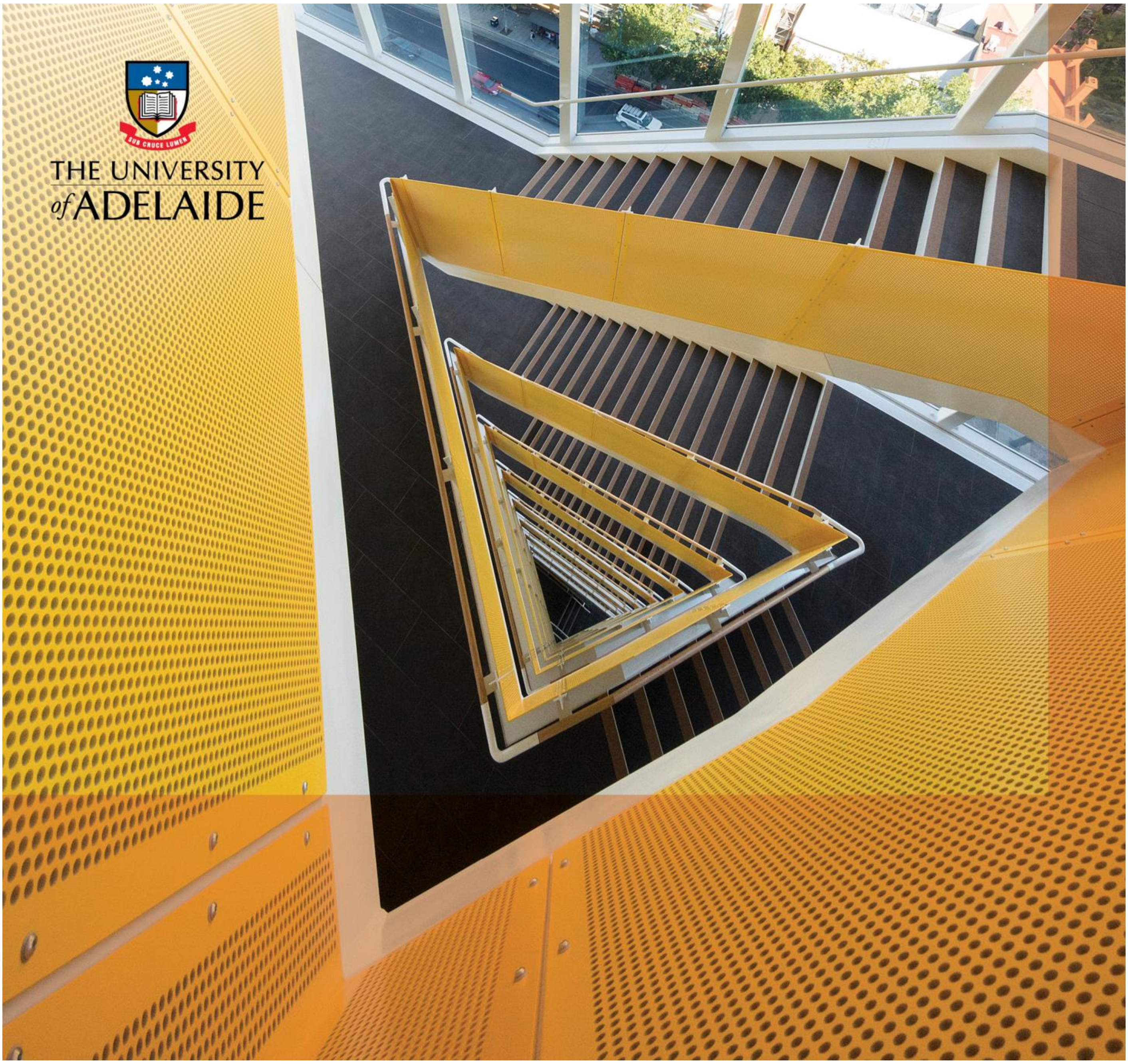

DESIGN STANDARD

D. Electrical Services

Contents

Revision log

Current issue

D. Electrical Services - UoA Design Standards. FINAL Version 4. August 2018

Previous issues

Version	Authors	Description	Revision	Date
1.0	Vicki Jacobs, Capital Projects Delivery, UoA	D. Electrical Services - UoA Design Standards	DRAFT Version 1	Dec 2017
2.0	GHD	D. Electrical Services - UoA Design Standards	DRAFT Version 2	Dec 2017
3.0	Vicki Jacobs, Capital Projects Delivery, UoA/ GHD	D. Electrical Services - UoA Design Standards	DRAFT Version 3	March 2018
4.0	Vicki Jacobs, Capital Projects Delivery, UoA/ GHD	D. Electrical Services - UoA Design Standards	FINAL Version 4	August 2018

List of revised items

Version	Authors	Revised items	Date

Revision management

It is envisaged that revisions to this document will be undertaken at intervals of not more than two (2) years.

Endorsement body

Director of Infrastructure

Owner

Capital Projects Delivery

Contact person

Associate Director, Capital Project Delivery

Authors and acknowledgements

The standards have been developed by Capital Projects with the assistance of UoA staff, external consultants, contractors, and colleagues from other education institutions. The University conveys its thanks.

Abbreviations

AS/NZS	Australia or Australian/New Zealand Standards
BCA	Building Code of Australia
CPD	University of Adelaide- Capital Projects Delivery
DDA	Disability Discrimination Act
NCC	National Construction Code
OSH	Occupational Safety and Health
SEPP	State Environmental Planning Legislation
SiD	Safety in Design
UoA	University of Adelaide
WHS	Work, Health and Safety

Abbreviations continued

AHF	Active Harmonic Filter
ANSI	American National Standards Institute
ATS	Automatic Transfer Switches
BMCS	Building Management and Control Systems
CCTV	Closed Circuit Television
CM	Campus Management
DB	Distribution Switchboards
DC	Direct Current
DRUPS	Diesel Rotary Uninterruptable Power Supply
ESD	Ecologically Sustainable Design
ELV	Extra Low Voltage
FSSB	Fire Services Switchboard
GEC	General Electric Company
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HRC	High Rupturing Capacity
HSSB	Hydraulic Services Switchboard
HV	High Voltage
IDMT	Inverse Definite Minimum Time
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IPA	Industrial Projects Australia
ISO	International Organisation for Standardisation
LED	Light Emitting Diode
LPG	Liquified Petroleum Gas
LV	Low Voltage
MDB	Main Distribution Board
MEN	Multiple Earth Neutral
MSB	Main Switchboard
MSSB	Mechanical Services Switchboard
NCC	National Construction Code
PCC	Point of Common Coupling
PFC	Power Factor Correction
PVC	Polyvinyl Chloride
RCBO	Residual-current circuit breaker with overcurrent protection
RCD	Residual Current Device
RFI	Radio Frequency Interference
RGB	Red Green Blue
SSO	Switched Socket Outlet (sometimes formerly known as GPO)

UPS	Uninterruptible Power Supply System
USB	Universal Serial Bus
UoA	The University of Adelaide
SADCM	South Australian Distribution Connection Manual

1. Introduction

This section outlines the purpose, structure, related documents, and definitions for the University of Adelaide (UoA) Design Standards.

1.1 Purpose of the document

The UoA Design Standards (the Standards) respond to the strategic vision for the University, outlined in Beacon of Enlightenment 2016-2035, and the guiding planning principles contained in the UoA Masterplan 2016-2035. Prepared in recognition of the University's unique historical context, the Standards are guided by the aims of supporting physical, social and cultural connectivity, embracing diversity, equity and accessibility, and promoting sustainability and academic excellence.

The Standards specify the minimum, mandatory requirements for the design, construction and management of all University of Adelaide infrastructure projects. Requirements are specific to the University's needs, and are over and above minimum mandatory Authority requirements. They include:

- Methodological requirements for project delivery; and
- Technical requirements for the finished product.

The objective is to support the consistent delivery of a high quality product, while allowing sufficient scope for innovation, creativity and technological advancements.

The Standards must be used by any parties involved in the planning, design, construction, occupation management, maintenance and operation of UoA facilities. This includes external consultants and contractors, UoA planners, designers and project managers as well as professional and faculty staff, facility managers, maintenance contractors and other service providers – all of whom must be aware of the Standards as they apply to their project and scope of work.

1.2 Structure of UoA Design Standards

D. Electrical Services Design Standard (this document) is a part of the UoA Design Standards suite of documents (the Standards).

The Standards are divided into the following volumes for ease of use:

- A. Project Process Checklist
- B. Building and Architecture
- C. Mechanical Services
- D. Electrical Services (this document)
- E. Communication Services
- F. Hydraulic Services
- G. Fire Services
- H. Security Services
- I. Vertical Transport
- J. External Works
- K. Documentation
- L. Metering and Monitoring
- M. Audio Visual
- N. Signage and Wayfinding

The Standards must be considered in their entirety, regardless of the project's size, specific disciplines or responsibilities.

In particular, UoA staff and consultants using this volume must ensure familiarity with the mandatory project procurement obligations, detailed in A. Project Process Checklist.

Each volume within the Standards is structured into three parts:

- Part 1 – Introduction

- Part 2 – General requirements
- Part 3 – Technical requirements
- Part 4 – Schedules

1.3 Related documents and legislation

1.3.1 Documents

During the earliest strategic feasibility and planning stages of the project, review and analysis of the latest edition of the following UoA strategic planning documents must be carried out and outcomes of that review reflected in the Project Brief (refer to clause 1.4 – Definitions of this volume).

