CURTIN UNIVERSITY

PROJECT DELIVERY GUIDELINES

ELECTRICAL SERVICES GUIDELINES

000312

Curtin University

Definitions of terms and abbreviations found in this guideline can be found in Section 14 – Definitions on Page 113.

Details of revisions			
Level	Details	Date	Initial
1	*Creation of original document by consolidation of previous series*	*Jul-2016*	*RPS*
1	*Minor corrections to finalise document for publication*	*Oct-16*	*RPS*
2	*Minor corrections to simplify appendices*	*Jan-17*	*RPS*
3	*Integration of this document with 000346 PDG Services Metering Guidelines*	*Oct-18*	*RPS*
3	*Inclusion of wording to allow departures from the existing guideline*	*Nov-19*	*RPS*
4	*Major restructure and update*	*Jan-20*	*GL*
4	*Addition of new section 1.2.4 – Consultant and Contractor Requirements*	*Feb-20*	*GL*
4	*Further updates*	*July-20*	*GL*
4	*Insertion of Documentation Deliverables Guidelines as a reference*	*Aug-20*	*RPS*

CONTENTS

1 INTRODUCTION

The purpose of this Project Delivery Guideline is to summarise electrical design and installation practices at Curtin University. It covers both high voltage and low voltage installations.

The guidelines recognise discrete design stages and details, scopes of services and deliverables for each stage. Full or partial service may be requested by Curtin.

Specific electrical design requirements are also contained in a number of sections addressing particular systems or sub-systems.

The guidelines outline the responsibilities, scope of services and deliverables required of Electrical Consultants and Contractors when engaged to carry out work for Curtin University.

Electrical Consultants and Contractors shall be capable of providing services for the following project stages, as detailed in Section 2 of this document:

- schematic design
- documentation
- tendering
- construction
- post-construction.

The Consultant shall prepare a compliant design in accordance with the University requirements as well as all applicable regulations, codes and standards.

The Consultant shall submit and obtain required consents or approvals (including high voltage applications to the Supply Authority, if applicable) for the project.

If appointed as Lead Consultant, coordination and liaison with other consultants and authorities shall be required.

The Consultant shall provide any documents or advice or information as requested by Curtin University to allow periodic review of the project.

The Project Delivery Guidelines have been prepared in consultation with Curtin University subject matter experts and stakeholders. It is recognised that the subject matter of Guidelines will not always be suitable for all project elements and departures from the Guidelines may be required or desirable. Departures from Guidelines must be agreed upon in consultation with the relevant University Guideline subject matter expert. Departures must be recorded in a project register and recorded and reviewed in the Project Control Group meeting minutes under its own meeting agenda item "Project Delivery Guideline Departures". Where the University subject matter expert identifies that a departure adds ongoing value to the University, the subject matter expert will update the relevant Guideline.

1.1 THE UNIVERSITY AS A LONG TIME OWNER

The University has a vital interest in the quality of its built environment. A quantitative measure is life-cycle costing and this should be minimised as far as possible. The qualitative terms 'buildability' and 'maintainability' are equally relevant.

The as-constructed project must conform to established University building standards and represent the best possible value for money consistent with planning and financial restraints. It must also be easy to maintain, energy efficient, easy to clean and environmentally and aesthetically acceptable, both internally and externally. It must be buildable and in the final form must be flexible enough to allow ready and inexpensive alterations. Environmentally responsible processes and technologies must be employed throughout the project, including the recycling and re-use of materials, sustainable/environmentally sound sourcing and the safe disposal of dangerous materials unavoidably used in project processes.

1.2 CURTIN REQUIREMENTS

1.2.1 DISABILITY ACCESS AND INCLUSION PLAN

Curtin University believes in creating equitable and inclusive access for people with a disability to its facilities, services, events and academic programs on all its Western Australian campuses.

The *Universal Design Guideline* has been developed to reflect a commitment to equity and inclusion for all by embedding Universal Design principles into project planning, design and delivery guidelines. Consultant architects, designers and engineers should make themselves familiar with the particular requirements of the *Universal Design Guideline* before responding to a project brief.

1.2.2 HEALTH AND SAFETY

Curtin University is committed to providing and maintaining high standards of health and safety in the workplace and will:

- ensure compliance with relevant legislation and the University's Health and Safety Management System
- promote an organisational culture that adopts health and safety as an integral component of its management philosophy
- ensure that health and safety is part of the business planning processes and that it is adequately resourced by all areas
- maintain an effective mechanism for consultation and communication of health and safety matters
- maintain an effective process for resolving health and safety issues and managing health and safety risks
- provide appropriate health and safety training
- regularly review health and safety performance to monitor the effectiveness of health and safety actions and ensure health and safety targets and objectives are met.

A copy of our Health and Safety Management Standards can be found at: https://healthandsafety.curtin.edu.au/local/docs/HSManagementStandards.pdf

1.2.3 SUSTAINABILITY AT CURTIN

It is Curtin University policy that all new or refurbishment projects on site should support its status as Australia's first university to achieve a 5-star Green Star — Communities rating from the Green Building Council of Australia (GBCA). Designers should understand and incorporate the Green Star criteria into designs and specifications in order to maintain and enhance Curtin's Green Star status. Information on the criteria can be found in the *PDG Green Star – Communities Design Guidelines.*

1.2.4 CONSULTANT AND CONTRACTOR REQUIREMENTS

All contractors and consultants must demonstrate the following:

- evidence of participation in training programs, including safety training, to ensure knowledge and skills are kept up to date with industry changes and related standards
- experience working on projects with complex infrastructure in campus-style environments, including client-controlled systems and services.

CONTRACTORS

Electrical contractors must demonstrate the following:

- evidence of a current Electrical Contractor's Licence
- evidence of a current Electrician's Licence for key personnel
- experience with system and integrated system commissioning
- proprietary/vendor systems endorsements including vendor warranty.

CONSULTANTS

Electrical consultants must demonstrate the following:

- HV/LV experience
- electrical or electrical engineering qualifications and affiliations
- A minimum of 5 years' experience delivering services in a similar context
- experience in delivering specific types of infrastructure integrated systems (e.g. Schneider).

1.3 SAFETY

1.3.1 GENERAL

Curtin University is committed to providing a safe working environment and safe systems of work for all employees and contractors carrying out electrical works.

Developers, designers, consultants and contractors have the same level of obligation within their spheres of influence while undertaking electrical work at Curtin.

1.3.2 SAFETY IN DESIGN

Legislation has been introduced to ensure that designers follow systematic methods and document their decisions relating to safety in design. Typical design issues for electrical work include:

- adequate lighting provision
- appropriate earthing systems
- hazardous areas defined
- coordination with standard operating procedures (SOPs), which include laboratory management and engineered solutions requiring operational and maintenance consideration
- adequate space for safe operation and maintenance around equipment
- electrical equipment appropriate to the area classification
- transits and bulkhead penetrations with the appropriate fire rating treatment.

While designing with safety as the priority, designers should also look to manage the business risk arising from failures or shutdowns and avoid such outcomes wherever possible.

1.4 CONSULTANCY

The Electrical Consultant shall be able to provide consultancy services for the various project stages including schematic design, documentation, tendering, construction and post-construction activities.

A summary of the services and deliverables to be delivered during the course of a project is as follows:

- design works associated with the total delivery package
- all specifications and drawings included as a tender package
- provision of submissions and consents
- preparation of tender documentation, management of the tender process and preparation of a tender evaluation report
- project surveillance during the course of construction from kick-off meeting to final commissioning and handover
- management of defective work and oversight of its rectification during the course of the works
- responsibility for the as-constructed component of the project, ensuring that:
  - all as-constructed drawings are provided in accordance with the Curtin University *Documentation Deliverables Guidelines*
  - Curtin University has received all operations and maintenance manuals specified
  - all in-ground infrastructure is surveyed at the time of installation, including the coordination of information into the Curtin SIS system.

The Consultant shall provide a full service unless advised by Curtin University that a nominated partial service is required.

2 DESIGN

2.1 STANDARDS

Reference to Australian standards is made in each consultancy brief and within standard specifications.

GENERAL ELECTRICAL STANDARDS

AS1100:	Technical drawing
AS1882:	Earth and Bonding Clamps
AS1931:	High-voltage test techniques
AS1939:	Classification of degrees of protection provided by enclosures for electrical equipment.
AS2293:	Emergency escape lighting and exit signs
AS2374:	Power transformers
AS/NZS3000:	Wiring Rules
AS3008:	Selection of cables
AS3010:	Electrical Installations: Generating Sets
AS/NZS3017:	Electrical installations - Verification guidelines
AS/NZS3439:	Low-voltage switchgear and controlgear assemblies
	Lighting Standards:
AS/NZS1158:	Public Lighting Code (All parts)
AS1428:	Design for Access and Mobility
AS1680:	Interior Lighting (All parts)
AS1798:	Lighting Poles and Bracket Arms
AS2293	Emergency Evacuation Lighting in Buildings.
AS2560:	Sports Lighting (All parts)
AS2946:	Suspended ceilings, recessed luminaires and air diffusers. Interface requirements for physical compatibility.
AS4282:	Control of the Obtrusive Effects of Outdoor Lighting
AS/NZS60598:	Luminaires
AS/NZS CISPR 15:	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

OTHERS:

AS1026:	Impregnated paper insulated cable for electrical supply at working voltages up to and including 33kV.

AS1049:	Telecommunication Cables Insulation and Sheath Polyethylene
AS1170.1:	SAA Loading Code Part 1: Dead and live loads and load combinations
AS1170.2:	SAA Loading Code Part 2: Wind loads
AS1554:	Structural Steel Welding
AS1668:	The use of mechanical ventilation and air conditioning in buildings (All parts)
AS1768:	Lightning Protection
AS1940:	SAA Flammable and Combustible Liquids Code.
AS2159:	Piling - Design and installation
AS3600:	Concrete Structures
AS4100:	Steel structures
AS/NZS4600:	Cold-formed steel structures
AS4680:	Hot Dip Galvanising
AS4791:	Hot Dip Galvanising
AS4792:	Hot Dip Galvanising
AS/ACIF S009:	Installation requirements for customer cabling (Wiring Rules)

2.2 SERVICE LIFE

The design life of electrical equipment is to be generally 20 to 30 years, as tabled below. The effective life can be limited by the availability of replacement parts. While the actual functional life of an installation is dependent on the use and load applied to it, the following shall be used as a guide:

Item	Average Life in Years
Main Switchboards	30
Distribution Switchboards	30
Sub-main Cables	30
Sub-circuit Cables	25
Luminaires	25
Emergency Lighting Batteries	5

2.3 MAINTAINABILITY

Electrical designs shall allow for maintainability of the installation.

Typical design issues include:

- access requirements of all in situ inspections
- major equipment assessment with regard to the method of transporting from its installed location to a workshop
- lifting pad eyes provided where required
- requirements for special tools in relation to normal operations, calibrations, overhaul and diagnostics
- special tools to be purchased within the main contract
- means of isolation to allow safe in situ repair or removal
- commonality of components to reduce stockholding of spares
- components easily removable without significantly affecting other components.

2.4 COMPATIBILITY

All new technologies shall be trialled prior to installation to minimise compatibility issues.

2.5 HIGH VOLTAGE INSTALLATION PRACTICES

2.5.1 HIGH VOLTAGE INSTALLATIONS

In general, Curtin follows AS2067:2008 Substations and high-voltage (HV) installations exceeding 1 kV AC practices for high-voltage equipment installations, with the exception that underground cabling is to be installed at a depth of 1.2 metres.

Reference is made to the WA Electrical Requirements manual for installation practices.

All new transformers and switchgear installed on the 11 kV system shall be 22kV-rated (transformers to be dual tapped) in readiness for migration to a Campus-wide 22 kV distribution system.

2.5.2 HIGH VOLTAGE SWITCHGEAR

HV switchboards/RMUs (Ring Main Units) will generally be installed within dedicated indoor substations internal to new buildings, or in some special cases, externally. It is considered more aesthetically pleasing to locate HV switchboards internally and the lifespan is likely to improve due to better environmental conditions.

The adoption of SF_6-free HV switchgear is required as it mitigates any issues with the storage, handling and disposal of the SF_6 gas.

2.5.3 TRANSFORMERS

Transformers shall generally be installed within dedicated indoor substations or, in some special cases, externally. It is considered more aesthetically pleasing to locate transformers internally and the lifespan is likely to improve due to better environmental conditions.

Oil-filled transformers are considered to have a design life of 40 years. The utilisation and installed environment of the oil-filled transformer must also be considered, as both factors can prematurely degrade the transformer's performance.

Dry-type transformers are considered to have a design life of 25 years. The utilisation and installed environment of the dry-type transformer must also be considered, as both factors can prematurely degrade the transformer's performance. Dry-type transformers require more frequent maintenance, due to Ingress Protection (IP) ratings being typically lower than oil-filled transformers to achieve similar performance.

The specification of a transformer with respect to oil-filled or dry-type must be considered in each application. Maintainability and availability of spares is also to be considered. The use of dry-type transformers is preferred in applications where transformers are located inside buildings for reasons relating to managing fire risk. However, there is no mandate that all transformers installed within buildings shall be dry-type. The use of oil-filled transformers is preferred in outdoor applications, for reasons relating to IP ratings, though the mineral oils used must be appropriately handled/contained, as this presents an ongoing environmental risk.

2.5.4 LABELLING

HV cables shall be asset registered based on switchgear switch references, with the lowest alpha numeric reference being first. There is no requirement to add labels to the cables themselves.

HV switchgear shall include labels based on the following:

Z(a) [Zone] – (bbb) [Building] – (c) [Switch Ref] – (d) [Switch Type]

Key:

(a) – There are four zones at Curtin numbered 1, 2, 3 and 4. This reference relates to the zone the switchgear is fed from under normal network conditions, i.e. with all NOPs (normally open points) in place.

(bbb) – Each building has a 3-digit reference, the "B" reference is not included here.

(c) – Switches are referenced left to right physically as the operator approaches the switchgear, i.e. the far left switch shall be 1 with the next being 2 and so on.

(d) – Switch type is a reference to switchgear having a physically separate isolator for earth which would be a "7" line isolators being "0". No such switchgear exists any longer at Curtin and therefore all references are now "0".

Example 1 – Z1-136-1-0:

- fed by Zone 1 under normal operational conditions
- located in building B136
- the switch on the far left
- isolation switch.

Example 2 – Z2-117-2-0:

- fed by Zone 2 under normal operational conditions
- located in building B117

- the switch second from left
- isolation switch.

Option:

Where a building HV switch room (specifically a single room fed by a single zone) has more than one RMU it shall include an additional reference /(e) directly after the building reference. This is a numerical reference and is left to right as it appears when facing the switchgear assemblies (RMUs) in the room, i.e. left-hand switchgear assembly is 1 and the right-hand switchgear assembly is numbered 2.

Example 1 – Z1-500/2-2-0:

- fed by Zone 1 under normal operational conditions
- located in building B500
- switchgear assembly (RMU) on the right
- the switch second from left
- isolation switch.

Example 2 – Z2-155/1-4-0:

- fed by Zone 2 under normal operational conditions
- located in building B155
- switchgear assembly (RMU) on the left
- the switch fourth from left
- isolation switch.

Transformer references shall be T(bbb) with (bbb) being the building number. Where a building has more than one transformer, the reference shall be given an additional number at the end starting at ".1".

Example 1 – T410:

- transformer located in building B410.

Example 1 – T500.2:

- second transformer located in building B500.

2.6 HIGH VOLTAGE CABLING INFRASTRUCTURE

2.6.1 GENERAL

All HV Cabling will be installed in accordance with relevant Australian Standards, industry/utility standards and guidelines. In particular, the Utility Providers Code of Practice for Western Australia must form the basis of the design where HV cables are being installed in a common services trench.

2.6.2 SPECIFICATION

All HV network feeder cables will be rated for 24 kV, irrespective of the system voltage at the particular distribution substation. This allows for flexibility in the HV network and also the ability to upgrade the voltage from 11 kV to 22 kV at a distribution substation, without having to replace/upgrade the existing HV cabling.

All HV network feeder cables will have the following specification.

Cable Rated Voltage	12.7/22 kV (24 kV)
Configuration	1 x 3C
Size	240 mm^2
Material (active conductors)	copper (Cu), stranded
Conductor Screen	Semi-conductive XLPE
Insulation	Cross-Linked Polyethylene (XLPE)
Screen	copper (Cu), stranded Individually screened, course fault protection heavy duty screens
Termite Protection	Nylon
Additional Protection	Double Brass Tape
Armour	Steel Wire
Sheath Material	Option 1 – PVC – V90 Option 2 – HDPE

2.6.3 INSTALLATION

INSTALLED UNDERGROUND

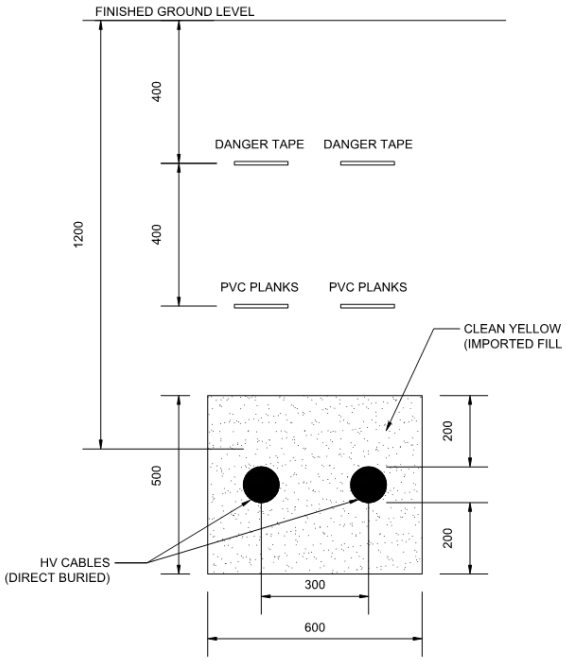
All underground HV network feeder cables will be direct buried where possible and installed within heavy duty PVC conduit/polypipe for road crossings or where future access/removal is necessary.

New or replacement HV cabling will either be directional-drilled (direct buried or in polypipes) or open trenched as per traditional methods on Campus. Directional drilling is less invasive on the environment as compared to open trenched. The method of HV cable installation should be considered to address any specific requirements or limitations that may be applicable. The methodology is to be agreed with the Public Realm portfolio manager where vegetation may be impacted.

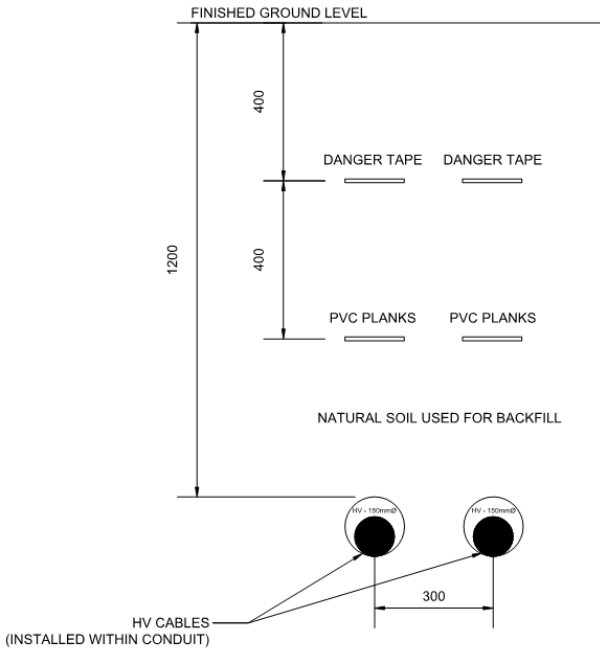
The direct buried HV cable will be installed at 1,200 mm below finished ground level and will have imported clean yellow sand as the bedding material. The use of clean fill other than imported yellow sand will not be acceptable. The direct buried HV cable route will be provided with PVC covers and danger tape as per Australian Standards.

The installation of HV network feeder cables using underground boring techniques is to be agreed with Curtin University, as the final installation conditions will differ

significantly compared to a direct buried cable that is open trenched. The requirement for installing PVC covers and danger tape isn't generally applicable when underground boring techniques are used.



HV Cable Route – Direct Buried



HV Cable Route – Installed within Conduit/Polypipe

2.7 LOW VOLTAGE MAINS CABLING (TRANSFORMER CABLING)

Low voltage (LV) mains cabling is typically installed indoor and impact to the external environment is extremely limited.

2.8 LOW VOLTAGE MAIN SWITCHBOARDS

LV main switchboards are typically installed indoor and impact to the external environment is extremely limited.

2.9 LOW VOLTAGE SUBMAIN CABLING (BUILDING CABLING)

LV submain cabling has very little environmental considerations, other than the impact to natural vegetation as a direct result of excavation during installation/removal.

LV submain cabling that is being proposed to address the load growth under Roadmap Part 2 will be installed within buildings or externally within PVC conduits. Methods of LV submain cable installation should be considered as part of the proposed developments to address any specific requirements or limitations that may be applicable.

2.9.1 LOW VOLTAGE INSTALLATION

In general, low voltage installations follow the requirements of the relevant Australian/New Zealand standards and in particular AS/NZS3000:2007 Electrical Installations (known as the Australian/New Zealand Wiring Rules).

2.9.2 UNDERGROUND CABLE ROUTES

Underground cable installations outside tenancy boundaries are to have their routes accurately recorded prior to backfilling.

