# CIS Lighting Standard

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<tr>
<th>Documents No:</th>
<th>CIS-Standard-Lighting</th>
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<tbody>
<tr>
<td>Revision No:</td>
<td>001</td>
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<tr>
<td>Issue date:</td>
<td>21 August 2013</td>
</tr>
</tbody>
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1 PURPOSE

The CIS Lighting Standard sets out the University of Sydney's minimum requirements for the design, construction and maintenance of interior and exterior lighting systems. It ensures new and refurbished lighting systems are energy efficient, fit-for-purpose, made from durable good-quality materials, contain no or minimal environmentally harmful substances, and are cost efficient to operate and maintain.

Applicable requirements documented in Workplace Health and Safety legislation, Disability Discrimination legislation, State Environmental Planning legislation, Commonwealth and State legislation, National Construction Codes (NCC), the Building Code of Australia (BCA) and Australian and New Zealand Standards (AS/NZS) are the minimum and mandatory compliance requirements.

Where any ambiguity exists between this standard and the aforementioned mandatory requirements then:

a. the highest performance requirements must apply
b. applicable requirements must follow this order of precedence:
   I. Workplace Health and Safety legislation
   II. Disability Discrimination legislation
   III. State Environmental Planning and Assessment legislation
   IV. All other Commonwealth and State legislation
   V. NCC and BCA
   VI. AS/NZS
   VII. This standard and other University standards

2 SCOPE

This standard describes minimum requirements for design, purchase, construction, and operation and maintenance of internal and external lighting systems for buildings and spaces owned, operated, maintained and/or managed by the University of Sydney. It applies to:

a. new building construction
b. refurbishment projects for University-owned spaces over 50m² excluding external walls
c. refurbishments of spaces that form part of a broader medium-term (less than five years) programme/plan of progressive upgrades to a University-owned building
d. refurbishment projects for long-term University-leased (more than five years post-refurbishment) spaces over 50m² excluding external walls
e. facilities maintenance services

The standard covers most University-specific space types and applications. Where specific applications are not explicitly covered or ambiguity exists, the intent of the design standard must be satisfied. In such cases a return design brief must be provided for review and approval by the issuer of this standard or their appointed delegate who must have relevant technical competence in the subject matter.

The standard applies to planners, project managers, consultants, contractors, sub-contractors, tenants, managing agents, University staff and others involved in the design, construction, installation, operation and maintenance of existing, new and proposed University buildings and facilities.

Lighting products and services provided or specified by designers, consultants, staff and contractors must conform to this standard.
3 GLOSSARY OF TERMS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>C/B</td>
<td>Circuit breaker</td>
</tr>
<tr>
<td>C-Bus</td>
<td>Proprietary electronic digital lighting control system now owned by Schneider Electric. Originally developed in Australia.</td>
</tr>
<tr>
<td>Colour rendering Index</td>
<td>Measure of the ability of a light source to render colours of a space accurately. A higher index is preferable. &gt;80 is acceptable and typical of modern light sources.</td>
</tr>
<tr>
<td>DB</td>
<td>Distribution Switchboard</td>
</tr>
<tr>
<td>Dirt Depreciation (DD)</td>
<td>The correction factor that must be applied to calculations to account for the accumulation of dirt over a fixed period of time.</td>
</tr>
<tr>
<td>DSI</td>
<td>Digital Signal Interface electronic ballasts, group switching and dimming.</td>
</tr>
<tr>
<td>DALI</td>
<td>Digital Addressable Lighting Interface electronic ballasts, individual programmable luminaire dimming and switching.</td>
</tr>
<tr>
<td>Lamp Depreciation (LD)</td>
<td>The correction factor that must be applied to calculations to account for the depreciation of lamp lumen output over a fixed period of time.</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode. Modern light source.</td>
</tr>
<tr>
<td>LOR</td>
<td>Light output Ratio. Measure of total efficiency of a luminaire.</td>
</tr>
<tr>
<td>Lumen</td>
<td>Measure of raw light flux from a lamp.</td>
</tr>
<tr>
<td>Luminaire</td>
<td>Light fitting complete including all hardware, reflector, diffusers, ballasts, lamps and wiring.</td>
</tr>
<tr>
<td>Luminous Efficiency</td>
<td>Measure of lumens per watt for a lamp.</td>
</tr>
<tr>
<td>Lux</td>
<td>Measure of the incident light flux on a given surface. Equals lumens / area.</td>
</tr>
<tr>
<td>MSB</td>
<td>Main Switchboard</td>
</tr>
<tr>
<td>Quad-phosphor</td>
<td>Type of light emitting material inside fluorescent lamps. Special standard using red, green, blue + 1 phosphors to generate higher quality white light.</td>
</tr>
<tr>
<td>RCD</td>
<td>Residual Current Device (Earth leakage protection)</td>
</tr>
<tr>
<td>T5</td>
<td>16mm diameter linear fluorescent lamp. Current state of the art for general, classroom and office interior spaces.</td>
</tr>
<tr>
<td>T8</td>
<td>26mm diameter linear fluorescent lamp. Older standard but still acceptable in some areas.</td>
</tr>
<tr>
<td>Tri-phosphor</td>
<td>Type of light emitting material inside fluorescent lamps. Current standard uses red, green and blue phosphors to generate white light.</td>
</tr>
</tbody>
</table>
4 AUTHORITIES & RESPONSIBILITIES

The design standard is owned by CIS. It is approved and signed-off by the Director CIS and the Engineering & Sustainability Unit is responsible for reviewing and maintaining the standard and keeping it up-to-date. The standard must be reviewed and kept up-to-date at least biennially.

5 TECHNICAL REQUIREMENTS

Details of design and construction requirements for lighting systems are outlined in this section.

5.1 GENERAL REQUIREMENTS FOR LIGHTING SYSTEM PRODUCTS AND EQUIPMENT

All lighting system products and equipment must:

a. comply with AS/NZS and codes and have relevant current compliance certifications to quality management systems, standards and codes
b. be readily available on-demand and in large volumes in the local market from a wide range of reputable long-standing local suppliers
c. be readily serviceable by a wide range of electrical contractors
d. be supported by a large quantities of locally available critical spare parts that can be delivered to the University on demand
e. demonstrate proven local track record of performance and longevity in comparable applications
f. be made from durable good-quality materials
g. contain no, or minimal, environmentally harmful substances e.g. hazardous materials and chemicals
h. be cost efficient to operate and maintain

5.2 MINIMUM COMPLIANCE AND ENERGY EFFICIENCY REQUIREMENTS

Artificial lighting must as a minimum satisfy current energy efficiency performance requirements of the BCA Section J, current requirements of any AS/NZS related to lighting and associated electrical requirements.

5.3 LIGHTING SYSTEM DESIGN SOFTWARE

Lighting designers and contractors must carry out lighting calculations for typical and unique spaces using University-approved computer models. Current deemed-to-comply software is provided in Attachment 1. Equivalent models can be accepted as deemed-to-comply after review and approval by the issuer of this standard.

Designers must provide native calculation files and PDF printouts of lux grids which must be used to verify the installed lighting performance.

5.4 LIGHTING SYSTEM DESIGN PARAMETERS

5.4.1 TECHNICAL REQUIREMENTS

The following computerised lighting calculation point densities must be used to ensure accurate and representative values are obtained and displayed:

1. Interior spaces 0.2m grid
2. Exterior spaces 0.5m grid
Note: Use of excessive point spacing leads to results with holes in the data, or inaccuracies due to the low effective sampling rate against the luminaire spacing.

Lighting design calculations must not include interreflection for calculations in spaces with high workstation partitions or shelving. They must be based on minimum maintained average levels i.e. the average lighting level over the effective work area at the end of the worst cleaning / relamping cycle.

For example, a new office space designed for 320 lux must have an initial measured average lighting level of 400 lux at 100 hours. With a required uniformity of at least 0.75, this equates to an absolute minimum of 390 lux and a maximum of 500 lux at any point in the space.

Lighting illumination must conform to AS/NZS 1158 and AS/NZS 1680 and must ensure:

a. each luminaire is corrected to a minimum power factor of 0.9 lagging
b. installations must conform to IEC 61547 for minimum radio interference.
c. appropriate levels of visual comfort and use of low glare diffusers and systems in areas such as terraced lecture theatres, etc
d. resistance to dirt built up and use of luminaires with appropriate IP ratings
e. use of minimum shielding angle of the luminaires where screen-based equipment
f. use of plug-in luminaires method wherever possible.

Table 1 shows lighting calculation parameters to be used for design.

