical and horizontal illuminance requirements. Where not specifically defined, refer to the following:

- AS/NZS 1158.3.1
- AS/NZS 1680.1 *Interior and workplace lighting Part 1: General principles and recommendations*
- the notes to Clause 19.1 of AS 1428.2–1992 *Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities*

5.5.5. Limitation of glare related to artificial light

When a bright light source or reflection interferes with the visibility of an object, this is caused by either discomfort glare or disability glare or both. Disability glare is glare that impairs the vision of objects without necessarily causing discomfort. Discomfort glare is glare that causes discomfort without necessarily impairing the visibility of objects. Discomfort glare can cause an instinctive desire to look away from a bright light source. Disability glare and discomfort glare can occur simultaneously or separately.

Glare shall be adequately controlled with special care given to the design of lighting in the following locations:

- control rooms and equipment rooms
- track vicinity
- station entry and exit
- intersection, information and decision making points
- wayfinding and other signage locations
- ticketing areas
- ticketing gates and security camera locations

Glare can be reduced by reducing the luminance of the glare source. The choice of luminaire type and model, its orientation and mounting position in relation to the eye is critical to providing the required visibility and minimising glare.

To limit glare from light sources, luminaire luminance should not exceed 2500 cd/m2 between 60 degrees and 90 degrees from nadir (vertical direction pointing directly below a particular location).

The following fixtures are exempt:

- wall wash fixtures aimed at walls as specified by the manufacturer's data
- indirect uplighting fixtures provided there is no view down into these uplights from a public space above

Other glare remedies are specific to the particular context of a lighting application. In some situations, shielding of a glare source may be considered an adequate mitigation measure. Avoid indirect glare from light sources that are visible in reflective surfaces.

The requirements of this section shall be applied in conjunction with other glare mitigation measures described in AS/NZS 1680.1.

5.5.6. Light pollution

Spill light shall not adversely affect the surrounding environment. For example, lighting from commuter car parks, open footbridges, open platforms or other area lighting such as stabling yards should not extend to neighbouring areas.

Light pollution control measures shall comply with AS 4282 *Control of the obtrusive effects of outdoor lighting*. In some situations, measures exceeding the requirements of the standard may be required and compliance with the recommended limits for the various light technical parameters may not be the sole basis for the approval of a particular design.

5.6. Lighting for equitable access

Lighting is one of the elements of an inclusive design. To facilitate equitable access in the public areas of public transport spaces, vertical and horizontal illumination in all areas that comprise continuous accessible paths of travel and circulation spaces shall comply with the *Disability Discrimination Act 1992* (DDA) and the *Disability Standards for Accessible Public Transport 2002* (DSAPT).

These areas include spaces such as accessible toilets, walkways, ramps, landings, stairs, passage ways, and connecting walkways between accessible car park facilities and the station. However, as different forms of low vision respond differently to different aspects of lighting, a universal solution such as an increase in lighting level alone will not be sufficient to ensure good visual conditions.

To aid the elderly, people with children, people travelling with luggage and people with disabilities, lighting designs need to complement specific architectural measures and account for factors that include the following:

- appropriate colour and reflectance of interior and exterior surface finishes
- provision of relative contrast between different elements of space and specific areas such as the platform edge and yellow line, handrails, door openings, floor edges and steps

- increased level of light (horizontal and vertical illumination)
- adequate level of vertical illumination to facilitate lip-reading
- use of high CRI light sources to improve colour perception
- avoidance of sudden changes in light levels to minimise eye adaptation time
- avoidance of glare and excessive contrasts in brightness of surfaces in the field of view, for example, windows and luminaires
- signage of bold size and appropriate contrast

5.7. Lighting for security and crime prevention

Lighting design shall contribute to safety and security by complementing the location-specific architectural layout and features of the facility to be protected, based on evaluation of the risk of crime at the location.

5.7.1. Risk of crime and vandalism

Australian lighting standards include the risk of crime (categorised as high, medium or low) as a criterion for the selection and design of lighting.

The security risk for a particular area shall be determined through a detailed analysis and risk assessment process developed to assist the lighting design to match the requirements to the unique local area. This risk assessment shall be undertaken in accordance with T MU SY 20001 ST *Surface Transport Fixed Infrastructure Physical Security Standard*.

All agreed measures shall be included as part of the lighting design and installation process.

The degree of luminaire protection against mechanical impact is defined as the extent (level) of protection of the equipment provided by an enclosure against harmful mechanical impacts and verified by standardised test methods, classified in accordance with the corresponding IK code rating provided in IEC 62262 *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).*

The degree of luminaire protection against mechanical impact and the corresponding IK rating for a luminaire to be used on a particular site shall be determined based on the outcome of the risk assessment. Where protection against vandalism is necessary, fittings with an IK rating of 8, 9 or 10 shall be used.

To decrease the likelihood of accidental damage and vandalism, luminaires shall be mounted out of the public reach. Lights in public areas shall not be mounted below 2.4 m to the bottom of the light.

5.7.2. Crime prevention through environmental design (CPTED)

Good lighting is an important CPTED factor as it can create visual conditions that discourage crime. For example, illuminating an asset in a populated area may enhance natural surveillance and therefore enhance security.

Refer to T MU SY 20001 ST for security requirements.

5.7.3. Lighting for closed circuit television (CCTV)

Adequate illumination shall be provided to meet closed circuit television (CCTV) operational requirements which are detailed in T MU SY 10001 ST *Public Transport Closed Circuit Television (CCTV) Functional Requirements Standard*.

To facilitate face recognition, vertical illumination requirements shall be included in the security design.

The following factors shall be discussed with relevant stakeholders and applied during the design:

- adequate level of illumination in the vertical plane
- using white light, high CRI light sources
- provision of even and continuous lighting that does not create shadows or dark spots
- ensuring that lighting does not create glare for the cameras (thereby obscuring or flaring images)
- avoiding directional lights that create shadow zones, for example in an area between parked vehicles

5.7.4. Blue light

Blue light usage shall be managed to ensure that platform-located guard's indicator railway signals are not misinterpreted.

Case-by-case specific applications of blue light shall be approved by the Lead Stations and Buildings Engineer, ASA.

5.8. Heritage aspects

The *Heritage Act 1977* is designed to protect, maintain and manage heritage in NSW, including items of natural, built and archaeological significance. When changes are proposed to heritage items, the following applies:

- for items listed on the NSW State Heritage Register, the provisions of the Heritage Act shall be met
- for items on the Section 170 state heritage and conservation register, the principles and relevant guidelines in the *State Agency Heritage Guide* shall be followed

Identifying the significant features, values and characteristics of a heritage item or precinct is an essential step in undertaking maintenance of, or guiding change within heritage-listed precincts. New works or cyclical maintenance shall not compromise the identified heritage significance of an item or precinct, including its contributory elements and values.

Advice from a competent heritage professional shall be obtained early in a project's scoping and design stage to identify heritage opportunities and constraints, to guide the nature and extent of proposed works, and assess potential impacts to heritage significance.

Maintenance or upgrade works that may affect existing lamps, light fittings or electrical switches which contribute to the heritage value of a building or place shall be planned with the intention of conserving that heritage significance. Original or early lamps, light fittings, luminaires and other related lighting elements should be conserved in situ (that is, in its existing location) if possible and shall at all times be adequately protected from potential damage during construction (whether they remain in situ or need to be salvaged and stored for later reinstatement).

If a fitting is not able to be retained in situ, it may, subject to specific advice from a competent heritage professional, be removed, salvaged, conserved if need be and safely stored for reinstatement towards the end of the project. Reinstatement of a significant early lamp or fitting to its original position using salvaged or traditional fixings is preferable to refixing it in another location.

Where it is necessary to increase levels of illumination, any upgrade to heritage significant existing light sources or the installation of supplementary light fittings shall be carried out in a controlled and appropriately sensitive way. Supplementary light fittings shall be selected and positioned to ensure aesthetic compatibility and to reinforce the heritage character of the space, item or precinct. The guidance of a competent heritage professional should be sought to determine the suitability of supplementary light fittings in this regard.

Supplementary light fittings shall be one of the following:

- suitable commercially-available fittings that can be installed to be concealed from view as much as practicable
- manufactured copies of original fittings based on physical evidence or defensible archival research

For significant spaces located within and adjacent to existing heritage buildings, the number, location and visual character of the light fitting used shall be appropriate for the aesthetic qualities of the space.

Any modification to heritage light fittings shall address factors such as context, compatibility of adjacent materials, features and finishes.

Prior to any disturbance, or carrying out of works (including demolition or removal of fabric), existing light fittings with heritage value shall be recorded in accordance with the following documents published by the NSW Heritage Office:

- *How To Prepare Archival Records Of Heritage Items*
- *Photographic Recording Of Heritage Items Using Film Or Digital Capture*

5.9. Signage and wayfinding

All on-site, static customer information elements (for example, directional signs, identification signs and maps in poster cases) shall be lit either by ambient light or by self-illumination to ensure recognition and adequate legibility during all periods of facility and service operation.

