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E.3.4 HIGH VOLTAGE – SCHEDULE OF CHANGES

As a guide only, attention is drawn to changes that have been made in the following clauses since the last revision

Revision	Clause	Date
	General revision	
	E.3.4.3	August 2004
4.1	E3.4.3 –V1	Nov 2013
5	General revision	February 2014
6	General revision	April 2018

E.3.4. HIGH VOLTAGE

E.3.4.1. Overview

The UNSW Main Kensington Campus 11 KV distribution system is supplied via three points from Ausgrid's 11,000volts distribution network as follows:-

1. High Street Intake Station at Building B12a – consists of two HV feeders known as Feeder 1 and Feeder 2.
2. Botany Street Intake Station at Substation 29 – consists of a single feeder known as Feeder 3 and
3. Barker Street Intake Station at Substation 24 at TETB Building – consists of two feeders known as Feeder 4 and Feeder 5.

However, those buildings at the Western Campus and the residential colleges and student accommodations, fronting Anzac Parade and Barker Street, are supplied from Ausgrid's low voltage distribution network.

The campus has an extensive 11,000volt high voltage network of underground cables interconnecting twenty-five (25) substations. Generally, underground HV mains cables are consisted of three-core 400 sq mm PILSWA aluminium cables either directly buried and/or in conduits. For ease of making connection to HV switchgear, at entry points to substations locate within buildings, trifurcated joints are made with these single core PILSWA 300 sq mm copper cables that are then run from this point to the indoor switchgear.

These substations are arranged in four rings, commonly referred to as the red (upper), green (mid), Blue (lower campus) and black rings. The rings are designed to operate as "closed rings", to ensure minimum disruption to UNSW operations, should a high voltage fault occur on campus. The campus network is owned and operated by the UNSW.

An alternate supply, interconnect High Street Intake Station and the Botany Intake Station at Substation 29, is to provide limited back up power in the event of failure of supply from one of these two supply points. This arrangement necessitated the provision of a Castell keying regime to ensure that the two supplies are separated. The capacity limitations are about 15MVA from High Street Intake Station, 6.2MVA from the Botany Street Intake Station respectively And 7.5 MVA from the Barker Street Intake Station.

Generally, substations within the Kensington campus are interlinked with feeders' protection blocking schemes. The protection between substations is achieved by employing directional over current and earth fault protection. New substation protection design must interface with the protection schemes in the adjoining substations (protection settings and wiring changes) and review the existing scheme configuration settings is required. All new installation shall be designed to match existing protection system.

E.3.4.2. HV Cables – General Requirements

Feeder Cables

New HV cables shall be installed underground and/or installed in underground service tunnels. Exact route shall be referred to UNSW EM Engineering for concurrence prior to finalise the design.

For a new run of HV feeder inter-connecting two substations, copper cables may be used subject to agreement by the UNSW EM Engineering .

Transformer Cabling

Transformer feeder cables shall be copper flexible single core HD screened Siemens Protolon 22kV, or similar to suit the HV network fault rating and the transformer rating.

Pilot Wire Protection Cables

Existing pilot wire protection cables are four or six-core (plus earth) 6mm^2 PVC/SWA/PVC which run with the HV cables they are intended to provide protection.

For new pilot wiring installation, a minimum 6 cores (plus earth) 10mm^2 shall be installed or to meet protection schemes requirements plus 50% spare for future.

Cable Installation

HV cables shall be run underground and/or in-service tunnel as required.
In the course of laying underground cables the Contractor shall take due care in their handling to avoid any undue bending and damage. Cable installation shall meet the cable manufacturer's recommended laying procedures, minimum bending radii and constraints, including the use of specialised equipment (e.g. rollers).

Cable Trenches

Consultants and Contractors shall ensure that site conditions have been checked and ascertain the precise location and depth of existing services prior to finalise the design of the cables routes and cutting any trenches.

