Technical Specification - HV Installations

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Revision details

Version No.	Clause	Description of revision
1.0		General revision
2.0		General revision
3.0	All	Format update, changing ‘shall’, ‘should’ and ‘may’ to must where relevant to Sydney Water, ‘approved’ replaced with ‘accepted’, minor editorial changes elsewhere.

Introduction

This Specification is for the design, supply and installation of HV Installations for Sydney Water assets.

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

It is the user’s sole responsibility to ensure that the copy of the Specification is the current version as in use by Sydney Water.

Sydney Water accepts no liability whatsoever in relation to the use of this Specification by any party, and Sydney Water excludes any liability which arises in any manner by the use of this Specification.

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Acronyms

Term	Definition
AC (ac)	Alternating Current
ANSI	American National Standards Institute
AS	Australian Standard
AUD	Australian Dollars
c/w	complete with
GA	General Arrangement (drawing)
GPS	Global Positioning System
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)
IEC	International Electro Technical Commission

Term	Definition
IEEE	Institute of Electrical & Electronic Engineers
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LV	Low Voltage (i.e. greater than ELV but ≤ 1000 V AC or ≤ 1500 V DC)
MSDS	Material Safety Data Sheet
MV	Medium Voltage (note this term is not used in this specification)
PPE	Personal Protection Equipment
pu	per unit
PVC	Poly-Vinyl Chloride
SAA	Standards Association of Australia
SCADA	Supervisory control and Data Acquisition
Sec.	second
SLD	Single Line Diagram
TBA	To Be Advised
TBC	To Be Confirmed
VLF	Very Low Frequency

1. General

1.1 Introduction

This Equipment Specification defines the minimum technical requirements for the design and Installation of High Voltage (HV) Installations. This Specification does not apply to the commissioning or performance testing of equipment.

1.2 Scope

This Specification includes (but is not limited to) details regarding the following:

a) Installation of conduit and pit systems for HV cables

b) Cable installation

c) Substation design.

1.3 Proprietary items

Nomination of a proprietary item by Sydney Water does not imply preference or exclusivity for the item identified.

Alternatives that are equivalent to the nominated items can be submitted to Sydney Water for acceptance. The submission must include appropriate technical information, samples, calculations and the reasons for the proposed substitution, as appropriate.

2. Technical requirements - general

2.1 Environmental requirements

The HV installation and associated equipment must be constructed and installed for operation in the following environmental conditions.

Environmental conditions		
Maximum ambient temperature		+45 ºC
Maximum 24hr average temperature		+35 ºC
Minimum ambient temperature (corresponds to “minus 5ºC indoor class”)		-5 ºC
Maximum relative humidity	For one month	90%
	For 24 hours	95%
Maximum elevation above sea level		1000 m

2.2 Standardisation

All installation equipment must be designed with standard parts and components readily available within Australia. Parts and components must be standardised as much as possible. All replaceable and consumable equipment must be standard supply equipment. The use of “one off” special designs is only permitted with an approval from Sydney Water’s High Voltage Authorised person with documented justification. The intent is not to encourage special designs that will create nonstandard versions.

3. HV Installations

3.1 Installation principles

The following principles guided the compilation of this document.

- Electrical installation does not expose personnel to the hazards of electricity
- Personal protective systems are not compromised by the electrical installation
- Electrical installation complies with the design requirement
- The electrical installation is safe to isolate, operate and maintain
- Electrical plant, equipment and devices are uniquely and permanently labelled
- Signage is installed to indicate electrical hazards
- Prevention of inadvertent access to live exposed conductors
- Installed equipment has adequate protection for expected exposures to damage caused by environmental exposure or impact events
- Electrical installation equipment type accords with Sydney Water and the local plant requirements.

3.2 Minimum requirements

- The electrical installation and work must comply with Government Acts, Regulations, Codes of Practice and Industry Standard Codes
- Modifications, repairs or additions to the electrical installation must comply with the requirement of this document and not compromise the integrity of the installation
- Equipment, devices and tools used in the electrical installation must be installed and used in accordance with the manufacturer's specification
- Material and equipment must be suitable for the environment
- Hazards introduced by construction must be reduced to as low as practical.