Primary identification signs, such as public transport mode identification signs, should be internally illuminated whereas other customer information elements may be internally or externally lit. Door signs (for example, signs identifying a staff room) shall be clearly visible and readable under normal lighting conditions in the area.

No signs shall be mounted on tilting lighting columns.

Signage design, manufacture and installation, and related internal or external illumination arrangements, shall ensure that customer information content is legible in all lighting conditions during all periods of facility and service operation in compliance with the DDA. The signage location, letter sizing, letter to background colour contrast, level of illumination and brightness of individual elements, resulting visual contrast and glare shall be sufficiently controlled to ensure adequate viewing conditions from different viewing angles.

5.9.1. Self illumination

Individual and logical groupings of customer information elements shall be supplied by a dedicated circuit.

Some signs, such as internally located directional signs, may require continuous illumination. All other externally located signs should be controlled by devices such as daylight switches, intelligent dimmers or timers that do not require manual adjustment for daylight saving. This is to ensure signs only illuminate during periods of low level ambient light and when the relevant public transport facility is accessible to customers and has services operating.

5.9.2. Ambient illumination

Some customer information elements rely on external illumination to ensure recognition and legibility. While fixed type directional lighting fixtures could be acceptable for illumination of customer information elements, lighting fixtures that can be manually aimed or adjusted shall not be used to prevent any possible operational and maintenance problems.

Under illumination can result in an illegible display of content. Over illumination can result in flaring, glare or a halo resulting in loss of legibility. The light intensity required for these elements is in Section 7.

5.10. Luminaires and lamps

Luminaires and lamps shall comply with SA/SNZ TS 1158.6:2015. The selection of luminaires and lamps shall be determined by the life cycle cost of the entire lighting system.

The choice of luminaires shall reflect a balance between properties of various luminaires, the requirements of the space and the function they are chosen to serve. Luminaire selection shall be based on the following:

- light distribution properties
- energy efficiency and economic life
- construction features including IP and IK ratings
- ease of installation and maintenance
- luminaire appearance

Some lamp types such as HIDs require a cooling down period of up to several minutes before they can be switched back on. This can adversely affect the lighting of a space and can create a potentially unsafe situation; for example, a momentary power outage can result in a prolonged period of lighting being unavailable.

5.10.1. Acceptable technology

The following are acceptable for use subject to adequate quantification of life cycle requirements, compliance with this standard and appropriate assurances being provided:

- T8 (25 mm diameter) tubular fluorescent tri-phosphor lamps and electronic control gear. Whereas the conventional ballast runs the lamp at mains frequency (50 Hz) the electronic ballast runs the lamp at a much higher frequency, usually around 30 kHz. Specifically recommended are extra-long life T8 fluorescent tubes (for example, XXT) with lamp life up to four times the life of a standard lamp, in all situations where infrequent maintenance is preferred.
- HID metal halide luminaires utilising ceramic metal halide (CDM) technology (in preference to quartz arc lamps) and energy efficient, electronic control gear due to their better efficacy, light quality, colour consistency and improved re-strike and warm-up times.
- Light emitting diodes (LED).
- The design of the LED luminaire (especially the heat sink) is critical to the life of LEDs. Only LED light fixtures of reputable quality, with five years manufacturer's warranty on LEDs and the driver (control gear) with acceptable testing results and a certificate from a recognised testing facility may be used. The use of LED luminaires with replaceable LED modules is preferred to facilitate the ability to easily upgrade LED lighting as the technology advances.
- Large numbers of compact fluorescent downlights have been used on existing TfNSW installations. Although the use of compact fluorescent fittings for new projects is not prohibited, the use of tubular fluorescent lamps or LED light sources is recommended due to their higher efficiency.
- Other innovative or energy efficient technologies such as plasma lighting may be approved based on adequate evidence and assurance being provided.
- Other lamp types may only be considered for special applications such as facade, public art and landscape lighting.
- T5 (16 mm diameter) tubular fluorescent lamps with electronic control gear may be suitable for locations where the lamp operating temperature can be maintained at 35 °C. However, in lower ambient temperatures, the light output of these lamps decreases. These lamps are not suitable for environments where ambient temperatures cannot be accurately controlled, which is the case of most transport applications.

5.10.2. Legacy technology

The following light sources shall not be used in new or refurbished installations:

- Incandescent lamps.
- T12 (32 mm diameter) tubular fluorescent lamps. These are operated with rapid start gear. Both tubes and gear technology are obsolete. These luminaires shall be replaced with more efficient T8 fluorescent technology or LED fixtures.
- T8 (25 mm diameter) tubular lamps with switch-start control gear (a configuration that uses a starter in parallel to assist in the ignition of the lamp). The majority of fluorescent luminaires on existing stations use this configuration. These luminaires shall be replaced at the end of their life cycle with more efficient fluorescent technology or LED fixtures.
- HID metal halide luminaires utilising quartz arc technology. The post top luminaires currently used on the platforms use quartz arc lamps. Quartz arc lamps shall be replaced at the end of their life cycle with CDM lamps.
- Light sources of other types that do not meet the requirements of this standard such as mercury vapour or sodium lamps. Remaining existing fixtures shall be replaced at the end of their life cycle by an approved type fixture.
- Halogen lamps. The shift away from this technology is underway due to its relatively short useful life, lower efficacy and the increasing availability of LED alternatives.

5.10.3. Luminaire construction

The design and construction of luminaires and lamps shall comply with SA/SNZ TS 1158.6 and this standard.

The body (casing) of light fixtures installed in underground and enclosed stations shall be constructed of halogen-free materials.

The luminaires shall be selected to have an appropriate degree of protection against touch potential.

The luminaires shall be selected to have an appropriate degree of protection against direct contact, ingress of dust and ingress of water. The specific IP protection rating shall be achieved by a complete luminaire, including cable entries that match the luminaire IP class. All light fittings shall be equipped with a diffuser.

The degree of protection against mechanical impact and the corresponding IK rating shall be matched to the requirements of security and vandalism risk assessment for the particular site.

Light fittings mounted in public areas and below 2.4 m above ground level shall be vandal proof and tamper proof.

5.10.4. Replacement of existing luminaires or their parts

Where existing luminaire locations do not enable the new luminaire choice to achieve appropriate lighting levels, new height and spacing selection are required. It shall not be assumed that existing height and spacing will automatically be adequate. No changes to an existing installation or procurement of new light fixtures shall proceed unless the suitability and adequacy of the proposed solution is proven.

The IP and IK ratings for the proposed new fixtures shall not have a rating that is lower when compared to the fixtures that are being replaced.

The replacement of existing lamps with new lamps of the same type and characteristics does not necessitate additional requirements.

For all other lamps, full compatibility shall be ensured. This includes the lamp's physical properties, mounting, lamp light quality and correct light distribution when installed in the existing luminaire.

LED tubes shall not be used as a direct replacement of fluorescent tubes in existing luminaires due to potential heat build-up adversely affecting the LED and control gear (driver) performance which can shorten life expectancy and cause potential liability issues.

The following methods for the replacement of existing luminaires are acceptable subject to meeting all other requirements of this standard:

- The entire light fitting is replaced with a new fitting.
- An approved, complete LED replacement retrofit kit (including the LED array with integral driver and lamp holders) from the original luminaire manufacturer is used with corresponding removal of the relevant lighting elements such as original lamp holders, ballasts and necessary wiring changes. This method is acceptable, provided that it can be justified on a life cycle basis and the LED retrofit kit is backed by appropriate manufacturer's guaranties and warranties.

5.10.5. Lamp life and lamp replacement strategy

The rated life of a lamp is specified by the manufacturer and provides an indication of how long a particular light source is likely to last. Rated life of conventional light source lamps is defined differently from that of LED sources; hence it can be expressed as either RL or L70:

- RL – Lamp life for conventional light sources has traditionally been expressed in terms of survival rate. The rated life is defined as the point when 50% of the lamps initially installed are still operating.
- L70 – Luminaire life, defined as life of an LED light source, defined as the point where the lumen maintenance drops to 70% of the initial lumens. This only relates to the LEDs and does not apply to the control gear.

The economic life of lamps is shorter than their rated life (effectively around 60% to 80% of the rated life).

Rated life and economic life may influence the planning of periodic lamp replacement. While some lighting installations can provide the legislative required level of lighting even in the event of a failure of a few lamps (light sources), there are lighting installations where a failure of a single lamp may have more serious implications and can render the lighting system noncompliant.

A lamp replacement program shall include the checking of lighting level compliance. Lamp replacement shall be prioritised in areas that have been identified as affecting safety, viability of accessible path and equitable access, and in any other situation where diminished level of lighting may adversely affect railway operation in observance of relevant legislation. Lighting levels shall comply with legislative requirements at any time during the lighting system operation.

Faults other than lamp failures shall be repaired as soon as possible to maintain viable railway operation.

5.10.6. Mounting of luminaires

Luminaires shall be securely fastened to a building structure, support member or a purpose installed nogging. Luminaires shall be accessible for maintenance without the need for bespoke scaffolding or suspension harnessing arrangements.