Generally, trenches shall be run straight, between changes of direction and junctions, with vertical sides and uniform grades. Trench widths shall be kept to the minimum required, consistent with the laying and bedding of the cables used, cable pit construction and its particular configuration.

After laying and bedding of the cables the Project Officer shall be invited to inspect this work. After approval is obtained from the Project Officer the trenches shall be immediately backfilled.

Backfilling shall be carried out in layers not greater than 200mm loose thickness and compacted to the required density and trimmed to the final earth works level. Backfilling material shall not contain any stones or sharp objects with a diameter greater than 10mm.

Prior to backfilling underground cable routes shall be accurately recorded.

Cable Location Markers

Route markers shall accurately indicate the location of underground cables. These shall consist of engraved brass marker plates set flush in a concrete base not less than 200mm diameter x 200 mm deep, placed at each joint, route junction, change of direction, termination and building entry point, and in straight runs at regular intervals.

E.3.4.3. HV Switchgear

All HV switchgear shall utilise vacuum technology as the dielectric and circuit-interrupting medium.

Six different suppliers' products are now in use in the campus. Preference to use one of these products must be considered during the design selection to match the project requirements. Consideration for ease of maintenance shall also be considered in all HV design. Any additional new product specified shall be concurred by UNSW EM Engineering prior to finalise design.

Main busbars for Main intake HV switchboard with two multiple incoming feeds shall be designed in multiple sections couple by a bus section circuit breaker, to allow maintenance of the switchboard without major shut down of the HV installation.

All HV Switchgear shall be designed and constructed to Australian Standards and/or equivalent international standard, and to any other relevant Australian or international standards.

The switchgear shall be designed for local operation (with provision for remote operation) and hence shall provide complete safety to the operator by ensuring full fault containment against all short circuit faults.

Busbars and conducting elements shall be of high conductivity copper or equivalent aluminium to suit cabling system requirements. Busbars and connections shall preferably be epoxy encapsulated or be insulated with a solid dielectric. Provision shall be provided for dissimilar medals connection.

Each HV switchboard shall be fitted with a copper earth bar of not less than 105mm^2 section, running the whole length of the switchboard, to which shall be effectively connected all metal parts not intended to be alive. Care must be taken for any dissimilar metals connection.

The general arrangement of a HV substation, located within a building, shall be: Two (2) ring-main unit circuit breakers and transformer circuit breakers to suit project design.

Selection of the ring-main unit circuit breakers shall be compatible with the operation of the existing directional protection scheme requirements.

Switchboard Construction

Switchboards shall be of the metal enclosed type with a "dead front" exterior. The switchboards shall preferably be of the front access type and of compact design, with minimum floor space requirements.

The construction shall be preferably of the indoor, non-withdrawable, freestanding metal enclosed cubicle type of such design as to require front access for connection, maintenance and repair.

The switchboard shall be designed to facilitate future extension at both ends, and busbars shall have provision for the fitting of fasteners for future extension without the need for drilling or other work.

Switchboard height shall not exceed 2000mm, unless otherwise specified.

Components requiring inspection or adjustment shall be not more than 2000mm or less than 400mm from finished floor level.

New HV switchboard is generally consisted of two incoming circuit breakers (RMUs) and outgoing transformer feeder circuit breaker(s) and each incorporating a series protection relay. These relays shall be set to achieve for discrimination with the downstream LV transformer circuit breaker(s) and upstream HV distribution ring relays.

Cable Facilities

Cable connection facilities shall be provided and sized for the termination of power cables as specified in the data sheets. The switchgear shall be suitable for cabling when the switchboard is fully assembled

Cable connection chambers shall be air insulated and shall be suitable for cables utilising a "Raychem" or similar heat-shrink sleeving stress control-insulating system.

HV Circuit Breakers

Unless other required, all HV circuit breakers shall comply with, or be provided with the following features:

Operating Mechanism: A trip-free closing mechanism (as defined in AS 2006), effective during the entire closing cycle, with a clear and distinct mechanically operated OPEN/CLOSED indication. In event of failure to latch in the closed position, the circuit breaker shall trip free at normal tripping speed. The mechanism shall be designed to close onto a short circuit and break short circuit currents, without damage.