Registered surveyors are to be engaged by the contractor to survey installed cables.

2.10 DRAFTING PRACTICE

Attention is drawn to the Curtin University *Documentation Deliverables Guidelines* (latest edition) for drafting requirements.

2.11 TESTING

Testing shall be as specified in the relevant sections of Australian standards and BCA, latest editions.

2.12 RECORD DRAWINGS

Record drawings shall be drafted in accordance with the requirements of the Curtin University *Documentation Deliverables Guidelines*.

2.13 UNDERGROUND SERVICES

A multitude of underground services, such as low and high voltage electrical services, as well as gas and water mains exist on the campus. Information on the services should be requested from the Service Coordination Centre (SCC), tel (08) 9266 2020, before design or modification work is undertaken.

3 POWER SUPPLIES AND METERING

3.1 GENERAL

Power supply to the installation will be three-phase, four-wire, 415/240 V, 50 Hz. All equipment supplied as part of a contract shall be suitable for the actual voltage and frequency available from the Supply Authority.

Early in the design stage, the consultant, in consultation with Curtin, shall:

- evaluate the anticipated Maximum Demand (MD) and energy consumption for the project
- recommend the appropriate load and energy management techniques.

The consultant shall prepare and submit to Curtin a pre-design report addressing the issues nominated above.

3.2 LOAD BALANCING

The loads and circuits shall balance as evenly as possible over the three phases throughout the installation.

3.3 CONTINUITY OF EXISTING ELECTRICAL SERVICES

Existing premises are required to remain fully operational during the course of any contract and all works must be coordinated to minimise the number of shutdowns and shutdown time on services and allowance should be made for after-hours work.

Works affecting the continuity of existing services are to be undertaken at the least inconvenient time to the occupants. The work should be organised to minimise the duration of any interruption. All shutdowns are to be coordinated with the Principal to the Superintendent’s approval.

Temporary services to areas outside of any area being demolished are to be provided where required.

3.4 EARTHING

The earthing system shall be a Multiple Earth Neutral (MEN) system as outlined in, and in accordance with, the requirements of AS3000, the Supply Authority and the Australian Communications Authority (ACA).

Main earth electrode, earth bar shall be provided with an engraved label with red-filled letters inscribed: "MAIN EARTH - DO NOT DISCONNECT". Refer also to the labelling section.

Where required, electrical earth electrodes shall be:

- a minimum 15 mm diameter extensible copper-clad steel 2 m in length per section driven to a maximum depth of 8 m, equal to Furse RB series
- a sufficient number of electrodes to achieve the necessary resistance to earth
- installed within a pit fitted with a lid inscribed in red-filled letters - "MAIN EARTH - DO NOT DISCONNECT"

- driven into the ground by mechanical hammering.

A proprietary mixture of earth-enhancing compound (e.g. Furse Marconite) is to be used in accordance with the manufacturer's recommendations where it is required to reach compliance requirements for earth readings.

Bonds or joints subject to moisture and/or positioned where they are not readily accessible for inspection or maintenance are to be made by means of 'Cadweld' or approved equivalent.

3.5 METERING

Refer to section 3 ELECTRICAL SERVICES of *000346 PDG Services Metering Guidelines* for all detailed requirements for electricity metering.

Meters are required to meet National Construction Code requirements, project specific ESD objectives such as Green Star and support operational billing requirements both now and in the future, i.e. each lettable tenant space is to have a separate utility grade meter.

3.6 ELECTRICAL DEMAND

Electrical demand calculations are to use existing installation information available from the Curtin Metering System. Information from this system can be provided through the Electrical Infrastructure Manager.

Load calculations to be completed and included in the design information package:

1. Internal infrastructure load – applies to the sub mains and electrical panel infrastructure within the building and includes capacity for local future expansion, refer table 6.1.1.
2. External infrastructure point of connection – applies to the incoming power cable and transformers, includes spare capacity to the building from the internal infrastructure, refer also section 4.
3. Campus load – this is the fully diversified anticipated load to the campus upon project completion. It shall not include spare capacity and contingency power. The power demand should be assessed based on time of day demand, the time assessed should be set as 09:00 to coincide with the campus existing maximum demand. The campus maximum demand time is to be confirmed with the Electrical Infrastructure Manager prior to proceeding.

4 CONSUMER MAINS

Consumer mains shall be designed, including voltage drop, to accommodate the anticipated maximum demand plus 25 per cent as determined in consultation with Curtin and the Supply Authority.

5 POWER FACTOR

Electrical services equipment installed shall maintain a power factor of not less than 0.95 lagging @ 75 per cent calculated campus full load. Where the installed equipment is found to be less than 0.95 lagging, the contractor will be required to implement all necessary rectifications with no variation to the contract and at no cost to Curtin.

Some mechanical services equipment may have an undesired effect on the power factor of the overall system. For these situations, the consultant shall consider and make recommendations for the use of power factor correction equipment as required to achieve the desired overall power factors for the installation.

Power factor correction (PFC) equipment shall generally be located as close as possible to the source of the equipment in need of correction. The final location of PFC equipment shall be determined in consultation with Curtin.

The manufacturer and the type of PFC equipment shall be specified to Curtin's approval.

As part of the design process it is required that the consultant investigate and advise Curtin on the benefits of aiming for an overall power factor higher than 0.95 lagging and shall make appropriate recommendations.

6 ELECTRICAL SWITCHBOARDS

6.1 INTRODUCTION

The purpose of this brief is to provide guidance for the specification of electrical switchboards in Curtin University projects.

The brief outlines the performance expectations for electrical switchboards and shall not limit the Consultant in the provision of specific project solutions. In all instances it is the responsibility of the Consultant to provide a solution that is compliant and suitable for application, in function and performance.

The University shall be consulted for all electrical switchboard solutions and the Consultant shall secure formal approval in all instances for switchboard proposals.

The design of electrical switchboards shall comply with the requirements outlined in Table 6.1.1.

Table 6.1.1 Curtin University Switchboard Brief

	Site MSB	Building MSB	Floor MDB	DB
Construction	2 mm	2 mm	1.6 mm	1.6 mm
Fault level (min)	Consult Manager Electrical Engineering	36 kA	25 kA	10 kA
Nominal current (min)	Rated to suit TX capacity	Maximum demand + 40%	Maximum demand + 30%	Maximum demand + 20%
Form of Separation (min)	4B	4B	2Bih	2Bih
Switchgear	As Nominated			
Electronic trip units	All MCCB = > 250A			
Air circuit-breaker	All CBs = > 800A			
Load break switch fault rated	Cascading allowed. Documentation to be forwarded to Manager Electrical Engineering			
Temp rise 65/40 deg. C	-	Yes	Yes	Yes
Temp rise 50/40 deg. C	Yes	-	-	-
25% spare capacity	Yes	Yes	Yes	Yes

Compliance with the National Construction Code 2.13 (d) Metal segregation of emergency ccts from general	Yes	Yes	Yes	Yes
Solid metal dividers, perforated sheet metal sections allowed for heat circulation but must be <=15% of surface area & IP2x	Yes	Yes	Yes	Yes
AS3439 Annex ZA to be addressed between client and manufacturer	Yes	Yes	Yes	Yes
All boards shall have a warning label if conditional short cct rating achieved by cascading.	All Boards			
General Notes:	All designs shall be verified by discrimination studies and associated documentation shall be provided with single line diagram. Particular note shall be made to the AS3000:2007 Section 7 when boards are equipped with "Safety Services".			

6.2 STATUTORY REQUIREMENTS

The brief provides guidance for the electrical switchboard installations at Curtin University. It is the responsibility of the Consultant to verify that electrical solutions are compliant with statutory requirements. The Consultant shall reference statutory requirements within project documentation and shall verify that installations meet these requirements. Statutory requirements shall include, but not be limited to:

- National Construction Code
- national and local work health and safety requirements including all Acts and regulations
- Western Australian Electricity Regulations
- Western Australian Electrical Requirements
- Curtin University site-specific requirements.

6.3 AUSTRALIAN STANDARDS

Australian standards for electrical switchboards are scheduled for reference by the engineering Consultant. It is the responsibility of the Consultant to ensure that the

most recent revision of the Australian standards is applied at each Curtin University project.

Table 6.3.1. List of Australian Standards

STANDARD	TITLE
AS/NZS1768	Lightning Protection
AS/NZS2293 (set)	Emergency Evacuation Lighting in Buildings
AS/NZS2467	Maintenance of Electrical Switchgear
AS/NZS2700	Colour Standards for General Purposes
AS/NZS3000	SAA Wiring Rules
AS/NZS3008	Electrical Installations – Selection of Cables
AS/NZS3100	Approval and Test Specification – General Requirements for Electrical Equipment
AS/NZS3111	Approval And Test Specification For Miniature Overcurrent Circuit Breakers
AS/NZS3190	Approval and Test Specification – Residual Current Devices (Current-Operated Earth Leakage Devices)
AS/NZS3439.1	Low Voltage Switchgear and Controlgear Assemblies
AS/NZS3820	Essential Safety Requirements for Electrical Equipment
AS/NZS4383 (set)	Preparation of Documents in Electrotechnology
AS60044.1	Instrument Transformer – Current Transformers
AS60529	Degrees of Protection Provided by Enclosures.
AS/NZS60947 (set)	Low Voltage Switchgear and Controlgear
AS62053.22	Electricity Metering Equipment (AC) – Particular Requirements – Static Meters for Active Energy (Classes 0.2S and 0.5S)

6.4 SWITCHBOARD CATEGORIES

Curtin University switchboards covered in this brief include:

- sub-station boards
- main switchboards
- main distribution boards
- mechanical services switchboards
- distribution boards.

6.5 SWITCHBOARD CRITICALITY

The assignment of criticality is for guidance only, and to assist designers and installers in understanding the University intent for switchboard design. The guidance is not to be relied upon or used for final design solutions. At all times the designer shall develop a detailed understanding of services connected at switchboards and service criticality. The final switchboard specification and application of criticality shall be agreed with the University.

A risk-based approach has been undertaken for the University switchboards as a consequence of power disruption(s). The risks considered include:

- safety of staff, students and community
- commercial loss
- security of campus and facilities
- availability of ICT network
- loss of research and development materials and processes.

Based on the risk areas identified above, the University switchboards are categorised to Low, Medium and High levels of criticality.

Each space within the University that is serviced by differing levels of switchboard criticality is summarised in Table 6.5.1.

Table 6.5.1. Switchboard Criticality and Services

SWITCHBOARD CRITICALITY	SERVICES
Low	• lecture theatres • tutorial rooms • open learning areas • student general laboratories • common areas/foyers/corridors • storerooms (general) • plant rooms (general services)
Medium	• cafes/restaurants

	• leased tenancy spaces • external lighting (e.g. security and sports lighting) • external services (e.g. irrigation) • staff office spaces • staff meeting rooms
High	• research and development spaces • storage of sensitive materials • data centre facilities including: – primary building distributor – floor distributor – laboratories (specialised) – emergency services

The Consultant shall design a switchboard to meet the design criteria based on the switchboard criticality provided in Table 6.5.2.

Table 6.5.2. Design Criteria for each Switchboard Criticality

DESIGN CRITERIA	SWITCHBOARD CRITICALITY		
	• LOW	• MEDIUM	• HIGH
Fault current rating	SSB – To suit transformer rating MSW – Minimum 36 kA for 1 second MDB – Minimum 25 kA for 1 second MSB – Minimum 25 kA for 1 second • SWB – Minimum 10 kA for 1 second		
Form of separation (minimum)*	• 2	• 2	• 3b
IP rating (minimum)	• To suit	• To suit	• IP56
Provision for physical connection of future circuits	• Not required	• Not required	• Sufficient for connection with minimal isolation required
Spare capacity: Rating	• MD + 30%	• MD + 50%	• MD + 100%
Spare capacity: Physical connection	• 30%	• 50%	• Up to 100%

Surge suppression	• Not required	• Not required	• Required
Stand-by generator connection facilities	• Not required	• Not required	• Required
Location	• To suit	• To suit	• Secured area
Power monitoring	• Required on incoming or upstream outgoing.	• Required	• Required. Individual circuit monitoring should be considered.

* Refer Section 6.8.7 for SSB form of separation requirements.

Table 3 is provided with the following exceptions:

- The supply from an upstream switchboard shall have equal or greater level of criticality.
- A switchboard supporting an essential service as identified within AS/NZS3000:2007 Electrical Installations (known as the Australian/New Zealand Wiring Rules) may not need to be rated as a high criticality level provided that the essential supply is arranged in accordance with the Standard's requirements.
- NMI retail metering is required for third party and tenants.

For item(s) not listed in the table above, consult and seek approval from the University.

6.6 EQUIPMENT SELECTIONS

All equipment shall be designed to be suitable for continuous, reliable operation 24 hours per day, 7 days per week, 365 days per year, in the conditions specified unless clearly identified for intermittent duty.

6.7 ENVIRONMENTAL CONDITIONS

Based on Bureau of Meteorology recordings, the highest temperature recorded in 2015 at Bentley, WA 6102 was 43.8 °C with an average temperature of 20.4 °C.

On this basis the following switchboard environmental conditions is recommended:

- indoor: controlled temperature 25 °C but may rise to 35 °C
- outdoor: maximum ambient temperature 50 °C.

6.8 CONSTRUCTION DESIGN

6.8.1 ELECTRICAL SWITCHBOARD

STANDARDS

AS/NZS3000, AS/NZS3439, AS/NZS1939 and AS/NZS60529.

ENCLOSURES

Provide an enclosure comprising panels, doors and the like, giving the specified enclosure, segregation and degree of protection as specified.

All enclosures or partitions including locking means for doors, withdrawable parts etc. shall be of a mechanical strength sufficient to withstand the stresses to which they may be subject in normal service and when subjected to their designed prospective electrical fault levels.

Bespoke panels and all SMSB enclosures shall include lines on the panel body that indicate the bus bar connection pathways between devices.

DEGREE OF PROTECTION

The minimum degree of protection of a switchboard, after installation in accordance with the manufacturer's instructions, shall be as follows:

- indoor
  - Generally IP42
  - IP52 in fire egress paths
  - IP56 in plant room or wet areas
- outdoor
  - IP56.

In the case of a switchboard intended for use in a location with high humidity and temperatures varying in a wide range, suitable arrangements shall be considered to prevent harmful condensation within the switchboard. Suitable arrangements include ventilation and/or heating, drain holes etc. The switchboard's degree of ingress protection shall be maintained.

CABLE ENTRIES

Provide sufficient clear space within each enclosure, adjacent to the cable entries, to allow the incoming cables and wiring to be neatly run and terminated, without overcrowding.

For cable entry and internal distribution, provide cable entries of not less than 100 mm depth by the full width of cubicle space, which is unrestricted by equipment or internal wiring.

Provide to each entry a removable gland plate fitted with a gasket to maintain the specified degree of protection.

Cable glands for all entering and exiting cables (bunches of cables) are to provide a close fit around cabling in accordance with the requirements of AS/NZS3000. Seal cable entries to provide a close fit in all instances and to maintain the switchboard protection rating.

DOORS

Door width is to suit accommodation and shall not be more than 900 mm.

Door swing shall be no less than 90° and adjacent doors shall be sufficiently spaced such that both doors can open the minimum 90° simultaneously. Door stays shall be provided for outdoor assemblies. Door openings shall have single right angle return on all four sides and fit a suitable seal in accordance with the degree of protection.

Hang doors on heavy-duty chromium-plated block hinges that allow easy removal of the door when in the open position.

Doors taller than one metre shall be fitted with three hinges.

Door hinges shall be corrosion-resistant pintle hinges or integrally constructed hinges.

Removable doors shall have staggered pin lengths to achieve progressive engagement as doors are fitted. Non-lift-off doors shall have restraining devices and opposed hinges.

Doors shall be fitted with corrosion-resistant lever-type handles, operating a latching systems with latching bar.

Doors shall be fitted with dual, edge-mounted, corrosion-resistant Carbine 'T' handles to suit Curtin key locking cylinders. Doors shall include a 3-point pad lockable latching system. The Carbine 'T' handles will be issued free to the contractor. The Consultant shall allow $200 + GST per door handle (supply only) in the project budget estimates. It is the Project Manager's responsibility to execute a Curtin University online request to Security for the quantity of door handles required. The contractor is responsible for obtaining the door handles from Security and installation to the switchboards, including all costs in their tender submission.

Doors shall be provided with a resilient strip smoke seal, of foamed neoprene or the like, around each door, housed in a suitable channel or housing and fixed with an approved industrial adhesive.

Doors shall be provided with seal contact with a flat surface of the enclosure at least as wide as the seal strip.

Door shall be provided with a circuit schedule holder on the inside of the door. The schedule shall be readable without removing it from the holder. Do not use adhesive to fix the holder. Protect the schedule with a hard plastic cover.

EQUIPMENT FIXING

Equipment forming part of the switchboard shall have distances complying with the requirements of their relevant specifications and these distances shall be maintained during normal service conditions.

These distances include creepage distance and clearances or impulse withstand voltages. A creepage distance is the shortest permissible distance between two conductors on the surface of an insulated material.

Equipment clearances shall be sufficient to enable the circuits to withstand the test voltage according to Clauses 7.1.2.3.2 and 7.1.2.3.4 of AS3439.1. The dimensions of creepage distances shall comply with Clause 7.1.2.3.5 of AS3439.1. When dimensioning clearances, creepage distances and insulation between separate circuits, the highest voltage ratings shall be used.

Equipment shall be mounted by bolts or set screws fitted into tapped holes in metal mounting panels, studs or proprietary attachment clips. Equipment shall be mounted so equipment fixings can be accessed to allow equipment changes after commissioning.

Lightweight equipment may use combination rails and proprietary clips.

LIFTING PROVISIONS

Provide fixings in the supporting structure, and removable attachments, for lifting switchboard assemblies where floor-mounted. Provide switchboards in sections as required to enable installation in their final location.

MOUNTING PANEL

The internal mounting panel to support various components shall be a minimum of 2 mm thick. The panel may be constructed from metal or non-metallic material. A non-metal board shall have heavy metal angle supports or plates bolted or welded to the enclosure sides. Non-metal boards shall comply with IEC60893-1. The panels shall provide front accessible cable zones of no less than 450 mm.

FLOOR MOUNTING

Provide a galvanised steel plinth channel, not less than 75 mm high, for mounting the complete switchboard assembly on site. Drill sufficient clearance holes for 12 mm diameter bolts, in the switchboard and the plinth, to rigidly fix the switchboard assembly to the plinth and the plinth to the floor.

WALL MOUNTING

For flush or semi-flush switchboards, provide a facing flange, of the same material and finish as the enclosure, and of a section which incorporates a return allowing the outside edge to fit neatly against the wall.

For switchboards located externally, provide an angled top to prevent water from pooling. Extension of the angled top should be considered for switchboards located externally that may need to be accessed during wet weather.

ESCUTCHEON PLATES/PANELS

Hinged removable escutcheon plates shall be provided with the front of the circuit breakers protruding through neat cut-outs.

Provide cut-outs for all spare space allowances. Provide individual proprietary clip-in pole fillers to each spare pole space. The escutcheon plate shall provide a flush surface between the edges of the distribution board case. Fit chromium-plated lifting handles to each escutcheon plate.

Rigidity: the escutcheon panel shall be not less than 1.6 mm thick and must be rigid. Stiffen or brace the panel as necessary to achieve this rigidity.

Frame: provide a continuous 12 mm-wide support frame for the fixing of each escutcheon plate, including additional support where necessary to prevent panel distortion.

Fixing: the escutcheon panel shall be secured by knurled, slotted, captive thumbscrews.

Maximum height: to suit accommodation or as specified.

Hanging: hang escutcheon plates on hinges which allow opening through a minimum of 90º and permit the removal of the escutcheon when in the open position.

CABLE DUCT/TRAY

The internal cable ducting shall be sized to house cables for maximum board capacity without restricting closure of the duct cover. Cable duct is to be a minimum of 70 mm wide for all boards and a minimum of 100 mm for boards with a total capacity greater than 60 poles. Allow for a cable tray should this be required.

6.8.2 DRAWINGS

DETAILED DESIGN PHASE

The detailed design documentation shall detail the following:

- general arrangement
- single line diagrams
- electrical maximum demand calculations
- cable sizing and voltage drop calculations
- protective devices rating, protection settings including long-time, short-time, and instantaneous tripping
- discrimination studies
- fault level calculations at each switchboard
- lightning protection assessment.

Submit the detailed design documentation suitable for tender.

CONSTRUCTION PHASE

Switchboard shop drawings shall be provided for Curtin University review and comment prior to fabrication.

The switchboard shop drawings shall detail the following:

- general plans, elevations and sections, construction and weights
- circuit diagrams, busbar and cable sizes

- current-carrying capacity, current and fault ratings
- equipment types and models, labelling and finishes
- protective devices rating types and models
- bill of materials listing of all items.

Additionally provide documentary evidence of fault withstand-type tests relevant to the applicable enclosure(s).

Complete the Switchboard Checklist prior to and at completion of switchboard installation for University review and approval. The Switchboard Checklist template is attached in Appendix A.

6.8.3 TEST SPECIFICATIONS

STANDARD

AS/NZS3439.1:2002 Low-voltage Switchgear and Controlgear Assemblies – type-tested and partially type-tested assemblies

REQUIREMENTS

The tests to verify the characteristics of a low-voltage switchgear and controlgear assembly include:

- type tests
- routine tests.