<table>
<thead>
<tr>
<th>Design parameter</th>
<th>Calculation requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective work area</td>
<td>0.5m from walls for enclosed spaces</td>
</tr>
<tr>
<td>Work plane height</td>
<td>0.75m for desk / 0.9m bench and 0m for travel areas, or as otherwise clearly defined by the space use</td>
</tr>
<tr>
<td>Storage or library shelving work plane</td>
<td>work plane must be a vertical surface taken from the middle of the lowest to the middle of the highest shelf tiers</td>
</tr>
<tr>
<td>Lamp Lumen Depreciation Factor (LD)</td>
<td>0.9 for T5 or T8</td>
</tr>
<tr>
<td></td>
<td>0.8 maximum for LED lamps</td>
</tr>
<tr>
<td></td>
<td>0.7 for Compact fluorescent</td>
</tr>
<tr>
<td></td>
<td>0.8 for discharge lamps</td>
</tr>
<tr>
<td>Dirt Depreciation Factor (DD)</td>
<td>0.8 for interior and exterior spaces</td>
</tr>
<tr>
<td>Total Light Loss Factor calculation formula</td>
<td>LLF = LD x DD</td>
</tr>
<tr>
<td>Reflection factors</td>
<td>Plaster, tile or white painted Ceilings 70%</td>
</tr>
<tr>
<td></td>
<td>Painted Walls 50%</td>
</tr>
<tr>
<td></td>
<td>Carpeted Floors 15%</td>
</tr>
<tr>
<td></td>
<td>Tiled floors 20%</td>
</tr>
<tr>
<td></td>
<td>Off form concrete 20%</td>
</tr>
</tbody>
</table>

These factors are based upon a typical two year cleaning cycle. Relamping is based upon lamp life and operating times.
5.4.2 Whole-of-Life Cost and Performance Considerations

Whole-of-life performance of proposed luminaires must be submitted for review and approval by the issuer of this standard. Designers must submit the whole-of-life cost performance evaluation using the spreadsheet form CIS-ENG-F002 provided in Attachment 1.

5.5 Customised Luminaries

Custom-designed, bespoke or modified special luminaries must not be specified or used without written formal approval from the issuer of this standard because they are expensive to design and it is difficult to reliably guarantee performance. Customised luminaires must only be considered for historic restoration projects where off-the-shelf products may not be available.

If approved, projects must specify, and contractors must supply:

- upfront purchase of 10% extra basic carcass / bodies for spares and alterations.
- standard commercial paint and powder coat colours that are readily and inexpensively available in the local market.
- 12 month warranty for the installed luminaire, ballast and lamp.
- Evidence of thermal and photometric performance testing by a NATA-accredited laboratory

5.6 Light Fittings and Lux Performance Requirements for Various University Space Types

Minimum maintained average horizontal lighting design levels must comply with AS/NZS1680. Lighting systems must not provide illumination maximum power densities above requirements of BCA Section J.

Table 2 provides light fittings and lighting levels that must be used for typical interior spaces.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Luminaire types</th>
<th>Minimum Maintained Average Light Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>General spaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amenities</td>
<td>LED downlight. Wide angle.</td>
<td>80 lux</td>
</tr>
<tr>
<td>Amenities for persons with disability</td>
<td>LED downlight Wide angle, or recessed T5 troffer</td>
<td>200 lux</td>
</tr>
<tr>
<td>Classrooms</td>
<td>1x28W T5 fluorescent. Recessed or surface / suspended with diffuser.</td>
<td>240 lux</td>
</tr>
<tr>
<td>Corridors</td>
<td>LED downlight Wide angle</td>
<td>150 lux</td>
</tr>
<tr>
<td>General Computer Classrooms</td>
<td>1x28W T5 fluorescent fitting with low brightness semi specular louvre.</td>
<td>240 lux</td>
</tr>
<tr>
<td>General Office areas</td>
<td>1x28W T5 fluorescent recessed T-bar troffer with low brightness semi specular louvre.</td>
<td>320 lux</td>
</tr>
</tbody>
</table>
## Areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Luminaire types</th>
<th>Minimum Maintained Average Light Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>Wire suspended 75% direct / 25% indirect T5 Fluorescent luminaire.</td>
<td></td>
</tr>
<tr>
<td>Meeting or Multipurpose Room</td>
<td>1x28W T5 fluorescent recessed T-bar troffer with low brightness semi specular louvre. and / or LED Downlights</td>
<td>Switchable level 240/450 lux</td>
</tr>
<tr>
<td>Meeting room general</td>
<td>1x28W T5 fluorescent recessed T-bar troffer with low brightness semi specular louvre.</td>
<td>320 lux</td>
</tr>
<tr>
<td>Meeting room with AV facility</td>
<td>LED Downlights. Low glare.</td>
<td>Dimmable 10 – 320 lux</td>
</tr>
<tr>
<td>Reception / Lobby</td>
<td>LED downlights &amp; decorative</td>
<td>As per AS1680</td>
</tr>
<tr>
<td>Stairways</td>
<td>Hi-specification LED bi-level lights with occupancy sensors</td>
<td>As per AS1680</td>
</tr>
<tr>
<td>Store Rooms – depends on task</td>
<td>1x28W T5 fluorescent recessed troffer, or surface mount diffused batten</td>
<td>As per AS1680</td>
</tr>
<tr>
<td>Video Conference</td>
<td>Vertical illumination special task special. Direct / indirect main source, plus dimmable LED downlights</td>
<td>400 lux at desk and a high facial vertical illuminance</td>
</tr>
</tbody>
</table>

### Laboratories

<table>
<thead>
<tr>
<th>Laboratories</th>
<th>Luminaire types</th>
<th>Minimum Maintained Average Light Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Hazard Area (PC1-3)</td>
<td>Specialty 1x28W Fully enclosed impact resistant fluorescent recessed or batten</td>
<td>To respective code</td>
</tr>
<tr>
<td>Chemical / Process / Biological / Research Laboratory</td>
<td>1x28W Fully enclosed impact resistant fluorescent recessed or batten</td>
<td>600 lux</td>
</tr>
<tr>
<td>Computer / Internet / Instrument / Signals Laboratory</td>
<td>1x28W T5 fluorescent fitting with low brightness semi specular louvre.</td>
<td>320 lux</td>
</tr>
<tr>
<td>General Laboratory</td>
<td>1x28W Fully enclosed fluorescent recessed or batten</td>
<td>450 lux</td>
</tr>
<tr>
<td>Machine / Power Laboratory</td>
<td>1x28W Fully enclosed impact resistant fluorescent recessed or batten</td>
<td>600 lux</td>
</tr>
<tr>
<td>Areas</td>
<td>Luminaire types</td>
<td>Minimum Maintained Average Light Levels</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td><strong>Theatre</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aisles and steps</td>
<td>LED downlight / concealed strip lighting</td>
<td></td>
</tr>
<tr>
<td>AV Presentation capable. Dimmable</td>
<td></td>
<td>10-240lux</td>
</tr>
<tr>
<td>General Lecture (with lectern / desk task light)</td>
<td>LED down light. Diffused T5 Fluorescent depending upon area and ceiling type</td>
<td>240 lux</td>
</tr>
<tr>
<td><strong>Sports Facilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gymnasiums</td>
<td>T5 fluorescent with microprism diffuser and secured hinged frame.</td>
<td>250 lux</td>
</tr>
<tr>
<td>Sports Halls</td>
<td>Suspended T5 fluorescent with microprism diffuser and secured hinged frame.</td>
<td>250 lux</td>
</tr>
<tr>
<td></td>
<td>LED or Metal Halide lowbay luminaires</td>
<td></td>
</tr>
<tr>
<td><strong>Internal Building Car parking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking bays and access bays (low risk)</td>
<td>1 x 36W T8 Fluorescent or Hi-specification LED bi-level lights with occupancy sensors. Note: LEDs must be approved by the issuer of this standard.</td>
<td>75 Lux</td>
</tr>
<tr>
<td>Pedestrian areas, lifts &amp; stairs</td>
<td>1 x 36W T8 Fluorescent or Hi-specification LED bi-level lights with occupancy sensors. Note: LEDs must be approved by the issuer of this standard.</td>
<td>100 lux</td>
</tr>
<tr>
<td>Ramps, corners and intersections (high risk)</td>
<td>1 x 36W T8 Fluorescent or Hi-specification LED bi-level lights with occupancy sensors. Note: LEDs must be approved by the issuer of this standard.</td>
<td>150 Lux</td>
</tr>
<tr>
<td>Vehicle entrance/exit zones</td>
<td>1 x 36W T8 Fluorescent or Hi-specification LED bi-level lights with occupancy sensors. Note: LEDs must be approved by the issuer of this standard.</td>
<td>75 lux (night) 300 lux (day)</td>
</tr>
<tr>
<td><strong>Residential Buildings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrooms</td>
<td>Surface LED or T5 fluorescent on ceiling.</td>
<td>To comply with BCA energy and AS1680</td>
</tr>
</tbody>
</table>
**Areas** | **Luminaire types** | **Minimum Maintained Average Light Levels**
--- | --- | ---
Common Rooms | LED or compact fluorescent bed lamp | light levels

**Table 3** provides light fittings that must be used for typical exterior areas and design lighting levels that must be maintained.