3.3 Working on high voltage equipment or in a high voltage area

When working in/on high voltage areas/equipment the installation Contractor must comply with Sydney Water High Voltage Operating Procedures.

All high voltage work must be performed under access permit conditions as described in the HV operating procedures.

4. HV substation design

The design of the substation must be such that it will have a minimum service life in the respective equipment and structure specification and is to be constructed from materials which will require minimal future maintenance.

4.1 Power system modelling

The installation design must include the modelling of the HV network with a full protection, arc flash and load flow analysis using SKM POWER*TOOLS for Windows to ensure grading of the various protection levels across the HV network and including the main LV circuit breaker after transformer as a minimum. The library file is available from Sydney Water and the current version must be requested for the model.

The model including all library files must become the property of and be handed over to Sydney Water's Urban Design and Engineering (UD&E) team at the completion of the installation design. The Intellectual Property (IP) will remain with Sydney Water.

4.2 Substation layout

The layout of the substation must be designed to ensure the security of supply to the plant. The following items must be considered when designing a HV substation:

1. The plants process requirements
2. The sites geographical layout and contours
3. The cable routes/layouts to processes
4. Fire ratings of buildings and the potential of fire propagation
5. Substation access (security, maintenance, operation).

The high voltage substation design must typically consist of the following items:

- Transformer bunding and yard
- HV Transformers
- HV switchroom
- HV switchgear
- Battery charger and Batteries system for the substation control and protection (typically one battery charger and batteries system per HV switchboard)
- Remote switching panel for the operating functions of the switchboard (i.e. opening and closing of circuit breakers, racking in and out of VCBs/FVCs, Starting and stopping of pumps, remote earthing). The remote switching panel location must be in the LV and auxiliary equipment room of the switchroom. The remote switching panel door must be lockable using Sydney Water 10 mm padlocks or keyed to Sydney Water bi-locks.
- Cable pit and conduit system
- HV and LV cabling between the various components of the substation
- Security fencing of the substation
- Earthing, bonding and lightning protection of the substation.

4.3 Civil design

The civil design needs to ensure that the substation can effectively withstand a 1 in 100 year flood or major storm event without significant damage. Typically, all control cubicles for the yard equipment and the buildings floor level must be designed and constructed a minimum of 500 mm above the expected flood levels. For high rainfall and coastal areas, the level minimum floor level may need to be considered to cater for extreme storm and higher than normal water levels.

4.4 Footings

A footing design must be developed for the specific situation and soil conditions. Typically, information from a geotechnical assessment of the site must be used to develop each footing design.

A footing layout drawing must be produced to provide the location and reference level information for the construction of all the footings.

4.5 Drainage

The substation must have a subsurface drainage system installed to remove excess water from the site and the site must be contoured in such a manner as to remove hollows, which may retain water and cause ponding. All drainage water must be collected in adequately sized drains to a suitable off site discharge point in a manner that complies with all relevant NSW government departments, local council and water authority regulations. Building basements, cable pits and trenches must be drained to the storm water system.

A drainage layout drawing must be produced to provide the location and reference level information for the construction of all drainage systems.

4.6 Earthing and Lightning protection design

The substation earth grid and lightning protection design must be produced and be in accordance with the requirements detailed in the Sydney Water earthing and lightning protection specification DOC0016 and Technical Specification - Electrical.

The earthing system must be designed to ensure equipotential bonding such that there are no dangerous potential gradients developed in the substation.

The earth grid layout drawing must provide all the information required to install the earth grid equipment and make all the necessary connections. The drawing must also include a material schedule listing the required types, sizes and numbers of conductors, earth stakes, inspection pits, connectors, lugs and fittings. The earth grid layout drawing must be updated after installation to include GPS co-ordinates for each earth stake installed.

4.7 Fencing

4.7.1 Design

Substation fencing must comply with the minimum requirements in AS 2067 and must be of the intruder resistant weld mesh type.

The substation fence must be designed such that, any structures or fixtures that might aid a person climbing the fence, are positioned clear of the fence.