These documents should also be read in conjunction with the UoA Design Standards.

- UoA Masterplan 2016-2035
- UoA Strategic Plan - Beacon of Enlightenment, 2013-2035
- Disability Action Plan 2013-2019
- Campus/ Building-specific Disability Action Plans
- Dormwell Framework
- UoA Reconciliation Statements
- Campus/ Precinct/ Building-specific Masterplans (e.g. Waite Masterplan, Union House Masterplan)
- Campus/ Building-specific Conservation Management Plans
- Faculty Masterplans
- Technical discipline/ space-specific Masterplans, including:
  - ITS Strategy Masterplan
  - Mechanical Services Masterplan
  - SAMP
  - Teaching Spaces Masterplan
  - Labs Standards and Masterplan
  - Library of the Future Masterplan
  - Space Standards Guidelines
  - Deferred Maintenance Schedule
  - Bushfire Prevention Plans
  - Campus Water Management Plan
- Campus Sustainability Plan 2017 and associated documents, including:
  - The Carbon Neutral Adelaide Action Plan 2016-2021
  - Innovation Hub/ Smart Cities
  - Building Performance Rating System

1.3.2 Relevant legislation

The planning, design and construction of each UoA facility must fully comply with current legislation. Legislation includes but is not limited to:

- Australia or Australian/ New Zealand Standards (AS/NZS)
- National Construction Code (NCC)
- Building Code of Australia (BCA)
- Occupational Safety and Health (OSH) legislation
- Disability Discrimination Act (DDA)
- Accessibility Aspiration Design Factors
- State Environmental Planning Legislation (SEPP)

- Commonwealth and State Legislation
- Local Council and Authority requirements
- Relevant Heritage Acts (for both Places and Natural Resources)

1.4 Definitions

For the purpose of this document, the following definitions apply:

Must	Indicates that a statement is mandatory
Should/ shall	Indicates a recommendation
May/ can	Indicates the existence of an option
The Standard/s	The University of Adelaide Design Standards
Project Manager	University of Adelaide staff member responsible for delivering the building project
Strategic Project Brief	The strategic project brief developed by the University, during the project feasibility phase. Used to develop the consultants scope of works. Refer to clause 2.1 of this document for further discussion.
Return Brief/ Project Brief	The detailed brief prepared by the consultant/ design team at the end of the detailed briefing phase, and signed off by the Project Stakeholder/s, prior to commencement of Concept Design, against which mandatory milestone certification checkpoints are measured. Refer to clause 2.1 of this document for further discussion.

2. General requirements

This section outlines:

- General administrative requirements related to the use of the B. Building and Architecture, and the process for project delivery for all projects, including: project specific documentation; discrepancies; departures; certification of compliance; project procurement process; value management; safety in design; WHS; environmental management; independent building commissioning; manufacturer's specifications; and professional services requirements; and
- General design requirements related to the B. Building and Architecture, including the University policy on sustainable design as well as durability, economy and flexibility.

2.1 Project specific information

Project-specific information will be contained in project- specific documentation, such as Project Brief. The Standards will supplement any project-specific documentation. Refer below clause 2.2- Discrepancies for clarification of precedence, should a discrepancy between Project Specific Documentation and The Standard arise.

Extracts from the Standards may be incorporated in contract documentation specifications. However, the consultant and the contractor must fully investigate the needs of the University and produce designs and documents that are entirely fit for purpose, which meet the intent of the Project Brief.

2.1.1 The project brief

In accordance with A. Project Process Checklist and clause 2.4 Certification of Compliance, the Project Brief must be developed and signed-off in the following manner, and utilised as a measure, against which periodic certification must be carried out.

1. The Pre-feasibility Statement and preliminary project brief contained therein, communicates proposed project objectives and scope, preliminary budget and any project- specific strategic targets (if known).
2. The Strategic Project Brief is typically developed by the University during the feasibility phase of the project. This brief reflects outcomes of the strategic project investigations. The Strategic Project Brief must be interrogated and verified by the Project Delivery Unit, Project Manager and key strategic stakeholders, prior to proceeding to the next Detailed Briefing Phase of the project delivery process. It is from this verified Strategic Brief, that the consultants brief will be developed.

The Strategic Project Brief must:

- Identify project- specific sustainability targets, over and above the Standards, and associated reporting obligations;
- identify proposed project budget and funding source. This must include:
    1. (i) Capital Budget (separated into construction and university costs), and
    2. (ii) Operating Budget (reflecting project- specific sustainability targets);
- identify other strategic targets associated with the project;

- identify list of known Stakeholders with a preliminary engagement plan developed. This includes identification of key stakeholders with whom sign-off approvals obligations will sit. Refer below Clause 2.4 Certification of Compliance with the Standard;
- identify general spatial and operational requirements of the end users;
- identify decanting and relocations proposals associated with works;
- identify a list of further investigations that are required (e.g. Heritage, DDA etc.);
- identify an indicative project program for the delivery of works;
- identify strategic risks associated with the project (Refer Clause 2.7 Risk Register);
- communicate any safety in design risks identified to date (Refer Clause 2.8 Safety in Design);
- The Return Brief (also referred to as Project Brief) is typically prepared by the Consultant at the end of the detailed briefing phase, during which intensive stakeholder consultation has occurred. The Project Brief must be signed-off by key stakeholders prior to proceeding to the next Concept Design Phase of the project delivery process. It is against the signed- off Return Brief (also typically referred to as Project Brief), that the mandatory, milestone, compliance certifications will be measured. (Refer to clause 2.4 Certification of compliance, in this document). For very simple projects, compliance may be measured against the Strategic Project Brief, or equivalent, provided it meets all mandatory due diligence obligations, related to the development of a brief, listed in A – Project Process Checklist.

The Return Brief must:

- Meet the obligations of the Strategic Project Brief (including, but not limited to budget and sustainability targets);
- identify detailed operational and spatial requirements of the end users;
- include room data sheets for complex projects (refer to A. Project Process Checklist for clarification).

2.2 Discrepancies

The Standards outline the University's general requirements above and beyond mandatory authority requirements and legislation.

Where the Standards outline a standard higher than the relevant legislation, the Standards will take precedence.

If any discrepancies are found between any relevant legislation, the Standards, or project-specific documentation, these discrepancies must be highlighted in writing to the Associate Director, Capital Projects Delivery.

2.3 Departures

The intent of the Standards is to achieve consistency in the quality of the design and construction of the University's built forms.

In addition, University staff, consultants and contractors are expected to apply industry best-practice and strive for improvement and innovation in design and construction techniques wherever possible. In recognition of this expectation, application to depart from the Standards, must be made in writing to the Associate Director, Capital Projects Delivery via the UoA Project Manager, using the Alternative Design Solution Application Form. The application must include:

- Reference to the Standard clause under consideration
- Details of the departure and alternative proposal
- Impact of that departure on:
  - Compliance with the Project/ Return Brief
  - Project capital budget
  - Operating budget

Where a departure from the Standards is sought, dual-approval to proceed must be issued in writing by both the Associate Director, Capital Projects Delivery and the Director of Infrastructure. Until this approval is granted, the consultant is not authorised to proceed to the next project phase. Any departures made without written confirmation must be rectified at no cost to UoA.

At the completion of the project, all authorised Alternative Design Solution Application Forms must be submitted to the Associate Director, Capital Projects Delivery by the UoA Project Manager. Alternative Design solutions must be monitored over time for success and may be considered for inclusion in subsequent versions of the Standards.

2.4 Certification of compliance

At regular intervals the consultant team must certify in writing that both the Standards, and the Project Brief, have been met.

This can be done using the templates provided in A- Project Process Checklist, or an equivalent, approved reporting tool.

Discrepancies and departures must be declared, with justification, at this time, in accordance with clauses 2.2 Discrepancies and 2.3 Departures of this document.

Approval must be granted prior to proceeding to the next project phase in accordance with the process outlined in A- Project Process Checklist.

It should be noted that The Standards, as they relate to this clause, refer to all Volumes of the Standard, including A- Project Process Checklist.

2.4.1 Frequency of certification

Frequency of certification is based on the size and complexity of the project. Refer to A. Project Process Checklist for frequency of certification requirements based on the complexity of the project.

For new all new building projects, (multi-disciplinary) projects, or projects with a value greater than $500,000, Certification must occur at the end of each of the following project phases:

- Concept Design Phase
- Design Development Phase
- 50% Complete Contract Documentation Phase
- 100% Complete Contract Documentation Phase
- Project Hand-Over Phase

For very small or simple (single discipline) projects, Building Standard Certification must occur at the following times:

- At an agreed point, prior to the end of the 50% Complete Documentation Phase
- At an agreed point prior to the end of the 100% Complete Contract Documentation Phase

2.4.2 Additional certification requirements

In addition to the above mandatory certification check-points, certification of compliance with the Design Standards and The Project Brief, must also occur as part of any Value Management Session, in accordance with clause 2.6. Value management of this document.

2.5 Project procurement process

All project team members must follow the project process outlined in A. Project Process Checklist. The checklist is a planning and tracking tool to be used by the project manager, consultants and contractors, to ensure adherence to the approved UoA process for project delivery and to ensure the Standards are achieved as a minimum on all projects.