### Table 3 Exterior Design Lighting Levels

<table>
<thead>
<tr>
<th>Areas</th>
<th>Maintained Average Light Levels</th>
<th>Minimum Light at any point</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main pedestrian walkways</td>
<td>AS/NZS 1158</td>
<td>5 lux</td>
<td>AS/NZS 1158</td>
</tr>
<tr>
<td>Secondary pedestrian walkways</td>
<td>AS/NZS 1158</td>
<td>5 lux</td>
<td>AS/NZS 1158</td>
</tr>
<tr>
<td>Main Roads</td>
<td>AS/NZS 1158</td>
<td>AS/NZS 1158</td>
<td>AS/NZS 1158</td>
</tr>
<tr>
<td>Secondary Roads</td>
<td>AS/NZS 1158</td>
<td>AS/NZS 1158</td>
<td>AS/NZS 1158</td>
</tr>
<tr>
<td>Park / grass areas</td>
<td>15 lux</td>
<td>5 lux</td>
<td>25%</td>
</tr>
<tr>
<td>General Sport Ovals</td>
<td>20/50/100/200 lux switchable</td>
<td>20 lux</td>
<td>50%</td>
</tr>
<tr>
<td>Event Sports Oval</td>
<td>400-500 lux</td>
<td>200 lux</td>
<td>70%</td>
</tr>
</tbody>
</table>

### 5.7 Luminaire and Lamp Requirements

Luminaire designers and specifiers must give precedence to:

- a. fitness-for-purpose
- b. durability and good quality construction
- c. lamp quality and energy efficiency
- d. local on-demand availability
- e. cost effective and safe serviceability and maintenance

over aesthetic considerations that incur high capital, operational and maintenance costs.

#### 5.7.1 Luminaire Design and Selection

Whenever new luminaires are being proposed, production quality luminaire samples must be provided for approval by the issuer of this standard prior to confirming selection.

Luminaire design and selection process must satisfy these requirements:

- a. Lenses / diffusers must be tight-fitting and well-secured.
b. Relamping of ceiling lights must be easy, safe and quick to perform using ladders for lights fittings up to 3m height. Any large components of luminaires that need to be removed for relamping whilst on a ladder must be retained with a lanyard or hinge.

c. Fittings that have to be dismantled to replace lamps must not be used. Locate ceiling mounted fixtures so lenses can be removed and their components can be replaced without removing adjacent mechanical or electrical equipment.

d. Luminaires mounted up to 3m high must be designed so they can be fully relamped by a tradesman safely and quickly. Mounting design must consider the ease and efficiency with which a tradesman can set up the ladder, climbing up, disassemble required luminaire components, remove existing lamps to a disposal container, relamp, clean the luminaire, reassemble components, climbing down and remove the ladder.

e. Locate stair lighting under the soffit at landings

f. Locate interior lighting within easy reach of simple platforms or ladders that can be safely carried in a set up by a single tradesman.

g. Avoid mounting luminaires higher than 3m to minimise maintenance and specialist equipment-hire costs. Luminaries installed higher than 3m must be easily accessible by lifting equipment or have a mechanism to lower the luminaire down to a height of 3m.

h. Obtain approval from the issuer of this standard before locating fixtures or remote ballasts where a lift or scaffolding is required for maintenance.

i. Fixings must be designed to minimise stresses and damage to any plastic parts and to ensure tight and continuous sealing of any gasket contacts.

j. Reflectors must be high grade bright vacuum aluminised coated metal or plastic, accurately formed and fixed in place to prevent movement relative to the lamp.

k. Reflectors or lenses must be easily removable without a risk of damage. Reflector clips or catches must operate smoothly and without undue force.

l. Metalized plastic reflectors are acceptable only if fixed in a way that prevents stress on the plastic materials. Fixing using a single fixing screw through unreinforced plastic is not acceptable.

m. Lamp holders must precisely and securely hold the lamps in place both for safety reasons and to ensure photometric performance is maintained over the luminaire life with relamping and cleaning.

n. Luminaires in outdoor or corrosive environments must have appropriate coating finishes applied to ensure high durability in such exposed environments. Special metal primers and powder coating or equivalent coatings must be applied.

o. Robust and easy-to-use luminaire fixings to the mounting surfaces must be used. They must be capable of removal without damaging the underlying mounting surface.

p. Luminaires must use the latest high quality electronic ballasts offered by manufacturers. Note that ballasts from manufacturers typically come in at least two quality grades for life expectancy and features.

q. Fluorescent luminaires in areas subjected to physical damage must use wire guards, acrylic lenses and HID luminaires in such areas must use tempered glass lenses.

5.7.2 LAMP TYPE SELECTION

Lamp design and selection process must:

a. ensure long lamp life and low replacement and maintenance cost

b. use the University’s preferred lamp types and limit the number of different lamp types used in a project

c. consider risks of colour shift, instability and premature failure.

d. Thoroughly scrutinise new and emerging technology and to check for risks of instability

e. only adopt LED lamps that have demonstrated and proven stability, durability and illumination performance in comparable applications

f. not use low wattage compact and reflector HID discharge lamps that have potentially short life, very high relamping cost and colour shift issues
g. not use high wattage (32W and 42W) compact fluorescent lamps that have a very poor durability due to overheating
h. only use high efficiency lamps that have good-quality and well-constructed heat dissipaters to reduce overheating risks.

All lamp colour temperatures must be reviewed and approved by the CIS Planning team’s architects and interior designers. The following lamp colour temperatures apply:

a. 4000K for internal workplaces with predominantly white walls e.g. offices, computer labs, laboratories, etc
b. Warmer colours 2700K to 3000K for:
   i. heritage building interiors
   ii. exterior lighting of sandstone facades and walls
   iii. passive recreational, dining, breakout spaces and theatres
   iv. to enhance red and orange wall colours

The University's current schedule of deemed-to-comply lamps is provided in Attachment 2 and unacceptable lamps are provided in Attachment 3. These schedules are neither exhaustive nor exclusive. They must be updated from time-to-time by the issuer of this standard at least biennially when the standard is reviewed and updated.

Alternative lamp products must be accepted based on evaluation of demonstrated and proven performance to the requirements of this standard.

5.7.3 LAMP BALLASTS

Requirements for ballasts for common lamps used at the University are provided here and must be satisfied by designers and specifiers.

Fluorescent lamps are the dominant luminaire across the University and their performance and efficiency is affected by the quality of ballasts used. Ballasts for fluorescent lamps must meet these requirements:

a. TYPE: quick-connect, electronic, high power factor, high frequency, constant lamp current, universal multi-wattage lamp type with an energy-efficiency index (EEI) of A3 or better. Designers and specifiers must select from manufacturers’ premium long life range.

   b. DIMMING: Use 0-10V or Digital Signal Interface (DSI) by preference for general areas, or Digital Addressable Lighting Interface (DALI) electronic dimming ballasts for specialised applications such as AV presentation areas.

   c. LOSSES: The lamp wattage and ballast losses at the operating temperature, measured in accordance with AS/NZS must be within the limits specified in Table 4.

   d. NOISE: Ballasts must be inaudible when installed. Ballasts generating noise levels above 26dB(A) at the working plane are unacceptable.

   e. LAMP FAIL OPERATION: Ballasts must provide automatic end-of-lamp life protection shutdown for the failed lamp only. Multi-lamp ballasts must continue to support remaining lamps in operation at full lumen output.

Ballasts must be mounted remotely when noise, temperature, radio-frequency interference, and electromagnetic fields considerations are critical.