Each assembly of low-voltage switchgear and controlgear shall be type-tested (TTA) or partially type-tested (PTTA) and routine tested.

Type Tests

TTA is a low-voltage switchgear and controlgear assembly that is physically tested and verified to meet the required performance in accordance with AS/NZS3439.1.

PTTA is a low-voltage switchgear and controlgear assembly containing type-tested and non-type-tested arrangements. The non-type-tested arrangements are required to be derived from type-tested arrangement in the form of calculations or the like.

The TTA and PTTA are intended to verify compliance with AS/NZS3439.1 for a given type of assembly.

Type tests include the following:

- verification of temperature rise limits
- verification of the dielectric properties
- verification of the short-circuit withstand strength
- verification of the effectiveness of the protective circuit
- verification of the clearances and creepage distances
- verification of mechanical operation
- verification of the degree of protection and internal separation.

Routine Tests

Routine tests are intended to detect faults in materials and workmanship. Routine tests are also required to be carried out on every new assembly.

Routine tests include the following:

- inspection of the assembly including inspection of wiring and electrical operation test as required
- dielectric test
- checking of protective measures and electrical continuity of the protective circuits
- verification of insulation resistance.

NEW STANDARD

A new Standard is being developed (AS/NZS 61349) which will supersede the current AS/NZS3439.1 for switchgear and controlgear testing. This standard has not been formally released at the time of publishing this electrical switchboard brief.

The new standard intends to remove the requirement for new assembly designs to be type-tested and requires new designs to be design-verified. Design verification extends the variety of characteristics to be tested from seven (required by AS/NZS3439.1) to 13. Design verification will require three different methods to test the 13 characteristics:

- physical testing (similar to type testing)
- comparison/derivation from a tested assembly (previously certified by physical testing)
- assessment (using calculations and the application of design rules

The new standard will be applied at new installations only. Retrospective testing of existing installations is not required.

It is the responsibility of the Consultant to ensure that the most recent standard is applied to the switchboard design.

6.8.4 BUSBARS

REQUIREMENT

Provide a three phase busbar assembly with high-conductivity copper busbars designed for a maximum current density of 1.5 A/mm^2 from the termination of the incoming unit to the line side of the protective equipment for outgoing circuits.

FUTURE EXTENSIONS

Pre-drill the main busbar assembly for future extension and extend busbar droppers to spare locations. Drill each dropper to suit connection of future equipment of the same type as that specified.

CROSS-SECTION

Radius edges and corners to prevent damage to insulation.

SUPPORT

Provide support sufficient to withstand the maximum prospective fault currents without damage. Do not support busbars from circuit-breaker terminals.

JOINTING

Make busbar joints with high tensile bolts and nuts, locked in position with lock nuts or locking tabs. Tighten bolts to the manufacturer's recommendation with a tension wrench. Do not use tapped holes and studs or the like for jointing current-carrying sections.

INSULATION

Insulate busbars as follows:

ACTIVE AND NEUTRAL BUSBARS

Fully insulate the busbars with suitable plastic insulation of appropriate colours to designate phases. Busbar assemblies shall be red, white, blue phases from left to right when viewed from the front of the switchboard. Maintain phase colours (and rotation) throughout the installation.

JOINTS

Insulate either by taping or plastic coating, as follows:

- taped joints: apply a non-adhesive stop-off-type tape, coloured to match the specified colour coding, half lapped to achieve a thickness of not less than that of the solid insulation.
- plastic-coated joints: apply, in accordance with the manufacturer's recommendations, and to a minimum thickness equal to that of the solid insulation, an air drying plastic coating material that achieves a tensile strength in excess of 17 MPa, and a minimum elongation of 300 per cent.

COLOUR CODING

Colour the insulation as follows:

- active busbars: red, white or blue
- neutral busbars: black where applicable
- earth busbar: green and yellow where applicable.

NEUTRAL BUSBAR

Extend the neutral busbar into each switchboard compartment containing outgoing circuits with neutral connections. Provide terminals or drill the busbar for neutral connections.

Identification: clearly mark and number terminal connections.

6.8.5 NOMINAL CURRENT

The minimal nominal current for each switchboard shall be to suit the upstream capacity or protection devices rating.

For instance, a site MSB nominal current shall be rated to suit the site transformer capacity. Switchboards downstream of the site MSB are required to be rated to the protection devices rating installed within the site MSB.

6.8.6 FAULT LEVEL

The minimum fault level for each switchboard shall be rated in accord with the following:

- upstream equipment (transformer or switchboard) short-circuit current rating
- cable type
- cable size
- cable length.

Obtain site transformer information from the University to determine the transformer short-circuit current rating.

Should the transformer information not be available, the Consultant shall detail assumptions for switchboard fault rating calculations.

6.8.7 SEPARATION FORM TYPE

STANDARD

To AS/NZS3000 and AS/NZS3439.1.

GENERAL

The purposes for the forms of internal separation within a switchboard include:

- protecting against contact with live parts belonging to adjacent functional units
- limiting the possibility of initiating arcing faults
- protecting against the passage of solid foreign bodies from one unit of assembly to an adjacent unit.

The forms of internal separation shall be agreed upon by the University and the Consultant. Seek approval from the University for forms of separation selection.

REQUIREMENTS

The forms of separation within a switchboard should be selected based on but not limited to the following:

- SSBs require separation at a minimum of Form 4b
- rated current of the switchboard e.g. switchboards rated more than 800 A require separation at a minimum of Form 3b as per AS/NZS3000 Clause 2.5.5.2 to reduce the probability of initiating an arcing fault.

- requirement of additional integrity by having separation between the functional units and busbars
- requirement of accessing the functional units for limited maintenance or change of settings with adjacent functional units remaining live
- requirement of accessing cable terminals of a functional unit with adjacent functional units remaining live.

Isobar or Grizzbar chassis should be considered for switchboards that require additional circuits to be installed without switchboard isolation.

6.8.8 ARC PROTECTION/CONTAINMENT

STANDARD

To AS/NZS3439.1.

GENERAL

The Consultant should consider the selection of a switchboard that will provide increased security against the occurrence or the effects of internal arcing faults under normal operating conditions, with all doors closed and all covers and internal barriers in place.

The purposes of providing increased security include:

- to provide means to reduce the probability of the initiation of an internal arcing fault
- to protect personnel from injury in the event of a fault under the normal operating conditions of the switchboard
- to limit as far as possible the extent of damage to equipment in the event of a fault.

REQUIREMENT

The means of reducing or minimising the probability or magnitude or duration of internal arcing can be achieved by the following:

- insulation of all live conductors
- arrangement of busbars and switchgears in vented compartments designed to promote rapid extinction of the arc and to prevent the arc or arc products affecting other sections of the switchboard
- use of switchgears designed to interrupt the fault
- use of devices sensitive to the energy radiated from an arc that will initiate the interruption of the arcing current
- use of earth current detection devices
- combinations of the above items.

TESTING

Internal arcing-fault tests shall be carried out in accordance with AS/NZS3439.1.

SAFETY AND SIGNAGE FOR ELECTRICAL SWITCH ROOMS

SMSBs shall have their arc flash levels calculated by the Consultant. Signage is to be included, consistent with existing signage at Curtin Campus, to advise of arc flash levels and appropriate PPE to be worn in these rooms. Refer also to "CURTIN UNIVERSITY – CONTRACTOR HEALTH AND SAFETY HANDBOOK".

6.8.9 NEUTRAL AND EARTH LINKS/BARS

LOCATION

Locate neutral and earth links within 600 mm of each cable entry unless written approval of greater spacing is obtained.

CONNECTIONS

Provide stud connections for cables of cross section 16 mm^2 or larger.

IDENTIFICATION

Clearly mark and number terminals. Numbers on circuit-breakers, neutral and earth link/bars for each circuit shall correspond.

TERMINALS

Provide a separate dual-screw neutral terminal and earth terminal for each circuit-breaker pole or fuse on each switchboard section. Provide additional terminals for future circuits.

CLEARANCES

A minimum of 100 mm wiring channel shall be provided between neutral and earth links and switchboard sheet metal enclosures. Provide adequate clearance or insulating barriers between links and all live conductors. The minimum clearances and creepage distances between neutral and earth links/bars shall comply with AS3439.1 Table 14 and Table 16.

6.8.10FINISHES

SURFACE PREPARATION

Where metal surfaces are to be painted, prepare them appropriately to avoid corrosion, and to withstand the relevant environmental conditions.

PAINT SYSTEMS

For indoor locations use a system not inferior to FULL GLOSS, SOLVENT BORNE: INTERIOR PAINTING. Colours are to be provided to AS2700, to the approval of the University.

PAINT COLOURS

Colours are to be provided to AS2700, to the approval of the University. Typically these are externally grey and internal white with red doors as required on any life safety system sections.

BUSWAY INDICATION

Black lines shall be included on the front of the panel to indicate the internal busway pathways.

6.8.11 LABELLING SCHEME

Refer labelling section.

6.8.12 SCHEDULE CARDS

For general lighting and power distribution provide printed circuit schedule cards of minimum size A4 identifying the following:

- sub-main designation size and rating
- light and power circuit number, protection device type, area supplied, cable size, protection rating.

Mount the circuit schedule cards in the holder fixed to the inside of the enclosure door.

6.8.13 POWER FACTOR CORRECTION

STANDARDS

AS/NZS3439, IEC61921 Ed. 1.0 and IEC60831-1.

GENERAL

Design, construct, supply and install an automatic power factor correction unit including switchgear and controlgear. The equipment shall be capable of achieving no less than 0.98 lagging power factor under all load conditions.

DESIGN CRITERIA

The system shall be designed in accordance with the following criteria:

- nominal operator voltage: 400–415 V, three-phase
- rated insulation voltage: 690 V
- nominal operating frequency: 50 Hz
- rated insulation voltage: 690 V
- network pollution level: < 15% at 400–415 V
- capacitance tolerance: -5% to +10%
- power frequency withstand voltage: 2.5 kV, 50 Hz, 1 minute
- operating temperature: -5 to +60 °C.

GLAND PLATES

Provide removable gland plates for all entries.

MAIN ISOLATOR

Provide a main isolator to match the maximum setting of the upstream circuit-breaker.

VENTILATION

Provide one or more thermostatically controlled fans designed to maintain thermal temperatures to the manufacturer's requirements. Each fan is to incorporate a removable and washable filter. Generally the fans shall be installed to the base of the unit, with the exhaust provided on top.

FUSES

Provide a set of HRC fuses for each group of capacitors. There shall be no more than one group of capacitors per fuse.

HARMONIC BLOCKING REACTOR

Provide harmonic blocking reactors in series with each step. The series resonant frequency of the circuit shall be designed to 189 Hz.

EARTHING

Provide earthing of all modules utilising an earth bar within the enclosure.

BUSBAR

Provide fully shrouded busbars, which will be rated no less than the maximum circuit-breaker rating upstream.

CONTACTORS

Selected specifically for use with capacitor switching to avoid short circuits within the capacitor banks, and shall be of electromagnetic type. The contactors shall incorporate current-limiting resistors to allow the reduction of transient overvoltage, and be capable of a minimum of 300,000 operations at 400 V.

CURRENT TRANSFORMERS

Current transformers shall be installed in accordance with the manufacturer's requirements, and shall be installed to the location as nominated on the drawings accompanying the specification. Provide labels as described in the labelling section on the relevant switchboards for identifying PFC current transformers behind.

REACTIVE POWER CONTROLLER

The reactive power controller shall control the automatic switching of each capacitor step to achieve the desired power factor. The controller shall have the following features:

- minimum of six steps
- manual on/off control for capacitors
- multifunction display indicating stages activated, actual power factor, reactive current, active current and apparent current
- built-in alarm indicator of faults including over current, equipment failure, incorrect power factor, harmonics
- built-in alarm indicator for over-temperature, fan failure
- balanced cyclic use of capacitor steps to ensure uniform usage
- front panel-mounted, and accessible without door removal
- RS485 Modbus outputs for remote monitoring via the BMS
- shall be of 'Schneider Varlogic' manufacture or approved equivalent.

ALARM PANEL

Provide a power factor correction alarm panel installed outside the Main Switch Room (or an in alternative approved location) for audiovisual alarm in the event of a system failure. The alarm shall incorporate a mute button installed within reach, to disable the audible alarm. The panel shall be appropriately labelled to identify its purpose, refer to the labelling section.

6.9 SWITCHGEAR

6.9.1 GENERAL

All switchgear shall comply with relevant Australian standards.

6.9.2 AIR CIRCUIT-BREAKER

STANDARDS

To AS/NZS60947 and AS/NZS3100 category 1.

TYPE

Open construction, withdrawable three-pole, back-connected, trip-free.

RATED DUTY

Based on uninterrupted duty in a non-ventilated enclosure.

RATED SHORT CIRCUIT-BREAKING CAPACITY IN SERVICE

Suitable for fault rating at the point of connection.

CLOSING OPERATION

Trip-free closing mechanisms for operation. With positive mechanically operated ON-OFF indications.

OPENING OPERATION

Provide a mechanically operated release for opening of circuit breakers.

AUXILIARY SWITCH CONTACTS

Provide contact sets with a minimum rated operational current of 6 A at 230 V, 50 Hz. Provide at least two spare contacts, one normally open and one normally closed. Provide a series-connected auxiliary contact (early make, late break) for the shunt trip release coil. Provide contacts that remain connected in the test or isolate position.

PROTECTION SYSTEM

Integral to the circuit breaker, incorporating a solid-state protection relay.

LOCKING

All ACBs shall be completed with padlocking facilities for locking in the open and withdrawn position.

ABNORMAL OPERATIONS

All ACBs shall not be operable with the following operations:

- slow closing or opening of contacts
- independent manual closure should springs fail
- released of charged springs while contacts are closed.

COMPARTMENT

House each ACB in a separated, self-contained, enclosed subsection within the assembly.

MOUNTING

Mount each ACB on a withdrawable carriage with racking gear that fixes the unit into the following position:

- connected
- test and isolated
- disconnected.

INTERLOCKING

Provide interlocking to the ACB to prevent it from the following:

- rack in or withdrawn unless the ACB is in an open position

- close unless it is either connected or in test and isolated position.

SHUTTERS

Provide automatic shutters to busbars when carriage is withdrawn. Shutters shall be completed with padlocking facilities.

EARTHING

Provide earthing connection between the withdrawable carriage and the assembly earth busbar which makes before breaks other contacts on the ACB carriage.

MONITORING

Communications modules for remote monitoring or potentially operating should be considered. The communications module protocol shall meet the University BMS protocol requirements.

METERING

The Consultant shall consider the option of ACB in-built metering for energy monitoring purposes. It should be noted that these lack accuracy at low energy flow levels and are not NMI pattern approved for billing purposes or energy rating tools.

6.9.3 MOULDED CASE CIRCUIT BREAKERS

STANDARDS

To AS/NZS60947.2.

CURVE TYPE

Select circuit-breaker trip curve types to suit the connected equipment including instantaneous and running load current characteristics.

ULTIMATE BREAKING CAPACITY

At least equal to the prospective fault rating at the point of connection, unless the limitation capacity of an upstream circuit-breaker allows cascading.

SERVICE BREAKING CAPACITY

For MCCBs up to 630 Amps, the Ics shall be 100 per cent of the Icu.

REVERSE FEED

All MCCBs shall be possible to reverse feed the circuit-breaker without performance reduction.

FIXING

MCCBs shall be fixed, plug-in or withdrawable models and in 3-pole or 4-pole versions.

OPERATION

All MCCBs shall be operated by a toggle or handle which shall clearly indicate the three fundamental positions ON, OFF and TRIPPED.

OPERATING MECHANISM

Quick make, quick break type, with the speed of operation independent of the operator. Mechanically trip-free from the operating handle so as to prevent the contacts from being held closed against short-circuit and overload conditions. All poles shall operate simultaneously during opening, closing and tripped conditions.

ROTARY HANDLE

If applicable, provide a handle shaft connecting to the switchboard door-mounted handle. The handle shaft shall be installed to facilitate the handle mechanism. The handle shall be in the horizontal when the circuit-breaker is in the open position and shall rotate clockwise to close the circuit-breaker.

LOCKING

All MCCBs shall be completed with padlocking facilities for locking in the open position.

MONITORING

A communications module for remote monitoring or potentially operating should be considered. The communications module protocol shall meet the University BMS protocol requirements.

METERING

The Consultant shall consider the option of larger MCCB in-built metering for energy monitoring purposes. It should be noted that these lack accuracy at low energy flow levels and are not NMI pattern approved for billing purposes or energy rating tools.

PROTECTION UNITS

All MCCBs shall be fitted with RMS-sensing electronic trip units.

The trip units of MCCBs shall be easily interchanged using standard tools.

All electronic components shall withstand temperatures up to 125 ºC.

All settings on trip units shall have provision for sealing. Where circuit-breakers are nominated to be sealed, the adjustable controls shall be concealed behind an escutcheon sealed with authority tags or otherwise.

Universal electronic trip units shall provide:

- long-time protection with adjustable time delay
- short-time protection with adjustable time delay
- instantaneous protection
- all with adjustable thresholds.

All universal trip units will incorporate a load monitoring function.

It shall be possible to install the following options without increasing the circuit-breaker volume:

- high threshold earth-fault protection
- load monitoring with adjustable threshold
- LEDs to indicate the cause of tripping
- data transmission via a bus.

All breakers from 1,250 to 3,200 A shall be fitted with trip units of the solid-state interchangeable type.

AUXILIARIES AND ACCESSORIES

All accessories and electrical auxiliaries shall be manufactured in such a way that they can be easily field-fitted without adjustment.

The circuit-breakers will have a double insulation of the front face allowing field installable auxiliaries without isolating the unit.

All electrical auxiliaries shall be equipped with built-in control terminals. All internal electrical auxiliaries shall be of the snap-in type.

It shall be possible to fit the MCCB with a motor mechanism without affecting the circuit-breaker characteristics.

All electrical auxiliaries shall be separated from power circuits and their addition shall not increase the volume of the circuit-breaker.

It shall be possible to retrofit a Residual Current Device (RCD) directly to the existing circuit-breaker enclosure.

It shall be possible to equip the circuit-breakers with devices indicating faults without tripping the circuit-breaker.

6.9.4 MINIATURE CIRCUIT-BREAKERS

STANDARDS

To AS/NZS3111

RATING

Up to 125 Amps and no less than 10 kA fault capacity.

CURVE TYPE

Provide non-standard curve type circuit-breakers for all mechanical or refrigerative plant. Alternatively increase the size of circuit-breakers and sub-circuit cabling to allow starting currents in accordance with AS/NZS3000.

RESIDUAL CURRENT DEVICE

Provide combined MCB/RCD circuit-breakers in accordance with AS/NZS3000. MCB/RCDs should have a maximum tripping current imbalance of 30 mA within 300 ms complying with AS/NZS3190. MCB/RCD circuit-breakers shall utilise a single pole space.

TAGGING

All MCBs shall be complete with facilities for tagging in the open position.

MONITORING

A communications module for remote monitoring should be considered. The communications module protocol shall meet the University protocol requirements.

6.9.5 CASCADING AND DISCRIMINATION

GENERAL

All installations shall be arranged so that only the protection device immediately upstream of the fault shall operate to clear the fault using non-manufacturer-specific basic discrimination.

Installations shall avoid the use of enhanced discrimination and cascading between upstream and downstream devices wherever possible. Specific dispensation is to be gained from the Electrical Infrastructure Manager where this approach is being considered.

6.9.6 CONTROL, TEST SWITCHES AND EQUIPMENT

STANDARDS

To AS/NZS60947.

RATED OPERATIONAL CURRENT

Not less than 6 A 230 V AC at utilisation category AC-14 and AC-15.

DEGREE OF PROTECTION

Not less than the degree of protection specified for the switchboard.

6.9.7 SELECTOR SWITCHES

STANDARDS

To AS/NZS60947.1.

GENERAL

Selector switch wiring shall be installed in flexible corrugated conduit to provide mechanical protection and to ensure the wiring is not shrouded by door swings. The selector switches shall be padlockable in the OFF position. The Consultant shall liaise with the University for the requirements of key selector switches, maintained or spring return.

MOUNTING

Mount the selector switches on the switchboard door with sufficient clearance to other equipment in the same space. The selector switches shall be of a mechanical strength sufficient to withstand the stresses to which they may be subject in normal service.

DEGREE OF PROTECTION

Not less than the degree of protection specified for the switchboard.

6.9.8 INDICATOR LAMPS

STANDARDS

To AS/NZS60947.1

GENERAL

Indicator lamp wiring shall be installed in flexible corrugated conduit to provide mechanical protection and to ensure the wiring is not shrouded by door swings.

The Consultant shall liaise with the University for colour selection of the indicator lamps.

MOUNTING

Mount the indicator lamps on the switchboard door with sufficient clearance to other equipment in the same space. The indicator lamps shall be of a mechanical strength sufficient to withstand the stresses to which they may be subject in normal service.

DEGREE OF PROTECTION

Not less than the degree of protection specified for the switchboard.

6.9.9 RELAYS/CONTACTORS

STANDARDS

To AS/NZS60947.2.

TYPE

Block type, air break, DIN rail-mounted and labelled, refer to the labelling section.

RATED OPERATIONAL CURRENT

Not less than the full load current of the load controlled.

RATED DUTY

Uninterrupted (continuous).