A. Project Process Checklist Design Standard caters for different project complexity types. For clarification of the project complexity type, refer to Manager, Capital Projects Delivery.

A. Project Process Checklist Design Standard does not alleviate any responsibility to ensure familiarity and compliance with all aspects of the Design Standards. The checklist (or an approved, project specific version) must be maintained as an active document throughout the project, and must be submitted to the Manager, Capital Projects Delivery, via the UoA Project Manager at project completion.

A. Project Process Checklist Design Standard is divided into project delivery phases. While the order of actions listed can be varied to suit a project, all actions listed must be completed, and certified as complete, prior to proceeding to the next phase. Project-specific variations of the checklist involving alteration to the number of mandatory milestone certification checkpoints, or elimination of any action, must be treated as a departure from the Standards and submitted for approval to the Associate Director, Capital Project Delivery at the commencement of the project start-up phase.

Project managers, consultants and contractors must ensure that adequate time and resources are allocated to meet the requirements of A. Project Process Checklist Design Standard and, in particular:

- Mandatory milestone certification checkpoints and associated approvals processes (refer to clause 2.4 Certification of compliance)
- Engagement and consultation obligations with stakeholders
- DDA, Safety in Design, and Risk Management workshops
- UoA peer reviews
- Two-step value management process, refer to 2.6 Value- management

2.6 Value management

1. A mandatory two-step value management (VM) session must be carried out when the project has reached the 50% Complete Contract Documentation Phase (or at a time deemed appropriate by the UoA Project Manager). Additional value management sessions may be required and must follow the same process. Consultants and Project Managers must make appropriate allowance for resources and time to meet the requirements of this clause.

Any value management sessions must take the following two-step process:

2. Value management (VM) session; followed by

3. Written certification (in accordance with disclosure and approvals obligations set out in clause 2.4 Certification of compliance in this volume), that the proposed value managed solution:
4. Meets the requirements of the Design Standard
5. Meets the requirements of the Brief. This includes (but is not limited to) confirmation of the following:

- Estimated order of cost for capital and operating budget; and
- Project-specific sustainability objectives

2.7 Risk Register

The Risk Register records details of all the risks identified at the beginning and during the life of the project, their grading in terms of likelihood of occurring and seriousness of impact on the project, initial plans for mitigating each high-level risk, the costs and responsibilities of the prescribed mitigation strategies and subsequent results.

This Risk Register must be maintained for all projects, throughout the life of the project. Initial risk assessment must form part of the Project Feasibility Phase for the project. If strategic risks are identified, they must be recorded and managed separately to those that are related to worksplace health and safety. The preliminary register (or list of issues) must be communicated in the Strategic Project Brief.

The register must continue to be developed and maintained by the UoA Project Manager for all projects. Later the register will be maintained by the Managing Contractor, Service Delivery maintenance staff, and potentially end-users. The register will be updated regularly as existing risks are re-graded in the light of the effectiveness of the mitigation strategy, and new risks are identified. For larger projects a Risk Management Plan may be required also. In smaller projects, the Risk Register can be used as the Risk Management Plan.

Refer to clause 2.8 for further discussion about Safety in Design and the mandatory Safety in Design Risk Assessment Workshop.

Refer to A. Project Process Checklist for the Project Risk Register Template.

Refer to clause 2.8 Safety in Design/ workplace health and safety for discussion on cultural safety.

2.8 Safety in Design/ workplace health and safety

Safety in Design (SiD) aims to prevent injuries and disease by considering hazards as early as possible in the planning and design process. A safe design approach considers the safety of those who construct, operate, clean repair and demolish an asset (the building, structure, plant or equipment) as well as those who work in or with it. Designers are in a unique position to reduce the risks that arise during the life cycle of the asset during the design phase.

In accordance with Safety in Design/ WHS Legislation, at each phase of the design process, risk identification must take place with the view to eliminating the risk, or where this is not possible, reducing risk as low as reasonably practicable, through the implementation of control measures. Safety in Design Risk Assessments must be carried out throughout the job and reported on at regular team meetings, keeping the status of control measures and the residual risks at a current level. Refer to clause 2.7 Risk Register for further information about reporting obligations.

For all new building projects, complex refurbishment projects, or high-risk projects a mandatory Safety in Design Risk Assessment Workshop must be carried out no later than the 50% Documentation Phase. This should be led by a member of the consultant team and in addition to the contractor, the consultant team and relevant other parties such as fabricators/ operators specific to the project, the workshop must be attended by a UoA WHS Representative and the UoA End-User Representative.

The assessment should involve hazard identification, assessment of risk of harm for each hazard, and strategy for eliminating or controlling the risk. One outcome of the assessment may be that Safe Operating Procedures (SOP) need to be developed. The SOPs identified in the Safety in Design Risk Assessment Workshop must be incorporated into the End-User Building User Guide and Safety Induction.

As part of the Safety in Design Risk Assessment, confirm with the Associate Director Capital Projects Delivery, as to whether consultation with the Gender Equity and Diversity Committee (or delegate) is required, to establish risks associated with cultural and gender safety associated with the project.

2.9 Independent building commissioning

For all new buildings, or where the Project Brief requires it, an independent commissioning agent not involved with the design or construction of the project must be engaged.

Detailed testing and commissioning requirements must be specified for each project by the UoA-appointed consultant/designer.

Project hand over inspection and testing plans (ITPs) must be developed by the consultant/contractor to allow the system to be handed over to the University. Detailed testing and commissioning records must be provided for each system and each component, taking into account the requirements of the Standards. All such records must be witnessed and verified by the UoA-appointed project consultant/ designer.

2.10 Post-occupancy Building Services Performance Report

After one seasonal cycle of operation, an independent building services performance review must be carried out and report prepared. Refer to the Manager, Sustainability for details. This may be carried out internally, or by an external consultant. Requirements of the Post-Occupancy Building Services Performance Report will be established by the Manager of Sustainability.

2.11 Manufacturer specifications

All installation must be carried out in accordance with manufacturer specifications and data sheets to ensure product performance over its intended life and so as not to invalidate any warranties.

2.12 Sustainable design

The adoption of environmentally sustainable building philosophies must be considered a primary objective of all projects, regardless of size. Opportunity to implement responsible design and construction solutions must be considered as a matter of course during every phase of the project. Project specific sustainability initiatives and targets must be identified in the Project Brief along with associated reporting obligations relating to both:

a. the requirement for the designer to certify/ rate/ measure the proposed design solution prior to construction; and

b. the requirement for the designer to include physical equipment and processes for measuring the performance of the building throughout its life- cycle (refer Vol Metering and monitoring).

In the absence of the identification of project- specific sustainability targets, and in addition to sustainability considerations covered in the relevant Volumes, the following must be incorporated in all architectural and engineering services designs.

2.12.1 Energy demand and thermal comfort

To minimise energy demand and improve thermal comfort in buildings, the following must be considered:

a. Use of basements and underground parking areas and labyrinths to pre-cool intake fresh air in mechanical systems if viable and where excessive dehumidification is not required.

b. High levels of thermal insulation to roof, floors and walls.

c. Reflectance of external building materials.

d. Thermal and solar performance of glazing.

e. External shading of north, east and west facing windows and walls.

f. Building orientation and massing.

g. Design glazing to achieve optimal day lighting and solar heat gain and to minimise the need for mechanical heating or cooling.

h. Appropriate design for temperature, air velocity, fresh air ventilation rates, relative humidity for different functional spaces as required by C. Mechanical Services Design Standard.

2.12.2 Use of natural daylight

a. Design façades and windows to maximise natural daylight in usable floor areas and incorporate use of sky lights, light wells and internal atriums or courtyards where appropriate.

b. Avoid overshadowing and visual intrusion onto adjoining sites.

c. Design buildings to avoid undesirable glare impacts on pedestrians, motorists, people using open spaces and those in other buildings.

d. Minimise the impact of night lighting on adjacent sites and buildings.

2.12.3 Indoor environmental quality

a. Provide appropriate lighting to suit the use of the space in accordance with E. Electrical Design Standard. Record the as-designed lighting levels and controls per functional space within the post-construction As-built documentation package.

b. Use materials, fittings and furnishings with low-VOC content i.e. paints, adhesives, sealants, carpets, timber products and furniture to avoid and minimise off-gassing impacts on building occupants' health.

c. Design to minimise unacceptable noise.

d. Utilise natural cross ventilation of habitable rooms and corridors to minimize the requirement for mechanical air conditioning.

2.12.4 Energy efficiency

a. Electrical appliances with the highest Australian Government Energy Star Ratings must be used for the relevant capacity ranges of appliances. These appliances include but are not limited to refrigerators, freezers, clothes dryers, dishwashers, electric hot water boilers, televisions, computer monitors and air-conditioning units.

b. Preference must be given to locally manufactured products where multiple products have the highest energy rating.

c. Electrical equipment, including specialised laboratory equipment not covered by Energy Star Rating Scheme must include energy efficiency as part of the selection criteria and have controls to prevent unnecessary energy consumption.

d. All buildings must provide utility meters to monitor, electricity, gas and water in accordance with C. Mechanical Services Design Standard, D. Electrical Services Design Standard, F. Hydraulic Services Design Standard, and L. Metering and Monitoring Design Standard:

— Energy efficient lighting and lighting controls must be provided to meet minimum illumination requirements in accordance with the D. Electrical Services Design Standard.