In areas that are prone to vibrations, suitable precautions shall be taken to ensure the following:

- short and long term performance of the luminaires are not affected
- prevailing external forces and vibration shall not cause luminaires to become loose or dislodged

Fixing brackets, bolts and screws shall be selected and sized to withstand external forces without deformation or damage. Explosive powered fixings shall not be used.

Structural elements shall not be drilled into or otherwise weakened without prior assessment by a qualified structural engineer.

For aesthetic reasons, luminaire fixings shall be concealed. Luminaires shall be installed in accordance with the manufacturer's recommendations.

Luminaires mounted on Unistrut trunking or similar shall be secured using approved bolted joints with locknuts. Bracket-mounted light fittings shall use proprietary brand aluminium brackets or hot rolled mild steel angles utilising full depth fillet welds. Drill brackets to suit mounting arrangements shall be hot dip galvanised after fabrication. At least two fixings shall be used on the light fixture and another two fixings shall be used on its support bracket.

5.11. Lighting control system

Lighting in public interior spaces shall be controlled to ensure the required illumination during operating hours and security lighting outside of operating hours.

Lighting of staff areas shall be controlled according to operational requirements.

The lighting control system (LCS) shall optimise the operation of interior and exterior lighting. The controls shall facilitate the maximum use of daylight and avoid unnecessary lighting during periods when spaces are unoccupied.

A small building or railway station can be adequately served by a light sensor and timer arrangements complemented by manual switches, while a large facility can necessitate more complex arrangements, such as a software-based LCS.

The LCS shall be configured to comply with Section J6 of the NCC, volume one where applicable. Any one or a combination of, the following arrangements shall be included as applicable:

- manual switching through local light switches for internal areas not accessible to the public where individual persons are normally in control of the space
- automated switching of groups of lights through photo-sensors, contactors, timers with on, off and fault status reporting to a building management control system (BMCS) where available
- automated switching of groups of lights by an intelligent system as part of a BMCS with artificial lighting management including switching and dimming, solar shading and daylight management in buildings equipped to do so

The LCS time schedule shall properly account for daylight saving.

The location of the lighting control sensors shall be clearly labelled on the respective switchboard. Manual bypass shall be provided to override automatic actions of the system. Each lighting circuit shall be equipped with manual override regardless of the normal operation control method used.

Software-based LCS shall be capable of counting and reporting total cumulative hours of lamp operation to help planning the replacement of lamps based on their time in service.

The following lighting control communication protocols are approved for use:

- DALI
- DSI
- KNX (EIB)
- DMX

- C-BUS
- DyNet

Controls of lighting in public spaces shall be fail-safe so that the lighting in public areas remains switched on even if a control system failure takes place.

Dimming and switching may be used to create specific lighting moods or scenes, or to accentuate public art or features of architectural design.

5.11.1. Interior lighting control

Dimming and switching shall be organised to support daylight harvesting and energy saving strategies.

An appropriate daylight harvesting strategy shall be applied to control the amount of natural light entering the space. Adjustment of artificial lighting through dimming or on and off switching of relevant predetermined groups of lights based on the amount of daylight entering the space (that can itself be adjustable either manually or automatically) shall be included as part of the strategy. This can be complemented by dimming or switching of predetermined groups of lights based on occupancy (presence) detection.

All parameter settings and operational management shall be determined by the system operator. Parameter settings and operational management of software-based systems shall be available through the system user programming.

Buildings not equipped with active daylight harvesting systems

In areas where daylight is available, for example, on at-grade and above ground concourses and platforms, nominated groups of lights will be automatically switched on or off to account for changes in the amount of available daylight.

The provision of automatic switching for staff only areas like depots, workshops and maintenance facilities is dependent on the profile of activities and use of the space and user requirements.

The following methods of lighting control shall be used as part of the LCS:

- To coordinate the operation of artificial lighting with available daylight, the system shall use light sensors to detect the prevailing light level, luminance or illuminance. This data shall be processed by the system controls to adjust the amount of artificial (electric) lighting based on the available daylight in the space. For simple systems, a daylight sensor signal shall be used to switch lights off when sufficient natural light is available and switch lights on during times when no sufficient natural light is available. There shall be a five minute to ten minute delay in switching lighting off in response to daylight, to prevent frequent switching.
- For locations where switching on and off times are determined by the system operator, a time clock (available through the LCS or BMCS system programming or manual setting of an appropriate time clock device) shall be employed.
- In areas that require continuous operation, lighting circuits shall be connected to respective lighting distribution boards through contactors and manual override switches.
- Presence detectors shall be provided for transient spaces with low traffic.

Buildings equipped with active daylight harvesting systems

Where active daylight harvesting is used, the LCS shall additionally sense the amount of daylight and adjust automated mechanical devices to increase or decrease the amount of natural light admitted to the space. When the amount of natural light is not sufficient, the system shall supplement the light levels inside the controlled space with artificial (electric) light.

5.11.2. Exterior lighting control

All external lighting shall be controlled through appropriately located daylight switch, and manual override. For lighting that does not need to remain switched on during all hours of darkness, the LCS shall additionally include the operator-adjustable ability to switch off designated groups of lights at pre-programmed times.

The daylight sensor is a primary means of control that overrides the operation of any timer controls at times when natural light is available. There shall be a ten minute delay in switching lighting off in response to daylight. The amount of daylight shall provide at least twice the required levels of illumination before electric lighting is switched off. Daylight switches shall be suitably set to account for the lighting levels differentiation between the open and covered areas.

During the daytime, fully-open platforms are usually adequately illuminated by natural lighting. However, platform areas covered by a canopy may not receive enough illumination. Open platform post-mounted luminaires shall be arranged such that these are connected to circuits that are separately controlled from under canopy lighting.

After hours, dim or switch lighting groups to levels required to maintain adequate lighting for safety and security.

5.11.3. Adaptive lighting

The lighting levels used in a compliant design may not be justified throughout all hours of darkness. It may be permissible for temporal changes such as a decrease in illumination levels to occur.

A possibility exists to dynamically adjust the lighting levels according to the actual need for a given period when operational conditions change. For example, lighting levels may be reduced in preselected areas at times when facilities are very lightly used, such as in car parks in the early morning hours (for example, after 1 am), or on facades and landscape lighting.

Legislative-compliant lighting levels shall be ensured at all times.

5.12. Lighting columns

Lighting columns (poles) shall be made of hot dip galvanised steel in accordance with AS/NZS 4677 *Steel utility services poles*. The nominal dimensions of lighting columns, bracket arms and luminaire fixing spigots shall be in accordance with the recommendations of AS 1798 *Lighting poles and bracket arms – Recommended dimensions* as applicable.

For extensions and partial replacement of existing installations, the following drawings may be referred to where appropriate:

- EL0003997 *Railway Station Lighting, lighting pole for Type 3f & 3g lighting column – Details*
- EL0003933 *Railway Station Lighting, Platform Lighting Column Type 3g – General Arrangement*
- EL0008945 *Railway Station Lighting Platform Standard, Single or Double Arm Support Details*
- standard lighting columns as indicated on EL0002759 *Station Lighting: Typical Arrangement Details for Platform Lighting Columns (Platform Standards)*

Steel columns and accessories shall be hot dip galvanised in accordance with one of the following standards as applicable:

- AS/NZS 4680 *Hot-dip galvanized (zinc) coatings on fabricated ferrous article*
- AS/NZS 4792 *Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process*

All columns shall allow cabling inside the column to be supported on a catenary chain to the top of the column. The column base shall facilitate conduit entry. Each column shall be equipped

with an access panel to a mounting plate on which a terminal block, isolating circuit breaker and earthing terminal are mounted.

Lighting columns on platforms, stairs and footbridges, and all columns over four metres in height shall be collapsible (collapsing, tilting or fold down columns).

The lighting column's positioning, equipment arrangement and tilting arrangement shall ensure that minimum approach distances from live electrical apparatus specified in SMS-06-GD-0268 *Working around Electrical Equipment* and relevant legislation are observed.

These clearances shall be further increased as necessary to ensure safe working conditions for personnel at all times and in any column-tilting position.

Sufficient clearances to other obstacles such as fences, potential parked vehicles, and so on shall be ensured for all positions of the light column during the collapsing, tilting or fold down process.

The tilt arrangement design shall incorporate a counterbalance to facilitate easy tilting operation. Suitable security fixings shall be provided to ensure the tilt columns are not prone to vandalism.

Where required, columns shall be capable of being used for mounting CCTV cameras ensuring that they are resilient against vibration and movement in accordance with AS 4806.2 *Closed circuit television (CCTV) Part 2: Application guidelines*.

Where required, columns shall have internal ducting to ensure separation of different services.

Column foundations and footing design shall be certified by an appropriately qualified engineer.

Prefabricated concrete plinths may be used in the design if it is likely that an installation will require remedial work during its life; or, if resurfacing and re-grading is likely to take place in the surrounding area of the installation (such as a platform). The design shall be approved by the Lead Stations and Buildings Engineer, ASA.