Manual Closing: The HV circuit breakers (CBs) shall be provided with an independent, manually operated mechanism, as follows:
Mechanical indication of the spring charge condition
Capability of in-service spring charging
A padlock facility shall be provided to prevent manual close operation

Motor Charging: All CBs shall be provided with a motorised spring-charging facility. The circuit breakers shall have a 24DC motor winding mechanism for the charging springs. Terminals shall be provided for future addition of a remote OPEN/CLOSE operation.

Rating: Apart from intake switchgear, which is rated to Ausgrid requirements, HV switchgear within the campus shall be rated as follows:

Main busbars shall be rated at a minimum of 900amps
Tee-offs from the main busbar system shall be rated at 630 amps
Short circuit current making and breaking capacity – 20kA (for three seconds) & 50kA (peak)
Short circuit current withstand – minimum 20kA to suit Ausgrid supply.
Arc fault containment during short circuit conditions – minimum 20kA for 0.1 sec.
Design voltage levels – 12kV, 95 kV power frequency test, 95 kV BIL (insulation level)

Vacuum Interrupter Units: These shall be readily accessible for inspection, removal and replacement. The vacuum interrupter shall be rated for at least 100 short circuit breaking operations and 30,000 full load operations.

Earth Switch: A manually operated earth switch shall be provided in the outgoing circuit.

Site Dimensions & Shipping

The Contractor shall inspect the site and verify all site dimensions to assure that the entire equipment assembly offered is of a size that will fit within the proposed switchroom. If access is restricted, shipping sections of the switchgear are to be made in sizes to enable easy installation.

The Contractor shall provide for all transport, lifting and off-loading on-site, as well as all equipment and personnel to move and install the switchgear as required in-situ.

Access arrangements are to be made with the UNSW EM ENGINEERING (where required).

Site Supervision of Construction by HV Switchgear Supplier

The contractor shall engage and coordinate with the HV switchgear supplier for the supervision of installation and commissioning of the HV switchgear.

HV switchgear supplier shall provide certificate of compliance to manufacturer guidelines.

E.3.4.4. Substations

The UNSW has a variety of HV substations. However, in general there are two main types, the indoor type that is located within a building, and the outdoor type that is usually a kiosk, enclosing a transformer with high and low voltage switchgear.

Consultants are to discuss the options available, including space considerations, ventilation and associated matters with UNSW EM Engineering.

Cost benefits, life cycle and aesthetic considerations are important issues.

Substation Access
Adequate provisions shall be made to enable transformers, switchgear and other equipment to be easily brought into the substation, or removal of same, for repairs or maintenance. To this end, suitable doors, removable panels and other features useful in this regard shall be provided.

Air Conditioning/Ventilation
Indoor substations shall be air conditioned also be provided with adequate filtered ventilation equipment as a backup system.
Air conditioning and ventilation installations shall be provided to maintain the internal temperature within ambient temperature specifications of installed equipment.

The consultant shall provide proposals for utilising the building air handling plant or split A/C units for substation air conditioning purposes and shall submit proposals to UNSW EM Engineering for consideration.

Substation Floor
The Contractor shall ensure that floor levels are appropriate for the HV equipment to be installed and, if necessary, to make such adjustments and provisions (e.g. use of suitable shims) as are required to achieve this. Check with manufacturers to obtain specific level requirements for equipment to be provided. In addition, the Contractor shall modify or provide appropriate floor support structures for any HV switchgear or power transformer.

Following the installation of the electrical equipment suitable galvanised checker plates are to be installed to cover any open cable pit areas. Suitable lifting holes and lifting tools shall be provided.

Electromagnetic Interference
Transformers and current carrying conductors in substations give rise to magnetic fields. These electromagnetic fields can impact on PC operation as well

as affect some experimental work. For this reason, it is essential to locate substations in areas that will have minimal impact.