The substation fence must have as minimum two pad lockable personnel gates and a pad lockable double vehicular gate of minimum 5metres wide. Each personnel gate must be located at either end of the substation. Typically, one personnel gate is located adjacent the vehicular gate. The vehicular gate must be internally accessed via the personnel gate.

The substation HV switchroom building may form part or whole of the substation perimeter fence, only if the HV switchroom building has high security ratings for the doors, windows and or security systems. The HV switchroom exterior must be smooth to minimise hand and foot holds.

4.7.2 Climbing points

All climbing points must have measures to prevent entry. The fence design must ensure that any climbing device is 3 m or more away from the fence. If this is not practical, then increase the height of the fence above the barrier to ensure minimum height.

a) Gate locks - the locks must not create an external foot or hand hold

b) Stairs - remove/relocate stairs and/or provide increase in fence height. Otherwise provide a security grill/mesh around the stairs.

c) Adjacent fence - where an abutting fence (non-intruder resistant) cannot be removed or relocated, then increase the height of the intruder resistant fence to 2.4 m above the highest foot hold

d) Adjacent pole - if the pole cannot be removed or relocated then the fence will need to be redirected around the pole with a reduced clearance of 2 m

e) Overhanging vegetation - remove or prune back to 3 m away from fence (and provide on-going inspections). If this is not possible trim trunk smooth to a height of 6m to remove any climbing points.

f) Ground material - all material (cable and storage drums, steel work, containers, pallets etc.) must be kept in designated storage areas, or at least 3 m away from the fence.

4.7.3 Kerbs

Concrete kerbs must be included in the design of the substation fence. They prevent the integrity of the fence being compromised due to subsidence, erosion and burrowing. Typically, the kerb centre line must be centred directly below the fence line. If a concrete kerb cannot be used, then a concrete path must be constructed.

The bottom of the fence must not be more than 50 mm above the concrete kerb or path.

4.7.4 Weld mesh fencing

Closed space welded mesh fence is the preferred type and must be a single layer mesh fence with 4 mm galvanised high tensile steel wire with an aperture size of 13 mm x 76 mm. The orientation of the mesh must be such that the horizontal mesh aperture (76 mm) is larger than the vertical mesh aperture (13 mm).

The weld mesh must be galvanised and powder coated prior to installation. The colour of the powder coating must be approved by Sydney Water prior to manufacture.

4.7.5 Construction

The construction must be as follows:

a) Plumb, level and true to design position

b) All steel, fully welded, galvanised and powder coated typically dark green (approval from Sydney Water required)

c) As a minimum 2400 mm high panels of mesh with 500 mm of topping spaced 100 mm off the finished ground level with top and bottom rails. Where the height of the fence increases due to an adjacent climbing aid then a mid-rail must be included in the sloping and heightened panels and have appropriate bracing.

d) The 500 mm topping above the panels must be fitted with spiral rolled barbed wire or razor wire

e) The mesh must be under tension or ensure there are no slack sections. If there are slack sections then a mid-rail must be installed and fixed.

f) Mesh to be installed with the vertical wire on the outside of the fence to reduce scalability

g) Foundations, braces, vertical and horizontal supports are required to withstand the loads imposed on a fence to AS/NZ 1170. This includes self-support, wind loads, ramming and pulling over.

h) All vertical posts must be set in concrete (minimum 25 MPa)

i) All concrete to be reinforced to AS 3600

j) A straining post must be installed for each end, corner, change of direction and acute variation in the level of the fence. For straight runs, a straining post is required every 50 m minimum. Each straining post must be supported by a brace in each direction of the fence line.

k) Mesh to mesh and mesh to post joins must be with galvanised tamper resistant or locking, nuts and bolts

l) Mesh to mesh joins (if any) must overlap a minimum of 200 mm. Each overlap must have a securing every 100 mm horizontally and 300 mm vertically.

m) Any metal exposed during construction must be coated with a two part epoxy corrosion inhibitor

n) Final surface finish for all parts must be homogenous and approved by Sydney Water.