5.13. Containment and wiring

Unless specified by the architect, all wiring in publicly accessible areas shall be fully concealed. Containment and wiring shall comply with AS/NZS 3000 *Electrical installations (known as the Australian/New Zealand Wiring Rules).* All cable and wire sizes shall be determined by the design.

The lighting circuits shall be divided and segregated so that if there is a loss of one phase of the power supply, the risk of a total loss of lighting in any one area is minimised.

Luminaires in the following stations shall be supplied from at least two physically-separated lighting distribution boards, located as close as possible to the opposite ends of the concourse hall:

- underground stations
- surface stations with at least one end of a platform connected to a tunnel
- stations where adjacent tracks are covered linearly for a length of more than 90 m
- category A and category B rail stations as defined in ESB 001

On small stations where installation of the two boards can be impractical, a single lighting distribution board may be permitted.

In all cases, luminaires shall be wired to alternate circuits fed from separate circuit breakers. This ensures that half of the lighting will still be provided if one circuit fails. Refer to drawings EL0005172 *Station low voltage electrical services general information* and EL0002759 for approved wiring configurations.

Only single phase circuit breakers shall be used for the protection of final lighting circuits so that a single-phase fault does not disconnect all three phases.

The minimum wire size shall be 1.5 mm^2 for above ground wiring and 2.5 mm^2 for below ground wiring (for example, column-mounted platform lighting).

Non-metallic trunking shall not be used.

Conduits shall comply with AS/NZS 2053 (all parts) *Conduits and fittings for electrical installations*. All non-metallic conduits and fittings shall be protected against solar radiation (T), be of a non-flame propagating type, and shall pass the test of ignitability and flame propagation in accordance with AS/NZS 2053.1 *Conduits and fittings for electrical installations Part 1: General requirements*.

Only low smoke zero halogen (LSZH) cables and halogen-free (HF) conduits and fittings shall be used in the following areas:

- tunnels
- underground stations
- surface stations with at least one end of a platform connected to a tunnel
- stations where adjacent tracks are covered linearly for a length of more than 90 m
- stations, where appropriate natural ventilation cannot adequately extract smoke to the degree necessary to ensure viable egress for agreed scenarios
- major rail stations and transport interchanges

Containment and wiring fixings or penetrations shall not affect the integrity of a building structure. If any structural component is likely to be affected, prior approval from a structural engineer is required.

Adequate segregation shall be achieved as stipulated in AS/NZS 3000 and AS/CA S009 *Installation requirements for customer cabling (Wiring rules).* Refer to T MU SY 10001 ST for CCTV requirements.

Refer to T HR SS 80002 ST *Low Voltage Electrical Installations* for further requirements.

5.14. Electrical precautions

Earthing and bonding shall be designed, constructed and maintained in strict accordance with TfNSW standards.

Significant harmonic distortion can be present in parts of the RailCorp high voltage network and can have detrimental effects on the low voltage power supplies derived from the network. Refer to EP 03 00 00 01 TI *Rectifier Transformer & Rectifier Characteristics* for information on harmonics generated by traction power rectifiers. In locations where excessive levels of harmonics or other power quality problems can adversely affect the operation of light fixtures and related control equipment, appropriate mitigating steps shall be taken during lighting system design and throughout the life of the lighting installation to ensure trouble-free operation.

HID lamps will only operate at their rated wattages if the line voltages are within their specified parameters. Variations in lamp and line voltages can cause a lamp wattage variation of up to 20%. HID lamps turn on and off 100 times per second, and the lamp stays hot enough to automatically re-strike after this very short outage. However, if several cycles of the alternating current power are lost or drop out, the lamp cools sufficiently to turn off and will re-strike only after a considerable time. Likewise, an overly-sensitive photo control unit can cause cycling in an HID lamp installation, with prolonged periods required for a lamp to re-strike. The lighting design shall ensure that the above described phenomena do not occur.

To limit the number of disconnected luminaires in case of a fault, each luminaire shall be individually protected by a factory in-built fuse terminal block such as Clipsal BP504F2 or approved equivalent. The device shall be properly coordinated with an upstream circuit breaker and rated at the prospective fault level at the point of insertion.

Where a lighting point (that is always equipped with an earthing wire) is used for a connection of a class II luminaire (double insulated), the end of the earth wire shall be safely insulated and contained within the luminaire so as not to touch the light source or any hot parts.

Each permanently installed double insulated (class II) luminaire shall be marked with a Traffolyte label inscribed with the following words, ‘Caution – Double Insulated luminaire’.

Refer to Appendix A for information on luminaire electrical protection classes.

5.15. Installation conditions

Lighting installations shall take into account specific environmental requirements of the rail environment which are often harsh. Indoor and outdoor installations have different requirements for protection against dust and water ingress.

The degree of protection (the extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and against ingress of water and verified by standardised test methods) shall be determined according to the equipment location with a view to minimise the possibility of dust and moisture induced deterioration of light output. The extent of protection shall be weighed against other relevant factors such as cleaning and maintenance intervals and related cost.

Light fittings installed in the following areas shall be rated IP65 or higher (in accordance with IP classification) defined in AS 60529 *Degrees of protection provided by enclosures (IP Code):*

- tunnels and underpasses
- all areas subject to the presence of brake dust such as areas in direct vicinity of the railway track, low level mounted luminaires on platforms and luminaires mounted in the path of exhaust air
- open areas without any cover such as car parks, platforms and walkways

The IP rating for all other locations shall be determined by the outcome of a life cycle analysis that takes into account local environmental conditions, cleaning and maintenance intervals, and other relevant factors.

It is recommended that all luminaries installed in the following areas be IP65 rated:

- outdoor areas under roofs such as areas under canopy fittings, roofed access ways, passages and similar structures, covered car parks, covered pedestrian walkways and underpasses
- ceiling-mounted luminaires located on underground and open platforms and in directly adjacent areas

Additional protective measures are required for lighting installations that are subject to adverse factors such as UV exposure, pollution or corrosive environments, and coastal locations.

5.16. Systems safety

System safety shall be integrated into the design and development process of new or altered assets to effectively manage the risks associated with the safety change, the operational context, boundaries, interfaces, organisational safety change structure and responsibilities for the change to the new or altered system or asset in accordance with T MU MD 20001 ST *System Safety Standard for New or Altered Assets*.

5.17. Life cycle costing

The final selection of all equipment shall be based on a life cycle analysis, assessment, and life cycle costing process in accordance with T MU AM 01001 ST *Life Cycle Costing*.

The choice of lighting design, light fittings, light sources and all other components of a lighting system shall take into account the capital and operational expenditure throughout the life of the system that the asset is part of. This includes relevant technical requirements, installation, operation and maintenance, energy consumption and end-of-life disposal costs.

The life cycle assessment of the lighting component shall include a cost impact analysis of all relevant aspects including, at a minimum, the following factors:

- design life, design efficiency and design optimisation that includes light sources, luminaires, mounting (for example poles), number and spacing of units required to address the requirements
- luminaires, lamps, infrastructure components including lighting columns and cabling
- technical selection of the following:
    - lighting technology efficiency
    - adequate protection against ingress of dust and water (IP)
    - energy efficiency
    - control systems that supports programming and customisation to further optimise energy efficiency
- construction and installation requirements
- maintenance requirements that include ease and economies of maintenance, maintenance access, lamp replacement, cleaning and luminaire replacement
- end-of-life disposal requirements

Lamps, ballasts, control gear, enclosures and any other component that is collected during the replacement or disposal program shall be sent to an appropriate recycling facility to recover glass and metals in accordance with Australian best practice.

The life cycle costing shall be based on a period of 25 years.

5.18. Standardisation and commercial requirements

The number of different types, makes and models of light fittings, poles, mountings and accessories that are used throughout the heavy rail network need to be restricted in order to achieve a degree of standardisation and to optimise stock levels of spare fixtures and parts. All equipment that comprises the lighting system shall be standardised as much as practicable.

5.19. Identification and labelling of lighting assets

A logical system shall be used to facilitate easy asset identification, maintenance planning and reporting. The system shall ensure that uniform numbering and labelling principles are applied throughout the network and permit unique identification of each lighting asset throughout the railway network.

The labelling system shall be based on EP 00 00 00 15 SP *Common Requirements for Electric Power Equipment*.

Each luminaire shall have its IP, IK and electrical protection class clearly indicated.

Permanently-connected light fittings shall be labelled with the controlling DB and CB numbers as well as unique fixture number. Temporary light fittings (with plug-in leads) shall be labelled with unique identifiers.

Engraved Traffolyte labels shall be permanently attached to the relevant part of the equipment, for example to the end of the luminaire base. Labelling of light fittings shall be visible without having to remove an inspection plate or any component.

For lighting poles on platforms, labels may be affixed above the cable connection hatch or inside the hatch.

Lettering shall be black font on white background.

6. Specific applications of lighting

Specific applications of lighting are governed by the NCC, DDA, DSAPT and the requirements of this standard.