Table 4 Maximum energy consumption criteria for ballasts and lamps
<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Lamp configuration</th>
<th>Lamp true wattage (W)</th>
<th>Ballast loss (W)</th>
<th>Total lamp and ballast loss (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T8</td>
<td>1 x 18W</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>T8</td>
<td>2 x 18W</td>
<td>32</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>T8</td>
<td>1 x 36W</td>
<td>32</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>T8</td>
<td>2 x 36W</td>
<td>64</td>
<td>6</td>
<td>70</td>
</tr>
<tr>
<td>T5 HE</td>
<td>1 x 14W</td>
<td>14</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>T5 HE</td>
<td>2 x 14W</td>
<td>28</td>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>T5 HE</td>
<td>1 x 28W</td>
<td>27.9</td>
<td>3.9</td>
<td>31.8</td>
</tr>
<tr>
<td>T5 HE</td>
<td>2 x 28W</td>
<td>55.6</td>
<td>7.4</td>
<td>63</td>
</tr>
<tr>
<td>PLC</td>
<td>1 x 18W</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>PLC</td>
<td>2 x 18W</td>
<td>36</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>PLC</td>
<td>1 x 26W</td>
<td>21</td>
<td>3.5</td>
<td>24.5</td>
</tr>
<tr>
<td>PLC</td>
<td>2 x 26W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>1 x 32W</td>
<td>32</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>PLC</td>
<td>2 x 32W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Data is obtained from review of recognised major manufactures technical data in 2012.

Ballasts for LED Lamps must meet these requirements:

a. TYPE: High frequency, constant lamp current, universal multi lamp. Designers and specifiers must select from manufacturers’ premium long life range.

b. DIMMING: Use DSI by preference, or DALI electronic dimming ballasts.

c. LED Current: Maximum constant driver current must be 500mA unless approved up to 750mA

d. MANUFACTURE & WARRANTY: Use only drivers from the lamp manufacturer with an integrated package written warranty of minimum 5 years.

e. LOSSES: Include driver losses in all energy calculations.

HID Lamp Ballasts must meet these requirements:

a. TYPE: High frequency, constant lamp current. Designers and specifiers must select from manufacturers’ premium long life range.

b. AMBIENT RATING: -5°C to +65°C ballast compartment temperature

5.7.4 GENERAL LUMINAIRE CONSTRUCTION

Luminaires must be well-constructed, good quality, durable and have the following features:

a. STIFFNESS: The materials, body shape, and method of manufacture provide adequate stiffness to prevent warping or sagging when installed in position.

b. RELAMPING: Lamps must be easily removable from the front of the luminaire when mounted in a ceiling.

c. BODY SHAPE: Rectangular and square luminaires must have straight parallel edges and square corners.

d. SURFACE MOUNTING: For fixing of surface-mounted luminaires to ceilings or walls provide fixing holes as follows:
   a. Square and Rectangular Luminaires: minimum four symmetrical holes.
   b. Circular Luminaires: minimum three holes.

e. SUSPENSION MOUNTING: Provide suspensions and luminaire suspension connectors capable of supporting, without damage, five times the mass of the luminaire, or 25kg, whichever is the greater.
f. REFLECTOR & LENS RETENTION: Provide vibration resistant, positive location and retention of the reflector or lens.

g. MANUFACTURER’S MARKING: Provide a durable non-fading permanently affixed label on all light fittings indicating the manufacturer’s name and catalogue number, and compliance with AS/NZS.

h. MATERIALS: Use zinc-coated steel, grade 304 stainless steel, extruded aluminium or other equivalent performance materials unless otherwise approved by the issuer of this standard. These material thicknesses apply:
   I. Minimum zinc-coated steel thickness of 0.6mm provided adequate thickness is achieved by body shape and folding techniques, otherwise 1mm.
   II. Minimum grade 304 stainless steel thickness 1mm.
   III. Minimum extruded aluminium thickness 1mm.

5.7.5 DOWNLIGHT CONSTRUCTION

Downlights must be well-constructed, good quality, durable and have the following features:

a. FIXINGS: Provide a minimum of three clamping points from the rim to the ceiling fabric. Downlights with asymmetrical ballast housings and only two point fixings are unacceptable.

b. SUPPORT FLANGE: Provide a minimum of 5mm support flange around ceiling hole cut outs for small downlights, and 10mm for larger downlights. Trimless downlights are unacceptable.

c. REMOVABILITY: The downlight must be removable from underneath the ceiling without damaging the luminaire or the ceiling.

d. BALLAST HOUSING: Provide central or remote electronic ballast housings. Downlights with offset ballasts and uneven balance may cause distortion of ceiling materials and are unacceptable.

5.7.6 PHOTOMETRIC, THERMAL AND ENERGY DATA

Designers and specifiers of luminaires must provide photometric, thermal and energy consumption data as follows:

a. Provide and obtain approval for full photometric, thermal and energy consumption data before delivering a standard luminaire, or commencing to manufacture a non-standard luminaire. Photometric data must be in IES standard electronic format and the tests must be performed by an accredited NATA or equivalent accredited reputable laboratory.

b. Provide thermal performance test data confirming compliance with AS/NZS and lamp manufacturers’ recommendations.

c. To comply with the current AS/NZS for glare for relevant to the application / task.

5.8 EXTERIOR LIGHTING

5.8.1 GENERAL REQUIREMENTS

Pole or building mounted lighting directing illumination downwards or horizontally must be provided wherever feasible.

In-ground lights must be avoided due to higher risks of damage, moisture ingress and premature failure. Upward decorative building facade, landscape and feature lighting must be avoided to prevent light pollution. Approval of the issuer of this standard must be sought for use of upward lighting.

5.8.2 EXTERIOR LIGHT POLES, FIXINGS AND WIRING

Design and specification of exterior light installations must fulfil these requirements:
a. STRUCTURAL CALCULATIONS: Provide wind loading calculations for all pole installations.
b. FIXING MATERIALS: Use stainless steel hardware and fixings with tamper-resistant heads.
c. RAG BOLT FIXINGS: Use hot-dip galvanised rag-bolt assemblies installed in a concrete plinth finished at the finished surface level for hard surfaces, and not less than 50mm above finished ground surface levels.
d. IN-GROUND WIRING: Install PVC-insulated wiring in underground conduits on the loop in loop out principle to each luminaire. Do not use intermediate junction boxes or T-off boxes.
e. WIRING SIZING: Generally, underground circuits must be wired in minimum 4mm² cables. Use oversized conductors to the first luminaire to maintain voltage drop to less than 1% at the first luminaire.
f. LIGHT FITTINGS: Must be individually protected by HRC fuses, with adequate ventilation and degree of protection (IP rating). Reflectors must be manufactured from high quality (purity) aluminium.
g. POLES: Multi-functional galvanised poles must be used. They must be painted with one coat of metal primer, one undercoat, plus two top coats of enamel paint. Approved anticorrosive powder coating is acceptable. Colours must be in accordance with the CIS Grounds and Heritage Standards requirements. HRC fuses must be installed at the base of the pole and be accessible from the pole inspection plate. Exit conduits must be installed at the last pole for future installations. Poles must be provided with an engraved stainless steel label affixed to the front of the inspection plate cover as a means of identification. The information must include the University asset number and lamp type and must be transferred to the University record exterior lighting 'as-built' drawings and registered according to the CIS Asset Management Standard by the Contractor.

5.9 LIGHTING CONTROLS

5.9.1 GENERAL REQUIREMENTS

All lighting control systems must comply with the BCA Section J and the University energy conservation requirements and be arranged to minimise energy consumption and maximise lamp life.

The general requirement for lighting control is to turn off the lights when not in use. All lighting systems must have switching and control capabilities to turn off lights when not needed. Light output and power consumption must be able to be reduced when full light output is not needed. Mandatory requirements include:

a. Lights on each floor of a building must be controlled by a separate automatic control device
b. Light switches and controls must be provided in each room
c. Daylighting controls must be provided where sufficient daylight illumination can be provided to a space
d. Automatic shut-off switch and occupancy sensor must be provided to ensure lights are off after business hours
e. Separate switching of any display lighting and general lighting must be provided

5.9.2 SWITCHES

Independent lighting switches must be provided for each area enclosed by ceiling height partitions. Automatic controls must still allow an occupant to manually turn off all of the lights in a room using the switch.

Each room must have its own light switches and each switch must be limited to lighting a zone of maximum of 100m². For larger areas, different switches for lighting different zones must be placed in a control panel. Light switches must be configured to manual "on" operation or, if automatic "on" is desired, the room must be wired and controlled such that no more than 50% of the general lighting turns on automatically. This light switching approach must be used in dry and wet laboratories and
workshops where there are significant safety hazards. Only manual switches must be used in lieu of occupancy sensors in substations, electrical, mechanical and telecommunications rooms.

All switches must be placed in a clearly visible location, at a height of 1m above the floor, be easy to identify and use, and be accessible by persons with a disability. Two-way switching at entry/exit points must be provided for large spaces with two entry/exit points that are more than 10m apart. Place switches at the exits from rooms and use two-way switching to encourage occupants to turn off lights when leaving the room. Where ever possible locate switches on the door handle side of doors. Gang switching of multiple rooms is unacceptable.