MINIMUM RATING

Contactor: 20 A at 415 V AC

Relay: 6 A at 24 V AC/DC

UTILISATION CATEGORY

Not less than AC 3 or DC 3 as applicable.

MOUNTING

Mount the contactor/relay with sufficient clearance to other equipment and to its enclosure to allow full access for maintenance, removal and replacement of coils and contacts, without the need to disconnect wiring or remove other equipment.

INTERCONNECTION

Do not connect contactors in series or parallel to achieve the specified ratings.

MANUFACTURE

Siemens or Sprecher and Schuh unless otherwise approved, with rating and utilisation category to suit the application.

6.9.10 FUSES WITH ENCLOSED FUSE LINKS

MANUFACTURE

Provide fuse holders and fuse links to GEC Red Spot manufacture or equal.

FAULT CURRENT LIMITER

Fuses installed solely for fault current limiting shall be achieved using a combination of circuit-breakers.

FUSE HOLDER

Mount the fuse holders so that the fuse carrier may be withdrawn directly towards the operator and away from live parts, and provide fixed insulation that shrouds all live metal when the fuse carrier is withdrawn.

FUSE LINKS

Enclosed, high rupturing capacity (HRC)-type mounted in a fuse carrier. Provide a 'fuse blown' indication which is visible when the link is fitted to its carrier. Where necessary for safe removal and insertion of the fuse carrier, provide extraction handles and mount them on clips within the spares cabinet.

SPARES

Provide a minimum of three spare fuse links for each size of fuse link on each switchboard. Mount the spares on clips within the relevant switchboard.

6.9.11 SWITCH-ISOLATOR AND COMBINATION FUSE-SWITCH UNITS

STANDARDS

To AS/NZS60947.1 and 60947.3.

OPERATION

Fault make, load break switches. Independent manual operation including positive ON/OFF indicator and with interlocked door and retractable handle. ‘O’ and ‘I’ indicators are not acceptable.

LOCKING

Fitted with padlocking facilities for locking in the OFF position.

SHROUDING

Effective over the range of switch positions.

DESIGN

Totally enclosed unit incorporating arc control devices and shrouded stationary contacts. Double make and break, silver-plated contacts and plated copper terminals.

AUXILIARY

Provide auxiliary contacts as required.

LABELLING

Provide labelling on front of fuse-switch units to indicate actual fuse cartridge rating, the maximum rating and the load they supply, refer to the labelling section.

6.9.12 SURGE PROTECTION DEVICES

STANDARDS

To IEC61643-11.

General: Provide surge protection devices to distribution boards supplying sensitive electronic equipment. Consult with the University for the definition of sensitive electronic equipment and the requirements to provide surge protection for such equipment. The Consultant shall complete lightning protection assessment in accordance with AS/NZS1768. Irrespective of that risk assessment, the designer shall engage with project stakeholders to assess the likelihood of a lightning strike and the outcome to the University in terms of impact and cost. Ongoing insurance premiums should also be considered when assessing business cases to install lightning protection.

Surge protection devices should comprise the following characteristics:

Nominal voltage	• 220–240 V (single phase) • 380 V (three-phase)
Maximum continuous operating voltage	• 275 V AC, 350 V DC (single phase) • 440 V AC, 580 V DC (three-phase)
Maximum discharge current	• shown on detailed design drawings at 8/20 µS
Status indicator	• mechanical flag and auxiliary • LED indicator with buzzer to exterior of enclosure • surge counter • contact for BMS connection
Upstream protection	• provide 100 A circuit breaker upstream, or as recommended by manufacturer
Installation	• DIN Rail
Rating	• 100 kA, 60 kA, 40 kA, 20 kA, 15 kA or 10 kA to suit
Manufacturer	• Erico Critec series/Novaris or approved equivalent

6.9.13 GENERATOR FACILITIES

GENERAL

All new buildings shall have some levels of considered generator capability. The nature of the buildings' use shall dictate which of the following solutions is to be incorporated, in order of perceived criticality and practicality:

1. Permanent connection whole building
2. Permanent connection partial building
3. Temporary direct connection whole building
4. Temporary direct connection partial building
5. Designated connection whole building
6. Designated connection partial building.

Methods 1 and 2 require the installation to have a fully automated transfer and load shedding system as required. Methods 3 to 6 require a method statement including recommended generator rating and connection/ hook up point.

The definition of a temporary and designated connection is:

- Temporary connection requires a purpose-made connection point external to the building and a main panel that is segregated for generator use. The arrangement shall be automatic and will include mechanical and electrical interlocks.
- Designated connection shall include an internal connection that is manual. It shall require attendance of a controlling electrical trade to install and monitor the load. The connection and safety of the temporary power shall follow a pre-determined plan that shall be developed as part of the building design development process.

PERMANENT GENERATOR CONNECTION

GENERAL

Switchboards requiring generator facilities shall be fitted with terminations for a stand-by generator to suit project requirements.

OPERATION

Transfer of normal supply to emergency supply shall be by the means of Automatic Transfer Switch (ATS).

TEMPORARY GENERATOR CONNECTION POINT

GENERAL

Where provision of a temporary generator connection is required to a building main switchboard, provide a temporary generator connection chamber. The temporary generator shall be at a point external to the building and shall allow termination of temporary generator sub main cabling without the requirement to isolate the switchboard. The temporary generator connection chamber shall provide a means for

maintaining the temporary generator sub main cabling connection with the door closed and such that unauthorised access is not available. The temporary generator connection chamber cable entry point shall maintain the IP rating of the chamber. The chamber shall be lockable and not require continuous presence during operation.

The Consultant shall liaise with the University for the location of the connection point chamber/panel.

OPERATION

Transfer of normal supply to temporary supply shall be by the means of an ATS.

DESIGNATED GENERATOR CONNECTION POINT

GENERAL

Where provision of a designated generator connection is required to a building main switchboard, a methodology shall be written that shall be posted in the switch room. The generator connection chamber shall allow termination of temporary generator sub main cabling without the requirement to isolate the switchboard. The temporary generator connection chamber shall provide a means for maintaining the temporary generator sub main cabling connection while switchboard doors are in the locked position. The temporary generator connection chamber cable entry point shall maintain the IP rating of the switchboard. An external padlockable flap to the temporary generator connection section shall be provided.

The Consultant shall liaise with the University for the location of the switchboard.

OPERATION

Transfer of normal supply to temporary supply shall be by the means of an MTS.

6.9.14 TRANSFER SWITCH

GENERAL

A transfer switch is generally categorised as:

- automatic transfer switch (ATS)
- manual transfer switch (MTS).

Both ATS and MTS shall include two motor-operated circuit-breakers up to 3,200 A.

The Consultant shall liaise with the University on the requirements for closed transition switches.

OPERATION

Manual operation shall be controlled by user interface and selector switch as a minimum. To ensure continuity of service, both circuit-breakers shall have two stable positions, CLOSED and OPEN. It shall be possible to manually operate each circuit-breaker in the event of the absence of control voltage.

MAINTENANCE

The transfer switches shall have a neutral position with both circuit-breakers in the OPEN position for maintenance.

LOCKING

Both breakers shall be fitted with padlocking facilities for locking in the OPEN position.

INTERLOCKING

The ATS/MTS shall be of the mechanically held type, mechanically and electrically interlocked to exclude any possibility of paralleling the normal and emergency sources.

AUXILIARY

Each circuit-breaker shall include the provision to connect auxiliary contacts and alarm contacts if required.

MONITORING

ATS/MTS status monitoring shall be available via the University BMS.

CONSTRUCTION

The following items shall be included in the ATS/MTS as standard:

- time delay for emergency to normal
- engine start signal on normal supply failure
- voltage sensing on normal supply (3-phase)
- control logic protective devices complete with batteries to ensure continuous power supply during transfer
- five-position selector switch.

All operations of the circuit-breakers shall be by a stored energy mechanism. It shall be possible to fit and maintain the mechanical interlock on site, and to have access to all components from the front. The interlocking shall be achieved with either rigid rods (vertical interlocking) or by Bowden cable (horizontal interlocking).

6.10 EMERGENCY LIGHTING CONTROL SYSTEM

STANDARDS

To AS/NZS2293 (set).

GENERAL

Refer to Section 11 – EMERGENCY LIGHTING AND EXIT SIGNS. All monitoring control hardware is to be din rail-mounted in electrical switchboards irrespective of the agreed final monitoring solution.

6.11 ACCESSORIES, INSTRUMENTS, METERS

6.11.1 ELECTRICITY METERING EQUIPMENT

STANDARD

To AS62053.22.

TEST LINKS AND STUDS

Provide test links/test terminals for the purpose of calibrating instruments and meters and for shorting of current transformer secondaries. Test terminals shall be positioned in the instrument panel to provide easy access for testing tasks. DIN rail-mounted test links shall consist of screw-clamped slide links and an earth link.

LOCATION

Main panel meters shall be located in a separate panel with removable links in the main panel to allow meter replacement without the need for a main panel shutdown. Where room space limitations do not allow a separate panel, the meters shall be housed in an isolated section of the panel such that meter removal can be performed without the need for a full panel shutdown.

6.11.2 CURRENT TRANSFORMERS

STANDARD

To AS60044.1.

GENERAL

The quantity and rating of current transformers shall be shown on the detailed design and shop drawings.

The current transformers shall be rated to the fault rating at the point of installation without thermal or magnetic damage.

ACCURACY

Accuracy classifications and class to be provided as follows:

- energy measurements: 0.5 M
- indicating and recording instruments: 2 M.

RATINGS

Rated Short Time Thermal Current (Ith) – Current transformers shall have a rated short-time thermal current that is not less than the rated short-time withstand current of the circuit to which the current transformer is installed.

Rated Primary Current (IP) – Current transformers shall have a rated primary current not less than the current rating of the functional unit on the same circuit.

Rated Secondary Current (IS) – Current transformers shall have a rated secondary current of 5 A with the star point earthed.

INSTALLATION

Current transformers shall be installed to permit easy removal in future.

Removable links to length shall be provided for transformers fitted on busbars.

6.11.3 MULTIFUNCTION METERS

GENERAL

Provide multifunction meters having a digital LCD display. Meters shall be DIN rail-mounted, and be of Schneider Electric PowerLogic series or approved equal. The Contractor shall provide current transformers as required by the manufacturer.

Class 1 meters shall be utilised for onselling energy for leasing and tenancies.

Multifunction meters should be designed to be capable of monitoring the following functions as a minimum:

- voltage (line to line, line to neutral) per phase
- current per phase
- thermal demand current, 15-minute averaging
- kW, kVAr, kVA
- power factor
- frequency
- sliding window demand for kW, kVA
- individual and total harmonic distortion to 15th harmonic
- total harmonic distortion (THD).

All above values shall be presented in real time, minimum and maximum.

PROTOCOLS

To suit Curtin University Energy Monitoring System (EMS).

The Contractor shall include all necessary interfaces to ensure full compatibility with the University EMS.

7 LABELLING

7.1 GENERAL

At each light switch, fan switch, equipment power isolator switch and at all GPOs, identification labels shall be provided. Labels shall be installed either at the top of fixing screws or on the inside of removable front plates.

The identification labels shall be engraved with the circuit number and phase colour of the circuit relating to the switch and/or GPO. The base colour of the identification labels shall match the colour of the switch and/or GPO.

7.2 ASSET NUMBERING AND LABELLING

Marking shall include labels for each switchboard control, circuit designations and ratings, fuses fitted to fuse holders, current-limiting fuses, warning notices for operational and maintenance personnel, and the like.

Screw-fix each label adjacent to its relevant item of equipment. Label fixing on equipment is not permitted. Do not use self-tapping or thread-cutting screws.

Labels shall be two-colour laminated plastic Traffolyte.

Printed labels, such as Dymo, Epson, Casio and Brother, will not be accepted.

The colour of labelling shall be as follows:

- warning notices: white letters on red background
- other labels: black letters on white background.

The label lettering height is to be generally not less than the following:

- main switchboard designation: 25 mm
- distribution assembly designations: 15 mm
- HV switchgear and transformers: 15 mm
- small distribution boards: 10 mm
- main switches isolators: 20 mm
- sub main control switches: 10 mm
- identifying labels: 4 mm
- equipment labels within cubicles: 3 mm
- warning notices: 10 mm for main heading, 5 mm for rest.

Refer to the Curtin Labelling Standard for labelling requirements. All labels shall be requested from the operations and maintenance team, which shall update the Curtin database and systems to include the new asset.

Refer to section 2.5.4 for the HV labelling system.

Where legacy or non-system labels exist, the project shall include both labels at each end. The panel manufacturer is to provide a copy of the new label to be installed at the legacy equipment and include both approved system and legacy labels for ease of identification and cross-referencing on site and to as-constructed documentation.

Curtin requirements are secondary to legislative and local authority compliance requirements. Any deviations for this reason are to be noted to Curtin as a deviation stating "for purpose of legislative compliance with [DFES, NCC, Other] requirements".

8 TESTING AND COMMISSIONING

This section outlines the requirements of testing and commissioning to the electrical equipment installed in Curtin University.

8.1 TESTING

STANDARDS

To AS/NZS3000 and AS/NZS3760.

GENERAL

All testing and commissioning shall be undertaken in accordance with regulatory and manufacturers' requirements.

Provide a schedule of equipment that has been tested and tagged including date of test and schedule for next test. The testing results shall be recorded and inserted into operations and maintenance manuals.

INSPECTION/TESTING SCHEDULE

Provide a comprehensive inspection and testing work plan for University approval prior to first inspection/testing.

Provide 10 working days' notice for exact time and date of each inspection/testing.

WITNESSING

All testing and commissioning shall be witnessed by the University.

APPROVAL FOR ENERGISING

Approval shall be obtained from the University prior to energising newly installed or reconnected wiring or equipment.

FAULTY INSTALLATION

Rectify faults, replace fuses and all equipment damaged as a result of incorrect installation works during testing.

CERTIFICATES

Provide regulator and University electrical Certificates of Compliance for approval. Insert copies of Certificates of Compliance within operations and maintenance manuals.

8.2 COMMISSIONING

STANDARD

To AS/NZS3000 and AS/NZS3760.

GENERAL

Provide sufficient notice to the University prior to the commissioning of equipment. A minimum notice of five working days is required.

The site commissioning shall include the following:

PHASE SEQUENCE

Test phase sequence prior to commencement of commissioning to ensure the correct phase sequence is maintained throughout the installation.

BALANCING OF LOAD

Balance load in accordance with AS/NZS3000. Design all circuits so that load balance is achieved at maximum demand and during normal operation.

SWITCHBOARD, RETICULATION AND ACCESSORIES

The installation contractor is required to carry out the following:

- insulation resistance measurements
- full functional and operational check on energised control equipment and circuits, including adjustment for the correct operation of protection devices
- full functional and operational checks for all SSOs and RCDs. Log all RCD test results
- secondary injection testing of circuit-breakers. Adjust settings as required
- earth resistance measurements
- bonding of exposed metal or conductive electrical equipment
- injection testing for the primary of the circuit-breaker supplied from site transformer if secondary testing is not possible.

MULTIFUNCTION METERS

Check and verify operation, calibration and correct output of all meters. Provide calibration and test results.

ATS AND MTS

Check and verify operation of the ATS and MTS. Include all necessary temporary equipment for testing and commissioning if required.

EMERGENCY LIGHTING TESTING SWITCHES

Check and verify operation of the emergency lighting test switches.

DEFECTS

Rectify all defects upon notification. At completion of defects, provide written notice and photographic evidence to the University.

9 RETICULATION DISTRIBUTION

9.1 GENERAL

All cables shall be stranded copper conductors; PVC insulated 0.6 kV, V75 grade conforming to AS3147.

General power circuits shall be wired in not less than 2.5 mm^2 TPS cable.

General light circuits shall be wired in not less than 2.5 mm^2 TPS cable. Cables shall be concealed wherever possible.

Cables installed as surface wiring shall be enclosed in PVC mini ducting in lieu of PVC conduit, subject to approval. The duct shall be fixed to the wall with suitable fixings, not double-sided adhesive tape.

All metal ladders and ducts shall be earthed including joints for electrical continuity.

9.2 NEW AND EMERGING TECHNOLOGIES

Curtin University encourages the use of new systems and innovation within the building services industry. Where project-specific requirements consider new technologies for power reticulation, they shall meet the following:

- approved for use in Australia
- all equipment and parts of the system to be installed in strict accordance with product manufacturer's guidelines
- completed installation to be inspected by the product manufacturer or approved representative
- 5-year full support warranty
- any software license(s) to be provided free issue to Curtin with no ongoing license fees for updates or upgrades
- replacement parts to be available at the Campus within 48 hours or spares provided to maintain operation
- first-of-kind technology deployments on Campus must align with Curtin's connectivity capabilities/strategies
- all technology selections that depart from the Curtin Services Guidelines must be agreed by the relevant technical stakeholders i.e. infrastructure and operations managers. Previous technology use at the Campus does not set a precedent for future use.

Systems that cannot be restored to operation on site within 24 hours shall not be considered for critical project infrastructure.

9.3 TEE-OFF BOXES (RISING MAIN INSTALLATIONS)

Tee-off boxes required for connection of sub-mains shall be provided with circuit-breaker take-offs.

Construction shall allow for easy access of the equipment from the front. Tee-off boxes shall be of a Curtin-approved type.

9.4 BUS DUCTS

Bus ducts may be used for mains cabling of a capacity in excess of 1,600 amps per phase, subject to Curtin's approval.

Bus ducts shall be used only in situations where only horizontal bus duct routes are involved.

Where vertical routes are required to accommodate transitions in bus duct route levels, the vertical runs shall be kept to a minimum. The installation of the bus duct shall be to the manufacturer's requirements to accommodate possible future duct expansion and building structural movements.

Bus ducts shall not be used for sub main and/or vertical riser cabling. Installation of bus ducts over acceptable routes shall be provided in such a manner as to facilitate future maintenance and extension. Acceptable bus duct manufacturers are Square D and Pyrotenax or equivalent.

9.5 METAL CABLE DUCT

Where required, metal duct shall be specified by manufacturer and product code.

9.6 CABLE TRAY AND CABLE LADDER

Cable tray and cable ladder shall be specified by manufacturer and product code.

9.7 SKIRTING WALL DUCT

Skirting/wall duct shall be specified by manufacturer and product code and comply with latest AS3000 requirements. The duct manufacturer, the method of fixing, type and duct lids shall be to Curtin's approval.

9.8 CHASING-IN OF CABLES

Any cables chased into masonry shall be installed in suitable PVC conduit.

9.9 SOFT WIRING SYSTEMS

9.9.1 INTRODUCTION

The purpose of this section is to set out Curtin University’s minimum requirements for the design of soft wiring systems within items of loose furniture. The aim is to meet full compliance with relevant legislation and standards while retaining a degree of flexibility for the University in its operations.

Any design aspects not specifically addressed by this brief or variations to the design standards requirements shall be identified by the consultant during the design process and shall be brought to Curtin University’s attention for resolution. Variations in the design standard shall be submitted in writing to The Manager Electrical Infrastructure or nominated delegate for comment and approval, prior to any such changes or variations being implemented.

It is mandatory that the installation of electrical services and equipment in the buildings associated with the project shall comply with all current statutory requirements and current Australian standards; hence these are not specifically referenced as part of this document.

In all instances the design shall be carried out in accordance with the latest edition of AS/NZS3000 and AS/NZS4703.

For the purpose of this design brief, whenever reference is made to Curtin and/or Curtin University it shall be understood to mean the Curtin University Services Project Manager or Curtin University's nominated representative for the project. In all instances the soft wiring system services shall be documented in accordance with this design standard, in consultation with the designated Curtin representative.

This document confirms the required method and standards to be adopted for all furniture fixed electrical services, as defined under AS/NZS4703.

9.9.2 SCOPE OF WORKS

The scope of works for the electrical services is defined on a project-by-project basis in a separate consulting agreement document, which is to be read in conjunction with this brief. Note that this brief generally covers works associated with electrical services only and does not generally cover the soft wiring aspects of a project.

For details on the communications systems requirements, refer to the *000313 PDG Data Cabling Network Requirements*.

It should be noted that all CAT6/6A communication cabling should only be terminated to a fixed non-movable building fabric such as walls, floor boxes, columns or permanently fixed laboratory benches/furniture adjoining a wall. CAT6/6A cabling shall not be run through loose furniture. From the fixed wall point, fly leads will be used to directly connect into the item of equipment.

9.9.3 REGULATIONS

All designs shall be prepared to ensure compliance of the installation can be achieved in accordance with, but not limited to, the following standards:

- AS/NZS3000
- AS/NZS3008
- AS/NZS4703
- Office of Energy (WAER).

It shall be noted that AS/NZS4703 contains specific requirements not only relating to the quality of material, but also installation methods for electrical services within furniture.

9.9.4 SYSTEM COMPONENTS

9.9.4.1 General

The following system component requirements define the minimum standard acceptable to Curtin University.

Where components are referred to using a brand name or reference this does not imply exclusivity for that item or brand, but does indicate required properties of quality, finish, method of construction, performance and similar that have previously been deemed acceptable to Curtin University.

Variations in the design standard shall be submitted in writing to The Manager Electrical Infrastructure or nominated delegate for comment and approval, prior to any such changes or variations being implemented.