The fence must form a continuous conductive path with a grading wire included under the fence and bonded to every bay/panel. All aspects of the fence must be bonded to the earth system, including gate bonding, grading rings etc. must be in accordance with the Sydney Water Earthing Standard. The earth grading ring must be located clear of any concrete path to ensure safe step potentials.

Substation signage must be installed on the fencing in a clearly visible and readable location and be in accordance with AS 2067, AS 1319 and Sydney Water requirements.

4.8 HV switchroom

The HV switchroom design must be produced and be in accordance with the requirements detailed in the Sydney Water switchroom specification DOC0018.

4.9 Transformer oil containment

Where power transformers are not enclosed in a pre-fabricated self-bunded substation, they are to be installed with facilities to contain any oil spillage in the event of a tank failure. The containment facility must be sufficient to contain oil volume in accordance with AS 1940 and AS 2067. Bund walls must be constructed on the concrete slab that forms part of the transformer foundation. No oil must be allowed to leech into the soil below the bund. Oil containment is to be in accordance with AS 2067.

The transformer bund size and height must be designed in accordance with AS 1940 section 5.8 and appendix H. The constructed transformer bund must include a concrete pad raised above the oil containment level on which the transformer must be mounted. The transformer bund must include a sump pit located at one of the front corners of the bund. A 50 mm diameter drain pipe must be installed between the bund sump pit and the external wall of the bund at a minimum 150 mm above the external ground level. The drain pipe protruding from the external wall of the bund must be fitted with a pad lockable gate valve. The valve must be fitted with a suitable flange to allow the connection of an oil water separator system.

Where specified, an oil water separation system must be designed and installed at each substation.

Where a concrete oil water separation tank is installed the water overflow from the tank is to undergo suitable treatment within the property boundaries of the substation site using an appropriate secondary filtration process. This is to ensure full compliance with regulatory and legislative requirements.

A transformer footing and bund design drawing must be produced detailing the information and materials required to construct the footing and bund. The footing layout drawing must provide the location and reference level information for the construction of the transformer pad and bunding. The installation of the oil water separator and associated pipe work must be included on the drainage layout drawing.

The transformers must generally be separated by a minimum distance of as specified in AS 2067. If these distances cannot be met a blast wall must be constructed between the transformers. The blast wall must be designed as per the requirements of AS 2067.

All conduits entering the transformer bund must have a finish height above the oil containment bund height and must be sealed to prevent the ingress of any liquid and be fire rated.

The design of the oil containment must consider the operability and maintainability of the installation throughout the equipment design life.

5. Pits and conduits

5.1 General

Separate pit and conduit systems must be provided for the HV and LV installations. Instrument and power cables may be laid in the same pit but in separate conduits. Barriers must be provided in the pits to separate instrument and power cables.

All cable pits must be spaced no more than 50metres apart and provided at each turn of change in direction of conduit run.

The pits must have minimum of 1200 x 1200 mm clear opening and a 100 mm drain with vermin proof drain pipe to the nearest drainage system with non-return valves provided in the pits.

All pit covers must comply with the requirements outlined in the latest Sewerage Code of Australia WSA 02 - 2002.2.2 Sydney Water Edition for MH (Manhole) Covers.

The last pit in the pit and conduit system must be lower than the switchroom floor or trench and be drained away to avoid water entry into the switchroom.

Pits deeper than one metre must have approved non-corrosive step iron installation for safe access.

Conduits and fittings must be PVC and comply with the Australian Standards. Conduits smaller than 50 mm diameter must not be used.

High voltage conduits must be minimum 150 mm diameter. At least one 150 mm spare conduit for future use must be installed.

Polypropylene draw wires must be installed in all spare conduits. A length of cord minimum 1000 mm long must be left securely fixed at the ends of each conduit run.

Conduits must be in long, straight, smooth and free from rags, burrs and sharp edges. Off-cuts must not be used to fabricate long lengths of conduit. Conduits must be set wherever possible to minimise the number of joints.

Conduits must be coupled using spigot and socket arrangements. PVC solvent cement must be used first as a primer for both mating surfaces. Glue must then be applied to bond the primed surfaces.

All joints must be properly made to eliminate the entry of water and foreign matter into the installed conduits.