In cases where location of a substation is driven by other considerations, it may be necessary to install suitable shielding material.

Power Transformers

Power transformers and associated equipment shall be designed to comply with the requirements of AS2374 and AS60076. Transformers shall also be designed to meet load requirements, for continuous operation under normal site conditions and to provide a minimum of 25% spare capacity for future use.

The noise level of transformers when energized shall not exceed the level specified in AS60076 Part 10.

Minimum degree of enclosure ingress protection to AS60529 shall be IP65 for outdoor and IP42 for indoor applications.

Power transformers shall be manufactured by a reputable manufacturer to AS2374 and the following requirements:

Type	:	Vacuum Cast Coil Dry Type
Rating	KVA	(To meet design requirements)
Voltage level	:	20KV
System Voltage	HV/LV	10,500V/433V (No load)
Frequency	Hz	50
Vector Group	:	Dyn 1
Tapping Range	:	± 2x2.5%
Insulation Class	:	F
Winding Material:	HV/LV	Cu/Cu
Cooling mode	:	AN (w/- provision for AF cooling).
Design Standard	:	AS60076/IEC 60076

The final dimensions and mass of transformers shall be designed to meet site conditions.

E.3.4.5. Metering and Protection Transformers

Voltage Transformers (VTs)

One (1) set of voltage transformers shall be supplied and installed on the main busbar.

Voltage transformers shall be of the types, ratings and ratios required for proper operation of the protection relays as well as the EMACS digital metering. VTs shall be in accordance with AS 1243, rated at minimum 50 VA. and an accuracy class of 0.5M.

For protection purposes the VT voltage ratios shall be 11,000/110/63.5V. EMACS meters are rated at 240V.

Voltage transformers shall be of the epoxy resin encapsulated type of single-phase box-type construction, incorporating fuse protection on the secondary side. The configuration shall be Y-Y, with the primary star point earthed for protection purposes and the secondary star point for safety reasons.

Current Transformers (CTs)

Protection CTs

Protection current transformers shall comply with AS 1675 and be of ratio, accuracy and rating as required for proper operation of the protection system relays.
Current transformers shall be capable of being left on open-circuit with the primary circuit at rated current for one minute, without overheating or damage.
Current transformers shall be of the epoxy resin encapsulated type and shall not be embedded in compound filled chambers. Duplicate current transformer labels shall be fixed in a readily accessible position to the outside of chambers housing current transformers.
The primary winding of current transformers shall be capable of carrying, without thermal or electromagnetic damage or deformation, the rated making current and rated short circuit current (magnitude and duration) of the circuit breaker.

Metering CTs

A second set of CT's shall be provided within each circuit breaker unit, for the purpose of metering, and shall be connected to the digital meters, which are usually installed elsewhere within the switch room. The classification of the CTs shall be 0.5M.

Test blocks with shorting links, GEC type MMLG or similar (subject to approval), shall be provided in all CT secondary circuits.

Feeder Differential Protection

E.3.4.6. Protection System

Overall HV System is intended that the campus HV system shall operate on a closed ring basis, with Substations Nos. 12 and 13 being fed from Sub 29 on a spur, as is Sub 5a from Sub 33a and Sub 9a from Sub 9.

In general, existing series protection relays are consisted of Alstom Directional Over-Current Relays Type Microm P127, KCEG140 KCEG 142 and SEPAN S42 (by Schneider).

The Alstom Microm P127, KCEG 140 and SEPAN series relays have remote communication capability. To provide for future remote monitoring of the campus HV protection system, data cables shall be run from all such meters within a substation HV switchgear assembly to a clearly labelled terminal strip. This terminal strip shall be easily accessible from the front of the assembly by means of a hinged door. Data cables shall be of a type that will not be subject to interference in the in-situ operational environment.

All new or refurbished substations shall interface with the protection schemes in the adjoining substations and have the protection system tested by Primary Injection testing techniques.