— Buildings must incorporate technology to reduce peak power demand, i.e. use of thermal storage for cooling and heating, power factor correction devices, etc.

— Roof design must maximise orientation to the northwest to northeast to optimise potential for installing roof top solar energy systems.

2.12.5 Water use

a. Water sub-metering must be provided to monitor large water consuming processes in accordance with F. Hydraulic Services Design Standard and L. Metering and Monitoring Design Standard.

b. All sanitary fixtures and tap ware must achieve WELS ratings specified in F. Hydraulic Services Design Standard.

c. Rainwater harvesting and reuse (toilets, cooling towers, fire test water and landscape irrigation) must be considered for all projects and applied where feasible. Ensure system design allows for future upgrade and expansion. Opportunities to integrate 'demonstrator' education must be explored. Refer also to F. Hydraulic Services Design Standard.

2.12.6 Water sensitive urban design

University campuses must implement water sensitive urban design principles by:

a. Reducing potable water demand through water efficient appliances, hydraulic standard.

b. Capturing rainwater for beneficial reuse including irrigation, cooling water and toilet flushing.

c. Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent re-use and or release to receiving waters.

d. Passively treating urban stormwater using bio-filtration and wetlands systems to meet water quality objectives for reuse and or discharge to surface waters.

e. Using stormwater in the urban landscape to maximise the visual and recreation amenity of developments.

f. Grey water must not be reused where expensive wastewater treatment involving significant inputs of energy, chemicals and high maintenance is required.

2.12.7 Materials

a. Materials must be selected to meet sustainability requirements specified in Section 12 of B. Architecture and Building Design Standard (this document).

b. Selection of construction materials must consider 'cradle-to-grave' environmental impacts which look at impacts associated with raw materials extraction, manufacture, use and re-use potential and disposal.

c. Preference must be given to construction materials with recycled content and reused materials where practical.

d. Life cycle costing principles must be considered in selection of materials and systems. This includes capital, operations and maintenance, and disposal costs.

e. Use recycled and recyclable content in building materials, where fit-for-purpose from a durability and performance perspective.

f. Use suitable demolition materials for on-site fill.

g. Rainforest timber and timber from Australian high conservation forests must not be used.

h. Consider appropriate design detailing for engineered products to avoid any off-gassing potential from volatile compounds used in manufacture.

2.12.8 Noise mitigation

a. During the planning process isolate noise generating activities to avoid impact on sensitive receptors and quiet activities.

b. Protect all occupied spaces from noise pollution from external and internal sources.

c. Plant and equipment located on roofs must have acoustic treatment if they generate excessive noise.

d. Plant locations and noisy equipment must be designed and situated to avoid noise impacts on sensitive receptors and local residents.

e. Minimise noise emitted from external equipment such as fans, air-conditioners, compressors, and from other noise generating sources.

f. Minimise noise transmission within multiple occupancy buildings.

2.12.9 Construction and demolition waste

Building contractors and designers must provide infrastructure for recovery of building, construction and demolition materials to minimise waste disposal to landfill. They must:

a. Prepare and implement a materials recycling and waste management plan in the construction phase for all construction and demolition waste as part of the project environmental management plan.

b. Identify the range of materials that will be collected for recycling and describe procedures, management practices and reporting.

c. Formally apply dimensional co-ordination where it will practically assist the efficiency of material use, preference for modular components and materials supplied in set sizes or dimensions.

d. Consider ease of disassembly and recycling of construction materials and components at the time of refurbishment or completion of a facility's life.

e. Ensure project planning, specification and programming for the recovery, storage and transfer of reusable materials from demolition works including their transport from site to recycling and re-use facilities.

f. Implement procedures for disposal or recycling of hazardous materials at properly licensed facilities.

2.13 Durability, economy and flexibility

The University's goal is to achieve the optimal balance between capital and operating costs, whilst providing occupants a high level of environmental quality and service throughout the lifetime of each building. A whole-of-life asset value-for-money solution must be sought.

The University's building elements, services and external spaces must be:

- Cost-effective to operate and maintain.
- Designed with consideration of capital as well as operating expenditure in mind.
- Robust and durable.
- Easily and safely cleaned and maintained.
- Standardised to minimise individual specialisation and customisation.
- Flexible in the design to allow for expansion or adaption to new uses.
- Designed with built-in flexibility of space, plant and equipment to reasonably accommodate future uses.

2.14 Building compartmentation and sealing

Building fire compartments (existing and proposed) must be clearly identified within the contract documentation package and within the post-construction package. All penetrations through the barrier must be fire treated. Provide motorized dampers connected to the fire alarm system for any fixed open louvers such as at elevator shafts. Provide damper and controls to all air intakes/ exhausts.

Building envelopes must be designed and constructed with a continuous air barrier to control air leakage into, or out of, the conditioned space. Clearly identify all air barrier components on construction documents and detail the joints, and penetrations of the air barrier. The air barrier must be durable to last the anticipated service life of the assembly. Do not install lighting fixtures with ventilation holes through the air barrier.

3. Technical requirements

This section outlines the specific technical requirements for D. Electrical Services UoA Design Standards.

3.1 Design considerations

The design considerations are intended to facilitate the provision of functional spaces which are safe, comfortable and aesthetically pleasing.

3.1.1 Consistency

Combining electrical systems that vary in manufacturer and operating principals cause unnecessary complications during maintenance periods.

Within buildings, and across campuses, UoA seek uniformity in electrical systems design, effectively achieving coherence and compatibility across components both portable and fixed.

3.1.2 Functionality

UoA expect designers to understand the functions of the space and produce designs that practically serve the intended purpose of the space, permitting simplistic usability for every day operation and maintenance.

Determining logical functionality should involve consideration of several factors including special power requirements, overall cost and probability of expansion. Preference lies in the delivery of complete cost effective packages that refrain from over engineering and unnecessary expenditure.

Where applicable, the designer must identify UoA preferred standard selections of plant and equipment.

3.1.3 Safety and maintainability

Maintenance of electrical equipment and systems is crucial. Poor maintainability of equipment often leads to unexpected failures and lengthy power outages.

Reducing maintenance difficulties and optimising availability of products is essential. Design solutions must prioritise safety at all stages from equipment selection through to construction and ongoing operation and maintenance.

3.1.4 Innovation

Incorporate contemporary technology and innovative engineering for aesthetics and functionality. Designers should perform life cycle analysis, where requested by the brief or where required to prove best solution, on systems to ensure that selected equipment will last the expected life of the building and replacement equipment remains available throughout.

3.2 Spare capacity

Supply and distribution systems must have capacity to deliver the project maximum demand at quality parameters to within tolerance of the end use equipment specifications, without exceeding the manufacturer's ratings for reliable operation of any system component. Systems should have capacity to accommodate load growth as defined by UoA.

Electrical maximum demand for particular spaces such as laboratories and data facilities tend to change in size throughout the life of the building. Provide electrical infrastructure capable of accommodating any expansion.

Provision must be made for spare capacity in components of the electrical system. As a general rule, a minimum of 25% spare capacity should be allowed for when sizing electrical equipment such as:

- Power Transformers and Switchgear
- Feeder Cabling
- Submains Cabling
- Main Switchboards and Distribution Switchboards (including Mechanical Services Switchboards)
- Cable Containment Systems
- Sub-circuit cabling
- Generators
- UPS Systems

Any essential distribution systems (cabling and distribution boards) must be designed with a minimum 50% spare capacity.

Laboratory spaces should be designed with a minimum 40% spare capacity but the requirement will vary from project to project and the designer is responsible for coordinating and confirming the requirement.

3.3 Redundancy and criticality

Where equipment within a space is considered to be critical to the operation of the space, redundant infrastructure, back-up power supplies and the like must be included within the design. Assessment of a space's functionality should provide clarity on whether redundant equipment is required.

3.3.1 Laboratories

Some of the functions within UoA laboratories may require a diverse power supply. Criticality of power supplies in laboratories is to be determined in the early design phase specific to each project.

3.3.2 Plant rooms

Plant rooms provide support to the functions within the particular building and generally house safety services plant and control gear that is critical to facilitate safe evacuation during an emergency. The criticality of such areas should match the requirements for the occupation within the building. Power supplies designed for plant room equipment should be in line with essential services.

3.3.3 Data facilities and communications rooms

These facilities are usually of high criticality, requiring diverse redundant power supplies for servers and critical data storage equipment, and support services. Assessment must be made for the required level of redundancy during the early design phase.

3.4 Energy conservation and sustainability

Energy conservation is a fundamental design principle within UoA. Electrical works must comply with the requirements of the National Construction Code (NCC) and UoA sustainability requirements.

Consultants must co-ordinate with the broader design team to consider environmentally sustainable design (ESD), including environmental impacts and energy efficiency.

Additional initiatives and requirements will be identified by the project brief.

3.5 Standards and codes

New electrical systems and modifications must comply with all relevant Australian Standards, National Construction Code, SA Electrical Requirements, SA Electricity Act 1945, and Work Health and Safety Requirements (Public Buildings) Regulations.

Where Australian Standards are not available, relevant IEC and/or ISO standards must be referred to.

Applicable Standards include (but are not limited to) those listed within the References section of this document. Standards listed should be reviewed for current versions and additional amendments.