All conduits must be sealed against the ingress of water and any foreign material which may hinder the removal and or pulling through of cables.

All unused conduits must be sealed using approved conduit sealing materials.

Used conduits (i.e. conduits with cables in them) must be sealed to prevent the ingress of any liquid and be fire rated.

Conduits entering pits and trenches must be smooth to eliminate damage to cables during cable pull. All gaps around the conduit entry to pit or trench must be sealed.

External conduits and above ground conduits subject to the possibility of damage must be mechanically protected.

A 150 mm wide yellow or orange marker tape with a metallic tracer must be laid above all underground electrical conduits.

Cable route markers must be installed every 25 metres on straight runs, at each change of direction and at each side of a road crossing. Cable markers must be brass engraved labels on hard surface and flexible “Telstra type” posts for open areas.

Bends must be at least 12 times the cable diameter and must be formed with proper formers. Correctly sized springs must be used to form bends in UPVC conduits. Conduits manipulated or bent must maintain true effective diameter and shape at all parts of the bend.

Saddles must be stainless steel double-sided for steel and PVC conduits. PVC saddles must not be used.

Saddles supporting conduits must be effectively secured to the surface on which they run with plastic plugs up to No.8 gauge stainless steel screws, for larger fastenings stainless steel Dyna bolts or Loxin anchors or chemical anchors must be used. Saddles must be proprietary brand installed as supplied.

5.2 Heavy duty UPVC conduits

This conduit is for both underground use and above ground use. When used above ground the conduit must be painted to prevent deterioration of the conduit due to exposure to sunlight and be fitted with a “DANGER HV” sign. All fittings must be of the same material as the conduit and all joints must be made with adhesive cement recommended by the supplier of contracting colour.

5.3 Conduits in concrete

Unless otherwise indicated, conduits must not be run in the concrete toppings. Conduits run in the fill under floor slabs must be HD-UPVC. Corrugated conduits are not permitted.

Conduits must be securely fixed to the reinforcing rods, passing above a single layer of rods or between a double layer of rods, generally mid-way in the thickness of the slab. Attention must be paid to routes of conduits in slabs to avoid crossover and to keep the number of conduits in any one location to a minimum. Conduits in slabs must be spaced not less than 75 mm apart.

Conduits may cross, provided they interest at angles greater than 30 degrees and are tied together. The minimum cover over the conduits must be not less that the conduit diameter or 20 mm, whichever is larger.

Conduits must not be installed in a slab through the areas around a column to one quarter the distance from the column to the next column, supporting beam or wall, except to outlets in the area.

Conduits in concrete must be inspected by Sydney Water prior to pouring concrete. Sufficient notice, time to alterations or modifications found necessary during inspection must be allowed. Sydney Water attendance is mandatory during concrete pouring to ensure that conduits are not displaced, broken or damaged.

5.4 Installation

The minimum laying depth of conduits must be in accordance with AS 2067 and AS 3000.

UPVC conduit must not be installed on exterior surfaces. However, short runs of HD-UPVC pipes from underground sub-mains may be surface run where they enter an existing building if it is not practicable to conceal them, provided that they are suitably protected from mechanical damage and sunlight.

Jointing of conduits and fittings must be carried out strictly in accordance with the manufacturer’s recommendations.

Conduits which are installed underground or concealed in concrete floor slabs, foundations or the like must be cleared of foreign material and obstructions after installation and prior to cables or draw wires being drawn in.

Conduits must be installed so that the system may be wired using the “Draw in loop in” system.

The installation of elbows, tees, etc. is prohibited on conduits installed in inaccessible locations.

Excavated trenches must be straight as possible and the bottom of the trench must be firm and smooth free of rocks, pebbles, foreign matter and sharp projections.

All conduits must be effectively capped during construction.