Feeder Differential Projection
For faults on the feeders from the HV Intake Substations, where protection is unable to trip the associated CB due to CB failure, the KCEG140/Microm P127/SEPAN series relay protecting the feeder shall provide CB fail backup protection by back tripping after an appropriate time delay.

Over-current and Earth Fault Protection & Differential Protection
Each feeder and incomer shall be protected with IDMT over-current and earth fault protection, which shall be provided with the KCEG140/Microm P127/SEPAN series relays.

Transformers shall be protected by three-phase over-current, and single-phase earth fault protection and/or differential protection systems.

Discrimination of Protection
All equipment and protection devices to be installed are to be selected and/or adjusted at the time of commissioning to achieve appropriate discrimination and grading between the various levels of protection, in accordance with good design practice. Discrimination and grading shall fully consider upstream and downstream protection devices as well as the configuration of the campus reticulation system and the equipment connected thereto.

Statistical Metering

For statistical metering purposes, the following indications shall be provided on the protection series relays:

Vph	- ph line voltage	Vph - n	phase voltage
A	- current	kW	- kilowatt
kVar	- kilovar	pf	- power factor
f	- frequency		

All associated CTs, VTs and such other devices or power supplies required to ensure these indications are achieved shall be provided.

E.3.4.7. Tripping Battery and Charger

All substations that comprise of motorised circuit breakers and protection relays require a tripping battery and associated charger to operate them

The tripping battery and charger unit shall comprise a self-contained battery charger, complete with batteries, housed in a lockable sheet metal cabinet (baked enamel finish). In general, SAFT-Nife units have been installed in substations.

The unit shall be wall-mounted, incorporating two distinct and separate sections; a charger section and a battery section. The charger section of the cubicle shall be dust and vermin proof with the degree of protection: IP52 to AS 1939. The battery section of the compartment shall be vented.

The input voltage shall be 240V, 50 Hz, single phase and the output shall be 24V d.c.

The unit shall provide a constant potential d.c. output and shall compensate for load current and supply voltage fluctuations. The d.c. output stability shall be within plus or minus 1%.

The battery shall be of the nickel-cadmium type and shall have adequate ampere-hour capacity to supply the standing load for a minimum period of 3 hours, on loss of a.c. supply. At the end of this three-hour period it shall still be capable of tripping circuit breakers of the HV switchgear assembly at least 10 consecutive times.

Batteries shall have a life expectancy of at least ten (10) years.

The charger output shall be capable of carrying any standard load of the switchgear, in addition to charging the battery, and shall be matched to the recommended charging rate of the battery.

The charger output shall automatically regulate the trickle (float) and fast (boost) rate, depending on the charged state of the battery

The charger shall be self-protecting against overload and short-circuiting of the output and be capable of being subjected to the situations without damage to the charger.

The following equipment shall be included:

Input circuit-breaker

(b) a.c. charger ammeter/indicator

(c) Battery voltmeter/indicator

(d) Visual indicators

a.c. boost charge
Charge fail
Low battery voltage
High battery voltage
Low electrolyte level
Earth fault

The above shall be achieved by a computer-based system with digital display.

The unit shall be provided with a data communication port to enable remote monitoring, by means of Modbus RTU or BACnet protocols, of the status of the key unit indicators, listed above.

A common battery fault alarm shall be provided for indicating faults in the battery, also a voltage free contact shall be provided for remote sensing.

Both visual and audible alarms shall be provided including visual indicator test switch, mute button to cancel audible alarm and a flashing visual indicator to show that the audible alarm has been muted. These shall be located on the front panel.

For the solid-state protection relays to be used, the system output shall be arranged to ensure that during boost charging the voltage supply to the relays remains within allowable limits. An acceptable scheme would comprise series voltage dropping diodes in circuit during boost cycles.

All items on the front panel, as well as relevant internal items, shall be clearly and suitably labelled.

Circuit and connection diagrams as well as maintenance requirements shall be provided.

E.3.4.8. Substation Earthing

This section deals with the work associated with substation earthing, including substation equipment, by the direct bonding of all non-current carrying exposed metal to the substation earthing grid.