3.6 Infrastructure

3.6.1 Load profile development

Due consideration must be given to the accurate development of the project load profile.

The adequacy of supply must always be assessed prior to proceeding with any electrical design. An increase in the maximum demand above that currently covered in the existing University network (and also possibly more than allowed by SAPN) is to be requested and approved through the University (including where relevant application to SAPN) as part of the design.

3.6.2 Shutdowns

Electrical supply should not be disconnected or isolated without prior notice. Notice periods are subject to University's academic calendar (to take into account activities such as exams), but also subject to change and should be determined for specific project requirements. As a general rule, the following minimum notice periods should be allocated: long term planning – 2-6 months; confirmation of project timetable – 2 weeks; immediate requirements – 48 hours.

3.6.3 Temporary supply for construction purposes

The temporary supply of electricity to a construction site is the responsibility of the building contractor and is inclusive of temporary wiring and distribution boards.

The building contractor must determine the appropriate point and method of connection and submit for approval. Final connection of the temporary supply must be witnessed by UoA.

3.7 Electricity metering

Metering must be provided to enable effective monitoring of the energy use throughout the building and space charging. For detailed requirements refer to L. Metering and Monitoring Design Standard.

3.8 High voltage distribution

3.8.1 General

HV infrastructure must be designed with consideration of ease of maintenance and installed in accordance with Australian Standards, NCC and the South Australian Power Networks requirements.

The various aspects of the HV distribution system must be coordinated with architectural design requirements, fire protection strategy and security requirements. Refer to B. Building and Architecture, C. Mechanical Services, G. Fire Services and H. Security Services.

All new installations must be HV ready in anticipation of a transition to the University becoming a High Voltage customer in the future.

Where there are high voltage transformers and switch gear on site it must:

- Either be housed in buildings or structures remote from student and staff areas or be located in a fire isolated part of the main building
- Comply with the requirements of the NCC and Statutory Authority requirements for fire separation and/or isolation from buildings
- Include separation for redundancy of supply where required for critical loads
- Only be accessible by authorised persons
- Be installed in environments where it can be accessed safely for operation and maintenance during the most extreme credible risk management conditions, e.g., restoration of services during a storm
- Be provided with lighting served from the essential electricity supply
- Be provided with power to control switching served from the essential electricity supply.

3.8.2 HV cable

HV cable routes for new installations must be determined through consultation with UoA..

All trenching or ground penetration for HV cables must be coordinated with all other in-ground services. Trenching, back-filling and surface treatment must comply with J. External Works.

New HV cables must be installed underground or in service tunnels where available. For new HV cable routes, consideration must be given to utilising the dedicated service corridors which have been established on site.

Cable distribution paths for both HV and LV distribution systems must include diverse routing for redundancy of supply where required for critical loads.

3.8.3 HV network rings

HV network feeder cabling should be aluminium XLPE/PVC, or as confirmed with UoA for the specific position in the network.

The HV network feeder cable should be buried to a minimum of 900mm below finished ground level or laid within dedicated trenches.

The HV network feeder cable can be installed direct buried or within conduit, however must be installed within conduit for road crossings.

3.8.4 HV transformer cable

HV transformer cabling must be copper XLPE/PVC.

The HV transformer cabling must be buried to a minimum of 900mm below finished ground level or laid within dedicated trenches.

The HV transformer cable must be installed direct buried or within conduit, however must be installed within conduit for road crossings.

3.8.5 HV switchgear

3.8.6 Ring main units

HV Switchgear must be rated at 12kV and have a minimum fault rating of 25kA/1s.

The HV Switchgear should utilise vacuum technology as the dielectric and circuit-interrupting medium. Gas insulated (SF6) HV Switchgear may also be considered as an alternative.

HV Switchgear must be metal clad, modular and extensible. Extensibility must be provided at one end as a minimum, to allow for additional functional units to be added in the future.

All HV Switchgear must be designed and constructed to Australian Standards (or equivalent international standards) providing complete safety to the operator by ensuring full arc fault containment. All HV Switchgear is to be provided with Type Test Certificates by the manufacturer.

The typical general arrangement of HV switchgear must consist of the following functional units:

- x Network Isolator Switches
- N x Transformer Circuit Breakers (where N = number of Transformers)
- +1 x Transformer Circuit Breakers where required for redundancy or future expansion

Provision must be made for the HV switchgear to be operated remotely but without removing local switching ability.

The HV Switchgear must also be fitted with motorisation on the Network Isolator Switches. Equipment must be compatible and integrate with the BMCS for remote operation.

Transformer Circuit Breakers do not require motorisation unless deemed necessary for the design.

3.8.7 Protection relays

Protection Relays on Ring Main Units must be microprocessor based and self-powered. Auxiliary powered relays (e.g. DC) can also be considered as an alternative, if deemed necessary for the design.

Protection Relays must be capable of providing the following protection functions:

- Feeder Protection Functions (IEEE/ANSI) – full selectable range of Instantaneous and IDMT for Over Current and Earth Fault.
- Configurable Curve Types (IDMT Stages) – full selectable range of Instantaneous through to Standard Inverse.

3.8.8 HV power transformers

3.8.9 Dry type transformer (cast resin)

Power transformers and associated equipment must be designed to meet load requirements for continuous operation under normal site conditions (AN) plus spare capacity for future use. Air forced cooling (AF) must be considered, if deemed necessary for the design.

Consideration must be given to noise requirements specified in Australian Standards.

Transformers must be specified as having dual primary voltages of 6.6kV & 11kV to allow for future upgrade of the system voltage from 6.6kV to 11kV.

Minimum degree of protection for power transformers must be IP66 for outdoor applications and IP23 for indoor applications.

3.8.10 Oil type transformer

Oil type transformers are not preferred, unless deemed absolutely necessary for the design. Where the use of such transformers is unavoidable, additional measures will need to be adopted and approved.

3.8.11 Earthing of HV systems

All earthing must be designed, installed and tested in accordance with AS 2067 and AS 3000.

3.8.12 HV switching

All HV switching must be undertaken in conjunction with UoA nominated authorised electrical officers.

Prior to any switching on campus, a switching programme must be approved by UoA authorised representative. All switching operators must be competent, licensed and have completed a Western Power approved High Voltage Switching Course.

Refer to Campus Management for UoA switching policy.

3.8.13 Substations

The design of substations should conform to the requirements of all authorities, regulatory bodies and Code/ Standards.

A single line diagram of the high voltage system should be mounted in the switch room and show:

- Source of supply
- Extent of the system
- Ownership interfaces of the equipment
- Supply Authority contact person details
- Ratings of protection
- Ratings of cables
- The location of any earthing equipment needed for the switchgear
- The location of any standard switching schedules associated with use and maintenance of the switchgear
- The location of safety and test equipment needed for switching
- Contact details of persons authorised to carry out, and qualified to perform the switching.

3.8.14 Accessibility

Provision must be made to enable removal and replacement of equipment such as transformers and switchgear for maintenance by means of sizable doors and removable panels. Access covers can also be considered to allow for lifting the equipment through the roof, if deemed necessary for the design.

3.8.15 Cable conduits & pathways

Consideration must be made for the path of heavy mains cables.

Conduits must be sized to conform to AS 3000 and to facilitate pulling cables with ease.

Cable pits and trenches must be sized to facilitate the specified bending radii of the cables and permit cable jointers to work within them.

Concrete Cable Trenches

The size of cable trenches and pathways must be large enough to facilitate maintenance activities and prevent unnecessary bunching of cables.

Direction changes within trenches must be large enough to allow for the bending radius of heavy submains cabling.

Trench covers must be constructed of a material that is easily removed by two maintenance personnel. The top of the covers must finish flush with the finished floor level as to avoid tripping hazards.

All concrete cable trenches must be tanked to avoid ingress of ground water and designed to allow for drainage to prevent flooding.

3.8.16 Ventilation/ air conditioning

Adequate ventilation/ temperature controls must be provided to ensure that equipment does not exceed maximum ambient temperature ratings of all equipment under maximum operating conditions.

Natural ventilation must be considered primarily, though where impractical, must be by means of air conditioning and/or exhaust fans. Mechanical ventilation/ conditioning equipment must be controlled locally and be monitored by the BMCS.

3.8.17 Fans and drive motors

Fans and drive motors must be selected in such a way that 100% design air quantities for a given system are delivered when air handling equipment is operating at not more than 80% of the maximum available design static pressure or design flow (L/s), whichever is less. In general, larger fan sizes that allow lower operating speeds and noise levels are preferred.

3.8.18 Access control

Substations must be secured to prevent unauthorised public access. The door locking system selected must comply with H. Security Services. Facilities for emergency egress must be provided at all times.

3.9 Back-up power supply

Electrical designs must be assessed for the need of back-up power supplies. Integration of back-up power may include redundant HV network rings and equipment, uninterruptible power supply (UPS) systems and generators.

Selection of a type of back-up power system will call for assessment of project specific functionality.

The design and installation of diesel generators, battery bank UPS units and automatic transfer switches (ATS) is not mandatory unless specified for the project brief.

Back-up power supply system alarms must be integrated to the BMS for monitoring.

3.9.1 Transfer switching

Assessment must be made to determine the type of switching for connection of alternate power sources that is appropriate for the project.

Manual transfer switches would be considered for connection of alternate power for maintenance involving interruption to non-critical loads; for example, connection of a portable generator via a plug connection.