Any new work or modifications to an existing electrical installation shall ensure that any risks related to or resulting from the existing installation shall not be increased.

6.1. Railway track vicinity

Lighting installed in the vicinity of the railway track shall provide visibility for operation and security purposes. The lighting shall not interfere with reading and comprehension of signals and signs by train drivers and shall be designed and installed to ensure that clear visibility of the signs is not diminished by any adverse phenomena.

Glare shall be controlled so that it does not interfere with or decrease a train driver's ability to see and react without undue distraction or confusion.

The correct choice of luminaires and appropriate location, orientation and shielding of glare sources are necessary to minimise adverse effects of the glare. The particular issue of glare at tunnel or underpass entry and exit points (to and from natural light or artificially lit areas such as underground stations) shall be adequately addressed in the design. Within the field of vision of

train drivers, an appropriate graduation of this lighting transition is required to aid the adjustment and adaptation of the human eye so that disability and discomfort glare are minimised to acceptable levels.

Stroboscopic effects can cause distraction, discomfort and fatigue and induce serious physical symptoms such as epilepsy, nausea or headache in some predisposed individuals. Designers and operators should be aware of the following parameters that can contribute to strobing or flickering:

- luminaire and light source type and characteristics
- luminaire horizontal spacing
- luminaire vertical location
- light level and light intensity related to directionality
- a person's location and field of vision
- train speed and track speed limits
- characteristics of the train interior or cabin interacting with any of the above factors
- duration of individual exposure, particularly with train drivers

The designer shall assess the influence of these unwanted visual effects on train drivers and passengers and include appropriate mitigation measures in the lighting design.

6.1.1. Tunnels

Direct lighting from a light source or light reflected off tunnel walls and surrounding surfaces shall not interfere with signal colour, contribute to colour confusion or diminish signal visibility.

The tunnel emergency lighting, as described in T HR SS 80003 ST *Infrastructure Emergency Lighting*, is utilised during train and tunnel evacuation. This lighting, where installed, operates continuously and provides a low level of illumination that aids orientation within a tunnel space at all times.

Permanent non-emergency lighting may be installed in any part of a tunnel as necessary. In addition, a number of permanent power points for connection of temporary lighting shall be provided in appropriate locations corresponding with the nature of activities that require lighting.

Access for maintenance work in a tunnel is restricted and normally requires a track possession. Maintenance planning shall include the provision of adequate lighting to facilitate safe access to the maintenance work location and to carry out planned maintenance activities at the location.

This lighting may be permanent or temporary for the duration of the maintenance activities. It is recommended that permanent lighting is installed in frequently accessed areas or where there is recurrent operational or maintenance work taking place. Long life lamps and suitably located luminaires shall be used in such locations.

The tunnel emergency lighting shall aid maintenance crews in accessing their place of work. Depending on the type and configuration of equipment and tools required for the maintenance, supplementary illumination may be required. Such supplementary lighting shall be provided en route to ensure the safe passage of staff and equipment from the tunnel entry to the location of the work.

The exact attributes of lighting necessary to perform a specific maintenance activity depend on the type of tasks carried out and shall be determined in the maintenance planning stage. Such lighting shall meet the requirements of relevant Australian standards and may be accomplished using temporary lighting, permanent lighting or a combination of both.

Permanently installed lightning in the area around lineside signals infrastructure is beneficial for maintenance activities. The lighting shall not have a negative impact on train driver or train guards ability to interpret and respond to the railway signal.

6.1.2. Sidings, stabling yards, depots and workshops

All external lighting fixtures shall be IP65 rated, robust and vandal-resistant. Lighting levels around and in between stabled trains shall meet the illumination requirements specified in Section 7 of this document. The illumination level shall be increased in areas where personnel require a higher level of vision such as specific work areas or train amalgamation areas.

The external lighting shall be an overhead type and provide illumination of the following areas:

- the front, back and each side of every train and areas in between stabled trains
- perimeter fences and areas where CCTV is operated
- site entry and exits points, all roadways, footpaths, walkways and access paths
- car parks including entry and exit
- train amalgamation areas (lighting shall cater for the varying lengths of rolling stock)
- stairs, building perimeters, buildings entry and exit
- confined spaces where regular access is required

Lighting poles shall be installed parallel to stabled trains and located so as not to encroach on the clear passage of the walkway. Light pole base plates shall be constructed and installed to eliminate or minimise trip hazards. Where a tripping hazard cannot be eliminated, it shall be highlighted to minimise the possibility of accidents.

An adequate number of power points for connection of temporary lighting shall be provided in appropriate locations and be adequate for the nature of work carried out in that area.

6.1.3. Level crossings

Lighting shall be provided at level crossings. Road (vehicular) lighting shall comply with the requirements of AS/NZ 1158 (all parts) *Lighting for roads and public spaces* and additional Roads and Maritime Services (RMS) requirements where applicable.

Pedestrian lighting shall illuminate the level crossing accessible path and immediate surrounding areas including enclosures and mazes. Pedestrian lighting shall comply with the exemption granted by the Australian Human Rights Commission to Australasian Railway Association (ARA), TfNSW being a member, on 1 October 2015. In line with the exemption, ASA considers the following illumination parameters values as adequate for the accessible paths at level crossings:

- Eh (average horizontal illuminance at ground level) = 42 lx
- Emin (minimum horizontal illuminance at ground level) = 21 lx
- Ev (minimum vertical illuminance at the height of 1.5 m) = 14 lx
- uniformity (maximum illuminance divided by average illuminance) = 7

The lighting design for level crossings shall not adversely affect the ability of users (including train drivers, vehicle drivers, cyclists and pedestrians) to read relevant signals and information.

Only light sources with a minimum CRI value of 80 shall be used.

Lighting columns and light fittings shall be mounted outside of the danger zone and positioned to facilitate safe access from outside of the danger zone at all times.

The lighting design shall ensure that glare is minimised, and that the light fittings, their location, mounting height and spacing are selected to ensure adequate illumination at the level crossing and gradual transition zones in its direct vicinity to support eye adaption when entering and exiting the crossing.

6.1.4. Safety in vicinity of railway track

Refer to Section 5.12 for requirements concerning lighting columns.

Lighting systems including mounting supports and light fittings shall be mounted at least 2 m away from 1500 V dc overhead wiring support structures, with personnel access restricted to ensure that the clearance envelope defined in T HR EL 08001 ST *Safety Screens and Barriers for 1500 V OHW Equipment* is maintained at all times.

Where the separating distance cannot be achieved or where luminaires are mounted on 1500 V dc support structures, the following shall apply:

- Light fittings shall be supplied from an isolating transformer compliant with EP 17 00 00 11 SP *Low Voltage Isolating Transformer*. Active and neutral conductors used to connect the primary winding of the isolating transformers shall be double-insulated.
- Class I luminaires shall be powered from an isolating transformer mounted on the structure with one isolating transformer per structure. The isolating transformer secondary winding neutral shall be connected to the support structure and to the luminaire earthing terminal.
- Class II (double insulated) luminaires shall be powered from a common isolating transformer mounted at least 2 m away from the 1500 V dc overhead wiring support structures. The preferred location is at the distribution board that supplies the light fittings. Double insulated active and neutral conductors shall connect the light fittings to the isolating transformer secondary winding. The transformer secondary winding neutral shall not be connected to the support structures.
- In locations where unintended interconnections between various conductive parts or inadequate clearances can exist, only class II luminaires shall be used.
- Circuits supplying isolation transformers shall not be used for any other purpose.

6.2. Offices and staff areas

Lighting of offices and staff areas shall be determined by a user requirements brief and AS/NZS 1680.

The design shall ensure that there are no high luminance spots above 1500 cd/m2 on the walls or ceiling. Guidance for specific staff operation areas is provided as follows:

- Offices

  The recommended illuminance over the task area in any room where office work is carried out is generally in the range 300 lx to 500 lx. In offices where the tasks are mainly screen-based, the illuminances at the lower end of this range should be used. Where the tasks are mainly document-based, illuminances at the higher end of this range should be used. For the ceiling not to appear dark, the average illuminance on the ceiling, from both the direct and reflected components, should be at least 30% of the average horizontal illuminance across the working plane.

- Meeting and conference rooms

  The lighting shall provide good working light over any table and sufficient light across the space to light people’s faces. Combined direct and indirect luminaires are recommended, since they provide good direct illumination of working plane and soft general lighting.

Dimming is recommended as various visual presentation systems may be used in the room.

- Security and building management rooms

  The lighting shall be positioned to light the desks, the fronts of any control or alarm panels and any emergency equipment kept in the room. Panels incorporating display screens need careful lighting to avoid reflections.

- Training facilities

  Education and training facilities shall comply with the requirements of AS/NZS 1680.2.3 *Interior and workplace lighting Part 2.3: Educational and training facilities*.

6.3. Public toilets

Toilets with multiple cubicles and or a common space shall be equipped with at least two lights to ensure that failure of one light does not leave the space dark. Separate circuits, with separate switching arrangements, shall be provided for male, female and family accessible toilets.