The following installation procedure is for dry bedded banks of 150 mm conduits:

1. Place 105 mm deep layer of bedding material at the bottom of the trench and compact the bedding down to 70 mm
2. Lay the first row of conduits. Maintain a minimum separation of 70 mm between conduits, and 70 mm between the outer conduits and the sides of the trench
3. Place bedding material over the first row of conduits to a depth of 345 mm and compact the bedding material down to 230 mm
4. Lay any additional rows, then place more bedding material and compact the rows in the same manner as 3
5. Place 150 mm layer of bedding material over top layer of conduits and compact down to 100 mm
6. Place polymeric cable protection covers with metallic tracer complying with AS 4702 directly above the bedding material over the entire length of the cable route. The polymeric cable cover strip ends must overlap by at least 20 mm to provide continuous protection and overlap either side of the conduits or cables by at least 40 mm. A 15 0mm layer of backfill should be placed immediately over the installed cable covers to secure the cover in position.

Note: When adding and compacting the bedding material, care must be taken to avoid dislodging the laid conduits from there required position. Care must be taken when bedding to ensure that excavated material is not maxed with the bedding material.

5.5 Backfill

Ideally the excavated materials should be replaced in the same position from which it was excavated and in the same state with regards to content and compaction. If the material is unsuitable to be reused due to it containing building material and rocks or contaminated substances, then suitable replacement backfill must be used.

All backfill material must be compacted in layers not exceeding 150 mm compacted thickness. Compaction methods that do not cause damage or misalignment to the underlying utility service, adjacent services or structures must be used.

All excess spoil must be removed from the site.

All excavated surfaces must be restored in a continuous manner to a condition equivalent to that existing at the commencement of the works.

After installation and backfilling of a bank of conduits, all conduits must be thoroughly cleaned and tested to ensure their integrity. Conduits found to have defects which may cause damage to cables must be repaired or replaced.

5.6 Restoration of surfaces

Reinstate the existing surfaces removed or disturbed by trench excavations to match existing and adjacent work.

Lawn areas

Provide 150 mm of loam and returf the lawn over the trench and other disturbed areas. Note the turf type must match the existing surface removed or disturbed.

Concrete surfaces

A crushed rock base and sub base to match the existing pavement must be provided. Where straight cut edges are damaged, re cut the edges to provide a straight edge for the whole trench route. Prime coat the cut edges of the existing surfaces with cement slurry. Lay and compact concrete so that the edges are flush and the centre is cambered 10 mm above the adjoining existing surfaces.

Minimum concrete thickness must be 75 mm or the adjacent pavement thickness, whichever is thicker.

If required provide steel reinforcement with dowels into adjacent concrete.

Expansion joints must be installed in locations to coincide with and match joints in existing pavement.

The concrete strength must be 25 MPa and must be cured by keeping it continuously wet for 7 days.

Bituminous surfaces

A crushed rock base and sub base to match the existing pavement must be provided. Where straight cut edges are damaged, re cut the edges to provide a straight edge for the whole trench route. Prime coat the edges of the existing surfacing with bitumen. Lay and compact hot-mix asphalt so that the edges are flush and the centre is cambered 1 0mm above the existing pavement.

Minimum asphalt thickness must be 50 mm or the adjacent pavement thickness, whichever is thicker.

Segmental paving

Sand bedding and compacted crush rock base must be provided, if required to match the existing construction reinstate the paving units.

6. Reticulation and wiring

6.1 Drawings

For installations of new/replaced power cables, a detailed drawing of underground cabling, conduits and pits must be completed and must include GPS co-ordinates of all cables, conduits and pits at each direction change.

6.2 Setting out of runs

In setting out the work, the following directions must be followed:

- Cables and conduits must be fixed parallel to building members, walls, doors, etc. and must be run on the square wherever possible. In slabs, conduits may be run diagonally as directed.
- All cables and conduits must be arranged in a neat and workman-like appearance
- Cabling must be installed so that it may be replaced. Where cabling passes through an inaccessible space it must be capable of being drawn through the space. Note. This may require the installation of conduit through the space.
- Underground conduits containing cables must be laid straight with minimum deviation from the horizontal and vertical planes
- Cable runs in infinite access floors must be in cable trays
- Cable runs in cable trenches must be in cable trays.

6.3 Underground reticulation

To preclude damage, cables must be drawn using rollers, drum jacks and a cable stocking of the correct size.