Time delay switches must be set to operate for a preset time of no more than an hour and must only be used when spaces experience short periods of activity and occupancy. Examples include out-of-hours cleaning, toilets, etc.

Programmable Automatic time switches must be used in to control lighting based on sunrise and sunset hours. They must automatically adjust the turning on and off of lights every day of the year, typically using an internal program based on longitude and latitude. Automatic time switches must meet these requirements:

a. Sunrise and sunset prediction accuracy within +/- 15 minutes and timekeeping accuracy within 5 minutes per year.

b. Store astronomical time parameters (used to develop longitude, latitude, time zone) for at least 7 days if power is interrupted.

c. Have an automatic daylight savings time adjustment.

d. They must interface to the University lighting control network to permit remote interrogation and adjustment of the time program.

5.9.3 OCCUPANCY SENSORS

Independent occupancy sensors powered by the lighting circuit must be provided for each area enclosed by ceiling height partitions. Occupancy sensors must be provided in general work spaces, circulation spaces and teaching and learning spaces and amenities areas. They must not be used in dry and wet laboratories and workshops where there are significant safety hazards.

Follow the manufacturer’s spacing instructions to achieve total space coverage by the occupancy sensor. Because manufacturer's offer a range of occupancy sensors, ensure the correct high quality occupancy sensor model is used appropriate to a particular use or space. The density of occupancy sensors in a space must not be less than:

a. 1 sensor every 16m², or a 4.5m x 4.5m grid, for spaces with a floor to ceiling height of up to 2.4m

b. 1 sensor every 25m², or a 6m x 6m grid, for spaces with a floor to ceiling height of greater than 2.4m

Occupancy sensors must offer 360° sensing for ceiling mounted applications and 180° sensing for wall mounted applications. They must have a minimum detection range of 4m diameter for floor to ceiling heights of up to 2.4m, 6m diameter for floor-to-ceiling heights between 2.4m and 3m diameter, and at least 4m for other applications. Manual “on” and Automatic “off” must be the standard settings for occupancy sensors and they must be adjustable to switch off controlled lighting up to at least 30 minutes after space is unoccupied. Workspace areas must not have dead band zones which are not detected by occupancy sensors. The occupancy sensors must be sensitive enough to detect a single individual in a workspace typing in front of a computer. Occupancy sensors in a room must not be activated by occupants outside the room. Sensors must be designed to operate in temperatures from 0-35°C and relative humidity of 0-90%, non-condensing. They must have an estimated design life cycle of 15 years.
The occupancy sensors must be located where line-of-sight to occupants is not inhibited by building structures e.g. beams, changes in ceiling height or other building elements such as surface mounted air conditioning ducts, cable trays and pipe work etc. Strictly follow the manufacturer’s recommended separation from air diffusers, return air grilles and other building features which can affect proper occupancy sensor performance. Generally, they must also be situated at least 600mm from the edge of ceiling air conditioning grilles to avoid air drafts over the sensor and not be exposed to direct sunlight as these factors could adversely affect sensor performance. Locate corridor sensors at each entry point to the corridor unless it is less than 5m long and can be covered by a single central sensor.

Occupancy sensors must default to “on” in case of sensor failure. Generally, good quality passive infra-red (PIR) sensors with high density of detection zones are preferred because they are sensitive to detecting small movements and do not consume energy to operate. They must be used in at least the following University spaces:

a. Individual offices  
b. Open plan offices  
c. Wet/dry laboratories  
d. Computer rooms/laboratories  
e. Corridors  
f. Lobby areas  
g. Foyers/reception areas/circulation areas  
h. Student accommodation bedrooms  
i. Toilets and bathrooms  
j. Gymnasiums  
k. Kitchens  
l. Lounge rooms  
m. Libraries  
n. Stairwells

Hybrid sensors using PIR/ultrasonic or PIR/ microphonic sensing may be considered in sensitive areas where use of good quality PIR sensors are causing nuisance false “on” and “off” events. PIR/ultrasonic sensors must not adversely affect hearing aids. To prevent nuisance false “on”, PIR/ultrasonic sensors or PIR/ microphonic must not be used in spaces with moving mechanical equipment or mounted close to areas experiencing airflow. University spaces where hybrid sensors may be considered include:

a. Auditoriums/Lecture theatres  
b. Classrooms/seminar rooms  
c. Computer rooms/laboratories  
d. Meeting rooms  
e. Conference rooms  
f. Areas with very high ceilings  
g. Areas requiring 100% cut-off and/or small motion sensing  
h. Stairwells

5.9.4 USE OF DAYLIGHT SENSORS

Daylight photo sensors and separate switching must be used to control lighting in perimeter areas adjacent to windows and in areas containing skylights. The lighting designer must clearly identify daylit areas on the lighting plans to identify floor areas and luminaires to be controlled by photo sensors.

Daylit areas are floor areas without high light-obstructing vertical partitions:
a. next to perimeter windows that extend on 600mm on either side of the window in a direction parallel to the window and one window head height perpendicular to the window and having a minimum area of at least 25m²
b. extending 70 percent of the floor to ceiling height from the edges of the atrium/skylight opening in the ceiling and having a minimum area of at least 250m²

Luminaires in daylit areas with good levels of daylight illumination must be controlled by occupancy sensors that automatically reduce the general lighting power by at least two-thirds of rated power consumption in response to available daylight, or switch lights off when there is adequate daylight illumination. Daylight photo sensors must be placed close to the source of daylight. If daylight photo sensors reduce lighting in control steps, it must incorporate time-delay circuits to prevent lights turning on and off when daylight levels are fluctuating. The light sensor must have an accurate linear response over the range of illuminance measured to accurately respond to wide range daylight levels. Daylight sensing capability of sensors must be easily disabled if required.

5.9.5 EXTERIOR LIGHTING CONTROL

Lighting for all exterior applications must be controlled by a photo sensor or astronomical time clock capable of automatically turning off the exterior lighting when adequate daylight is available. Lighting must be off during the day. Lighting is controlled during the night so it is either “off” or operating at a reduced level.

5.9.6 STAIRWELL LIGHTING CONTROL

Lighting controls must be used in stairwells to provide minimum illumination on the stair treads while in use as required by AS/NZS 1680 and must provide fail-safe operation, activate the lighting upon occupancy, and keep the lights on for at least 15 minutes after the area becomes unoccupied.

Where 24/7 illumination of stairwells is required, bi-level stairwell lighting must be used to provide partial illumination of 20% when unoccupied, increasing automatically to full illumination when a person enters the stairwell for as long as occupancy is detected in the stairwell area.

In all cases, stairwells exposed to daylight must additionally have daylight lighting sensor controls to switch-off lights when sufficient ambient daylight to provides minimum required illumination on the stair treads as required by AS/NZS 1680.

5.9.7 BUILDING CAR PARKING AREA LIGHTING CONTROL

Movement sensors and exposed perimeter daylight sensors must be used in car parks. Lighting control in internal car parking areas must enable dimming of luminaires down 20 per cent when there is no movement detected after 20 minutes with automatic shut off after designated hours. Automatic daylight switching control must be provided for perimeter lights. Lights must be zoned to switch on to full illumination only in areas where movement is detected.

5.10 LIGHTING CONTROL NETWORKING SYSTEMS

Lighting control network systems must be provided for new buildings and refurbishment of areas more than 250m² to control lighting system switches, occupancy sensors and photo sensors. They must be must include gateways and interfaces to integrate with the Building Management Control System (BMCS) including, but not limited to, BACnet, Modbus, DSI, Digital Addressable Lighting Interface (DALI), and TCP/IP. Systems must enable controllers from multiple vendors.

Lighting control network systems must allow high-speed control and monitoring of installed lighting systems via the TCP/IP allowing multiple systems to be controlled over the University’s local or wide
area network. They must have remote access from multiple computers via an intuitive, easily operable
general user interface.

Systems must be capable of interfacing with C-bus and Dynalite systems, which have been installed at
a number of locations across the University. C-bus installation must comply with minimum
requirements in Attachment 5.

Lighting control network systems must be scalable from single rooms to entire buildings, precincts and
campuses and be able to be linked together on the University’s Ethernet.

The lighting control network system must be installed, designed, documented, programmed and
commissioned by product certified installers.

5.10.1 LIGHTING CONTROL NETWORK CONFIGURATION

The lighting control network system must easily satisfy the following configuration:

a. Networks, part names, area addresses and group addresses must be given descriptive logical
   names.
b. Every building level must have its own network.
c. Networks must be named after the building number and level e.g. A14 Level 1.
d. Area addresses within a level must relate to the compass bearings e.g. Level 1 West.
e. Group addresses must relate to the room numbers e.g. Room 141-147.
f. All addresses must be based on the building name and number, the levels and the room
   numbers of the location.
g. There must be a single system clock for synchronising data.
h. Allow easy configuration and reconfiguration to accommodate changing circumstances.