Light switches shall not be installed in the toilet areas. The preferred switching arrangement is to incorporate an energy saving device such as a movement detector (for example, a passive infrared sensor).

Movement detectors shall be equipped with an adjustable time delay and be positioned to sense door movement.

Light fittings shall be surface mounted or recessed, vandal resistant, moisture resistant and incorporate tamper-proof fixings.

6.4. Lifts

Lighting in lifts shall comply with the requirements of relevant Australian standards. In addition, lighting of the lift car, lift shaft and pit, and lift machine room shall be in compliance with the latest lift specification available on request through the Lead Stations and Buildings Engineer, ASA.

Where a lift forms part of an accessible path, lift landing areas shall be included in the path. Adequate lighting shall be available on each landing floor in the vicinity of the landing doors.

This lighting shall achieve a minimum of 150 lx illumination at floor level excluding any light from the car interior. The level of lighting shall transition smoothly with that of the surrounding area.

6.5. Escalators

Lighting shall provide a minimum of 150 lx maintained illumination at the floor or tread level.

6.6. Plant and maintenance areas

Lighting in plant room and maintenance areas shall provide general and local illumination in line with the following:

- relevant Australian standards
- safety, operational and maintenance requirements
- plant manufacturer's recommendations

Security lighting shall be provided around equipment and plant installed in external areas.

In both external and internal plant locations, an adequate number of power points for connection of temporary lighting shall be provided in appropriate locations.

6.7. Electrical substations and sectioning huts

All substations and sectioning huts shall be equipped with artificial lighting. Lighting in substations and sectioning huts are not required to comply with lighting power densities limits set in Section 5.4.6 of this standard.

All light fittings shall be located so they can be accessed for maintenance without the isolation of any substation equipment.

6.7.1. Internal lighting

Internal lighting shall comply with AS/NZS 1680.1:2006 *Interior and workplace lighting Part 1: General principles and recommendations* and AS/NZS 1680.2.1 with additional requirements as follows:

- General areas and circulation spaces such as walkways, stairways and connecting spaces shall be lit to achieve 80 lx average horizontal illuminance at ground level in accordance with Clause 9.1 of Table D1 in AS/NZS 1680.2.1:2008.
- In areas where equipment needs to be accessed for operation or maintenance from a particular direction (for example, the front or the behind of a switchboard panel) lighting shall be positioned to illuminate the specific elevation of the equipment and the floor in front of the relevant side of the equipment to achieve 160 lx average horizontal illuminance at ground level. Additional luminaires positioned at a low level shall be provided if necessary to illuminate relevant equipment, for example batteries on the lower levels of battery racks. The position of light fittings shall ensure that shadows are not created by the personnel operating the equipment or the equipment access doors, which can obscure the equipment being operated.
- Electrical installations in battery rooms that contain vented batteries shall be suitable for Zone 1 in accordance with AS/NZS 60079.10.1 *Explosive atmospheres Part 10.1:*

Classification of areas—Explosive gas atmospheres (IEC 60079-10-1, Ed.1.0 (2008) MOD). This includes light fittings, switches, cable glands, ventilation equipment (for example, extract fans, and so on).

- Lighting for the basement of a substation shall be on a separate dedicated circuit, with light switches located at the access point of the basement. Where the basement has multiple access points light switches shall be provided at all points.
- Two way switching shall be installed adjacent to each access door where the substation or a dedicated switching room has two access doors.

Task and equipment lighting

Task and equipment lighting shall be provided in accordance with AS/NZS 1680.2.4 *Interior lighting - Part 2.4: Industrial tasks and processes* and AS/NZS 1680.2.2:2008 *Interior and workplace lighting - Part 2.2: Specific applications – Office and screen-based tasks*.

Illumination for the office and screen-based visual tasks shall be provided in accordance with Clause 1.1 and Clause 2.2 (b) of Table E1 in Appendix E of AS/NZS 1680.2.2.

Equipment areas where inspection (including the inspection of battery electrolyte level), use of gauges and detailed maintenance work are carried out shall be provided in accordance with Clause 29.2 of Table E1 in Appendix E of AS/NZS 1680.2.4.

The lighting shall be positioned to illuminate the relevant surface (for example, writing tables, schematics and operating diagrams, use of gauges, electronic equipment and control panels).

125 V dc backup lighting

125 V dc backup lighting is intended to provide a general level of illumination after emergency lighting batteries have been exhausted.

The lighting shall be available once the intruder alarm is disarmed. The lighting shall be controlled by a manual switch.

In equipment areas, the lighting shall ensure that 50% of 'normal' illumination is provided. General areas and circulation spaces shall be provided with 25% of 'normal' illumination; that is, 20 lx average horizontal illuminance at ground level.

For a deemed-to-comply arrangement, see drawing EL0204559 *Staff Access, Backup Lighting, A/C & HWU*.

Emergency egress lighting and exit signs

Interior emergency egress lighting shall be provided in accordance with T HR SS 80003 ST. Due to the presence of 125 V dc backup lighting, the requirement for automatic testing of emergency lighting in T HR SS 80003 ST is not required for freestanding substations and sectioning huts. Where the substation or sectioning hut is integrated into other structures, for

example, a station, the emergency lighting shall be part of the automatic testing system of the structure.

Escape route signage shall direct personnel to areas outside the building that are safe, and the personnel is authorised to enter.

6.7.2. External lighting

IP65, vandal-proof light fittings shall be used to illuminate the external areas. Switching shall be provided by a daylight sensor, with manual switches inside the building next to the main entrance door to the substation. Lighting switches with neon indication shall be used.

A light fitting shall be located over all access doors to the substation. The light over the main entry door shall be operated by a proximity switch.

Where the substation has an HV outdoor yard, the light fittings shall have the following attributes:

- not be accessible from outside of the substation perimeter
- be installed so that the working clearance to live parts can be maintained during maintenance of the light fittings
- be supplied from a separate dedicated circuit
- be switched by a manual switch adjacent to the substation door that provides access to the HV outdoor yard
- have a dedicated daylight sensor installed with the intent of turning off the HV outdoor yard lights if they have been left on. The lights are normally off.

Where the substation or sectioning hut has a 1500 V isolating and rail connecting switch (IRCS) yard, the light fittings shall have the following attributes:

- be supplied from a separate dedicated circuit
- be switched by a manual switch adjacent to the 1500 V IRCS yard access gate.
- be installed so that the working clearance can be maintained during maintenance of the light fittings

Transformer bays shall have light fittings with the following attributes:

- be supplied from a separate dedicated circuit. A separate circuit is not required for each bay.
- be switched by a manual switch adjacent to the door that provides access to the transformer bay

Task and equipment lighting

An illumination level of 160 lx measured on the face of the equipment controls and other relevant equipment components necessary for normal operation, in accordance with Clause 9.2 Table D1 of AS/NZS 1680.2.1. Local on/off switching controls shall be provided.

Illumination for all areas around external equipment, for example marshalling boxes, power cubicles, operating points, and near control buildings shall be provided in accordance with AS/NZS 1158.3.1 for subcategory P6.

Access roads and approach path lighting

Illumination for roads and paths leading to the substation shall be provided in accordance with AS/NZS 1158.3.1 for subcategory P1 areas.

6.8. Commuter and staff car parks

For commuter car park accessible parking bays, access footpaths and pedestrian links to stations, lighting levels shall comply with the DSAPT.

Road lighting shall comply with the following standards:

- AS/NZS 1158.1.1 *Lighting for roads and public spaces Part 1.1: Vehicular traffic (Category V) lighting—Performance and installation design requirements*
- AS/NZS 1158.1.3 *Lighting for roads and public spaces Part 1.3: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance*
- AS/NZS 1158.4 *Lighting for roads and public spaces Part 4: Supplementary lighting at pedestrian crossings*

Where a pedestrian link or footpath is to be provided on land owned by TfNSW, the lighting shall be designed so that the footpath or pedestrian link meets accessibility requirements in accordance with this standard.

Where a proposed new station car park is separated from the railway station by an allotment that is not in TfNSW's ownership and the access over this allotment is by a council footpath, the accessible lighting requirements of the footpath within the car park and the station shall extend to the boundary of the allotment.

The council footpath lighting design and illumination levels are governed by local council and Australian standards. Separate power supply and metering arrangements shall apply.

6.9. Landscape, facade and decorative lighting

Landscape, facade and decorative lighting shall be determined by the user requirements brief and architectural requirements. Consultation with relevant stakeholders may also be required.

6.10. Portable and temporary lighting

Portable and temporary luminaires and their supply leads shall be double insulated. The luminaires and leads shall be periodically tested to ensure that they are safe for intended use.

7. Illumination levels

Illumination level is the parameter that is most often used for checking compliance as it is the easiest to measure. All illumination levels detailed in this standard refer to 'maintained illuminance' levels.

The illumination levels detailed in this section constitute a recommendation consistent with the exemption granted by the Australian Human Rights Commission for members of the ARA on 1 October 2015.