9.9.4.2 Starter Socket

A fixed connection point into the permanent electrical installation has traditionally been achieved using a proprietary manufactured starter socket. For Curtin University projects the starter socket shall be a 20 A-rated switched socket outlet equivalent to Clipsal 2015/20. The outlet surround shall be engraved in accordance with Curtin requirements for a socket outlet (refer sample drawings).

The use of a soft wiring manufacturer's proprietary starter socket, which is brand-specific, will not be permitted under any circumstances.

The use of auto-disconnect socket outlets shall not be permitted.

9.9.4.3 Interconnecting Lead

All interconnecting leads within a soft wiring system shall be double-insulated with a minimum 20 A rating.

All leads and associated plug connectors shall be manufactured in accordance with AS/NZS60898.1.

The designer shall ensure that strain relief of the lead is provided. This is of particular importance for the lead between the wall point and furniture.

Ensure that any lead within the furniture is correctly supported and not allowed to drape along the floor. Where not installed within a cable management system, cables shall be secured at 300 mm intervals as required by AS/NZS4703.

Where multiple sections of furniture are interconnected using a soft wiring system each section of desk shall be fixed together, to ensure that leads are not unnecessarily strained if the furniture is pulled apart. For example, carrels are to be bolted together as indicated on the sample drawings.

For height-adjustable workstations, the cable lead between the under-desk cable tray and the tabletop socket outlet shall be installed within a flexible umbilical to ensure that, when lowered from the extended position, the cable lies back in the cable tray.

9.9.4.4 Furniture Fixed Socket Outlets

All socket outlets shall be of the individually switched type. The use of auto switch socket outlets shall not be permitted.

Outlets shall not be mounted flat (facing up) under any circumstances, irrespective of whether an overall cover is provided or not. All outlets shall be installed so as to maintain a minimum 30 degree incline from the horizontal.

Above-desk socket outlets are typically provided as an angled clamp-on unit. The height of the clamp-on housing shall maintain a minimum clearance of 50 mm between the bottom of the lowest pin on the outlet and the surface of the worktop. This is to ensure that a range of plug top chargers can be used. For example, the CMS Electracom tabletop outlet (ref PO2S00WT) achieves these minimum requirements.

The maximum number of soft wiring outlets connected to a wall-mounted starter outlet shall be limited to:

Staff Workstation:

Maximum of 4 workstations comprising of 3 double socket outlets (Total 12 double outlets).

Student Carrels:

Maximum of 4 singles or can be a combination of multiple outlets.

Photo 1: Under-desk outlet with mounting bracket

Below-desk outlets are typically fixed to an under-desk cable tray system. These outlets shall be provided with a mounting bracket to ensure that the socket is fitted so as not to be facing upwards. The bracket shall also ensure the socket outlet does not move when used.

9.9.4.5 Island Furniture

Where furniture is located away from a wall or column, such as a remotely positioned series of workstations, the permanent installation shall be terminated within a floor box or service pole. The soft wiring installation can then be connected to these fixed and permanent service positions. Service poles should be fixed, top and bottom, to the building fabric i.e. the floor slab.

9.9.4.6 Standard Layouts

Included within this brief are standard designs for a typical workstation, lectern and student carrel. These should be used as a point of reference only and coordinated with the individual project requirements.

Brand items and part numbers should be re-confirmed for each project, as components are regularly updated by the various manufacturers. Installation certificates shall be provided for each project, as noted in the following clauses.

9.9.5 INSTALLATION METHOD

To ensure compliance of the overall installation, the type of installation method is critical. For example, AS/NZS4703 stipulates cable support spacing, segregation of cables and protection of socket outlets.

The installer shall ensure that the documented project works maintain compliance with AS/NZS4703.

9.9.6 TESTING AND COMMISSIONING

The completed installation shall be tested in accordance with requirements of Section 10 of AS/NZS4703 and the following Curtin University additional requirements:

- Test the operation of the RCD from the last socket outlet on the soft wiring circuit.
- Verify that the correct cable supports and outlet configuration (mounting detail) has been achieved.

The consultant shall ensure that the above requirements are completed by the installation contractor and recorded with the project operations and maintenance manuals.

9.9.7 INSTALLATION CERTIFICATION

On completion of the works ensure that the following information is obtained:

- installation test results verifying that tests have been completed as stated above. Testing shall be undertaken by a licenced electrician
- certification from the soft wiring system installer confirming compliance with AS/NZS4703 has been achieved
- certification from the soft wiring system manufacturer for each component item
- certification from the installation contractor confirming compliance with AS/NZS3000.

A record of the above information shall be added to the Electrical Services Operations and Maintenance Manuals.

9.9.8 RELOCATIONS OR MODIFICATIONS

When an existing soft wiring installation is modified or relocated, the above requirements shall be maintained. This will require retesting and certification.

9.9.9 SAMPLE DESIGN DRAWINGS

Links to relevant sample drawings are provided at Appendix B.

9.10 EMERGENCY POWER CUT OFF SYSTEMS

There are areas at Curtin where use of electrical power increases risk to specific operational safety in facilities identifying the need for manual or automatic shutdown.

Typically laboratories and workshops using machinery include emergency stop facilities. It is the intent of this section to expand upon those requirements.

9.10.1 OPERATION AND SAFETY CONSIDERATION

All engineering controls need to complement standard operating procedures (SOPs).

While safety is paramount, operational considerations also need to be taken into account. Curtin has experienced operational problems with safety power systems being tripped and damaging or even destroying years of research.

No research shall be valued over the preservation of life.

9.10.2 DESIGN CONSIDERATIONS

The specific risk and mitigation strategy need to be considered. As an engineering control the emergency stop system should ideally complement the management of the area. Consultation should take place to select the area (**where**), equipment (**what**) and control system (**how**) the risk is to be controlled to manage a safe working environment.

Failsafe systems frequently include no-volt protection. No-volt protection also means that any momentary power outage will remain isolated until reset. These systems are important where a sudden re-energisation of power would lead to increased risk to life typical of moving machinery starting up.

Where no operating procedure is available, the design should adopt a failsafe solution that can be later adapted to an alternate solution.

9.10.3 WHERE – AREA

Emergency stop systems should only disrupt power in the area that the hazard exists. It is not acceptable to have multiple areas being isolated due to an emergency stop button being used or an automatic control sensing a hazard in an adjacent area.

9.10.4 WHAT – EQUIPMENT

The system should only isolate power to equipment that forms part of the risk. Lights and ventilation systems do not necessarily require isolation. For example, a workshop concerned with moving machinery should isolate power to the moving equipment only; isolation lighting is not required and may lead to an increase in risk to occupants. Alternatively, a laboratory using flammable goods may require full isolation as part of an engineered solution.

In the case of lasers and flammable goods, most of these systems and equipment include additional precautions. Failure of a dangerous goods store to ventilate or a laser to maintain temperature conditions is likely to lead to a decreasing safety and operationally poor outcome. The facility manager is to be consulted and agree upon a control method that complements the standard operating procedure. This approach is generally supported in the specific Australian Standard that applies to safety management of the particular facility.

9.10.5 HOW – CONTROL SYSTEMS

The following are options to avoid recognised issues with providing emergency shut off facilities including some of the areas where they apply. The systems identified are not exhaustive but seeks to inform regarding options and engineered solutions.

Interfacing to third party systems needs to be carefully considered. Systems that require power to be disrupted, such as gas leak detection or low explosive limit sensors, may also be capable of resetting the system if not interfaced correctly. This may in some instances be desirable. Again, the operation of the system needs to be understood and a functional description is to be written up and included in the area safety management plan. Where no such plan is available upon request and is not developed as part of the project, the failsafe system shall be explained to the Curtin project stakeholders and submitted with the project design report and on the controls single line drawing.

Functional descriptions generally are to be included on the single line diagram for the emergency shutdown control system.

9.10.5.1 Emergency Stop System with Failsafe No Volt Protection

DESCRIPTION

Typical system used and recognised to have the highest safety. Can be interfaced to manual (red stop buttons), automatic (detectors) or any combination that cut power to equipment powered downstream of the controlled circuit. A contactor is energised that maintains power to downstream equipment. The contactor is powered by a momentary switch, which can be keyed or a green push button that is to be labelled "Emergency Power Reset".

TYPICAL USAGE

Areas where moving machinery presents a danger to occupants where sudden start up would cause injury. It is not ideal in areas where high value research processes are taking place or samples are stored in refrigerators, where sustained power outages will lead to operational loss.

CONSIDERATIONS/PRECAUTIONS

Do not include non-hazardous powered equipment in the same area as emergency stop-controlled environments where possible.

Monitor the emergency stop system such that research staff can be notified of power outages, which may lead to staff needing to be available 24/7 to reset.

9.10.5.2 Battery Back Up to Emergency Control

DESCRIPTION

As above, but includes a battery in the emergency shut-off control circuit to avoid any short-term power outage dropping out the control contactor and therefore requiring a manual reset.

TYPICAL USAGE

Areas where sudden machinery start-up is not a safety concern. May be of benefit where a controlled hazardous detection system, such as dangerous goods, is in use

that has automatic shutdown and can be interfaced to the area electrical power supply. The system, once interrupted, requires a manual reset to be performed.

Good for areas with coolers, heaters, or similar equipment that start where power is available without manual intervention and that cannot be located outside the controlled area.

CONSIDERATIONS/PRECAUTIONS

Backup batteries must be routinely maintained and monitored to ensure the system operates correctly.

The power to equipment is not maintained; it is only restored when power comes back assuming any input system is configured in the same way, i.e. if a detector loses power and opens the circuit it will not restore. Ensure stakeholders understand that this is not a power back-up system and that equipment will receive power but must be able to restart any internal controls automatically.

9.10.5.3 Uninterruptible Power Supply (UPS) to the Whole Area

DESCRIPTION

Uses a standard emergency stop system but includes a monitored UPS that maintains power to the whole area except when an emergency stop is activated.

TYPICAL USAGE

High-value research areas or facilities where a power outage would lead to loss of information or damage equipment to the extent that it cannot be recovered.

CONSIDERATIONS/PRECAUTIONS

A UPS only provides a short-term power back-up that will overcome a brief power outage, typically less than 10 minutes.

They are expensive to maintain, monitor and require plant area to be housed.

They do not necessarily include support systems to areas such as cooling or general lighting.

Any detection system not on the UPS would still trip out the power unless specifically configured to restore power.

Critical equipment should also consider inclusion of a generator-backed supply, examples may include ice sample storage or bio-science research.

9.10.5.4 Fail Powered Systems

DESCRIPTION

Uses normally closed contacts to power systems such that the controls system is required to be powered to disconnect power.

TYPICAL USAGE

These systems are used to send non-critical information to managers or operators where there is no immediate danger to safety. Examples include BMS warnings, low fluid levels or ventilation failure where backed up by failsafe systems that shut down processes or power where required.

CONSIDERATIONS/PRECAUTIONS

They are not typically used on true emergency systems and need specific dispensation to be used in Curtin facilities as a frontline safety system.

They do not provide isolation if the circuit fails and the system does not require to be reset (although emergency buttons will need to be released where they are the lock-in type).

10 GENERAL PURPOSE LIGHTING AND POWER RETICULATION

10.1 GENERAL

General purpose outlets (GPOs) shall be provided throughout as required to locations determined in consultation with Curtin. For typical office space allow for a double GPO to be installed for every 5 m². For all other areas, the number of required power outlets shall be determined in consultation with Curtin.

Lighting sub-circuits shall:

- use cabling of a minimum of 2.5 mm^2
- be limited to a maximum of 2,000 W connected load or 25 lighting points per 2.5 mm² circuit
- be mindful of manufacturer's recommendations in relation to LED inrush current*
- have capacity to add 25 per cent more fittings.

* Leading LED driver manufacturers have technical information relating to minimum protective device ratings that can be used on LED drivers, whereby the inrush can be 50 to 80 times higher than the running current. The maximum number of fittings on a single protective device is limited, and advice from manufacturers should be sought. Many lighting controls in the industry are not designed for high inrush. High inrush on LEDs may damage internal relay contacts in photocells and occupancy sensors, particularly in a retrofit solution.

Major escape stairs shall be provided with two lighting circuits supplied from a distribution switchboard located at the main switchboard or in the immediate vicinity. All stair lighting shall be situated in a place that is readily accessible by maintenance staff and can be easily reached without the assistance of scaffolding or similar.

At least one of the stair lighting circuits shall be arranged so that it operates as a 24-hour circuit or as a circuit which is switched off by a movement sensor or a photoelectric (PE) cell where adequate natural lighting is available. Other stair lighting circuits may be controlled by either lighting motion sensors or PE cells, all in compliance with BCA, Part J6.

Power sub-circuits shall:

- have a minimum nominal rating of 20 amps each
- have a maximum number of double GPOs per circuit of five double GPOs for air conditioned spaces
- be mindful of nuisance tripping and operational continuity, in critical facilities this may require additional separate circuits to avoid high priority equipment losing power due to unrelated faults on third party equipment.

For specialised areas where equipment load demands are low and are considered permanent, the number of points per circuit may be extended. For such a circuit the total connected load of the equipment shall not exceed 70 per cent of the rated protective device. These power outlets shall be numbered and labelled with their circuit identification.

Provide dedicated power sub-circuits for each:

- item of permanently connected equipment
- 15-amp switched socket outlet.

Combined lighting and power circuits are not permitted.

10.2 LIGHTING CONTROL FUNCTIONAL DESCRIPTIONS

The general function of the lighting controls shall include but not be limited to the following scenarios:

10.2.1 OFFICES/ADMINISTRATION OPEN PLAN AREAS

- Local switch On/Off, (with daylight sensing where applicable)
  - Provide intelligent programmable light level sensors, to measure the natural daylight levels and, according to a predetermined lux level, to intelligently monitor and dim various circuits depending on these factors.
- 360° occupancy sensors to be located within these areas as depicted on plans and set-up to automatically turn lighting off after pre-determined periods of no movement.

10.2.2 SECURITY, CORRIDOR AND FOYER LIGHTING

Internal and external security lighting shall be provided to operate during normal hours of darkness. Corridor and foyer lighting shall also be provided throughout all buildings. The lighting shall be switched in the following groups:

Group 1: external security lighting

Group 2: internal security lighting

Group 3: corridor/foyer lighting.

These lighting groups shall each be contactor-controlled at the local sub-board with switch control also available in corridors/foyers. A master/slave or contactor system shall be used where the master contactor is controlled by the time switching function of the C-Bus control system. This shall apply to all external lighting.

External security lighting shall be controlled via C-Bus and shall incorporate a PE cell and time clock function. Information relevant to types and sources of external lighting shall be discussed with the University Project Manager and the Manager, Electrical Engineering. Designated "safe-lit corridors/safe-lit car parks" are to be identified by the University Project Manager and such designated areas to be totally controlled by C-Bus.

Each external lighting group shall have a manual override provided at the local supply distribution board.

10.2.3 CORRIDORS

- Light switch panel to be located at the entry to the corridor to allow for out-of-hours use

- If occupancy sensors are installed they shall be programmed as a re-triggerable timer to automatically turn lights on/off after 60 minutes if no movement is detected.

10.2.4 STORE ROOMS/CLEANER ROOMS

- Switch On/Off, with occupancy sensor, sensors to be programmed as a re-triggerable timer to automatically switch lights on/off after 15 minutes, if no movement is detected.

10.2.5 OFFICES

- Controlled by a local switch and a PIR occupancy sensor
- Switch in the On position sets the system in auto mode turning the lights on and enabling the occupancy sensor, occupancy sensor to be programmed as a re-triggerable timer to switch lights off after 20 minutes if no movement is detected
- The switch in the Off position disables the occupancy sensor and the lights remain off.

10.2.6 PLANT ROOMS AND SERVICE CUPBOARDS

- Local On/Off switch configured with an after-hours reset (typically 17:00 and 00:01).

10.2.7 REST ROOMS

- Controlled by PIR occupancy sensor to be programmed as a re-triggerable timer to turn lights off after 30 minutes if no movement is detected. Should movement be detected in the Off mode, the lights will immediately turn on
- Light switch shall be provided in toilets and shall be programmed with an On function only (i.e. no Off facility) – off function shall be derived from the PIR
- Occupancy sensors to be located in both the air lock and toilet cubicle area.

10.2.8 STAIRS

- Controlled by PIR occupancy sensor to be programmed as a re-triggerable timer to automatically turn lights off after 30 minutes if no movement is detected. Should movement be detected in the Off mode, the lights will immediately turn on
- Light switch shall be provided in stairs at all entry and exit points and shall be programmed with an On function only (i.e. no Off facility) – off function shall be derived from the PIR.

10.2.9 STAFF/MEETING/CONFERENCE/BOARD ROOMS

- Lighting is to be controlled via a local light switch panel and PIR occupancy sensors. Dynamic Label Technology (DLT) switches shall not be used.
- The light switch panel will have the ability to turn the lights On/Off and dim.

- Occupancy sensor is to be programmed as a re-triggerable timer set to 45 minutes, when no occupancy is detected the lights to fade off over 30 seconds.
- Dimming facility will be via the light switch panel with the ability to turn the lights off adjacent to the projector screen.
- Where applicable, interfacing to other media facilities shall be provided.

10.2.10 LABORATORY/TEACHING/PREP AREAS/FOYERS/STUDY AREAS

- Lighting is to be controlled via a local light switch panel and PIR occupancy sensors.
- The light switch panel shall have the ability to turn the lights On/Off and dim.
- Occupancy sensor is to be programmed as a re-triggerable timer set to 30 minutes turning lights to auto after 30 minutes if no movement is detected.
- Dimming facility via the light switch panel with the ability to turn the lights Off adjacent to the projector screen/whiteboard.

10.2.11 PERIMETER DIMMING

- The luminaires on the perimeter of the building shall generally be controlled such that in the event of there being sufficient natural light from the windows, the luminaires shall be dimmed in response to the available natural illumination via the lighting control system.
- Where perimeter dimming is used an appropriate dead band and ramp time shall be set up in the system to ensure that lighting does not visibly ramp up or down causing distraction to the users. Perimeter dimming shall not switch lights off within any space.

10.2.12 PRESENTATION AREAS

- Luminaires shall replicate the needs of the presentation through dimming and scene setting.
- There shall be a human interface device (HID) that has direct control of the fittings through the lighting control system.
- There shall be a programmable lighting control system used to control lights as described in this document.
- Refer to the *000318 Audiovisual Guidelines Part 6 – Room Design and Construction* for lighting control requirements relating to audiovisual presentation areas.

10.2.13 THIRD PARTY CONTROL SYSTEMS

- Where lighting control scenes are selected by a third party system such as presentation systems they shall interface to the Curtin lighting control system.
- Third party systems shall not have direct control of luminaires.
- A mimic HID shall be installed in the controlled area; the HID shall have the same scene settings available as to the third party system.

- The system shall be arranged such that the last input from either the third party system or the HID shall set the scene that the lighting control system uses to set light levels.

10.3 LIGHTING CONTROL SYSTEM EQUIPMENT

10.3.1 TOUCH SCREEN

The colour touch screen shall be capable of controlling and monitoring the lighting control system.

A programmable touch screen device connected to the data network shall provide scheduling and scene management. Functionality to be provided by the touch screen product shall be a minimum of:

- touch screen to be located in a nominated room (generally the main switch room or secure appropriate facility within the building)
- pages to be set up to mimic inputs and outputs to individual areas as nominated
- real-time clock display and setting facilities from the touch screen
- touch screen to provide scheduling function for internal, external and security lighting
- schedules shall be able to be modifiable by the user without the use of any programming tools or devices.

10.3.2 SWITCHES

One switch shall be provided for each on/off/dim function. Dynamic Label Technology (DLT) switches shall not be used.

10.3.3 ETHERNET INTERFACE

Provide a C-Bus Ethernet Interface, (part number 5500CN), located in the communications room and patched back to the communications cabinet. Network the system so that it can be connected to a central maintenance lighting control centre using scheduled software.

10.3.4 NETWORK BRIDGE

Network bridges shall be allowed for the building as required. Limit each network to a maximum of 70 devices and 700 metres of network cabling to allow 30 per cent expansion for future use. A backbone network topology for the project is to be submitted to Clipsal Integrated Systems for approval prior to construction.

10.3.5 RELAY AND DIMMER CONTROLLERS

The relay, dimmer and gateway modules shall be housed in an approved enclosure adjacent to the floor distribution switchboard within the electrical riser. Alternatively an extension to the floor distribution switchboard can be provided to house the modules.

10.3.6 MAXIMUM CABLING LENGTH AND NUMBER OF DEVICES

The maximum total cable length for a network is 1,000 metres or a maximum of 100 devices. Our recommendation is not to exceed 700 metres or 70 devices per network to allow 30 per cent expansion for future use. If this is to be exceeded the project must be split into multiple networks and then joined via a 5500B network bridge.

10.3.7 SYSTEM INTERFACE

The lighting management system shall have the ability to interface to the building management system at various levels:

- volt-free contact
- BACnet IP Gateway
- OPC Server software.

10.4 LEGACY LIGHTING CONTROL STANDARD C-BUS

This section describes the requirements for legacy lighting control systems that use C-Bus technology at Curtin University. Section 10.5 describes the requirements for the digital addressable lighting interface (DALI) system that Curtin University now uses.

10.4.1 C-BUS

The C-Bus system provides total lighting control for internal and external lighting including: building, grounds, architectural and security lighting attributed to the project. The lighting control system includes all switching modules, dimmers, switches and other control devices, control panels, power supplies, wiring and other equipment necessary to provide a complete and operational installation.