5.10.2 LIGHTING CONTROL NETWORK HARDWARE INSTALLATION

Lighting control network system hardware installation must:

a. be the latest model range and version
b. be DIN rail mounted in a powder-coated metal lockable enclosure keyed to Sydney
   University’s maintenance BiLock Electrical Master key system.
c. use a modular to facilitate maintenance by allowing relays to be replaced individually and
   without having to replace any other components.
d. be mechanically held, latching relays with a manual override switch, a quick connect plug and
   an appropriate short circuit current rating and not accept electrically held relays.
e. be located in the same cupboard as the switchboard, or at a high accessible level on a wall
f. not be located within 240V switchboards

g. provide a minimum 25% spare network capacity and channels for future expansion
h. provide DSI or DALI dimming interface modules
i. be connected to the University LAN using suitable communication gateways
j. allow all controlled switches and lighting system devices to operate independently in case of
   computer or software problems
k. reset to the standard operating state after a power interruption without manual intervention to
   resume normal activity
l. be provided with safe isolation between the mains electricity supply and the control system
   circuitry
m. have communications cables with mains-rated sheathing
n. have over current protection.
5.10.3 LIGHTING CONTROL NETWORK SOFTWARE INSTALLATION

Lighting control network system software installation must:

a. Provide graphical display of lighting system energy consumption.
b. deliver occupancy status information directly to the BMCS.
c. Be able to implement a dynamic load shed.
d. Have time clock-activated preset events.
e. provide the status of all components of the system.
f. implement after hours mode for setpoint change in occupied and unoccupied states.

5.10.4 LIGHTING CONTROL NETWORK DOCUMENTATION

Schematic layout design drawings and manuals of the lighting control network system must be provided to the issuer of this standard for review and approval.

Provide diagrammatic schedules of the lighting control network system in holders adjacent to lighting control boards. Diagrammatic schedules must show:

a. inputs and outputs (I.O.s) in a typed spreadsheet format and CAD floor plan marked with light fittings (or zones of lighting indicating the number and type of luminaires) and showing the output relay/dimmer number controlling each fitting or zone
b. control points complete with item address on each floor plan
c. single line diagrams showing all panels, number and type of switches, dataline, and network timeclock
d. drawings for each panel showing hardware configuration and numbering.
e. panel wiring schedules
f. typical wiring diagrams for each component.

All lighting control network system scheduling data and documentation must become the property of The University of Sydney and provided electronically to the issuer of this standard.

Manufacturer must provide system documentation including:

5.10.5 CONTROL ZONING

Lighting control zones must achieve compliance with BCA Section J energy management, and the University guidelines. Table 5 provides typical requirements.

Table 5: Control Zoning requirements

<table>
<thead>
<tr>
<th>All areas</th>
<th>1 x 16A lighting subcircuit = 14 lights of any type. (this is limited by ballast leakage and RCD protection to avoid nuisance tripping).</th>
</tr>
</thead>
<tbody>
<tr>
<td>All areas</td>
<td>Programmable time control with normal/after hours control modes. This applies to every area in addition to the specific modes below.</td>
</tr>
<tr>
<td>All areas auto “off” mode warning</td>
<td>Either dim the lights to 50% for 1 – 2 minutes, or provide a 1 second off warning blip 2 minutes before final turn off.</td>
</tr>
<tr>
<td>Audio Visual meeting rooms</td>
<td>Motion detection “on” / programmable timer “off”. Multi channel dimming including front, perimeter, centre zones minimum.</td>
</tr>
</tbody>
</table>
Building car parks

- Motion detection to 100%. Automatic daylight switching control for daylit perimeter lights. 24 hour dimming capability to 20% when there is no movement detected. Automatic shut off after designated hours.
- Lights must be zoned to switch on to full illumination only in areas where movement is detected.

Fire stairs

- 24 hour dimmed to 50% for fluorescent lights and 20% for others, motion detection to 100% with programmable time to re-dim.

Interior spaces with work stations, office and enclosed rooms

- Motion detectors and a local manual switch.
- Motion detection “on” / programmable timer “off”.

Perimeter areas or rooms with more than 50% height exterior facing windows or located on an atrium/light well

- Daylight dimming control for daylit spaces adjacent to perimeter or atrium-facing windows.
- Motion detection “on” / programmable timer “off”.

Laboratories

- All lights come on or off by manual switch. Provide 50% lights on motion detector timed off control, and remaining 50% on manual off switch only.

5.11 ENERGY MODELLING

Energy modelling must be performed for new buildings over 2000m². The model must meet energy modelling requirements of the Green Star Education Energy Modelling guidelines or the ABCB Handbook ‘BCA Section J – Assessment and Verification of an Alternative Solution.’. Contractors must provide a report forecasting the annual energy consumption for each space type in a building and the aggregated total annual energy consumption for the building. Energy models must be prepared for during the detailed design stage and at practical completion. The report must conform to the **CIS Energy Performance Modelling Requirements template (CIS-ENG-F002)** form. All energy model data files must be submitted to the CIS Engineering and Sustainability Team in unlocked format for detailed review and assessment of all inputs and outputs at the detailed design stage and at practical completion.

6 COMMISSIONING

Commissioning must be performed according to the CIS-Commissioning Standard.

An independent commissioning agent not involved with the design or construction of the project must test, verify and certify that the lighting controls meet or exceed the required performance criteria of this standard.

Lighting system commissioning must involve the following:
a. All lighting control equipment must be integrated and commissioned to ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer’s installation instructions.

b. For occupant sensors, time switches, programmable schedule controls, or photo sensors are installed, at a minimum, the following must be confirmed:
   I. Placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance.
   II. Time switches and programmable schedule controls are properly programmed.
   III. Photo sensor controls reduce electric light levels.

c. Control system supplier must conduct and certify the functional testing.

d. Control system supplier must provide 24/7 local technical phone support.

e. Lighting level verification measurements must be performed for new lighting installations after a minimum 100 hours operation using a calibrated light meter.

f. Exterior lighting measurements must be carried out at the base of each luminaire, and a minimum of 4 intermediate points between luminaires, including a 2 dimensional grid at the same spacing for large areas.

Where daylight photo sensor control is implemented, measurements must be taken at midday and night time. Measurements must be recorded on CAD plans and included in project manuals. Measure lighting levels in the centre of each work desk/place. Typical representative measurements are acceptable for large homogenous uniform spaces.

7 DOCUMENTATION & RECORDS

The following documents for the design and construction of lighting systems must be provided:

a. Return Brief defining the lighting systems proposed and any deviations from this specification
b. Computer design lighting calculations for all types of spaces e.g. W/m²

c. Point-to-point photometric layout for each typical space showing average, maximum and minimum illumination values in the horizontal work plane

d. Reflected ceiling plans

e. Lighting control basis of design
f. Isolux diagrams for all exterior floodlighting or landscaping area lighting calculations

g. Lighting energy consumption summaries for each area type and/or the whole building demonstrating BCA Section J compliance

h. Statement of design compliance with BCA Section J energy requirements
i. Luminaire specification sheet or legend drawing detailing:
   I. Luminaire and lamp type
   II. Luminaire manufacturer and product number
   III. Mounting configuration
   IV. Ballast type
   V. Luminaire body colour where applicable
   VI. Details of product accessories
   VII. Current luminaire budget costs
   VIII. Luminaire photometric data

8 OPERATIONS

Facilities Maintenance must establish, document and implement procedures for lighting system operation and maintenance to ensure lighting is fit-for-purpose, complies with requirements of this standard and lighting controls in all buildings and spaces are adjusted to optimise energy efficiency and reduce energy costs. Facilities maintenance must shutdown or operate lighting systems in
buildings and spaces or operate them at reduced capacity during University holiday shutdown periods or to support special events.

9 AUTHORISATION OF VARIATIONS

Project managers, consultants, contractors, commissioning agents and facilities maintenance personnel must ensure compliance with these requirements is achieved.

Variations to this standard must only be considered where:

a. the University Standard's requirement cannot physically or technically be achieved.
b. the alternative solution delivers demonstrated and proven superior performance for the same capital and life cycle cost or better.

Consultants and contractors must identify and justify requirements of the standard that do not apply to the project or which need to be varied and these which must be approved by the issuer of this standard. Formal requests for all variations to this Standard must be submitted using the CIS Request Dispensation from Standard Form (CIS-ENG-F001). The issuer of this standard or their delegated authority must review and consider requirements of stakeholders from clients, projects and facilities management before deciding whether to approve variations. Their formal sign-off is required for acceptance of any non-compliances and departures from this standard's requirements.