The earthing system shall be the combined earthing type, as per AS 3000, incorporating the HV substation and LV switchroom earths. The combined earthing system shall have a resistance to earth not greater than one (1) ohm

The substation earthing grid shall be designed to ensure the safety of personnel and equipment. The design and as constructed touch and step potential shall be within allowable limits for the design fault clearance time.

Internally within a HV substation, the earthing provisions shall include a copper strip (of not less than 50 x 6.3 mm cross section) fixed 100 mm above substation finished floor level. This strip shall be spaced 25 mm off the respective walls by means of suitable stainless-steel tubes fitted over metal screws expanding bolts, to secure the terminal strip to the walls. Copper earth strips shall be thermally rated for the relevant fault current and its duration.

All substation steel structures shall be bonded to the substation earthing grid. All steel support structures shall have two earthing tail conductors to the substation earthing grid. Each tail shall be thermally rated for the relevant fault current and its duration.

E.3.4.9. Testing of HV System

At the completion of specified works a NATA registered specialist contractor or organisation shall be engaged to test the UNSW HV protection system and ensure that all the various aspects of the system operate as required. The tests shall also ensure that there is a full complementary coordination within the campus HV system and with the upstream AusGrid HV protection system. To this end adjustments or resetting of the various protection systems shall be made as may be required.

HV power frequency tests shall also be carried out on associated HV cables.

A typed record of such tests and relay settings (3 sets) shall be provided to the UNSW at Practical Completion or as may otherwise be required.

The Contractor shall allow for and pay the cost of all charges or fees that AusGrid may impose or charge for their advice and/or attendance in relation to this

E.3.4.10. Testing of HV Switchgear

The following tests are required of the HV switchboard:

Type Tests
Certified type test reports are required to verify:

Ability of the circuit breakers, switches and combination to make, carry and break their rated currents;
Insulation level of all equipment;
Temperature rise together with millivolt drop or resistance readings of equipment type tested for temperature rise;
Radio interference voltage tests.

Routine Tests
All equipment shall be subjected to the following routine tests and copies of these shall be supplied in duplicate:

Mechanical operating tests;
Power frequency voltage withstand test;
Partial discharge tests;
Millivolt drop or resistance readings to compare with temperature rise type tests;
Insulation resistance.
Test of auxiliary devices

E.3.4.11. Labelling

The location and content of labels shall be clear, concise, appropriate and sufficient to enable even operators unfamiliar with the installation to easily establish the purpose and function of the plant, equipment, control devices and systems.

In addition to the circuit description, each switchboard panel shall carry a sequential number label, starting with pane No 1, from left to right when viewing the front of the switchboard.

All cables shall be clearly identified by appropriate cable codes approved by the UNSW EM Engineering.

Proposed label details shall be submitted to the UNSW EM Engineering for approval prior to manufacture.

All labels, unless otherwise specifically approved by the UNSW EM Engineering, shall be engraved on plastic laminate material (Traffolyte or similar). Labels shall have adhesive backing and be screw fixed in the required locations.

In general, labels shall consist of black lettering on a white background.

Cables shall be identified at each end (also cable type and size) and at terminations, on both sides of floor and wall openings, where cables enter conduits or ducts from a trench or cable pit. Unconnected cables shall be suitably tagged.

Tags on HV cables shall be of approved material, free from sharp corners and edges and attached to the relevant cables through two holes at each end so that the tags lie flat and longitudinally along the cables. The tags shall be fixed in such a manner to enable the labels to be easily read from the direction or point of access.

E.3.4.12. Testing and Commissioning

All relevant tests shall be carried out to ensure that the HV switchgear and associated equipment not only perform as specified and required, but also to do so safely.

For the testing and commissioning aspect of HV projects contractors shall supply all equipment (e.g. earthing sticks, meters etc.) and personnel to undertake all relevant tests (including any specialist works e.g. testing and programming of protection system) at their own cost.