Personnel carrying out works on the Clipsal C-Bus ALCS are required to have undertaken the Basic and Intermediate C-Bus Training carried out by Clipsal Integrated Systems. In addition individuals must have attained an Approved Installer and/or PointOne Accredited Integrator qualification for the Clipsal C-Bus ALCS.

A list of suitably qualified personnel undertaking work on the C-Bus project shall be submitted to the Project Manager and Responsible Officer prior to any work being undertaken on the C-Bus installation.

Installation, testing and commissioning of the Clipsal C-Bus ALCS shall be carried out in conjunction with Clipsal Integrated Systems and an approved commissioning technician.

10.4.2 SYSTEM

The Clipsal C-Bus ALCS is microprocessor-based and utilises Category 5E Unshielded Twisted Pair (UTP) cable with 240 V AC insulation rating as the communication medium between intelligent network nodes to control lighting.

The system comprises modules with in-built microprocessors, which can be programmed via either learning the relationships between input and output devices

without the use of a personal computer or at a higher level with a personal computer using Microsoft Windows-based application software.

All hardware shall meet the requirements for electromagnetic compatibility for certification with the CE mark.

New devices shall continue to maintain programmed parameters during power failures with Non-volatile Random Access Memory (NV-RAM). The control system shall remain fully functional in the event of supervisory computer shutdown or failure.

The Clipsal C-Bus ALCS shall use high-speed, full duplex communications protocol. The system shall provide constant feedback on the operational status of inputs and outputs and have the ability to interrogate the status of specific modules.

The Clipsal C-Bus ALCS protocol shall implement the International Standards Organisation (ISO) Open Systems Interconnection (OSI) seven-layer reference model for communication protocol.

The Clipsal C-Bus ALCS protocol shall provide transmission error checking for all information passed over the network.

The C-Bus Automatic Lighting Management System shall incorporate the following facilities:

- time-based scheduling for energy management control of lighting
- photoelectric cell dimming control of the open plan area artificial lighting and lumen depreciation compensation
- occupancy sensors for energy management control of lighting
- easily programmable energy management and time control, using PC and Windows-based configuration software
- the ability to interface with the Building Management System (BMS) at high or low level
- automatic OFF control of lighting if required
- automatic ON control of lighting if required
- automatic ON and OFF control of lighting using occupancy sensors
- manual ON/OFF control of lighting at all times
- an easily configurable logic engine to enable implementation of network logic functions and control scenarios
- a full range of plastic, stainless steel and glass-faced switch panel options
- the option for 'Dynamically Labelled' switch identification using DLT technology
- compatibility with luminaire control gear generally available.

The above control philosophy shall form the basis of the C-Bus ALCS design. Where the designer believes inconsistencies exist between the design philosophy and the building intent or where the designer believes individual safety may be compromised through any functions or design element of the lighting control, the designer shall bring this to the Project Manager's and client's attention as a matter of urgency.

10.4.3 ELECTRICAL

The Clipsal C-Bus ALCS uses an extra-low-voltage (less than 36 V DC) bus to interconnect all control and switching units. Curtin standard data installation methodology shall be used as the wiring medium for this bus, refer to *000313 PDG*

Data Communications Cabling Requirements. Input and output units shall be connected on the system bus in parallel.

The Clipsal C-Bus ALCS shall be powered by a two-wire network, superimposing data and unit DC power supply onto one pair of data wires, avoiding multiple connections of the networked devices. Short circuit of the network power supply shall have no long-term effect on the system once the fault is repaired.

Each unit shall have a unique serial number embedded in firmware for ongoing product traceability and warranties, be individually programmable and be identified by a unique network address code.

The Clipsal C-Bus ALCS bus shall be electrically isolated to 3,500 V AC RMS for one minute from the mains wiring.

10.4.4 LIGHTING CONTROL SYSTEM DESIGN REQUIREMENTS

10.4.4.1 Documentation

The installing contractor shall provide a complete set of as-constructed drawings and an end user instruction booklet.

Label all C-Bus distribution board schedules internally and include C-Bus unit numbers on the module, refer to the labelling section.

Include secure copies of electronic databases of all programmed devices including C-Bus Tag database, C-Touch Project file xml, PAC xml file or any other files needed for backup and/or continued operation of the system.

10.4.4.2 Warranty

The Clipsal C-Bus carries a two-year warranty; the installer shall provide proof of installed dates to Clipsal and ensure the installation is subject to the manufacturer's conditions of warranty. At completion of this the contractor shall notify the University through the Project Manager that this has been undertaken so that the warranty period can be validated.

10.4.4.3 Placement and Selection of Accessories

Accessories shall be positioned in a logical and meaningful way such that, when an individual enters an area, lights can be quickly, easily and safely activated.

With respect to internal areas, reliance on sensors alone for switching purposes is not acceptable as such switches shall accompany all areas having motion sensors.

The designer shall specify adequate numbers of motion sensors to allow for low occupancy levels and/or where occupants may be relatively inactive for long periods of time e.g. examination venues (extending re-trigger times is not seen as an acceptable solution for a shortfall in motion sensor numbers).

Individual C-Bus controls shall have a dedicated feed from the local distribution board.

C-Bus relays and dimmer units shall be located on each floor in a centralised position within a dedicated custom-made metallic distribution enclosure. The number, size and

location of C-Bus distribution enclosures shall be dictated by the installation technical requirements as well as the size and shape of the floor area. Adequate spare capacity shall be incorporated on each C-Bus distribution board for future expansion of the lighting control system.

For designers who are inexperienced in C-Bus installation, it is prudent to contact Clipsal Integrated Services in respect to system functionality and appropriate technical and design information.

10.4.5 LIGHTING CONTROL SYSTEM NAMING CONVENTION

10.4.5.1 Purpose

A naming convention is required to ensure the following:

- consistency in the naming of the various projects, networks, devices and load groups in each building
- a mechanism to easily identify where the device is located and what area it controls
- minimising the use of cryptic acronyms wherever possible.

10.4.5.2 General Format

The general format of a point name shall be:

Project - Network - Application - Group Address

where each field is described below:

Project	Describes the name of the building and site (up to 8 characters)
Network	Describes the vertical or horizontal location as a floor level (floor level, car park, basement, Level 1 West)
Application	Describes the control system application (Lighting, Heating, Enable, Control, Lighting Level 1)
Group Address	Describes the controlled load type and location (Room 2.011, Passage West Wing, Theatre Front Row, Step Lights)

Notes:

- The concept is that a programmer or maintenance staff member is able to identify the group address or tags with minimal reference to drawings or documentation.
- The project identifier can only have up to 8 characters; all of the other identifiers have up to 32 characters.
- Use of the application address for lighting control is restricted to C-Bus Application Addresses 048 to 094 (Hex 30 to 5E) – default application is 056 (Hex 38).

Project	Network Tag	Application Tag	Group Address Tag
Admin 1	Level n	Lighting	RM2.011 Front W1
Build 21	Basement n	Lighting_Level 1	RM2.011 Centre R1
Theatre	Car Park	Lighting_Level 2	Lift Lobby
	Level n West Wing	Administration_Level 2	Table Light
		Motorised Blinds	Corridor West Side
		Heating	Foyer
		Lighting_Level 1	RM2.011 Blind
		Lighting_Level 2	Toilet Male
		Lighting_Level 2	Toilet Female
		Lighting_Level 2	Toilet Disable
		Enable Control	Level 1 AM On
		Trigger Control	Boardroom All On (scene)

10.4.6 DEVICE IDENTIFICATION

All units on a C-Bus network have a unique identity code called a Unit Address, which identifies a specific device connected to the C-Bus network. A reserved unit address approach should be taken when designing the project and the following format should be considered.

Each field is described below:

Unit Address: Unique code that identifies each unit on a single network

Part Name: Tag to identify unit, restricted to 8 characters

Tag Name: Tag to identify unit, up to 32 characters.

- Reserved address approach should be used where the outputs start at Unit Address 001 and input devices from Unit Address 020 and above.
- Unit Address 255 is reserved as a default for new units, no C-Bus device with this address should be left connected to the network once commissioning and handover has been completed.
- Where detailed information is required the Tag Name property box should be utilised to provide as much information as possible.

C-BUS DEVICE TABLE OF IDENTIFIERS

Unit Address	Part Name	Tag Name
Decimal addresses	Up to 8 characters	Up to 32 Characters
001	RM_508	RM_508_Switch 1
to	RM_508	RM_508_PIR 1
254	CORRIDOR	Corridor West wing
	FOYER	Foyer Reception Area
	PIR_1	RM_206
	Switch_1	RM_206
	DB1_RLY1	DB_1 Relay 1
	DB1_DIM1	DB_1 Dimmer 1

Notes:

- Where the naming convention would result in the same description for two units, each should be individually identified using numbers (e.g. RM_508_Switch 1, RM_508_Switch 2).
- Level/floor numbering and switchboard zones should correspond with the latest version of construction drawings.
- For load group and room numbering please refer to architectural drawings prior to developing an addressing hierarchy.
- Abbreviations are strongly discouraged. They should only be used where the C-Bus system cannot accommodate the full text description.

10.5 LIGHTING CONTROL STANDARD DALI

10.5.1 INTRODUCTION

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

All lighting control systems shall have read/write capability both locally and from the Operations and Maintenance Management Building.

The lighting control system will be a multi-master digital addressable lighting interface (DALI) system with electronic control gear (ECG) in all light fittings, emergency lights and exit signs controlled by multi-master DALI electronic control devices (ECD) connected to DALI lines throughout the interior space. The electronic control gear in

light fittings and electronic control devices such as switches and sensors are to fully comply with the DALI Standard (IEC62386) enabling equipment from multiple manufacturers to be used in the system. Where possible, all electronic control gear shall comply with Version 1 of the DALI Standard in order to provide manufacturer, serial number and other related data held in DALI memory.

DALI lines are to be linked on an Ethernet network using DALI control DCBMx-1608 line controllers from Clipsal to provide scheduling, monitoring, configuration and control functions over the Ethernet network. The DALI line controllers are to expose lighting status and configuration data over Ethernet for integration with other building services.

The lighting system must provide manual control, scheduled occupancy control, automatic presence detection, absence detection and daylight harvesting to dim down the electric lighting in response to daylight admittance.

The lighting controls are to utilise time schedules, occupancy sensors, light sensors and switches to control the lighting in the interior spaces on each floor. The overall intent is to provide electric light only when the space is occupied and to provide as little electric light as is necessary to achieve the required light level for the workplace.

The line controllers are to automatically monitor the status of all DALI ECGs in luminaires and emergency light fittings on the DALI lines and to provide the tools to identify and replace ECG and lamp failures.

The electrical subcontractor should engage Clipsal & Schneider Electric Partner Business Project Services Group for the design, commission and project management of the digital lighting control system and the emergency and exit lighting system, or an equivalent service provider approved by the Curtin University Infrastructure Manager.

10.5.2 SYSTEM DESCRIPTION

The lighting control system shall consist of multiple DALI lines linked to form a building-wide solution using intelligent DALI control DCBMx-1608 line controllers connected on an Ethernet network.

The system is designed as a distributed control system where all DALI line controllers, switches, sensors, input modules and other DALI ECDs must co-exist, enabling devices from different manufacturers to be mixed and matched to provide maximum flexibility now and in the future.

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

The DALI system shall be capable of incorporating DALI ECGs from multiple vendors including:

- ballasts for linear and compact fluorescent lamps
- exit signs and emergency light units
- control gear for high intensity discharge lamps
- transformers for low voltage fittings
- dimmers for incandescent lamps

- drivers for LEDs including RGB fittings
- relay and output modules
- fan controllers
- blind controllers
- future DALI ECGs from various manufacturers.

The system is to be capable of incorporating multi-master DALI ECDs including;

- line controller
- pushbutton switch
- rotary switch
- up/down rocker switch
- motion detector
- light sensor
- infrared receiver
- multi-sensor with auxiliary input
- advanced 4-input module
- future DALI ECDs and controllers from various manufacturers.

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

The DALI power supplies shall be intelligent devices with integrated on/off button, test button and status LEDs for each DALI line equal to the following Clipsal unit:

- DCDALCIP250-2 Dual Intelligent Power Supply.

10.5.3 WIRING AND INSTALLATION

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

A single DALI line has the following constraints:

- The voltage range at the DALI power supply must be between 11.5 V and 22.5 V, with a typical value of 16 V DC.
- The voltage drop over the length of the DALI control wires must not exceed 2 V DC.
- The maximum permitted line current is 250 mA.
- The maximum number of addressable DALI ECGs is 64.
  (ECGs that take a DALI short address include fluorescent ballasts, LED drivers and emergency inverters. DALI ECGs must not draw more than 2 mA.)
- The maximum number of addressable DALI ECDs is limited by the DALI power supply and the number of DALI ECGs on the DALI line.
- The sum of the current consumptions of all the DALI ECGs and DALI ECDs on the DALI Line must not exceed the nominal current of the DALI power supply used.

In order to provide simple installation, ease of modification and expansion, DALI Lines shall be wired using a five-wire mains-rated soft-wiring system equivalent to the Clipsal DALI infinity m3 5-pole cabling system.

The cable shall have the following characteristics:

Marking	Conductor Size	Wire Colour	Description
N	2.5 mm^2	Blue	20 A Neutral Conductor
Earth Symbol	2.5 mm^2	Green/Yellow	Protective Earth
L	2.5 mm^2	Brown	20 A Active Conductor
DA-	1.5 mm^2	Grey	DALI Control Wire
DA+	1.5 mm^2	Black	DALI Control Wire

Luminaires shall be connected to the DALI line via a 5-core fly lead and T-connector. The 5-core fly leads are to be supplied to suit the installation but shall have a minimum length of 1.5 m.

ECDs such as switches and sensors shall be connected by 5-core or 2-core fly leads as required.

Emergency luminaires and exit signs shall be connected to the nearest DALI line and be powered by the DALI active conductor to minimise cabling and installation costs.

10.5.4 DALI LINE CONTROLLERS

The DCBMx-1608 line controllers are required to link the distributed DALI lines onto an Ethernet network to provide a building-wide DALI system. The line controllers provide configuration, monitoring, control, reporting and maintenance functions.

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

The line controllers shall provide local intelligence and features including:

a) integrated real-time clock with automatic daylight savings adjustment and leap-year correction
b) integrated sunrise/sunset support based on site location (latitude and longitude)
c) automatic time schedules to control groups for scheduled occupancy with support for active periods and holiday exceptions
d) 16 multi-function digital inputs for pushbutton switches and sensors, including occupancy sensors and daylight sensors, and for integration with other building services such as access control and security panels
e) four input profiles to provide tailored input configurations for different periods of the day including office hours and after-hours
f) eight digital outputs for additional control and interlocking to external equipment such as fans and blinds
g) up to 32 configurable sequences for override sequences, mood and effect lighting
h) up to 32 configurable command lists for advanced control and effects

i) support for one or two DALI lines (up to 64 or 128 DALI ECGs)
j) zone control, whereby groups on different DALI lines are controlled together as one entity
k) an in-built web server for status and error reporting of DALI line, ECG and lamp failures. The status shall include lamp hours
l) DALI emergency testing and reports
m) local processing. In the event of network failure or disconnection from the Ethernet network, the line controller is to continue to run automatic time schedules and sequences and process inputs independently
n) computer monitoring and configuration. The Line Controller shall allow configuration, monitoring and analysis from computers on the Ethernet network
o) computer control. The line controller shall have the ability to control the local lighting using their computers on the network.

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

10.5.4.1 Line Controller Inputs and Input Profiles

The DCBMx-1608 line controller inputs are required to provide manual control through the use of switches and pushbuttons, occupancy control using motion detectors and daylight harvesting using light sensors. The inputs may also be used for integration with lift controllers, fire panels, security panels, access control systems and building managements systems.

The line controller shall provide:

a) 16 multi-function digital inputs for use with switches, pushbuttons, occupancy sensors, light sensors etc.
b) multi-group functionality so that one input can control multiple DALI groups. An input is not to be limited to a single group
c) dynamic input profiles that enable an input to operate differently for normal-hours and after-hours operation.

Examples of uses for this functionality include but are not limited to:

a) Wallplate Pushbutton

Office Hours: Single button dimmer
After Hours: Toggle MAXIMUM/OFF with override sequence

(30 mins MINIMUM, 5 mins OFF)

b) Wallplate Pushbutton – After-hours cleaners

Office Hours: Single button dimmer
After Hours: Toggle 60%/OFF with override sequence

(25 mins MINIMUM, 5 mins OFF)

c) After-hours Occupancy Sensor

Office Hours: disabled (lights are scheduled ON)
After Hours: 30-minute override sequence

(30 mins MINIMUM, 5 mins OFF)

d) Occupancy Sensor with variable override

Office Hours: 60-minute override sequence
After Hours: 30-minute override sequence

e) Toilet occupancy – Occupancy Sensor

(Toilet lights are scheduled ON to MINIMUM)
Office Hours: MAXIMUM, 15 mins MINIMUM
After Hours: 30-minute override sequence.

10.5.4.2 Automatic Time Schedules

In order to cater for scheduled occupancy of the building the line controllers shall include an integrated real-time clock and automatic schedule control.

The line controller shall provide:

a) an integrated real-time clock to allow automatic time schedules to be run independent of the Ethernet network and which is to provide automatic daylight savings adjustment and leap year correction
b) sunrise/sunset support based on site location. Schedules are to be provided with a configurable offset to allow lighting to be controlled relative to dusk and dawn
   e.g. Sunrise +20 minutes
   Sunset –30 minutes
c) active periods where a timer can be configured to fire only within a defined date range
   e.g. From June 1 to Aug 31 2012.
   From June 1 to Aug 31 every year
d) custom time schedules, to be configurable for an absolute time
   e.g. Office Open, Monday to Friday at 8:30 am
   Cleaners lights, Thursdays at 8:00 pm
e) repeat timers
   e.g. Run façade lighting sequence every 30 minutes from 7 pm until 11 pm
f) Time schedules must be able to be configured to include or exclude holiday periods. Holiday periods are to be configurable for one or more days and are to be able to be selected as perpetual (e.g. January 1, every year)
g) Scheduled actions are to include all DALI arc levels (e.g. 80%), DALI indirect commands (e.g. GOTO MAXIMUM, RECALL SCENE2), Sequences (e.g. 50%, 5 mins 25%, .5 mins OFF) and Command Lists.
h) Configuration of the time schedules is to be completed from a computer over the Ethernet network.

10.5.4.3 Sequences

Control sequences are required to provide multi-step override timers and mood and effect lighting.

Examples of uses for sequences include:

Simple Override Sequence	30 mins MINIMUM, 5 mins OFF
Complex Override sequence	30 mins 75%, 5 mins 50%, 5 mins 25%, 5 mins OFF
Delayed exit button	Go to 50%, 5 mins MINIMUM, 5 mins OFF
Façade colour mixing	Variations in red, green, blue over time
Mood lighting	SCENE1, 20 sec SCENE2, 30 sec SCENE3, 40 sec SCENE4

- The line controllers are to be able to store 32 sequences of up to 8 steps where each step consists of a configurable time delay and action. Longer sequences are to be achieved by linking sequences.
- Sequences are to be activated by a time schedule, from an input or by touch screen via the Ethernet network.
- Configuration of the sequences is to be completed from a computer over the Ethernet network.

10.5.4.4 Command Lists

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

- The line controllers are to be able to store 32 command lists of up to 8 steps where each step consists of a target ballast, group or zone, a configurable time delay and an action. Longer command lists are to be achieved by linking command lists.
- Command lists are to be activated by a time schedule, from an input or by touch screen via the Ethernet network.
- Configuration of the command lists is to be completed from a computer over the Ethernet network.

10.5.4.5 Status and Error Information

The line controllers are to monitor the connected DALI lines and are to provide status and error information for DALI lines, ballasts and lamps.

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

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

10.5.4.6 Maintenance and Control Gear Replacement

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

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

10.5.5 POWER SUPPLIES

DALI power supplies are critical to the operation of the system and the communication between devices and must fully comply with the DALI Standard.

The DALI power supplies must provide:

- between 11.5 V DC and 22.5 V DC with a typical value of 16 V DC
- a maximum line current of 250 mA
- over-voltage protection
- the ability to operate within the environmental conditions up to a 55 °C temperature and a 90 per cent relative humidity.

In addition the DALI power supplies must include the following functions to enable control, installation test and commissioning to be carried out locally at the switchboard:

- on/off buttons for each DALI line
- test buttons for each DALI line to cycle lights and identify emergency lights and control devices
- automatic DALI addressing without the need for a computer or network connection
- status LEDs for each DALI line
- integrated commissioning port for local configuration changes.

DALI power supplies will be Clipsal DALI control DCDALCIP250-2 Dual DALI Intelligent Power Supplies or an approved equivalent.

10.5.6 ELECTRONIC CONTROL DEVICES

DALI Electronic Control Devices are connected to a DALI line and issue commands to control DALI lighting, emergency lighting, relays and other electronic control gear. ECDs include pushbutton switches, rotary switches, rocker switches, motion detectors and light level sensors.

- DALI ECDs shall be able to control up to four DALI targets. Each target may be a DALI Group Address or a DALI ECG Short Address so that the ECD can control four groups, four short addresses or a combination of the two.
- DALI ECDs shall support up to four profiles. Each profile shall contain a separate configuration for the ECD so that it can control different lights and provide different functionality for each profile.
- DALI ECDs shall support override sequences that can be used to ensure that lights do not remain ON when a room or area becomes vacant. ECDs must be

able to provide a visual warning and warning period before commanding the lights OFF.