Open transition automatic transfer switching would be considered for non-attended operation and connection of critical loads. In this instance, the re-connection of mains power would involve a break in the power supply and would be appropriate where this momentary loss of power does not compromise the operation of connected equipment. In addition to occurrences of loss of mains power, this momentary loss of power to a critical load would occur during periods of testing the operation of the alternative power supply arrangement.

For any load where such a momentary loss of supply would have a deleterious effect on the performance or operation of the equipment, then the more appropriate form of switching would be a closed transition ATS system.

Where the capacity of the alternate power source is lower than the normally connected load, load shedding procedures should be incorporated into the distribution design.

Where functionality allows all transfer switches should be integrated into the BMS/alarms system.

3.9.2 Standby generators

Back up generation must be designed with a minimum back up time of 24 hour run time at full load. All new back-up generators must be Modbus compatible to communicate with the existing power monitoring system including ATSs.

Generators must be supplied and installed complete with all controls, safety devices and auxiliaries to provide safe and unattended operation. All controls and alarms must be integrated into existing UoA systems and be able to use the existing established communications protocol.

Generally, generators must be sized such that the maximum connected load is <70% of the generator rating and minimum connected load is >50% of the generator rating. Additional future load must be considered when sizing the generator.

Where transfer switching forms part of the distribution of power across the campus, an ATS logic procedure diagram must be displayed in the associated switch room for maintenance contractor reference.

Standby generators must have fuel supply arrangements that will keep them in operation for the longest credible normal supply outage as determined by risk analysis or as nominated by UoA.

The fuel system must have provision for emptying fuel tanks so that fuel can be replaced if fuel condition monitoring indicates quality has deteriorated.

Generators must be installed in an environment where they can be serviced and maintained in all conditions.

Routine testing must be configured to be undertaken on live loads, but without disruption to the normal operation of the facility. Provision must be made for a load bank connection point rated to >70% of the generator rating.

3.9.3 Uninterruptible Power Supplies (UPS)

UPS power supply provisions must be assessed according the criticality and functioning of the load, as appropriate to the specific needs of each project.

All UPS systems must be configured for coordinated distribution of power, required levels of redundancy, autonomy time to suit equipment shutdown or alternative longer term power back up and diverse power flow where required. Determine the appropriate selection of centralised versus distributed systems, fully on-line versus standby operation, positioning of large and potentially heavy plant, energy storage options, system maintainability and functionality.

A complete UPS maintenance plan must be developed and agreed upon in consultation with UoA.

3.9.4 Static UPS

Static UPS units must be designed and installed in accordance with the relevant equipment manufacturer's specifications and relevant Australian Standards.

UPS system batteries must be housed in a suitably designed rack or enclosure. All battery enclosures are to be designed to allow adequate space for maintenance activities. Enclosures must be positioned in a room to allow for sufficient ventilation, cooling and maintenance.

Flywheel energy storage systems must be positioned to suit the structural design of the building. Adequate access for removal must be provided.

All equipment must be provided with adequate clearances to allow safe exit in the case of an emergency.

Where a standalone rack mountable UPS system is to be introduced, heat dissipation must be considered especially for small switch rooms and enclosures. Where the ambient temperature is likely to exceed 25°C a ventilation or air conditioning system must be installed.

3.9.5 UPS maintenance

A copy of the manufacturer's specifications and commissioning report including test values established at setup must be included in the Operation and Maintenance manuals and in the system's enclosure.

3.10 Renewable energy sources

Renewable energy sources must be considered in line with project specific requirements and UoA guidelines.

Where renewable energy sources (for example, solar PV systems) are to be incorporated, all regulatory protocols required must be incorporated into the project, including all necessary consultation with and obtaining the approval of UoA.

3.11 Switch rooms

3.11.1 Spatial

The size of switch rooms and switchboard cupboards must be sufficient to accommodate the switchboard, additional associated electrical equipment and the free movement of maintenance personnel carrying out maintenance activities. Switchboard rooms and cupboards must be sized to the requirements of AS 3000, including the use of two points of egress if required.

Provide adequate access and egress pathways, not only for the switch room itself but for surrounding emergency egress areas that may be affected by the switch room positioning. Such areas may include lift lobbies/ openings, emergency exits into stairwells and narrow corridors

Allowances must be made for free movement of trolleys and lifting aids where replacement of electrical equipment may be required.

Ceiling height or space between the top of switchboards and under soffit must be adequate to allow for overhead cable containment, sufficient bending radius of cables and ventilation/ air movement.

If the building is to be extended in the future, the switch room must be of adequate size to enable the switchboard to expand on both ends.

Space must be considered for potential auxiliary equipment, such as metering, harmonic filtration, power factor correction units, external lighting control units and general light and power distribution boards, plus items which may be required as part of future expansion.

All new locks must be provided to comply with UoA master keying system requirements.

3.11.2 Ventilation

Switch room ventilation must be by means of louvered vents, air conditioning and/or exhaust fans. Special consideration must be made for ventilation of equipment that produces excessive heat such as UPS systems and Power Factor Correction Units. All air intakes must be provided with filters to avoid dust build up in the rooms.

Ventilation of switch rooms housing several large switchboards and pieces of electrical equipment must be locally controlled and monitored by the BMS.

3.11.3 Security

Doors must be fitted with the appropriate security equipment to prevent unnecessary entry by unauthorised personnel, while allowing for exit from within the switch room without the use of a key. Doors must open outwards in the direction of egress from inside the switchroom.

The door locking system should comply with the UoA master keying system and be integrated with the building security system. Refer H. Security Services.

Emergency egress must be provided at all times.

3.11.4 General light and power

Power supply for general lighting and power within the main switch room and other large switch rooms must be derived from the essential services side in such a way that allows for the safe operation of equipment within the room during times of electrical shut-downs.

At least one general power outlet and one data outlet must be installed within each switch room for use of miscellaneous equipment or tools such as hydraulic crimpers, vacuum cleaners, laptops etc.

An allowance must be made for data outlet/connection for all systems including MBS, metering, alarms etc.

3.11.5 Signage / labelling

Doors of main switch rooms and cupboards must be fitted with UoA standard door nameplate detailing the room number and name. Refer to UoA As-Constructed Documentation Specification for room numbering.

HV substation and switch room doors must contain the correct signage in accordance with AS 1319. Signage on doors must comprise the words 'DANGER', 'High Voltage' and 'Authorised Persons Only'.

3.12 Switchboards

3.12.1 General

This section applies to Main Switchboards (MSB), Main Distribution Boards (MDB), Distribution Switchboards (DB) and Other Services Switchboards, such as Mechanical (MSSB), Fire Pumps (FSSB), Hydraulics Pump Systems (HSSB) and the like.

Internal wiring must be neat without unnecessary crossing of cables. Cable looms must be tied regularly and secured to cable basket or tray to avoid cable sag and free movement.

HRC fuses are not preferred but where fitted as part of an existing installation consult with UoA Service Delivery Team in regards to upgrade or change to modern circuit protection devices.

3.12.2 Inspection and testing

Witness testing by the design consultant will be required as part of commissioning activities to ensure the lighting levels meet the design intent, and to ensure over- lighting has been avoided.

The following sequence of inspections and tests should be carried out by UoA representative (this may be the consultant):

- Approval of switchboard drawings after selection of switchboard manufacturer but prior to commencement of manufacture
- One factory inspection when the switchboard is substantially assembled but before painting and finishing has been started
- One factory inspection before the finished switchboard leaves the works including ductor, primary and secondary current injection and hi-pot test of all automatic equipment on the switchboard
- A thorough on-site inspection of the whole switchboard including all connections to it before the board is energised
- During the highest load timeframe of the warranty period a thermal graphic survey must be carried out and a written report must be submitted to Campus Management.

3.12.3 Main switchboard

The main switchboard must be designed for the specific project requirements.

Hinged panels must be suitably stiffened and fitted with lift-off hinges. Large lift-off panels are not favoured, though if unavoidable, must be fitted with appropriate D handles for ease of removal. Such panels must have a means of support such as guide studs or support ledge for use while fixing screws are being fastened.

Escutcheon covers and hinged panels must be fixed in place with a fixing screw able to be loosened without the use of a tool.

The switchboard must be mounted on a welded, galvanised channel that is pre-drilled to allow for hold down bolts.

Provide type tested assemblies that are identifiable with respective Type Test Certification.

The main switchboard may have front or back access.

Provision must be made for connection of future submain circuits using a variety of different circuit breaker sizes, with overall capacity as noted in Section 3.2 Spare capacity of this document.

Cable containment leading to and within the main switchboard must be sized to accommodate cables for future expansion.

For all switchboards located in cupboards or rooms, the external finish must be two coats of gloss enamel paint in a colour approved by UoA. Internal finish colour should be gloss white. Where the switchboard is exposed to view and the colour scheme of the building requires a different switchboard colour, the actual selection must be to UoA's requirements and approval. For switchboards serving essential or critical loads, or requiring clear identification for reasons of functionality or operation, an alternative colour scheme must be developed to UoA's requirements and approval.

During the highest load time-frame of the warranty period a thermographic survey must be carried out on all main switchboards, major distribution switchboards and switchboards serving essential or critical loads. A written report must be submitted to UoA.