Where required by the Wiring Rules, mechanical protection for cables, other than those enclosed in heavy duty enclosures to AS 2053, must be proprietary manufactured or precast bricks or covers, with the letters “ELECTRIC” permanently indented. Covers cast on site will not be acceptable.

Where electric bricks or covers are not required over underground wiring a 150 mm wide yellow or orange marker tape with metallic tracer and bearing the words “WARNING - ELECTRIC CABLE BURIED BELOW” or similar must be laid in the trench 150 mm below ground level for the entire length.

6.4 Penetrations

Generally, all penetrations and repairs to penetrations must be coordinated as indicated. Penetrations through damp courses will not be permitted.

Penetrations Though Waterproof Membranes:

Conduits which enter a building at ground level must run under waterproof membrane and vertically penetrate through the membrane and the concrete slab at the appropriate position.

Penetrations Through External or Existing Structure:

Where conduits pass through external walls, existing ground floor slabs or existing ground floor beams, a penetration 10 mm greater than the conduit diameter must be provided. The penetration space around the conduit must be made waterproof by using a proprietary sealing method.

7. Cables

7.1 General

HV cables must have copper conductors, XLPE insulation, PVC sheathed and a copper heavy-duty fault screen. The minimum size of conductors must be as follows:

Minimum HV cable sizing	
33 kV cables	95 mm^2
22 kV cables	95 mm^2
11 kV cables	95 mm^2
6.6 kV cables	50 mm^2
3.3 kV cables	35 mm^2

All external cables must be run in an underground conduit and pit system or a covered trench system.

HV cables must be run on separate cable tray dedicated to HV cables only.

HV cables run on ladder tray, must be fixed with suitably fault rated stainless steel ties designed for securing of HV cables.

All cables must be continuous throughout their route length.

Correct phase to phase relationship, phase colours, orientation and phase rotation must be maintained at all terminations of cables throughout the installation.

Cables in concrete trenches must not exceed three layers.

All decommissioned cables must be removed and disposed of from the existing pits, conduits, trenches and cable trays as per the requirements in the Technical Specification -Electrical.

Any cable that suffers abrasion or damage to the insulation during drawing in must be replaced.

Cables must not be laid under areas designated for future switchboards.

7.2 Installation

HV cables must be laid in the longest lengths possible (subject to maximum drum lengths and the pulling tension requirements).

Materials used to lubricate cables whilst drawing-in to conduits must be non-conductive, non-abrasive and non-hygroscopic.

The internal bending radius of the cable being laid must be minimum 12 times the overall diameter of the cable and not less that the cable manufactures specification.

The pulling tension of the cables being laid must not exceed the cable manufacturer's specification.

Any plant used to pull cables must be firmly anchored before a pull commences to prevent uneven tension on the cable due to winch movement. The cable must be drawn smoothly into position with a minimum of stop.

The cable must be placed so that the cable is pulled from the top of the drum.

Appropriate rope tension fuses must be used between the pulling rope and stocking for each cable pull where a driven winch is used.

Where cable is pulled around corners or angles, special corner rollers are to be used. The cable must not enter or leave any cable rollers at an excessive angle or exceed the cable manufacturers recommendation for internal bending radius.

On completion of cable pulling all cables must be inspected for damage. Any damage to cables resulting from installation must be repaired or replaced at the contractor expense.

In the plant rooms without cable trenches or underground conduits, cable trays must be used for all HV cable routes whereby the main cable routes must be wall mounted "overhead" and at least 2100 mm above the finished floor level.

All cable entries must be machine-cut (hole-saw) and free of burrs and sharp edges. Cutting of holes by burning methods must not be acceptable.

Care must be exercised when laying cables in ducts, cable ways, trenches and ladder trays. They must be neatly layered and run parallel. Wherever possible cables must be run in North-South or East-West straight runs. Bunching will not be acceptable and crossovers must be confined to cables entering and leaving the medium.

All cables must be terminated with suitable cable glands for the type of cable used.

(NB: Brass glands must not be used with aluminium or aluminium alloy boxes.)

7.3 Cable joining and terminations

Cable jointing kits/materials and cable termination kits/materials must be suitable for the nominated cable being installed. All cable joints and terminations must be completed by suitably qualified and Sydney Water approved personnel.