ECDs such as pushbutton and rotary switches are mounted in wallplates while sensors are mounted in wallplates or in the ceiling (recessed or surfaced-mounted).

Wallplates with various configurations of switches and sensors are required to provide manual and automatic control of lighting in a room or area. Wallplate styles are detailed in the drawings and configuration details for operating hours, after-hours and backup power operation are detailed in the specification control schedule.

The ECDs are positioned as indicated on the drawings and may contain the following types:

10.5.6.1 Pushbutton Switches

Pushbutton switches are required to provide the occupant with manual control of the workspace lighting. The switches are to be configurable so that they can issue different DALI commands depending on the usage requirements of the space.

The pushbutton switches are to be connected directly to the DALI line containing the lights they are controlling. The pushbutton switch will be a Clipsal DALI control DCDAL31M2 or DCDAL31S-PB or approved equivalent and provide the following configurable functionality:

a) Single Action Button

The pushbutton switch sends the same command each time it is pressed
e.g. Goto Scene 1 (i.e. Presentation Scene)

b) Multi-Action Button

The pushbutton switch has a list of up to four commands. The pushbutton switch sends the next command each time it is pressed e.g. Press1: Recall MAXIMUM, press2: Goto Scene 1, press3: OFF

c) Toggle Button

The pushbutton switch alternates between two commands each time it is pressed
e.g. Recall MAXIMUM, OFF

d) Single Button Dimmer

The pushbutton switch toggles between different commands depending on the current group state and whether there is a short press or a long press e.g. Short press: Recall MAXIMUM or OFF, long press: Up or Down

e) Two Button Dimmer

The pushbutton switch sends different commands depending on whether there is a short press or a long press
e.g. Short press: Recall MAXIMUM, long press: Up
Short press: OFF, long press: Down

f) Status LED

A LED that can be configured to provide group status, communications status and nightlight.

10.5.6.2 Rotary Switches

Rotary switches are required to provide the occupant with manual dimming control of the lighting. The rotary switch provides pushbutton ON/OFF control and a rotary knob for dimming.

The rotary switches are to be connected directly to the DALI line containing the lights they are controlling. The rotary switch will be a Clipsal DALI control DCDAL31M2 with DCDAL31S-ROT or approved equivalent.

10.5.6.3 Rocker Switches

Rocker switches are required to provide the occupant with manual dimming control of the lighting. The rocker switch provides ON/OFF control and an up/down rocker for dimming.

The rocker switches are to be connected directly to the DALI line containing the lights they are controlling. The rocker switch will be a Clipsal DALI control DCDAL31M2 with DCDAL31S-UD1 or approved equivalent.

10.5.6.4 Occupancy Detectors

Occupancy detectors are used to control lighting depending on the occupancy of an area.

The detectors shall have configurable settings that enable them to be configured for fully automatic or semi-automatic operation with configurable idle and warning periods. The idle period defines the length of time an area is vacant before a warning command is issued and the warning period is the length of time before the OFF command is issued.

The occupancy detectors are to be connected to the DALI line containing the lights they are controlling. The detectors are to provide the following configurable functionality:

a) **Fully Automatic Presence Detection**
   The sensor sends a command to bring on the lights when motion is first detected in an area. If an area is vacant for a period of time the lights are dimmed before being commanded OFF.
b) **Semi-automatic Absence Detection**
   The lights are brought ON by a switch or other DALI ECG. If the lights are left on and the area becomes vacant for a period of time the sensor dims the lights before commanding them OFF.

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

The occupancy detectors will be a Clipsal DALI control DCDALMS360 or DCDAL31M-OD or approved equivalent, as indicated on the drawings.

10.5.6.5 Light Sensors

Light sensors are used to control the dimming level of a group of lights depending on the light level of an area as determined by a light sensor. The light sensor is typically used to control a group of ballasts adjacent to a row of windows.

The group of lights to be controlled is to be configurable allowing the space to be reconfigured or modified without changing the fixture wiring. The light level sensor will be a Clipsal DALI control DCDALMS360 or DCDAL31M-PE or approved equivalent.

When the group is on, the light level shall be raised or lowered depending on whether the light level determined by the light sensor is above or below the set point.

10.5.6.6 Multi-sensors

Multi-sensors are required to provide manual and automatic lighting control for a room or office. The multi-sensor must provide a motion detector, a light sensor and an auxiliary input to connect a push-to-make switch.

The switch is required to provide the occupant with manual on/off and dimming control of room lighting while the motion detector ensures that the lights do not remain ON when the room is unoccupied. The multi-sensor shall be a Clipsal DALI control DCDALMS360 or approved equivalent. The push-to-make switch shall be a Clipsal 30PBBP pushbutton bell press switch or similar.

10.5.7 ELECTRONIC CONTROL GEAR

DALI ECDs are to be supplied in luminaires and emergency and exit lighting as indicated on the drawings. The luminaires are connected to a DALI line and are to be controlled by commands from DALI electronic control devices such as DALI switches and sensors.

DALI ECGs shall comply with the relevant part of the IEC 62386 DALI Standard as follows:

201 Fluorescent Lamps

202 Self-contained Emergency Lighting

203 Discharge Lamps

204 Low Voltage Halogen Lamps

205 Incandescent Lamps

206 Conversion from Digital into D.C. Voltage

207 LED modules

208 Switching function (Relays)

209 Colour control

210 Sequencer

211 Optical control.

ECGs should be compliant with Version 1 of the DALI Standard unless otherwise approved.

10.5.7.1 DALI Relay Modules

The DALI relay modules are required to provide on/off control for non-dimmable loads such as fixed output electronic ballasts, incandescent lamps, fans, motors and blinds. The modules are to accept DALI commands over the DALI line allowing modules to be placed adjacent to the load to be controlled.

DALI relay modules are:

a) to be compliant with Part 208 of the DALI Standard
b) to support threshold settings
c) to support DALI scenes.

The DALI relay modules shall be Clipsal DALI control DCDALRM2 or an approved equivalent and are to be provided as indicated on the accompanying drawings.

10.6 ACCESSORIES AND OUTLETS

10.6.1 GENERAL PURPOSE OUTLETS

General purpose outlets (GPOs) shall be selected from the standard range of a Curtin-approved manufacturer and shall be specified as white from the corresponding standard colour range.

Double outlet combinations shall be specified throughout the installation.

IP56 Series shall be specified for wet areas. The circuit current load shall be no more than 60 per cent of capacity when initially installed.

All circuits for GPOs and lighting shall be protected by earth leakage circuit-breakers (ELCBs) or residual current devices (RCDs). RCDs are to be installed in the switchboards instead of on their respective power points.

Emergency stop buttons shall be installed for safety control for laboratory power outlets. The location of any RCD or ELCB remote from the corresponding switchboard shall be approved by Curtin.

10.6.2 LIGHT SWITCHES

Light switches shall be selected from Clipsal or from any other Curtin-approved manufacturers and shall be specified as white from the corresponding standard colour range. 15-amp mechanisms shall be specified for all standard light switches.

10.7 GENERAL

10.7.1 ENERGY EFFICIENCY

Lighting installations shall be designed for economical life, energy consumption and low greenhouse gas emissions. All materials installed or replaced shall be sourced or

disposed of in line with environmentally sustainable industry best practice, for example lamp disposal and lifecycle analysis.

10.7.2 LAMP TECHNOLOGY

Important characteristics of lamps used for University lighting are the energy efficiency and the lamp life.

The University's aim is to use high efficacy LED light fittings.

In line with international trends, the University wishes to phase out High Intensity Discharge lighting across its campus as quickly as possible. Mercury vapour lamps shall not be used within the University.

10.7.3 MAINTENANCE

The number of consumable items such as lamps and control gear should be rationalised to minimise the stock of spare parts.

10.8 INTERNAL LIGHTING

This clause addresses only the general lighting aspect of the installation. Any other specialist lighting requirements shall be discussed separately with Curtin.

Lighting design shall comply with AS1680.0 'Interior Lighting' including recommendations detailed in AS1680.2.2 – Interior Lighting – office and screen-based tasks.

- Light fittings and lamp type shall be selected as appropriate for the area to be served and as required for compliance with BCA, Part J.
- The entire lighting installation shall comply with the requirements of Part J of the current BCA. In addition, it is Curtin's intention for project internal lighting systems to achieve an overall efficiency of less than 8 watts/m².

Interior luminaires shall have the following requirements/characteristics/features:

- positive locking of diffusers
- covered control gear
- UV-rated cabling
- fused terminal block
- IES data provided for luminaires
- use of Phillips, ATCO, Meanwell or Voscher Swarbe control gear.

Dichroic and Dulux tubes shall not be used.

Maintenance factors used as part of the design solution to achieve recommended light levels must be endorsed by Curtin University as operationally acceptable. This specifically includes frequency of luminaire and room cleaning.

The following requirements are applicable for typical office lighting:

- lighting layout to be uniform, efficient and in harmony with the area concerned
- uniform lighting levels, measured at a task height of 720 mm, with the ratio of minimum to average being 0.7 or more

- light fittings to be manufactured to Australian standards
- lighting wiring to enable future lighting alterations with ease
- light fittings shall comply with all applicable Australian standards.

10.9 SECURITY AND EXTERNAL LIGHTING

External security lighting shall be provided at all entrances and exits. External lighting shall be provided to ensure safe circulation space around the building and the wider campus. The design shall incorporate the principles of "Crime Prevention Through Environmental Design" (CPTED).

All external lighting shall be controlled using DALI protocol. Where projects form a minor extension to an existing system, any new fittings shall make provisions for future to migrate to DALI. This includes a minimum provision of DALI control gear and hard-wired communications infrastructure.

Curtin University wishes to rationalise its exterior lighting on campus to achieve the following objectives:

- SOCIAL – improve lighting to enhance the safety of the university community
- ECONOMIC: – reduce running costs and ease of operation and maintenance and achieve a competitive selection of equipment
- ENVIRONMENTAL – energy, greenhouse gas, lamp disposal and sky glow (refer Green Star communities rating requiring 5% or less ULOR).

These guidelines recommend light technical parameters such as lighting levels, uniformities and colours.

Generally lighting designs shall be considerate of:

- obtrusive spill light that causes annoyance, discomfort, distraction or reduction in the ability to see. Street lighting luminaires shall comply with the obtrusive light requirements of AS/NZS1158.
- materials that need to be selected for durability, safety, potential recycling and low content of hazardous substances. AS/NZS1158.6 requires a metal body with a plastic or glass lens.
- the University's preference for hot-dipped galvanised steel poles that may be powder-coated to an architect's selected colour. Such poles are required to be durable and have low embedded energy.
- preventing shadows cast by dense low foliage. Lights should be placed between trees and below the tree canopy.
- Providing light to people's faces for a feeling of safety. As a guide, recognition of faces at four metres needs an illuminance of 0.8 lux (semi-cylindrical).
- CCTV light levels to provide facial recognition and for the purposes of criminal prosecution.
- low glare to avoid ocular discomfort and CCTV blinding.

As a minimum the design shall comply with the following standards:

- AS/NZS1158 (all parts)
- AS1170.2 – Minimum Design Loads on Structures – Wind Loads
- AS1554 – Structural steel welding
- AS 1798 – Lighting Poles and Bracket Arms

- CISPR15 – Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
- CISPR TR30 – Test methods on electromagnetic emissions from electronic ballasts for single and double-capped fluorescent lamps.
- AS/NZS4676 – Structural design requirements for utility services poles
- AS4680 – Hot-dipped (zinc) coatings on fabricated ferrous articles
- AS4100 – Steel structures
- AS/NZS4782 – Double-capped fluorescent lamps – Performance requirements.
- AS/NZS4783.2 – Energy labelling and minimum energy performance standards requirements
- AS/NZS4934.2 – Fluorescent lamps for general lighting service – Minimum Energy Performance Standards (MEPS) requirements
- AS/NZS60598 – Luminaires
- IEC62262 – Degrees of protection provided by enclosures for electrical equipment against mechanical impacts (IK Code)
- AS/NZS61347 – Lamp control gear
- Austroads Part 12 – 2004 – Guide to Traffic Engineering Practice: Roadway Lighting
- AS2890.1: 1993: Off-road Car Parks
- BS/EN13201 – Road Lighting
- IES (North America) Recommendations for Road Lighting
- IES (North America) Guidelines for Security Lighting for People, Property and Public Spaces
- Road Lighting: van Bommel and de Boer. 1980
- Reports of the WA Coroner October 2003 and April 2004
- Discussions with University officers.

10.9.1LIGHT LEVEL REQUIREMENTS

This design brief offers a basis for design without being prescriptive about equipment selection.

Specific recommendations for each area are outlined in general terms below.

10.9.1.1 Central Walkway

The Central Walkway shall be lit to AS/NZS1158 Category P1 with white light.

10.9.1.2 Primary Walkways

These routes shall be lit to AS/NZS1158 Category P2 with white light.

10.9.1.3 Secondary Walkways

These routes shall be lit to AS/NZS1158 Category P2 with white light.

10.9.1.4 External Roadways

Access roads with less than 3,000 vehicles per day shall be lit to AS/NZS1158.3.1 Category P4.

Local distributor roads with between 3,000 and 6,000 vehicles per day shall be lit to AS/NZS1158.3.1 Category P3.

Primary distributor and district distributor roads with between 6,000 and 15,000 vehicles per day shall be lit to AS/NZS1158.1.1 Category V5.

The University's ring road may be a local distributor (Category P3, or higher) or may be a district distributor (Category V5). The traffic flow in vehicles per day is needed to assist in determining the road hierarchy.

The vehicular entrances from Dumas Road, from Beazley Avenue and from Manning Road have lighting that does not comply with AS/NZS1158. Similarly the bus station entrance and exits onto Hayman Road do not comply with AS/NZS1158. As the roads are under local government control, it is recommended that the local government be approached to arrange upgrading of the lighting. The University may also need to provide additional lighting within its boundary to achieve compliance.

10.9.1.5 Crosswalks

Crosswalk lighting shall comply with Category PX3 of the current version of AS/NZS1158.4.

10.9.1.6 Car Parks

Outdoor car parks should be lit to AS/NZS1158.3.1 Categories P11 and P12. Category P12 applies to disabled bays and Category P11 applies to general car park areas. Category P11 has three sub-categories P11a, P11b and P11c in descending rank. The selection of the sub-category depends on the level of night-time activity, night-time occupancy, and the risk of crime.

For car parks, lighting shall be installed to AS/NZS1158 Category P11a with facilities to step dim to Category P11b after hours for energy saving.

The status of some car parks may vary from year to year. Based on this, all car parks shall be designed for Category P11a with step dimming to Category P11b. The appropriate category of lighting can then be selected as and when status changes.

10.9.1.7 Architectural Lighting

Lighting of buildings shall be energy efficient and be focused on particular features. Waste light to the sky shall be avoided.

10.9.1.8 Building-mounted Lighting

Exterior building-mounted luminaires shall be coordinated with the interior and exterior lighting. In particular, the lighting of the building threshold, where people leave a brightly lit building and enter a well-lit exterior zone, needs careful attention. In a two-metre zone from a building exit, the horizontal illuminance shall be at least 20 lux (maintained). This provides a transition from the average 160 lux recommended by AS1680 for lobbies and the average 3.5 lux recommended by AS/NZS1158 for Category P2 lighting.

10.9.1.9 OH & S Lighting

Pedestrians need to see stairs and any obstacles or irregularities in the stairs. The location of lighting equipment shall consider the projection of shadows by pedestrians on the stairs. The three-dimensional geometry of the stairs needs to be considered when designing the lighting.

Exterior stairs should be lit to CIE-136. CIE-136 requires that pedestrian staircases and ramps be lit as follows:

Area	Horizontal Illuminance (Maintained)	Vertical Illuminance (Maintained)
Staircase risers	-	< 20 lux
Staircase treads	> 40 lux	-
Ramps	> 40 lux	-

There needs to be a contrast in the illuminances of the risers and treads to provide easy visibility.

10.9.2 LOCAL AREA TRAFFIC MANAGEMENT DEVICES

AS/NZS1158.3.1 distinguishes between two classes of local area traffic management (LATM) device:

- LATMs intended to slow traffic
- LATMs intended to deter traffic, other than vehicles with their origin or destination in that road, from flowing through local access roads.

Generally the University LATMs are intended to slow traffic. For such areas AS/NZS1158.3.1 requires a maintained horizontal illuminance of 3.5 lux over the surface of the carriageway for the extent of the design area. This design area extends 3 m beyond the immediate area of the traffic management device. The purpose of the lighting is to reveal to motorists the form and extent of the traffic management device.

10.9.3 POLE LOCATION AND TYPES

For footpaths, light poles shall typically be set back a minimum of 500 mm from the edge of the footpath.

For minor roads (Category P) where the speed limit is less than 70 km/h, light poles shall typically be set back about one metre from the kerb or edge of carriageway.

Where there is a reasonable likelihood of vehicular impact, impact-absorbing frangible poles should be used. For minor roads and footpaths, frangible poles are not required.

Pole types shall be selected based on pedestrian or road type, (refer to pre-approved light fitting information included in section 10.10.3). At the time of writing, guideline pole selections are based on the bus exchange project with pedestrian being a smaller scale version of the road type. Where projects propose an alternative light fitting to

match an existing theme/installation or for a project specific aesthetic outcome, all non-lighting services shall use the service pole included in section 10.10.3.

Existing installations with existing poles shall be identified to the Project Manager for Curtin direction.

10.9.4 SOLAR POWERED LIGHTING

Solar powered lighting is commercially available but is expensive in terms of capital and ongoing maintenance cost. Where solar powered lighting is considered, it shall be an established technology with proven backward compatibility in terms of maintenance replacement parts, fittings and or light sources.

Solar powered lighting installations shall satisfactorily address environmental and occupational safety concerns in terms of operation and maintenance, as well as compliance with AS/NZS1158.

Solar powered lighting may be economic if the source of power is remote and the cost of cabling exceeds the cost of the solar powered lighting installation.

Where solar powered lighting is being considered, holistic payback methods for the calculation of the economic life of the installation shall be undertaken and submitted to the University for prior approval to proceed with design. The payback method shall include but not be limited to the cost for purchase and disposal of batteries in an appropriate manner.

10.10 LIGHT FITTINGS

Light fittings shall be selected as appropriate to provide a lighting system in compliance with relevant Australian standards and BCA requirements (in particular BCA, Part J).

Light fittings shall be appropriate for the task intended to be illuminated and shall be in harmony with the architectural requirements for the corresponding areas. Light fittings shall be selected for ease of access to the lamps for maintenance purposes.

The Consultant shall nominate the type of light fittings, including suppliers' details (at least two where possible) and shall obtain Curtin's approval before tender.

Internal luminaires including (but not limited to) linear extrusions, downlights, track and track-mounted fittings shall have a minimum 5-year warranty for all components.

Internal luminaires including (but not limited to) decorative pendants, task lights, and flexible LED strip shall have a minimum 3-year warranty for all components.

External luminaires including (but not limited to) pole, catenary, façade and inground uplights lighting shall have a minimum 5-year warranty for all components.

External luminaires including (but not limited to) linear and flexible LED strips shall have a minimum 3-year warranty for all components.

Luminaires shall be fitted with drivers from reputable manufacturers such as Osram, Tridonic, EldoLED and Meanwell. The luminaire supplier is to provide confirmation that the driver is suitable for the LED being used in the luminaire and that the warranty covers both the driver and luminaire.

Internal luminaires including (but not limited to) linear extrusions and downlights shall be fitted with LED componentry that can be replaced by an electrician on site.

Luminaires shall be fitted with LED componentry that can be replaced either by the manufacturer or by the electrician on site. Include 10 per cent or a minimum of two (whichever is the greater) spares to be provided to Curtin for each luminaire where LED replacement is required to be done offsite. Curtin may accept a cost reduction where spares are already available or a temporary replacement can be used pending ordering of a specific replacement.

Externally rated and flexible LED strip is to be replaced with new once failed. Provide one roll of each specified type of flexible LED as a spare to Curtin.

Any alternatives proposed to luminaire specification shall have NATA-accredited photometric information supplied together with compliance with the above requirements. Working physical samples of all specified and any proposed alternative products are to be viewed and approved by project stakeholders.

All external lighting shall be 4000k to provide white light unless specific project requirements dictate otherwise. These requirements must be endorsed and considerate of facial recognition issues for security.

10.10.1 PROPOSED LIGHTING EQUIPMENT

The proposed lighting equipment shall be selected after discussion with the University as being readily available and, where possible, off-the-shelf equipment representing established technology.

10.10.2 SPARE LUMINAIRES

It is generally Curtin's policy to request to be provided with spares of certain luminaires considered to be of a special nature and essential for the operation of the premises. The list detailing the quantum and the type of spare light fittings shall be determined in consultation with Curtin.

10.10.3 PRE-APPROVED LIGHT FITTINGS

The below is a list of pre-approved manufacturers and fittings types for use at Curtin University.