3.12.4 Busbars

Busbars must be of adequate dimensions to accommodate the power load to be carried by the switchboard throughout the anticipated life of the building. Consideration for larger bars installed in the first instance may save a costly rebuild of the switchboard if the building is ever extended.

Care should be taken to ensure that the busbars are rigidly supported. All bolts on busbar systems must be correctly tightened and checked. All bolts must be high tensile strength.

Busbars in open sections of a board such as the connections to the rear terminals of switches or switchgear must be insulated with phase-coloured insulation. Busbars must not alter in cross sectional area along the entire length on installation.

3.12.5 Other services switchboards

For general design criteria for other services switchboards (MSSB and the like) refer to Section 3.12.3 Main switchboard of this document.

3.12.6 Distribution switchboards

Where practicable, distribution switchboards must be located in circulation spaces, corridors or foyers in a secure dedicated cupboard or room. Consideration must be made to locate DB's close to vertical services risers. Switchboards must be positioned to avoid subcircuit cabling cross fire zone boundaries.

Ceiling access panels (minimum size 600x600mm) must be installed close to the distribution board to facilitate easy access for installation of additional cabling.

Completed circuit schedules must be provided to UoA and incorporated in Operations and Maintenance manuals.

All new distribution boards and distribution board equipment and accessories must be selected to match existing UoA preferred selections. Consult with UoA Service Delivery Team.

3.12.7 Size and construction

Distribution switchboards must be designed with large cable zones and equipment space.

All distribution boards must:

- Comprise single main isolating switch with shrouded terminals
- Be constructed from sheet steel
- Have gland plates for top and bottom entry

The main isolating switch must not interlock with the escutcheon cover.

3.12.8 Numbering of distribution boards and circuit breakers

Each distribution switchboard must be clearly numbered and labelled. The numbering system is to be self-evident and consistent across the project, with no possibility of duplication of numbers or confusion between the switchboard position and the area served, for example. The numbering on distribution boards must be carried out in accordance with Section 3.21 As installed documentation and operations and maintenance manuals and utilise the next available number within the system.

Where a switchboard is supplied with power from an upstream distribution switchboard, it must bear the originating switchboard's designation followed by its own identifying numeral. By this means the number of the switchboard will describe the origin of supply. This numbering would apply even if a sub-distribution board on one level supplies power to a board on another level.

Both the phase and circuit numbers of each circuit breaker should be clearly shown on the distribution board escutcheon. The numbering sequence should be Red 1, White 1, Blue 1, Red 2, White 2, Blue 2 etc.

This can best be achieved by coloured indicating buttons (IPA markers) mounted adjacent to each circuit breaker.

Circuit Schedule

A clear, legible, typed circuit schedule on white A4-size UoA approved template cardboard must be installed in a metal holder either adjacent to or attached to the inside of the door of each distribution switchboard. A copy of the circuit schedule must be provided to UoA Services Delivery electrical staff.

In a new building, the room numbers and designations must be checked as these may change during the course of construction.

3.12.9 Externally mounted switchboards

External mounted switchboards are not preferred but where they be avoided the switchboards must be designed to the conditions.

Where switchboards are mounted external to buildings and subject to weather conditions, the outer enclosure must be fabricated from 3mm gauge marine grade aluminium with a sanded finish. Door locks must be stainless steel.

3.13 Power quality

3.13.1 Power factor correction

All electrical installations must be designed with high efficiency equipment. All loads and equipment must be provided with power factor corrective devices, to optimise the total connected load with high lagging power factor.

Power factor correction must be considered for loads (buildings or individual switchboards, as appropriate) with a maximum demand above 400 A.

At the point of attachment to new buildings, the power factor must be maintained at not less than 0.85. If SAPN require the power factor to be higher due to the size of the load then the SAPN minimum requirement must be met.

Units must be reliable with a minimum life expectancy of 10 years for all components.

Power factor correction units must be fitted with fault and overheating alarms that are integrated into the building alarm monitoring BMCS system.

Power factor optimisation equipment must be in conjunction and coordinated with harmonic distortion minimisation devices.

3.13.2 Harmonics

Harmonic voltages and currents are undesired phenomena that occur in power systems containing non-linear electrical loads and are very common in contemporary electrical installations. The presence of harmonics in a system often results in increased heating in the equipment and conductors, misfiring in variable speed drives and torque pulsations in motors.

Where any non-linear electrical equipment is selected for installation, provision must be made for additional harmonic mitigation/ filtration equipment to meet the SAPN minimum prescribed levels. Such mitigation measures must comprise active or passive equipment as appropriate to the interference issues that are present.

Harmonic filtration must be provided to limit harmonic distortion at the point of common coupling (PCC). The definition of PCC must be taken to mean, broadly, the point of connection of a specific load or switchboard to other parts of the electrical installation – this may comprise the building HV connection point, building main switchboard, mechanical services or other plant switchboards or other distribution switchboards with harmonic rich equipment connected.

The maximum harmonic content at any of the selected PCC must be maintained within the limits permitted for connection to the Western Power network. The equipment must be placed within the electrical system in such a way to best protect the rest of the installation from the areas where harmonics are generated.

3.13.3 Lightning protection

Lightning protection risk assessments must be carried out on all UoA facilities to comply with AS/NZS 1768.

Risk assessment outcomes and mitigation strategies must be agreed and recorded. Risks must be mitigated, including surge protection on incoming and electrical distribution services, and passive Faraday cage building protection. Active (collector) type building protection systems are not considered acceptable.

3.13.4 Surge protection

Provide surge protection devices in all switchboards in accordance with the measures as selected in the AS/NZS 1768 assessment process. As a minimum, coarse protection must be provided at every building entry and at all locations where the supply cabling is subject to elevated induced voltage through a lightning strike. Fire protection must be provided on all subcircuit runs to equipment deemed to have critical functionality.

Surge protection equipment must be installed with neon indicators visible through the switchboard escutcheon. The indicators must display the condition of the suppression equipment.

3.13.5 Cable support and containment systems

Cables must be supported at all positions along the cable route to deliver a neat, practical and maintainable installation.

Cable support systems may comprise:

- Cable Tray - preferred
- Cable Ladder
- Cable Basket

- Cable Duct/ trunking
- Clips, cable ties and cleats.
- Catenary Wire – only used when no system above cannot be utilised; justification will be required.

Cable tray, basket and ladder must be galvanised or stainless steel and be complete proprietary systems. Only the same manufacturer's standard fittings and joining plates must be used.

Trays must be generously sized so that cables are not entangled and it is practicable to remove redundant cables as any become disused.

3.13.6 Underground services

All activities involved with underground services must be coordinated with other services and be in accordance with J. External Works.

The location and depth of existing underground services in the vicinity must be confirmed during the design phase of the project and verified on site prior to commencement of any earth works or trenching. On-site testing must be undertaken through the use of Ground Penetrating Radar (GPR), potholing and other non-intrusive methods.

Trenching

Where existing services lay in the proposed route of a trench, provision must be made for trenching by hand to avoid possible damage. Existing services must not be tampered with in any way unless instructed by UoA Service Delivery. Accidental damage to existing services must be reported immediately.

Trenching must be performed at agreed times to minimise disruption to normal personnel movement.

Safety barriers must be erected for personnel commuting in the area.

Conduits must be provided for all underground cables installed beneath paths or roads whether sealed or not. Conduits must extend 1m on both sides of the road or path.

Spare conduits must be provided for mains cable routes.

Cable pits

Cable pits must be provided in cable routes at regular intervals and changes of direction to facilitate the ease of cable pulling and maintenance activities.

Conduit entries must be drilled neatly to the size of the associated conduit. Any gaps around the conduit and entry hole must be suitably sealed. Drainage holes must be drilled in the bottom of the pit.

Trafficable lids must be installed to pits where there is an increased likelihood of vehicle movement.

Pits must be sized to suit the bending radius of largest cable being installed.

Cable pit lids must be labelled as to the service within.

3.13.7 Conduits

Where conduits are required for cable reticulation, the installation method preferred is PVC insulated cables installed in Class B heavy-duty PVC conduit.

PVC conduit must be used in areas where corrosive gases may be present. Where PVC conduits are installed in service areas or accessible roof spaces they must be neatly racked and fixed to SAlls or structural members. They must not be installed without further protection in areas where they can be damaged by traffic. Conduits must be installed such that they do not obstruct access to roof or similar spaces.

PVC conduit must not be used where exposed to excessive temperatures, exposed to direct sunlight (e.g. in glasshouses) or where radio shielding of the power cables is necessary (e.g. Physics building). Heavy-gauge galvanised screwed steel conduit can be used as a suitable alternative for these areas.

Conduits must have a minimum diameter of 20mm. The number of cables installed in conduits must comply with AS 3000.

Draw wires must be installed in all conduits.

Heavy duty orange conduit and fittings must be used underground and where exposed in plant and switch rooms, service ducts and roof spaces.

Exposed conduits are to be avoided wherever possible.

3.14 Seismic restraints

All services must be seismically restrained to Australian Standard requirements.

3.15 Lighting

3.15.1 General

Lighting designs must meet all the applicable requirements of the NCC, AS 1680 and AS 1158. All lighting designs must provide adequate functional lighting to suit the tasks of the spaces, create a comfortable working space, complement architectural design requirements, be in accordance with sustainability requirements for the project, be simple to operate, be readily maintainable and flexible for future uses of the facility.