Where alternative luminaires are proposed by contractors, all information and detailed calculations must be submitted for review in accordance with this specification. The contractor must pay any costs associated with design verification for the alternative proposal.

Custom built or modified standard luminaires must only be permitted under exceptional circumstances and with rigorous technical evaluation and physical testing.

10 QUALITY CONTROL

10.1 DESIGN STANDARD COMPLIANCE

Compliance with requirements of this standard must be checked throughout the design, construction and commissioning phases of projects by:

a. The CIS project consultant
b. The issuer of this standard or their delegate

Competent CIS representatives must check compliance with this standard during design reviews and formal site inspections. Any non-compliances with requirements of this standard must be documented in the Non-conformance Report Form, CIS-SYS-F001 and provided to the CIS Project Manager for issue to contractors and their consultants. Project Managers must maintain a register of non-conformances and manage close out of outstanding non-conformances. Contractors and their consultants issued with non conformances must take appropriate corrective or preventive actions. Proposed corrective or preventive actions and close out of non-conformances must first be formally approved by issuer of the standard or their delegate.

10.2 DESIGN STANDARD CERTIFICATION

Contractors and their consultants must certify compliance to the design standard by completing and submitting the CIS Project Design Certification Form, CIS-PROJ-F001 to the CIS Project Manager at each of the following project phases:
a. Design and Documentation
b. Tender
c. Construction

Notwithstanding CIS’ internal quality control processes, contractors and their consultants must implement their own robust quality assurance and control procedures to ensure compliance with requirements of this standard.

11 REFERENCES

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>AS 2676</td>
<td>Installation and maintenance of batteries in buildings</td>
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<td>AS 3011</td>
<td>Electrical installations - Secondary batteries installed in buildings</td>
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<tr>
<td>AS 3439.1</td>
<td>Low Voltage Switchgear and Control Gear Assemblies</td>
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<td>AS 60529-2004</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
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<tr>
<td>AS/ACIF S008</td>
<td>Requirements for customer cabling products</td>
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<tr>
<td>AS/ACIF S009</td>
<td>Installation requirements for customer cabling (wiring rules)</td>
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<tr>
<td>AS/NZS 1158</td>
<td>Lighting for roads and public spaces</td>
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<tr>
<td>AS/NZS 1680</td>
<td>Interior Lighting</td>
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<tr>
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<td>Lighting protection</td>
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<tr>
<td>AS/NZS 2053</td>
<td>Conduits and fittings for electrical installations</td>
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<tr>
<td>AS/NZS 2293</td>
<td>Emergency escape lighting and exit signs for buildings</td>
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<td>AS/NZS 3000</td>
<td>Electrical installations (also known as the Australian/New Zealand Wiring Rules)</td>
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<td>Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions</td>
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<td>AS/NZS 3009</td>
<td>Electric installations - Emergency power supplies in hospitals</td>
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<td>Electrical installations – Classification of the fire and mechanical performance of wiring systems</td>
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<td>AS/NZS 3017:2007</td>
<td>Electrical installations—Verification guidelines</td>
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<td>AS/NZS 3019:2007</td>
<td>Electrical installations—Periodic verification</td>
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<td>AS/NZS 3080</td>
<td>Telecommunications installations - Generic cabling for commercial premises</td>
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<td>AS/NZS 3084</td>
<td>Telecommunications installations - Telecommunications pathways and spaces for commercial buildings</td>
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<td>AS/NZS 3100</td>
<td>Approval and test specification – General requirements for electrical equipment</td>
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<td>AS/NZS 3947.3</td>
<td>Low-voltage switchgear and controlgear - Switches, disconnectors, switch-disconnectors and fuse-combination units</td>
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<td>AS/NZS 5000</td>
<td>Electric cables – Polymeric insulated</td>
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<tr>
<td>ASC 168</td>
<td>Fluorescent lamp ballasts</td>
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<tr>
<td>BCA</td>
<td>Building Code of Australia Building Code of Australia, specifically Section J energy efficiency</td>
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<tr>
<td>BS 5042</td>
<td>Specification for lampholders and starter holders.</td>
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<td>EIA/TIA 569</td>
<td>Commercial building standard for telecommunications pathways and spaces</td>
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<tr>
<td>EN 55015:2006</td>
<td>Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment</td>
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<td>EN 55022</td>
<td>Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement</td>
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<td>EN 60929</td>
<td>AC-supplied Electronic Ballasts For Tubular Fluorescent Lamps - Performance Requirements</td>
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<tr>
<td>EN 61347</td>
<td>Lamp control gear</td>
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<td>IEC 60038</td>
<td>Standard Voltages</td>
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### Standard

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<tr>
<td>IEC 60044.1</td>
<td>Instrument transformers - Part 1: Current transformers</td>
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<td>IEC 60051</td>
<td>Direct acting indicating analogue electrical measuring instruments and their accessories</td>
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<td>IEC 60529</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
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<td>IEC 61000</td>
<td>Electromagnetic compatibility (EMC)</td>
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<tr>
<td>IEC 61547</td>
<td>Equipment for general lighting purposes - EMC immunity requirements</td>
</tr>
<tr>
<td>IEC 62052</td>
<td>Electricity metering equipment (AC) - General requirements, tests and test conditions</td>
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</table>

| SIR | Supply Authority Service Installation Rules |
| -- | Workcover requirements |
| -- | All Health Authority Requirements |
| -- | State Fire Brigade requirements |
| -- | All Local Council regulations |
| -- | Electricity Safety (Installations) Regulation |

### 12 NOTES

N/A

### 13 DOCUMENT AMENDMENT HISTORY

<table>
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<tr>
<th>Revision</th>
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### 14 ATTACHMENTS

- **Attachment 1**: Lighting Whole-of-Life Costing Form
- **Attachment 2**: Deemed to comply lighting design software packages
- **Attachment 3**: Deemed-to-comply lamps
- **Attachment 4**: Unacceptable lamps
- **Attachment 5**: Minimum C-bus network installation requirements
# Attachment 1 Lighting Whole of Life Costing Form CIS-ENG-002

Lighting designers must be provided this spreadsheet form to document whole-of-life luminaire costs.

<table>
<thead>
<tr>
<th>Lighting Upgrade Project Evaluation Form</th>
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<tbody>
<tr>
<td><strong>Building/Space:</strong> GS12 Office Groundfloor South</td>
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<tr>
<td><strong>Power Draw (W)</strong></td>
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<tr>
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<tr>
<td>No. fittings</td>
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<tr>
<td>lamps per fitting</td>
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<tr>
<td>Total No. of lamps</td>
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<tr>
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<tr>
<td>Ballast power draw (W)</td>
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<tr>
<td>Total power draw (W)</td>
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<tr>
<td><strong>Annual Power Consumption (kWh)</strong></td>
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<tr>
<td>Space operating hours per weekday</td>
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<td>Space operating hours per weekend</td>
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<tr>
<td>Operating hours per year</td>
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<tr>
<td>Annual energy consumption (kWh)</td>
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<td><strong>Annual Light Energy Costs</strong></td>
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<td>Average electricity tariff (c/kWh)</td>
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<td>Total annual energy cost ($)</td>
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<tr>
<td><strong>Maintenance Costs</strong></td>
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<tr>
<td>Maintenance time per lamp (mins)</td>
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<tr>
<td>Maintenance labour rate ($/hr)</td>
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<td>Lamp cost ($/lamp)</td>
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<td><strong>Net Capital Cost</strong></td>
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<td>Equivalent No. of cars off the road</td>
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</table>
Attachment 2  Deemed to comply lighting design software packages

1. AGI
2. Dialux
Attachment 3 Deemed-to-comply lamps

Generally acceptable lamp types include:

- Well-constructed durable LED fittings with high-quality heat dissipation
- LED fittings with bi-level illumination
- T5 linear fluorescent 14W and 28W
- T5 linear fluorescent new 25W reduced energy (only with constant current ballasts)
- T8 linear fluorescent 18W and 36W with electronic ballast
- Compact Fluorescent PLC13W to 26W only, with preference for comparable LED types alternatives
- High quality LED MR16 direct replacement lamps from Philips Masterline or Osram Parathom Pro ranges
- LED Strip lighting for decorative concealed lighting
- Conventional tubular or elliptical metal halide coated and uncoated 150W – 400W

Acceptable LED luminaires:

LED Luminaires or lamps which are acceptable are:

- TARGETTI downlights and decorative luminaires
- PHILIPS Luxspace
- ZUMTOBEL Credo 9.5W or 14W for public /amenity / corridor areas (note these is not suitable for office or work spaces due to glare)
- Philips Master LED (9Watt) and Osram LED Parathom Pro(7W) LED MR16 direct replacement lamps
- Illumanite bi-level LEDs
- Maxlight LEDs
- Enlighten Chamaeleon LED emergency stair way lighting model SN450MFL-122-E

Acceptable Fluorescent Troffer luminaires:

- Davis lighting
- Harcroft lighting
- Pierlit
Attachment 4  Unacceptable lamps

The following lamps are not acceptable:

- High output T5 linear fluorescent lamps
- LED linear retrofit into existing fluorescent fittings.
- Compact HID discharge lamps of all types 20W -100W
- Circular fluorescent lamps
- T5 retrofit adapters.
Attachment 5      Minimum C-bus network installation requirements

1    OVERVIEW

The system must be installed by a contractor under the direction of a Platinum Partner who is responsible for the overall system implementation and project management. The Platinum Partner must provide shop drawings, functional/addressing details, device programming, on site commissioning/verification, as-built documentation and defects liability maintenance. Where high-level integration is required, the contractor must consult with the relevant third party companies prior to commencement of installation, to review the methodology/protocols and document the responsibility of each party to ensure the solution operates seamlessly.