Manufacturer	**Description**	**Lamp**
ZUMTOBEL PERLUCE LED LED5200-840 Q620 LDE IP54 WH	Surface mounted square LED luminaire. Complete with all mounting equipment, electronic DALI control gear and opal diffuser. White in colour. IP54 weather protected.	LED 4000k 42.2W
THORN POPPACK LED LED3000-840 HFI L1200	1200 mm surface-mounted batten LED luminaire complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 28W

Manufacturer	Description	Lamp
THORN POPPACK LED LED3000-840 HFI L600	600 mm surface-mounted batten LED luminaire. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 28W
THORN WEATHERFORCE LED4800-840 I12 HFI	1200 mm surface-mounted batten LED luminaire. Complete with all mounting equipment and electronic DALI control gear. White in colour. IP65 weather protected.	LED 4000k 51W
THORN WEATHERFORCE LED4800-840 I12 HFI	600 mm surface-mounted batten LED luminaire. Complete with all mounting equipment and electronic DALI control gear. White in colour. IP65 weather protected.	LED 4000k 28W
THORN WEATHERFORCE LED4800-840 I12 HFI + EMERGENCY KIT	1200 mm surface-mounted batten LED luminaire. Complete with all mounting equipment, emergency kit in accordance with AS2293 and electronic DALI control gear. White in colour. IP65 weather protected.	LED 4000k 51W
THORN WEATHERFORCE LED4800-840 I12 HFI + EMERGENCY KIT	600 mm surface-mounted batten LED luminaire. Complete with all mounting equipment, emergency kit in accordance with AS2293 and electronic DALI control gear. White in colour. IP65 weather protected.	LED 4000k 28W
THORN EQUALINE MINI L1680 LED DALI DIM + CONNECTS	1200 mm surface-mounted batten LED luminaire. Complete with all mounting equipment, continuous linking and electronic DALI control gear. White in colour.	LED 4000k 18W
THORN EQUALINE MINI L580 LED DALI DIM + CONNECTS	600 mm surface-mounted batten LED luminaire. Complete with all mounting equipment, continuous linking and electronic DALI control gear. White in colour.	LED 4000k 18W
THORN POLAR LED LED3500-840 6X6 D8	600 x 600 mm surface-mounted LED panel. Complete with all mounting equipment (surface kit) and electronic DALI control gear. White in colour.	LED 4000k 32W
THORN POLAR 2 LED LED3500-840 12X3 HIFX PH D8 CM5	1200 x 300 mm surface-mounted LED panel. Complete with all mounting equipment (surface kit) and electronic DALI control gear. White in colour.	LED 4000k 32W

Manufacturer	Description	Lamp
THORN POLAR 2 LED LED3500-840 12X3 HIFX PH D8 CM5	1200 x 300 mm T-bar grid LED panel. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 32W
THORN POLAR 2 LED LED200-840 12X3 HIFX PH D8 CM5	1200 x 300 mm plasterboard recessed LED panel. Complete with all mounting equipment (plasterboard kit) and electronic DALI control gear. White in colour.	LED 4000k 22W
THORN POLAR 2 LED LED2500-840 12X3 HIFX PH D8 CM5	1200 x 300 mm surface-mounted LED panel. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 22W
THORN CHAMELEON LED LED2400-840 12X3 L840 Y5 FP	1200 x 300 mm surface-mounted LED panel. Complete with all mounting equipment and electronic DALI control gear. White in colour. IP54 weather protected.	LED 4000k 30W
THORN POLAR 2 LED LED3500-840 12X3	1200 x 300 mm chain-suspended LED panel. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 32W
THORN POLAR LED LED2500-840 6X6 D8	600 x 600 mm recessed LED panel. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 22W
ZUMTOBEL PANOS EVO R150L 10W LED840 LDO SM WH	Recessed LED downlight. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 10W
ZUMTOBEL PANOS EVO R200L 16W LED840 LDO SM WH	Recessed LED downlight. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 16W
ZUMTOBEL PANOS EVO R200L 22W LED840 LDO SM WH	Recessed LED downlight. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 22W
ZUMTOBEL PANOS EVO R2001 + SURFACE MOUNT HOUSING WH	Surface-mounted LED downlight. Complete with all mounting equipment and electronic DALI control gear. White in colour.	LED 4000k 22W
External Lighting		

Manufacturer	Description	Lamp
IGUZZINI WOW POLE-TOP	External pathway post mounted LED area light. Complete with all mounting equipment, MULTIPOLE 300 SERIES MINI TYPE pole with sunken base and electronic DALI dimmable control gear. Standard finish. Optics and size to suit project specific requirements.	LED 4000k xxW
IGUZZINI WOW POLE-TOP	External roadway pole-mounted LED lantern with narrow road optic. Complete with all mounting equipment, MULTIPOLE 300 SERIES 6000 pole with sunken base and electronic control gear. Standard finish. Optics and size to suit project specific requirements.	LED 4000k xxW

The above list is not intended to preclude other luminaires from use at Curtin but is intended to avoid a patchwork approach to aesthetics at the Campus with exceptions being made by project specific requirements. Exceptional fitting selections based on product aesthetics are required to be endorsed by the Curtin project stakeholders. Those selections must have equivalent, or higher, technical specifications as included in this guideline.

Excepting external areas, the above list does not identify typical areas for each fitting type. Each fitting type is required to be selected in consultation with the project stakeholders.

With regards to external areas, significant parts of the Campus currently use the Thorn Plurio light fitting. These areas are to be highlighted to the Curtin Delivery Manager for alignment with the Curtin future planning. One such example is the Sir Charles Promenade, which is retaining use of Thorn Plurio at this time.

The above list is intended to support selection of typical light fittings for projects in general teaching and administration spaces, not specialist areas such as laboratories, hazardous goods stores, exhibition, sports areas, etc.

11 EMERGENCY LIGHTING AND EXIT SIGNS

11.1 GENERAL

Curtin University operates the proprietary Legrand Axiom centrally controlled emergency lighting system.

The lighting system is to include monitoring and testing of the emergency luminaires and exit signs such that a separate monitored emergency lighting system is not required.

Emergency luminaires and exit signs shall be provided and installed throughout the building in compliance with the requirements of AS/NZS2293 and the Building Code of Australia (BCA).

The scope of the emergency and exit lighting system includes:

- provide self-contained emergency luminaires as shown on the drawings
- provide self-contained exit signs as shown on the drawings
- provide a centrally monitored emergency lighting system using the Legrand Axiom lighting control system
- provide automatic testing facilities for all emergency luminaires and exit signs.

The installation shall comply with the requirements of:

- AS/NZS2293 Emergency Evacuation Lighting in Buildings
- Building Code of Australia
- local government authority
- fire brigade.

11.2 EMERGENCY LUMINAIRES

11.2.1 SINGLE POINT EMERGENCY LUMINAIRES

All self-contained, non-maintained, single-point fittings shall be provided complete with batteries, charger and Axiom compatible emergency inverter.

11.2.2 INTEGRAL TYPE EMERGENCY LUMINAIRES

Where shown on the drawings, normal lighting luminaries shall incorporate a non-maintained emergency lighting lamp, a self-contained power pack and an Axiom compatible emergency inverter.

11.2.3 ILLUMINATED EXIT SIGNS

All illuminated exit signs shall incorporate a maintained emergency lighting lamp, a self-contained power pack and Axiom compatible electronic control gear.

All exit signs shall be of pictograph type with running man and directional arrows. The exit signs shall be capable of being mounted on ceiling, wall or suspended. The exit signs shall be edge-lit LED exit fixtures.

11.3 ADDRESSING AND IDENTIFICATION

All emergency luminaires and exit signs shall be addressed with other luminaires on the existing Legrand Axiom system which is monitored at the operation and maintenance management building. The luminaires shall be identified by their unique fitting address. The address shall correspond with the report identification and the as-constructed drawings.

All emergency luminaires and exit signs shall provide visual feedback to the monitoring system in order to easily locate a luminaire.

11.4 AUTOMATIC TESTING

All emergency and exit lighting shall be able to perform a battery discharge test according to the required emergency standard (i.e. IEC62034, AS/NZS2293).

In order to maintain the integrity of the emergency lighting system, duration testing shall be conducted in sections so that adjacent emergency luminaires are not tested together.

11.4.1 EMERGENCY STATUS

The Central Emergency Monitor software shall indicate the status of the emergency luminaires. The control system shall display when the fitting is in emergency stand-by mode, when a test is pending or running, and the date and result of the last test.

The result of a test and its validity shall remain unchanged until a new test is performed.

If a test can't be started or is interrupted due to an emergency situation (mains failure), the test shall be automatically delayed until the battery is recharged.

11.4.2 REPORTING

Results of discharge tests at practical completion shall be recorded and stored in the logbook. The logbook shall be retained on site.

The system shall be capable of displaying the lamp hours of a luminaire in normal operation and in emergency operation.

11.4.3 INTEGRATION OF CONTROLS INTO SWITCH BOARDS

The Consultant shall liaise with the product manufacturer to schedule all equipment required to be incorporated into the switchboard complete with all necessary power supplies and terminal strips to ensure a fully operational system.

The Consultant should also consider local emergency lighting testing facilities within each local switchboard that supplies exit and emergency lighting circuits.

11.4.4 EXISTING CENTRALLY MONITORED LEGRAND AXIOM SYSTEM

ALL INSTALLATIONS

Emergency exit signs shall be of the pictograph type and illuminated by an LED light source for both emergency and 240V operation. Sustained emergency luminaires shall not be used, that is, emergency luminaires shall not be used for normal lighting.

All exit signs shall be installed at a minimum of 2,200 mm above floor level to the bottom of the luminaires.

Exit sign luminaires shall be circuited separately from the local distribution board.

Protected type emergency luminaires shall be provided in all toilets and office fittings.

A maximum of 80 per cent of available fittings per area controller is to be maintained. As applicable in large installations, an area controller on each level is required.

Multi-level buildings shall have a communications cable run as a backbone spine to one centralised Lantronix unit to enable each individual area controller. The location of the Lantronix unit shall be determined in consultation with Curtin Information Technology Services. Wireless connectivity shall not be used.

Emergency lighting and pictograph exit signs shall be provided throughout the buildings in accordance with the requirements of AS2293 and BCA Part J6.

Note: Commissioning of the emergency lighting system is to be undertaken by a Curtin-nominated contractor. Refer to the Curtin-approved Contractor List.

NEW BUILDINGS/SYSTEMS

The emergency lighting system shall utilise the existing Legrand Axiom monitoring through network gateways to the University network. The project shall include for all hardware and software upgrades necessary to maintain the existing centrally monitored system capability.

FITOUTS AND REFURBISHMENTS

All new fittings installed shall utilise existing Legrand Axiom systems or network connection where these have been established. Where no system exists these shall be installed as part of the project. The project shall investigate and present costs to migrate all existing emergency lights onto the existing centrally monitored system.

Where other proprietary systems or manual testing systems are in use, Legrand Axiom-compatible fittings shall be installed and the University shall give specific direction regarding monitoring. No Single Point units are to be used due to the difficulty in testing. (Note: The Commander fitting can be tested Single Point where a computerised monitoring system has not been installed.)

For situations where only part of the floor area is affected by the project works, the design of the emergency lighting system shall consider the entire floor area for compliance. Particular emphasis shall be the path of escape to fire escape stairs, within the stairs and to the final exit.

MINOR SYSTEM UPGRADES AND REPLACEMENTS

Minor, i.e. replacements of existing, shall utilise established supported emergency lighting monitoring systems. Currently many of the buildings utilise manual testing facilities.

12 UNINTERRUPTIBLE POWER SUPPLY SYSTEM

Where specifically requested by Curtin, the consultant shall investigate and advise on the need to provide an uninterruptible power supply (UPS) system. On consultation with Curtin, the consultant shall:

- determine the extent of the equipment that is absolutely critical to be operating uninterrupted, and the extent of the critical equipment that can tolerate interruptions of short to medium time durations
- determine the required degree of security for the UPS power supply and determine the extent of redundancy to be provided
- determine the extent of the equipment required to be connected to a standby power supply system (if available)
- prepare and issue for approval a detailed report outlining the:
  - number and size of the UPS
  - location of each UPS unit
  - UPS reticulation system
  - testing strategy and maintenance
  - equipment type and list of manufacturers suitable for the project.

All UPS systems are to be monitored. If a system warrants a UPS then the system needs to be monitored. This may be local by the user or through the network according to the nature of the operation and location of the UPS.

13 PRACTICAL COMPLETION DOCUMENTATION

13.1 OPERATIONS AND MAINTENANCE MANUALS

These are to be prepared for each project and contain:

- plant description (separate heading and descriptions of each item)
- operating instructions
- manufacturer's literature, specific to the plant installed
- routine maintenance procedures
- commissioning data
- as-constructed drawings
- all contents of the manuals are to be delivered in electronic format
- descriptive in PDF and MS Word
- drawings in PDF and DWG.

GENERAL

The operations and maintenance manuals are to be written in clear concise English, with comprehensive descriptions of assemblies, operation and maintenance frequency and instructions, equipment, components and accessories, schedules and commissioning records.

Provide appropriate diagrams and other illustrations necessary to facilitate knowledge and understanding about the operation of the system.

The Consultant shall consult with the Project Manager for the requirements of operations and maintenance manuals if engaged by a lead consultant.

SUBMISSION

Number of copies: one hard copy and one electronic copy for a standalone electrical project.

Installation manuals are to be provided by the contractor in both hard copies and electronic form.

Prototype copy: provide a prototype copy for approval before proceeding with final copies.

Final approval copies are to be received before and as a pre-condition to Practical Completion.

FORMAT

White A4 sized hard cover, 4 D-ring vinyl-covered binder with main title in 30 pt font Times New Roman and secondary lettering in 12 pt and 10 pt upper and lower case as appropriate.

Cover to label manual as detailed below:

OPERATIONS AND MAINTENANCE MANUAL

CURTIN UNIVERSITY

<CAMPUS> – <BUILDING> – <PROJECT NAME>

<THE UNIVERSITY'S PROJECT NUMBER>

<DISCIPLINE>

<COMPLETED YEAR>

The spine shall label as follows:

<CAMPUS> – <BUILDING> – <PROJECT NAME>

Provide durable dividers for each separate section.

SECTIONS

Each operations and maintenance manual shall contain the following:

- front cover
- contents
- contractor's name, address, telephone number and emergency telephone numbers
- general description of the installation, consistent with providing a general understanding of its features and operation
- schedule of technical data/parts list
- list of equipment suppliers' and manufacturers' catalogues and descriptive matter to provide a complete source of information
- a copy of work as-constructed drawings
- a copy of switchboard workshop drawings and all other construction drawings
- a copy of all final distribution board legend cards
- maintenance instructions
  - routine
  - preventative
- test results taken during acceptable tests and authority certificates including:
  - RCD test results
  - Authority Electrical Certificate of Compliance
  - list of guarantees and warranties of equipment supplied.

COMPLETION OF DEFECTS LIABILITY PERIOD

Should any changes have occurred during the defects liability period, the contractor is required to mark-up and update the work as-constructed drawings at the end of the defects liability period.

Re-issue drawings for the operations and maintenance manuals including updating the drawing schedule.

A set of as-constructed drawings shall be issued in full-size hard copy and electronic format corresponding to the latest updated drawings in the operations and maintenance manuals.

13.2 WORK AS-CONSTRUCTED DRAWINGS

GENERAL

Before the date of Practical Completion and as a pre-condition to Practical Completion, provide work as-constructed drawings.

The work as-constructed drawings shall include the following minimum information:

- actual locations of installed equipment
- protective devices actual protection settings including long-time, short-time, and instantaneous tripping on the respective single line diagram
- circuit numbers and phase for all final sub-circuits
- actual cable and cable tray routes including sizes
- location depths of all underground conduits and pits dimensioned from permanent landmarks.

The approved work as-constructed drawings shall be included in the operations and maintenance manuals.

SUBMISSION

Provide the number of copies as follows:

- two hard copies for review and resubmit upon amendments
- one approved full-size hard copy and an electronic copy of drawing set to be incorporated into each operations and maintenance manual
- one approved full-size hard copy, one A3 hard copy and an electronic copy of each drawing for University drawing records
- one approved full-size laminated copy of the switchboard single line diagram to be mounted adjacent to the switchboards with high criticality or switchboard categories including SSB, MSW and MDB
- one approved full-size copy of the switchboard single line diagram to be folded and installed to the schedule holder for switchboard(s) other than listed in 4.

Submit work as-constructed drawings in AutoCAD DWG format in accordance with the Curtin University *Documentation Deliverables Guidelines*.

14 DEFINITIONS

AC	area controller
ACB	air circuit-breaker
ATS	automatic transfer switch
BCA	Building Council of Australia
BMS	building management system
CB	Circuit-breaker
Consultant	Organisation or person qualified and appointed by CU to lead an area of work on the project
Contractor	Organisation or person qualified and appointed by contract to work on the project
CU	Curtin University
DALI	digital addressable lighting interface
DB	Distribution board
DIN	Deutsches Institut für Normung
DLT	Dynamic Letter Touchscreen
DSI	Digital Serial Interface
ELCB	earth leakage circuit-breaker
Electrical Consultant	Organisation or person qualified and appointed by CU to lead electrical work on the project
Electrical Contractor	As defined by the Electrical Licencing Regulations
ELV	extra low-voltage
GPO	general purpose outlet
HRC	high rupturing capacity
ISO	International Standards Organisation
LATM	local area traffic management
Lead Consultant	Organisation or person qualified and appointed by CU to lead all work on the project
LV	low-voltage
MCB	miniature circuit-breaker
MCCB	moulded case circuit-breaker
MD	maximum demand
MDB	Main Distribution Board
MEN	multiple earth neutral
MSB	Mechanical Switchboard
MSW	Main Switchboard
MTS	manual transfer switch
NMI	National Measurement Institute
PFC	power factor correction
PIR	Passive Infrared

Practical Completion	Issued to a Contractor acknowledging completion of works to a stage where the works have been completed as per the contract documents and are "reasonably fit for occupation or their intended use".
Project Manager	The person managing the project on behalf of the University
PTTA	partially type-tested assembly
RCD	residual current device
Responsible Officer	The University's representative on projects, nominated by the Portfolio Manager, as the person responsible for the project.

RMS	Root Mean Square
SIS	Spatial Information Systems
SSB	Substation Switchboard
SSO	Switched Socket Outlet
Supply Authority	Western Power, also known as the Network Operator
SWB	Switchboard
TPS (cables)	Thermal Plastic Sheath
TTA	type-tested assembly
UPS	uninterruptible power supply
UTP	unshielded twisted pair

15 APPENDIX A

Curtin University

ELECTRICAL SWITCHBOARDS CONTRACTOR CHECKLIST

Project Number:

Project Name:

Date:

Switchboard:

ITEM	NO	YES	CONTRACTOR COMMENTS
1. PRIOR TO CHANGEOVER			
Have all circuits been traced and circuits identified?	☐	☐	
Has redundant wiring been labelled ready for removal?	☐	☐	
Has the pole capacity at the switchboard been confirmed to provide 25% spare (min)?	☐	☐	
Have cable entry/exit provisions and access been confirmed? Are gland plates and glands ready for installation?	☐	☐	
Has wiring that requires extension been identified? Are in-line crimp joints and heat shrink ready for sub-circuit cable jointing?	☐	☐	
Do larger cables (> 10 mm^2) require extension? Has the methodology been agreed with Curtin University?	☐	☐	
Has cable management (PVC ducts and alike) been checked to provide sufficient space?	☐	☐	
Has a draft schedule card been produced and issued to Curtin University for review?	☐	☐	
Are 'boots' available for termination of sub-circuit cabling?	☐	☐	

Are all switchgears rated to design capacity and rating?	☐	☐	

CONTRACTOR NOTES

ITEM	NO	YES	CONTRACTOR COMMENTS
2. AT COMPLETION			
Are all cables terminated securely?	☐	☐	
Are cable strands escaping from circuit breaker tunnels? If so, reterminate.	☐	☐	
Is sufficient space available within cable ducts for easy access, modification to existing wiring systems and installation of future wiring systems?	☐	☐	
Are duct covers fitted without pressing on cables?	☐	☐	
Are major sub main cables labelled at each cable end identifying the cable size, protection device rating and setting, distribution board supplied and other information required by the electrical specification?	☐	☐	
Are any wiring systems strained? If so, reinstall.	☐	☐	
Are cables installed through glands providing a close fit in accordance with AS3000? If not, reselect the gland size.	☐	☐	
Can the escutcheon be closed without exerting force? If not, revisit the installation.	☐	☐	

Has a completed schedule card been placed in the switchboard card holder?	☐	☐	
Are all redundant materials removed from the switchboard and surrounding area including debris?	☐	☐	
Are all redundant cables removed from the switchboard and for the entire length?	☐	☐	
Are wiring systems bunched neatly and secured with cable ties or the like? Are cable tie ends cut to an appropriate length?	☐	☐	
Are all sharp edges and burrs removed entirely?	☐	☐	
Have insulated caps been provided to spare circuit-breaker bus terminals?	☐	☐	
Are spare cable bushes sealed to maintain IP rating?	☐	☐	
Are power monitoring devices and other active devices configured correctly?	☐	☐	
Are ELV-type wiring systems (such as communications connections to networkable meters) installed within a conduit or the like for separation from LV wiring systems?	☐	☐	
Is the switchboard label installed and in accordance with the electrical specification?	☐	☐	
Has the appropriate handle been installed and is the keying correct?	☐	☐	
Have Electrical Certificates of Compliance been completed and submitted to Curtin University?	☐	☐	
Have all testing and commissioning results been submitted to Curtin University?	☐	☐	

CONTRACTOR NOTES