Areas must be illuminated by natural light or artificial means to afford safety and visibility commensurate with the purposes of each area.

Where working positions are fixed, task lighting may be used.

Consideration must be made for occupant safety and security lighting, including adequate provisions for night time.

Over lighting significantly above the Australian Standards (>25%) should be avoided.

Light fittings and components must be assessed against the following points for selection:

- Energy Efficiency
- Maintainability
- Number of compatible lamps
- Switching control method
- Cost

The type and position of fitting selected must allow for easy repair and maintenance.

Recessed fittings must be installed complete with a length of flexible cable and plug top.

3.15.2 Types of Lighting

Lighting designs must deliver a complete lighting solution that is functional to the space and embraces the following elements:

General environment light

Environment light is the type of light that provides a blanket wash of illumination. The function of environment light is to facilitate general orientation and activity. Environment light must be the base foundation allowing for additional accent lighting.

Task/direct light

Direct lighting can be used to provide contrast. This type of lighting must be employed where the aim is to accentuate focal points and highlight important areas. An example where task lighting may be applied is within a laboratory.

Feature light

Feature lighting (e.g., the use of coloured lamps and RGB LED fittings) may be used to create a decorative feature to the overall lighting design. Although feature lighting does not necessarily provide practical functionality, it must be considered for public areas and foyers. This aspect of lighting could also assist with signage and wayfinding.

3.15.3 Luminaires

Luminaires installed within reach must be suitably constructed or protected by guards against accidental damage so that bare lamps are not directly exposed.

Luminaires in plant rooms must be suitably protected from physical damage.

Selected luminaires must be of high quality construction fabricated by reputable manufacturers, with a long-term prospect of availability of spare parts and replacements for future maintenance and refurbishments.

All lighting designs must incorporate contemporary lamp and luminaire selections that are proven through past installations and offering the latest in commercially available technology.

All luminaires must be flicker-free.

LED fittings must primarily be considered for new or refurbishment projects. Feasible alternatives may be considered through consultation with UOA. Only energy efficient alternatives will be considered.

LED fittings must be manufactured by a reputable manufacturer with representation and support in Adelaide. All luminaires must comprise matched lamps and drivers and have proven photometric performance, colour stability through life, demonstrable lumen depreciation, guaranteed lumen output for the nominated life of the fixture and guarantee of replacement parts. All luminaires must be provided with an unconditional warranty for the life of the fixture.

3.15.4 Lamps

All lamps throughout must be of the same make and type and provide energy saving characteristics. LED light sources must be used.

Colour temperature of lamps must be determined in the design phase to best suit the room functionality.

3.15.5 Lighting control

Energy consumption is to be minimised through the use of appropriate lighting control. Simple uncomplicated local control is preferred.

Lighting control functionality must be determined during design phase and must best suit the intended purpose of the room. Where automatic control of lighting is used, a prominently mounted separate manual switch must be provided in the area serviced to directly override all automatic controls.

Smart lighting systems must be considered primarily for all projects. Lighting control is generally achieved via motion sensors, although must not be used when it poses a safety risk. Controller override switches must be installed to allow lighting to work in the event that a controller fails.

General light switches must be positioned in easily accessible locations for operation by staff.

Dimmable drivers are preferred for all lighting installations. Justification must be provided where non-dimmable drivers are specified.

Lighting in lecture theatres must dim to 20% after 30 minutes without motion detection, after a further 5 minutes, the lights should turn off.

Lighting within multipurpose rooms such as meeting rooms and teaching facilities must be controlled via motion sensors on a 15 minute timer.

3.15.6 Emergency lighting

Emergency and Exit lighting must be documented on separate drawings in accordance with K. Documentation.

3.15.7 Exterior lighting

External areas must be provided with lighting for the purposes of safety for pedestrian movement and egress from the building, identification of traffic ways, identification of features and architectural design elements (this may also be coordinated with artwork, signage and way finding), enhancement of night-time visual effects (including consideration of landscaping elements) and avoidance of insecure dark spaces.

External lighting may be fixed to the building or mounted on separate posts. The type of external lighting selected is to harmonize with the building décor, coordinate with CCTV and conform to the general landscape in the area.

External lighting must be connected to circuits separate from those supplying the lighting in foyers, entry porches, emergency escape passageways and similar areas providing means of entry or egress. External lighting circuits are to be controlled by the BMS or similar smart lighting control system. All circuits must include a manual override switch to enable daytime maintenance.

The primary preferred lamp source is LED.

Minimum lighting levels for all campus roadways must be to P3 category. Minimum lighting levels for external carparks must be to P11 (c) category and P12 for parking spaces specifically intended for people with disabilities.

3.16 Variable speed drives

Variable Speed Drives may be used for control of mechanical equipment such as pumps and air handling units. VDSs must be of high quality and reputable manufacturer.

VSDs must be appropriately sized for the application or equipment of which it is serving. Installation must be in line with manufacturer's requirements. Refer to C. Mechanical Services.

Variable speed drives (VSDs) must be supplied with harmonic and RFI filtering equipment to meet project specific requirements.

3.17 BMS integration

The Building Management System (BMS) is generally provided as part Mechanical Services or Communications Services works. All portions of the electrical installation that require monitoring by an electronic control system for operation, management and/or maintenance must be connected to the BMS.

In general, it is intended that the BMS be provided with comprehensive information regarding the operation of all plant and equipment within the building. All proprietary control systems of electrical equipment must be provided with Status and Alarm identification to the BMS.

The following equipment should be connected to the BMS (other equipment may also be required to be connected):

- HV switchgear, power supplies
- LV main switches and transfer/ load shedding control systems
- Metering
- Surge Protection Equipment
- Generator and Back-up Power Systems, including fuel systems
- UPS systems, battery systems

- Power Factor Correction and Harmonic Filtration Units
- Lighting control system
- Emergency lighting systems
- External Lighting

3.18 Electrical equipment in hazardous areas

Areas and rooms may contain elements such as flammable gas, combustible dust and flammable liquid that produce vapours. These areas may be classified as hazardous due to the atmosphere potentially becoming explosive.

Hazardous Area Classification Specialists should be engaged for classification of areas.

Electrical equipment that must be installed in such classified locations must be specially designed and tested to ensure it does not initiate an explosion due to arcing contacts or high surface temperature of equipment.

3.19 Redundant cabling and equipment

Where cabling cannot be completely removed, the cable ends must be confirmed and made safe by means of junction boxes, termination connectors and information tags.

3.20 Testing, commissioning and certification

Prior to practical completion, testing and commissioning must be performed on all installed equipment and systems to verify that they operate correctly and function as intended.

Testing and commissioning must include as a minimum:

- Inspection of each element to establish it is complete and of the quality required for the function/ use of the space
- Testing of each element and service to establish it performs correctly in each operating mode, including operating sequences and interlocks
- Review of arrangements for operation, servicing and maintenance to ensure that they are adequate for UoA needs
- Thermographic survey of switchboards, switchgear and cable joints
- Calibration of controls and protection
- Checking the certification provided by the supplier of electrical switchgear that circuit protection discrimination complies with requirements.

Additional commissioning and certification must be delivered to demonstrate compliance of:

- HV switchboards and transformers
- LV switchboards
- The low voltage installation
- Lightning protection systems.

Results should be incorporated into the As Installed documentation and handed over as part of Practical Completion.

3.20.1 Inspections

The University reserves the right to carry out inspections during the course of construction and to undertake tests on completed installations.

Witness testing may be required for various testing and commissioning activities.

3.21 As installed documentation and operations and maintenance manuals

All projects must be completed with the handover of As Built documentation detailing all information necessary to enable safe and efficient ongoing operation and maintenance of the new works. In general the 'As Installed' documentation must comply with the requirements of K. Documentation.
In some cases, this documentation may need to take the form of upgrading existing documents. All such As Built documentation must include the following information as a minimum:

- Maximum Demand and cable sizing calculations and/ or measurements
- Power and lighting layout diagrams, including all circuiting and controls details
- Dimensioned positioning of all in-ground and concealed services
- Electrical schematic diagrams

- Switchboard and single line diagrams
- Earthing positions and tested earth resistance measurement
- Technical catalogue and documents for all installed equipment
- Schedules of all points lists and control ladder diagrams
- Compliance certificates
- Samples of all proposed electrical equipment
- Operation instructions
- Contact details and schedule for all spare and replacement parts
- Maintenance manuals, testing registers and schedules

Refer to K. Documentation for further information.

3.22 Asset register

The addition and removal of the following list of assets must be updated on the UoA asset register.

- HV switchgear and Ring main units
- HV Cables
- Transformers
- Switchboards
- Generators
- Uninterruptible power supplies
- Power factor correction and harmonic mitigation units
- Battery banks
- LV air circuit breakers
- Residual current devices
- Emergency and Exit Lighting

The following details must be entered into the asset register:

Switchboards

- Manufacturer
- Main switch size
- Switchgear make
- Number of SAys, RCDs and spare SAys.
- Supply source and rating

Generators / PFC / UPS / Battery Banks/ AHF

- Manufacturer
- Make/model
- Serial number
- Rating

HV switchgear/ ring main units / transformers

- Manufacturer
- Make/model
- Serial number
- Rating
- No. of SAys (HV switchgear)
- Supply source and rating

HV cables

- Size
- Length
- Rating