2    DOCUMENTATION

Prior to project sign-off the Contractor must compile an operation and maintenance manual and deliver it to the project manager. The Operation and Maintenance Manual must include the following information:

   a. System architecture diagram
   b. Switchboard layout drawings
   c. C-Bus tags and programmed functions
   d. Channel connection identification
   e. Floor plans showing C-Bus device and load
   f. Recommended scheduled maintenance procedures
   g. Technical literature for each type of C-Bus device used in the project
   h. C-Bus configuration files on CD-ROM including C-Bus Toolkit, PICED, Schedule Plus as applicable.
   i. Documentation for integration with the University's existing Building Control Management Systems (BCMS).

All drawings and diagrams must be provided as hard (printed) copies and software files (in PDF and either DWG or DXF format). Drawings must be updated to an "as installed" state for placement in the Operation and Maintenance Manual.

3    NETWORK TOPOLOGY

The C-Bus Backbone is to utilise a dedicated Ethernet Network Topology (refer to line diagram on the next page). This backbone must be designed and installed ensuring:

   a. Ethernet cabling must be blue Cat-5 unshielded twisted pair (UTP) and must be segregated from mains cabling in accordance with AS3000.
   b. C-Bus networks shall be designed and installed to individual levels of each building to eliminate the possibility of service work on one C-Bus network affecting another. Each level shall be networked back to the central PC station for the updating of schedules
   c. Cable must be continuous, joined only by RJ45 connectors. The RJ45 terminations must be completed in align with TS568A data standard.
   d. An Ethernet cable must be installed from a single C-Bus enclosure per floor. Where multiple C-Bus enclosures are installed on a level, the most easily accessible id to be utilised.
e. The C-Bus enclosure must include a C-Bus Network Interface (5500CN) and a dedicated power outlet to accommodate a 12V plug pack. This power outlet is to originate from the C-Bus control circuit.

f. The Ethernet Switch must be installed in a suitably sized wall mounted lockable data rack enclosure. The location of the enclosure must be in central electrical or communications cupboard adjacent to an existing C-Bus enclosure.

g. A power outlet must be installed originating from a dedicated circuit.

h. The Ethernet switch must have at least 25% spare capacity for future expansion.

i. The project must provide a dual data outlet for C-Bus connection to the university network.

The purpose of this network topology is:

a. The Ethernet network allows for high data traffic and can accommodate the large amounts of data travelling to and from remote C-Bus networks.

b. The Ethernet network allows for fast connectivity and interrogation of C-Bus remote networks from the head end software (Schedule Plus and Toolkit).

c. The isolation of C-Bus networks to individual levels eliminates the possibility of a C-Bus network fault at one level affecting other levels.

d. The isolation of C-Bus networks to individual levels must eliminate the possibility of service work on one C-Bus network affecting another. This service work may include shutting down switch boards, replacing faulty C-Bus equipment etc.

e. The isolation of C-Bus networks to individual levels must eliminate the possibility of changes and additions to a C-Bus system on one level affecting other levels.

f. The allocation of a single C-Bus network per level provides maximum scalability for any future expansions of the system.
A dedicated Lighting Control PC with necessary accessories must be installed in each building to provide central monitoring and control of the C-Bus control system. Where a dedicated PC is already installed it must be upgraded to meet the following minimum requirements:

- Intel I5 3GHz
- 2 Gb RAM
- 19" LCD monitor
- Minimum Windows or 7 Professional Operating System
- Mouse and keyboard
- Toolkit 1.10.6
- Schedule Plus 4.10.0 with USB Network licence with 25% spare network capacity
- Copy of all information requested in the Documentation section of this document

### 4.1 Schedule Plus Software

The head end software must be the latest version of Schedule Plus available and utilise a USB Network licence with at least 25% spare capacity. The Schedule Plus software must be setup to provide the following minimum functions:

- Setup and store all time based schedules in Schedule Plus
- Provide simple and clear method of monitoring and adjusting of time schedules from main graphics screen.
- Provide the ability to manually enable / disable time schedules from main graphics screen.
- Provide the ability to manually override areas controlled by time schedules.
- Provide the ability to manually control and monitor all C-Bus controlled loads via buttons or graphical floor plans. The layout and descriptions of these components are to be logical and utilise per University naming conventions.

### 5 LOGIC AND SCENE PROCESSING

Each C-Bus network includes a local logic controller. This controller must be the C-Bus Pascal Automation Controller (PAC) as a minimum. The function and purpose of these controllers is to:

- Provide all local conditional logic processing for the respective network. This must increase system reliability by removing critical reliance on backbone topology and central head end PC for essential tasks.
- Store and process all presets that apply to the local network. These presets are to be limited to the ones that exceed the processing capabilities of C-Bus Key Input Units (KIU). Presets are to be stored in the respective KIU whenever possible.
- Where a Touch Screen is installed it must provide the ability to override all C-Bus controlled devices on that network that are not controlled by any other local C-Bus device (e.g. KIU, PIR etc). All Touch Screen graphic components are to be clearly labelled for easy navigation by the end user.
- The location and basic function of each logic controller (i.e. PACs and touch screens) must be noted in the Clipsal Toolkit software. Comprehensive manuals must be provided to detail the function of the logic controller and where applicable assist the end user to operate all relevant menus on touch screens.

### 6 INTERFACING TO BMS
In buildings where interfacing to the BCMS is implemented (via BACnet), this interface must be upgraded to:

- Make all necessary wiring changes to ensure physical connectivity between C-Bus and BCMS.
- Ensure BACnet gateways are setup with suitable IP settings and are operating correctly.
- Test and confirm connectivity between C-Bus and BCMS at each BACnet gateway location. This must be completed with the BCMS services contractor.
- Work with mechanical services contractor to determine lighting zones across all levels and ensure BCMS graphics represent C-bus layout.
- Ensure time scheduling of C-Bus is provided through the BCMS.

### 7 SITE TESTING

A test plan must be produced by the Platinum Partner prior to commencement of installation. Once the installation and programming of the C-Bus network is complete, the Platinum Partner must carry out site testing in accordance with the test plan. As each test is performed with a passing result this must be recorded on the test plan. As a minimum, the following tests must be included in the test plan and performed prior to sign-off:

#### 7.1 C-Bus to Earth short test

Use a multimeter to measure the absolute voltage from Earth to C-Bus negative, and Earth to C-Bus positive. The voltages must be in opposite polarity. The highest of these absolute voltages must be no more than 120% of the lowest. For example, the values +17 V and -19 V are acceptable as 19 is less than 112% of 17. However, the values +16 V and -20 V are unacceptable as 20 is 125% of 16.

#### 7.2 Minimum C-Bus Voltage

Use a multimeter to test the voltage from C-Bus negative to C-Bus positive. Test the voltage at various points on the network, particularly at points where C-Bus units are located at the greatest distance from a C-Bus power supply. The voltage must be $\geq 22$ V at all test points.

#### 7.3 System Functionality Test

Verify that all C-Bus inputs and outputs function correctly by carrying out the following minimum checks:

- Confirm that every output channel controls the correct load.
- Confirm that every input unit controls the correct outputs.
- Test all power failure recovery settings.
- Test all movement sensor time out operations.
- Test and calibrate any light level sensors.
- Test all Ethernet backbone connectivity and devices.
- Test all BMS interfacing with mechanical services contractor.

#### 7.4 Power line AC Signal Test

Use a digital multimeter or CRO to verify that no AC signal exceeding 1.0 V p-p is present across C-Bus positive and negative. Check this at the extremities of each C-Bus run.