All cable joints and terminations must be completed in accordance with the manufacturer's installation instructions.

Joints on cable rack/ladder must be positioned in accessible locations clear of any obstructions and must be in a straight section with at least two metres of straight cable at either side of the joint.

Joints on cable in conduit and pit arrangements must be completed in pits with at least two metres of straight cable at either side of the joint.

Joints on direct buried cable must be positioned in accessible locations clear of any obstructions and must be in a straight section with at least two metres of straight cable at either side of the joint.

7.4 Labelling and identification

All power cables must be identified at each termination by the appropriate red, white and blue phase colour, and black for the neutral.

All earth conductors must be identified at each termination by the colour green or green/yellow. Other colours must not be acceptable. Under no circumstance must the colour green or green/yellow be used for other than earth conductor identification.

The cable identification must be in accordance with the cable schedule and/or interconnection wiring diagram.

8. HV Installation testing and inspection

All factory and site testing of specific HV equipment including Switchgear, protection relays, power transformers, cables, motor starters, PFC, Overhead line equipment, battery chargers, earthing and lighting systems, HV switch-rooms etc. must be in accordance with their respective Sydney Water specifications and Australian Standards.

All HV cables must be VLF withstands tested and insulation resistance tested to ensure they are acceptable to be put into service after being joined or terminated.

All transformer bund drain valves, oil containment system and oil water separation system must be operated to ensure they function correctly.

The final test on the overall substation power system must be to energise all the HV equipment with no load and allow to soak for 24 hrs after which load can be added if no issues found.

Temporary HV installations for project cutover or equipment repair are deemed to be new installation, the equipment must comply with relevant current specifications as much as practical. Temporary switchgear must be AFLR and/or capable of carry out switching remotely. Prior approval is required when temporary installation deviate from relevant specifications.

9. Reference documents

The HV Installation and all associated equipment and materials must be designed, constructed, manufactured, installed and tested in accordance with the latest revisions of the Federal and State statutory requirements, applicable Australian and IEC Standards, as well as the Sydney Water standard specifications:

Document type	Title
Legislation	- Latest edition of the Work Health and Safety Act - Latest edition of the Service and Installation Rules of New South Wales
Policies and procedures	- WSA201 - Manual for Selection and application of protective coatings - Supplement to WSA201 - Manual for Selection and application of protective coatings - PCS100 - Protective Coatings - SDIMS0026 - Service Delivery Safety Signage Specification
Other documents	- DOC0016: Specification Earthing and Lightning Protection

Document type	Title
	- DOC0018: Specification HV Switchrooms
Standards	- AS ISO 1000: The International System of Units (SI) and its application (ISO 1000) - AS 1319: Safety signs for Occupational environment - AS 1428: Design for access and mobility - AS 1940: Storage and handling of flammable and combustible liquids - AS 2053: Non-metallic conduits and fittings - AS 2067: Switchgear assemblies and ancillary equipment for alternating voltages above 1 kV - AS 2700: Colour standards for general purposes - AS3600: Concrete structures - AS/NZS 3000: Electrical installations (known as the Australian/New Zealand Wiring Rules) - AS/NZS 3008.1.1: Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6 / 1 kV - Typical Australian installation conditions - AS 62271.1-2012 High-voltage switchgear and controlgear - Common Specification

9.1 Conflicts between Specification, Standards and/or Codes

Review the above standards and make use of them where they are applicable. Identify any conflicts between the above standards and recommend which criteria to use. The Contractor must refer any conflicts in the information to Sydney Water for clarification.

Ownership

Ownership

Role	Title
Group	Integrated Systems Planning - Liveable City Solutions
Owner	Manager of Urban Design and Engineering
Author	Lead Engineer Electrical

Change history

Version No.	Prepared by	Date	Approved by	Issue date
1	Robert Lau / Andrew Manganas / Paul Zhou	05/12/2014	Norbert Schaeper	05/12/2014
2	Robert Lau / Paul Zhou	14/09/2018	Ken Wiggins	14/09/2018
3	Paul Zhou	20/02/2020	Steve-Keevil Jones	20/02/2020