The specified works shall be commissioned in total to ensure that the entire works operate in the intended manner.

Ensure the correct phase sequence of the HV switchboard busbars after connection of supply. Test energy meters, where fitted, on connected loads for correct operation.

The remote monitoring functionality of the protection relays shall be tested by means of a PC connected to the protection relay communication data terminal strip. The Contractor shall provide all software to enable this testing to be undertaken and proven.

Immediately upon completion of the works the Contractor shall replace the HV Diagram and Substation Layout in all Campus substations with an updated laminated version to reflect and incorporate the new works. The HV Diagram and Substation Layout shall be in the same colour, size and format as existing.

All testing and commissioning outcomes are to be documented and incorporated within the manuals required at the time of Practical Completion or as required.

E.3.4.13. As-Installed Documents

The UNSW EM Engineering shall make available to the successful tenderer a copy of the Campus HV reticulation diagram in Autocad compatible format.

Prior to granting of Practical Completion, the Contractor shall modify and upgrade this diagram to reflect the new works.

The Contractor shall submit this updated layout in the same format as originally supplied by the UNSW EM Engineering.

These layouts shall also incorporate the protection relay settings (and CT ratios) and schematic connection diagrams at each affected substation, as revised in accordance with the specified works.

A separate wiring and single line diagram of the protection system as well as tender drawings (where applicable) shall also be provided, to the Contractor, on 3½ inch HD floppy disk (or CD ROM) in Autocad compatible format. This shall also be updated by the Contractor to reflect the new works and/or associated interrelated adjustments.

E.3.4.14. Manuals

Requirements

Before commencement of operational maintenance, provide the specified number of copies of a site-specific combined operator's manual and technical manual, consisting of information collated and arranged in a logical order. This shall be written in clear concise English, containing a title page listing suppliers' names, addresses and telephone numbers, a table of contents, and the following data:

Operator's Manual:

Safe working procedures: For switching, isolation and earthing the high voltage supply and distribution system;

Operation and maintenance: Information for the satisfactory long-term operation and maintenance of the installation;

Maintenance periods: Recommended maintenance periods and procedures;

Equipment and tools: Particulars of maintenance equipment and tools provided, with instructions for their use.

The time frame for Operational Maintenance & Equipment and Tools shall be over the anticipated operational life of the equipment.

Technical Manual:

Diagram: A single line diagram of the circuit breakers, fuse-switches, switches, disconnectors, earthing switches and earthing points in the system;

Technical description: Detailed technical description of the equipment, functions of individual items, with diagrams, illustrations, protective relay curves, software information on microprocessor equipment, etc., where appropriate;

Dismantling equipment: Such drawings, data, details or procedures, shall be provided as may be necessary for the UNSW EM Engineering to install, maintain, dismantle, reassemble or adjust all parts of the works and repair or replace all parts particularly those liable to wear and failure, should this be required to be undertaken by the Principal at a future time.

Spares: List of spare parts provided;

Drawings: The work-as-executed drawings.

Form: A4 size, printed or typed on durable printing paper, each page consecutively numbered, and neatly bound in durable vinyl or similar hard covers.

Number of copies: Three (3)

E.3.4.15. Training

The Contractor shall arrange for and make available persons competent in the operation of the equipment provided in the works and carry out in-depth training workshops on the various items of equipment, aspects of the equipment operation, maintenance and associated safety matters.

Training shall be integrated and relate closely to the site-specific Operator's and Technical Manual.

It is anticipated that this would entail site-specific off-site (at equipment supplier's training facility) and 'hands-on' on-site training. Handout notes and provisions shall be made for ten (10) UNSW EM Engineering staff to attend.

At the end of the training sessions, participants should be able to program, operate and maintain the equipment with confidence and safety.

E.3.4.16. Authority Compliance

The HV installation shall comply with the requirements of latest Australian Standards (as applicable), the NSW Service & Installation Rules, the Supply Authority Regulations, The New South Wales Occupational Health and Safety Regulations 2001 and any other applicable rules or regulations.