All illumination calculations shall follow the methodology and comply with requirements of relevant Australian standards, with additional requirements stipulated in this standard and the ARA exemption.

Where there are discrepancies between standards with respect to a particular application, the higher illumination values and the uniformity values resulting in better uniformity shall be used.

The following are some of the lighting technical parameters (LTP) used in AS/NZS 1680.1, AS/NZS 1158.2 *Lighting for roads and public spaces Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting*, and the ARA exemption:

- Eav average horizontal illuminance at a given plane
- Emin minimum horizontal illuminance at a given plane
- Eh average horizontal illuminance at ground level, Clause 2.2.3 of AS 1158.2:2005
- EPh horizontal point illuminance at ground level, Clause 2.2.3 of AS 1158.2:2005
- EPv vertical point illuminance as defined in Clause 2.2.3 of AS 1158.2:2005 (measured at 1.5 m above walking surface)
- EVmin minimum vertical point illuminance as defined in Clause 2.2.3 of AS 1158.2:2005 (measured at 1.5 m above walking surface)
- U1 uniformity of interior lighting illuminance is the ratio of the minimum illuminance to the average illuminance on a given plane within the specified area
- Ue2 (also U2) illuminance uniformity for pedestrian (category P) lighting is the ratio of the maximum illuminance to the average illuminance on a horizontal plane at ground level within the specified area (Clause 2.2.3 of AS 1158.2:2005).

- Calculation grids:
  - for internal lighting refer to appendix B of AS/NZS 1680.1:2006
  - for external lighting refer to clause 3.3 of AS/NZS 1158.2:2005

The minimum maintained vertical point illuminance (EVmin) grid spacing as defined in Clause 3.3.5 and Clause 3.3.7 of AS/NZS 1158.2:2005 shall apply to external lighting calculations.

Lighting levels specified in Table 1 to Table 5 shall be provided in the respective areas.

Table 1 – Illumination levels for public enclosed or covered station areas

Enclosed or covered station areas	Eav	Emin	EVmin	U1	U2	ASA comment
Entrance, passageway and walkways	150			0.5		At ground level
Stairs	150			0.5		At ground level
Ramps	150			0.5		At ground level
Toilets and locker rooms	200			0.5		At ground level
Counter tops	250			0.5		At counter top
Displays (timetables)	200			0.5		At surface of non-illuminated displays
Telephones (ticket machines)	200					At surface of relevant equipment
General platform	160			0.5		At ground level
Yellow line (platform edge)see note 1		150				At ground level

Table 2 – Illumination levels for public open station areas

Open station areas	Eav	Emin	EVmin	U1	U2	ASA comment
Toilets and locker rooms	200			0.5		At ground level
Counter tops	250			0.5		At counter top
Displays (timetables)	200			0.5		At surface of non-illuminated displays
Telephones (ticket machines)	200					At surface of relevant equipment
Yellow line (platform edge)see note 1		30				Non-covered area of the platform
General platform see note 2	42	21	14		7	Non-covered area of the platform

Open station areas	Eav	Emin	EVmin	U1	U2	ASA comment
Covered areas	160			0.5		At ground level
Core areas (awnings)	160			0.5		At ground level
Ramps and steps (open) see note 3 and note 4	42	21	14		7	At ground level
Open footbridge	42	21	14		7	At ground level
Primary access paths see note 2	42	21	14		7	At ground level
Enclosed footbridge	150			0.5		At ground level
Subways see note 5	150	17.5	17.5	0.5		ASA requirement

Notes:

1. *Not specifically covered in any standard. The recommended minimum level of illumination is higher than the minimum for the remainder of the platform. Illuminance at the yellow line shall be calculated separately to the remainder of the platform.*
2. *Illumination level is approximately twice that recommended in AS/NZS 1158.3.1.*
3. *Level of illumination not less than that of adjoining area.*
4. *Footbridges shall be regarded in the same manner as ramps and stairs.*
5. *The ASA adopts a higher lighting level than that stipulated by the ARA exemption. A higher lighting level is necessary for security purposes. As many subways constitute an accessible path to the platform, the lighting level of 150 lx has been adopted. The illumination levels provided in Table 3 for accessible car spaces and accessible paths to the station entry are derived from the requirement to provide a continuous path of travel between the station and other accessible facilities.*

Table 3 – Illumination levels for station commuter car parks and precincts

Station commuter car parks and precincts	Eh	EPh	EPv	UE2	ASA comments
Transport interchange (open walkways)	42	14	14	10	Consistent with ARA exemption
Accessible path – open (station entry to car park accessible spaces, bus stop, taxi stand, kiss and ride)	42	14	14	10	Consistent with ARA exemption

Station commuter car parks and precincts	Eh	EPh	EPv	UE2	ASA comments
Open car park – accessible spaces	42	14	14	10	Consistent with ARA exemption
Open car park – other areas	14	3	3	10	P11a AS/NZS 1158.3.1:2005
Accessible path - enclosed (station entry to car park accessible spaces, bus stop, taxi stand, kiss and ride)	150				Consistent with ARA exemption
Covered car park – accessible spaces	150				Consistent with ARA exemption
Covered car park – other areas					Relevant AS standards apply
Bike racks – open areas	42	14	14	10	Consistent with ARA exemption

Table 4 – Illumination levels for TNSW staff areas

Areas	Lighting requirements
Station circulation spaces	AS/NZS 1680.2.1 applies
Stations offices	AS/NZS 1680.2.2 applies
All other areas and building types	Relevant AS standards apply
Non-commuter car parks (for example, staff car parks)	Relevant AS standards apply

Table 5 – Illumination levels for sidings, stabling yards, depots and workshops

Areas	Eh	EPh	EPv	UE2	ASA comments
The front, back and each side of every train and areas in between stabled trains where no work is carried out	14	4	4	10	P7 - AS/NZS 1158.3.1:2005
Areas where maintenance and cleaning work is carried out (assigned areas in between stabled trains and other designated areas including driver and cleaner platform)	80	10	10	5	AS/NZS1680.5:2012, Table 3.1, with increased illuminance in vertical plane to facilitate cleaning of trains.
Site entry and exits points, all roadways, footpaths, walkways and access paths	14	4	4	10	P7 - AS/NZS 1158.3.1:2005
Stairs, building perimeter, building entry and exit	14	4	4	10	P7 - AS/NZS 1158.3.1:2005
Indoor work areas					AS/NZS 1680.2.4 applies
Outdoor work areas					AS/NZS 1680.5 applies

8. Assurance

A documented process to demonstrate assurance at configuration management (CM) gateways, project milestones and continuously throughout the asset life cycle shall be applied. This section provides non-exhaustive, lighting-specific assurance requirements and references that shall be applied in conjunction with the requirements described in T MU AM 04001 PL *TfNSW Configuration Management Plan* and TS 10753 *Assurance and Governance Plan Requirements*.

The assurance process shall include active coordination and integration assurance inclusive of all interfaces related to interior, exterior and emergency lighting.

Refer to T HR SS 80003 ST for infrastructure emergency lighting requirements.

All work shall be carried out in observance of the *Work Health and Safety Act 2011* and *Work Health and Safety Regulation 2011*.

Lighting installation, maintenance and decommissioning activities shall be carried out by licensed and competent electricians in accordance with approved procedures.

8.1. Lighting design

The nature of lighting design dictates that in addition to assurance at each CM gateway and as required for all other project milestones, the assurance process needs to occur continuously throughout all design stages.

The assurance process shall demonstrate that all relevant factors have been addressed and conclusions documented and implemented.

The process shall, at a minimum, provide assurances of the following:

- the design is compliant with the lighting requirements described in this document
- building surfaces, colours and reflectances have been agreed and relevant design parameters for different spaces recorded
- natural light usage has been assessed and relevant control measures implemented
- artificial lighting extent, type and relevant features have been selected according to stipulated criteria
- luminaires and lighting equipment have been chosen according to stipulated criteria
- lighting densities W/m2 have been documented and energy efficiency measures implemented
- lighting control system extent and control methodology have been agreed
- any discrepancies have been noted and brought to stakeholders' attention

During the final stages of lighting design, the assurance process shall demonstrate the following:

- relevant aspects of project specific environment and site context have been included in the lighting design to correctly support the architectural design intent
- correctness of the relevant input data into the lighting calculation software have been checked for the following factors:
    - dimensionally correct model of the physical space used
    - correct reflectance factors for ceiling, walls and floor for all interior spaces applied
    - correct choice and location of the luminaires in the space selected
    - luminaires photometric data valid and correctly used
    - appropriate calculation methodology applied
- calculated lighting levels comply with legislated requirements for horizontal and vertical illumination levels. The design maintained lighting levels shall meet the minimum values for a given application and should aim not to exceed these values by more than 20%.
- the electrical design related to the lighting, including but not limited to switchboards, circuits, switching arrangements and lighting controls has been carried out correctly

Lighting design shall be carried out by a competent person; that is, a suitably qualified and experienced lighting designer. The lighting designer shall have a minimum of 10 years' experience in the field of architectural lighting design, shall be a member of a relevant professional body, and shall demonstrate a detailed understanding and experience of the application of light in an architectural environment.

Lighting design and documentation shall be aided by software that supports both numeric and rendered solutions, and is capable of including day lighting in the calculation and simulation processes.

Illuminance-based lighting design methodology shall be used for all internal spaces and pedestrian lighting. Luminance-based lighting design may be applicable for access roads where directed by the relevant Australian standard.

While it is possible to calculate average illumination levels, proving the results through field measurements is not practical. Therefore, average illumination, minimum and maximum illumination levels, and attained uniformity levels shall also be proved through appropriate calculations and software simulation performed using the approved software.

The calculation and modelling shall be based on the use of proprietary (specifically selected luminaires and lamps) photometric data. An option to utilise an equal and approved product should be included for common application luminaires. The onus of proving the quality of the

proposed alternative product and the suitability of the lighting solution (to the satisfaction of the engineer) is with the proponent.

The calculation and modelling software shall utilise photometric data and methodology required by the following standards:

- AS/NZS 1680.3 *Interior lighting Part 3: Measurement, calculation and presentation of photometric data*
- IES LM-63 *Standard File Format For Electronic Transfer Of Photometric Data*

AS/NZS 1158.2 shall be used for outdoor applications. The photometric data shall be verified by an approved independent laboratory.

Only approved lighting design software (AGi32, Elum tools, DIALux) shall be used for illuminance calculations and software modelling.

Other software may be approved on specific application to the Lead Stations and Buildings Engineer, ASA. All software shall only be used by qualified lighting professionals with relevant knowledge and experience.

Final design shall demonstrate compliance (including calculations and results) in an approved format and evidence through renderings that the visual requirements have been met.

Lighting design shall include the lighting control system operational strategy and preliminary circuiting to ensure that the lighting installation is able to operate in accordance with the design intent, including legislated requirements, this standard, location-specific requirements and operational preferences.

These will serve as input to electrical engineering design. Full control circuit diagrams shall be provided as part of the project design documents.

Refer to Appendix B for further guidance on lighting design.

8.2. Lighting construction and commissioning

Newly constructed lighting assets shall be assured as part of the construction process. Construction and handover shall be carried out in accordance with legislative and contractual requirements.

The commissioning process shall demonstrate that all relevant factors have been implemented for all systems.

The process shall, at a minimum, provide assurances of the following:

- all light fittings have been selected, procured and installed in accordance with the approved design
- attainment of the stipulated minimum and maximum illumination levels have been proven and confirmed by site measurements

- the lighting control system has been installed, commissioned, correctly programmed, and proven through proper and uninterrupted operation for at least seven days
- the electrical installation including all associated electrical equipment is tested, commissioned and certified compliant
- all previously identified lighting defects and discrepancies have been rectified

An assurance certificate shall be issued on satisfactory commissioning and handover to operation.

8.3. Lighting operation and maintenance

As-built drawings and operation and maintenance manuals provided on completion of the lighting installation shall be used to help formulate operation and maintenance strategies.

The operator shall include all uniquely identified lighting assets in a suitable database, and review and update the database regularly. This will include the luminaire location, type, rated power, date of installation, details of infrastructure required to support the luminaire and any other information required to properly identify the status of each asset.

The lighting operating hours and switching on and off times shall be configured according to operational requirements.

Periodic inspections shall be carried out to ensure that the lighting system operates as intended. The inspection frequency is dependent on a number of location specific factors. It is recommended that inspections be carried out at least once every six months.

The operator shall identify lighting assets to be covered by a technical maintenance plan and assess the state of each asset as necessary. The findings shall be used as an input into the maintenance requirement analysis. Further audits, inspections and all maintenance of lighting installations shall be carried out at predetermined intervals by competent persons. At the completion of an audit or an inspection any deficiencies found shall be recorded and rectified as soon as is practicable.

Lighting shall be operated and maintained in accordance with the following standards:

- AS/NZS 1158.1.2:2010 *Lighting for roads and public spaces Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance*
- AS/NZS 1680.4 *Interior lighting Part 4: Maintenance of electric lighting systems*

Lighting-specific technical maintenance plans shall be developed and implemented in accordance with the requirements of T MU AM 01003 ST *Development of Technical Maintenance Plans*. Technical maintenance plans shall define the routine maintenance tasks applicable to lighting assets and outline the maintenance frequencies. The maintenance tasks and their frequencies may be periodically adjusted.

Maintenance programs shall include luminaire cleaning, lamp replacement, renewal of failed parts, checking of gaskets and optical elements to ensure that optical performance remains adequate throughout the life of the luminaire.

8.4. Documentation and record keeping

Lighting design documentation and all calculations including software input and output information, and relevant assurance certificates shall be available for audit at all times.

Up-to-date records of all maintenance activities and any other work affecting the lighting system shall be kept in an electronic database. All records shall be readily available for inspection and audit.

Further documentation requirements are detailed in EP 00 00 00 15 SP.

8.5. Reporting

Periodic inspection and reporting of the lighting assets' condition shall be carried out throughout the operational life of the assets and the results recorded for maintenance planning and audit purposes. The maximum time between inspections shall not exceed 12 months.

Appendix A Luminaire electrical protection classes

The luminaire electrical protection classes are as follows:

- Class I luminaires – class 1 luminaires are designed for connection to a protective conductor (earth). Earthing protects exposed metal parts that could become live in the event of basic insulation failure.
- Class II luminaires - class II luminaires have reinforced or double insulation. Protective earth terminal is not provided.
- Class III luminaires - class III identifies luminaires that are intended for operation with protective extra low voltage (50 V max).

Symbols for the different luminaire protection classes are shown in Figure 1.

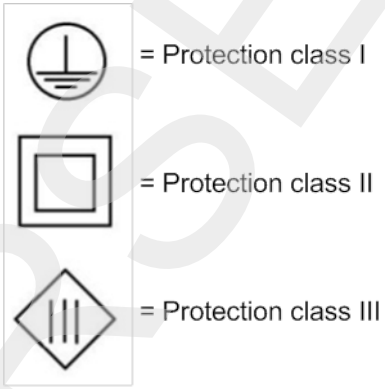

Figure 1 – Symbols for luminaire protection classes

Appendix B Guiding notes on lighting design

Safety, efficiency, functionality, users' comfort and environmental care are measures of good design. As a major design element, lighting contributes significantly to the overall design effectiveness of a project. Lighting design should facilitate a simple, safe and easily accessible installation, capable of being safely maintained without the need for special equipment, track possessions and isolation of the traction electrical system, or isolation of large parts of the station low voltage system.

The lighting design of public areas is an important part of customer experience engineering aimed at enhancing the customer's wellbeing and providing easy orientation and wayfinding to support commuter flows. Non-public area infrastructure lighting focuses on providing an optimal operational environment.

Lighting design should reflect aesthetics through the true rendering of space and form, and incorporate regulatory (including safety, ergonomic and environmental) and economic considerations.

As lighting closely relates to the architecture, interior type, decor (and light reflectance of its elements) as well as various building engineering systems, an integrated design process is recommended to ensure a good design outcome. The process requires involvement of the lighting designer from the beginning to the end of a project.

As the level of requirements and specific details of different systems described in project briefs vary from project to project, designers should analyse and explore different options to satisfy the intent of the brief.

The designer should be guided by their professional judgement and outcomes of project specific risk assessments, and increase illumination levels where the light levels higher than the minimum prescribed by this standard are justified.

Early in the design process, the lighting designer should discuss with architects and interior designers the style of lighting, the lit effect that needs to be created, provide advice on optimal vertical and horizontal illumination levels, daylight harvesting and solar shading techniques, discuss glazing characteristics, interior surfaces reflectance values and any other aspects that may affect the lighting levels and the desired visual appearance of the space.

Natural, artificial and emergency lighting should be coordinated and optimised to create a safe and ergonomic environment.

Lighting design is an iterative process that involves consideration of different factors. The design is optimised through the process of subsequent iterations.

The designer will need to define the design methodology for the project and address specific requirements, including stakeholder consultation and quality management processes (involving design correctness, coordination, documentation, records, verification and assurance).

The list of basic design tasks below serves as an example of design activities that may be included as part of the design procedure; it can be expanded and elaborated to address relevant considerations for each project:

- decide the quality of illumination needed for a particular space and related architectural elements
- determine the appropriate lighting level required for safety and the nature of the task or process
- respond to the concerns of safety, ergonomics, operation and maintainability
- select lighting fixtures, their layout and mounting heights that best satisfies all the requirements
- review the environmental impact and verify life cycle costing for different options
- optimise the equipment selection and spatial parameters of the design through photometric studies and computer simulation
- mitigate any adverse effects related to the equipment or the way it is used in the design
- verify that all the relevant factors have been properly considered in the design
- document compliant final design
- during and on completion of the design, provide assurance, using approved process that is commensurate with the scale and complexity of the project